SWITCH ON FOUNDATION

RAYS OF CHANGE

NAVIGATING THE SOLAR ENERGY LANDSCAPE IN WEST BENGAL

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EXECUTIVE SUMMARY

Introduction: The report highlights the growing importance of solar energy in West Bengal, which has an estimated **generation potential of 20,000 MW but currently utilizes around 636 MW.** The state has set ambitious renewable energy goals, aiming to generate **20% of its electricity from renewable sources by 2030.** The government is actively promoting rooftop solar installations and renewable energy sourcing through policies like the Green Open Access Rules. Despite challenges, ongoing government initiatives and support from organizations like the SwitchON Foundation position West Bengal on a promising path for solar energy development.

Solar Energy Status of West Bengal: West Bengal's solar power generation is gradually evolving, with the state **ranking 23rd nationally, generating 125.04 million units in 2022-23,** and achieving a cumulative solar capacity of **194.06 MW.** While the 2012 policy set an ambitious goal of **15% renewable energy by 2020,** progress has been steady, with recent initiatives showing promise. These include **solar-powered irrigation schemes, ground-mounted and rooftop solar projects,** and the installation of solar pumps under the **PM-KUSUM scheme.** The state has also made strides in **solarizing educational institutions and government buildings.** Currently, solar energy contributes **less than 1% of the state's total installed capacity,** with renewable energy comprising **10% of total electricity consumption**. Looking ahead, the government has outlined plans to tap into the state's substantial solar potential through projects like the **500 MW Solar Park** and the **1200 MW Solar PV Power Project.** With continued **government support, subsidies, and proactive policies,** the foundation is being laid for expanded solar adoption in the coming years.

Challenges of West Bengal in Solar Regime: West Bengal faces several challenges in advancing solar energy. **Heavy reliance on fossil fuels** hampers the transition to renewables, affecting both environmental sustainability and economic resilience. The state has only utilized **8% of its renewable energy potential** as of February 2024, lagging behind states like Karnataka and Gujarat. While progressive policies like the **Green Open Access Rules** have been introduced, the overall **regulatory framework** remains less conducive compared to other states. West Bengal also has **limited capacity in distributed solar,** with only about 4% of its renewable energy capacity in this segment. **Low participation in green markets** further limits solar adoption, with just 0.3% of power traded in these markets. Additionally, the pace of **infrastructure development** is slower than in other states, and the absence of a **comprehensive decarbonization policy** following the lapse of the 2022 renewable energy policy complicates efforts to promote solar energy effectively.

Conclusion: West Bengal's solar energy development, while showing promise, lags behind leading states like Gujarat and Rajasthan. Gujarat's **Surya Urja Rooftop Yojana** offers substantial subsidies for rooftop solar, and **Rajasthan's solar parks,** like Bhadla, have attracted significant investment and optimized land use. Maharashtra's **net metering policies** and Karnataka's **community solar projects** further highlight effective models for enhancing solar adoption. Despite West Bengal's ongoing projects, such as the 10 MW canal bank solar project and a proposed 500 MW solar park, the state's solar capacity remains low, constrained by **less favourable geographic conditions** and a less proactive regulatory environment. By adopting successful strategies from these leading states—such as enhanced subsidies, comprehensive solar parks, and effective net metering—West Bengal can accelerate its solar energy growth, improve its renewable energy share, and make significant strides toward reducing fossil fuel dependence and boosting sustainability.

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LIST OF ACRONYMS

MW	**Megawatt**
GW	**Gigawatt**
KW	**kilowatt**
WBERC	**West Bengal Electricity Regulatory Commission**
kWh	**Kilowatt-hour**
kWp	**Kilowatt peak**
WBERC	**West Bengal Electricity Regulatory Commission**
PPSP	**Purulia Pumpled Storage Project**
PM-KUSUM	**Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan**
MNRE	**Ministry of New and Renewable Energy**
WBSEDCL	**West Bengal State Electricity Distribution Company Limited**
WBREDA	**West Bengal Renewable Energy Development Agency**
WBPDCL	**West Bengal Power Development Corporation Limited**
PV	**Photovoltaic**
RPO	**Renewable Purchase Obligation**
RIPS	**Rajasthan Investment Promotion Scheme**

1. INTRODUCTION

Solar energy is increasingly critical for West Bengal, offering significant potential to meet energy demands, drive economic growth, and address environmental concerns. The state has an estimated solar energy generation potential of around 20,000 MW, with current utilization at approximately 636 MW (WBREDA, 2012). As of February 2024, West Bengal had utilized only 8% of its renewable energy potential, with renewables accounting for just 10% of the state's total electricity consumption (Rana & Upadhyay, 2024). Furthermore, distributed solar energy represented a mere 4% (~80 MW) of the state's installed renewable energy capacity (Rana & Upadhyay, 2024). **The West Bengal government has set ambitious goals, including generating 20% of its electricity from renewable sources by 2030 (Department of Power, 2023)**, and is actively promoting rooftop solar installations and renewable energy sourcing through policies like the Green Open Access Rules. Despite challenges, West Bengal is on a promising path with ongoing government initiatives. The state receives an average of about 5.5 kWh/m²/day of solar energy across its various regions for approximately 300 days a year. Harnessing this solar insolation effectively could help meet the state's electricity needs while also reducing its reliance on fossil fuel-based power generation.

This report provides an overview of the current state of solar energy penetration in West Bengal, including its historical background, comparisons with national and other state-level examples, challenges encountered, government initiatives at both state and central levels, future opportunities, and potential areas for intervention.

2. SOLAR ENERGY IN WEST BENGAL

2.1. HISTORICAL CONTEXTS

- **Establishment of Renewable Energy Policy and Targets:**

In 2012, the West Bengal government launched a policy to boost renewable energy adoption with an ambitious goal: **by 2020, 15% of the state's energy needs would be met through renewable sources.** At the policy's inception, the state's renewable energy potential was estimated at 2,206 MW, yet only around 193 MW had been realized by that time (Government of West Bengal, 2012).

- **Set-up of New Department**

The West Bengal government established the Department of Non-Conventional and Renewable Energy Sources in November 2019. The department was created to boost the state's renewable energy generation capacity and explore new avenues for effectively harnessing renewable energy sources (WBNRES, 2024).

