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REVIEW ARTICLE

Unleashing India's Solar Potential: A Review of the National Solar Mission and the Path to Sustainable Energy in India

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Abstract

India possesses vast potential for generating clean energy from Renewable Energy Sources (RES), specifically hydro, wind, and solar. This potential has been appropriately recognized, indicating India's commitment to reducing its carbon footprint as a developing nation. The significance of this endeavor is becoming increasingly evident worldwide. The objectives of this review study are to provide an overview of the abundant solar energy resources in India, including availability, current status, strategies, perspectives, challenges, achievements, and future prospects. The review study examines the Government of India's Jawaharlal Nehru National Solar Mission (JNNSM), launched in 2009 to promote clean energy. This mission, initiated on January 11, 2010, is one of the eight missions under the National Action Plan on Climate Change (NAPCC–2008). The JNNSM aims to deploy 22,000 MW of solar power through grid-connected and off-grid solar power plants. The review results show that as of August 2023, India has achieved a cumulative installed solar power capacity of 63,000 MW, exceeding the initial target of 22,000 MW set under the JNNSM. The country has seen a significant increase in solar energy deployment, with an average annual growth rate of 18% over the past five years. India's solar energy potential is estimated to be around 750 GW, indicating vast untapped resources. The review study recommends that India should continue to strengthen its policy and regulatory frameworks, incentivize private sector participation, and invest in research and development to further harness its solar energy potential. Addressing challenges related to grid integration, storage, and financing will be crucial for the sustainable growth of the solar energy sector in India.

Keywords: Alternative Sources; Solar Energy; Sustainable Energy; Progression of Solar Power; Obstacles and Hurdles in Solar Energy Advancement; Policies Regarding Solar Energy

Introduction

India has enormous potential for producing clean energy via the use of Renewable Energy Sources (RES), particularly sun, wind, and hydropower (IEA,2024). This potential has been duly acknowledged, demonstrating India's determination as a growing country to lessen its carbon impact. Globally, the importance of this undertaking is becoming more and more apparent (UN,2024). Because conventional energy sources like coal and oil have a limited supply, sustainable energy alternatives are crucial for the future (IPCC,2024).

India has a lot of potential for solar energy because it is located in the sun-rich region. In 2009, the Indian government initiated the Jawaharlal Nehru National Solar Mission (JNNSM) with the aim of advancing sustainable energy (MNRE, 2024). One of the eight tasks of the National Action Plan on Climate Change (NAPCC, 2008) was started on January 11, 2010 (MEFCC, 2024). Through grid-connected and off-grid solar power plants, the JNNSM hopes to deploy 22,000 MW of solar power (MNRE, 2024). An overview of India's vast solar energy resources is given in this document, together with information on their availability, status as of right now, tactics, viewpoints, obstacles faced, successes achieved, and potential future developments.

Any country's urbanization, industrialization, economic expansion, and enhancement of its residents' quality of life all depend on power. India is the world's fifth-largest producer of power. In particular, India has a staggering 276.783 GW of power production capacity (as of August 2015). Of this, 69.6% comes from thermal sources, 15.2% from hydro, 2.1% from nuclear, and around 13.2% from renewable sources (IDFC, 2015).

With coal reserves providing for about three-fifths of the country's capacity, India's power industry is mostly dependent on non-renewable energy sources. Significant volumes of toxic chemicals, including NOx, COx, and SOx, are released by thermal power plants, endangering both human health and the environment. In recent decades, the production of renewable energy in India has increased. In actuality, in the early 1980s, India was the first nation to create a Ministry of Non-Conventional Energy Sources.(MNRE, 2024)

Renewable energy sources like solar and wind are abundant and safe for the environment. Solar energy is abundant and readily available in the majority of the world's areas, but wind energy is less practicable due to low wind speeds and unpredictability. Technology related to solar energy is essential for lowering carbon emissions worldwide. Recent years have seen a steady decline in the cost of solar energy installations, suggesting more reductions to come. As of right now, India has 4.22 GW of installed solar energy capacity, with aims to reach 100 GW by 2024.(MNRE, 2024)

