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Assessing Solar Energy Potential in India: Trends, Regional Insights, and Future Directions

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Abstract
This study presents a comprehensive examination of India's evolving energy landscape with a particular focus on solar power development between 2013–14 and 2023–24. Utilizing descriptive secondary data analysis drawn from government sources such as the Ministry of New and Renewable Energy (MNRE), Central Electricity Authority (CEA), and Energy Statistics (Pejagotus), the research evaluates year-wise production trends, installed capacities, growth rates, and state-wise performances. The findings underscore the dynamic rise of solar energy, which recorded the highest Compound Annual Growth Rate (CAGR) among all renewable sources, with Rajasthan, Gujarat, and Tamil Nadu leading in installed capacity. However, the study also identifies persistent barriers impeding widespread adoption, namely inadequate grid infrastructure, storage and intermittency issues, high capital investment, and policy execution gaps. It emphasizes the need for targeted strategies, including financial instruments for MSMEs, improved subsidy disbursement systems, and investment in energy storage technologies. By comparing traditional and renewable generation patterns, the paper highlights India's growing alignment with global sustainability commitments and its readiness for a solar-powered future. The study concludes by suggesting that future research should explore the technical and economic feasibility of solar installations in MSMEs, particularly in emerging solar states like Kerala. Such focused analysis could inform localized energy planning and foster inclusive, low-carbon industrial growth.

Keywords: Solar Energy, Renewable Energy, SDG goals, India, Regional Analysis, Policy Barriers.

1. Introduction

India's energy consumption is growing at a fast pace, fuelled by the growth of population, urbanization, and the expansion of industries (Franco et al., 2017). The International Energy Agency (2009) estimates that the energy consumption of the country is going to grow substantially, requiring huge investments in energy production and infrastructure to fulfil this increasing demand. This upsurge emphasizes the compelling necessity for clean and viable sources of energy to guarantee energy security and promote economic development (Wang et al., 2022).

Solar energy has become a central element of India's energy policy, providing a sustainable and infinite source to manage India's energy needs (Raina & Sinha, 2019). The Government of India introduced the National Solar Mission aimed at ensuring that India would become one of the leaders in solar energy generation through creating beneficial policy environment to introducing solar energy to large scale use (Chaudhary et al., 2015). Currently, solar power represents indispensable component to the overall renewable energy capacity of India since by December 2023, it constituted an approximate 54.76% (Mohd Chachuli et al., 2022). This study aims to assess India's solar energy potential in terms of expansion trends and expansion barriers. Through the analysis of data regarding the installed capacities, generation trends and region performances, the work will be an opportunity to find out what treats the solar energy in its development. This paper intends to sensitize policy thinkers and business people on the investment and innovativeness opportunities that are present in the solar sector and in the long run contribute to the sustainable future of Indian energy situation.

2. Methodology and Data Sources

The present research adopts a descriptive secondary data analysis method to analyze the growth and regional spread of solar energy in India between 2013–14 and 2023–24. Data were obtained from official government documents, which include the Ministry of Statistics and Programme Implementation's (MoSPI) Energy Statistics India 2024 and the Ministry of New and Renewable Energy's (MNRE). These resources offer in-depth details on energy production, installed capacity, and development of renewables throughout the nation.

Compound Annual Growth Rate (CAGR) of energy production and capacity, year-on-year expansion, comparisons of generated and capacity of solar energy by state-to-state statistics are also highlighted in the study. By examining these indicators, the research shall establish patterns and loopholes in the uptake of solar energy among different regions. The CAGR provides the view of long-term trends of solar energy expansion, and in the year-by-year growth trends, it is possible to observe recent trends and dynamic of the industry. Comparative study is conducted at the state level to identify the geographical location of the solar energy infrastructure and production. This implies comparing each state by both installed capacity and energy production, and therefore calculating aspiring states, which are ahead of the curve. The findings of this research should support policy-makers and companies on opportunities of investments and development in the industry of solar energy, which could make future decisions and their planning.

3. India's National Energy Landscape: Trends and Transitions

India's energy scenario has witnessed a remarkable change in the last ten years with considerable changes in the production and consumption of energy resources. Coal production went up from 556.40 million tonnes during 2012–13 to 778.19 million tonnes in 2021–22 with a Compound Annual Growth Rate (CAGR) of 3.80%. On the other hand, crude oil production dropped from 37.86 million tonnes to 29.69 million tonnes with a negative CAGR of -2.66%. Production of natural gas decreased as well with the CAGR of -1.97% over the same period of time. Generation of electricity, on the other hand, showed a strong growth from 204,035 GWh to 369,652 GWh with a CAGR of 6.83%.

