ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940www.ijsem.org

Vol 5, Issuse.2 May 2017

Solar Energy Harnessing in India: An Overview

B.HARI, T.RAMANNA, V RAMESH, KOTLA SANTHOSH KUMAR

Abstract

India's economy is expanding, which means more people will need access to electricity, yet there is now a significant shortage. The need to find alternatives to fossil fuels has prompted the investigation of alternative energy sources. Solar energy, among these alternatives, has attracted a lot of attention since it is both abundant and simple to access. The relevance and advantages of solar energy are discussed in this study. The potential for using solar energy in India is discussed, along with its current state, obstacles, government regulations in its favour, and future prospects.

Key word : renewable energy; solar; solar power; government regulations.

INTRODUCTION

Since energy sustains economies, a nation's progress is proportional to its energy reserves. [1] Energy is the most fundamental and global indicator of a country's progress. The only answer to the problem of traditional energy sources' depletion and inadequacy to satisfy the requirements of the modern population is to make use of alternative energy sources. Power shortages, declining fossil fuel reserves, and rising pollution levels have prompted significant consideration of new energy options. Sustainability, renewability, and pollution reduction are foundational ideas of alternative energy resources. To meet the demand and protect our limited natural resources for future generations, it is crucial for the modern world to focus on renewable energy sources. Hydroelectric, wind, solar, biomass, etc. are only few of the sustainable energy sources that may be used. Solar energy is essential to the operation of the vast majority of these alternative power sources. Differential heating of the Earth's surface causes air to move about (wind) and precipitation to develop when the air is raised, resulting in hydroelectric power.

The use of panels or collectors to transform sunlight into usable energy is known as solar power. Sunlight captured by plants is called biomass. We focus on solar energy, which comes from the sun and can never be depleted, as our sustainable energy source of choice. The sun's irradiance reaches Earth in great quantity, and if stored correctly, it may be utilised as a superior replacement for nonrenewable energy sources. The manner of collecting solar energy determines whether a technology is considered active or passive. Solar thermal energy systems heat water to drive turbines and create electricity, whereas photovoltaic systems convert sunlight directly into electricity. For passive technologies, the optimal use of sunlight in construction is a key component. This study is dedicated to the topic of using active solar technology in India. Electrical power generation and consumption in India both

ASSISTANT PROFESSOR[1,2,3], STUDENT [4]
Department of EEE
Arjun College Of Technology & Sciences
Approved by AICTE& Affiliated to JNTUH

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rank third globally. As of 30 November 2019, [3] India's national electric grid has an installed capacity of 364.96 GW, of which 63.1% came from fossil fuels, 13.8% from hydro, 1.9% from nuclear, 8.6% from solar, 10.2% from wind, and 2.6% from the biomass sector. [4] Established in the 1980s, India's Ministry of New and Renewable Energy (MNRE) is the world's first and only of its kind. The Ministry of Energy's goal is to promote energy security and self-sufficiency by increasing the use of renewable energy sources and decreasing reliance on fossil fuels. The solar energy industry has been given a lot of attention. Although coal-based thermal power plants are now the most cost-effective way to generate electricity, technical advancements and the falling price of solar panels have opened the door to the possibility of a shift in the future. We have summed up the state of solar energy in India and its potential in the future in this report.

INDIA'S POTENTIAL FOR SOLAR POWER

Solar power has the most potential among India's renewable energy sources. Due to our proximity to the equator and generally bright tropical environment, most of our nation enjoys clear, warm weather for around 250–300 days every year. There is a wide range, from 1600 to 2200 kWh/m2, in the amount of solar radiation that a given area of land receives annually. As can be seen in Fig. 1, the average daily solar radiation received throughout India is shown on a map. When fully exploited, it has the potential to produce almost 6,000,000,000 GWh of power annually. Also, "India is a tropical nation, where sunlight is accessible for longer hours each day and with considerable intensity," as stated in the National Action Plan on Climate Change. Therefore, solar energy is a promising option for the future. Benefit number two is that it allows energy to be distributed in a decentralised fashion, which in turn gives local communities more say over their own development. [5]

SUN'S REWARDS

The sun provides the Earth with a steady supply of renewable solar energy. It's versatile enough to be set up anywhere from a field to the side of a building. One with no energy production costs: Because solar power plants don't need any additional resources to function, their operational and energy generation expenses are effectively zero. After installation, the panels generate energy with minimal upkeep and no waste products.

