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Growth of solar energy in western Rajasthan

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Abstract

This paper is structured to focus on the growth and future scope of solar energy in Western Rajasthan. Western Western Rajasthan's solar energy potential positions it as a renewable energy powerhouse, capable of meeting local energy needs and contributing significantly to India's green energy transition. This highlights the strategic importance of Western Rajasthan in harnessing solar energy, driven by its favorable geographical and climatic conditions, including high solar radiation and arid landscapes. Western Rajasthan, characterized by its extensive wasteland areas, offers a unique advantage for solar energy development also. The success of "Bhadla Solar Park" exemplifies the region's potential for large-scale renewable energy projects, serving as a global model for sustainable energy initiatives. This case underscores the critical role of leveraging natural advantages to advance renewable energy adoption and meet future energy demands sustainably.

Keywords: Western Rajasthan; Solar energy; Growth; Future scope; Hotspots; Wasteland

1. Introduction

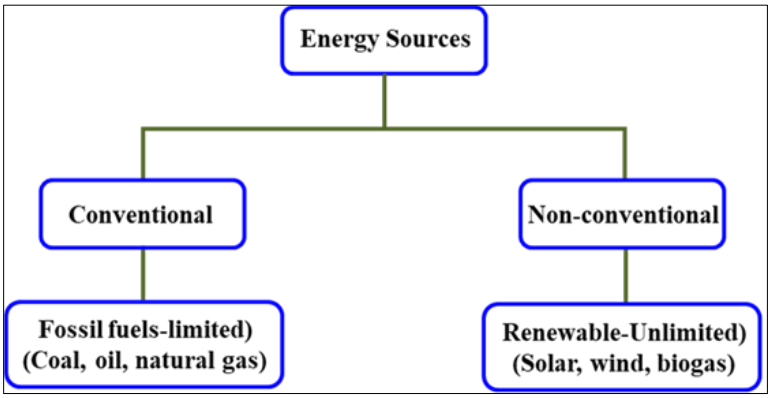

Figure 1 Main energy resources

Energy is indeed a fundamental driver of economic development and plays a significant role in improving a country's Human Development Index (HDI). India, despite being rich in natural energy resources, faces challenges such as a growing population and the depletion of conventional energy sources like coal and oil. This has led to an increasing demand for alternative (renewable) energy sources, which are seen as key solutions to meet the country's future energy needs in a sustainable manner. The renewable energy landscape in Western Rajasthan is evolving, with solar, wind,

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biogas, geothermal, and tidal energy emerging as promising alternatives to conventional energy. Solar energy, in particular, has gained considerable attention due to the country's geographical advantage of abundant sunlight as illustrated in Fig.1 [1, 2].

2. Natural (conventional) energy sources

Though, limited fossil fuels and environmental problems associated with them are seeking towards the renewable energy sources. As depletion of fossil fuel (coal, petrol, wood, crop residue etc.) is being rapidly, the state might face the problem of power shortages due to energy uncertainty. Generally, there are some common natural domestic energy sources like as firewood, crop residue, and cow dung cakes are frequently used for household purpose (i.e., cooking, heating, lighting) in traditional rural area of Western Rajasthan as shown in Fig. 2. Which are all of in category of fossil fuels.

Figure 2 Main energy sources for cooking and household purpose in Western Rajasthan

3. Power scenario in India

In the past, a huge part of energy (i.e., 86% /170,343 MW) is produced by limited conventional energy sources (fossil fuels) such as coal, oil and natural gas and only 12% part of total India's energy production was obtained by renewable energy sources (i.e. solar, wind, biogas and Hydro) [3]. This dependency on fossil fuels poses both environmental and sustainability challenges, especially as these resources are finite and their environmental impacts are significant. In contrast, renewable energy sources, including solar, wind, biogas, and hydro, contribute only around 12% to India's total energy production, with solar energy making up a relatively small 3.63% of this share as shown in Fig. 3.

