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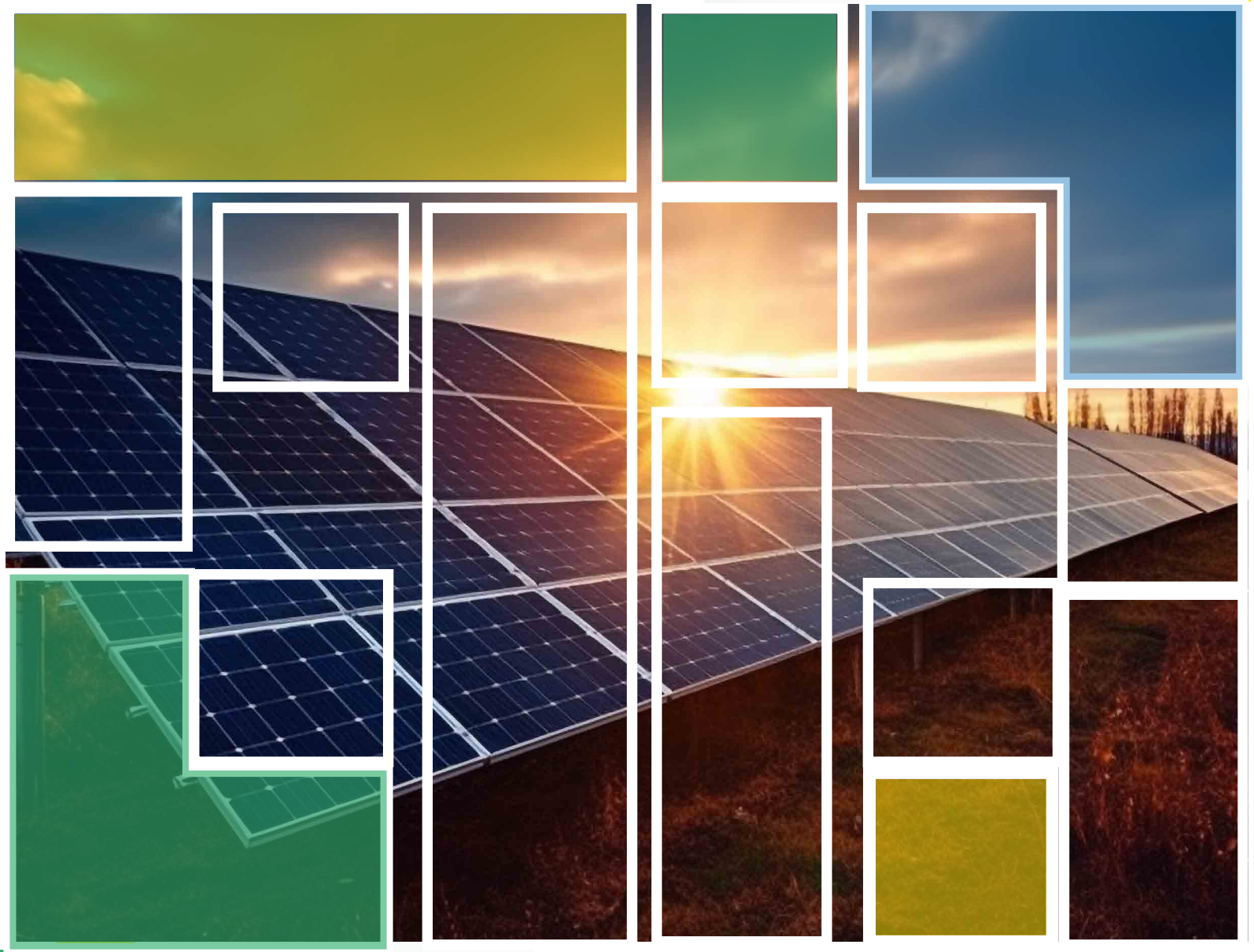
Assessing the Trajectory of **Ground Mounted Solar PV** in India



2025

Credits

Authors

Mr Jaideep Saraswat, Associate Director - Clean Power, Electric Mobility and Emerging Technologies, Vasudha Foundation

Mr Nikhil Mall, Senior Manager - Clean Energy, Electric Mobility and Power Sector, Vasudha Foundation

Mr Varun BR, Manager - Power Sector, Vasudha Foundation

Mr Saksham Goel, Assistant Manager - Clean Power & Green Hydrogen, Vasudha Foundation

Mr Tushar Katiyar, Senior Policy Officer – Clean Energy, Vasudha Foundation

Mr Karan Deep Sood, Policy Officer - Clean Energy, Vasudha Foundation

Reviewer

Mr Amit Kumar Singh Parihar, Director, Shakti Sustainable Energy Foundation

Mr Srinivas Krishnaswamy, Chief Executive Officer, Vasudha Foundation

Mr Tanay Tarany, Senior Programme Manager, Shakti Sustainable Energy Foundation

Editorial

Ms Khushi Sharma, Assistant Manager - Strategic Outreach & Communication, Vasudha Foundation

Layout Design

Mr Aman Kumar, Assistant Manager - Graphic Design, Vasudha Foundation

About Vasudha Foundation

Vasudha Foundation is a non-profit organisation set up in 2010. We believe in the conservation of Vasudha, which in Sanskrit means the Earth, the giver of wealth, with the objective of promoting sustainable consumption of its bounties. Our mission is to promote environment-friendly, socially just and sustainable models of energy by focusing on renewable energy and energy-efficient technologies as well as sustainable lifestyle solutions.

D-2, 2nd Floor, Southern Park, Saket District Centre,

New Delhi-110 017, India

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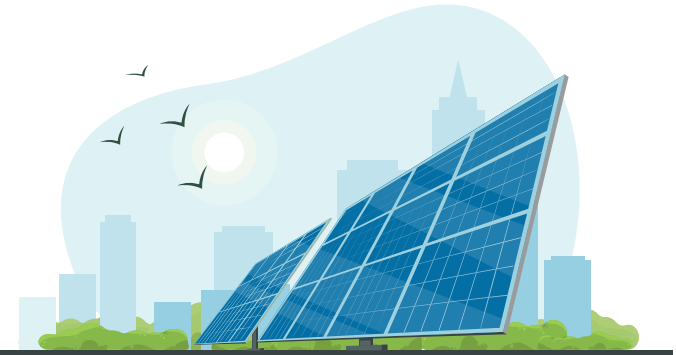


1. Introduction

Globally, the transition to clean energy is accelerating to reduce emissions and mitigate the effects of climate change. At the forefront of this effort is expanding renewable energy (RE) to help decarbonise the electricity grid. India has witnessed a significant transformation in its energy sector, with installed RE capacity increasing from 58 GW in 2010-11 to 228.2 GW as of March 2025, making it the fourth-largest in the world in terms of installed RE capacity[1]. This expansion aligns with the country's ambitious RE target of achieving 500 GW from non-fossil sources by 2030[2].