- **Progress in Solar Energy Development:**

A significant milestone in West Bengal's solar energy journey was achieved in December 2019, when the WBERC approved the development of 20 MW of solar projects in the Birbhum district. These projects were entirely financed by the state government through a 100% grant, removing the financial burden of capital investment from the involved distribution companies. This initiative marked a critical advancement in the state's commitment to expanding its solar energy capacity (Parikh, 2019).

- **Increase in Installed Capacity:**

As of September 2019, **West Bengal had an installed solar capacity of 94 MW, with an additional 64 MW under development.** By 2022, the state's solar capacity was expected to grow significantly, supported by various projects and initiatives aimed at enhancing renewable energy infrastructure (Parikh, 2019; Teja & Fernandes, 2024).

- **Feed-in Tariff Adjustments:**

In October 2021, the WBERC set a feed-in tariff of ₹3.20 (~$0.042) per kWh for solar projects up to 5 MW. This tariff is subject to annual review and is part of ongoing efforts to enhance the financial viability of smaller solar projects. The commission also extended the net metering arrangements for projects up to 5 kW until the end of 2021, indicating a supportive regulatory environment for residential solar installations (Ranjan, 2021).

2.2. GOVERNMENT OF WEST BENGAL 2024-25 FINANCIAL BUDGET ON STATE SOLAR INITIATES

- **Solar-Powered Irrigation Initiatives:**

The Government of West Bengal has emphasized utilizing renewable energy for agricultural purposes. In this effort, 208 Minor Irrigation schemes powered by solar energy have been completed, covering an irrigation potential of 2,789 hectares. Additionally, funds amounting to Rs. 47,76,200 have been sanctioned and utilized for the installation of solar pumps for irrigation in 22 Self-Help Groups in the Manbazar-I Block of Purulia District, a project that has been successfully completed.

- **Ground-Mounted Solar Power Projects:**

Significant strides have been made in ground-mounted solar power generation. The state has undertaken a 125 MW Ground Mounted Solar Power Project at Goaltore, Paschim Medinipur, and a 10 MW Solar Power Project at PPSP Upper Dam, Purulia. These projects aim to bolster West Bengal's solar energy capacity significantly.

- **Grid-Connected Solar Pumps:**

Under the PM-KUSUM Scheme of the MNRE, Government of India, the **WBSEDCL has initiated the deployment of 150 MW Grid-Connected Solar Pumps (7.5 kW each) to supply power to 20,000 agricultural consumers. Additionally, 22.5 MW Off-Grid Connected Solar Pumps (7.5 kW each) have been installed to cater to the needs of 3,000 agricultural consumers.** Furthermore, an application window for a non-subsidy scheme under Component B of PM-KUSUM has been launched on the WBSEDCL Portal.

- **Rooftop Solar PV Power Installations in Educational Institutions:**

The government has prioritized installing Rooftop Grid-Connected Solar PV Power systems in educational institutions. Clearance has been granted for installations in 950 Government schools and Madrasahs, with 401 schools having completed the installation. Net metering has been arranged by WBSEDCL for 107 of these sites. In the fiscal year 2023-24, an additional 610 schools have had rooftop solar PV power plants installed.

- **Solar PV Installations in Government Buildings:**

Beyond educational institutions, the government has also focused on solarizing government infrastructure. Rooftop Grid-Connected Solar PV Power Plants have been installed at the Circuit House in Jhargram and the Collectorate building in Purba Medinipur.

- **Energy Generation from Ground-Mounted Solar PV Projects:**

Ground-mounted solar PV projects have already begun contributing to the state's energy grid. For instance, a 10 MW Ground Mounted Solar PV Project at Bhajanghat in Nadia District has generated 7.531 MU in FY 2023-24. Similarly, a 2 MWp Grid-Connected Ground Mounted Solar PV Power Plant at Jamuria in Paschim Burdwan generated 0.1014 MU during the same period.

2.3. ONGOING SOLAR PROJECTS IN WEST BENGAL

- As of February 2024, West Bengal's solar energy generation accounts for less than 1% of its total installed capacity. West Bengal's share of renewable energy consumption in the total electricity consumption within the state accounted for just 10%, one of the lowest amongst the 21 states considered in the SET 2024 report (Rana & Upadhyay, 2024).
- The WBREDA has been actively involved in implementing solar energy programs, including the electrification of remote villages through solar home and street lighting systems. These projects have received financial backing from both the state government and the MNRE of India (WBREDA, 2012a; WBSEDCL, 2024).
- In this context, WBSEDCL has recently intensified efforts to advance solar energy projects in response to the national push for renewable energy, particularly solar power. The ongoing projects include:

a. Ground-mounted solar power project: In March 2024, WBPDCL invited bids to operate and maintain a 10 MW ground-mounted solar power project at the Sagardighi thermal power project.

b. Canal Bank Solar Power Project: 10 MW near Teesta Canal Fall Hydro Electric Power Plant in Uttar Dinajpur, nearing completion.

c. Purulia and Bankura Solar Projects: Three 10 MW solar power projects, with tender finalization imminent.

d. 500 MW Solar Park Development: Phased development in Purba Medinipur, Paschim Medinipur, and Bankura districts, with the Detailed Project Report (DPR) for the first phase of 210 MW at Dadanpatrabar, Purba Medinipur completed.

e. 1200 MW Solar PV Power Project: Planned for providing clean energy to existing and upcoming pumped storage projects in Purulia district.

f. Rooftop Solar PV Projects:

Installation of 10 kWp rooftop solar PV plants at 100 government and government-aided schools across various districts, has already been completed.

- Program for installation of 10 kWp rooftop solar PV systems at 200 more schools, in progress.
- 5 MW cumulative solar rooftop project under Integrated Power Development Scheme (IPDS) for different sub-stations, offices of WBSEDCL, and other government buildings in urban areas of 18 districts.

g. Floating solar power plant: Vikram Solar has a floating solar power plant in West Bengal that covers 0.025 acres and powers the park and street lights in nearby areas.

As of February 2024, West Bengal has utilized approximately 636 MW of its renewable energy potential, representing about 8% of its capacity (Rana & Upadhyay, 2024).

2.4. SOLAR ACHIEVEMENT OF WEST BENGAL STATE UNDER THE FLAGSHIP SCHEME OF MNRE

West Bengal has made notable achievements in solar energy under the flagship schemes of MNRE. The state has been actively implementing various solar initiatives, particularly through the WBREDA and the WBSEDCL.