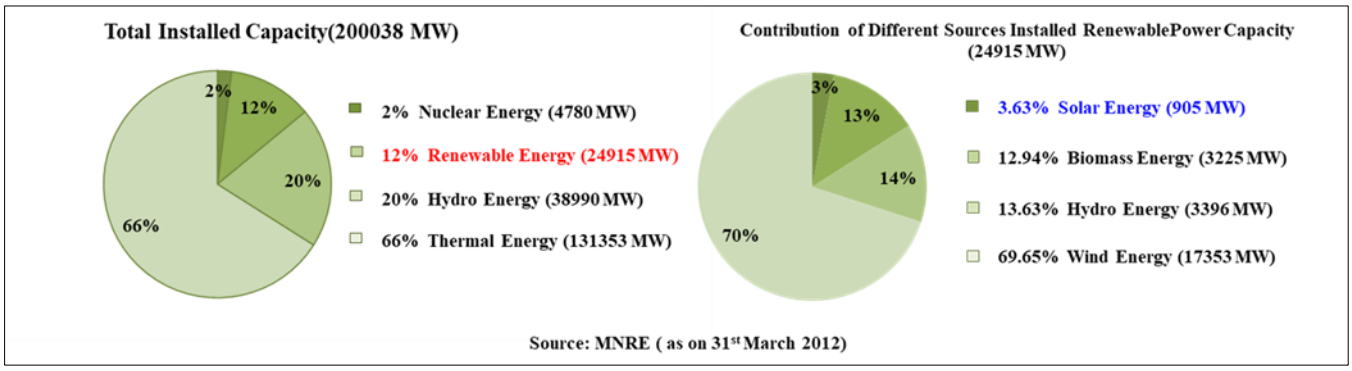

Figure 3 Past power scenario of conventional and renewable energy sources in India [4]

In this situation, only a renewable energy resources seems to be a perfect performer to meet the power hope the future. In India, renewable energy sources like solar, wind, and biomass are essential for meeting the growing energy needs, accounting for 33% of primary energy consumption as shown in Fig. 4 [5].

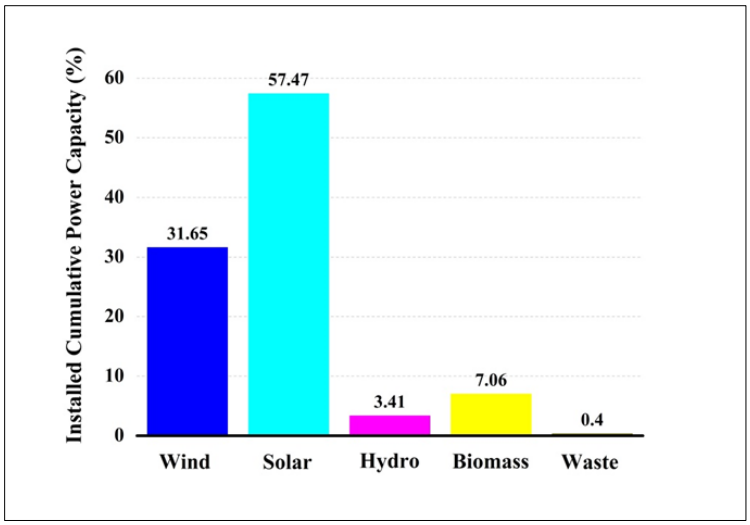

Figure 4 Installed capacity of cumulative renewable energy sources in India (as on May 2024) [4]

4. Growth of solar energy in Rajasthan

Meanwhile, in nature, a great opportunity and potential is present for harnessing the solar energy more than any other renewable energy source. The country is positioned to harness large amounts of solar power due to its favorable climate and high levels of solar insolation in western regions (i.e., *Western Rajasthan*). Therefore, it is need to exploit this energy resource through commercially viable technologies for generating solar power capacity in the country as presented in Fig. 5.