Solar and Wind energy dominate India's RE landscape, accounting for 61 percent and 29 percent of the total installed RE capacity (excluding large hydropower plants), respectively. Solar energy has played a dominant role in India's renewable expansion, increasing from 7.1 GW in 2015-16[1] to 105.6 GW in 2024-25, making it the fastest-growing segment[3]. The highest annual capacity addition was recorded in 2024-25, with 23.83 GW installed, as shown in Figure 1, demonstrating India's rapid solar expansion.

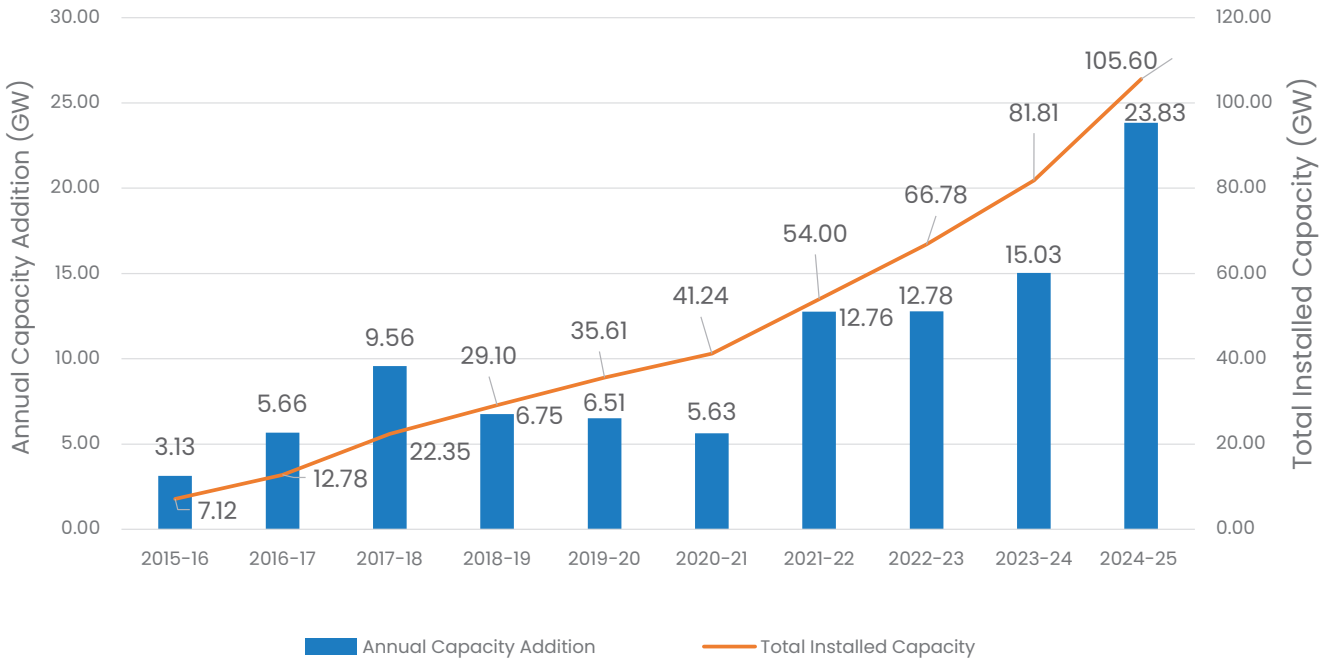
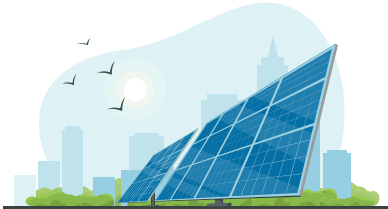


Figure 1: Yearly addition of solar energy capacity from 2015-16 to 2024-25

1 https://iced.niti.gov.in/
2 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2073038
3 https://iced.niti.gov.in/



Ground mounted Solar energy plants constitute the most widely adopted solar technology in India, reflected by their majority share in installed capacity of solar energy. It involves large-scale solar farms (minimum capacity 5 MW) set up on land, often in high-radiation areas such as Rajasthan and Gujarat. Ground mounted solar projects have contributed significantly to India's overall solar capacity and are expected to remain a key deployment model in the future. The current installed capacity of ground mounted solar stands at 76.94 GW, while the total estimated potential is 749 GW, indicating that nearly 90 percent of the potential remains untapped, as shown in Figure 2. Rajasthan leads with 23.08 GW of installed capacity, followed by Gujarat (11.71 GW), Karnataka (8.48 GW), and Tamil Nadu (8.57 GW).

