

Application of ICAT Renewable Energy Methodology in India- An assessment of PM- KUSUM scheme



The Energy and Resources Institute

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AUTHORS

Amshika Amar, Associate Fellow, TERI
Sneha Kashyap, Associate Fellow, TERI
K Sai Dinesh, Research Associate, TERI
Dr Manish Kumar Shrivastava, Associate Director and Senior Fellow, TERI
Ms Suruchi Bhadwal, Programme Director and Senior Fellow, TERI

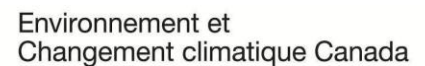
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1. Background

In March 2019, the Government of India launched Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUSM) with the objective to provide energy and water security to farmers, enhance their income, de-dieselize the farm sector, and reduce environmental

pollution by promoting solar power for irrigation and enabling farmers to sell surplus energy.¹ It reaffirms India's commitment to increase the share of installed capacity of electric power from non-fossil fuel sources to 50% by 2030 as part of Nationally Determined Contributions (NDCs). The Central Electricity Authority (CEA) estimates a total of 292,566 MW solar photovoltaic (PV) installed capacity by 2029–30.² While the primary focus is on large-scale solar power generation, several schemes have been introduced to develop decentralized solar energy plants that can be directly connected to substations in the power distribution networks operated by various distribution companies. This is expected to result in reduced transmission system requirements and lower transmission and distribution (T&D) losses. PM-KUSUM is a vital scheme aimed at enhancing synergies between the energy and agriculture sectors. From the implementation perspective, while the scheme is a national initiative, its actual implementation relies on state-level participation. This includes additional financial support provided by state governments beyond that mandated by the scheme; determining tariffs for surplus solar power; determining installation timelines and penalties; and selecting vendors responsible for the design, supply, installation, and commissioning of solar agriculture pumps.

PM-KUSUM has three primary components:³

Component A: Setting up of 10,000 MW of decentralized ground/stilt-mounted grid-connected solar or other renewable energy-based power plants by the farmers on their land

Component A focuses on the development of renewable energy-based power plants (REPPs) with capacities between 500 kW and 2 MW, to sell the generated electricity to distribution companies (DISCOMs) at a feed-in tariff (FiT) determined by the respective state electricity regulatory commission (SERC). Participating DISCOMs would be eligible to receive a performance-based incentive of Rs 0.40 (USD 0.0048) per unit purchased or Rs 6.6 lakh (USD 7950) per MW of capacity installed, whichever is less, for a period of five years from the commercial operation date (COD). The Ministry of New and Renewable Energy (MNRE), in 2024, expanded the scope of Component A to include 'other renewable energy-based power plants.

Component B: Installation of 14 lakh stand-alone solar agriculture pumps

Component B supports individual farmers in installing stand-alone solar-powered agricultural pumps with a capacity of up to 7.5 horsepower (HP) in off-grid areas. The MNRE in 2024 revised the target for Component B from the initial 17.50 lakh to 14 lakh stand-alone solar agriculture pumps.⁴ Under Component B, 30% of the cost is provided as the Central Financial Assistance (CFA). Additionally, at least 30% subsidy is provided through the state government. Farmers have to bear 40% of the costs of their solar water systems. The CFA contribution is 50% in the case of special states (Northeastern states, Sikkim, Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Lakshadweep, and Andaman and Nicobar

¹ Details available at <<https://pmkusum.mnre.gov.in/#/landing/read-more>>

² Central Electricity Authority (CEA) (2023). Report on Optimal Generation Mix 2030 Version 2.0. Details available at <https://cea.nic.in/wp-content/uploads/notification/2023/05/Optimal_mix_report__2029_30_Version_2.0__For_Uploading.pdf>

³ Ministry of New and Renewable Energy (MNRE) (2024). Details available at <<https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/01/20240118413909461.pdf>>

⁴ Ministry of New and Renewable Energy (MNRE) (2024). Details available at <<https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/01/20240118413909461.pdf>>

Islands). In these states, the state government will provide at least 30% subsidy, and the remaining 20% of the cost is to be mobilized by the farmer.⁵

Component C: Solarization of 35 lakh grid-connected agriculture pumps, including feeder-level solarization

Under this component, individual farmers are supported to solarize their grid-connected agriculture pumps.⁶ It aims to reduce the burden of power subsidies on states by solarizing existing agricultural feeders and connections. A one-time capital investment could help reduce the recurring power subsidy burden. Power procured from decentralized solar units and plants located near the point of consumption could reduce the cost of power supply for the DISCOMs. Component-C consists of two models:

- 1. Solarization of individual existing grid-connected pumps:** Under this model, farmers with existing grid-connected pump sets are eligible for subsidies to solarize their connections. In addition to the benefit of adequate daytime supply, farmers would be able to sell any excess power to the grid at a predetermined tariff, gaining supplementary income.
- 2. Feeder-level solarization (FLS):** Under this model, the DISCOMs could develop decentralized solar power plants near agricultural feeders to cater to the entire feeder loads, to reduce their cost of power supply to agricultural consumers. This model has similarities with Component A and draws inspiration from the ongoing Mukhyamantri Saur Krushi Vahini Yojana (MSKVY) scheme in Maharashtra, which set the objective of 30% feeder solarization by 2025 as 'Mission 2025' through the implementation of 7,000 MW of decentralized solar projects.

All three components of the scheme aim to add solar capacity of approximately 34,800 MW by March 2026, with a total central financial support of ₹34,422 crore (USD 4.15 billion).⁷ However, by January 2025, as March 2026 approaches, the scheme has achieved 5% of its targeted 34.8 GW solar deployment.⁸ Both financial and operational challenges have hindered the achievement of targets. Since January 2024, the scheme has witnessed a surge in interest, evidenced by the 25 GW tenders floated under Components A and C.⁹ States, including Maharashtra, Rajasthan, and Gujarat, awarded nearly 15 GW of projects. Tariffs for nearly 19 GW were approved by different SERCs, reflecting an accelerating number of projects in the pipeline. Both financial and operational challenges need to be addressed to sustain this momentum. State budgets should allocate sufficient funds, address implementation challenges, and complement the centre's broader efforts regarding the scheme.

⁵ *Ibid.*

⁶ Ministry of New and Renewable Energy (MNRE) (2017). Details available at <https://tpsouthernodisha.com/Editor_UploadedDocuments/Content/MNRE_Guidelines_for_Implementation_of_PM_KUSUM-C_existing_grid-connected_agricultural_pumps.pdf>

⁷ *Ibid.*

⁸ Center for Study of Science, Technology and Policy (CSTEP) (2025). A budget boost for solar power could reshape India's energy and agricultural landscape. Details available at <<https://cstep.in/publications-details.php?id=3142>>

⁹ A budget boost for solar power could reshape India's energy and agricultural landscape (2025). *PV Magazine*

1.1 Context of the PM-KUSUM scheme

The PM-KUSUM's focus on promoting solar energy generation through the active participation of farmers needs to be understood in the context of the twin-policy objectives of contributing to the achievement of non-fossil energy targets under the NDCs, as well as of bringing financial stability to the DISCOMs through the rationalization of subsidies in favour of renewable energy. In addition, it can help address two long-standing challenges in the agricultural sector: low growth in farmers' incomes and unsustainable groundwater extraction for irrigation, often attributed to free/cheap access to electricity.

Tariff subsidies are intended to provide affordable electricity to consumer categories such as agricultural users. The subsidies are billed by distribution utilities and constitute a significant financial burden on the DISCOMs. In 2021–22, tariff subsidies billed by the DISCOMs increased from USD 17 billion (Rs 1,44,469 crore) to USD 20 billion (Rs 1,69,532 crore) in 2022–23.¹⁰ Although tariff subsidies as a percentage of total revenue decreased marginally from 17.77% in 2021–22 to 17.53% in 2022–23.¹¹

Several states, namely Andhra Pradesh, Karnataka, Punjab, Tamil Nadu, and Telangana, provide free electricity for irrigation.¹² The remaining states have highly subsidized agricultural electricity, making agricultural load charges extremely nominal for farmers. For example, Haryana charges 10 paise per unit under agricultural loads, and Himachal Pradesh charges 30 paise per unit.¹³ These subsidies have enabled farmers to access electricity at prices below the marginal cost of supply.

In 2009, of the total amount of groundwater extracted, 89% was for irrigation, and 11% was for domestic and industrial use.¹⁴ The *National Water Policy, 2012*, recommended minimizing over-extraction of groundwater by regulating the use of electricity for its extraction. The Commission on Price Policy for Kharif Crops¹⁵ for 2015–16 and 2017–18, recommended fixing quantitative ceilings on per-hectare use of both water and electricity. This would also encourage farmers to adopt water-efficient practices, such as drip and sprinkler irrigation. Installing solar water pumps can help mitigate the problem of uncontrolled water uptake, as these systems often require drip or micro-irrigation, promoting more efficient water use.

The Central Electricity Authority's 20th Electric Power Survey of India (2023) estimates that India will achieve 63% of its installed capacity from non-fossil fuels by 2030.¹⁶ However, it also

¹⁰ Report on Performance of Power Utilities (2022–23). Details available at <https://www.pfcindia.co.in/ensite/DocumentRepository/ckfinder/files/Operations/Performance_Reports_of_State_Power_Utillities/Report%20Database%202022-23%20-%20updated%20up%20to%20April%202024EntityApr.pdf>

¹¹ *Ibid.*

¹² Free electricity to farmers. Details available at <<https://sansad.in/getFile/loksabhaquestions/annex/175/AU3890.pdf?source=pqals>>

¹³ Details available at <https://cea.nic.in/wp-content/uploads/fs___a/2023/11/Book_2022.pdf>

¹⁴ Suhag, R. (2016). Overview of Ground Water in India. Details available at <https://prsindia.org/files/policy/policy_analytical_reports/1455682937--Overview%20of%20Ground%20Water%20in%20India_o.pdf?utm_source=chatgpt.com>

¹⁵ Price Policy for Kharif Crops: The Marketing Season 2017–2018. Details available at <<https://ruralindiaonline.org/hi/library/resource/price-policy-for-kharif-crops-the-marketing-season-2017-18/#>>

¹⁶ Report on Optimal Generation Mix 2030 (2023). Details available at <https://cea.nic.in/wp-content/uploads/irp/2023/05/Optimal_mix_report__2029_30_Version_2.0__For_Uploading.pdf>

notes that, in making these projections, the impact of various factors needs to be included, such as reductions in T&D losses, energy-efficiency improvement measures, the production of green hydrogen, the penetration of electric vehicles (EVs), rooftop solar, solar-powered agricultural pumps, and the electrification of households. It estimates that, in 2029–30, the all-India energy requirement offset from rooftop solar installations will be approximately 34.8 billion units (BU).

1.2 Objective of the Assessment

The general objective of this study is to apply the ICAT Renewable Energy Methodology to undertake an assessment of the PM-KUSUM scheme through a case study. The application of the Renewable Energy Methodology together with the Sustainable Development Methodology will include:

- Assessing the expected and or achieved change in terms of greenhouse gas (GHG) emissions/removals, sustainable development impacts, and/or extent of transformational change resulting from a policy or action,
- Assessment of the role that the ICAT guide can play in the development of policies, enhancing the NDC update and/or implementation process, other climate action, or other relevant aspects of the Paris Agreement, and/or the use of the assessment results to raise resources.

These assessments are expected to contribute to broader climate policy design and implementation, including the following:

- Improved quality of reporting to the United Nations Framework Convention on Climate Change (UNFCCC) [biennial transparency reports (BTRs)] and national communications.
- New or refined policies and measures in support of a collective ambition in NDCs.
- Improved climate and/or sustainable development policies.

1.3 Scope of Assessment

The expected outcomes of the PM-KUSUM scheme are the following-

- Renewable energy capacity will be enhanced:* Renewable energy estimates from the Central Electricity Authority's report for 2029–30 are set at 292,566 MW.¹⁷ As of 31 August 2025, the installed capacity is 1,23,130.13 MW, of which distributed solar/PM-KUSUM contributes 5122.12 MW.¹⁸ The PM-KUSUM, through its three components, aims to add a cumulative installed capacity of 34,800 MW by March 2026.
- Reduced emission of GHG:* Replacing the use of diesel or highly fossil fuel-intensive grid power with solar power will result in abatement of GHG emissions.

¹⁷ Central Electricity Authority (CEA) (2023). Optimal mix report. Details available at <https://cea.nic.in/wp-content/uploads/irp/2023/05/Optimal_mix_report__2029_30_Version_2.0__For_Uploading.pdf>

¹⁸ Ministry of New and Renewable Energy (MNRE) (2025). State-wise (location based) installed capacity of renewable power as on 31 August 2025. Details available at <<https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/09/202509151763544231.pdf>>

- C. *Reduced input cost of irrigation*: Running diesel irrigation pumps is expensive. Adoption of solar water pumps will enable farmers to avoid the use of expensive diesel as source of energy for irrigation.
- D. *Increase farmers' income*: Additional income can also be generated through the sale of excess electricity to the grid during non-irrigation hours, in addition to contractual agreements with DISCOMS under Component A.
- E. *Contribution to SDGs*: Implementation of the scheme will contribute to the following Sustainable Development Goals:
Goal 1: No Poverty, Goal 2: Zero Hunger, Goal 7: Affordable clean energy, and Goal 13: Climate Action of SDGs.

1.4 GHG Assessment boundary

PM-KUSUM GHG assessment boundary includes emissions avoided from diesel and grid-based electricity. It excludes the lifecycle emissions associated with manufacturing solar infrastructure. These exclusions are consistent with prevailing policy assessment practices, as these emissions are relatively smaller compared with operational emission savings. In Table 1, column (i) describes the GHG impact, column (ii) describes the relevant GHG emissions, column (iii) describes the likelihood of GHG impact, column (v) describes if the GHG impact is included or excluded, and column (vi) describes if the GHG impact is significant or not.