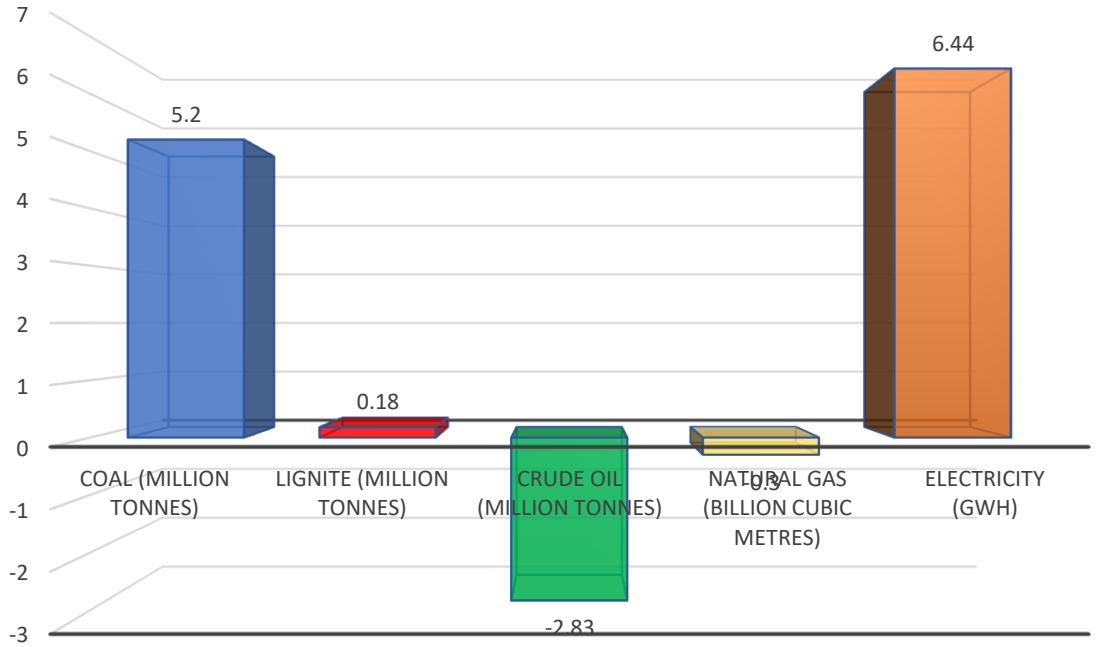
These statistics highlight an ongoing dependence on coal for the production of electricity, with power generated using coal amounting to nearly 73% of all electricity generation during 2021–22. However, renewable energy sources have made quite an inroad. As an example, renewable energy-based electricity generation (excluding large hydro) went up from 65.78 billion units in 2015–16 to 203.55 billion units in 2022–23, representing a CAGR of 17.5%. Significantly, solar power generation increased from 7.45 billion units to approximately 102 billion units over the same period, demonstrating a staggering CAGR of 45.3%.

The shift towards renewable energy is also reflected in India's aggressive targets to install 500 GW of renewable energy capacity by the year 2030. The renewable energy capacity of the country has mounted at three times its capacity in March 2014, which was 75.52 GW, rising to 232 GW as of May 2025, indicating a strong intention to expand clean energy capacities. The shift not only aligns with international sustainability objectives but also opens up possibilities for investment and innovation in the renewable energy space.

According to the report of Ministry of Coal, Government of India (Electricity from Hydro, Nuclear and other Renewable energy sources), the data on year-wise production of energy resources in physical units explains that, Coal production increased considerably from 565.77 million tonnes during 2013–14 to 893.19 million tonnes during 2022–23, reflecting a strong Compound Annual Growth Rate (CAGR) of 5.20%. Electricity production also had the same increasing trend, rising from 234,595 GWh to 411,512 GWh, with the highest CAGR of 6.44%, representing India's increasing energy requirement and development in electricity infrastructure. Compared to that, crude oil production gradually fell from 37.79 million tonnes to 29.18 million tonnes over the same timeframe, representing a negative CAGR of -2.83%, which demonstrates stagnation and increasing dependency on imports in the petroleum industry. Production of natural gas also fell slightly, with a CAGR of -0.30%, whereas lignite was comparatively stationary with an insignificant CAGR of 0.18%.