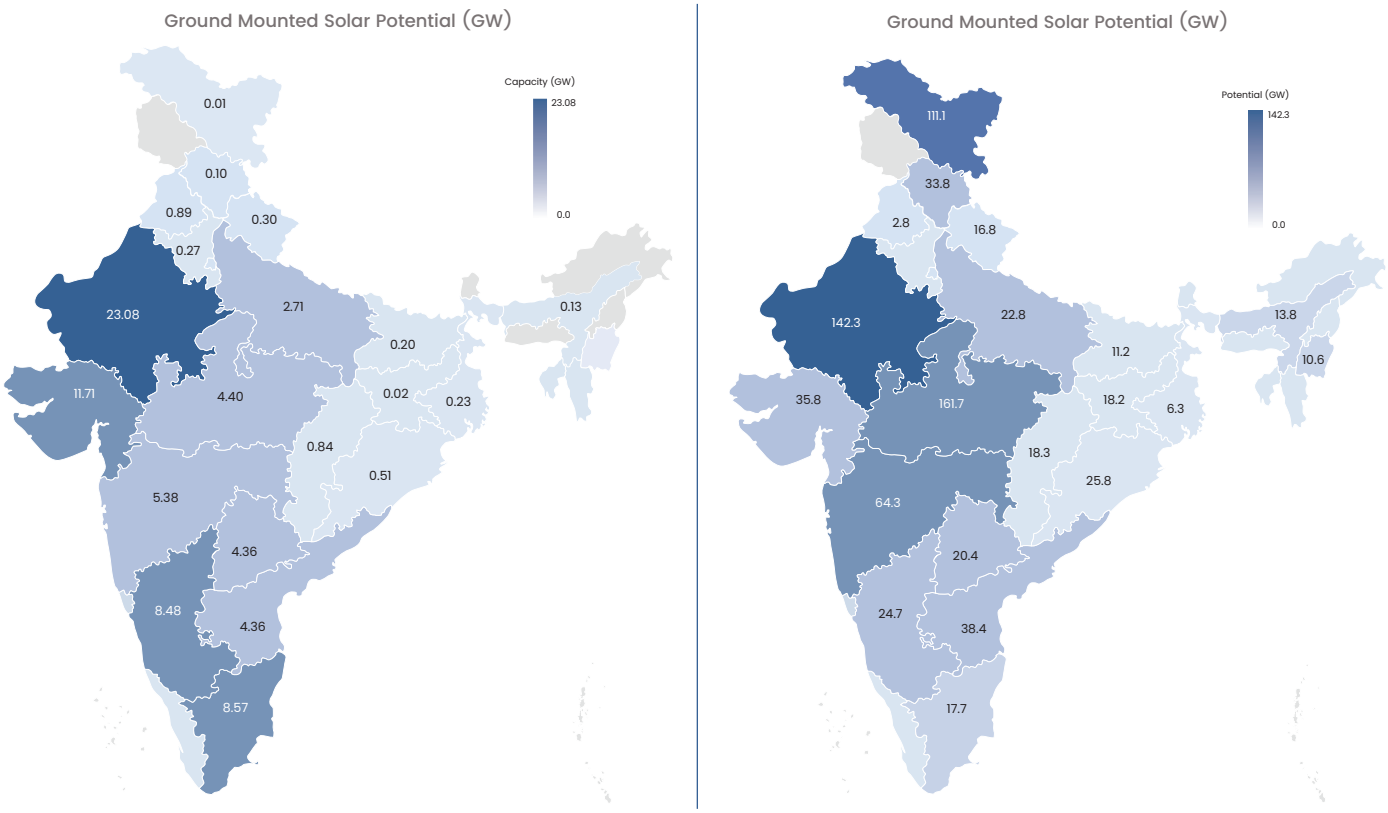
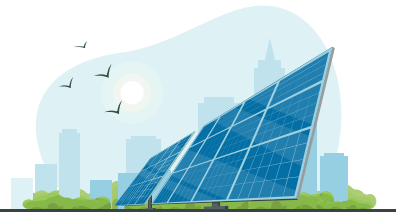


Figure 2: State-wise ground mounted solar capacity and potential

Other states, including Maharashtra, Madhya Pradesh, and Uttar Pradesh, also contribute substantially to ground mounted solar capacity. Despite this, vast untapped potential remains, particularly in states like Rajasthan (142.3 GW), Maharashtra (64.3 GW), and Madhya Pradesh (61.7 GW), presenting immense opportunities for future expansion. The government has also been providing support for increased adoption of ground mounted solar energy via setting up of solar parks, through provisions outlined in PM-KUSUM (Component-A), bidding trajectory for projects, and the introduction of PLI for enhanced domestic manufacturing of solar modules to bring down the project cost.

Agri-photovoltaics (AgriPV) is also an emerging typology of ground mounted solar projects, which is being implemented in the country, on a pilot scale. Under AgriPV, farmers can install ground mounted solar plants, at a slightly raised height, for agriculture activities to take place under the solar modules, generating dual income for farmers- income from agricultural activities and revenue from solar energy generated. A few research reports also suggest increased crop yield while deploying AgriPV on a farmland. Through still in its early stages, AgriPV has the potential to optimise land use and increase renewable energy generation in rural areas. The total estimated AgriPV potential in India ranges from 3,156 MW to



13,803 MW, with an average of ~8480 MW. Figure 3 showcases the leading states with high AgriPV potential - Maharashtra (1078.8 MW), Uttar Pradesh (959 MW), Rajasthan (954 MW), and Punjab (953.4 MW). These states possess vast agricultural landscapes that can be leveraged for AgriPV expansion, enabling dual land use and increasing farmer incomes.

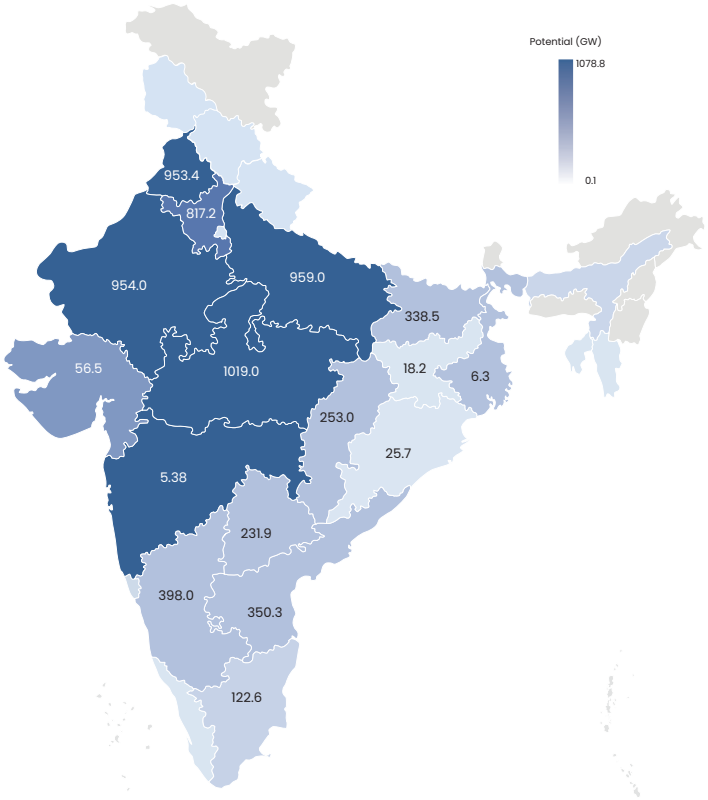


Figure 3: AgriPV potential across India[4]

This report captures the issues highlighted by various government implementing agencies, utility-scale solar developers, and Original Equipment Manufacturers (OEMs), including possible solutions, which shall lead to increased deployment of ground mounted solar projects, aiding India's goal of achieving 50 percent non-fossil fuel energy by 2030.