Table 1: GHG sources, their impact under PM-KUSUM scheme in the assessment boundary

GHG impact	Relevant GHGs	Likelihood	Relative magnitude	Included or excluded	Explanation
(i)	(ii)	(iii)	(iv)	(v)	(vi)
Reduced emissions due to shift in dependence from thermal power plant to solar/renewable energy power plant	CO ₂	Very likely	Major	Included	Significant impact under the scheme
Increased GHG emissions from renewable energy power plant equipment manufacturing	CO ₂	Possible	Minor	Excluded	Considered insignificant and is offset by decreased emissions from construction of fossil fuel power plants
Reduced GHG emission due to reduction in use of diesel in pumps and increase in stand-alone solarized pumps	CO ₂	Very likely	Major	Included	Significant impact under the scheme

GHG impact	Relevant GHGs	Likelihood	Relative magnitude	Included or excluded	Explanation
Increased GHG emissions from solar pump manufacturing	CO ₂	Possible	Minor	Excluded	Considered insignificant and is offset by decreased emissions from manufacturing, from diesel pumps, and the use of diesel
Reduced GHG emissions due to decreased use of fossil-based grid power for agricultural pumps	CO ₂	Very likely	Major	Included	Significant impact under the scheme
Reduced GHG emission at feeder level due to shift from fossil to solar PV power consumption	CO ₂	Very likely	Major	Included	Significant impact under the scheme
Increased GHG emissions from solar PV component manufacturing	CO ₂	Possible	Minor	Excluded	Considered insignificant and is offset by decreased emissions from the use of grid electricity in pumps at the individual and feeder level

1.5 Casual chain for emission reductions under the PM-KUSUM scheme

A causal chain describes the process by which a policy intervention leads to specific outputs, outcomes, and impacts. It identifies intermediate effects and GHG impacts due to a policy change.

Component A leads to an increase in solar generation capacity, causing reduced emissions due to a shift in dependence from thermal power plants to solar power plants. At the same time, it is possible that the manufacturing of RE power plant equipment contributes to GHG emissions if the process, including transportation, is dependent on fossil fuel-based energy sources. However, life cycle assessment of emissions indicates that solar panels contribution is significantly lower than the fossil fuel-based power systems.¹⁹ Component C, IPS as well as FLS, also leads to emission reduction through same causal explanation.

The Component B leads to the replacement of diesel-based irrigation pumps with stand-alone solar pumps, thereby reducing GHG emissions by reducing diesel use and increasing the use

¹⁹ Peng, J., Lu, L., and Yang, H. (2013). Review on life cycle assessment of energy payback and greenhouse gas emission of solar photovoltaic systems. *Renewable and Sustainable Energy Reviews* 19: 255–74

of stand-alone solar pumps. The life cycle assessment of GHG emissions from solar power plant equipment manufacturing is comparatively lower than a diesel-based power system.²⁰

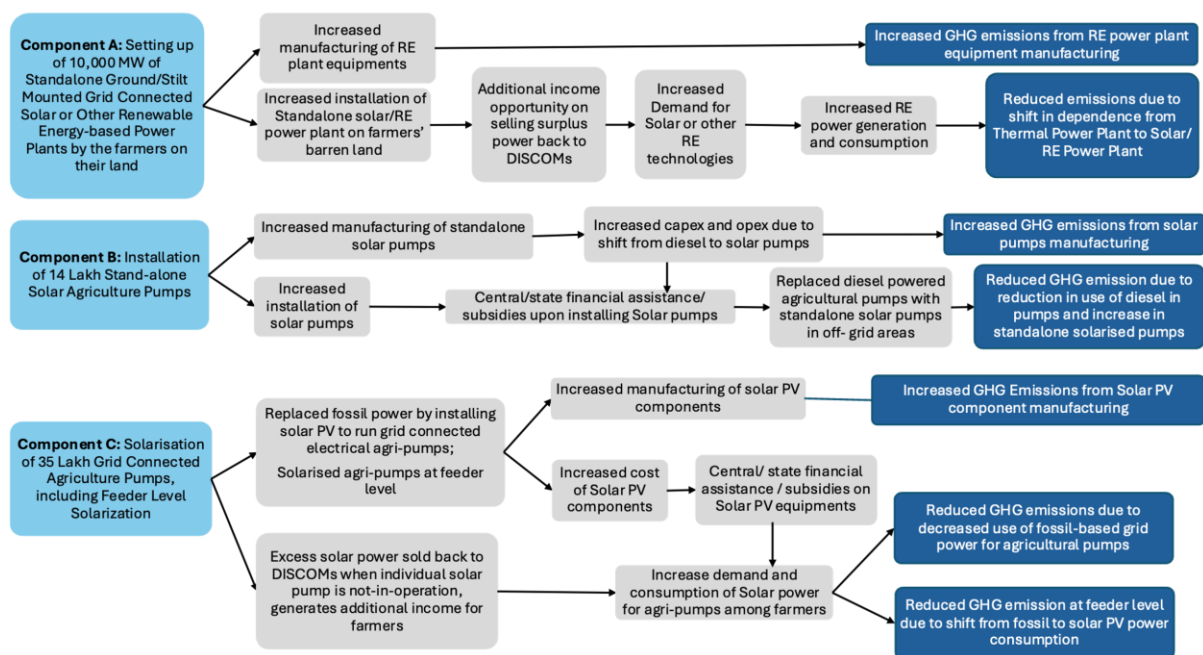


Figure 1: Causal chain for PM-KUSUM scheme components

2. Methodology

Mixed-methods methodology has been used, combining both quantitative and qualitative datasets. The data for the analysis has been collected through secondary sources. The different data sources include the Agriculture Input Survey and the MNRE. Qualitative analysis includes field visits, interviews of stakeholders at the administrative and ground levels, and subject matter experts.

2.1. Quantitative Analysis

2.1.a Estimating the renewable energy addition impact of the policy (mid-term)

The ICAT Renewable Energy Methodology provides a framework for estimating renewable energy additions resulting from policy interventions in an ex-ante context. However, since the PM-KUSUM scheme is already being implemented, the following methodology is adopted to evaluate its mid-term impacts.

According to the ICAT guide, the following four steps are applied to support the mid-term assessment. These steps aim to assess the policy's impact and identify the key challenges encountered during the ongoing implementation of the scheme.

1. Estimating the technical potential over the assessment period

²⁰ Mansour, M., Harajli, H., El Zakhem, H., and Manneh, R. (2024). Cradle-to-grave life cycle assessment of a photovoltaic–diesel hybrid system: the case of an industrial facility. *Environment, Development and Sustainability* **26** (7): 17353–81

The technical potential for renewable energy deployment under PM-KUSUM draws on the scheme's official policy documents and subsequent amendments. See Annexure 1.

2. Accounting for the design characteristics of the policy

A qualitative analysis for the design elements of all components is carried out. The ICAT methodology states that tender policy functions independently, whereas tax incentive policies overlap with subsidies. Component A has implemented a feed-in tariff policy, a mechanism to encourage investment in renewable energy by guaranteeing producers a fixed price for the electricity they generate and export to the grid. Typically, feed-in-tariff policy is implemented by issuing tenders, which are invitations for renewable energy projects. In Components B and C, subsidies are provided by the central and state governments to cover benchmark costs. Tax and subsidy policies are overlapping in their cost implications.

Table 2: Programmes/projects and information covered in the report

Programme/policy descriptions to identify impacts	Component A	Component B	Component C
Estimating the baseline scenario and emissions	✓	✓	✓
Estimating the GHG impacts ex-ante	✓	✓	✓
Policies interacting independently	✓		
Overlapping policies		✓	✓

3. Assessing financial feasibility

The financial feasibility is examined in line with Section 7.4 of the ICAT guide. The objective is to identify specific implementation challenges faced by stakeholders—particularly regarding the cost of agricultural pumps and the overall affordability of renewable energy technologies under the scheme. The ICAT methodology states that the levelized cost of electricity (LCOE) should be lower than electricity tariffs. For the diffusion of technology, the cost of a given technology should be less than the current technologies or financial incentives provided by the renewable energy policy. The SERC calculates the LCOE and decides on the tariff. Developers have opined that the tariff set by the SERC is unviable for several reasons. The existing tariff-setting mechanism is not aligning with the developer's expectations. The states need to modify their tariff setting to bring them to an optimal level. The LCOE is the ratio between the present value of the total costs of the PV system, and the present value of the energy generated by the system. The LCOE is very sensitive to module price fluctuations. Ceiling tariffs have remained static for years in most states while the LCOE corresponding to the module prices has fluctuated. Through stakeholder consultation, this opinion has been further examined to evaluate the financial feasibility of the technology.

4. Identifying existing barriers to implementation

The ICAT methodology requires the determination of barriers that affect the expected addition of renewable energy. The various barrier categories are: technical barriers; regulatory and policy uncertainty; institutional and administrative barriers; market barriers; financial or budgetary barriers; infrastructure barriers; lack of awareness of renewable energy and skilled personnel; public acceptance; and absence of environmental accounting. We will conduct an analysis for all components of PM-KUSUM, which has been carried out systematically through stakeholder consultations to develop a comprehensive understanding of the factors that limit the effective implementation of the PM-KUSUM scheme.

2.1.b Estimating the GHG impacts of the PM-KUSUM (ex-ante and ex-post)

This study examines the impact of the PM-KUSUM scheme by estimating both its anticipated future impacts and current outcomes regarding GHG emission reductions.

As an initial step, the assessment examines all potential GHG impacts of the scheme, along with their corresponding source categories. In the case of PM-KUSUM, the primary emissions reductions are expected from the displacement of fossil fuel use, with carbon dioxide (CO₂) being the predominant GHG reduced. To substantiate these and to identify the impact on other GHGs, a causal chain is developed to systematically trace how policy interventions lead to measurable changes in GHG emissions.

The next step is to define the assessment period. As previously outlined, both ex-ante (projected) and ex-post (actual) assessments have been conducted. To estimate GHG emissions reductions from renewable energy deployment, two modelling approaches are recommended in the guide: 1) the emissions trajectory method and 2) the grid emission factor method. Given that PM-KUSUM is a technology-specific, quantifiable, and multi-component programme with clearly defined targets for each component, the grid emission factor method is deemed more appropriate. This choice ensures consistency in estimation and minimizes data gaps across components. For example, Component B focuses on the deployment of stand-alone solar pumps for off-grid use, thereby making the emissions trajectory method less applicable. Thus, the grid emission factor method will be used to estimate the GHG impacts across all components of the scheme.

To conduct the assessment, three scenarios will be developed:

1. **Scenario 1: Baseline Scenario**

This scenario estimates emissions in the absence of the PM-KUSUM policy. It is based on the fossil fuel consumption patterns in 2019, the year preceding the scheme's launch. This provides a reference point for measuring the scheme's impact.

2. **Scenario 2: Ex-ante Scenario**

In the ex-ante scenario, the GHG impacts are estimated based on the targets outlined for the implementation of PM-KUSUM. Since the scheme is still ongoing, projecting its expected impacts is essential for understanding its potential contribution to emission reductions.

3. **Scenario 3: Ex-post Scenario**

The ex-post scenario evaluates the scheme's actual impacts using data from its implementation between 2019 and 2026. As the programme is partially implemented, this scenario will help identify realized outcomes and inform recommendations for enhancing the scheme's effectiveness.

For each scenario, a detailed methodology has been developed outlining the required data, data sources, and key stakeholders involved in the assessment process.

Table 3: Scenario description and targets of PM-KUSUM

	Baseline (2019)	Ex-ante (2019–26)	Ex-post (2016) Partial implementation
Component A: Grid-connected solar power plants	No policy	10,000 MW solar power plants installation	417.98 MW installed by 2025
Component B: Stand-alone solar-powered agriculture pumps	Diesel-powered agriculture pumps	20 lakh stand-alone solar-powered agriculture pumps	6,69,484 installed stand-alone pumps
Component C: Solarization of grid-connected agriculture pumps	Fossil fuel electricity consumption of agriculture pumps	15 lakh grid-connected agriculture pumps	5342 agricultural pumps solarized
Component C: Feeder-level solarization	Fossil fuel electricity distributed at feeder level	35,35,874 pumps sanctioned for feeder level	1,87,633 pumps solarized under feeder level

Table 4: Methodology and identified data requirements for each component of PM-KUSUM

Policy	Scenario description	Data indicators	Data sources
No policy	Baseline scenario (BAU)	Consumption of diesel and electricity for agricultural pumps	All India Agriculture Input Survey 2016–17; Data Link Energy Statistics 2019–20; CEA, Data Link Emission Factor , Data Link
PM-KUSUM A	Ex-ante and ex-post	- Installed capacity (MW) - Capacity utilization factor (CUF) - Grid emission factor (EFgrid) - Electricity generated (MWh/year)	- MNRE and PM-KUSUM implementing agencies: Central Electricity Authority (CEA) - project reports Emission factor
PM-KUSUM B	Ex-ante and ex-post	- Number of pumps installed - Average daily and annual operating hours - Diesel or grid electricity replaced - Emission factors (diesel EF or EFgrid)	- MNRE and state nodal agencies - CEA for EF - Implementation and project reports (Data Link) Emission factor
PM-KUSUM C	Ex-ante and ex-post	- Feeder-level electricity demand - Solar generation data (PLF) - Self-use v/s grid export estimates - EFgrid	- DISCOMs and MNRE – CEA reports – O&M and load data from implementing agencies, Data Link Emission factor

2.2 Qualitative Analysis

The analysis includes describing causal pathways through the theory of change. Once the theory of change has been mapped, relevant stakeholders will be identified. The relevant stakeholders and experts will be interviewed on the various dimensions of PM-KUSUM.

Expert interviews will also be conducted with subject matter experts, such as renewable energy specialists.

2.2.a Theory of Change (ToC)

We will outline the causal pathway arising from activities and outputs of the intervention for all three components.

