

Solar Applications in the Development of Smart Cities in India

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Abstract— The paper discusses the exploitation of solar energy for various applications in India, like solar street lights, solar water heaters and solar rooftop systems. Solar energy being a renewable and a sustainable source of energy is very useful in day to day life. Indian Government has supported this idea by taking initiatives to develop and deploy solar energy for meeting the demands of energy requirements of the country through various applications. This is helpful in the establishment of smart cities. A good research about the need, requirements, goals and objectives, benefits, challenges etc. regarding all the three applications have been provided as a part of development of smart cities. A comparison of present to future scenario with graphs, pictures and certain real life examples will also be included from various references.

Key words: Solar, Renewable, India, Applications, Smart

I. INTRODUCTION

At this day and age of smart phones and smart technologies, where everyone is running in a race of being smart or rather smartest, something is being left behind. Energy is the fuel in this race. With growing urbanization there is a rapidly rising energy demand which is in turn leading to increased emissions of greenhouse gases.

Renewable energy in these conditions is not just a topic of discussion but rather a concept of implementation.

In states like Gujarat and Rajasthan where there are nearly 300 days of full sunlight, the solar power or the solar energy can be the best replacement. It is the most readily available source of energy in abundance. And the best thing, it is not owned by anybody and therefore, it's free.

Solar energy is being used since prehistoric times but in a very primary way and merely without our knowledge. A great everyday example is when we hang our clothes out in sun for drying, we are actually using the energy from the sun. In a similar way a solar panel works, it absorbs the energy from the sun and store it or converts it in a usable form.

The following pie chart shows the energy production, in megawatts, of different states of India:

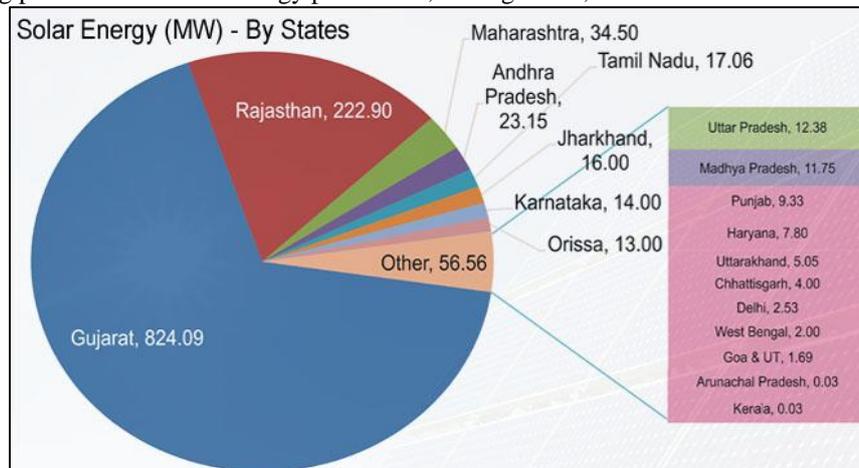


Fig. 1: The above pie chart shows solar energy production in Megawatts. [Source: www.projectstoday.com]

From the above pie chart (figure 1), we can say that Gujarat is leading with 824.09 megawatts followed by Rajasthan with 222.90 megawatts and other states.

II. APPLICATIONS OF SOLAR ENERGY

There are practically many applications of solar energy, from solar cookers to solar chargers to solar rooftops and many more. Three of them are discussed in detail in this paper. They are namely:

- Solar water heater
- Solar rooftops
- Solar street lights

A. Solar Water Heater

Products which run on the basis of solar energy help to reduce our carbon footprint in a dramatic way which helps in creating a sustainable living for our future generations.

The solar radiation incident on the surface of the earth can be very efficiently used for the benefits of humans. One of the most popular products that harness the solar energy is a solar hot water system (SHWS).

1) Basic Components of a Solar Water Heating System

The basic elements of most common solar water heaters are:

- Flat-plate collector-To trap the sun's energy
- Heat transfer fluid
- Storage tank - It is used to store hot water.

Other components such as heat exchanger, pumps, pipe network, valves, energy source, and control systems can be included according to the desired design.

2) Principle and Working of Solar Water Heaters

A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the water to the riser pipes below the absorber panel.