4 https://beta.cstep.in/staaidev/assets/manual/APV.pdf

2. Policy Landscape

As the urgency to combat climate change grows, effective policy and regulatory frameworks play a crucial role in accelerating the shift to cleaner energy. Clear guidelines, incentives, and stable regulations help de-risk investments, attracting both domestic and global players to drive RE and energy storage deployment and progress toward Net-Zero Emissions. 84 percent of global utility-scale renewable capacity growth from 2024-2030 is expected to be policy-driven[5]. Well-defined policies not only set long-term targets but also create investor confidence by ensuring clarity in implementation.

India's RE landscape has evolved through continuous policy adaptation at both national and state levels. These reforms are now expanding to address storage integration, ensuring smoother grid balancing and higher RE penetration, positioning the country to achieve its target of 50 percent cumulative electric power capacity from non-fossil fuel sources by 2030[6]. This section highlights key national-level policy and regulatory initiatives for enhanced adoption of ground mounted solar PV, followed by a comparative analysis of policies across 10 Indian states[7] that together represents over 72 percent of the country's renewable energy potential.

2.1 National Level Initiatives

Table 1 captures the key national-level policy initiatives that have been introduced to promote ground mounted solar PV projects. The initiatives have been described based on their key features, financial layout, expected impact, and implementation timeline. While the government has launched various key measures for increased adoption of ground mounted solar PV, no such initiatives have been taken for promotion of AgriPV projects in India.

Table 1: National level policy provisions

Initiative	Objective	Key Features	Financial Support	Impact (Achieved/ Expected)	Implementation Timeline
RE Tendering Trajectory	Tendering of 40 GW[8] of solar projects every year from 2023-24 to 2027-28	Selection of 4 Renewable Energy Implementing Agencies (REIA) for tendering, namely, SECI, NTPC, NHPC, and SJVN. Bids for trajectory may consist of vanilla solar, solar-wind hybrid, round-the-clock (RTC) renewable energy power	NA	In FY 2023-24, 69 GW[9] of RE capacity was tendered	Since 2023
TBCB Guidelines[10]	Procurement of renewable energy in a transparent, competitive, and cost-effective manner	Transparent L1 energy tariff discovery via competitive bidding. Promotes competition and efficiency in the power sector.	NA	NA	Since July 2023

5 https://iea.blob.core.windows.net/assets/17033b62-07a5-4144-8dd0-651cdb6caa24/Renewables2024.pdf
6 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2073038#:~:text=The%20solar%20photovoltaic%20(PV)%20sector,the%20end%20of%20the%20year.
7 States Studies- Andhra Pradesh, Gujarat, Rajasthan, Odisha, Tamil Nadu, Karnataka, Telangana, Uttar Pradesh, Maharashtra, Madhya Pradesh
8 https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/10/20231005148514213O.pdf
9 Vasudha Analysis
10 https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/10/20231005485636440.pdf

Initiative	Objective	Key Features	Financial Support	Impact (Achieved/ Expected)	Implementation Timeline
Green Energy Open Access Rules	Enable buyers to procur RE from any state	Open access for consumers with 100 kW+ demand	NA	90.4% growth in open access capacity, reaching 18.7 GW in FY24[11]	Since 2022
PLI for Solar PV Manufacturing	Develop domestic high-efficiency solar PV module manufacturing ecosystem	Under Tranche-1, manufacturing is to be initiated from outsourced polysilicon. Under Tranche-2, provision of 3 manufacturing baskets, namely, PWCM, WCM, and CM	Under Tranche-1, financial outlay of INR 4500 crore[12]. Under Tranche-2, financial outlay of INR 19,500 crore[13]	8737 MW[14] capacity awarded under Tranche-1. 39,600 MW[15] capacity awarded under Tranche-2	Tranche-1 was notified in April 2021. Tranche-2 was notified in September 2022
Approved List of Models & Manufacturers (ALMM)	Ensures reliable and high-quality power is being generated and injected into the grid	ALMM certification is necessary for developers to participate in government-tendered projects	NA	91.268 GW[16] of solar PV manufacturing capacity listed under ALMM	Since 2019
PM-KUSUM (Component-A)	10 GW of Decentralised Ground / Stilt Mounted Grid Connected Solar	Developers can commission a capacity of 500-2000 kW on individual farmers, groups of farmers, cooperatives, panchayats, Farmer Producer Organisations, and Water User associations' land	Procurement Based Incentive (PBI) to the DISCOMs at 40 paise/kWh or INR 6.60 lakhs/MW/ year[17] for 5 years from the Commercial operation date, whichever is lower	587.03 MW commissioned out of 10,000 MW[18]	Since 2019
RPO Trajectory	Obligated entities such as, State/ DISCOM are mandated to purchase[19] RE from Developers	Obligated entities must meet 43.33% of their energy requirement by 2029-30	NA	DISCOMS are actively procuring RE to meet the RPO targets	Since 2016
ISTS Waiver[20] for Solar projects	Reduce transmission costs for RE projects	100% waiver of ISTS charges for 12 years for projects commissioned till 30th June, 2025. For projects commissioned post this date, partial charges shall be levied	Waiver extended to projects commissioned till June 2025	Lower tariff for RE projects	Since 2016

11 https://ieefa.org/sites/default/files/2024-12/Impact%20of%20Green%20Energy%20Open%20Acess_Dec2024.pdf
12 https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/08/2023080898.pdf
13 https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/08/2023080863.pdf
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19 https://powermin.gov.in/sites/default/files/Renewable_Purchase_Obligation_and_Energy_Storage_Obligation_Trajectory_till_2029_30.pdf
20 https://powermin.gov.in/sites/default/files/Waiver_of_Inter_State_Transmission_Charges_on_transmission_of_the_electricity_generated_from_solar_and_Orders.pdf

Initiative	Objective	Key Features	Financial Support	Impact (Achieved/ Expected)	Implementa-tion Timeline
Solar Parks & Ultra Mega Solar Power Projects[21]	Develop utility-scale solar parks with plug-and-play infrastructure	40 GW by 2025-26. Individual plant capacity should be more than 500 MW	Minimum INR 12 lakh/MW or 30% of the project cost to SPPD for development of internal infrastructure. Rs 8 lakh/MW or 30% of the project cost to the CTU/STU for creation of external transmission infrastructure	Facilitates large-scale solar capacity addition	2014-15 to 2025-26

2.2 State Policy Provisions

A comparative analysis of utility-scale solar policies across ten leading Indian states reveals a broad alignment with national targets but considerable variation in the depth and quality of policy support mechanisms. While many states, such as Karnataka, Madhya Pradesh, and Uttar Pradesh, have set clear MW-level targets, others like Gujarat, Andhra Pradesh, and Telangana embed solar deployment within broader RE ambitions without standalone solar targets, potentially impacting clarity for investors.