Table 5: ToC-installation of solar energy-based power plants: Component A

Input	Activities	Outputs	Outcomes	Impacts (long term)
Policy development by MNRE	Capacity development and training Identification of suitable land Tenders are floated, bids invited for renewable energy power project Ensuring grid connectivity to DISCOM Tariff setting by SERC	Number of solar plants installed (500 kW to 2 MW) Number of successful bidders selected Number of power purchase agreements (PPAs) signed with DISCOMs State implementing agency (SIA) to coordinate between MNRE, developers, farmers, and DISCOMs State implementing agency (SIA) to coordinate between MNRE, developers, farmers, and DISCOMs Farmers can also take loan directly from the bank to establish solar plant DISCOM monitors the performance of the project and	Additional income for farmers from leasing land (Components A and C) Additional renewable energy generation at local level Avoidance of high cost of transmission lines and losses since the solar power plants will be installed within 5 km radius of the notified sub-stations (Component C) Daytime reliable power for irrigation Solar power plants and feeder-level solarization development by developers supplying renewable energy to grid (Component A and feeder-level solarization – Component C) Probability of success in implementation of all components increases	SDG 1: No Poverty SDG 7: Affordable and Clean Energy SDG 9: Industry, Innovation and Infrastructure SDG 13: Climate Action India's NDC Target 3 – reduce emissions intensity of its GDP by 45% by 2030 from 2005 level India's NDC Target 4 – achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030

resolve
bottlenecks

Table 6: ToC-installation of stand-alone solar agricultural pumps: Component B

Input	Activities	Outputs	Outcomes	Impacts (long term)
Central Financial Assistance (CFA): Subsidies provided by the Government of India covering up to 30% of the benchmark cost for solar pumps State government support: Additional subsidies covering up to 30% of the cost Farmer contribution and concessional finance: Remaining 40% of the cost	Identification of farmers who would want to replace existing diesel pumps Panelled vendors will supply and install solar pump system	Installation of 14 lakh stand-alone solar agricultural pumps Reduction in the number of diesel-powered pumps	Partially replaced diesel pumps with solar power pumps Reduction in irrigation costs Access to finance: Remaining 40% of the cost, which can be financed through bank loans or if the farmer can provide capital Marginalized farmers may not have access to scheme as they are landowners Increased disposable income for farmers Access to reliable daytime power for irrigation	SDG 7: Affordable and Clean energy SDG 13: Climate Action India's NDC Target 3: reduce emissions intensity of its GDP by 45% by 2030 from 2005 level. India's NDC Target 4: achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030

Table 7: ToC-solarization of pumps: Component C (IPS)

Input	Activities	Outputs	Outcomes	Impacts (long term)
Central Financial Assistance (CFA): Subsidies provided by the Government of India covering up to 30% of the benchmark cost for solar pumps State government support: Additional subsidies covering up to 30% of the cost Farmer contribution: Remaining 40% of the cost which	Identification and registering eligible farmers with grid-connected pumps Selection of vendors for the supply and installation of solar PV system	Reduced number of pumps that rely on conventional energy sources	Reduction in electricity costs for farmers Access to reliable daytime power for irrigation Reduction in carbon emissions due to decreased use of diesel engine	SDG 7: Affordable and Clean energy SDG 13: Climate Action India's NDC Target 3: reduce emissions intensity of its GDP by 45% by 2030 from 2005 level India's NDC target 4- achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030

can be financed through
bank loans

Table 8: ToC-solarization of agricultural feeders: Component C (FLS)

Input	Activities	Outputs	Outcomes	Impacts (long term)
Central Financial Assistance (CFA): Subsidies provided by the Government of India covering up to 30% of the benchmark cost for solar pumps	Identification of agricultural feeders	Installation of solar power plants that are tailored to the energy requirement of the agricultural feeder	Remaining 40% of the cost, which can be financed through bank loans.	SDG 7: Affordable and Clean energy SDG 13: Climate Action
Concessional finance: This can vary from state to state	Identification and registering of eligible farmers	Establishment of PPAs between RESCO and DISCOMs	Reduction in electricity costs for farmers	India's NDC target 3– reduce emissions intensity of its GDP by 45% by 2030 from 2005 level
Capital investment from the developers through CAPEX model	Solar plants of capacity that can cater to the requirement of the agriculture load of the selected feeder can be installed through CAPEX/RESCO mode for a project period of 25 years		Access to reliable daytime power for irrigation Reduction in GHG emissions due to decreased use of diesel engine	India's NDC target 4 – achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030

2.2.b Stakeholder engagement

The policy design and policy intervention for all three components differ. Hence, interventions for all three Components of PM-KUSUM vary. The intervention for each is expected to achieve its intended outcomes and impact the overall goals. However, the stakeholders will remain the same for all three components. We begin with stakeholder identification.

Table 9: Stakeholder engagement

Stakeholder	Overarching role	Detailed role	Type of stakeholder
Ministry of New and Renewable Energy	Policy formulation and oversight	Allocates initial capacities for pilot projects Central financial assistance is provided	Direct
State Electricity Regulatory Commissions (SERCs)	Setting of tariffs	The SERCs are responsible for setting tariffs for electricity generated	Direct
State implementing agencies	Implementation	Beneficiaries like farmers and developers are selected by them	Direct

Stakeholder	Overarching role	Detailed role	Type of stakeholder
		To ensure smooth implementation they work with DISCOMs and agriculture department	
DISCOMs	Purchaser of electricity	Under Component A, facilitate the integration of solar power into the grid. Enter into power purchase agreement with farmers or developers for the procurement of solar power	Direct
Developers	Beneficiary	Manufacture and install solar equipment	Direct
Individual farmers/ group of farmers/ cooperatives/ panchayats/Farmer Producer Organizations (FPOs)/Water User Associations (WUAs)	Beneficiary	Under Component A, farmers or group of farmers can either set up solar power plants (SPP) or lend their land to developer to build SPP Under Component B, farmers can install standalone solar pumps. In Component C, farmers can solarize existing grids	Direct
Banks and other financial institutions	Provision of loans	Provision of loans and financial products to farmers	Indirect
Department of Agriculture	Outreach and beneficiary identification	Conduct awareness campaign to inform farmers about the scheme.	Indirect
Department of Revenue (DOR)- Ministry of Finance	Management of land revenues and taxation	Accurate land revenue records are essential. DOR maintains these records which helps in identification of suitable land parcel DOR also oversees taxation policies	Indirect
Ministry of Rural Development (MoRD)	Outreach and integration with Rural Development Programmes	MoRD can assist in disseminating information about PM-KUSUM to farmers and rural communities Integration of Solar Pump Initiatives with irrigation projects	Indirect
Department of Water Resources	Management of water resources	Uses its ground-level irrigation networks to identify eligible farmers with diesel/electric pumps Ensure canal networks permissions to align with solar pump installations	Indirect

3. Results

3.1 Quantitative Assessment of Component A

The dataset provides state-wise capacity utilization factor (CUF), sanctioned capacity, installed capacity, and both target and actual GHG mitigation (in MTCO₂). In this component, the solar power plant is installed without any replacement of existing thermal power plants (so, baseline emissions would be zero). Hence, mitigation potential from Ex-post will be considered as the impact of the scheme.

The methodology to calculate GHG impact of policy is taken from ICAT Renewable Energy Methodology (REM) from Box 8.2. The formulas have been modified based on the technology intervention, like in this case it is a solar intervention.

Mitigation potential (ex-ante and ex-post):

- (i) Total Target GHG mitigation Ex-ante is calculated as the following -

$$EA = C \times CUF \times EF_{grid} \times 365 \times 24$$

Where,

EA: Ex-ante Emissions from Component A (MTCO₂)

C: Total Installed plant capacity (MW)

CUF: Capacity utilization factor (%)

EF_{grid}: Grid emission factor (TCO₂/kWh)

- (ii) Actual GHG mitigation Ex-post is calculated as the following -

$$EA = C \times CUF \times EF_{grid} \times 365 \times 24$$

Where,

EA: Ex-post Emissions from Component A (MTCO₂)

C: Total Installed plant capacity (MW)

CUF: Capacity utilization factor (%)

EF_{grid}: Grid emission factor (TCO₂/kWh)

Summary of results

Metric	Value
Total sanctioned capacity (MW)	10,000
Total installed capacity (MW)	839
Target GHG mitigation (MTCO ₂)	13.17
Actual GHG mitigation (MTCO ₂)	1.42
Target achieved (%)	10.81

The sanctioned portfolio totalled 10,000 MW, however, only 839 MW has been installed.²¹ The calculation shows an actual GHG mitigation of 1.42 MTCO₂ (ex-post: 2026) against a target of 13.17 MTCO₂ per year at the end of the policy period (ex-ante: 2019–26). The target installation has not been met under PM-KUSUM. There is also a gap of 11.75 MTCO₂ of unmitigated emissions. The target (mitigation of emissions) achieved is only 10.81%.

²¹ Ministry of New and Renewable Energy (MNRE) (August, 2015). Details available at <<https://pmkusum.mnre.gov.in/#/landing>>

Policy Implications of Component A

Figure 2 shows states by sanctioned capacity (MW) and installed capacity (MW), where Rajasthan is driving the uptake of Component A. Table 10 confirms that Rajasthan also has the highest GHG mitigated—both targeted and actual.

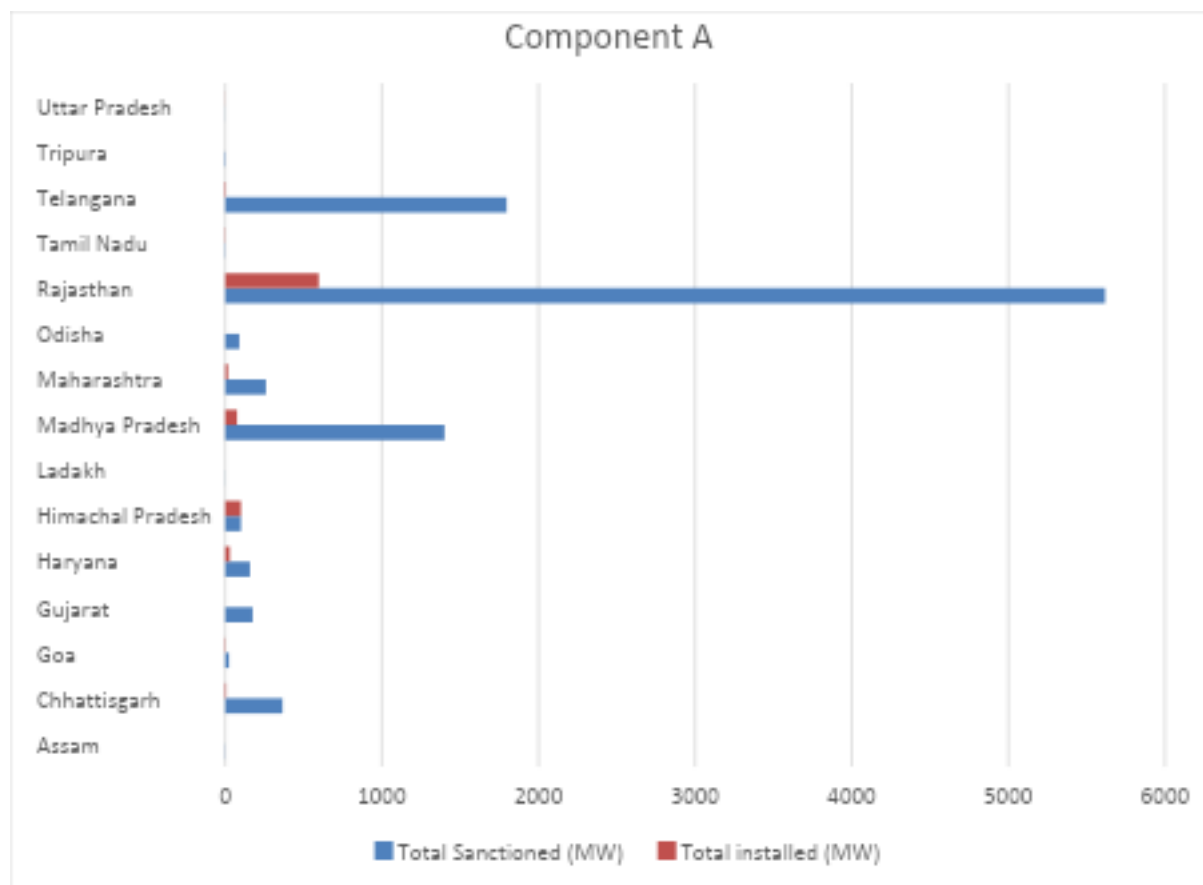


Figure 2: States by total sanctioned and installed capacity (MW)

Table 10: GHG mitigation in Component A

State	Component A	
	Ex-ante GHG Mitigation(MtCO2)	Ex-Post GHG Mitigated (MtCO2)
Chhattisgarh	0.4	0.01
Gujarat	0.1	0.00
Haryana	0.1	0.01
Himachal Pradesh	0.1	0.1
Madhya Pradesh	1.7	0.1
Maharashtra	0.2	0.00
Odisha	0.1	0.00
Rajasthan	8.3	1.2
Telangana	2.1	0.00
Total	13.17	1.42

Clearly, commissioning and generation have not kept pace with plans and uptake of this Component. Contributing factors include delays in land and permitting, limited progress on Power Purchase Agreements (PPAs) with DISCOMs, and slow developer mobilization. Except in states like Karnataka, Rajasthan, Maharashtra, and Gujarat, DISCOMs have routinely failed on timely payments. Further, many states exhibit modest Capacity Utilization Factor (CUFs), which deters realized generation and therefore emissions abatement. CUF differs among states depending on solar irradiation, wind speed, and weather patterns. States with more favourable weather conditions will have higher CUFs, which impacts energy generation.

3.2 Quantitative Assessment of Component B

The dataset provides sanctioned versus installed solar pumps, number of units of diesel pumps for 2016-17, Total fuel consumption (Mil Ltrs) for 2016-17, Emission factor of diesel, Net Calorific Value of diesel, density of diesel, and total operational time of diesel pumps. We have assumed that the diesel pumps are being replaced by 5HP pumps.

In this component, standalone solar Agriculture pumps are planned to replace existing diesel Agriculture pumps/irrigation systems in off-grid areas

Mitigation Potential (Ex-ante and Ex-Post)

- (i) Total Target GHG mitigation Ex-ante is calculated as the following -
 $EB = P \cdot D \cdot OT \cdot EF_{diesel} \cdot DD \cdot NCV$

Where,

EB= Emission from Component B (MtCO₂)

P= Total sanctioned standalone solar pumps (Nos.)

D= Diesel consumed per hour by 1 pump (Lt/hr)

EF_{diesel}: Emissions factor of Diesel (tCO₂/Lt)

OT: operation time for diesel pumps (Hrs)

DD: Density of diesel (kg/m³)

NCV= Net Calorific Value of diesel (TJ/kg)

- (ii) Total Target GHG mitigation Ex-post is calculated as the following –
 $EB = I \cdot D \cdot OT \cdot EF_{diesel} \cdot DD \cdot NCV$

Where,

EB= Emission from Component B (MtCO₂)

I= Total installed standalone solar pumps (Nos.)

D= Diesel consumed per hour by 1 pump (Lt/hr)

EF_{diesel}: Emissions factor of Diesel (tCO₂/Lt)

OT: operation time for diesel pumps (Hrs)

DD: Density of diesel (kg/m³)

NCV= Net Calorific Value of diesel (TJ/kg)

SUMMARY OF RESULTS

Metric	Value
Sanctioned solar pumps (nos.)	1,330,190

Installed solar pumps (nos.)	1,026,862
Diesel pumps (2016–17: Baseline year)	11,152,000
Fuel consumption (ML) (2016–17: Baseline year)	8029
Target GHG mitigation (MTCO ₂)	2.56
Actual GHG mitigation (MTCO ₂)	1.97
Target achieved (%)	77

Installations are highly uneven across states. Few states contribute a disproportionate share of GHG reductions achieved, driven by the faster installation of solar pumps replacing diesel pumps.