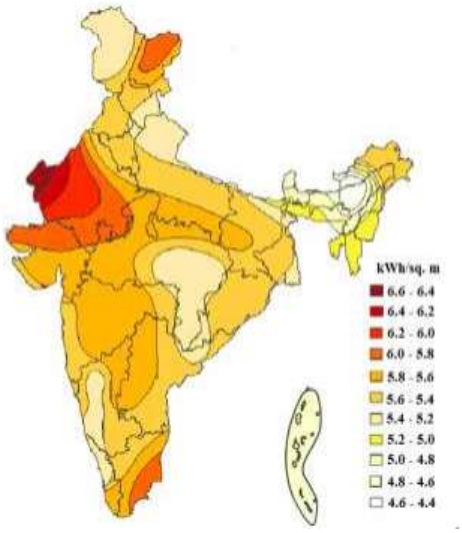

Figure 1: Map of India Average Daily Solar Radiation in units of kWh/m2 . [Source: http://www.cercind.gov.in]

Putting solar panels on people's roofs means less energy is lost in transmission, which improves the efficiency of the grid as a whole.

Versatile installation:

The most fascinating benefit is the ability of delivering energy in distant regions, where the expense of establishing electrical distribution lines is too expensive or impossible. In theory, solar panels may be set up anyplace there is sufficient sunlight.

Absolutely no harmful effects on the environment:

Once installed, solar energy systems do not release any harmful pollutants or greenhouse gases. Energy generated by the sun does not need the use of any h2o in the process. In contrast to fossil fuel power plants, which contribute significantly to water and air pollution due to their extensive use of water for cooling purposes and the release of toxic gases during energy generation, solar power has no negative impact on waterways or the environment. Pollutants in the discharged water are hazardous and pose a health risk to humans.

Power consumption is expected to increase as India's economy continues to expand. The best method to strike a balance between economic development and environmental preservation is via the widespread use of solar energy. Furthermore, with the introduction of Electric Vehicles, the use of renewable energy in the charging infrastructure would further stimulate the development of the

sector and, by extension, the economy. Solar power installations also boost local employment.

It takes less time and effort to set up than other renewable energy sources.

Because there are no moving components in solar panels, they are more durable and dependable than other renewable energy options over the long run.

The Present Solar Energy Situation in India

Solar energy, both in terms of technology and installations, is growing rapidly in India. With the exception of the United States and China, India's solar energy programme is the third-fastest growing in the world. As of October 31, 2019, the total installed capacity of solar energy in the nation was 31.696 GW. [6] As can be seen in Fig. 2, the cumulative capacity of solar photovoltaic installations has increased dramatically from 161 MW in 2010 to 28,181 MW in 2018. Figure 3 displays the annual breakdown of solar power generation in India. Figure 4 displays the total number of solar panels installed in each state.

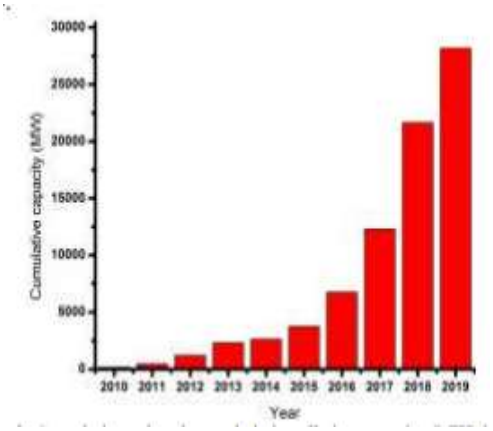

Figure 2: Cumulative solar photovoltaic installation capacity (MW) in India [3]