Land acquisition emerges as a relatively well-supported area, with most states—Maharashtra, Rajasthan, Andhra Pradesh, and Odisha - providing access to government land at concessional rates or through facilitative mechanisms like land banks. The single-window clearance mechanism has also been recognised as a key enabler, with states like Gujarat, Uttar Pradesh, and Andhra Pradesh actively implementing online portals to streamline project approvals.

Overall, while most states have laid foundational policy frameworks for utility-scale solar, the effectiveness lies in the implementation detail, particularly in land facilitation, grid readiness, banking flexibility, and unified clearance systems. Uniformity and predictability in these domains can significantly accelerate India's solar deployment trajectory. However, it is important to note that there are no AgriPV enabling policies at the state-level. Table 2 provides us with a comprehensive view of the policy provisions for ground mounted solar PV in state-specific policies.

21 https://mnre.gov.in/en/development-of-solar-parks-and-ultra-mega-solar-power-projects/#:~:text=Under%20the%20scheme%2C%20the%20Ministry,Detailed%20Project%20Report%20(DPR

Table 2: State policy provisions for ground mounted solar PV

Parameter	Deployment Target (MW) (segment wise)	Land Acquisition Support	Power Evacuation	Banking	Incentives	Single Window Clearance Mechanism
Andhra Pradesh	No standalone utility-scale solar MW target is specified. However, the state aims to contribute to the national target of 500 GW RE by 2030, with solar being a major component	NREDCAP will allot government/revenue land for utility-scale solar, especially within solar parks. Land is provided on lease at INR 31,000/acre/year with 5% escalation every 2 years	Developers must bear the cost of evacuation up to the interconnection point. Two options exist for CTU connectivity: 1) connect to STU and transfer asset, or 2) build full evacuation infrastructure with exemption from transmission charges for project life	Monthly energy banking is allowed under Green Energy Open Access Rules 2024. Unused energy in a billing cycle lapse. Banking charges and settlement terms follow APERC regulations	1. Exemption of land conversion fee for RE projects. 2. Reactive power charges are applicable as per IEGC. 3. Wheeling charges waived off when injection and withdrawal are at same voltage level. 4. REC benefits for all projects commissioned during policy period	NREDCAP to develop a single window clearance portal for time-bound statutory approvals for all projects under this policy
Gujarat	No specific MW target mentioned, but the policy aims to utilise 4,00,000 acres of land for RE projects with INR 5 lakh crore investment targeting 36 GW solar potential	Land can be allocated through the revenue department or SNA; government waste land may be given at concessional rates for DISCOM supply projects	Developers must set up evacuation lines to STU/ CTU substations; common transmission lines are encouraged for nearby projects	Allowed on billing cycle basis with applicable charges as per GERC. No charges for residential solar	Electricity duty as per prevailing Act; carbon credit benefits retained by the developer (except for rooftop)	GEDA will set up a unified web portal with auto-approvals and SOPs for single-window clearance
Karnataka	10,000 MW (10 GW) solar capacity targeted during the policy period (2022–2027)	Government land to be leased through KREDL; KREDL to maintain a land bank and facilitate land allotment to developers	KPTCL and ESCOMs are responsible for developing required grid infrastructure; developers are to submit evacuation proposals early in planning. Developers can construct evacuation lines; KPTCL/ ESCOMs to support interconnection at designated pooling substations	Banking allowed for captive and third-party sales; settlement at the end of the financial year; no carry forward permitted	Exemption from electricity tax for captive and self-consumption; concessional wheeling and banking charges; stamp duty concessions	KREDL is designated as the single-window clearance agency for utility-scale solar projects

Parameter	Deployment Target (MW) (segment wise)	Land Acquisition Support	Power Evacuation	Banking	Incentives	Single Window Clearance Mechanism
Madhya Pradesh	20,000 MW of solar capacity targeted by 2030	Government land will be allotted on lease for 30 years for RE projects; private land acquisition will be supported via facilitation	Evacuation to be ensured via intra-state and inter-state transmission networks; MPPTCL to coordinate for grid connectivity and infrastructure	Energy banking allowed for captive and open access consumers up to 30% of their monthly generation	Exemption from electricity duty and cess for 10 years; 100% exemption from wheeling charges for intra-state open access; land lease at concessional rates	Madhya Pradesh Urja Vikas Nigam Limited (MPUVNL) to act as nodal agency for approvals and coordination under a single-window system
Maharashtra	10,000 MW	1. MSEDCL/ Mahanirmiti/ Mahaurja will enter into lease/purchase agreements with other entities whose jurisdiction prevails over the concerned government land to set up RE projects. 2. MSEDCL/ Mahanirmiti/ Mahaurja will requisition land owned by itself from the concerned District collectors to set up RE projects on PPP basis with a mutually consented revenue sharing agreement. 3. MSEDCL/ Mahanirmiti/ Mahaurja is empowered to purchase/lease private land at their own expense by mutual consent of all parties	1. The survey of low-pressure, high-pressure, and ultra-high-pressure substations and transmission lines required for the project will be jointly conducted by the developers and distribution companies / Mahatransco. 2. Substations to be constructed at the developer's cost as per the technical parameters outlined by relevant authority. 3. Transmission connection projects will be made available until the policy period	N/A	N/A	Single window web system for permits and approvals about various administrative departments to be developed by Mahaurja

Parameter	Deployment Target (MW) (segment wise)	Land Acquisition Support	Power Evacuation	Banking	Incentives	Single Window Clearance Mechanism
Odisha	N/A	Government land earmarked for industry under the Land Bank' scheme of IDCO and other Government land. The Collectors shall facilitate purchase/lease of private land for the purpose of developing RE projects. The land used for development of grid connected RE projects shall be deemed to be converted for Non-Agricultural use. No charges as per Land Reforms Act (1960) of Odisha shall be applicable for such deemed conversion	1. The private solar developers shall be obliged to create common infrastructure facilities for development of power evacuation system. 2. Grant of connectivity approval from OPTCL will be provided preferably within 15 days from the date of receipt of requisite documents for registration	The unutilised banked energy shall be considered as deemed purchase by GRIDCO/DISCOMs at the power purchase cost, as may be determined by OERC. The payment for the deemed purchase of unutilised banked energy shall be capped at a certain percentage of the total banked energy during the month. Any unutilised banked energy beyond that shall be treated as free power to GRIDCO	1. Exemption of fifty (50) paisa per unit on Electricity Duty shall be provided to captive/ open access consumers on consumption of energy from RE projects set up inside the State during the policy period. 2. Energy Storage projects that source from RE projects in Odisha shall receive exemption of 50 paisa per unit on electricity duty. 3. 50% exemption of cross-subsidy surcharge for 15 years. 4. Exemption of twenty (20) paisa per unit on STU charges shall be provided to captive/ open access consumers on consumption of energy from RE projects. 5. 25% exemption of wheeling charges shall be provided to captive / open access consumers on consumption of energy from RE projects. 6. Stamp duty on purchase/lease of land, land conversion charges and registration charges shall not be applicable for RE projects	Nodal Agency shall provide a single window facility for approval of all RE projects in the State