The Current Scenario of Solar Power in India:

Even while some players are only now starting to plan, most are still afraid to put money into solar energy because they think there are weaknesses in the industry (Ashok & Arnab, 2011). It will need a sustained effort and a thorough comprehension of local dynamics to succeed in the solar energy industry. We conducted an extensive analysis of India's new solar energy projects, combining our findings with personal knowledge gained from several interviews with engineers, manufacturers, investors, players in the whole value chain, regulators, and legislators at the state and federal levels (Amita & Soni, 2011). Three important results emerged from our investigation:

Over the next ten years, the solar sector in India might be worth billions of dollars. Given that India's solar potential is now confirmed and that the enhancement climate is developing quickly, it is anticipated that the country will create a $6–7 billion market for capital equipment and produce about $4 billion in revenue annually from grid-connected solar generators over the course of the next ten years (UN, 2024).

Implementing a project, getting funding, and getting over challenges are essential. The viability of solar projects in India would depend critically on maintaining a low-cost structure. The increasing number of projects and stakeholders will make cost-effectiveness a crucial factor to consider. Long-term sustainable value will result from well-run initiatives, economical (and frequently creative) funding, and adaptability to setbacks (JNNSM, 2024).

Table 1: The electricity sector requirement and availability in India on March 2024 (JSRP, 2024)

In the electricity sector requirements and availabilities in India on March 20204		
	Energy in MU	Peak in MW
Availability of Energy	10,30,785.00	1,41,160.00
Requirement of Energy	10,68,923.00	1,48,166.00
Shortage of Energy	38,138.00	7,006.00
% Shortage of Energy	3.60	4.70

The downstream solar market is going to be dominated by domestic companies. In contrast to the current emphasis on the upstream industry (solar modules), we believe that local, or at least regional, firms will control the downstream industry, which includes project development, infrastructure, and distribution in the early years. Nonetheless, foreign companies venturing into the Indian market for the first time may prosper if they have enough time to modify their business plans. It will be imperative that players, both domestic and foreign, integrate and pick up the intricacies early on (Krithika & Siddha, 2014).

The JNNSM's goal of 20 gigawatts (GW) by 2024 looked unduly optimistic as late as 2009. There are now few doubts that the JNNSM will not only reach its goal, but significantly exceed it. Our estimates indicate that the combination of rising energy demand, difficulties with the cost and availability of fossil fuels, and advantageous environmental laws may raise solar power capacity to more than 50 GW by 2024. Between 2016 and 2018, when solar energy reaches grid parity with conventional electricity, the solar industry's structure will change quickly (JNNSM, 2024).

Table 2: Solar power will achieve grid equality with conventional power between 2016 and 2020 (JNNSM, 2024), (CEA, 2024),

State	Expected Year of Grid Parity	Notes	References
Rajasthan	2017-2018	Favorable policies and high solar irradiance	(KPMG, 2024)
Gujarat	2017-2018	High solar irradiance and supportive state policies	(KPMG, 2024)
Tamil Nadu	2018-2019	Rapid adoption due to high electricity costs	(KPMG, 2024)
Maharashtra	2019-2020	Industrial demand and state incentives	(KPMG, 2024)
Karnataka	2019-2020	High solar potential and proactive policies	(KPMG, 2024)
Andhra Pradesh	2019-2020	Significant investment in solar infrastructure	(KPMG, 2024)
Telangana	2020-2021	Rapid expansion of solar capacity	(KPMG, 2024)
Madhya Pradesh	2020-2021	Increasing solar installations	(KPMG, 2024)
Punjab	2021-2024	Growing focus on renewable energy	(KPMG, 2024)
Haryana	2021-2024	Policy support for solar energy	(KPMG, 2024)
Uttar Pradesh	2024-2023	Large-scale solar projects coming online	(KPMG, 2024)
Bihar	2023-2024	Gradual adoption and development	(KPMG, 2024)
West Bengal	2023-2024	Late adoption due to lower initial investments	(KPMG, 2024)