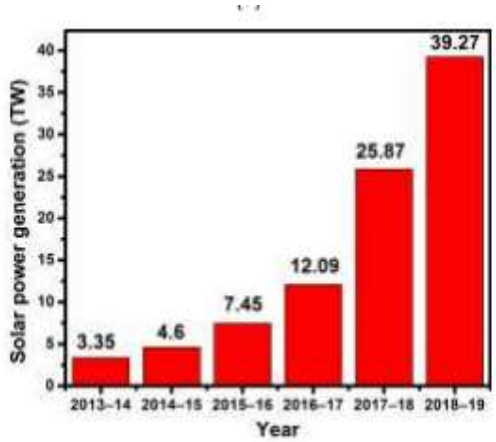

Figure 3: Year-wise solar power generation in India [5]

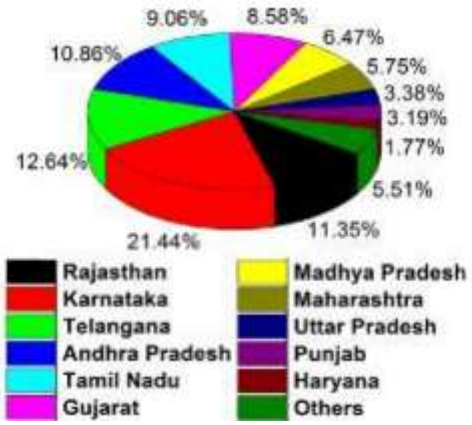

Figure 4: State-wise cumulative solar installation in MW as on 31 March 2019

The Indian government had set an initial target of 20 GW capacity of solar power for 2022, which was achieved four years earlier itself. [7]. The target was increased to 100 GW by 2022 in the year 2015 with an investment of US$100 billion. [8] This increase in solar power is supplemented by a steep drop in the cost of production of solar electricity as well. The cost of solar power generation per kW has come down from 12.16 in 2010 to 4.00 in 2019. India ranks first in the world in terms of the lowest capital cost per MW to install the solar power plants.

Solar energy is harnessed in India is in three forms

Large scale grid connected or Ground based solar plants which mostly refer to huge number of solar panels installed in a large land area such as solar parks.

Rooftop solar power generation which is 70% industrial or commercial.

Off-grid solar power for local needs which includes solar, solar home lighting systems, solar street lights, solar cooker, etc.

Total installed capacity of these three forms of solar energy is shown in Table 1. India has established more than 42 solar parks in which electricity is generated from solar energy with the help of a large number of photovoltaic cells connected in the form of a grid. The major solar power parks in India along with their peak power (DC) generation capacity are shown in Table 2. The Indian government has initiatives to increase off-grid solar by distributing solar laterns, increasing solar street lighting installations and distributing and popularizing the use of solar cookers.

TABLE 1: Photovoltaic (PV) installed capacity by application (MW) as of 31/7/2019 [5]

Application	Capacity (MW)
Ground mounted	27,930.32
Rooftop	2,141.03
Off-grid	919.15
TOTAL	30,990.50

TABLE 2: Major solar large grid power projects in India [5]

Plant	State	Peak power (MW
Pavagada Solar Park	Karnataka	1400
Kamuthi Solar Power Project	Tamil Nadu	648
Gujarat Solar Park-1	Gujarat	221
Welspun Solar MP project	Madhya Pradesh	151
ReNewPower, Nizamabad	Telangana	143
Sakri solar plant	Maharashtra	125

RENEWABLE ENERGY POLICY FRAMEWORK

The Government of India as well as most of the State Governments has put in place exclusive policies to promote renewable energy in general and solar energy in particular. [10-14]

As per the Electricity Act 2003, the government of India strives to promote electricity generation from cogeneration and renewable energy sources. The act accelerated the process of renewable energy development in the country.

The National Electricity Policy 2005 was a watershed policy that gave a fillip to rapid increase in renewable energy installations. It stipulates that progressively the share of electricity from non-conventional sources would need to be increased. It also mentions that the electricity generated from such sources could be purchased by the government form private companies through a competitive process.

The Tariff Policy of 2006 has stated that the appropriate Central government Commission shall fix a minimum percentage for purchase of energy from non-renewable sources taking into account availability of such resources in the region and its impact on retail tariffs.

Solar Atlas:

In June 2015, India began a ₹40 crore project to measure solar radiation. The Ministry of New and Renewable Energy (MNRE) has installed fifty-one solar radiation resource assessment stations across India by to create a database of solar-energy potential. Data is collected and reported to the Centre for Wind Energy Technology (C-WET) to create a solar atlas. This data is utilized in setting up solar power plants.