Parameter	Deployment Target (MW) (segment wise)	Land Acquisition Support	Power Evacuation	Banking	Incentives	Single Window Clearance Mechanism
Rajasthan	Rajasthan targets to add 90 GW of Renewable Energy by 2030; no specific split given, but utility-scale solar is a major component	Government land allotted at concessional rates; private land can also be aggregated through land aggregators	RE projects to be provided connectivity to CTU/STU/ DISCOM networks; deemed injection allowed until dedicated line is ready	Annual banking allowed up to 15% of energy injected into the grid; settlement at the end of financial year	Exemptions from Electricity Duty, Stamp Duty, and benefits under Rajasthan Investment Promotion Scheme (RIPS) 2024; also, facilitation of carbon credit trading	RREC will facilitate a single-window clearance system for project approvals and clearances
Tamil Nadu	Achieve an installed solar energy generation capacity of 9,000 MW by 2023	N/A	N/A	N/A	N/A	N/A
Telangana	No standalone utility-scale solar MW target is specified. However, the state aims to target solar capacity of 7889 MW by FY30 and 26374 MW by FY35	1) Deemed non-agricultural status will be accorded for the land utlised for the development of projects 2) The ceiling limit as per the Land Ceiling Act will not be applicable for any land acquisition for solar power projects 3) 100% reimbursement of Stamp Duty will be given for land purchased to set up solar projects	1) Power will be evacuated at the appropriate voltage level at the interconnection point of TGTRANSCO/TGDISCOMs, and evacuation up to the interconnection point will be the sole responsibility of the developer for the projects 2) TGTRANSCO/TGDISCOMs will process the proposals for the technical feasibility within 14 days of receipt of the application from the solar power project developer	Banking charge = 8% The permitted quantum of banked energy by a Green Energy Open Access consumer shall be at least 30% of the total monthly electricity consumption from the distribution licensee by the consumer	1) 100% exemption of electricity duty for MSMEs for 8 years from COD 2) Supervision charges levied by TGTRANSCO/ TGDISCOMs will be reimbursed to the project developer 3) 100% net SGST reimbursement will be given for fixed capital investment incurred for decentralised grid-connected solar projects developed by women SHGs/VOs (it will be 50% for all other solar projects)	Not explicitly mentioned
Uttar Pradesh	16,000 MW of ground mounted solar power capacity by 2026–27 (out of the total 22,000 MW RE target)	Revenue land/allotted government land may be provided on lease for 30 years at INR 15,000/ha/year with 6% annual escalation	STU to develop and augment evacuation infrastructure; developers to bear costs up to pooling substation as per UPERC norms	Banking permitted for captive/third-party use for intra-state projects; annual settlement allowed; banking charges at INR 2/unit or as determined by UPERC	Exemption from electricity duty, cross-subsidy surcharge (for captive/ third-party sale), 100% refund of SGST on project equipment purchased within UP	Online single-window portal under UPNEDA to facilitate project approvals, land allotment, connectivity, and clearances

3. Ground Mounted Solar Value Chain

To understand the challenges that persist in ground mounted solar PV project implementation and to find targeted solutions, it is necessary to take stock of the various stakeholders participating in the ecosystem. As depicted below in Figure 4 we observed that three primary categories of stakeholders influence the project implementation.

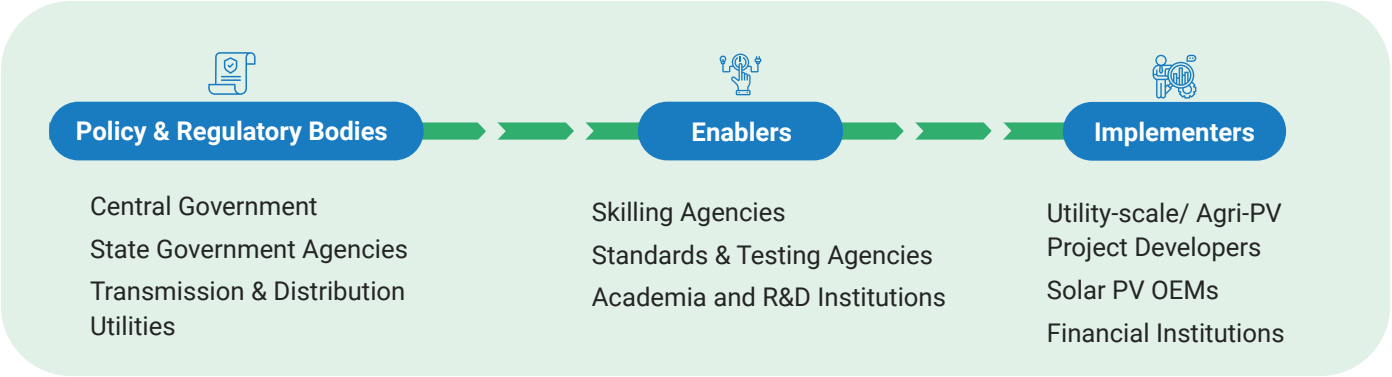


Figure 4: Stakeholder groups in the ground mounted solar PV ecosystem

3.1 Policy and Regulatory Bodies

Referring to the previous chapter, a stable policy and regulatory framework is of utmost importance for de-risking RE and energy storage projects, driving more investment into the sector, ensuring smoother implementation of the projects, and thereby leading to faster adoption in the country's energy mix. There are 3 major stakeholder groups concerning policy and regulatory affairs:

- **Central Government Bodies**
  The Central Government Bodies play an important role in formulating the policy and regulatory frameworks in India. The centre is expected to draw guidelines, launch subsidies, and release mandates, nationwide, for the states to gain guidance and make their state-wise policies for the implementation of RE and energy storage projects. Schemes and policies, as discussed in the above section, are created by the central bodies keeping the interest of the project developers /consumers in mind. The central government agencies approached for this study include the Ministry of New and Renewable Energy (MNRE) and the Solar Energy Corporation of India (SECI).