- ***Grid Connected Rooftop Solar Scheme:***

Under Phase II of the Grid Connected Rooftop Solar Scheme, West Bengal has implemented a capacity of 50 MWp specifically for the residential sector. This initiative aims to promote solar energy utilization among residential consumers across the state (WBSEDCL, 2024).

- ***Electrification Projects:***

WBREDA has completed projects to electrify remote villages in the Sundarbans through solar energy systems. This includes the installation of 6,161 Solar PV Home Lighting Systems and 616 Solar PV Street Lighting Systems, funded by the MNRE. The total investment for these projects was approximately Rs. 8.81 crores (WBREDA, 2024 b).

- ***Solar Home Lighting Systems:***

The state has sanctioned the installation of 19,783 Solar PV Home Lighting Systems in various parts of West Bengal, particularly in underserved areas. This initiative is part of the broader efforts to enhance energy access in rural regions (WBREDA, 2024 b).

- **Future Plans:**

West Bengal aims to harness its substantial solar potential, estimated at 20,000 MW, with plans to generate 500 MW from solar energy within the next three years. The state is actively encouraging investments in solar power plants to achieve this target (WBREDA, 2024 a).

2.5. PRESENT RENEWABLE PURCHASE OBLIGATION (RPO) STATUS

- The regulatory landscape for RPOs in West Bengal has evolved over the years. The WBERC, through a notification dated March 22, 2013, introduced the WBERC (Cogeneration and Generation of Electricity from Renewable Sources of Energy) Regulation 2013. This regulation outlined RPO targets up to 2017-18 for all utilities under the commission. Subsequently, for the years from 2018-19 onward, it mandated an annual increase of one per cent in RPO targets until the ultimate goal was achieved by distribution licensees (Gupta, 2023).

- Under Section 86(1)(e) of the Electricity Act 2003, the commission is mandated to specify RPO targets for distribution licensees. The current predicament stems from the absence of a specified RPO target for the fiscal year 2023-24, leaving distribution licensees in a challenging situation (Gupta, 2023).

2.6. GOVERNMENT SUPPORT AND SUBSIDIES:

The MNRE provides various subsidies to promote solar energy adoption in West Bengal. For instance:

Subsidy Rates: The government offers a 30% subsidy on the installation of grid-connected solar rooftop systems for residential and institutional buildings. The subsidy rates vary based on the system size, with higher percentages available for smaller systems (Chandra, 2023).

Policy Framework: The state has implemented mandatory requirements for large housing societies to install solar rooftop systems, ensuring a minimum of 1.5% of their total electrical load is met through solar energy (Chandra, 2023).

Table 1: Available Government Schemes regarding Solar Energy in West Bengal

STATE GOVERNMENT SCHEMES				
Name of Scheme	**Department/ fund**	**Purpose**	**Key Benefit (as per claim of the scheme)**	**Information Source (weblink etc.)**
Alosree	*Department of Power, Government of West Bengal*	*Programme of rooftop solar systems*	*(GRTSPV) System in all government buildings and buildings of local bodies with technically fit for such installations. Under this program, the beneficiary departments allocate funds for the installation of PV Systems and WBREDA being State Nodal Agency implements the programme.*	https://nres.wb.gov.in/solar_energy
Financial Support Scheme for Farm Mechanization (FSSM)	*Agriculture Department, Government of West Bengal*	*To purchase power operated farm equipment/ machinery with the aim to facilitate mechanization in agriculture*	*Subsidy ranging from 50-60% of the indicative price of machinery subject to maximum ceiling of ₹3,00,000/- will be provided to the beneficiary.*	https://www.myscheme.gov.in/schemes/fssm

CENTRAL GOVERNMENT SCHEMES				
Name of Scheme	**Department/ fund**	**Purpose**	**Key Benefit (as per claim of the scheme)**	**Information Source (weblink etc.)**
PM Surya Ghar Muft Bijli Yojana (2024)*	*Ministry of New and Renewable Energy - State Nodal Agency - WBSEDCL*	*Rooftop Solar*	*The PM Surya Ghar Muft Bijli Yojana offers an annual savings of roughly Rs 15,000 for a home consuming up to 300 units per month by installing a Roof Top Solar unit of 3 kW capacity.* *Rs. 30,000/- per kW up to 2 kW* *Rs. 18,000/- per kW for additional capacity up to 3 kW* *Total Subsidy for systems larger than 3 kW capped at Rs 78,000*	https://pmsuryaghar.gov.in/pdf/CFA_structure20240307.pdf
PM-KUSUM	*Ministry of New and Renewable Energy (MNRE) - State Nodal Agency - WBREDA*	*Enhance the income of farmers and promote sustainable agricultural practices through the use of solar energy*	*The scheme provides significant financial assistance, with the government covering 60% of the installation costs through subsidies and offering loans for an additional 30%. This means farmers only need to contribute 10% of the total cost for installing solar pumps and plants* *The scheme comprises the following components:* *Component-A: Installation of 10,000 MW of decentralised ground- or stilt-mounted grid-connected solar power plants or other renewable energy-based power plants. Individual farmers, cooperatives, panchayats, solar power developers and farmers' producer organisations can all install these plants.* *Component-B: Installation of 14 lakh standalone off-grid solar water pumps.* *Component-C: Solarisation of 35 lakh existing grid-connected agriculture pumps through (i) solarising individual pumps and (ii) solarising at the feeder level.* *Components B and C could benefit individual farmers, water user associations, primary agriculture credit societies and community-/cluster-based irrigation systems.*	https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/apr/doc202242548601.pdf

- The government of West Bengal, under the PM KUSUM scheme, aims to achieve a target of installing 1.75 million off-grid solar pumps. As of 28th February 2023, only 20 farmers in west Bengal have benefitted under the PM-KUSUM Scheme (MNRE, 2023).
- In West Bengal, Under component B 10000 off-grid solar pumps have been sanctioned and under component C 23700 grid-connected solar pumps have been sanctioned and 20 have been installed (MNRE, 2023 b)

Overall, the trajectory of solar energy development in West Bengal has shown an upward trend, with increasing budgetary allocations and supportive policies aimed at enhancing the state's renewable energy capacity. The focus on solar energy aligns with national goals for renewable energy and reflects a significant shift in energy policy within the state.