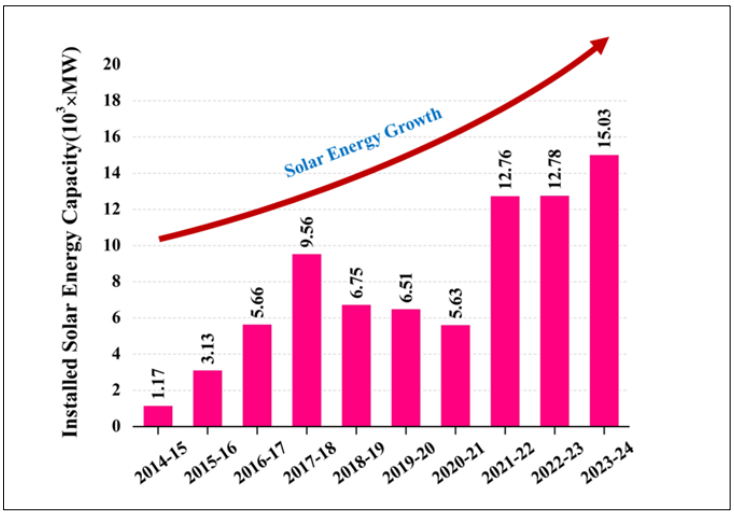

Figure 5 Year wise installed capacity of solar energy sources in India [4]

In this regards, Western Rajasthan ("*Thar*" desert) is emerging as an important zone for establishing the solar energy [6].

Here, it can be clearly seen that most of the part of renewable energy is generated by solar power. Thus, the scope of solar energy is being grown as major component of renewable power generation day by day very fastly as shown in Fig.6. Specially, in Rajasthan the installed of solar has been increased tremendously among.

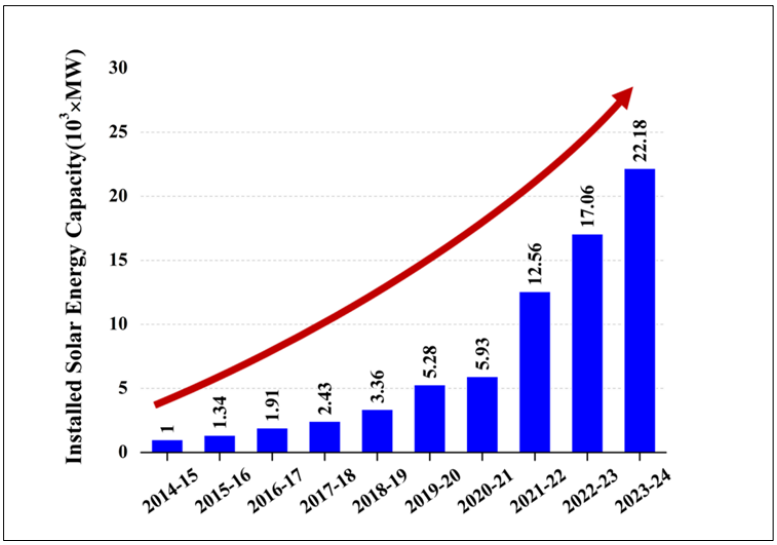

Figure 6 Yearwise installed capacity of solar energy sources in Rajasthan [4]

5. Why Solar Energy in Western Rajasthan?

Over the last few years large amount of research is carried out on solar energy. In which Government of Rajasthan has been sponsored many useful polices for supporting to solar energy sector in Western Rajasthan. The suitable climatic conditions and natural geographical situations offers a great opportunity to set up the solar hub in particular region [7, 8]. The state government also offers many discounts for launching the renewable energy projects. Furthermore, an essentially required infrastructure support is provided for the growing sector.