This development story is divided into two stages: the growth stage, which is marked by increased demand and good economic conditions that spur rapid industry expansion and draw larger utilities, and the seed stage, which is when independent solar power producers gain government backing. Targeted marketing will have been made

easier by the subsidy-driven market in the early stages, before solar power reaches grid parity. Investor confidence will be bolstered during this phase by the relaxation of use barriers and restrictions, including as renewable purchase obligations (RPOs), renewable energy certificates (RECs), and net metering. As the industry grows sufficiently, these elements will come together to speed up the next growth cycle (Matakiviti, 2006). During the 2016–18 timeframe, we predict a paradigm shift in the way corporate players see solar viability. In addition to being viewed as a feasible energy source, solar energy will also be considered as a major supplement to other sustainable energy sources, integrating into the mainstream grid control. The succeeding stage of this segment's quick growth will be further accelerated by the testing and improvement of off-grid and rooftop solar models during the seed stage (CEA, 2018).

The various Phases of Solar Energy Generation and Distribution

The initial stage: The overall appeal of solar power generation is waning as photovoltaic (PV) module costs generally decrease. This has caused a discernible decline in the number of competitive bids for JNNSM projects in India. India now has among of the lowest solar energy costs in the world, with typical expenses per kWh ranging from 15 to 17 cents. Over the next four years, prices are predicted to continue declining due to overcapacity in the module business before stabilizing. Solar energy may be up to 15% less expensive by 2016 than the priciest grid-connected conventional energy suppliers (JNNSM, 2024).

The combined potential capacity of these suppliers, or about 8 GW in standard terms, is the equivalent of 25–30 GW of solar power. But it's doubtful that the majority of this potential will be achieved by 2016 owing to performance issues. Due to its effectiveness, the competitive bidding mechanism is probably going to continue into the seed stage. The JNNSM and state-run projects like those in Gujarat and Rajasthan will be vital to the industry during this era (JNNSM, 2024). We project that during the seed stage, 12–14 GW of additional capacity will be added, mostly in the form of grid-connected utilities. During this phase, the off-grid space may see capacity additions of less than 1 GW. But when solar energy starts to outcompete other renewables, we anticipate off-grid capacity to rise at an exponential rate throughout the transition phase. The solar sector will see two major changes as a result of grid stability becoming a major concern. First, cross-sector capacity integration will go considerably more quickly than it has in the past because of the favorable investment circumstances. Furthermore, policies and regulations will be improved in order to encourage off-grid generating (JNNSM, 2024).

The stage of growth: The dynamics of the market will undergo a significant change after 2016. Falling solar energy prices combined with growing building power bills will force off takers—which include distribution networks, private businesses using open access, and businesses setting up shop—to acknowledge light-based energy as a financially viable alternative (figure 2). This transition will signal the beginning of a strategic change, during which time solar capacity constraints are expected to increase to about 35 GW by 2020 as planners attempt to satisfy off takers looking for affordable alternatives to conventional power as well as Renewable Purchase Obligation (RPO) mandates (MNRES, 2024).India is the tenth country in the world for the generation of solar electricity as of January 2014. India's solar energy capacity has increased significantly as a consequence of government-backed programs; starting in 2005, 6.4 MW of power were created annually. Installed capacity reached 4.22 GW by 2015, and expenses fell from Rs. 17.90 per unit in 2010 to about Rs. 7 per unit in 2015. By 2017–18, solar power is expected to reach grid parity due to market competitiveness and technology breakthroughs (IMS, 2018).

In the context of solar photovoltaic panels, grid parity—which denotes that the cost of power generated from alternative sources is equal to or cheaper than that from the grid—is an important idea in the global energy landscape. Authorized in April 2012, the Charanka Solar Park has an installed capacity of 224 MW, making it

the biggest solar park in Asia. As of September 2015, Rajasthan has the most percentage of solar power generation at 28.4%, followed by Gujarat at 24.4% (MPGI, 2024).