3. SOLAR ENERGY IN NATIONAL CONTEXT:

3.1. ONGOING NATIONAL INITIATIVES:

Solar Energy Promotion and Government Initiatives:

The Government of India, through the MNRE, has been actively advancing solar energy adoption with a series of key schemes and projects aimed at scaling up solar infrastructure across the country.

MAJOR SOLAR SCHEMES:

- **Grid Connected Rooftop Solar Programme (Phase-II):**

This program has been extended until March 31, 2026, to accelerate the installation of solar rooftop systems nationwide. It provides financial assistance to encourage the uptake of solar energy in both residential and commercial sectors, making solar power more accessible and affordable (MNRE Schemes, 2024).

- **PM Surya Ghar Scheme:**

Focused on promoting rooftop solar installations, this scheme offers substantial subsidies, potentially covering up to ₹78,000 per household. It aims to make solar energy more affordable, particularly in states like Kerala, thereby boosting adoption in the residential sector (Kondaas Automation, 2024).

- **Production Linked Incentive Scheme (Tranche II):**

This initiative supports domestic solar PV module manufacturing, with a total capacity allocation of 39,600 MW. Expected to generate significant employment and investment, the scheme aims to have operational capacities fully functional by 2026, enhancing India's self-reliance in solar technology (MNRE Schemes, 2024).

- **Development of Solar Parks and Ultra Mega Solar Power Projects:**

This project seeks to establish at least 25 solar parks with a cumulative capacity of 40,000 MW by 2025-26. These parks will be equipped with essential infrastructure, including transmission systems and road connectivity, to facilitate large-scale solar project installations (MNRE Projects, 2024).

Complementary Renewable Energy Initiatives:

- **National Bioenergy Programme:**

While primarily focused on bioenergy, this program, running until 2025-26, complements solar initiatives by promoting the use of other renewable energy sources such as biogas and biomass, contributing to the overall renewable energy landscape (MNRE Schemes, 2024).

Current Status and Achievements:

As of June 30, 2023, India has achieved a total commissioned solar capacity of 70.10 GW, encompassing ground-mounted, rooftop, and off-grid solar projects. The country now ranks fifth globally in solar power deployment, showcasing significant progress in the sector since 2014 (MNRE Solar Grid, 2024; MNRE Home, 2024).

Future Goals:

India has set ambitious targets of reaching 250 GW of renewable energy capacity by 2024 and 500 GW by 2030. These goals reflect the government's strong commitment to advancing sustainable energy solutions, ensuring energy security, and contributing to environmental sustainability (Kondaas Automation, 2024).

These comprehensive schemes and projects underscore the Indian government's dedication to expanding solar energy adoption, enhancing the country's energy security, and supporting a transition towards a more sustainable energy future.

3.2. HISTORICAL BUDGETARY ALLOCATIONS

The Government of India has made significant strides in solar energy development over the past years, marked by various budgetary allocations and policy changes aimed at expanding solar capacity and promoting renewable energy.

A. Initial Funding: The National Solar Mission was launched in 2010 with an initial allocation of ₹10 billion (approximately $120 million) for the fiscal year 2010-11, which was a substantial increase from previous budgets aimed at promoting solar energy (BEEIndia, 2019).

B.Target Increases: The Government has up-scaled the target of renewable energy capacity to 175 GW by the year 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power (PIB, 2015).

C. Recent Allocations: The budget for FY 2023-24 included plans to issue tenders for 40 GW of solar and hybrid projects, indicating a continued commitment to expanding solar infrastructure (India Budget, 2024).

3.3. CHANGES IN ALLOCATION AND POLICY

A. **Increased Capacity Addition:** Between 2016 and 2022, India saw an acceleration in the capacity addition of non-fossil fuel-based generation sources, although the annual addition did not exceed 16 GW. To meet the target of 500 GW of non-fossil fuel capacity by 2030, an average addition of about 49 GW per year is required (Dwivedi and Sharma, 2024).

B. **Subsidies and Financial Assistance:** The government has introduced various subsidies for rooftop solar installations, which have significantly lowered installation costs and improved accessibility for households and businesses. For instance, a recent announcement included a 23% increase in central financial assistance for rooftop solar installations under Phase II of the Rooftop Solar Scheme (Shankar, 2024).

C. Focus on Local Manufacturing: The government has also emphasized localizing the supply chain for solar components, with initiatives like the Production-Linked Incentive (PLI) Scheme for high-efficiency solar PV modules aimed at boosting domestic manufacturing capabilities (Dwivedi and Sharma, 2024).

D. Long-term Contracts and Financing: The introduction of long-term procurement contracts has been pivotal in attracting private investments in solar projects. These contracts provide a degree of financial security and have led to a decrease in solar power costs, making India one of the lowest-cost producers of solar energy globally (Shankar, 2024).

E. Future Directions: The upcoming budget for FY 2024-25 is expected to prioritize distributed renewable energy installations and further support for schemes with social benefits, such as the PM-KUSUM scheme. Investments in battery energy storage systems and green hydrogen initiatives are also anticipated to receive increased allocations (Shankar, 2024; Dwivedi and Sharma, 2024)).

The Government of India's approach to solar energy has evolved significantly, characterized by increasing budgetary allocations, ambitious targets, and supportive policies aimed at enhancing capacity and reducing costs. The focus on local manufacturing, financial assistance, and innovative financing models has positioned India as a leader in the global solar energy market.

3.4. Successful Initiatives of Other States:

3.4.1. GUJARAT:

Gujarat has emerged as a leader in solar energy development in India, driven by various government initiatives and projects aimed at harnessing its abundant sunlight. Here are the key solar schemes and projects currently shaping the landscape in Gujarat:

Table 2: Major Solar Schemes

Sl. No	Schemes	Key Takeaways
1	**Suryashakti Kisan Yojana (2022)**	This scheme enables farmers to install solar panels on their farms, allowing them to generate income by selling surplus energy back to the grid. Farmers receive a **60% subsidy** on installation costs, with additional financing options available (Sharma, 2024).
2	**Solar Rooftop Subsidy Scheme**	Under the **National Portal for Rooftop Solar**, residential consumers can access subsidies for installing solar rooftop systems. The subsidy varies based on the capacity of the system: • **Up to 3 kW**: ₹18,000 • **3 kW to 10 kW**: ₹9,000 per kW for the capacity above 3 kW **Above 10 kW**: Fixed subsidy of ₹1,17,000 (Amplus Solar, 2024, Euro Solar System, 2024).
3	**PM Surya Ghar Yojana**	Launched to promote solar installations in residential homes, this scheme aims to reduce electricity costs through subsidies, with the government directly transferring funds to beneficiaries' accounts (Euro Solar System, 2024).