The water passing through the riser pipes get heated up and is delivered to the storage tank. There, circulation of the same water through absorber panel in the collector raises the temperature to 80 C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system

3) Types of System

a) Active Systems

Broadly, the active solar water heating systems can be primarily divided into two categories. They are:

- OPEN LOOP OR DIRECT: In this type of system, the pumps circulate household water through the collectors and into the home. They work well in climates where the temperature aren't low enough to let the water freeze.
- CLOSED LOOP OR INDIRECT: In this type of system, the pumps circulate a non-freezing fluid which transfers the heat through the collectors and a heat exchanger. This heats the water which then flows into the home. They are popular in climates which are prone to freezing temperatures.

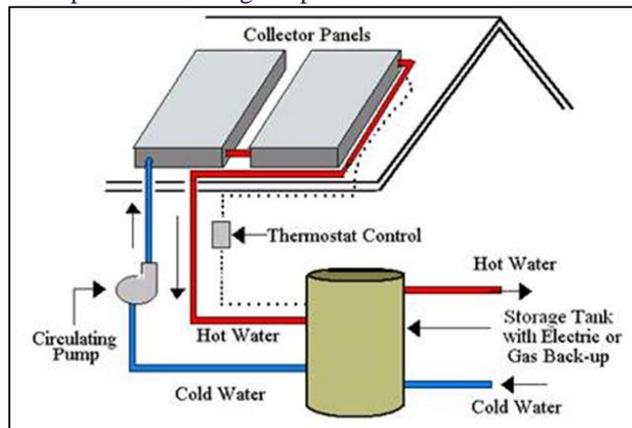


Fig. 2: Image of active solar water heating system [source-www.energydepot.com]

b) Passive Systems

Passive solar water heating systems are less expensive than active systems, but they're usually not as efficient as active systems.

There are two basic types of passive system:

- INTEGRAL COLLECTOR: This type of system is used to preheat water for conventional water heaters.
- THERMOSIPHON SYSTEMS: Refers to heat exchanging based on natural convection, without the use of a mechanical pump.

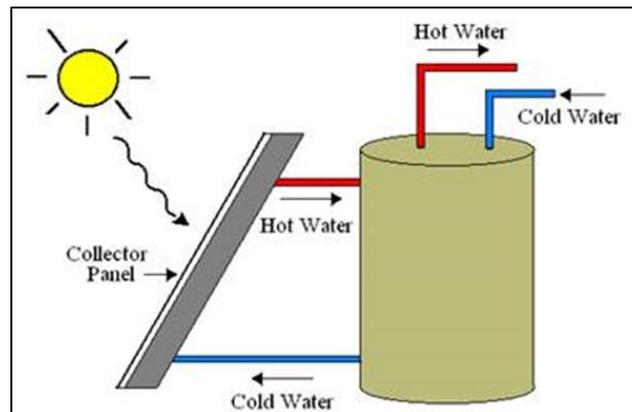


Fig. 3: Images of passive solar heating system [source--www.energydepot.com]

4) Based on Collector System Solar Water Heaters are of two Types-(According to MNRE)

a) Flat Plate Collectors (FPC)

The solar radiation is absorbed by Flat Plate Collectors, which consists of an insulated metallic box covered as outer cover and a glass sheet on the top. Inside the box there are metallic absorber sheets of black colour with riser tubes for carrying water. The function of the absorber is to absorb the incoming solar radiation and transfer the heat to the flowing water.



Fig. 4: Image of flat plate collector based solar water heater [source- www.redsunin.com]

b) Evacuated Tube Collectors (ETC)

Evacuated Tube Collectors are made of double layer borosilicate glass tubes evacuated for providing insulation. The outer wall of the inner tube is coated with selective absorbing material. It absorbs the sun's radiation and transfers the heat to the water which flows through the inner tube.



Fig. 5: Image of evacuated tube solar water heater. [source- www.atashsolar.com]

5) Advantages of Solar Water Heaters

- Helps in reduction of electricity bills as can reduce a significant portion of the conventional energy being used for heating water in homes, factories and other commercial and institutional establishments.
- Reduces emission of carbon dioxide which may help in reducing the carbon footprint.
- As India has high insolation value, so it is cost effective for warm countries like India.
- Average payback period is of five years
- Low maintenance cost.

6) Facts about Solar Water Heaters

- Fuel Savings: A 100 liters capacity SWH can replace an electric geyser and can save 1500 units of annual electricity.
- The use of 1000 SWHs of 100 liters capacity each can contribute to a peak load saving of 1 MW.
- A SWH of 100 liters capacity can help in preventing emissions of upto 1.5 tonnes of CO₂ per year.