The year 2022–23 saw sharp increases in coal (14.77%) and electricity (11.32%) production over the previous year, reinforcing the centrality of coal in India’s power generation. This data underscores a dual reality: while India has improved its electricity output, its dependence on fossil fuels, especially coal, remains high. The figures highlight the urgency of accelerating renewable energy adoption to diversify the energy mix and ensure long-term sustainability.

Chart 1. Compound Annual Growth Rate of Production of Energy Resources from 2013-14 to 2022-23(P)

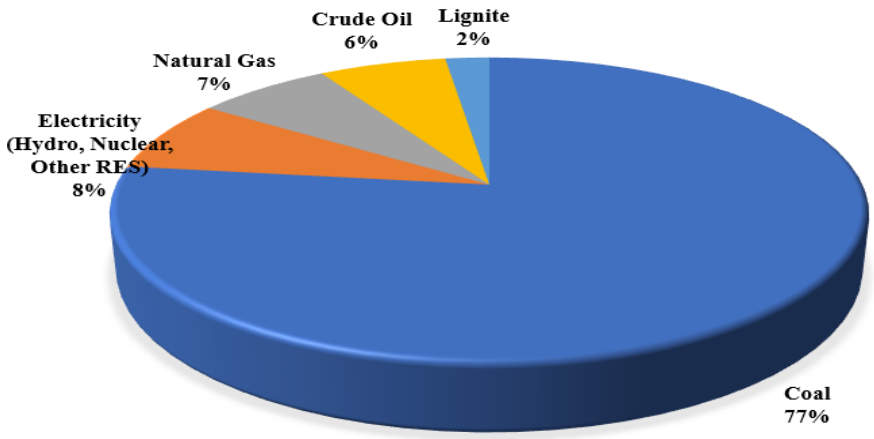


Source: Ministry of Coal and Energy Statistics (Pejagotus)

Chart-1 shows CAGR of Production of Energy Resources from 2013–14 to 2022–23 (P)', clearly illustrates the divergent growth patterns among major commercial energy sources in India over the past decade. Electricity leads with the highest CAGR of 6.44%, reflecting rapid expansion in generation capacity to meet escalating demand. Coal follows with a 5.2% CAGR, reaffirming its dominance as the backbone of India's power generation sector. These positive growth rates highlight the country's ongoing reliance on conventional, coal-based electricity, even as renewable sources gradually rise.

In contrast, crude oil production has declined at a negative CAGR of -2.83%, indicating growing dependence on imports to meet domestic requirements. Natural gas has also shown a slight negative trend, with a CAGR of -0.30%, suggesting limited expansion in domestic exploration or production. At the same time, lignite growth has been negligible at 0.18%, indicating stagnation as a source of energy contribution. The graph highlights the imperative need for Indian energy basket diversification, underlining the need for fast-tracking renewable energy development in order to provide long-term sustainability and ensure energy security.

Chart 2: Share Of Total Energy Generated (In Petajoules) From Different Commercial Sources In India During FY: 2022–23



Source: Ministry of Coal and Energy Statistics (Pejagotus), 2022–23

Chart 2 illustrates the share of total energy generated (in petajoules) by different commercial sources in India during FY 2022–23, providing a clear snapshot of the country's energy dependency profile. The graph shows that coal dominates the energy mix, with a huge 77% contribution to the entire energy produced. This dominating figure reflects India's persistent dependence on coal as the pillar of its power and industrial sectors. On the other hand, electricity from other forms, hydro, nuclear, and other renewable energy sources (RES), comes in at just 8%, reflecting relatively limited use of cleaner energy technologies even with increasing policy focus on sustainability.