Table 3: Major Solar Projects

Sl. No	Schemes	Key Takeaways
1	**Gujarat Solar Park (Charanka)**	Asia's largest solar park, located in Patan district, spans over **5,384 acres** and has an installed capacity of **730 MW**. The park is designed to facilitate large-scale solar energy generation and includes infrastructure for rainwater harvesting (GPCL, 2024).
2	**Dhuvaran Solar PV Projects**	The Dhuvaran site includes multiple phases of solar projects, with a total capacity of 150 MW across different phases. This site is part of Gujarat's efforts to expand its solar footprint (GSECL, 2024).
3	**Raghanesda Solar Park**	This project features a capacity of 100 MW in its first phase, with ongoing expansions aimed at increasing renewable energy generation in the region (GSECL, 2024).

Solar Energy Capacity and Achievements

- Gujarat has achieved an installed solar capacity of nearly **20,000 MW**, making it one of the top states in India for solar energy production. The state accounts for approximately two-thirds of India's residential solar energy systems despite having only 5% of the national population (Sharma, 2024).
- The state government has also removed capacity ceilings for solar projects and introduced net metering facilities, allowing consumers to sell excess power back to the grid at favourable rates (Sharma, 2024; Amplus Solar, 2024).

Gujarat's proactive approach to promoting solar energy through subsidies and large-scale projects positions it as a model for renewable energy adoption in India.

3.4.2. Rajasthan:

Solar Energy Potential and Policy Framework

Rajasthan has the second-largest solar energy production capacity in India, boasting around 14,454.70 MW of solar power installed as part of a total renewable energy capacity of 19,116.80 MW. The state government has implemented the **Rajasthan Solar Energy Policy 2019**, which aims to facilitate the establishment of solar power projects through various incentives, including tax exemptions and subsidies for developers and consumers alike (Sharma, 2024, HSA, 2020).

A. MAJOR SOLAR PROJECTS AND INVESTMENTS

- **Large-Scale Solar Parks:**

- The Rajasthan Solar Park Development Company has been allocated 4,780 hectares to establish three solar parks with a combined capacity of 2,450 MW in Bikaner district. Additionally, 910 hectares have been allotted to NTPC Renewable Energy Ltd for a 500 MW project in Phalodi district (PTI, 2024 b)

- **Investment Proposals:**

- **Reliance New Energy Solar Limited** plans to invest **₹1 lakh crore** to generate **20,000 MW** of solar power.

- **Greenko Group** is proposing a **₹30,000 crore** investment for a **4,500 MW** Wind-Solar Hybrid Power Project.

- Other significant proposals include **JSW** with **₹48,500 crore** for **10,000 MW** and **Renew Power** with **₹30,000 crore** for another **10,000 MW** (Sharma, 2024).

B. RECENT DEVELOPMENTS:

- In October 2022, the **Invest Rajasthan Summit** saw major announcements from Tata Power and Adani Group, with plans for utility-scale solar projects totaling **18,000 MW** and substantial investments of **₹65,000 crores** from Adani alone (Sharma, 2024).

C. SUBSIDY SCHEMES FOR RESIDENTIAL CONSUMERS

The Rajasthan government offers various subsidies to encourage residential solar installations:

- Under the **Solar Rooftop Programme Phase II**, homeowners can receive financial assistance to reduce the upfront costs of solar systems.

- The subsidy structure includes:

- **₹30,000 per kW** for systems up to **2 kW**.

- A combination of **₹30,000** for the first **2 kW** and **₹18,000 per kW** for additional capacity up to **3 kW**.

- A fixed amount of **₹78,000** for systems above **3 kW** (Amplus Solar, 2024).

D. FUTURE TARGETS

The state aims to achieve a target of **30 GW** of solar power generation by **2024-25**, supported by its extensive land resources and favourable climatic conditions. The government continues to promote renewable energy as a priority sector under the **RIPS 2019**, which provides various incentives for solar project development (Sharma, 2024; HSA, 2020).

Rajasthan's strategic initiatives and investments in solar energy are set to enhance its energy self-sufficiency, create local employment opportunities, and contribute significantly to environmental sustainability through reduced carbon emissions. The ongoing projects and supportive policies position Rajasthan as a leader in India's renewable energy landscape.

4. THE RANK OF WEST BENGAL AT THE NATIONAL LEVEL

4.1. Solar Power Generation (2022-23):

- As per the Ministry of New and Renewable Energy (2023 a) West Bengal ranks **23rd** in solar power generation for 2022-23, with a total of 125.04 million units (MU). The top five states leading in solar power generation are:
    - **Rajasthan**: 34,474.43 MU
    - **Karnataka**: 14,153.79 MU
    - **Gujarat**: 10,335.32 MU
    - Tamil Nadu: 9,419.39 MU
    - Andhra Pradesh: 8,140.72 MU

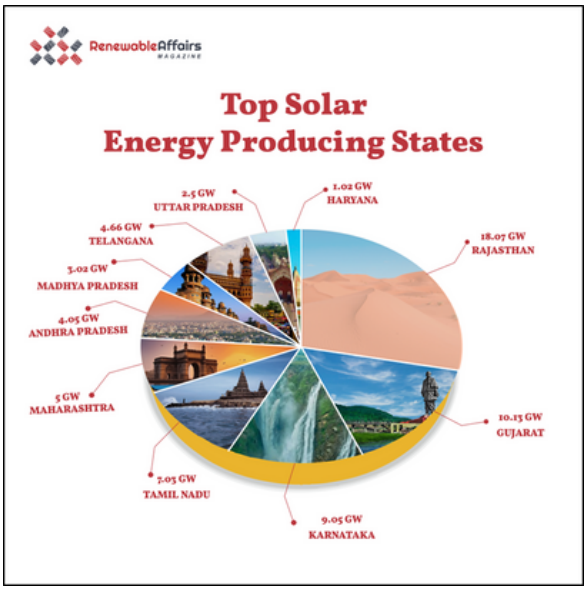

Figure: Top Solar Energy Producing States (Source: Khatter, 2024)