Conversely, states with low installation rates show negligible emissions impact despite sizable sanctions. The calculation shows cumulative actual GHG mitigation of 1.97 MTCO₂ per year (ex- post: 2026) against a target of 2.56 MTCO₂ per year (ex-ante: 2019–26). This shows a gap of 0.84 MTCO₂ of unmitigated emissions. The target (mitigation of emissions) achieved is 77%.

Policy Implications of Component B

Figure 2 shows states by the number of standalone solar pumps sanctioned and installed, where Maharashtra is driving the uptake of Component B. As shown in Table 11, Maharashtra also has the highest GHG mitigated, both targeted and actual

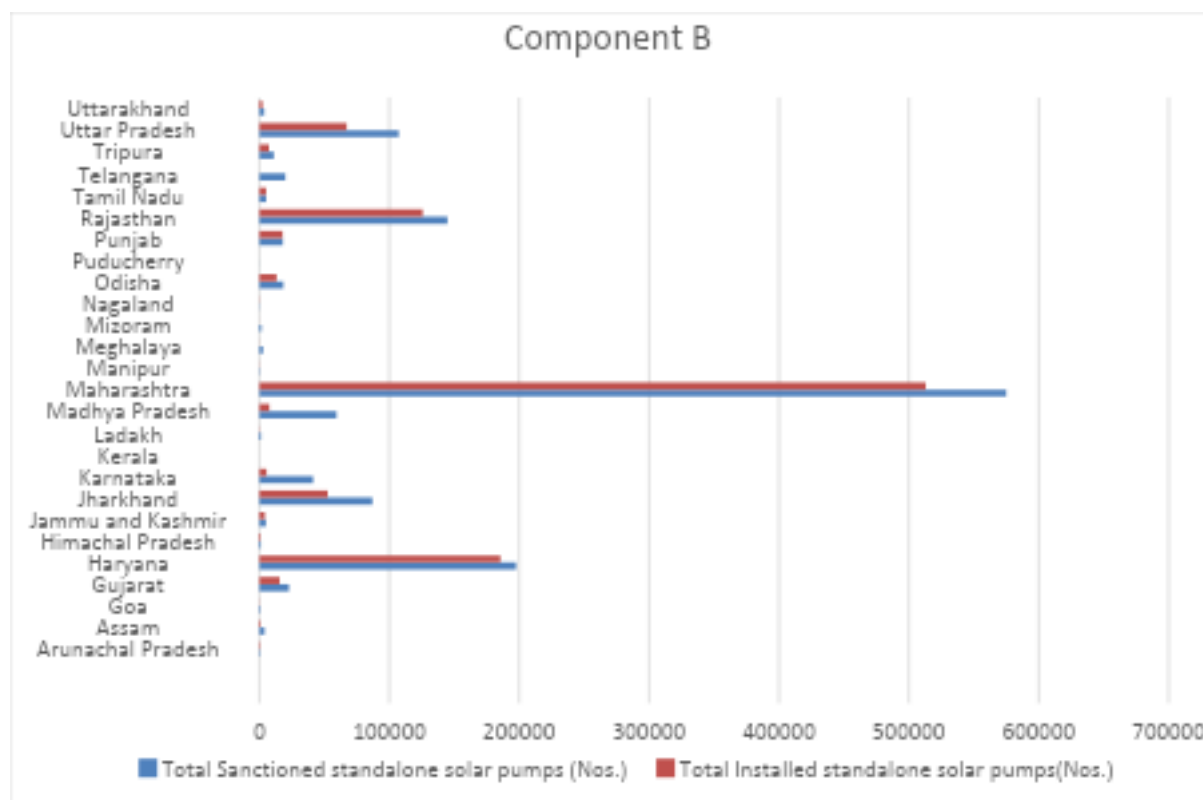


Figure 3: States by sanctioned and installed solar pumps

Table 11: GHG mitigation in Component B

State Name	Component B	
	Ex-ante GHG mitigation (MTCO ₂)	Ex-post GHG mitigated (MTCO ₂)
Assam	0.01	0.00
Gujarat	0.04	0.02
Haryana	0.38	0.36
Jammu and Kashmir	0.01	0.01
Jharkhand	0.17	0.10
Karnataka	0.08	0.01
Madhya Pradesh	0.11	0.01
Maharashtra	1.11	0.99
Meghalaya	0.01	0
Odisha	0.04	0.03
Punjab	0.03	0.03
Rajasthan	0.28	0.24
Tamil Nadu	0.01	0.01
Telangana	0.04	0.00
Tipura	0.02	0.01
Uttar Pradesh	0.23	0.13
Uttarakhand	0.01	0.13
West Bengal	0.02	0
Total	2.56	1.97

This low uptake traces back to (i) incomplete pump commissioning, (ii) slower-than-expected retirement of diesel pumps, and (iii) implementation frictions in states with weak SNA-DISCOM coordination. Incomplete pump commissioning refers to projects that have been sanctioned but not physically implemented, as well as pending applications delayed at various stages, such as approval, subsidy disbursement, vendor empanelment, or farmer-side financing. The retirement of diesel pumps has been slower because solar pumps, even with subsidies, involve high upfront costs and require access to credit that many small farmers lack, while diesel pumps remain cheap, easily available, and flexible to operate. These challenges are compounded by “implementation frictions,” which capture the gap between policy design and execution and arise from tendering delays, lagging subsidy transfers, coordination failures among MNRE, DISCOMs, state nodal agencies, and banks, as well as limited farmer awareness.

3.3 Quantitative Assessment of Component C (IPS)

The dataset provides sanctioned versus installed solar pumps, number of units of electrified pumps for 2016–17, total electricity consumption (MWh) for 2016–17, grid emission factor (tCO₂/kWh), and operational time. We have assumed that 3.5 HP diesel pumps are connected to the grid.

In this component, standalone solar agriculture pumps are planned to replace existing grid-connected electrical agriculture pumps/irrigation systems.

Mitigation Potential (Ex-ante and Ex-Post)

- (i) Total Target GHG mitigation Ex-ante is calculated as the following –

$$EC1 = EP \cdot UP \cdot OT \cdot EF_{grid}$$

Where,

EC1 = Emissions for Component C on IPS

EP = Total sanctioned standalone solar pumps

UP = Units of electricity consumed per pump

OT = Operational time (hrs)

EF_{grid} = Grid emission factor (tCO₂/kWh)

- (ii) Actual GHG mitigation Ex-post is calculated as the following –

$$EC1 = EI \cdot UP \cdot OT \cdot EF_{grid}$$

Where,

EC1 = Emissions for Component C on IPS

EI = Total installed standalone solar pumps

UP = Units of electricity consumed per pump

OT = Operational time (hrs)

EF_{grid} = Grid emission factor (tCO₂/kWh)**Summary of results**

Metric	Value
Sanctioned solar pumps (nos.)	55,392
Installed solar pumps (nos.)	12,787
Electric pumps (2016–17: Baseline year)	20,781, 689
Electricity consumption (ML) (2016–17: Baseline year)	44,888,448
Target GHG mitigation (MTCO ₂)	0.11
Actual GHG mitigation (MTCO ₂)	0.03
Target achieved (%)	23

Uttar Pradesh (UP), Kerala, and Rajasthan together account for 96% of realized mitigation; other states show negligible ex-post impact. Where installations have happened in UP, Kerala, and Rajasthan, ex-post benefits have materialized at scale, validating the IPS design for mitigation. The calculation shows cumulative actual GHG mitigation of 0.03 MTCO₂ per year (ex-post: 2026) against a target of 0.11 MTCO₂ per year (ex-ante: 2019–26). This shows a gap of 0.08 MTCO₂ of unmitigated emissions. The target achieved is 23%.

Policy Implications of Component C (IPS)

Figure 3 shows the states by sanctioned capacity (MW) and installed capacity (MW), where Telangana has the highest number of sanctioned solar pumps, with no installations. Rajasthan is the only state that has delivered on sanctioned capacity with a 100% installation rate. In Table 12, UP has the highest GHG mitigated, both targeted and actual.

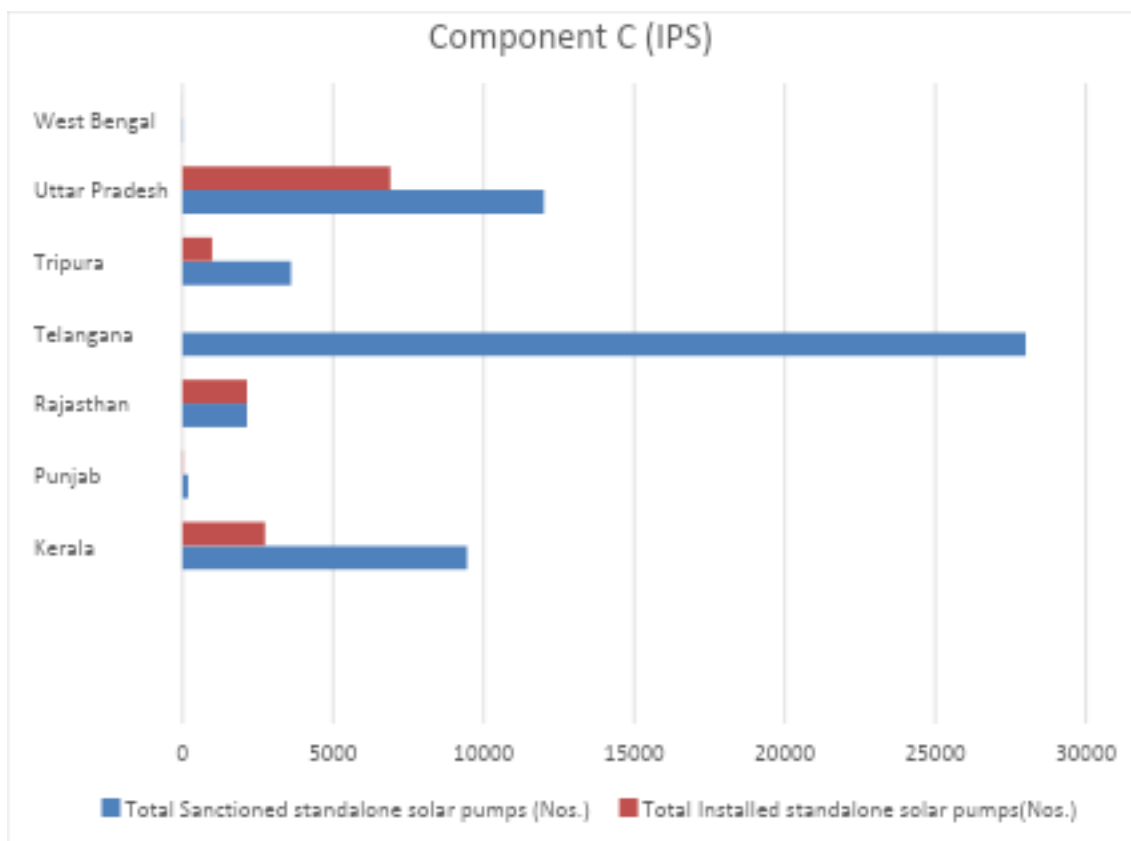


Figure 4: States by sanctioned and installed solar pumps

Table 12: GHG mitigation in Component C

State name	Component C – IPS	
	Ex-ante GHG mitigation (MTO ₂)	Ex-Post GHG mitigation (MTCO ₂)
Kerala	0.02	0.00568
Telangana	0.06	-
Tripura	0.01	0.002
Uttar Pradesh	0.02	0.01432
Rajasthan	0.004	0.000
Total	0.115	0.03

Telangana has 50% of sanctioned solar pumps; however, Telangana has not delivered on installations. The low installation rate of 23% of this component indicates that there are bottlenecks, and these include the willingness to pay the upfront cost by farmers for solarization of electric pumps, as they are already getting subsidized or free power from the state.

3.4 Quantitative Assessment of Component C (FLS)

The dataset provides sanctioned versus installed agricultural feeders. In this component, solarization of the agriculture feeders are planned to replace existing grid connected electrified agriculture feeders.

Mitigation Potential (ex-ante and ex-post)

(i) Total Target GHG mitigation Ex-ante is calculated as the following –

$$EC2 = F \times UP \times OT \times EF_{grid}$$

Where,

EC2 = Emissions for Component C on FLS

F = No. of feeders

UP = Units of electricity consumed per pump

OT = Operational time (hrs)

EF_{grid} = Grid emission factor (tCO₂/kWh)

(ii) Actual GHG mitigation EX-Post is calculated as the following –

Where,

EC2 = Emissions for Component C on FLS

F = No. of feeders

UP = Units of electricity consumed per pump

OT = Operational time (hrs)

EF_{grid} = Grid emission factor (tCO₂/kWh)

Summary of results

Metric	Value
Sanctioned solar pumps (no.)	3,513,602
Installed solar pumps (no.)	1,341,892
Target GHG mitigation (MTCO ₂)	5.58
Actual GHG mitigation (MTCO ₂)	2.78
Target achieved (%)	50

Maharashtra, Gujarat and Rajasthan account for 89% of realized mitigation. However, there have been challenges in the implementation processes in UP, Andhra Pradesh, and Bihar as these states have not been able to materialize the installations at the same rate as other States. The calculation shows cumulative actual GHG mitigation of 2.78 MTCO₂ per year (ex-post: 2026) against a target of 5.58 MTCO₂ per year (ex-ante: 2019–26). This shows a gap of 2.8 MTCO₂ of unmitigated emissions. The target achieved is 50%.

Policy Implications of Component C (FLS)

Figure 5 shows the states by sanctioned capacity (MW), where Maharashtra has the highest number of sanctioned capacity (MW). It also shows that Maharashtra GHG mitigation, both targeted and actual is the highest.