5.1. Topography of Western Rajasthan

Western Rajasthan is very suitable zone for establishing the solar energy in particular area. The state of Rajasthan is situated in the western part of India, which faces severe water scarcity, poor rainfall over the year. Rajasthan is the largest state of India (342239 Km^2), covering about 10.4% of the country's total area. In which 60% (208110 Km^2) land part is desert of the total area of state. Rajasthan receives one of the highest amounts of solar radiation (i.e., daily average radiation ranges between 6.0-7.0 kWh/m^2) gifted with over 300 – 325 clear sunny days (constant sunlight) i.e., only few cloudy days in a year making it suitable for setting up the solar power plants [9]. This uninterrupted sunlight leads to well output power generation. The output (Solar Electricity) from these hubs can be connected to the grid to supply electricity throughout the country.

State of Rajasthan is the main part of an incredible India. High population (5%) and only 1% water sources (need!) i.e., scarcity of water. In state, it is low temperature in winter (8°C to 28°C) and very high in (25°C to 50°C) in summer**.** low rainfall 100 mm (western deserts) while as 650 mm in the southeastern part.

5.1.1. Waste Land Bank

The major part (208,110 km^2) of Rajasthan is the desert area i.e., 60% of the land part is arid and semi-arid in the state. Major desert area lies in the Western region of the state. In India, Rajasthan has largest wasteland area 93689.47 sqkm (2005-06/ Map of Rajasthan) which is 27.38% of total area of Rajasthan. A major part (52.54%) of waste land occurs in four districts Barmer, Bikaner, Jaisalmer and Jodhpur i.e., Western Rajasthan as displayed in Fig. 7. This is also one of the key intentions why Western part is Rajasthan's largest maker of solar power in that region.

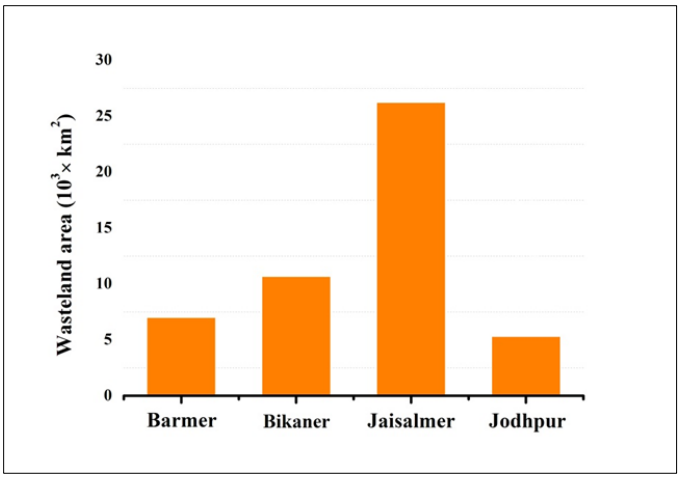

Figure 7 Representation of wasteland area of Western Rajasthan [10]

A Western region (*Barmer, Bikaner, Jaisalmer, and Jodhpur*) receive the best amount of solar radiation throughout year in the State. The consistency between waste land bank, capturing finest amount of solar radiation, and suitable climatic conditions offers a great opportunity for harnessing solar power energy in Western Rajasthan.

5.1.2. Solar Energy strategy and policies

Western Rajasthan, with its abundant solar resources and vast arid lands, aligns its solar energy ambitions with the "Rajasthan Solar Energy Policy", which emphasizes large-scale solar park development to boost renewable energy capacity and infrastructure. As part of this initiative; The state aims to develop solar parks with a huge cumulative capacity. These projects will be strategically implemented in Western Rajasthan (i.e., Jodhpur, Jaisalmer, Bikaner, Barmer), capitalizing on their high solar radiation potential and available land. Moreover, it is a big step in the direction of solar energy. The "Jawaharlal Nehru National Solar Mission" (also known as the National Solar Mission / JNNSM) is a major initiative in collaboration of the Government of India and State Governments to promote the solar energy technologies in particular area. The "JNNSM" launched in 2010 under the "National Action Plan on Climate Change" (NAPCC) by the "Ministry of New and Renewable Energy" (MNRE), is a flagship initiative of the Indian government to promote sustainable solar energy development.