Natural gas comes next with a 7% contribution, reflecting its limited position as a transition fuel, especially in urban and industrial applications. Crude oil makes up 6%, for transportation and petrochemical purposes mostly, and lignite making up the lowest proportion at 2%, reflecting its waning importance in India's energy plan. Overall, the pie chart clearly highlights the imperative for diversification of India's energy mix and a more aggressive shift towards renewable energy. The existing pattern creates hurdles for carbon reduction pledges as well as long-term sustainability targets

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4. Electricity Generation in India: A Comparative Analysis

The landscape of electricity generation in India has been through many changes in the last decade, underpinned by increasing demand, changing energy policies, and a slow transition to cleaner sources. This part contains a comparative study of year-wise electricity generation by utility and non-utility sources, including thermal, hydro, nuclear, and renewable energy sources (RES) from 2011–12 to 2022–23. The information reveals key insights into how different sources have made contributions to the national grid and how their proportions have changed over the years. Generation driven by utility, traditionally dominated by thermal power, particularly coal-fired units, has always comprised the lion's share of overall electricity output. In recent years, however, there has been a welcome increase in the generation of

electricity from renewable sources of energy like wind, solar, and bio-power, in the non-utility sector. The diversification in energy is in line with India's overall policy drive through plans such as the National Electricity Plan and the Green Energy Corridor to bring greater sustainability and minimize carbon emissions.

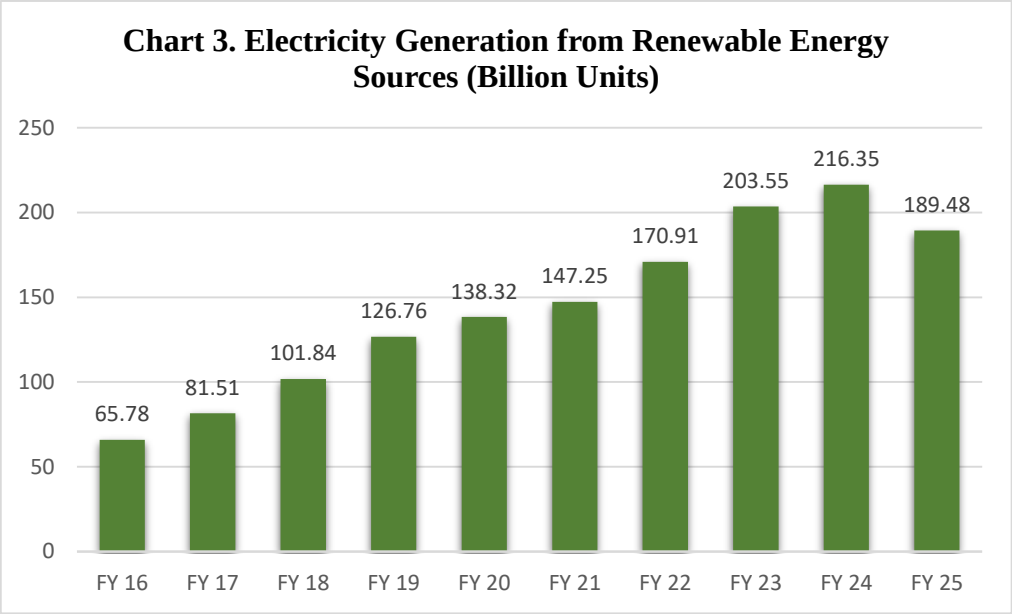
This analysis makes use of CAGR computation and year-over-year growth rate to follow up the trends of performance across various sources. It helps to know the growth patterns of India's electricity generation industry. The insights obtained help guide policy, investment strategy, and the country's shift toward a more resilient and low-carbon energy future.

According to the report on Year wise Gross Generation of Electricity from Utilities from Central Electricity Authority, It reveals that, thermal power continues to dominate, with steam-based generation contributing the largest share. However, a declining trend in gas-based power generation is evident, registering a negative CAGR of -6.69%. Diesel generation dropped sharply, showing a drastic decline with a -18.42% CAGR, reflecting reduced reliance on high-cost, polluting fuels. In contrast, hydro power grew modestly (4.79% CAGR), while nuclear increased only slightly (2.07%), indicating stability but limited expansion.

The standout performer is RES, which includes solar, wind, and other renewables. It recorded a remarkable 13.42% CAGR, increasing its contribution from 51,226 GWh in 2011–12 to 203,552 GWh in 2022–23. The year-on-year growth from 2021–22 to 2022–23 alone was 19.1%, signifying accelerating momentum in clean energy adoption. These trends highlight India's growing commitment to diversifying its electricity generation mix. While fossil fuels still lead, the rapid rise in renewables indicates a clear shift toward sustainable energy in alignment with national and global climate goals.