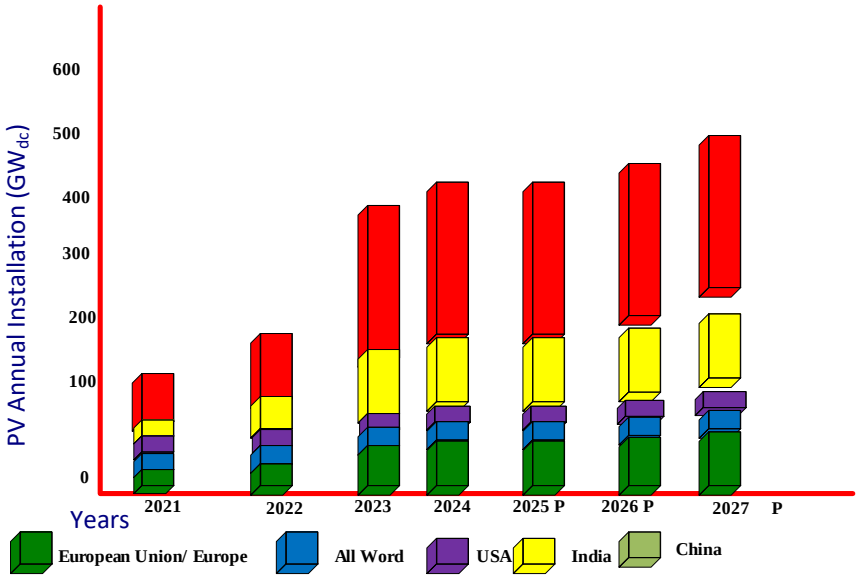

Figure 1: Solar radiation of India (NSRDB, 2024), (MPGI, 2024)

The present state of solar energy

Through radiation, solar energy is obtained from the sun. India has a wealth of solar power resources. India receives 200 MW/km² (megawatt per square kilometer) of solar radiation on average each year, with 250–300 bright days. India's underutilised solar energy resource is a significant one that has the potential to improve electricity supply, especially in rural regions, and increase the country's energy security. The availability of solar energy varies widely, with the northeastern areas having the lowest yearly radiation intensity and Western Rajasthan having the greatest. India receives annual solar energy output of more than 5000 trillion kWh. The range of daily solar radiation is 4 to 7 kWh/m², while the yearly peak values are 2300 to 3200. There is a similar range of 1600–2200 kWh/m² of annual total radiation to tropical and subtropical areas. It is estimated that the annual potential energy from solar radiation is 6000 million GWh. In comparison to other regions globally, like Japan, Europe, and the US, where solar technology development and adoption are more common, Fig. 3 illustrates solar radiation levels in different parts of India. It shows that while Rajasthan, northern Gujarat, and parts of Ladakh receive the highest annual radiation, Andhra Pradesh, Maharashtra, and Madhya Pradesh also receive substantial amounts (Sharma, 2011).

As of June 2010, India has shown 39.6 MW of solar power capacity using just photovoltaic (PV) technology; about 20 percent of this capacity was used for off-grid uses. India's plan to increase its energy supply and satisfy its dispersed energy demands has revolved around the development of alternative energy sources. The Indian Renewable Energy Development Agency Limited (IREDA), state energy development organizations, and the Ministry of New and Renewable Energy (MNRE) of India are in charge of this plan. These programs use a range of strategies to maximize solar power use and boost the share of renewable energy in the Indian market, including R&D, community-based solar projects, government subsidies, and private sector investments. (Singh, & Sood, 2011). India wants to produce 500 GW of clean energy from thorium-based nuclear power by 2050 and has set lofty targets to reduce the carbon intensity of its economy by 20–25% through the use of its rich solar resources.

The National Action Plan on Climate Change (NAPCC) set a goal of obtaining 5% of power from renewable sources by 2020, with a 1% yearly growth to reach 15% (Rachit, & Vinod, 2013).
Phase 1 will cover the remaining years of the Eleventh Plan and the first year of the Twelfth Plan (up to 2012–2013); Phase 2 will cover the remaining four years of the Twelfth Plan (2013–2017); and Phase 3 will extend into the Thirteenth Plan (2017–2024). These three phases will comprise the implementation of the Jawaharlal Nehru National Solar Mission (JNNSM). Enabling widespread solar power deployment for grid-connected and decentralized off-grid commercial energy uses is the goal (SSI, 2024).