- **State Government Agencies**
  State agencies oversee the entire project lifecycle, from tendering, providing state approvals, to commissioning. Their responsibilities include potential assessment, forecasting future demand, formulating state-specific RE policies, introducing state-level subsidies, and managing project tendering and implementation in alignment with projected demand. The state government agencies considered as part of this study are shown in Annexure-1.

» **Transmission and Distribution Utilities**

Transmission and distribution utilities play a crucial role in shaping the RE landscape of the country. As the custodians of the electricity grid, they are responsible for the efficient evacuation of power from RE plants and providing off-taker guarantees to RE projects. Reliable power facilitated through energy storage systems not only facilitates the integration of more RE into the grid but also helps Distribution Companies (DISCOMs) reduce their dependence on fossil fuels, enabling them to procure green energy from RE projects for supply to both domestic and commercial consumers in their regions. Annexure-2 captures the list of stakeholders operating at the state level and considered for our study.

3.2 Enablers

While policy and regulatory bodies create a favourable environment for the development of ground mounted solar PV projects, the continued growth of this sector also depends on a skilled workforce, ongoing research into new technologies, and robust testing processes to ensure the quality of power. The organisations that offer skilling programs for the workforce and those involved in the research and development of ground mounted solar PV technologies have been identified, as shown in Annexure-3.

3.3 Implementers

While policy-making organisations and enablers lay the foundation for the future of RE in India and work towards developing a skilled workforce, the role of implementers is crucial in turning the country's RE potential into reality through ground mounted solar PV project development. For the requirements of this study, a discussion was sought from institutions captured in Annexure-4.

4. Stakeholder Insights

For gaining a holistic view of the ground mounted solar PV ecosystem in India, in-person interactions with various stakeholders of the ecosystem were conducted. The stakeholders belonged to various facets of the ecosystem, as described in the previous section. These interactions played a crucial role in identifying the gaps that exist in the ecosystem and identifying the solutions that may be deployed to counteract the same, leading to an accelerated deployment of ground mounted solar PV projects via utility-scale solar projects as well as scaling up of AgriPV.

4.1 Overview of Key Challenges Identified

- **Difficulties in Land Acquisition:**
  Acquiring land for utility-scale solar projects remains a major bottleneck due to unclear ownership, fragmented land parcels, and bureaucratic hurdles in approvals. Developers face long delays, increasing project timelines, and costs.
- **Speculation-driven Land Price Increases:**
  Land owners often raise the price of land in regions where RE projects are planned, anticipating higher profits, which results in land costs exceeding government-set prices, affecting project cost dynamics.
- **Connectivity and Grid Bottlenecks:**
  Grid infrastructure constraints, including substation unavailability and delayed finalisation of substation locations, create significant obstacles to project execution. This leads to higher costs and inefficiencies in power evacuation.
- **Regulatory Delays and Documentation Issues:**
  Complex and time-consuming approval processes slow down final clearances for project commissioning, affecting investor confidence.
- **Delays in Power Purchase Agreements (PPA) and Power Sale Agreements (PSA):**
  The slow execution of PPAs and PSAs creates uncertainty for developers, affecting financing and overall project viability. In some cases, PSAs were signed as late as four years after the PPA was awarded. Such delays lead to increased costs for developers due to prolonged project planning, extended engagement of manpower, and higher overhead expenses, none of which are accounted for or compensated in the existing framework.
- **Increased Project Costs Due to ALMM:**
  The ALMM has led to a 60 percent rise in module costs, as domestic manufacturers still rely on imported components like solar cells and wafers, mainly from China. This poses challenges for developers by increasing capital expenditure, limiting supply options, and creating procurement uncertainties. With higher costs and fixed tariff commitments in PPAs, developers face squeezed profit margins, making project execution more difficult.

- **Lack of Uniform Guidelines Across States:**
  The lack of uniform guidelines across states creates challenges for developers, as each state has different regulations for land acquisition, grid connectivity, and financial incentives. Frequent policy changes further add to regulatory uncertainty, increasing project risks and complicating financing. This inconsistency forces developers to invest extra time and resources in compliance, slowing down project execution.
- **Barriers in Farmers' Mindset Regarding the Impact on Crops:**
  Many farmers believe that AgriPV installations will reduce sunlight exposure and harm crop yields, making them reluctant to adopt the technology. Addressing these misconceptions requires scientific demonstration projects and clear communication about how crop sunlight requirements can still be met under AgriPV setups.
- **Higher Land Requirements Compared to Conventional Solar Plants:**
  Unlike traditional solar farms, AgriPV installations need additional space to accommodate farming operations, including pathways for tractors and other agricultural machinery. Design constraints also arise from the need to avoid excessive shading from nearby crops and trees, which further complicates site selection and layout planning.
- **Regulatory Uncertainty Due to AgriPV Being Absent in Policy Frameworks:**
  AgriPV is not explicitly mentioned in most RE or agricultural policies, leading to confusion regarding incentives, land-use regulations, and grid connectivity. Clear policy guidelines and financial support mechanisms are needed to integrate AgriPV into national and state-level RE policies and plans.
- **Lack of Sufficient Pilot Projects to Demonstrate AgriPV Feasibility:**
  The absence of large-scale pilot projects across different agro-climatic zones prevents stakeholders from assessing the long-term impact of AgriPV on crop yields, water consumption, and financial viability. More government-backed demonstration projects could provide critical insights and encourage farmer participation.
- **Aesthetic Concerns from Landowners Impacting Project Approval:**
  In some cases, landowners are hesitant to adopt AgriPV due to concerns about how the solar structures might affect the visual appeal of their land. This challenge is particularly relevant in locations like Nahargarh, where maintaining the natural beauty of the surroundings is a priority, requiring additional design considerations and community engagement.
- **Building the Capacity of State Officials on New Typologies:**
  Another challenge in the deployment of innovative renewable energy solutions, such as AgriPV and other emerging technologies, is the limited capacity of state officials to understand and manage new project typologies. Many state officials are not fully equipped with the knowledge or expertise required to handle novel systems and technologies, leading to delays in inclusion in policies, approvals, implementation, and compliance. This lack of technical capacity among government staff can create bottlenecks in the project development process, slowing down progress.

