Grenze International Journal of Engineering and Technology, June Issue

Analysis of Initiatives Taken for the Development of the Solar Energy Sector in India

Xma R. Pote[1], S. P. Adhau[2] and Prateek Verma[3]
[1,2]Yeshwantrao Chavan College of Engg, Nagpur (M.S) India
Email: potexma@gmail.com, adhau_sp@yahoo.co.in
[3]Faculty of Engineering and Technology, Datta Meghe Institute of Higher Education & Research Wardha

***Abstract*—The economic development and prosperity of a country rely quite heavily on the availability of power. The sustained growth of the Indian economy will not be possible without significant efforts to improve the current infrastructure. An increase in demand daily makes the supply vs. demand matrix concerning electricity difficult for the Indian power sector to balance. Therefore, it becomes critical to switch to alternative energy sources to balance power production and consumption. Use of solar energy in India is vital not just in the context of increasing the power output, but strengthening energy dependability while being cost-effective, socially, and environmentally beneficial. This paper attempts to evaluate the current state of solar energy and its potential expansion with a strong emphasis on policies in the context of the dynamic future of the Indian power sector. This work concentrates on the development of solar energy and its application for sustainable development. In this case of energy requirements and environmental challenges, solar power becomes an asset to a country such as India. Integration of such technologies brings a host of benefits to the country, not the least of which includes reduced energy.**

***Index terms*—Energy, scenario, global, policies.**

I. Introduction

Electrical, nuclear, mechanical, chemical, thermal, and light energy are just some forms of energy that can be measured. Broadly, they are split into two groups based on how they are made and sourced: Renewables and non-renewables. Renewable energy sources can replenish naturally. They are generated without restrictions and the majority of fundamental natural occurrences can be relied on to replace them. Although they are variable and non-exhaustive, these resources can change how production is achieved. Some examples are geothermal energy, tidal energy, ocean energy, solar energy, wind energy, and biomass from wood. Conventional resources, on the other hand, are resources that have limited reach and cannot be generated within a time frame that is feasible for human beings. Fossil fuels such as coal, oil, and natural gas are conventional sources of energy. These resources help us cater to energy demands. An example would be thermal power generating electricity using coal.

II. Current Energy Scenario

Because of the current political climate, the world is slowly transitioning towards non-renewable energy. this is troubling because non-renewable energy sources are in limited supply and will be done completely at some point in the near future.

Grenze ID: 01.GIJET.11.2.192_20

Due to this, there is a direct need for a type of energy that is environmentally friendly, sustainable, and able to keep up with the current energy demand. This is where the use of renewable energy sources is beneficial as they are never-ending and clean. Currently, there seems to be an increase in the shift from non-renewable energy to renewable energy sources. In the context of the current situation, approximately 8-10% of the energy sources that are universally available are provided by renewable energy sources. As solar energy travels in the form of electromagnetic waves, it is not restricted to staying within the media, therefore it can pass through a vacuum. Solar energy can be converted to useful heat and electrical energy by devices known as solar thermal and photovoltaic collectors. Further, solar energy can be divided into two categories: Active and Passive methods. Solar energy may also be collected through solar water heaters (SWS).

A. Policies by government

To establish initiatives for pollution control, the ruling agencies have commenced certain schemes. These authorities have set targets for power generation in stipulated time and also keep a check on carbon emissions. These initiatives are being undertaken by most developing nations. In India, the prime renewable source of energy preferred is solar power generation since it is in abundance throughout the year. Solar energy is produced using Concentrated Solar Power (CSP) and Solar Photovoltaic (SPV) technologies [4][7]. The parameters for the generation of solar power are reviewed in Ref.[11]. The paper covered the various ways in which solar power is generated in India through SPV or CSP, including the aspects, criteria and important parameters involved. By 2050, CSP and SPV technologies are projected to equally supply approximately 27 percent of global power consumption, according to the “International Energy Agency” projections. Some agencies predict that by 2020 solar energy will constitute the majority of electricity produced with the most installations taking place in China and India. Due to the rapid economic development of India, it has emerged as the largest consumer of electricity in the world. The only way to create a clean and pollution-free world is to use renewable energy sources. There was also discussion of a method for allocating wasteland for the production of solar power while taking into account several variables, such as the wasteland’s accessibility, direct normal irradiance, and sustainability for the production of wind power, among others. India needs to shift from its reliance on fossil fuels to renewable energy sources like solar, wind, tidal, etc. To sustain economic growth while reducing greenhouse gas emissions. The structural model for barriers to solar power installation and use in an Indian context is highlighted in Ref. Some recommendations for removing obstacles related to solar power installation in India have been provided to the authors. One of the main initiatives of the Indian government to advance solar energy in the country is "JNNSM." The "Jawaharlal Nehru National Solar Mission (JNNSM)" claims that explains the technology, politics, and potential for CSP operation in the context of Indian power. Owing to Rajasthan's advantageous location and climate, numerous reputable firms have expressed interest in establishing solar power facilities there. A review of the literature indicates that numerous authors have focused on and emphasized various aspects of the growth of power derived from solar energy in India; however,as per the literature survey and knowledge of author, no one has covered every potential aspect of solar power in the country's current electricity sector. The present paper endeavors to encompass all the recent requisite measures, governmental campaigns, objectives, and accomplishments essential for advancing solar energy in the Indian power industry [5]. Additionally, a thorough analysis has been provided to any concerns regarding solar power systems made in India.