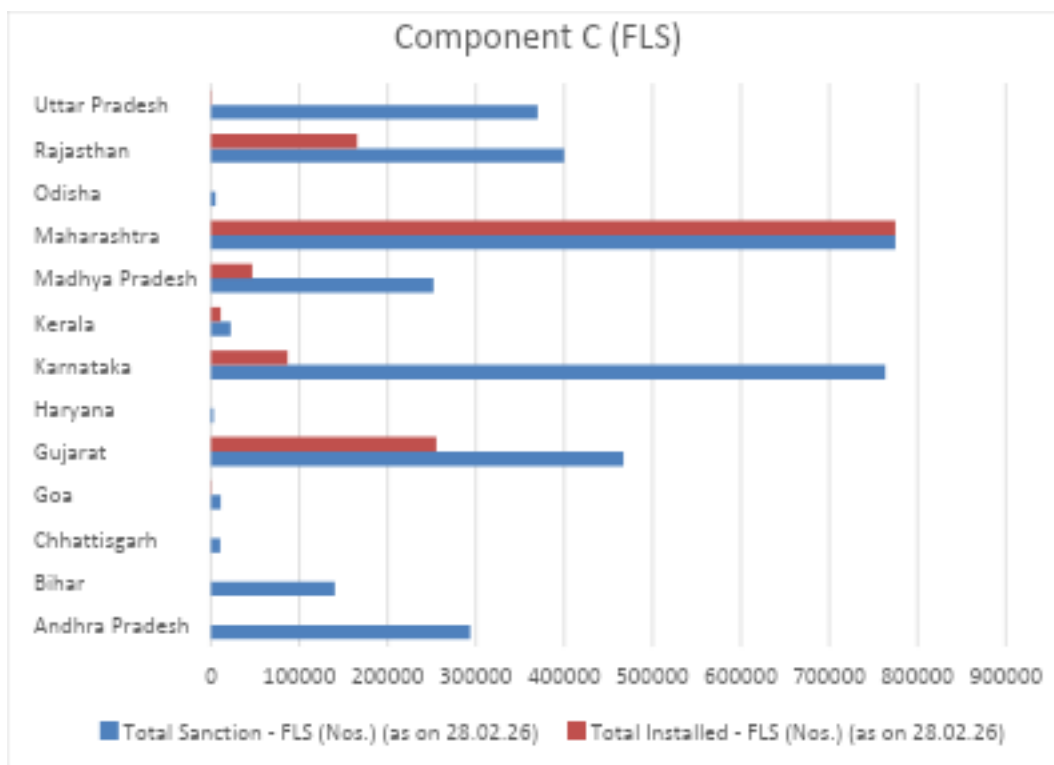


Figure 5: States by sanctioned capacity and installed solarized pumps

Table 13: GHG mitigation in Component C- FLS

State	Component C (FLS)	
	Ex-Ante GHG mitigation (MTCO ₂)	Ex-Post GHG mitigation (MTCO ₂)
Andhra Pradesh	0.47	-
Bihar	0.22	-
Chhattisgarh	0.02	-
Goa	0.02	0.00
Gujarat	0.74	0.53
Karnataka	1.21	0.04
Kerala	0.04	0.02
Madhya Pradesh	0.40	0.10
Maharashtra	1.23	1.61
Odisha	0.01	-
Rajasthan	0.64	0.34
Uttar Pradesh	0.59	-
Total	5.58	2.78

States like UP, AP, and Bihar, show little installed capacity, indicating challenges with regard to access to land near sub-stations, infrastructure-related limitations, including the grid for evacuation of power not being ready, and local permissions lag, and payment security is uncertain. For the viability of Component C, FiT is a critical determinant. The tariff should be sufficiently attractive for farmers to export surplus power in IPS and sell it in FLS. The tariff

is determined by a competitive bidding process by the State Electricity Regulatory Commission (SERC), like in Rajasthan, while other states rely on regulatory orders.

3.5 Technical Potential for the Assessment Period

ICAT Renewable Energy Methodology explains that in estimating the technical potential of RE, the addition involves the amount of renewable energy output that can be obtained by full implementation of the demonstrated technologies. 'Policy Cap' is defined as the maximum quantity of installed capacity that is supported by the policy in the ICAT guide and also for our assessment purposes.

Component A: The renewable energy addition is the state-wise installed capacity. In Figure 6, the highest renewable energy addition is in Rajasthan.

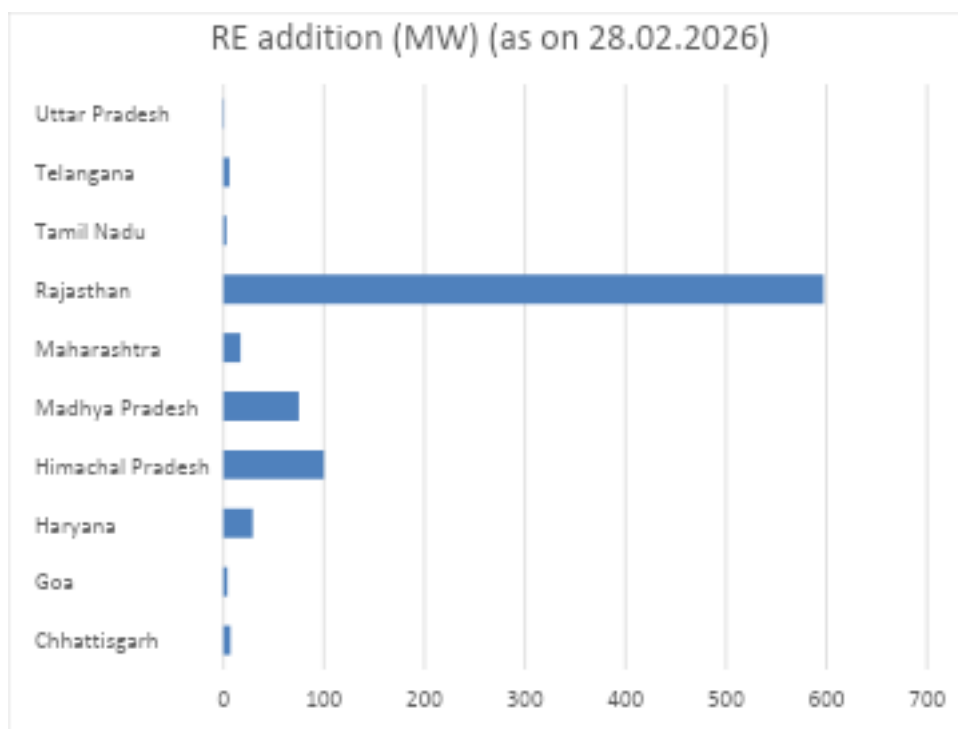


Figure 6: States by renewable energy addition under Component A

Component B: The installed capacity for solar pumps is the number of pumps that have been installed. To determine the technical potential, this value is converted to MW by multiplying the number of solar pumps by the sanctioned capacity, net calorific value of diesel, diesel density, and fuel consumption.

$$\text{RE addition (MW)} = S * \text{NCV} * \text{Density of diesel} * \text{Conversion factor of TJ into MWh} * \text{FC}$$

Where,

S = Sanctioned plant capacity (MW)

CUF = Capacity utilization factor (%)

NCF = Net calorific value of diesel (TJ/gG)

FC = Fuel consumption by 5HP of diesel pump per hour (in litre)

In Figure 7, the highest renewable energy addition is in the state of Maharashtra.

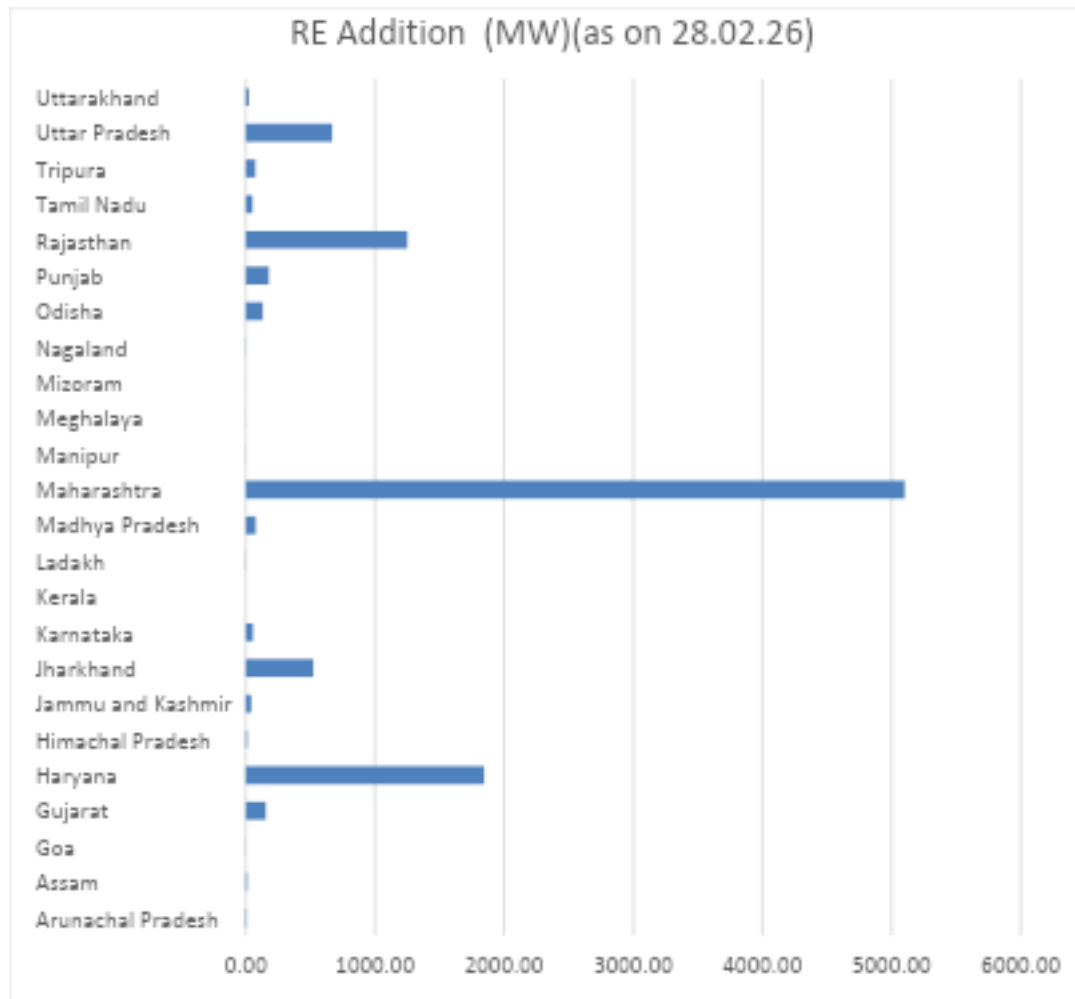


Figure 7: States by renewable energy addition under Component B

Component C (IPS): The installed capacity is the number of diesel pumps that will be solarized when connected to the grid . The technical potential is estimated as the product of the number of pumps and electricity consumption.

$$\text{RE addition ex-ante (MW)} = S \times E_t$$

Where,

S = Sanctioned plant capacity (MW)

E_t = Electricity generated by 3.5 HP electric pump that runs for 1 hr (kWh)

In Figure 8, the highest renewable energy addition is in the state of Telangana.

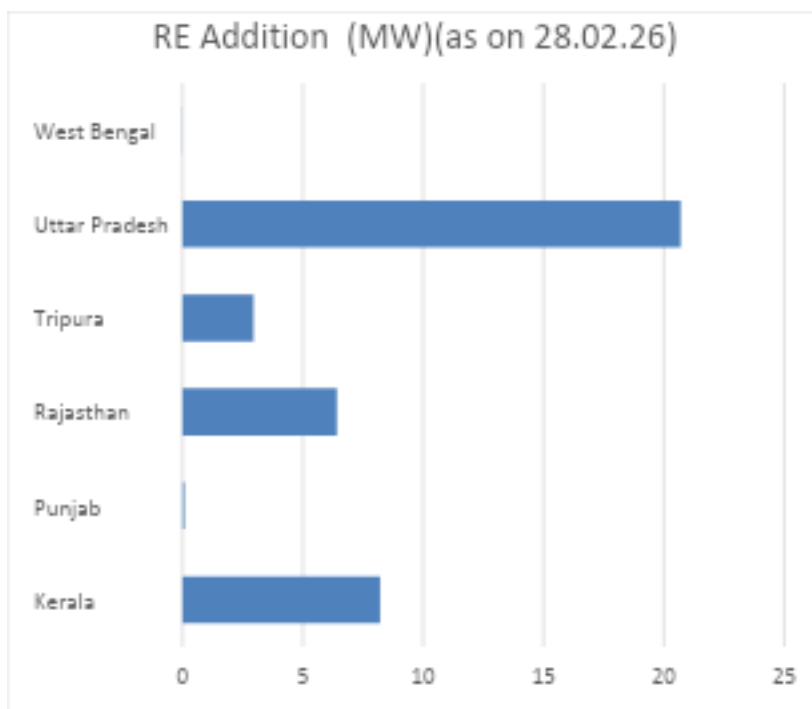


Figure 8: States by renewable energy addition under Component C (IPS)

Component C (FLS): The sanctioned capacity is the number of solar feeders that have been installed. To obtain the technical potential, this value is converted to MW by taking the product of the number of solar feeders and electricity consumption.

$$\text{RE addition ex-ante (MW)} = S \times Et$$

Where,

S = Sanctioned plant capacity (MW)

Et. = Electricity generated by 3.5-HP electric pump that runs for 1 hr (kWh)

In Figure 9, the highest renewable energy addition is in the state of Maharashtra.

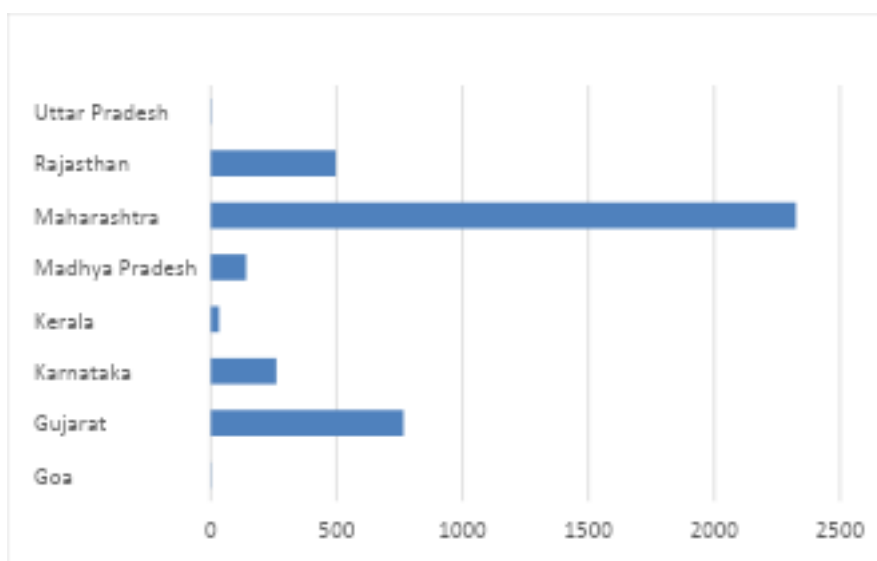


Figure 9: States by renewable energy addition under Component C (FLS)

3.6 GHG Emission Mitigated from 2025–30

Component A: Since solar power displaces grid-based electricity, the avoided emissions are estimated on an annual basis using plant capacity, capacity utilization factor (CUF), and the applicable emission factor. Thus, annual emission mitigation reflects the emissions that would have been produced in the absence of the solar installation.