Table 3: The segmentation across application sectors is outlined (SSI, 2024)

Phase	Plan Period	Years	Objectives
Phase 1	Eleventh Plan & Year 1 of Twelfth Plan	Up to 2012–2013	Initiate large-scale deployment of solar-generated power for both grid-connected and off-grid applications
Phase 2	Remaining Four Years of Twelfth Plan	2013–2017	Continue and expand deployment efforts started in Phase 1
Phase 3	Thirteenth Plan	2017–2022	Further expansion and consolidation of solar power deployment initiatives

Solar lighting offers substantial savings compared to grid electricity in India

With a 15-year system lifespan, the economic analysis of installed solar photovoltaic road lighting systems (in India) has been computed. In Table 4 lists all of the cost reductions in AC electrical energy that come from employing solar photovoltaic house illumination systems and road lights.

Table 4: Table: Economic Analysis of Installed Solar Photovoltaic Road Lighting Systems in India (MNREI-EAI, 2024)

Parameter	Value
System Lifespan	15 years
Initial Installation Cost	₹70,000 per unit
Annual Maintenance Cost	₹1,000 per unit
Total Energy Savings (over lifespan)	₹90,000 per unit
Cost Savings in AC Electrical Energy (annually)	₹6,000 per unit
Payback Period	12 years
Return on Investment (ROI)	28.57%

Government policies in India

Since 2000, the Government of India has implemented various initiatives to promote solar energy within the country. Some of these include:

Table 5: Key Policies and Initiatives for Solar PV Adoption in India (MOP, 2003-10)

S.No	Name of Policy/Initiative	Objective	Start Year	End Year	Current Status/Achievement	References
1	The Electricity Act of 2003	To consolidate laws relating to generation, transmission, distribution, and trading of electricity	2003	Ongoing	Introduced competition and private participation; aimed at promoting efficient and environmentally benign policies	(MOP, 2003)
2	National Electricity Policy of 2005	To provide access to electricity for all households and ensure reliable power supply	2005	Ongoing	Improved electrification and power sector reforms; enhanced focus on renewable energy	(MOP, 2005)
3	National Tariff Policy of 2006	To ensure availability of electricity to consumers at reasonable and competitive rates	2006	Ongoing	Encouraged rationalization of tariffs and promotion of renewable energy sources	(MOP, 2006)
4	National Rural Electrification Policies (NREP) of 2006	To provide electricity access to rural areas and promote socio-economic development	2006	Ongoing	Significant increase in rural electrification; improvement in rural livelihoods and economic activities	(MOP, 2006)
5	Tariff Policy of January 2006	To ensure financial viability of the power sector and attract investments	2006	Ongoing	Facilitated investment in the power sector and promoted the use of renewable energy	(MOP, 2006)
6	Efforts to Foster Solar PV Adoption in India	To promote solar power adoption and make it economically viable	2008	Ongoing	India became one of the largest markets for solar PV; significant growth in installed solar capacity	(MOP, 2008)
7	Semiconductor Policy of 2007	To promote the semiconductor and electronics manufacturing industry	2007	Ongoing	Attracted investment in semiconductor manufacturing; supported the growth of electronics industry	(MOP, 2007)

8	National Action Plan on Climate Change (NAPCC) of 2008	To address climate change through eight national missions, including solar energy and energy efficiency	2008	Ongoing	Launched missions to promote solar power, enhance energy efficiency, and develop sustainable habitats	(MOP, 2008)
9	National Five Year Plan (FYP)	To outline economic goals and strategies, including those for the energy sector	Every 5 Years	Ongoing	Each FYP includes targets for energy production, infrastructure development, and renewable energy adoption	(MOP, 2009)
10	Jawaharlal Nehru National Solar Mission	To establish India as a global leader in solar energy and increase solar power capacity	2010	Ongoing	Significant increase in solar capacity; major boost to solar infrastructure and policy frameworks	(MOP, 2010)

A subsidy of Rs. 15,050 crore has been approved by the Indian government to encourage the nationwide installation of solar power plants. Numerous urban and rural solar projects will be supported by this money. With an approximate expenditure of Rs. 90,000 crore, solar power plants would be constructed by combining thermal and photovoltaic power technology. Independent Power Producers (IPPs) and Public Sector Undertakings (PSUs) will be involved in these projects from the outset. To promote the growth of solar energy, a number of state governments have also implemented their own solar programs. Implementation is greatly aided by State Electricity Boards and other state-level organizations in charge of renewable energy (JNSM, 2024).