B. Global Solar Power Scenario

India is ranked fourth globally in terms of installed capacity for solar power, wind power, and renewable energy (including big hydro) according to the Renewables 2022 Global Status Report [6,9]. At COP 26, the country raised its target to 500 GW of energy derived from non-fossil fuels by 2030. In terms of solar PV deployment, India is now in fifth place worldwide as of the end of 2022 (Ref. REN21's Global Status Report 2023 & IRENA's Renewable Capacity Statistics 2023). Around 97.86 GW of solar power capacity had been installed as of December 30, 2024.

C. Power Scenario in India

Peak demand of 2023–24 climbed by 12.7% to 2,43,271 MW from 2,15,888 MW in the same duration in 2022-23, year, while maximum shortage in all of India decreased to 1.4% (3,340 MW) from 4.0% (8,657 MW) in the same duration for 2023-24. As of March 31, 2022, 482.232 GW was the total installed power generating capacity, which is the result of adding captive power, utility power, and other non-utilities. Peak demanding 2023–24 climbed by 12.7 % to 2,43,271 MW from 2,15,888 MW in the same period the previous year, while maximum deficiency in India decreased to 1.4% (3,340 MW) from 4.0% (8,657 MW) in the same period the previous year.

III. Solar Power Plants in India

India now has more than 72 GW of installed solar capacity. Furthermore, according to a recent IEA assessment, by 2030, solar energy is predicted to provide 18% of the country's energy needs. In terms of producing solar electricity, India is now ranked fourth in the world and third in Asia. Now, it makes up around 38% of the entire capacity for renewable energy. The biggest solar power plants in the nation are found in Tamil Nadu, Andhra Pradesh, Rajasthan, Karnataka, and Madhya Pradesh. The National Solar Mission is one of the initiatives the Indian government is using to prioritize supplying the nation's energy needs. By 2022, the government hopes to have 20 GW of installed solar capacity. With the growing need for clean and sustainable energy, solar power plants are becoming increasingly important to the global energy shift. These stunning solar parks are a huge achievement in terms of fully using solar energy. This paragraph will discuss the remarkable features and contributions to renewable energy of the world's five largest solar power plants: Bhadla Solar Park in India, Huanghe Hydropower Hainan Solar Parkin China, Pavagada Solar Park in India, Benban Solar Park in Egypt, and Tengger Desert Solar Parkin China. Our analysis of the worldwide solar power market indicates that the solar photovoltaic (PV) sector is expected to set a record for annual solar deployments in 2023, with an estimated 310 GW installed. This represents a 29.7% increase over the 239GW of solar capacity built in 2022. Since ancient times, people have revered the Sun as the source of life on Earth. We came to comprehend sunlight as an energy source throughout the industrial era. India has a large capacity for utilizing solar energy. India's land area gets approximately 5,000 trillion watt hours of energy yearly. In India, solar photovoltaic energy may be used quite successfully and has enormous ability. In addition, solar energy offers dispersed power generation and short lead times for quick capacity increase. From the view of utilization in villages and underprivileged areas, decentralized and solar thermal applications will be useful. This will satisfy their basic needs of cooking and lighting. In extremely cold regions this will be useful for heating spaces.

A. Solar Resources in India

As of December 31, 2023, India's installed solar power capacity was 73.32 GWAC. In India, solar power projects received around 20.7 billion US dollars in foreign investment between 2010 and 2019. Small hydropower and solar energy sources have a total installed capacity of 180.79 GW as of December 2023. The installed capacity for renewables is as follows: Power from wind: 44.73GW. 73.31 GW of solar power. As of March 2024, Renewable energy sources, including large hydropower, have a combined installed capacity of 190.57 GW. The installed capacity of Solar, wind energy, Biomass and Small hydro is 143.64 GW till March 2024. Due to its proximity to the equator, the Indian subcontinent experiences 200 days of abundant sun radiation annually. Most nations only get to enjoy this pleasure on considerably fewer days. India has long been unable to take advantage of this, even with plenty of sunshine and sufficient resources. Governments have attempted to design regulations and incentives to maximize the use of renewable energy resources like solar and wind power in response to the power shortfall of conventionally produced electricity as compared to demand [7]. India is currently making a strong effort to overtake other countries as the world's top producer of renewable energy. Presently, 10% or so of India's installed electricity capacity comes from renewable sources while India lobbies for a quicker global transition to renewable.