4.2. Cumulative Solar Capacity (as of June 30, 2023):

As per Ministry of New and Renewable Energy (2023 a) West Bengal ranks **28th** with a cumulative solar capacity of 194.06 MW. The leading states in installed capacity are:

- **Rajasthan**: 17,839.98 MW
- **Gujarat**: 10,133.66 MW
- **Karnataka**: 9,050.59 MW
- Maharashtra: 4,870.64 MW
- Telangana: 4,695.21 MW

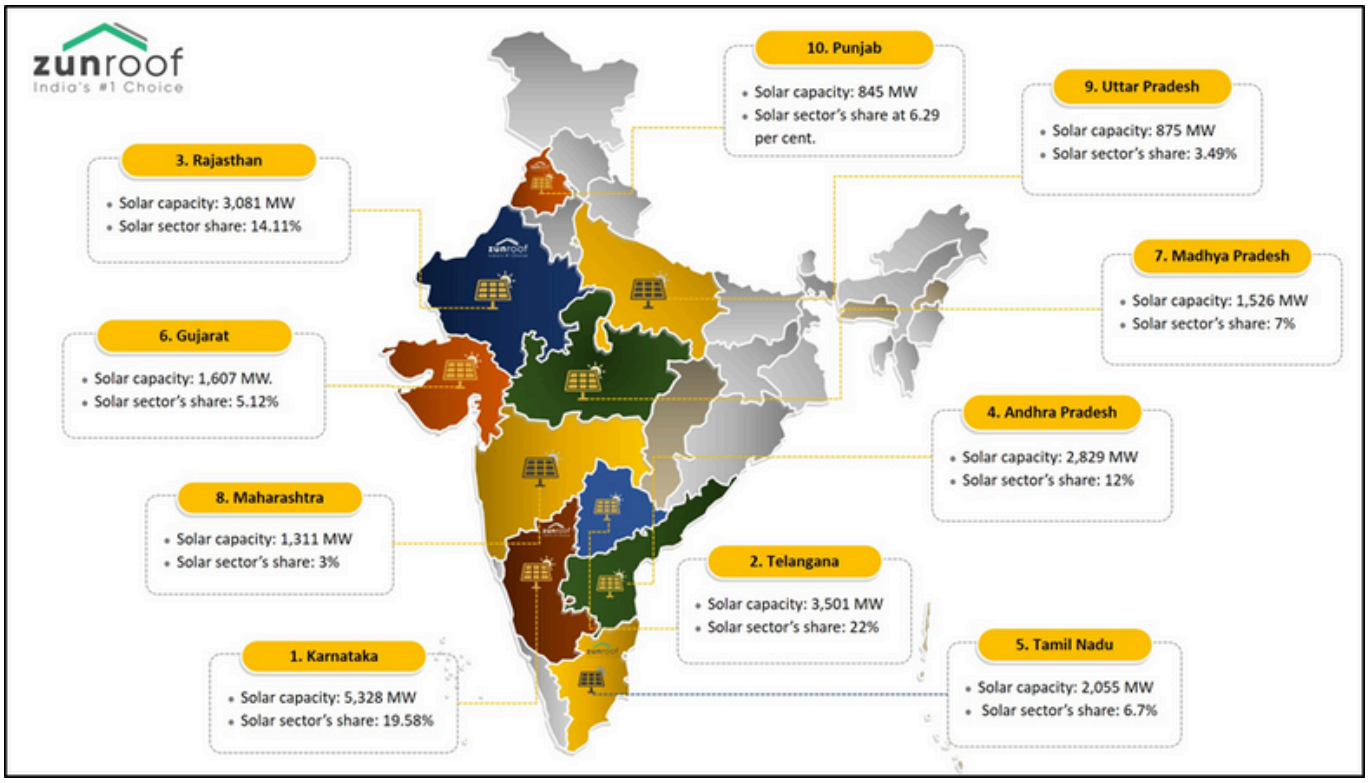

Figure: India's Top 10 State's Ranking By Installed Solar Capacity (Source: ZunTeam, 2019)

4.3. Number of Solar Pumps

State-wise details of number of diesel pumps as per "All India Agri Input Survey 2016-17 and number of standalone solar pumps reported installed cumulatively as on 31.10.2012.

S.NO.	States/UT	Total No. of Diesel Pumps as per All India Agriculture Input Survey 2016-17	Total No. of Standalone Solar Pumps installed till 31.10.2012
01	Andhra Pradesh	413600	34045
02	Arunachal Pradesh	2300	22
03	Assam	92100	45
04	Bihar	574000	2813
05	Chhattisgarh	113500	119282
06	Goa	11800	45
07	Gujarat	674800	12528
08	Haryana	322000	40994
09	Himachal Pradesh	1900	479
10	Jammu & Kashmir and Ladakh	29500	501
11	Jharkhand	330600	13399
12	Karnataka	334200	7734
13	Kerala	16000	818
14	Madhya Pradesh	1103600	25047
15	Maharashtra	393300	32814
16	Manipur	100	68
17	Meghalaya	11200	54
18	Odisha	495500	10689
19	Punjab	226700	16552
20	Rajasthan	1121000	102971
21	Tamil Nadu	278600	7701
22	Telangana	56200	424
23	Tripura	71900	1325
24	Uttar Pradesh	3607600	35492
25	Uttarakhand	43000	332
26	West Bengal	817000	653
27	Puducherry	600	21
28	Others	9600	4768
	Total	**11152200**	**471616**

Source: Patil et al. 2022

Following the table, As of 2024, the data on the current installation of solar pumps in West Bengal is limited. However, as per the information presented in the Parliament of India, West Bengal had installed 653 standalone solar pumps by October 31, 2022, placing it 14th among Indian states. The leading states in this initiative are Chhattisgarh with 119,282 pumps, Rajasthan with 102,971 pumps, and Haryana with 40,994 pumps.