Mitigation Potential (ex-post)

$$EA = S \times CUF \times 365 \times 24 \times EF_{grid}$$

Where,

EA = Emissions from component A (TCO₂)

S = Sanctioned plant capacity (MW)

CUF = Capacity utilization factor (%)

EF_{grid} = Grid emission factor (TCO₂/kWh)

Table 14: GHG mitigation in Component A

Year	Emission mitigated (MTCO ₂)
2025–26	12
2026–27	11
2027–28	10.1
2028–29	9.3
2029–30	8.5
Total	51

Yearly emission mitigation is calculated as the aggregate of emissions avoided across all states in a given year from Component A. Total emission mitigated from 2025–30 is 51 MTCO₂ for all states.

Component B: Under Component B, emission mitigation is achieved through the replacement of diesel-powered irrigation pumps with solar pumps. The mitigation potential is estimated based on the quantity of diesel displaced, using standard emission factors for diesel combustion, net calorific value, density of diesel and total operational time of the pump.

Mitigation Potential (Ex-Post)

$$EA = S \times NCV \times \rho \times EF_{grid} \times OT$$

Where,

EA = Emissions from component A (tCO₂)

S = Sanctioned plant capacity (MW)

NCV = Net calorific value

ρ = Density of diesel

EF_{grid} = Grid emission factor (tCO₂/kWh)

OT = Total operational time

Table 15: GHG mitigation in Component B

Year	Emission mitigated (MTCO ₂)
2025–26	2.5
2026–27	2.5
2027–28	2.5
2028–29	2.5
2029–30	2.5
Total	12.5

Yearly emission mitigation is calculated as the aggregate of emissions avoided across all states in a given year from Component B. Total emission mitigated from 2025–2030 is 12.5 MTCO₂ for all states.

Component C (IPS): Emission mitigation under Component C (IPS) is calculated based on the solar electricity generated, which displaces grid-based power consumption. The avoided emissions are estimated annually using the applicable grid emission factor, and electricity generated by the electric pump.

Mitigation Potential (Ex-Post)

$$EA = S \times Et \times EF_{\text{grid}} \times OT$$

Where,

EA = Emissions from component A (TCO₂)

S = Sanctioned plant capacity (MW)

Et. = Electricity generated by 3.5-HP electric pump that runs for 1 hr (kWh)

EF_{grid} = Grid emission factor (TCO₂/kWh)

OT = Total operational time

Table 16: GHG mitigation in Component C (IPS)

Year	Emission mitigated (MTCO ₂)
2025–26	0.08
2026–27	0.07
2027–28	0.07
2028–29	0.06
2029–30	0.06
Total	0.34

Yearly emission mitigation is calculated as the aggregate of emissions avoided across all states in a given year from Component C (IPS). Total emission mitigated from 2025–30 is 0.34 MTCO₂ for all states.

Component C (FLS): Emission mitigation under Component C (FLS) is calculated based on the solar electricity generated, which displaces grid-based power consumption. The avoided emissions are estimated annually using the applicable grid emission factor, reflecting the decarbonization of agricultural electricity use.

Mitigation Potential (ex-post)

$$EA = S \times EF_{grid}$$

Where,

EA = Emissions from component A (TCO₂)

S = Sanctioned plant capacity (MW)

EF_{grid} = Grid emission factor (TCO₂/kWh)

Table 17: GHG mitigation in Component C (FLS)

Year	Emission mitigated (MTCO ₂)
2025–26	5.1
2026–27	4.7
2027–28	4.3
2028–29	3.9
2029–30	3.6
Total	21.7

Yearly emission mitigation is calculated as the aggregate of emissions avoided across all states in a given year from Component C (FLS). Total emission mitigated from 2025–2030 is 21.7 MTCO₂ for all states.

3.6.1 Alignment of emission mitigated under PM-KUSUM with NDC targets

India's NDC targets, submitted in 2015, include reducing the emissions intensity of its GDP by 45% from 2005 levels by 2030, and achieving 50% of cumulative installed electric power capacity from non-fossil fuel-based energy resources by 2030. To achieve these targets various policies, schemes and programmes are launched to scale up India's action on both mitigation and adaptation.

Emission mitigation achieved under PM-KUSUM represents a decentralized contribution to India's NDC targets. By displacing grid electricity and diesel consumption in the agricultural sector, the scheme supports emission intensity reduction and expansion of non-fossil sources of energy.

The emission mitigation achieved is significant when assessed at scale, particularly when aggregated across multiple installations under the programme. The total emission reduction achieved by 2030 is 86 MTCO₂, contributing significantly to reducing emissions intensity by 2030.

3.7 Levelized Cost of Electricity and Financial Feasibility

The objective is to identify specific implementation challenges faced by stakeholders—particularly regarding the cost of agricultural pumps and the overall affordability of renewable energy technologies under the scheme. The ICAT methodology states that the Levelized Cost of Electricity (LCOE) should be lower than electricity tariffs. For the diffusion of technology, the costs of a given technology should be less than the current technologies or financial incentives provided by the RE policy. The State Electricity Regulatory Commission calculates the LCOE and decides on the tariff. Developers have opined that the tariff set by the State Electricity Regulatory Commission (SERC) is unviable for several reasons. The existing tariff-setting mechanism is not aligning with the developer's expectations leaving only a limited margin for the developers.

3.7.1 Component A

Parameter	Value
Plant Size	1 MW
Total CAPEX (assumed)	₹3.5 crore/MW
Discount Rate	10%
Plant Life	25 years
CUF	19%
O&M Cost	1.5%–2% of CAPEX/year

Annual Electricity Generation

= Plant size × Number of hours a plant is operated in year × CUF
 Where Number of hours a plant is operated is 8760 hours (24×365)
 =1MW×8760×0.19

= 1664.4 MWh/year

Using a capital recovery factor (CRF) for
 25 years, 10% discount rate:
 CRF≈0.110

Annualized CAPEX

=Total CAPEX× CRF
 =3.5 × 0.11= ₹38.5 lakh/year

Total O&M Cost

= O& M cost× Total CAPEX
 = 1.5% × 3.5 crore = ₹5.25 lakh/year

Total cost

= **Annualized CAPEX**+ **Total O&M Cost**
 = 38.5+5.25 = ₹43.75 lakh/year

LCOE

$$= \frac{\text{Total Cost}}{\text{Total Electricity Generation}}$$

$$= \frac{43.75 \text{ crore}}{1664}$$

$$= \mathbf{₹2.6 \text{ per kWh}}$$

Financial Feasibility - Tariffs under PM-KUSUM Component A are determined at the state level by Electricity Regulatory Commissions and are typically in the range of ₹3.1–₹3.3/kWh, based on levelized cost calculations and long-term (25-year) power purchase agreements. For instance, the Madhya Pradesh Electricity Regulatory Commission has determined a tariff of ₹3.25/kWh, while Telangana has set tariffs at approximately ₹3.13/kWh for Component A projects.²² However, year-wise tariff calculations indicate a declining trend, with per-unit

²² Madhya Pradesh Electricity Regulatory Commission. Details available at <https://mperc.in/uploads/petition_order_document/MPERC_PNo_13_2024_Final_Order_20_06_2024.pdf?utm_source=chatgpt.com>

tariffs reducing to around ₹2.6/kWh in later years due to lower financing costs and reduced debt servicing.

For Component B, we do not calculate LCOE as electricity generated from solar is not for sale and is only for consumption by farmers.

3.7.2 Component C (IPS)

Parameter	Value
Solar PV size	4 kW
Total CAPEX	₹2.4 lakh
Subsidy	60%
CAPEX after subsidy	₹1.0 lakh
Plant life	25 years
Discount rate	10%
CUF	19%
O&M cost	1.5% of total CAPEX

Subsidy: $60\% \times 2.4 \text{ lakh} = ₹1.44 \text{ lakh}$

Net CAPEX (CAPEX after subsidy) = ₹ (2.4 – 1.44) lakh = ₹0.96 lakh

Annual Electricity Generation = $4 \times 8760 \times 0.19 = 6657.6 \text{ kWh/year}$

Using a **capital recovery factor (CRF)** for

25 years, 10% discount rate:

$CRF \approx 0.101$

Annualized CAPEX = $0.96 \times 0.11 = 0.1056 \text{ lakh/year}$

Annual O&M

$O\&M = 1.5\% \times 2.4 = 0.036 \text{ lakh/year}$

Total cost = ₹ (0.1056 + 0.036) = ₹0.1416 lakh/per year

LCOE = $\frac{0.1416}{8,760 \times 6657.6}$
= ₹2.1 per kWh

Financial Feasibility: Tariffs under PM-KUSUM Component C (IPS) are determined at the state level by Electricity Regulatory Commissions and are typically in the range of ₹2.6–₹3.51/kWh, based on levelized cost calculations and long-term (25-year) power purchase agreements.

3.7.3 Component C (FLS)

Parameter	Value
Plant size	1 MW
Total CAPEX (assumed)	₹3.5 crore/MW
Subsidy (CFA %)	30%
Effective CAPEX	₹2.45 crore (total Capex – subsidy)
Discount rate	10%
Plant life	25 years
CUF	19%
O&M cost	1.5%–2% of CAPEX/year

Annual electricity generation = $1 \text{ MW} \times 8760 \times 0.19 = 1664.4 \text{ MWh/year}$

Using a **capital recovery factor (CRF)** for

25 years, 10% discount rate:

$CRF \approx 0.101$

Annualized CAPEX = $2.45 \times 0.11 = ₹26.95$ lakh/year

Annual O&M

O&M = $1.5\% \times 3.5 = ₹5.25$ lakh

Total Annual cost = ₹ (26.95+ 5.25) = ₹32.2 lakh

LCOE = $\frac{32.2}{16.64}$
= **₹1.94 per kWh**

Financial feasibility: Under Component C (FLS), tariffs are discovered through state-level competitive bidding processes and regulatory approvals. Recent evidence suggests tariffs ranging from approximately ₹2.1/kWh to ₹3.6/kWh.²³

3.8 Qualitative Assessment

The approach used is derived from World Bank stakeholder analysis,²⁴ involving a systematic approach to delineate aspects of policy in terms of their role in design, implementation, influence and on-ground engagement. Multiple reports on PM-KUSUM produced by the government and development agencies were reviewed. Based on this review, 13 criteria were selected, which anchor the analysis of the evaluation. Each interview conducted with the stakeholders was analysed with respect to 13 criteria. These criteria were selected based on an initial review of the existing literature on PM-KUSUM and an analysis of stakeholder interviews. These criteria also align with the TOC for each component. The inputs and activities in the ToC relate to policy, regulation, and institutional readiness. The outputs and outcomes measure tangible implementation results, adoption, and impact on farmers. The long-term impacts link directly to India's SDG commitments and NDC targets. The 13 stakeholder criteria effectively capture both operational bottlenecks, strategic goals, and long-term impacts, bridging the ToC from inputs to impact. The criteria are - 1) Alignment with State RPO targets; 2) State regulatory support for tariffs; 3) State regulatory support for land; 4) Capacity of state implementing agencies; 5) Coordination between MNRE, DISCOMs and Agriculture Department; 6) Monitoring and Reporting System; 7) Training and outreach mechanism for farmers; 8) Grid infrastructure readiness; 9) CAPEX and OPEX affordability for farmers; 10) Community Ownership Models; 11) Availability of concessional finance and credit; 12) Payment Reliability from DISCOMs; 13) Impact on water use efficiency.

The ICAT methodologies were then evaluated against these criteria by extracting evidence from ICAT-Renewable Energy Methodology (REM) and ICAT-Sustainable Development Methodology (SDM). This also substantiates the feasibility of REM, and SDM to evaluate renewable energy policy like PM-KUSUM in developing countries.

1. **Alignment with Renewable Purchase Obligation (RPO) targets:** Since 2010–11, the Ministry of Power, Government of India, has relied on the use of RPO as an instrument

²³ Tariffs (2025). Details available at <https://einfews.energyinfra.market/post/gerc-approves-lowest-tariff-rs215ckwh-for-pm-kusum-component-c-scheme/?utm_source=chatgpt.com>

²⁴ Stakeholder Analysis and Engagement Plan for Sundarban Joint Management platform

to meet the Nationally Determined Contributions (NDCs) and promote renewable energy deployment.²⁵ Decentralized agri-solar can contribute towards state RPO through Components A and C, which are structured to feed power into the grid via state-determined tariffs and PPAs, aligning agricultural solarization with utility obligations. Evidence gathered from Jaipur DISCOM shows that the DISCOM was not aligned towards the state RPO, however, due to successful uptake of PM-KUSUM, the DISCOM has started aligning capacity sanctioned under the components with RPO obligations. DISCOMs need time to align the component with their power-purchase planning and gain maximum benefit from the implementation of the component. REM mentions biofuels obligation and mandates similar to RPO obligations which is mentioned in the section of the overview of its methodology, however, not included in the methodology.