4.2 Recommended Solutions

- Simplifying land acquisition processes will eliminate bureaucratic hurdles, making it easier for developers to secure land for projects. For instance, establishing state-level land banks and providing them to developers will enable them to make more informed and strategic decisions.
- Establishing standardised guidelines will create a level playing field while ensuring project quality and sustainability. For instance, a standardised framework should be developed to guide developers and investors through every stage of execution, from inception to completion. All states must adhere to this framework to streamline procedures and reduce the burden on stakeholders.
- The Government of India should intervene with module manufacturers to assess the reasons behind the high cost of solar modules and ensure pricing aligns with global markets.
- Going forward, REIAs should initiate the tendering process only after securing firm demand from utilities or other consumers, ensuring a more efficient and predictable project development timeline.
- Conduct resource adequacy studies at the state level to identify future demand growth and how it will be met, allowing for better planning of transmission infrastructure to ensure maximum reliability and efficient energy delivery.
- Launch targeted education campaigns, showcasing successful AgriPV projects as case studies to educate farmers and stakeholders.
- Develop state-level roadmaps to provide policy support for AgriPV, stimulating demand and guiding local implementation.
- Establish a clear technical guideline that defines the structure height and spacing requirements for AgriPV systems.
- Implement demonstration projects to prove the financial viability and benefits of AgriPV systems.
- Create local markets for AgriPV-specific crops at the sub-district level, supporting agricultural diversification. This can be done by aggregating demand across districts, which will strengthen the ecosystem and significantly boost AgriPV deployment.
- Establish cold-chain storage facilities at the sub-district level to support the sale and distribution of AgriPV crops. Since horticultural crops offer a higher Land Equivalent Ratio in AgriPV systems, farmers will be more inclined to cultivate them, especially if cold storage facilities are available.
- Promote demand aggregation for AgriPV installations, enabling bulk purchases that reduce costs through economies of scale.
- Combine various financial instruments such as subsidies, loans, and feed-in tariffs (FiTs) to offer comprehensive financial support for AgriPV stakeholders.
- Amend land leasing policies to allow AgriPV installations on agricultural land, ensuring that crop yield guarantees are maintained (e.g. 90% of reference yields). This can be compared to the previous year's yield, addressing concerns from stakeholders regarding the food vs fuel debate. Implementing this requirement will ensure that farmers prioritise agricultural yield while also benefiting from returns on the AgriPV system.

Annexure-1

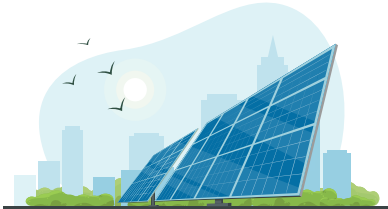
State Authorities Stakeholder Mapping

State	State Nodal Agency
Andhra Pradesh	New & Renewable Energy Development Corporation of Andhra Pradesh Ltd
Gujarat	Gujarat Energy Development Agency
Karnataka	Karnataka Renewable Energy Development Limited
Madhya Pradesh	Madhya Pradesh Urja Vikas Nigam Ltd
Maharashtra	Maharashtra Energy Development Agency
Odisha	Orissa Renewable Energy Development Agency
Rajasthan	Rajasthan Renewable Energy Corporation Limited
Tamil Nadu	Tamil Nadu Green Energy Corporation Ltd
Telangana	Telangana Renewable Energy Development Corporation
Uttar Pradesh	Uttar Pradesh New and Renewable Energy Development Agency

Annexure-2

State Distribution Utility & State Transmission Utility Stakeholder Mapping

State Distribution Utility Stakeholder Mapping		
State	Organisation Type	Organisation Name
Andhra Pradesh	State Distribution Utility	Andhra Pradesh Southern Power Distribution Company Limited
	State Transmission Utility	Transmission Corporation of Andhra Pradesh
Gujarat	State Distribution Utility	Gujarat Urja Vikas Nigam Limited
	State Transmission Utility	Gujarat Energy Transmission Corporation Limited
Karnataka	State Distribution Utility	Chamundeshwari Electricity Supply Corporation Limited
	State Transmission Utility	Karnataka Power Transmission Corporation Limited
Madhya Pradesh	State Distribution Utility	MP Paschim Kshetra Vidyut Vitran Company Limited
	State Transmission Utility	Madhya Pradesh Power Transmission Company Ltd.
Maharashtra	State Distribution Utility	Maharashtra State Electricity Distribution Company Ltd.
	State Transmission Utility	Maharashtra State Electricity Transmission Company Limited



State Distribution Utility Stakeholder Mapping		
State	Organisation Type	Organisation Name
Odisha	State Distribution Utility	TP Central Odisha Distribution Limited
	State Transmission Utility	Odisha Power Transmission Corporation Limited
Rajasthan	State Distribution Utility	Jaipur Vidyut Vitran Nigam Limited
	State Transmission Utility	Rajasthan Rajya Vidyut Prasaran Nigam Limited
Tamil Nadu	State Distribution Utility	Tamil Nadu Power Distribution Corporation Ltd
	State Transmission Utility	Tamil Nadu Transmission Corporation Limited
Telangana	State Distribution Utility	Telangana State Northern Power Distribution Company Ltd
	State Transmission Utility	Transmission Corporation of Telangana Limited
Uttar Pradesh	State Distribution Utility	Noida Power Company Limited
	State Transmission Utility	UP Power Transmission Corporation Limited

Annexure-3

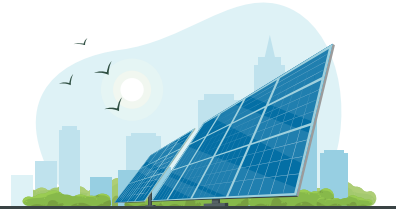
Ground Mounted Solar PV Enablers Stakeholder Mapping

Battery Energy Storage	
Skilling Agencies	Skill Council on Green Jobs
	National Institute of Solar Energy
Standards & Testing Agencies	TUV SUD
Research and Development & Academia	National Institute of Solar Energy

Annexure-4

Ground Mounted Solar PV Implementers Stakeholder Mapping

Developer	
ReNew Power	Adani Green Energy Limited
Vareyn Solar	Axis Energy
Solar PV Module Manufacturer	
Goldi Solar	Vikram Solar
Financial Institutions	
Asian Development Bank	World Bank



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Green ways for a good earth!

Vasudha Foundation
D-2, 2nd Floor, Southern Park,
Saket District Centre, New Delhi-110 017, India
www.vasudha-foundation.org