In contrast, **West Bengal ranks 4th in terms of the total number of diesel pumps**, with 817,000 pumps installed according to a 2016-17 survey, following Uttar Pradesh, Madhya Pradesh, and Bihar. This data suggests that while there is a considerable demand for pumps in West Bengal, **further efforts could be made to enhance the transition to solar-powered systems.**

4.4. Rooftop solar Capacity

On December 23, 2023, the Union Minister for New & Renewable Energy and Power announced that India has seen one of the highest rates of growth in renewable energy capacity globally over the past five years. **As of November 30, 2023, under the Grid Connected Solar Rooftop Programme, West Bengal ranks 17th in the nation, with a cumulative installed capacity of 67.13 MW** (Ministry of New and Renewable Energy, 2023). Notably, the state recorded zero capacity installations under the subsidy scheme of the Phase-II Programme. The top three states in terms of cumulative installed capacity in the overall sector are Gujarat (3174.04 MW), Maharashtra (1852.22 MW), and Haryana (518.49 MW).

5. RENEWABLE ENERGY POTENTIAL OF WEST BENGAL

West Bengal has significant potential for renewable energy development, particularly in solar energy. The WBREDA plays a crucial role in implementing various renewable energy programs in the state, under the guidance of the MNRE.

Solar Energy: West Bengal is estimated to have a solar energy potential of about 20,000 MW. This potential is being harnessed through various initiatives, including the Grid Connected Rooftop Solar Scheme, which has a capacity of 50 MWp specifically for residential sectors (WBREDA, 2024 a).

Installed Capacity: As of now, the state has an installed capacity of approximately 100 MW from different renewable energy systems, with 70 MW being grid-connected installations. The state aims to increase this capacity significantly in the coming years, with expectations of generating 500 MW through solar energy alone within three years (WBREDA, 2024 a).

6. KEY CHALLENGES OF SOLAR ENERGY IMPLEMENTATIONS IN WEST BENGAL

A. Fossil Fuel Dependency

West Bengal's heavy reliance on fossil fuel-fired electricity poses a significant barrier to transitioning to solar energy (Rana & Upadhyay, 2024). This dependency not only affects environmental sustainability but also threatens economic resilience. Addressing this challenge is crucial for fostering a successful transition to renewable energy sources.

B. Limited Renewable Energy Utilization

West Bengal has utilized only about 8% (636 MW) of its renewable energy potential as of February 2024, one of the lowest among Indian states (Rana & Upadhyay, 2024). In contrast, states like Karnataka and Gujarat have harnessed a much larger share of their renewable resources

C. Regulatory Framework

Although West Bengal has adopted some progressive policies, such as the Green Open Access Rules, which facilitate direct sourcing of renewable energy by commercial and industrial consumers, the overall regulatory environment remains less conducive than more proactive states. Other states have implemented comprehensive solar policies that encourage investment and development in solar infrastructure more effectively.

D. Limited Capacity in Distributed Solar

West Bengal has only about 4% of its renewable energy capacity in distributed solar, such as rooftop installations. This is significantly lower than in states that have aggressively promoted distributed generation (Rana & Upadhyay, 2024).

E. Market Participation

The state has low participation in short-term power markets, with only 18% of total power purchases and captive generation traded in these markets. Moreover, a mere 0.3% of this is traded in green markets, indicating a lack of engagement in renewable energy trading platforms that could facilitate greater solar adoption (PTI, 2024).

F. Infrastructure Development

While West Bengal is planning to enhance its renewable energy infrastructure, such as the proposed 900-MW pumped hydro storage project, the overall pace of infrastructure development lags behind that of other states. The absence of a comprehensive decarbonization policy, following the lapse of the previous renewable energy policy in 2022, further complicates efforts to promote solar energy effectively (Rana & Upadhyay, 2024).

7. COMPARISON OF WEST BENGAL WITH LEADING SOLAR ENERGY STATES

A. Surya Urja Rooftop Yojana from Gujarat

The Surya Urja Rooftop Yojana (SURYA-Gujarat) is a government initiative to promote rooftop solar installations across Gujarat, targeting widespread adoption among residential consumers. The scheme offers substantial subsidies, providing 40% for systems up to 3 kW and 20% for systems between 3 kW and 10 kW, significantly reducing installation costs for households (Surya Gujrat, 2024). West Bengal could implement similar subsidy structures to encourage more rooftop solar installations.

B. Solar Parks Development in Rajasthan

Rajasthan has established large-scale solar parks, such as the Bhadla Solar Park, which is one of the largest in the world. This initiative has attracted significant investment and has streamlined the process for solar power generation. West Bengal could benefit from developing dedicated solar parks, focusing on optimizing land use and attracting private investments (MNRE, 2016).

C. Net Metering Policies from Maharashtra

Maharashtra has implemented effective net metering policies that allow consumers to sell excess solar energy back to the grid. This not only incentivises the installation of solar panels but also promotes energy independence. West Bengal can enhance its existing net metering framework to encourage more residential and commercial solar installations (Green On Energy, 2024).

D. Community Solar Projects in Karnataka

Karnataka has successfully implemented community solar projects, allowing groups of individuals or businesses to collectively invest in and benefit from solar energy. This model can be particularly beneficial in West Bengal, where community engagement and cooperative models can help overcome individual investment barriers.

8. COMPARATIVE ANALYSIS OF WEST BENGAL'S SOLAR ENERGY DEVELOPMENT

West Bengal's solar energy landscape can be compared to other Indian states based on several factors, including installed capacity, government policies, and solar potential.

8.1. Solar Energy Installed Capacity

West Bengal has historically lagged behind leading states in solar energy installation. As of 2021, its contribution to solar power was minimal compared to states like Rajasthan and Gujarat, which have significantly higher installed capacities. For instance, in 2017, West Bengal's solar capacity was negligible, while Rajasthan and Gujarat were at the forefront of solar energy production due to favourable climatic conditions and proactive government initiatives (Ghosh and Acharyya, 2023).

In terms of specific figures, West Bengal's solar power installed capacity was only about 23.93 MW by 2017, which is substantially lower than other states. For example, Rajasthan and Gujarat have established extensive solar parks and rooftop solar installations, contributing to their leading positions in India's solar landscape (TERI, 2020).

8.2. Government Policies and Incentives

West Bengal has implemented several policies to promote solar energy, including the West Bengal Solar Policy, which aims to simplify the installation of solar systems and supports both large and small projects. The state government offers various incentives, such as financial assistance, tax breaks, and a net metering system, allowing users to sell excess energy back to the grid.