IV. Solar Power Organizations in India

The Electricity Act of 2003 was passed and started its operation on June 15, 2003. The targets were to safeguard the rights of consumers and give everyone authority. The Act establishes the National Electricity Policy, mandates license-free generation and distribution, requires mandatory metering, opens access in transmission and distribution in phases, requires SERCs, and imposes severe punishments for theft of electricity [8]. The Electricity Act of 1910, and the Electricity Supply Act of 1948, were in operation before the Electricity Act of 2003. The Electricity Regulatory Commission Act of 1998 was commissioned to set up CERC (Central Electricity Regulatory Commission). Later Electricity (Amendment) Act of 2003 and the Electricity (Amendment) Act of 2007 were released. The objective is to put the industry on a path of healthy commercial growth and make it possible for the States and the Centre to travel together and in unison. The production of electricity (including renewable energy) till July 2024 was 4,48,381 MW as compared to 4,23,359 MW i.e. an increase of roughly 5.59 % over July 2023.

A. Solar Power Institutions and Associative in India

In India, a few of the well–known organizations and groups with influence include: the Central Electricity Authority (CEA): This statutory body oversees directing, and arranging the growth of India's electrical industry.

- Ministry of Power: This government ministry is in charge of developing and carrying out policies and plans about the production, distribution, and transmission of electricity.
- Central Power Research Institute (CPRI): Located under the Ministry of Power, CPRI is an independent organization that conducts electrical power engineering research and development. Indian Electrical and Electronics Manufacturers' Association (IEEMA): IEEMA is an association that stands for the Indian industry that manufactures industrial electronics, electrical equipment, and related equipment.
- Indian Energy Exchange (IEX): Offering a platform for the trade of electricity and certificates for renewable energy, IEX is one of India's top power exchanges.
- Power Grid Corporation of India: This Maharatna firm oversees managing the nation's interstate transmission network.
- National Thermal Power Corporation (NTPC): Producing and distributing electricity, NTPC is one of India's top power companies.
- The Ministry of New and Renewable Energy (MNRE): is the Government of India's go-to ministry on all issues about new and renewable energy. The ministry's overarching goal is to increase India's energy To encourage solar energy in India, the Central and State governments have launched several projects, such as:
    - Established in 1981, the Commission for Additional Sources of Energy (CASE).
    - In 1982, the Department of Non - Non-Conventional Energy Sources (DNES) replaced CASE as the new name.
    - In 1992, DNES changed its name to the Ministry of Non-Conventional Energy Sources (MNES).
    - In 2006, MNES changed its name to the Ministry of New and Renewable Energy (MNRE).
    - National Institute of Solar Energy

The Ministry of New and Renewable Energy oversees the National Institute of Solar Energy (NISE), an autonomous organization. The 25-year-old SEC (Solar Energy Centre) of India has been transformed by the government into the Ministry of New and Renewable Energy. This organization became an and became self-regulating in the year 2013 to plan and implement the projects of the National Solar Mission and propagate and popularize free energy from the sun in rural areas of India. The standardization, exhibition, instruction, testing, and interactive research in solar technology are welcomed by the organization. NISE's 200-acre campus is located on Gurgaon - Faridabad Road, 8 km from Central Gurgaon and 25 km from India Gate. Current NISE initiatives: Investigation and advancement of solar power, collaboration on testing, assessment, and standardization with organizations and industry technologies.

B. Initiatives by Government of India to encourage Solar Energy Utilization

To boost solar energy in India, the Central and State governments have launched several projects, such as: The goal of the 2010–launched Jawaharlal Nehru National Solar Mission (JNNSM) is to reach 100 GW of solar PV by 2022.Pradhan Mantri Kisan Suraksha Urja Evam Utthan Mahabhiyaan (PM- KUSUM). By 2022, this program hopes to increase solar capacity by 30,800 MW.PM Suryodaya Yojana is a program that equips middle-class and impoverished households with rooftop solar panels [9]. The Energy Conservation Building Code (ECBC) establishes minimal energy requirements for newly constructed commercial structures. 50 solar parks are to be established as part of the Solar Park Scheme. Other initiatives stop promote the production of solar energy have also been introduced by the government, including:

- VGF Plans
- Defense Scheme for CPSU
- Scheme for Canal Bank and Canal Top Scheme for Bundling
- System of Grid-Connected Solar Rooftop

V. Constraints in the Growth of Solar Power In India

In India, many problems are being encountered for the expansion of solar power. The following list of concerns pertains to the development of solar electricity: Potential land is mostly needed by manufacturers and developers. The need for focused, goal-oriented, and cooperative research and development projects to assist India in achieving technical governance in the photovoltaic industry. The development of human amenities and training to manage the industry growth of solar energy is required. Collaboration amongst industries to expand the photovoltaic industry through the use of proper knowledge, sharing of thoughts employing seminars, associating with producers of the balance of systems, and compiling and disseminating precise trends, market data, and projections is a need of the hour. Educating consumers on solar technology, its applications, and its financial implications. The spread of solar photovoltaic projects is extremely challenging due to the complexity

of the subsidy structure and the involvement of too many organizations such as the Ministry of New and Renewable Energy, Solar Energy Corporation of India, Indian Renewable Energy Development Limited, Electricity Regulatory Commission, and Electricity Board. Under the GBI (Generation Based Incentive) system, the procedure of allocating land and executing a Power Purchase Agreement (PPA) is drawn out [9]. Manufacturers are mostly purchasing all of the equipment needed to generate solar power from overseas markets since the prices there are lower than in the Indian domestic market. Therefore, procurement of the materials and components for PV generation from other countries is hampering the local Indian market. The concerns and challenges mentioned above are all very important in India's solar power growth environment. The Indian government as concentrated on resolving all difficulties and working to break down obstacles.

VI. Conclusion

Ultimately, solar energy is the main source of wave, wind, hydropower, and biomass energy—all of which are massive sources of instantly usable energy. Despite notable variations depending on latitude and season, the bulk of the Earth's surface receives enough solar energy to enable low-grade heating of buildings and water. At low latitudes, simple mirror arrangements can focus enough sun energy to stop steam engines and even prepare food. Light energy shifts the electrons in some semiconducting materials. The phenomena can generate a noteworthy quantity of electrical power. The major challenge in the generation is the low efficiency of solar cells. Also, a large area of land is required for solar panel installations. The only non-conventional method that can progressively replace the world's existing non-renewable energy supply is direct solar energy utilization, however at the cost of a minimum of 500,000 square kilometers of land. The main benefit that we are getting is that we can reduce carbon emissions, enhance the clean environment, make our earth a better place to live

References

[1] Shruti Sharma, Kamlesh Kumar Jain, Ashutosh Sharma “Solar Cells: in research and applications”, Material Science and Application 2015, 6,1145-1155, doi:2015.612113

[2] Askari Mohammad Bagher, Mirzaei Mahmoud Abadi Vahid, Mirha Bibi Mohsen, “Types of solar cells and application”, American Journal of Optics and Photonics. Vol.3, No. 5, 2015, pp. 94-113. doi: 10.11648

[3] Akrami, M. Gilbert, S.J., Dibaj, M., Javadi, A.A., Farmani,R., Salah,A.H., Fath,H.E.S., and egm,A.(2020), “Decarbonization using hybrid energy solution”; a case study of Zagazig Egypt. Energy, 13(18).doi: 10.3390

[4] Balasubrahmanyan, C.S., & Gupta, O.H(2020), “Detailed study of solar energy conversion system using boost converter- a new MPPT technique general of the institution of engineers (India)”; Series B, 101(6),631- 639.doi:10.1007

[5] Gupta, A., Chauhan, Y.K.& Pachauri, R.K. (2016), “A comparative investigation of maximum power point tracking methods for solar PV system. Solar energy, 136,236-253 doi:10.1016

[6] Hasan, A.& Dincer,I.“A new performance assessment methodology of bifacial photovoltaic solar panels for offshore applications”, Energy conversion and management, 220(May 2020),112972, doi:10.1016

[7] Husain, A.A.F., Hasan, W.Z.W., Shafie, S., Hamidon, M.N., & Pande, S.S, “A review of transparent solar photovoltaic technologies”, Renewable and sustainable energy review 94(Jan 2017),779- 791, doi: 10.1016

[8] Fraas LM, “History of solar cell development. low-cost solar electric power 2014”; 1-12 doi: 10.1007/978-3- 319-07530-31

[9] Website:www.mnre.gov.in

[10] Mehmet Emin Meral, Furkan Dincer, “A review of the factors affecting operation and efficiency of photovoltaic based electricity generation systems”, Renewable and Sustainable Energy Reviews 15(2011) pp- 2176-2184,doi:10.1016.