State-level efforts are actively supporting solar power in addition to federal ones. Gujarat, for example, plans to add 350 MW of solar PV capacity by 2011 and is giving competitive feed-in rates of Rs. 15/kWh for the first 12 years and Rs. 5/kWh after that. Launched on January 11, 2009, the Jawaharlal Nehru National Solar Mission (JNNSM) seeks to reach 20,000 MW of grid-connected solar plants by 2024. Three phases comprise the mission structure: Phase I (2009–13), Phase II (2013–17), and Phase III (2017–22). Phase-I's goal was to incorporate 1,000 MW of grid-connected solar electricity by 2013 and 3,000 MW more by 2017. On the other hand, depending on resource availability and technical improvements, the aim for 2017 may be raised. The anticipated capacity expansions for the different years are shown in Table 5 (JNNSM, 2024).

Obstacles: The obstacles have been categorized into various factors as listed below:

Technological obstacles The development of solar energy raises a number of particular issues and vulnerabilities that have long been discussed in the real world. These include problems with assembly, risks related to technology and its infrastructure, the lack and irregularity of Direct Normal Irradiance (DNI) data, and a number of others. Due to these worries, solar energy is finding it more and harder to successfully compete with other, more established power sources.

Policy and regulatory impediments: Policies that are consistent and regulations that are helpful are necessary for the solar energy industry to grow steadily. When investors believe there are significant dangers in the industry, they frequently show hesitation and uncertainty, which can only be reduced by strong and alluring market growth

tactics. The long-term growth plans of a nation might be negatively impacted by unclear rules and regulations. The related legislative and regulatory obstacles for the solar energy industry are shown in Table 10.

Table 6: Planned Capacity Additions for Solar Power in India (JNNSM, 2024)

Initiative/State	Target Capacity	Year	Details
Gujarat State Initiative	350 MW	By 2011	Offering attractive feed-in tariffs: Rs. 15/kWh for initial 12 years, Rs. 5/kWh thereafter
JNNSM Phase-I	1,000 MW	2009–2013	Initial target for grid-connected solar power
JNNSM Phase-II	3,000 MW	2013–2017	Additional capacity planned; potential for upward revision
JNNSM Phase-III	20,000 MW	2017–2022	Long-term target for grid-connected solar projects

Financial barriers: Socioeconomic issues have a major impact on the advancement of solar energy since they can make the technology more difficult to accept and use. Significant funding is needed for the development, which cannot come just from public sources. As a result, it's important to draw in private investment, which might be motivated by strong returns on development investments. Since the market is still too young to draw in capital to grow the industry, questions are raised about the availability of direct funding. The development process is made more difficult by obstacles relating to land availability, lack of transparency in land title and ownership, intricate local government rules and zoning, and problems with easement rights on reserved or protected areas.

Achieving success in solar

With more businesses achieving scale and experience in global procurement, it is unclear that this will continue to be a differentiating element. Value creation in the Indian market need enough localization, funding, and finalization.

Finalization: Because solar projects have high upfront costs, delays can have a big effect on profitability. Even under the best of conditions, electricity projects in India can be difficult to navigate since installation problems and unreliable local suppliers regularly cause delays. Furthermore, effective project execution and ongoing delivery are sometimes hampered by a lack of cooperation among the federal, state, and municipal levels. As a result, putting together a group of knowledgeable troubleshooters and project managers will be crucial.

Financial support: Cutting-edge funding strategies will provide win-win situations for all involved parties and provide crucial direct incentives for project creators. Various options might include joint ventures with nations that provide concessional financing—Japan, for example—or with customers looking for tax rebates or efficiency gains. One clear benefit might be a pool of inexpensive project equity from retail or other finance sources.