7) Present Status of Indian Regions using Solar Water Heaters

Expected number of days of use of hot water per year	NORTHERN REGION USES FOR 200 DAYS	SOUTHERN REGION USES FOR 300 DAYS	WESTERN REGION USES FOR 250 DAYS	EASTERN REGION USES FOR 200
Expected yearly electricity saving of units	1000	1500	1250	1000

Table 1: Present Status of Indian Regions using Solar Water Heaters

This table shows hot water usage and savings of units per year due to the use solar water heaters

B. Solar Street Lights

Solar street lights are the street lights which work on the solar radiations i.e. on sun's energy.

They consists of a rechargeable battery. In this power is fed with the photo voltaic panels. The charge stored in the battery is used to light the LED lamp present in the street light. The sensors present in the solar street light automatically turns the lights on or off by sensing the light present outdoor.

1) Working Principle of Solar Street Lights

- The principle is very simple in this case.
- The solar panels present on top of the lights, as shown in the figure.1, contains solar cells which absorbs the solar radiations and converts them into electrical forms.
- The semiconductors present in the cells are responsible for this energy conversion.
- The process of conversion of energy is known as 'photo voltaic effect '.
- The system also consists of charge and discharge controllers.



Fig. 6: Image of a solar street light [REFERENCE: Google images]

2) Components of Solar Street Lights

A solar street light mainly consists of the following components:



Fig. 6: Components of a solar street light [source- Google images]

3) Advantages of Solar Street Lights

- Low operation cost
- Pollution free source of energy production
- Remote access applicable
- Low maintenance

4) Disadvantages of Solar Street Lights

- High setup cost
- Batteries need to be changed frequently
- Does not work in cloudy or rainy days
- Working is affected by moisture and snow

5) Solar Street Lights and Smart Cities

Solar energy can play a major role in development of a smart city. Application of solar street lights can reduce the energy consumption and in turn reduce the pollution due to the residues or emissions produced during the production of electricity. This works positively in reducing the carbon footprint.

C. Solar Rooftop System

Solar rooftop systems are designed to provide electricity in offices & homes with intermittent or no grid electricity. The solar rooftop system, being modular in construction, can be customized to generate and provide solutions based on your needs. Hence, roof mounted solar PV systems can play an important role in augmenting the power generation capacity



Fig. 8: Solar rooftop system [source- forbes]

1) Working of Solar Rooftop System

- 1) A solar rooftop system is composed of a set of solar PV panels, mounted on the rooftop of a residential or commercial building, connected together to generate electricity by converting solar radiation into electrical energy.
- 2) The electrical energy generated from the array of panels is transmitted to inverter, which converts DC output of solar module into utility grid electricity.
- 3) For off grid systems, a battery bank stores power that cannot be utilized directly by the load. This will be used when requirement of load is more than what the solar PV is providing at a particular time or when power from solar energy is not available, thus reducing the consumption of power from grid and increased savings on your electricity bill.

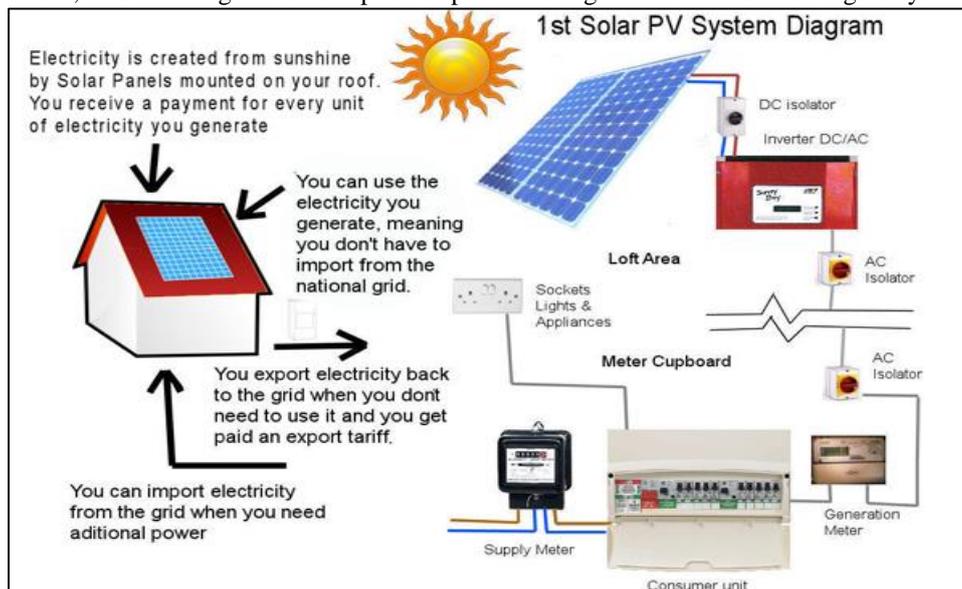


Fig. 7: Solar PV Roof Top System [source – www.wikipedia.org]