- 2. Tariffs are regulated by States:** The innovative process of inviting tariff-based bids for grid-connected solar power projects was adopted during the Jawaharlal Nehru National Solar Mission (JNNSM) launched in 2010. Solar tariff approved by the Central Electricity Regulatory Commission was ₹17.91/kWh in 2010–2011; however, over a period of time, solar tariffs have considerably reduced and were ₹2/kWh in 2022. Tariff discovery proceeds via competitive tenders and committee negotiations. Open tenders allow broad participation from developers, where the technical bid and then the financial bid are opened, and each can give its own tariff rate. These tariff rates are negotiated and finalized by the committee; the petition is then submitted to the regulator, which approves the tariff rates. MNRE's domestic content requirement (DCR) for module production increased CAPEX, as imported module prices are much lower.²⁶ In September 2024, the MNRE decided to reimpose DCR with effect from June 1.²⁷ Central Financial Assistance (CFA) under the PM-KUSUM Scheme is conditional on using domestically manufactured solar components (solar cells and modules)—except where a waiver applies. It is not viable to use domestically produced modules, given the amount of CFA provided and the tariff rates. The Rajasthan Electricity Regulatory Commission reported that bidders were asked to agree to counter-offer tariffs, indicating that DCR changes affect tariffs. REM provides evidence that, depending on the country's regulatory agencies and public utilities are responsible for designing and implementing RE policies. Feed-in-tariff (FiT) policies aim to promote RE deployment by offering long-term purchase agreements with power producers at a specified price per kilowatt-hour (kWh). FiT provides predictable long-term revenue, which is crucial for securing project finance. Developers under PM-KUSUM sign 25-

²⁵ List of RPO regulations accessed from https://www.recregistryindia.nic.in/index.php/publics/Reference_Documents (as on 15- June-2023)

²⁶ Imported modules for 1MW plant cost ₹2.75 crore while with DCR 1 MW cost ₹4.4 crore.

²⁷ Saur Energy (2025) MNRE eases ALMM Rules for Solar Cells use, Retains June 2026 Mandate

year PPA with DISCOMs at a prefixed FIT. Low FiTs disincentivize participation in PM-KUSUM, as developers cannot cover O&M and land-leasing costs at those tariff levels.

3. **Land Policy is regulated by the State:** Since land is a state subject, regulatory clarity on land leasing is uneven across states. Land leasing rate differs across states which impacts the compensation that farmers receive from developers. Land aggregation for setting up of solar power plants in Component A is required as the minimum requirement is 1 hectare, and land holdings tend to be less than 1 hectare. Portal, however, at times incorrectly reports that land aggregation is not available, hence there is a gap in information on the land that has been aggregated and what has been recorded in the portal. In Component C, there was difficulty acquiring suitable land near substations as some government land was unusable. Land acquisition delays can stall progress. If commercial activities like agrivoltaics²⁸ is undertaken on an agricultural land over a period of 2 years, the agricultural land automatically gets converted into commercial land, such specifications on land-use need reforms. New policies should be designed to increase the feasibility of the Farmer Producer Organization to retain land and ownership of the project. REM and SDM do not provide evidence on how land reforms can increase the deployment of renewable energy. SDM broadly discusses the identification and promotion of policies that contribute to multiple Sustainable Development Goals. Agrivoltaics is an SDG enabler, impacting SDG 2, SDG 7, SDG 8, and SDG 13. SDG 2: Zero Hunger – agrivoltaics allows farmers to grow crops under solar panels while earning income from leasing their land and diversifying livelihood. SDG 7: Affordable and Clean Energy – agrivoltaics directly adds renewable energy capacity without requiring additional land. SDG 8: Decent Work and Economic Growth – provides farmers with additional income from leasing land and selling power. SDG 13: Climate Action – supports mitigation by expanding renewable energy generation.
4. **Capacity of State Implementing Agencies (SIA):** There is noted unevenness in the technical and administrative capacity of SIAs to implement PM-KUSUM. Punjab is one of the more underperforming states in the country. Pumps up to the capacity of 15 hp are permitted to be installed under the PM-KUSUM scheme. However, a subsidy is only offered up to 7.5 hp. The pumps with a capacity of 7.5–15 hp are eligible for subsidy amount offered on a 7.5 hp water pump. The low water levels need bigger water pumps in order to lift water and to cover large landholdings. There is a lack of decentralization in the implementation – all Components of PM-KUSUM are handled by the State Nodal Agency, Punjab Energy Development Agency (PEDA). State Nodal Agencies (SNAs) in all states shoulder the complex tasks of tendering, vendor

²⁸ Agrivoltaics is the practice of combining agriculture and solar power on the same land

oversight, installation verification, ensuring timely O&M and regular progress reporting to MNRE and the Central Ministry. While SNA is also an energy agency, it has limited experience working with the farmers. Haryana is one of the top-performing states wherein the implementation is handled by State Nodal Agency (SNA) which is Haryana Renewable Energy Development Agency (HAREDA) and the state DISCOMs. Component B is handled by HAREDA and Component A, C are handled by DISCOM. Rajasthan is the most successful state across all three components. The implementation system in Rajasthan is decentralized, wherein Component A is managed by the State Nodal Agency- Rajasthan Renewable Energy Corporation Limited (RRECL), Component B is managed by the Horticulture Department, and Component C is managed by the state DISCOM. One reason for the successful implementation of Component B is the Horticulture Department's management, which has a strong network of block and field staff that raises awareness and disseminates knowledge about agricultural subsidies. There is also convergence among schemes such as PM Kusum, the Pradhan Mantri Krishi Sinchaye Yojana (PMKSY), the Rashtriya Krishi Vikas Yojana Remunerative Approaches for Agriculture and Allied Sectors Rejuvenation (RKVY-RAFTAAR), and the Atal Bhujal Yojana. SIAs should coordinate and collaborate with these schemes, as objectives often overlap. Atul Bhujal Yojana is a groundwater management scheme that aims to improve water use efficiency and enhance groundwater recharge. The inputs from this scheme can feed into PM-Kusum and will also enhance the capacity of SIAs. REM states that there is a lack of strong, dedicated institutions to implement policies, thereby creating institutional and administrative barriers. SDM provides evidence that enabling actions are training and capacity building of stakeholders involved in the programmes, such as government staff, utilities, and regulatory commissions.

- 5. Coordination between MNRE, SNA, DISCOMs, Irrigation Department, Department of Revenue and Agriculture Department:** Horizontal coordination is critical between MNRE, SNA and DISCOM for the implementation of all Components. MNRE's key function is policy formulation, including the issuance of operational guidelines, technical specifications, and financing norms for the scheme. It also releases Central Financial Assistance to SNA for Component B and C. Depending on the Component, SNA or the DISCOM is responsible for land identification and approvals, procurement & tendering, grid connectivity, and payments to developers & farmers. In the initial stage of PM-KUSUM implementation, effective coordination between the MNRE, SNAs and DISCOMs forms the foundation for operationalizing the scheme's objectives. This stage primarily focuses on policy alignment, resource allocation, and target-setting mechanisms. The second stage of implementation focuses on ground-level operationalization. DISCOMs and SNAs act as central facilitators and coordinate with farmers, DoR, the Agriculture Department, and the Irrigation Department. Evidence from Jaipur DISCOM indicates that coordination

among the MNRE, SNA, and DISCOM is smooth, as the MNRE regularly monitors the capacity commissioned by DISCOMs. If the DISCOM is unable to sign enough PPAs and commission capacity, the DISCOM is required to surrender capacity to SNA. While the MNRE, SNA, and DISCOM have established operational modalities, integration with indirect stakeholders, such as the Irrigation Department, the Department of Revenue, and the Department of Agriculture, remains fragmented. As mentioned in REM, there are complex interactions and a lack of coordination between the various authorities involved, which require institutional and administrative reforms. SDM states policy may not achieve its full potential because of governance challenges, such as a lack of capacity, interagency coordination, public participation or accountability.

6. **Monitoring and Reporting System:** National Monitoring Portal, which is the PM-KUSUM Dashboard is hosted by the MNRE, which captures state-wise progress across all portals, including solar installations, pump development, and feeder level data. The portal shows sanctioned vs commissioned data and does not report on intermediate data. For sanctioned capacity, it does not report on tenders issued and letters of award issued. For commissioned capacity, it does not report on signed PPAs or on commissioned capacity. The UK-India Power Sector Reform programme assisted the MNRE in designing the Solar Energy Data Management System (SEDM) platform, which enables real-time data integration from state monitoring systems. SEDM enables tracking of solar pump and plant performance, thereby strengthening accountability in subsidy approvals. SNAs integrate quarterly reports, including maintenance and performance metrics, into the MNRE system in accordance with the prescribed format and guidelines. The quarterly reports are prepared by engineers who visit the field sites to obtain performance data. In states such as Rajasthan, a PPA is cancelled if the project development timelines are not met. REM states that to measure installed RE capacity, monitoring reports, surveys, and installation registers should be used.
7. **Training and outreach mechanisms amongst farmers:** Farmers are key beneficiaries for installing solar pumps, leasing land for decentralized lands, and selling surplus power. Awareness of the scheme is low among small farmers, and uptake is higher among large farmers with larger landholdings. Collaboration is required amongst the implementing agencies, like the irrigation, agriculture, and horticulture departments in all states, to create awareness and training. REM provides evidence that there is insufficient knowledge about the availability, benefits and performance of RE. However, more clarity is required on how to raise awareness among the different types of RE end users.

8. **Grid infrastructure readiness:** The readiness of grid infrastructure is central to the success of PM-KUSUM, particularly for Components A and C. The MNRE guidelines require DISCOMs to ensure that substations, feeders, and evacuation infrastructure are prepared for project commissioning. However, readiness varies widely across states. In Odisha, where the scheme has performed poorly due to poor grid infrastructure quality, feeder segregation is not in place, and weak substations have delayed solarization. Since the Component A power plant is connected to the substation, poor maintenance of the substation by many DISCOMs often results in frequent tripping of the entire substation. Component C – FLS focuses on solarizing feeder lines by setting up decentralized solar plants near agricultural feeders, net metering allows farmers to sell surplus solar power to the electricity grid. The last-mile infrastructure is critical but often overlooked in a scheme’s planning. DISCOMs assign the lowest priority to agricultural feeder networks because revenue recovery is too low. Developers have also raised concerns about the poor state of rural feeder infrastructure. There are successful projects, such as in Karnataka, where nine villages in Bengaluru have reduced the burden on the Bangalore Electricity Supply Company (Bescom) grid by supplying 68 MW of electricity daily. Bescom hopes to save 2,400 MW daily when all its planned 150 KUSUM-C stations are operational.²⁹ Grid upgrading at the distribution level is critical; this can be facilitated by convergence with other schemes, such as the Revamped Reforms-based and Results-linked Distribution Sector Scheme. REM provides evidence of a lack of flexibility in the energy system, specifically the electricity grid, to integrate or absorb RE. Energy markets are not prepared for RE, i.e., integration of intermittent energy sources, grid connection, and access are not fairly provided. Grid connection costs are higher for RE. There is a history of technical problems with grid infrastructure that prevent decentralized access to the grid for RE.

9. **CAPEX and OPEX affordability for farmers:** Capital investment and operational cost are too high for small farmers. The cost of SPP is ₹3.5–4 crore/MW, with no subsidy in component A, and 60% subsidy from the state and central government for Component C, resulting in an upfront cost of ₹1.4–2.6 crore. For Component B, the cost of a 3 HP solar pump is ₹1.8–2.5 lakh, of which the farmer pays ₹45,000, and a 5 HP solar pump is ₹2.5–3.5 lakh, of which the farmer pays ₹65,000. This CAPEX is too high for small and marginal farmers which limits the participation in the scheme to big farmers. OPEX for a utility-scale plant is ₹2–2.5 lakh/MW and it increases to ₹4.5–5 lakh/MW for a small-scale distributed power plant. The scheme does not ensure equity and

²⁹ Times of India. (2024, April 23). *8 villages tap solar power, help BESCOM meet summer surge*. Details available at <<https://timesofindia.indiatimes.com/city/bengaluru/8-villages-tap-solar-power-help-bescom-meet-summer-surge/articleshow/120905574.cms>>

inclusion for small and marginal farmers.³⁰ REM and SDM do not provide evidence on the impact of RE on end users who are the farmers in this case.

10. **Community ownership models:** Achieving equity and inclusion requires a shift from individual participation models to community-based approaches. Leveraging cooperatives, panchayats, Farmer Producer Organizations (FPOs), Water User associations (WUAs) can enable collective decision-making, shared ownership, and pooled resources, especially for smallholders. Component A specifies these collective ownership and partnership models; however, these models haven't been widely adopted. Through FPO models, community-based land aggregation is encouraged; however, in practice, fragmented landholdings make pooling difficult. There is an absence of capacity building support for FPOs to participate in the scheme. REM states that building trust, collaboration, shared ownership and support for policies among stakeholder groups is critical for smoother implementation.
11. **Availability of concessional finance and credit:** Many banks classify Component A projects as high risk since there are payment delays from DISCOMs, absence of central and state subsidy, and lack of guarantees. Margin money requirements are 30% of the total project³¹ cost, many farmers were successful in acquiring bids but were unable to implement it due to large share of margin money requirements and inability to secure loans. Farmers have demanded a 9:1 loan-to-equity ratio to access bank loans, which is not acceptable by the banks. According to the MNRE guidelines, loans for feeder segregation can be taken from National Bank for Agriculture and Rural Development (NABARD), Power Finance Corporation (PFC), or Renewable Energy Corporation (REC). Similar guidelines for the provision of SPP loans to farmers in Component A can be introduced. The National Agriculture Infra Financing Facility could also be utilized to finance Component A projects. Under the Mukhyamantri Laghu Udyan Protsahan Yojana (MLUPY), a 6% interest subvention was provided, which encouraged farmers to set up SPPs. CFA should be increased in Components B and C, specifically if DCR modules need to be promoted, since it is not cost-effective to buy domestically produced modules. To promote equity and inclusion through community-based approaches, a subsidized credit window via NABARD specifically for holdings of less than 2 hectares should be established. REM and SDM do not provide evidence on how the availability of concessional finance and credit can increase the adoption of RE.
12. **Payment reliability from DISCOMs:** Apart from the DISCOMs of a few states like Karnataka, Rajasthan, and Gujarat, other DISCOMs have routinely failed on timely

³⁰ The data quoted is extracted from interviews with stakeholders

³¹ Rajasthan Policy Dialogue of PM-KUSUM Component A and Component C, 2023

payments. States should implement financial security mechanisms, such as payment assurances, to ensure regular payments to developers/farmers. Rajasthan has enforced payment assurances to protect developers/farmers. This has also boosted banks' confidence in financing farmers to set up solar plants. REM and SDM do not provide evidence on the mechanisms that can make an implementing partner more reliable, thereby encouraging RE.