Local adaptation: In India's solar business, local engineering and design will be very important. Designs for inverters and balances of systems that take into account regional specifications and smaller-scale parts better suited to international markets can have a big impact. In the end, integrated companies will see the advantages of

producing locally, especially for the Indian market. Lower system expenses might also result from local players competing with each other.

India's Future in Solar Energy

India has to choose between few possibilities and confronts two challenges: the environment and energy. The need to go forward with increasing the share of renewable energy sources in the future is evident, though. The Jawaharlal Nehru National Solar Mission (JNNSM) seeks to establish India as a solar energy leader in the world. In order to do this, it seeks to provide favorable circumstances for the rapid and broad adoption of solar energy across the country.

New project developers have been chosen to work on solar systems up to 100 MW in capacity (less than 33 kV). The solar systems in these projects range in size from 100 kW to 2 MW. By December 2011, it is expected that 150–200 MW of solar electricity would be put into service nationwide.

To create a workable plan for the installation of 20,000 MW of solar energy by 2024.

To increase the amount of solar electricity generated on the grid to 1000 MW in three years by 2013 and an extra 3000 MW by 2017 by requiring utilities to meet certain procurement commitments. With improved international funding and knowledge transfer, this capacity may be further increased, with at least 10,000 MW of installed capacity by no later than 2017. If the early stages are successful, it may open the door for the widespread use of grid-effective solar power, which is the ambitious goal of 20,000 MW or more by 2024. The scale-up might then move forward in accordance with that, making use of worldwide resources and technological innovations.

To establish advantageous circumstances for the capability of the solar manufacturing industry, notably for domestic production and market leadership, particularly in solar thermal technology.

To progress off-grid application activities, with a goal of 1000 MW by 2017 and 2000 MW by 2024.

To reach 15 million square meters of solar thermal collector area by 2017 and 20 million square meters by 2024.

By 2024, 20 million solar lighting systems will be distributed to rural regions.

A million households will benefit from the 1000 MW objective set by the JNNSM Mission by 2017. The Mission wants to equip over 10,000 hamlets and communities with solar-powered lighting systems in order to accomplish this goal. Furthermore, it intends to construct independent rural solar power plants in a few states and areas, including Jammu & Kashmir's Ladakh region, the Andaman and Nicobar Islands, and Lakshadweep.

On a 10,000-acre tract of land in the Kadiri, Anantapur district, the Andhra Pradesh State Government is building a solar residential complex called "Solar City". In its first phase, the Solar City project is anticipated to draw investments totaling Rs. 3000 crore. A memorandum of understanding has been signed by four firms (Sun Core, Lance Solar, AES Solar, and Titan Energy) with the state government to install their units within the complex. These businesses, which together have a capacity of 2000 MW, will act as anchor units in the solar city.

Karnataka Power Corporation Ltd. has authorized a third project with the same capacity, bringing its total to three completed projects with a combined capacity of 3 MWp. These solar power plants, which are situated in the districts of Kolar and Chikkaballapur, were put in place as part of the Arunodaya initiative to provide a consistent supply of electricity to rural regions, especially for irrigation pump sets. The purpose of these solar power plants is to provide irrigation pump end-point assistance.

Table 7: Key Initiatives and Planned Capacity Additions for Solar Power in India (NAPCC, 2024) (MNRE, 2024) (JNNSM, 2009)