Table 1 Solar Thermal Projects under development in JNNSM (Phase 1) [11]

Project Name	**Promoter**	**Location**	**Capacity (MW)**	**Technology**
Rajasthan Sun Technique Energy Private Limited	Reliance Power	Jaisalmer, Rajasthan	100	Compact Linear Fresnel Reactor
Diwakar Solar Projects Private Limited	Lanco Infratech	Jaisalmer, Rajasthan	100	Parabolic Trough
KVK Energy Ventures Private Limited	KVK	Jaisalmer, Rajasthan	100	Parabolic Trough
MEIL Green Power Ltd	Megha Engg & Infrastructure	Anantapur, Andhra Pradesh	50	Parabolic Trough
Aurum Renewable Energy Private Limited	Aurum	Mitrala, Porbandar, Gujarat	20	Compact Linear Fresnel Reactor
Corporate Ispat Alloys	Abhijeet	Pokaran, Rajasthan	50	Parabolic Trough
Godavari Green Energy Limited	Godawari Power and Ispat Limited	Jaisalmer, Rajasthan	50	Parabolic Trough

From the very beginning of mission, it can be observed from the tabulated data a maximum part of solar power was installed in Western Rajasthan as presented in Table 1. It is mean that Weastern Rajasthan is a front runner in which 400MW (85.12%) out of total 470 MW capacity of solar power is only allocated in Rajasthan. Moreover, the "*Bhadla Solar Park*", located in the Jodhpur district of Rajasthan (i.e., western Rajasthan), is one of the largest solar parks in the world [12]. It has gained significant attention for its role in advancing India's renewable energy capacity. The park has an installed capacity of over 2,245 MW (2.2 GW), making it one of the largest solar installations globally. It has been managed and developed under the "Rajasthan Renewable Energy Corporation Limited (RRECL)" in collaboration with various private and government stakeholders [13, 14].

Rajasthan is a leading state in India for solar energy production due to its vast arid landscapes, high solar irradiance, and supportive government policies. Several regions in Rajasthan are identified as solar hotspots because of their optimal conditions for solar energy projects. Here are the key solar hotspots in the state: (a) Bhadla (Jodhpur District); (b) Phalodi (Jodhpur District); (c) Pokhran (Jaisalmer District); (d) Osian (Jodhpur District); (e) Barmer District; (f) Nagaur District; (g) Jodhpur District; and (h) Jaisalmer District. These regions are the main part of Western Rajasthan [15, 16]. Therefore, most of the solar parks in Rajasthan are concentrated in western Rajasthan, primarily due to the region's unique geographical and climatic advantages. The main solar parks are:

- Bhadla Solar Park (Jodhpur District): The world's largest solar park.
- Pokhran Solar Park (Jaisalmer District): Situated in the Thar Desert.
- Phalodi Solar Park (Jodhpur District): A significant contributor to the state's energy grid.
- Barmer Solar Park (Barmer District): Focuses on using desert lands efficiently.

6. Conclusion

The data underscores Western Rajasthan's prominence in solar power development, as it hosts an impressive 85.12% of the region's total installed solar capacity, equating to 400 MW out of 470 MW. This highlights its strategic importance in India's renewable energy landscape. The significant allocation reflects the region's exceptional solar energy potential, driven by its geographical advantage of high solar radiation and arid climate. The success story of Bhadla Solar Park exemplifies the scalability and efficiency of solar energy projects in regions with high solar exposure. Serving as a model for similar initiatives worldwide, it demonstrates how leveraging natural advantages can drive progress in renewable energy adoption, positioning Western Rajasthan as a beacon for sustainable energy solutions. The opportunities for solar energy-related projects and businesses are immense in the western part of state in future.

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