Jawaharlal Nehru National Solar Mission (JNNSM):

The subsidies and incentives provided by the Government and since 2010 under JNNSM have been instrumental in adoption of solar energy. This mission was launched in 11 January 2009 with the target for Grid Connected Solar Projects of 20,000 MW by 2022. The Mission had adopted a three-phase approach with the three phases spanning from 2009-13, 2013-17 and 2017-22. The target was achieved 4 years ahead. This mission encouraged private companies to generate solar power by reducing the import duty on solar panels by five percent. This is expected to reduce the cost of a rooftop solar-panel installation by 15 to 20 percent. [15]

Indian initiative of International solar alliance (ISA):

In January 2016, Prime Minister Narendra Modi and French President François Hollande laid the foundation stone for the headquarters of the International Solar Alliance (ISA) in Gwal Pahari, Gurgaon. This alliance comprising over 120 countries lying wholly or partially between the Tropic of Cancer and the Tropic of Capricorn will focus on promoting and developing solar energy and solar products. ISA aims to achieve a reduction in production and development cost of solar power which will result in its widespread use in poor and remote regions. [15]

Initiatives taken by Central Government: Indian government has taken several Initiatives and provided subsidies to promote the growth of solar power generation. Some such initiatives are: Viable gap funding, opportunity to claim depreciation by solar power generating companies, capital subsidies to rooftop solar power plants, issuing tradable renewable energy certificates (REC), Assured Power Purchase Agreement (PPA) to guarantee purchase of solar power by government, waiving off of Interstate transmission system (ISTS) charges and losses during the period of PPA, upto 70% and 30% subsidy for the hill states and other states respectively for the installation of rooftop solar units, etc. [15]

BARRIERS AND CHALLENGES OF SOLAR ENERGY GENERATION

Even though the government has ambitious targets for

solar energy generation in the country, there are various barriers and challenges related to solar energy in India, which have been pointed below. [16]

- The main disadvantage of solar energy is its unavailability for all 24 hours. The weather conditions are major factor on availability of solar radiation.

- Large land area is required for solar power plants, which sometimes is not feasible. For example, the amount of land required for utility-scale solar power plants is currently approximately one square kilometer for every 20–60MW generation

- 100 GW of solar power generation would mean about 10.5% share for solar power in total generation of power in India. Such large share of intermittent sources requires huge investments in the power grid infrastructure for transmission, smart supply and demand management.

- To achieve a capacity of 60 GW for utility scale projects by 2022, there would be a requirement of investment of 2,80,000 crores. The government currently expects a big share of this to come from international sources. But an international fund for solar projects in India is very less.

- Storage problem is also very serious. Suppose if the demand of power is not so high then the electricity produced by the solar plant will have to be stored somewhere to supply when demanded. Therefore, storage technology in terms of economical and efficient batteries needs to be developed on priority.

- Temperature and dust problems affect the reliability of solar panels. In remote areas with high temperatures, it is being found that we are not getting the required units of power. The panels do not yield their optimal usage. Dust is a problem, especially in Rajasthan, where the dust conditions are really bad and require frequent cleaning around two times a month, which then increases the operational costs. The alluvial dust (present in plains of north India and delta regions of south India) turns into mud when water is poured is difficult to clean while sandy dust (present in Rajasthan and Gujarat) can be washed away easily with water.

CONCLUSION

India is poised for significant growth power generation through renewable energy sources. The government policy in the last two decades has provided the centre stage for exploitation of renewable energy sources in general and solar energy in particular. Being close to the equator, India is in favorable geographical location and enjoys abundant supply of solar radiation, almost throughout the year. However, if India has to reach the full potential in harnessing solar energy, it has to overcome several barriers, which may pose challenges to the stakeholders. Need to attract foreign investors and development of economical storage technologies are the primary issues we need to tackle. In addition, there are many technical problems, such as high temperatures in several places and harsh environment, which may pose problems for the longevity of solar installations. All stakeholders need to put collective efforts to overcome these challenges and reach the planned targets for solar energy generation.

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