According to the report of Year wise Gross Generation of Electricity from Non-Utilities (Central Electricity Authority), the data presents year-wise gross generation of electricity from non-utility sources in India from 2011–12 to 2022–23, covering thermal, hydro, and renewable energy sources (RES). This segment of electricity generation, while smaller than utility-based sources, has shown steady growth, particularly driven by renewables and private participation.
Thermal generation from non-utilities increased modestly over the period, growing from 133,079 GWh in 2011–12 to 216,700 GWh in 2022–23, with a Compound Annual Growth Rate (CAGR) of 4.41%. Within thermal sources, diesel-based generation declined significantly, registering a negative CAGR of -13.92%, while steam-based generation (mostly captive industrial plants) rose steadily (CAGR: 5.6%).

The most significant growth is seen in RES, which jumped from just 1,178 GWh in 2011–12 to 8,900 GWh in 2022–23, achieving an impressive CAGR of 18.7%. Hydro also expanded strongly (CAGR: 13.39%), albeit from a small base. The total non-utility generation grew from 1,056,839 GWh to 1,843,813 GWh over the decade, with an overall CAGR of 5.13%. The 2022–23 growth rates highlight a 30.63% increase in RES and 12.15% in hydro, indicating an accelerating trend in decentralized and renewable generation. This data supports the narrative of an evolving Indian electricity sector, with increasing reliance on clean, distributed energy sources outside traditional utility frameworks.



Source: India Brand Equity Source Foundation (IBEF), December, 2024

Chart 3 presents the year-wise electricity generation from Renewable Energy Sources (RES) in India from financial year 2016 (FY16) to FY25 (in billion units), offering a visual summary of the country's rapid progress in renewable electricity production. Starting at 65.78 BU in FY16, RES generation saw a consistent rise over the years, nearly tripling to 216.35 BU in FY24, marking a remarkable achievement in India's clean energy trajectory. The highest annual increases were seen between FY20 and FY24, where generation registered a leap from 138.32 BU to 216.35 BU, spurred mainly by aggressive capacity building in solar and wind segments, policy support, and greater involvement of private players.

While the estimated size for FY25 (135.25 BU) is lower, it has probably been drawn from incomplete data or conservative projections, and not due to a slide in performance. The total CAGR from FY16 to FY24 is a testament to India's achievement in ramping up its renewable generation capacities over less than a decade. This growth aligns with national energy goals aimed at achieving 500 GW of non-fossil capacity by 2030, as well as India's climate commitments under the Paris Agreement.

5. Renewable Energy Growth in India: Focus on Solar Energy

India has become a world leader in the development of renewable energy, with the country spurred by climate ambitions, energy security issues, and the imperative of sustainable development. This section examines India's development of Renewable Energy Sources (RES) between 2014-15 and 2023-24, with specific reference to solar. The period saw an incredible growth, with RES capacity going up from 39.95 GW in 2014–15 to 143.64 GW during 2023–24, a CAGR of 15.28%. The high growth indicates the Indian government's aggressive policies like the National Solar Mission and facilitative regulatory environments promoting investment in clean infrastructure.

Among the RES portfolio, solar has been the best performer, achieving a spectacular CAGR of 39.88% between the same time period. Solar installed capacity jumped from merely 3.99 GW in 2014–15 to a strong 81.81 GW by 2023–24, representing over 57% of cumulative RES additions between the decade. The growth in solar owes to advancements in technology, falling solar module prices, supportive policies such as viability gap funding and production-linked incentives, and a rise in private sector participation.

This section illustrate India's clean energy transformation, pointing out the way solar power is not only spearheading RES growth but also transforming the country's energy landscape into one that is sustainable and resilient.

According to the report on Installed Electricity Generation Capacity in India (GW)-2008-09 to 2022-23 (CEA, Growth of Electricity Sector in India), it explains installed electricity generation capacity in India for the period 2008–09 to 2022–23, in terms of gigawatts (GW), and indicates the transition of various sources of energy, thermal, hydro, nuclear, and renewable energy sources (RES). The figures show a consistent upward trend, and total installed capacity rose from 147.97 GW in 2008–09 to 416.06 GW in 2022–23, reflecting a CAGR of approximately 7.56%.

The most astonishing growth is recorded in the renewable energy sector (RES), which grew from a humble 13.24 GW in 2008–09 to 125.16 GW in 2022–23, with a CAGR of 15.28%. This steep increase mirrors India's strategic drive towards clean energy, precipitated by government initiatives like the National Solar Mission, wind development projects, and incentives for distributed generation. Thermal power still takes the lion's share of capacity, rising from 93.73 GW to 237.27 GW, although growth has slowed down in recent years. Hydro and nuclear capacities have exhibited comparatively modest growth with hydro getting to 46.85 GW and nuclear staying almost unchanged at 6.78 GW since 2016–17. This information supports India's pledge to a sustainable and diversified energy mix in which renewables, particularly solar, increasingly drive the nation's energy future.