INITIATIVE/STATE	TARGET CAPACITY	YEAR/ TIME FRAME	KEY OBJECTIVES/DETAILS
GUJARAT STATE INITIATIVE	350 MW	By 2011	Offering attractive feed-in tariffs: Rs. 15/kWh for initial 12 years, Rs. 5/kWh thereafter
JNNSM PHASE-I	1,000 MW	2009–2013	Initial target for grid-connected solar power
JNNSM PHASE-II	3,000 MW	2013–2017	Additional capacity planned; potential for upward revision
JNNSM PHASE-III	20,000 MW	2017–2024	Long-term target for grid-connected solar projects
NEW SOLAR PROJECT DEVELOPERS	150-200 MW	By December 2011	Selection of new project developers for installations ranging from 100 kW to 2 MW each
FRAMEWORK FOR 20,000 MW DEPLOYMENT	20,000 MW	By 2024	Effective framework for solar power deployment
AUGMENTATION OF GRID-CONNECTED SOLAR POWER GENERATION	1,000 MW	By 2013	Initial capacity expansion to 1,000 MW through mandatory procurement obligations
ADDITIONAL GRID-CONNECTED SOLAR POWER	3,000 MW	By 2017	Further expansion to 3,000 MW, with potential to reach at least 10,000 MW by 2017 through international financing and technology transfer
LONG-TERM GRID-CONNECTED SOLAR POWER TARGET	20,000 MW or more	By 2024	Ambitious target depending on success of initial phases
SOLAR MANUFACTURING CAPACITY	N/A	Ongoing	Creation of favorable conditions for indigenous solar manufacturing, particularly solar thermal technologies
OFF-GRID SOLAR APPLICATIONS	1,000 MW	By 2017	Target for off-grid applications
OFF-GRID SOLAR APPLICATIONS	2,000 MW	By 2024	Extended target for off-grid applications
SOLAR THERMAL COLLECTOR AREA	15 million square meters	By 2017	Target for solar thermal collector area
SOLAR THERMAL COLLECTOR AREA	20 million square meters	By 2024	Extended target for solar thermal collector area

SOLAR LIGHTING SYSTEMS FOR RURAL AREAS	20 million units	By 2024	Distribution target for solar lighting systems
SOLAR POWERED LIGHTING SYSTEMS	1,000 MW	By 2017	Target to benefit a million households, with installations in over 10,000 villages and hamlets, and standalone rural solar power plants in select states and regions
ANDHRA PRADESH SOLAR CITY PROJECT	2,000 MW	Initial phase	Establishment of "Solar City" in Kadiri, Anantapur district with Rs. 3000 crore investment, involving companies like Sun Core, Lance Solar, AES Solar, and Titan Energy
KARNATAKA POWER CORPORATION LTD. PROJECTS	3 MWp each (2 projects)	Completed	Projects located in Kolar and Chikkaballapur districts under Arunodaya scheme to support rural irrigation
KARNATAKA POWER CORPORATION LTD. NEW PROJECT	3 MWp	Recently approved	New project under Arunodaya scheme to ensure reliable power supply for rural irrigation

Conclusion

Due to its acute electricity scarcity, India will need significant improvements in order to meet the needs of its quickly expanding economy. Shifting to solar energy can improve energy security by increasing supply, decreasing dependency on imports, and stabilizing fuel prices. Solar energy is indigenous, decentralized, and has cheap production costs. In India, solar energy has developed from a meager environmental promise to a significant potential for economic growth. But before it can exist alone, strong policies for sustainable growth are needed.

With clear advantages in the social, economical, and environmental spheres, solar energy has grown to be an attractive investment opportunity. It also plays a significant role in economic change. As the industry develops, there are insightful lessons to be gained from both internal and external settings, as well as from prior experiences, which may be used with creative thinking. Although the solar industry in India appears to be suited for native competitors, it is also accessible to international companies that can adapt their knowledge to effectively satisfy local demands, possibly yielding substantial value.

Learning curves can be accelerated by collaboration between foreign expertise and local execution, but fair risk-sharing and incentive systems must be in place. Scoping out the market long-term and using the knowledge gained from early efforts to later ones will be essential for success, both locally and internationally. As the barrier to entry increases with advance planning, early participation is essential. To fully use India's multi-billion dollar solar market potential, a well-thought-out strategy centered on portfolio expansion and long-term flexibility would be essential.

This essay examines India's solar energy industry's present state and potential future growth, highlighting the need for more funding to advance the industry. Even while solar energy is becoming less expensive than other energy sources, it is still pricey. Consequently, until solar energy can successfully compete with conventional sources, ongoing assistance and funding are required.

Declaration

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