2) Key Challenges for Solar Rooftop System

- Grid Connectivity Issues-Some States like AP/Tamil Nadu/West Bengal have come out with connectivity norms.
- Quality, Safety & performance standards
- Metering Standards and Net metering regulations – Domestic content for cell and modules – Feed-in-Tariff for surplus power into the grid.

3) Implementations of Solar Rooftop System

Under Phase I of JNNSM, a separate scheme called ‘Rooftop PV and Small Scale Solar Generation Program (RPSSGP)’ was implemented for developing solar PV projects with maximum capacity of 2 MW as rooftop or, small scale ground mounted solar projects. A total of 100 MW capacities of projects under this program were to be installed and connected at a level below 33 KV. Similarly, the focus under most state solar policies, programs has been on the ground mounted grid-connected solar PV projects.

4) Advantages of Solar Rooftop System-

- 1) it avoids transmission and distribution (T&D) losses incurred in the case of centralized, larger plants.
- 2) This is a strong rationale for rooftop solar projects in India, where the national average of T&D losses hover at close to 30%.
- 3) The ease of connectivity with the consumer premises, particularly in net-metered arrangement, also provides an opportunity for utilizing the rooftop solar for captive consumption even when the grid is not available.
- 4) Rooftop solar projects also have the potential to create economic value for unutilized rooftops and are not faced with the issues of land availability, applicable for ground-mounted projects. The self-replication potential is thus very high for rooftop projects.
- 5) For consumers, it reduces the dependency on grid power.
- 6) Mitigates diesel generator dependency: Long term reliable power source
- 7) Most suitable for commercial establishments – Max generation during peak usage time. – Solar power cost is close to the commercial power cost.

5) Figures and Numbers for Solar Rooftop System

The solar rooftop system can begin at about 100 watts, going up to a 100+ kilowatts. A typical 4-person semi-urban/urban home can have a good mix of solar power and grid power, balanced by choosing to install a 1 KW solar rooftop system. A 1 KW system can help save up to Rs8,250 per year (compared to using grid electricity). When used as a power backup in grid-constrained locations, it saves fuel costs of up to Rs56,000 per year compared to the equivalent use of a 1 KVA gasoline generator

III. PRESENT SCENARIO OF SOLAR APPLICATIONS IN INDIA

India is climbing towards the development of smart cities and a few instances below can very well prove it:

- 1) In August 2015, India proved itself once again when world’s first fully-powered solar airport with a capacity of 12 MW solar power plant .was made in Kochi.
- 2) Baripatha, a village near Bhubaneswar, in August 2015, it became the first village of Orissa to be a fully solar powered place.
- 3) Government of Tamil Nadu following the footsteps of Haryana, has made installation of solar rooftop plants compulsory in the buildings . Even the District Rural Development Agency in Tiruchirappalli district of Tamil Nadu has installed around 1,900 street lights.
- 4) “UDAY” was launched by Ministry of Power, Coal and New & Renewable Energy on November 9, 2015. It states about the Integrated Power Development Scheme (IPDS). In consideration with urban areas urban areas, Smart Metering, Tamper-proof meters and rooftop solar panels will be introduced.

IV. CONCLUSION

As we know that an adequate supply of electricity is the key feature of a smart city which can be easily fulfilled by using solar energy.Hence it is a very wise option to harness the solar energy for multiple benefits. It proves to be an energy efficient measure which is two way beneficial- To the government as well as the citizens.It reduces our dependance on electricity .Being a renewable as well as an eco-friendly resource, we can ‘smartly’ exploit it.

In this century, where we daily need to face certain challenges like the change in climate, scarcity of resources and the fast growing population , deployment of solar power for street lights , water heaters and solar roof top systems has seriously helped in improving the quality of life.

Presently solar buses have also been introduced in many cities as a part of smat cities. In future, there might be many new research and developments towards the application of solar energy in enhancement of smart cities. This concept of “Solar Smart Cities” has provided us an opportunity to live more smartly and sustainably. We should seriously appreciate it with a thumbs up.

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