The report on Year wise Energy Generation under RES since 2014-15 (Renewable Energy Statistics 2023-24, MNRE, Govt. of India) shows the year-wise electricity generation from Renewable Energy Sources (RES) in India during the period 2014–15 to 2023–24, expressed in billion units (BU). The information provides a detailed disaggregation by major RES segments, wind, solar, bio-power (biomass, bagasse, waste-to-energy), and small hydro, elucidating sectoral shares and growth patterns.

The strongest observation is the exponential rise of solar energy, which leaped from mere 4.6 BU during 2014–15 to 115.98 BU during 2023–24, representing a whopping growth rate of 2421.3% and a CAGR of 43.13%. This spectacular growth highlights Solar’s pivotal position in India's renewable energy revolution, driven by falling costs, supportive policies, and popularisation in both utility and rooftop segments.

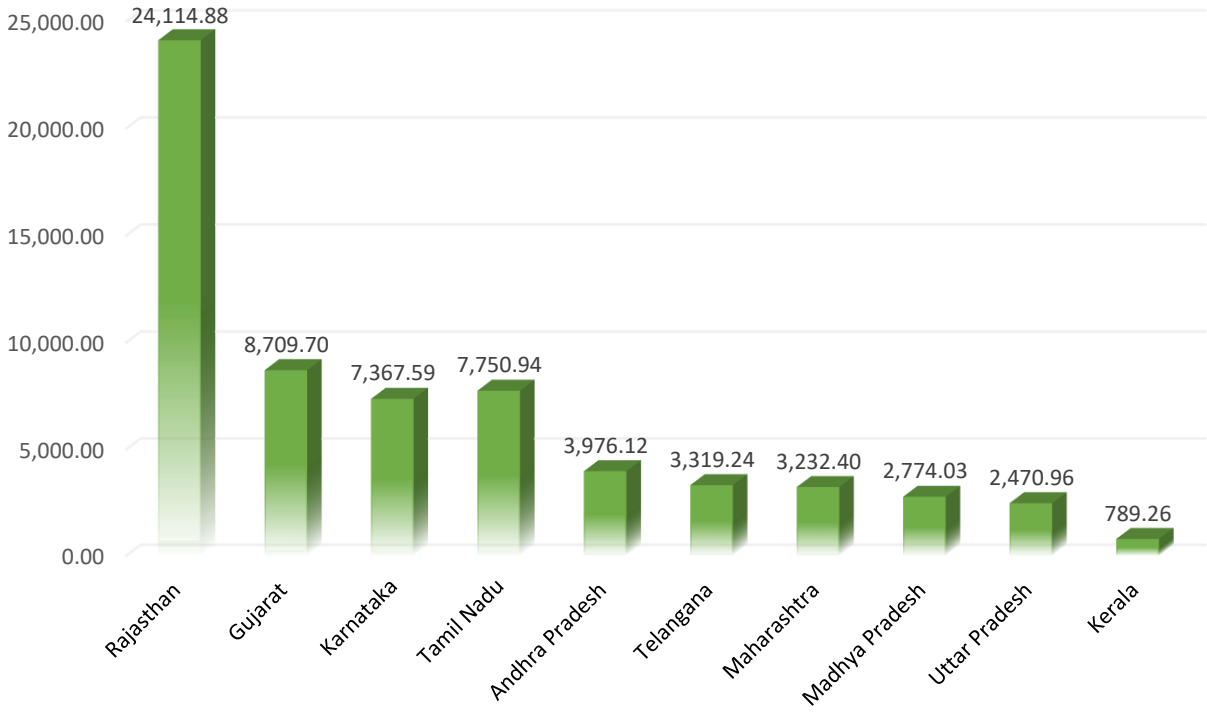
Wind power is still the second-largest contributor, rising from 33.77 BU to 84.39 BU over the time period, with a consistent CAGR of 10.57%. Other sources such as waste-to-energy also registered significant

growth (CAGR: 25.74%), albeit from a lower base. Bagasse-based generation, on the other hand, fell (CAGR: -0.93%), most probably owing to seasonal limitations and rivalry from other technologies.