In contrast, states like Gujarat and Rajasthan have more aggressive policies and infrastructure in place. For instance, Gujarat's initiatives through the Gujarat Energy Development Agency (GEDA) have made it a leader in grid-connected solar projects, while Rajasthan has developed the largest solar park in the country, attracting substantial investments and stakeholders in renewable energy (TERI, 2020).

8.3. Solar Potential and Geographic Advantages

Geographically, West Bengal faces challenges such as less sunlight compared to states like Rajasthan, which benefits from a dry climate and abundant sunshine. This climatic advantage allows Rajasthan to maximize solar energy production, making it a prime location for solar parks and large-scale installations.

West Bengal is making strides in solar energy development, with projects like the 10 MW canal bank solar power project and a proposed 500 MW solar park. However, the state still needs to enhance its solar capacity significantly to compete with the top-performing states in India (Ghosh and Acharyya, 2023).

9. INITIATIVES ON NEW RENEWABLE OPPORTUNITIES

West Bengal is actively pursuing new opportunities in renewable energy, particularly in Green Hydrogen and Pumped Hydro Storage. These initiatives are part of the state's broader strategy to enhance its renewable energy capacity and transition towards a more sustainable energy future.

9.1. Green Hydrogen Initiatives

- **State Green Hydrogen Policy:**

Launched in December 2023, West Bengal's Green Hydrogen Policy aims to establish the state as a hub for green hydrogen production and utilization. The policy focuses on creating a regulatory framework that supports the development of green hydrogen projects, promoting safety and quality standards, and facilitating investment in this emerging sector (Ernst & Young LLP *et al.,* 2024).

- **National Green Hydrogen Mission:**

The state aligns with India's National Green Hydrogen Mission, which has an outlay of approximately ₹19,744 crore. This mission aims to make India a global leader in green hydrogen production and its derivatives, thus providing a supportive backdrop for West Bengal's initiatives (PIB, 2024).

9.2. Pumped Hydro Storage

- **Existing Projects:**

West Bengal currently operates the Purulia Pumped Storage Project, which has a capacity of 900 MW (WBSEDCL, 2024). This facility plays a crucial role in balancing supply and demand in the state's electricity grid by storing excess energy generated during low-demand periods and releasing it during peak demand.

- **New Initiatives:**

The state has invited bids for an additional 900 MW pumped hydro storage project, aiming to enhance its energy storage capacity. This project is expected to support the integration of renewable energy sources into the grid and improve overall energy security (Rana & Upadhyay, 2024).

9.3. Comparison with Other States

- **Green Hydrogen:**

States like Gujarat and Maharashtra are also making strides in green hydrogen production, with established policies and significant investments from private sector players. For instance, Gujarat aims to leverage its existing industrial infrastructure to become a leader in green hydrogen production, while Maharashtra has announced various incentives for green hydrogen projects.

- **Pumped Hydro Storage:**

1. Other states such as Himachal Pradesh and Uttarakhand have also developed pumped hydro storage projects, capitalizing on their geographical advantages. These states have multiple operational projects that contribute significantly to their renewable energy portfolios.

10. RECOMMENDATIONS

At this juncture, the recommendations are intended to ensure that a balanced, sustainable, and economically viable solar energy regime for West Bengal is achieved, with a focus on integrating solar power across various sectors and scales.

A. Land-Based Solar Projects

- **Capacity and Land Use**: The target of 1600 MW through small-scale land-based solar projects is supported, with a recommendation that potential conflicts between agriculture and energy production be assessed. It is suggested that agro voltaic systems, allowing dual land use for agriculture and solar energy, be prioritized.
- **Rooftop and Spare Land Utilization**: Emphasis is placed on developing solar projects on spare land near substations and rooftops, with a recommendation that DISCOMs explore rooftop solar for additional capacity.

B. Solar Parks

- **Land Selection**: It is suggested that land banks be developed only on non-agricultural land, with a preference for expanding rooftops, distributed renewable energy (DRE), and floating solar projects, given Bengal's land constraints.

C. Consumer-Side Solar Projects

- **Flexibility and Targets:** It is recommended that the 1300 MW target for consumer-side solar projects be reviewed and potentially increased, the 80% capacity limit on residential rooftops be removed, and the net metering process be expedited. Innovative community solar models are also proposed.
- **Net Metering and Incentives:** Maintenance of net metering for larger rooftop systems is called for, and it is suggested that DISCOMs facilitate solar installations with ongoing maintenance services.

D. Decentralized Renewable Energy (DRE)

- **Key Applications:** It is advocated that solar cold chains, energy storage systems, and EV infrastructure be included within the policy. Additionally, it is suggested that solar water pumping be scaled up and solar street lighting be promoted at the local government level.

11. CONCLUSION

West Bengal's journey in solar energy development reflects a promising yet challenging landscape. Despite various initiatives, such as significant solar projects and funding for solar-powered irrigation, the state's overall solar capacity remains underutilized. With only about **8% of its renewable energy potential realized,** West Bengal's progress is notably behind states like Gujarat and Rajasthan, which have demonstrated effective models for solar adoption.

Gujarat's success is driven by large-scale solar parks and substantial subsidies for residential solar systems, positioning it as a leader in solar energy. Similarly, **Rajasthan's strategic investments** and expansive solar parks highlight the potential of leveraging favourable climatic conditions and substantial land resources. These states have effectively harnessed their solar potential through comprehensive policies and significant investments, setting benchmarks that West Bengal could aspire to.

West Bengal faces several challenges, including heavy fossil fuel dependency, limited renewable energy utilization, and a less proactive regulatory framework. The state's current solar capacity is constrained by geographical limitations and slower infrastructure development. The low participation in short-term power markets and distributed solar further underscores the need for a more dynamic approach to solar energy adoption.

To bridge the gap, West Bengal should consider adopting strategies from leading states. **Enhanced subsidies**, **large-scale solar projects**, and **efficient net metering policies** could significantly boost the state's solar capacity. By drawing from the successful models of Gujarat and Rajasthan, West Bengal can improve its renewable energy share, reduce its reliance on fossil fuels, and contribute more effectively to sustainable development. Accelerating solar energy growth will not only align the state with national renewable energy targets but also pave the way for a more sustainable and resilient energy future.

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