The cumulative RES generation increased from 61.72 BU in 2014–15 to 225.83 BU in 2023–24, registering a CAGR of 15.50%. This growth confirms India's surging pace towards cleaner energy and the strategic focus on solar as a growth driver.

6. Regional Solar Energy Potential: Top Performing States

Chart 4. Top 10 State-wise Solar Power Generation In India (Capasity in MU ,September 2024)



Source: India Brand Equity Foundation (IBEF), September 2024

Chart 4 displayed the top 10 Indian states for solar power production up to September 2024, demonstrating the varied regional solar performance profile. The information confirms the evident leadership trend, with Rajasthan emerging as the clear leader by a sizeable distance with 24,114.88 million units (MU) of production, almost threefold the amount produced by the second-placed state, Gujarat. Rajasthan has succeeded due to its large arid territory, intense solar irradiance, sparse population in solar regions, and favorable state policies, such as streamlined land acquisition and grid connection policies.

Gujarat, with **8,709.70 MU**, ranks second, benefiting from early adoption of solar initiatives, strong private sector participation, and a robust solar rooftop program. **Karnataka** and **Tamil Nadu**, ranking third and fourth respectively, have also made significant strides, generating **7,367.59 MU** and **7,750.94**

MU. These southern states leverage favorable solar exposure and industrial demand, coupled with effective policy execution.

Andhra Pradesh, **Telangana**, and **Maharashtra** represent mid-tier contributors with generation ranging between **3,200–4,000 MU**, driven by mixed solar park and distributed energy models. **Madhya Pradesh** and **Uttar Pradesh**, despite having high solar potential, still lag behind, indicating possible gaps in infrastructure, investment climate, or regulatory efficiency. **Kerala**, ranked tenth with **789.26 MU**, reflects the challenges of limited land availability and dependency on rooftop and floating solar solutions.

The distribution pattern reflects not only geographical solar potential but also the enabling environment created through state-specific policies, ease of doing business, infrastructure readiness, and stakeholder coordination. The top-performing states serve as benchmarks for others, offering replicable models in land use planning, policy stability, and public-private partnerships. Going forward, focusing on unlocking untapped potential in lagging states will be crucial for achieving national solar targets and ensuring balanced regional development.

7. Technical and Economic Barriers to Solar Energy Adoption

India's ambitious solar energy targets, including achieving 500 GW of non-fossil fuel capacity by 2030, have catalysed significant growth in renewable energy installations. However, several technical and economic barriers continue to impede the widespread adoption of solar energy across the country. These challenges encompass infrastructure limitations, storage issues, investment hurdles, and policy-related obstacles.

7.1 Infrastructure and Transmission Challenges

An efficient and upgraded grid system is required for balancing intermittent renewable energy sources such as solar power (Stephanie & Karl, 2020). The current transmission infrastructure in India tends to be limited in capacity and responsiveness to secure the variability of solar generation. Developers go through great difficulties in getting timely grid connections, with postponed transmission infrastructure development resulting in an underutilization of capacities installed. In addition, the financial positions of distribution companies (DISCOMs) influence the investments they can make in upgrades required for the grid, thus worsening integration issues (Poudineh et al., 2021).

Solar energy's dependence on sunlight introduces intermittency, necessitating effective storage solutions to ensure a stable power supply. While battery energy storage systems (BESS) offer a viable solution, their high costs and limited deployment hinder large-scale adoption. The World Bank emphasizes the need for integrating storage solutions with solar projects to enhance reliability, but financial and technical constraints remain significant barriers (World Bank, 2023).

7.2 Investment Costs and Return on Investment (ROI) Considerations

The initial capital expenditure for solar installations, particularly for residential and small commercial entities, poses a substantial barrier (Van Opstal & Smeets, 2022). Despite declining costs of solar panels, the overall investment, including installation and maintenance, remains high. A study by the World Bank (2013) highlights that limited access to affordable financing options deters potential investors, especially in rural areas. Moreover, uncertainties regarding the return on investment, influenced by factors like fluctuating tariffs and policy changes, further discourage investment.

7.3 Policy Gaps and Subsidy Effectiveness

While India has implemented various policies to promote solar energy, inconsistencies and gaps hinder their effectiveness. The World Bank report pins the challenges of having complex permitting procedures, non-standardized rules across states, and weak enforcement mechanisms. Subsidies meant to make solar cheaper often experience delayed release and confidentiality, which lessens their effectiveness. Even the cross-subsidy system where industrial consumers pay premium tariffs to cross-subsidize domestic consumers distorts the market and negatively impacts the financial viability of solar schemes (Painuly & Wohlgemuth, 2021).

In summary, tackling these challenges of a multifaceted nature demands a concerted effort through policy reforms, infrastructural development, financial innovations, and technological developments. Grid infrastructure strengthening, facilitating affordable storage options, maintaining consistent and transparent policies, and providing access to finance are instrumental towards overcoming obstacles and speeding up solar energy adoption in India.

8. Strategic Recommendations

In this section we provide key strategic recommendations based on the data observed throughout this study aimed at enhancing solar energy adoption in India and addressing identified technical and economic barriers:

8.1. Expand Access to Affordable Financing

Business enterprises and households frequently encounter difficulties obtaining cheap financing for solar installations because of the high capital costs and restricted credit access. Introducing focused financial tools, including concessional credits and credit guarantees, can mitigate these impediments. The Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE) offers MSMEs collateral-free credit, making it easier for them to invest in solar technologies.

8.2 Promote Innovative Financing Models

Adopting alternative financing mechanisms like third-party financing, leasing, and pay-as-you-go models can reduce the financial burden. These models allow businesses to benefit from solar energy without significant upfront investments, thereby accelerating adoption.

8.3. Strengthen Grid Infrastructure and Transmission Networks

Grid infrastructure development is the way forward for integrating solar power into the national grid. Plans to invest in transmission lines, like those of Gujarat's Green Energy Corridor, are initiated to improve the evacuation of green energy and ensure an efficient power supply.

8.4. Invest in Energy Storage Solutions

In order to manage the intermittency of solar energy, an investment in energy storage devices such as batteries is necessary. Improving cost-effective storage will facilitate load management and make solar energy more reliable.

8.5. Implement Comprehensive Policy Reforms

Harmonizing policies and regulations in states will provide a more favorable climate for adoption of solar. Making the permitting process simpler, having unified net metering policies, and speeding up subsidy releases will move more stakeholders towards solar investment.

8.6. Enhance Awareness and Capacity Building

Conducting awareness campaigns and training programs can educate households and entrepreneurs about the benefits of solar energy and the available support mechanisms. Building technical capacity among entrepreneurs and workers will facilitate smoother adoption and maintenance of solar systems.

8.7. Encourage Public-Private Partnerships (PPPs)

Encouraging partnerships between state agencies and private sectors can make available the required resources and know-how for mega solar projects. PPPs can be instrumental in establishing solar parks, manufacturing facilities, and research facilities, thus stimulating the solar ecosystem.

8.8. Leverage Digital Platforms for Streamlined Processes

Application processes for subsidies, loans, and solar project approvals can become easier through the use of digital platforms. The Pradhan Mantri Surya Ghar Muft Bijli Yojana, for instance, uses an online platform to allow registrations and monitor disbursement of subsidies, making it a more transparent and efficient process.

By considering these strategic suggestions, states can strongly expedite solar energy uptake in India, especially in the case of MSMEs, by overcoming financial, infrastructural, and policy-related impediments.

9. Conclusion

India's solar power industry has shown widespread growth in the last ten years to establish the country as a major player in the worldwide transition to renewable energy. The trends in power generation and installed base clearly place solar as the fastest-growing part of India's energy mix, fueled by policy support, regional programs, and declining technology costs. Regional leaders Rajasthan, Gujarat, and Tamil Nadu have taken the top spots, while promising new regions like Kerala hold untapped potential. Progress has

been made, however, in numerous technical and economic hurdles, namely, grid infrastructure limitations, storage shortcomings, up-front investments, and policy inconsistencies, which remain to impede the rate and scale of solar deployment. Removing these impediments with focused interventions, financial innovations, and de-bottlenecking regulations is central to realizing national renewable energy goals.

India's readiness for a solar-powered energy economy is apparent, but success will be contingent upon concerted efforts to promote equity, regional diversification, and technological convergence. As a potential research direction, a comparative study of the technical and economic viability of adopting solar energy among households and businesses especially Micro Small and Medium Enterprises (MSMEs) can provide useful lessons for scaling up decentralized clean energy access and promoting green entrepreneurship in various economic settings.

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