13. **Water use efficiency:** Groundwater plays a key role in boosting agricultural production. The provision of subsidized power to farmers has led to widespread use of irrigation pumps and over-extraction of the resource. In Punjab, a study by the Mahatma Gandhi State Institute of Public Administration (MGSIPA) suggested that groundwater depletion is linked to agricultural electricity supply. Cost-reflective electricity pricing is the long-term solution to address groundwater concerns.³² Due to political sensitivities, if states have to provide subsidized electricity supply, then they should consider other strategies for groundwater management, as free or subsidized supply of electricity often leads to higher extraction of groundwater. The Paani Bachao Paisa Kamao (PBKY) scheme was voluntary and employed a Direct Benefit Transfer (DBT) model to incentivize farmers to use electricity and water judiciously. The impact of PM-KUSUM scheme on water use efficiency still needs more clarity as experts have suggested that impacts on the groundwater are detectable only in the long term. The effect of Agrivoltaics (Agri-PV) on water use efficiency is more robust. Agri-PV will improve water use efficiency because panel shade will lower heat/wind, which will cut evapotranspiration and keep soil wetter between irrigation cycles. Data gathered from the field shows that Agri-PV can save up to 20% of irrigation water.³³ Water-use efficiency is addressed under SDG 6, which focuses on ensuring access to clean water and sanitation for all. SDM provides an example of an SDG monitoring plan for cities that sets a 2030 target to substantially increase water-use efficiency across all sectors, ensure sustainable withdrawals and supply of fresh water to address water scarcity, and substantially reduce the number of people suffering from water scarcity. The indicator used to measure change is water-use efficiency over time.

4. Reflections on the findings

4.1 Impact of the PM-KUSUM Scheme

The overarching scheme objectives are to provide energy and water security to farmers, enhance their income, de-dieselize the farm sector, and reduce environmental pollution by promoting solar power for irrigation and enabling farmers to sell surplus energy. All outcomes of PM-KUSUM meet these projective objectives. However, each outcome has a distinct contribution to the objective. These are discussed below.

³² IISD (2023) *Implementing Solar Irrigation Sustainably: A Guidebook for State Policy-Makers on Implementing Decentralized Solar Power Plants through PM-KUSUM Components A and C (Feeder-Level Solarization)*

³³ Jat, N. K., Poonia, S., Santra, P. (2025). Agrivoltaics: A Promising Farming System for the Western Arid Regions of India. *Indian Farming* 75 (3): 14–18. (ICAR-CAZRI)

1) Decentralized solar generation and feeder-level solarization

The contributions to the objectives are: a) Reduce DISCOM losses by lowering the cost of supplying subsidized agricultural power, b) Improve voltage stability in rural feeders, c) Improve daytime power availability, d) Grid resilience will be enhanced as dependence on centralized generation will be reduced.

2) Reliable daytime electricity for irrigation

The contribution to the objectives is – a) By lowering the electricity input costs for farmers, the dependence on diesel pumps is reduced, b) By enabling predictable irrigation schedules, it supports the adoption of efficient irrigation systems like drip irrigation and sprinkler irrigation.

3) Replacement of fossil-fuel-based energy with solar power

The contribution to the objectives is: a) Reduced GHG emissions from diesel and coal-based power production, b) Support energy security for farmers, c) Support India's NDC targets and enhance mitigation outcomes.

4) Long-term PPAs through competitive bidding

The contribution to the objectives is: a) Long-term subsidy burden is reduced on DISCOMs, b) By facilitating solar power for agriculture, it reduces the DISCOMs' procurement costs.

4.2 Usability and Practicality of REM, and SDM

Table 18 illustrates the feasibility of REM, and SDM in analysing the selected criteria for the overall framework. Using a normative analysis lens, the feasibility of applying different ICAT methodologies was evaluated in the context of renewable energy policy in developing countries, with specific focus on India's PM-KUSUM Scheme.

The comparative assessment across ICAT dimensions against the 13 criterion highlights clear differences in how the REM, and SDM methodologies capture enabling conditions and impact.

REM performs strongly on power-sector-oriented criteria, including aligning with RPO targets, State regulatory support for land leasing and tariffs, Capacity of state implementing agencies, Coordination between the MNRE, DISCOM & Agriculture Dept, Training & Outreach mechanism, Grid infrastructure readiness, and availability of concessional finance. It reflects adequately on institutional capacity, compliance with regulatory requirements at a federal level, and inter-departmental capacity. It provides methodological guidance on how to estimate emissions pathways and reductions resulting from the implementation of policies in the energy sector.

SDM performs strongly on Capacity of state implementing agencies, Coordination between the MNRE, DISCOM & Agriculture Dept, Monitoring and Reporting System, Training & Outreach mechanism, Community Ownership Mechanism, Payment Reliability from

DISCOM, and Water Use Efficiency. It addresses the socio-economic and sustainability dimensions.

The tick-and-cross matrix below shows how each methodology addresses each criterion.

Table 18: Feasibility of REM and SDM in analysing the criteria

Criterion	ICAT Dimension: Renewable Energy Methodology	ICAT Dimension: Sustainable Development Methodology
Alignment with RPO targets	✓	✗
State regulatory support for land leasing and tariffs	✓	✗
State regulatory support for land policy	✗	✗
Capacity of state implementing agencies	✓	✓
Coordination between MNRE, DISCOMs and Agriculture Department	✓	✓
Monitoring and reporting systems	✗	✓
Training and outreach mechanisms (farmer awareness)	✓	✓
Grid infrastructure readiness	✓	✗
CAPEX & OPEX affordability for farmers	✗	✗
Community ownership models	✗	✓
Availability of concessional finance and credit	✓	✗
Payment reliability from DISCOMs	✗	✓
Water use efficiency	✗	✓

4.3 Scope of Improvement in the ICAT Methodologies

- 1. Renewable energy methodology:** The methodology is intended for use by policymakers and practitioners. However, it does not integrate the impact on end users of the renewable energy policy, even though it included those affected by the policy in the stakeholder consultation process. It does not capture the CAPEX and OPEX affordability for end users. If CAPEX and OPEX are not feasible, the actual uptake will be much lower. Monitoring and reporting systems should be incorporated in the design of renewable energy policies. This will provide evidence of which policies are working and which are not. While analysing PM-KUSUM Scheme, how payment reliability impacts the uptake of the technology was explored. The impact of contractual enforcement, like enforcing PPAs, payment security mechanisms, and land lease on capacity commissioning and utilization also needs to be incorporated.
- 2. Sustainable development methodology:** It aims to evaluate the impact of policies and actions on sustainable development. However, it tends to oversimplify development benefits without sufficiently accounting for varied outcomes. These outcomes are closely tied to equity issues, as benefits are not evenly shared among the beneficiary groups. For example, income benefits from PM-KUSUM vary widely and are highly affected by local implementation conditions. These differences in the development outcomes were not reflected in the methodology. It also failed to fully address certain implementation-specific challenges, especially in a developing country like India, which has a federal governance structure.

Conclusion

The current assessment demonstrates that the intervention has the capacity to deliver measurable and policy-relevant GHG mitigation outcomes, with total ex-post emission reductions by 2030 estimated at 86 MTCO₂. The actual GHG mitigated ex-ante as of February 2026 was only 6.2 MTCO₂. This gap shows that implementation of the Scheme is constrained by financial and institutional limitations, thereby affecting the realization of its full deployment and mitigation potential. It represents a high impact mitigation potential within the agriculture-energy nexus.

Low tariffs disincentivize participation in the Scheme, as developers cannot cover operations and maintenance (O&M) and land-leasing costs at those tariff levels.

For Component A, the estimated LCOE of ₹2.6/kWh is lower than the prevailing tariff range of ₹3.1–3.3/kWh, indicating financial viability. However, the relatively moderate margin may limit investor attractiveness when accounting for operational and payment-related risks.

For Component C, the estimated LCOE of ₹1.94/kWh is below the observed tariff range of ₹2.1–3.6/kWh, indicating overall financial viability. However, at the lower end of the tariff spectrum, margins remain tight, making project viability sensitive to operational performance and payment-related risks.

This assessment report applies the ICAT REM and SDM to evaluate the policy design, implementation and impacts of the PM-KUSUM Scheme. The primary objective of this report was to estimate renewable energy additions, assess greenhouse gas (GHG) mitigation potential, and analyse the social, environmental, and economic impacts of the scheme through both quantitative and qualitative lenses. These objectives align directly with the broader ICAT assessment goals, which seek to:

- Improve quality of reporting to the UNFCCC (biennial transparency reports (BTRs) and national communications
- New or refined policies and measures in support of a collective 2/1.5-degree ambition in the Nationally Determined Contributions (NDCs)
- Improve climate and/or sustainable development policies

While the ICAT methodologies provide a structured framework for estimating impacts, conducting stakeholder consultations, and mapping causal pathways, the evaluation of the PM-KUSUM Scheme provides evidence that REM and SDM methodologies have gaps. They do not fully capture certain implementation-specific challenges specifically in a developing country like India which has a federal governance structure. States in India differ on land policy, tariff policy, RPO targets, these variations amongst states are not captured by REM and SDM. REM does not fully capture the end user impacts of renewable energy policies. SEM generalizes development benefits without adequately reflecting variation in outcomes.

Therefore, while REM and SDM serve as the guiding frameworks for structuring the analysis, the evaluation requires a more contextualized, field-driven approach. By integrating primary evidence from stakeholder consultations and state-level implementation insights, the report presents a comprehensive understanding of PM-KUSUM's progress, challenges, and opportunities. The findings identify pathways to enhance Scheme design, accelerate deployment, and improve policy coherence for future ICAT-aligned assessments.

The assessment highlights key lessons for improving the effectiveness and scalability of the Scheme in India. Tariff determination, capacity of state implementing agencies, and coordination across multiple institutions emerge as the most critical criteria influencing policy implementation, as they directly affect financial viability, pace of deployment, and on-ground execution.

The determination of tariffs by regulators needs strengthening to ensure greater profit margins for developers. The institutional capacity at the state level emerges as a critical bottleneck, affecting timelines, coordination, and overall implementation efficiency. States with stronger implementing agencies and clearer processes demonstrate higher deployment rates, indicating that administrative readiness is as important as financial incentives. Horizontal coordination across institutions is a critical determinant of implementation effectiveness. While coordination between the Ministry of New and Renewable Energy (MNRE), State Nodal Agencies (SNAs), and DISCOMs is relatively well-established and supported by defined roles, monitoring mechanisms, and clear operational responsibilities, gaps persist in integrating indirect stakeholders such as the Irrigation Department, Department of Revenue, and Agriculture Department. Evidence suggests that although MNRE-led oversight and structured processes enable alignment in early stages, coordination becomes more fragmented during ground-level implementation, where multiple departments are involved for land approvals, farmer engagement, and infrastructure deployment.

From a policy perspective, the results underline the importance of linking programme-level outcomes with national climate targets, particularly under India's Nationally Determined Contributions (NDCs). The intervention aligns with India's commitments to reduce emissions intensity of GDP and expand non-fossil fuel-based electricity capacity, while also supporting co-benefits such as energy security and improved rural livelihoods. To effectively track program-level outcomes, it is necessary to strengthen MRV frameworks as it would enable accurate tracking of energy generation, system performance, and associated GHG emission reductions.

Annexures

Annexure 1: Policy implementation status

Component: Objectives ³⁴	Achievements (as on 28 th Feb, 2026)	
Component A: 10,000 MW of solar capacity through installation of small solar power plants of individual plants of capacity up to 2 MW	Total sanctioned: solar capacity (MW)	Total installed: solar capacity (MW)
	10,000	839
Component B: Installation of 14 lakh standalone solar powered agriculture pumps	Total sanctioned stand-alone pumps (No.)	Total installed stand-alone pumps (No.)
	1,330,190	1,026,862
Component C: Solarization of 35 lakh grid-connected agriculture pumps, including feeder-level solarization	Total pumps sanctioned for individual pump solar – IPS (No.)	Total pumps solarized under installed individual pump solar- IPS (No.)
	55,392	12,787
	Total pumps sanctioned for feeder level solar-FLS (No.)	Total pumps solarized under feeder level solar- FLS (No.)
	35,13,602	13,41,892

³⁴ Ministry of New and Renewable Energy (MNRE) (2025). Details available at <<https://mnre.gov.in/en/pradhan-mantri-kisan-urja-suraksha-evam-utthaan-mahabhiyaan-pm-kusum/>>

Annexure 2: Assessment of GHG impacts of the PM-KUSUM scheme: summary results

State/UT name	Component A		Component B		Component C IPS		Component C FLS	
	Ex-ante	Ex-post	Ex-ante	Ex-post	Ex-ante	Ex-post	Ex-ante	Ex-post
Andaman and Nicobar Islands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Andhra Pradesh	0.0	0.0	0.0	0.0	0.0	0.0	0.47	0.0
Arunachal Pradesh	0.0	0.0	0.00	0.00	0.00	0.00	0.0	0.0
Assam	0.0	0.0	0.01	0.00	0.01	0.00	0.0	0.0
Bihar	0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.0
Chandigarh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chhattisgarh	0.4	0.0	0.0	0.0	0.0	0.0	0.02	0.0
Dadra and Nagar Haveli and Daman and Diu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delhi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Goa	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.00
Gujarat	0.1	0.0	0.04	0.03	0.0	0.0	0.74	0.53
Haryana	0.1	0.0	0.38	0.36	0.0	0.0	0.00	0.0
Himachal Pradesh	0.1	0.1	0.00	0.00	0.0	0.0	0.0	0.0
Jammu and Kashmir	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0
Jharkhand	0.0	0.0	0.17	0.10	0.0	0.0	0.0	0.0
Karnataka	0.0	0.0	0.08	0.01	0.0	0.0	1.21	0.18
Kerala	0.0	0.0	0.00	0.00	0.0196	0.01	0.04	0.02
Ladakh	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0
Lakshadweep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madhya Pradesh	1.7	0.1	0.11	0.01	0.0	0.0	0.40	0.10
Maharashtra	0.2	0.0	1.11	0.99	0.0	0.0	1.23	1.61

Manipur	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0
Meghalaya	0.0	0.0	0.01	0.00	0.0	0.0	0.0	0.00
Mizoram	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0
Nagaland	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0
Odisha	0.1	0.0	0.04	0.03	0.0	0.0	0.01	0.0
Puducherry	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.00
Punjab	0.0	0.0	0.03	0.03	0.0004	0.00	0.0	0.00
Rajasthan	8.3	1.2	0.28	0.24	0.0044	0.00	0.64	0.34
Sikkim	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.00
Tamil Nadu	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.00
Telangana	2.1	0.0	0.04	0.00	0.0581	0.0	0.0	0.00
Tripura	0.0	0.0	0.02	0.01	0.0075	0.00	0.0	0.00
Uttar Pradesh	0.0	0.0	0.21	0.13	0.0249	0.01	0.59	0.00
Uttarakhand	0.0	0.0	0.01	0.00	0.0	0.0	0.0	0.00
West Bengal	0.0	0.0	0.00	0.00	0.0000	0.00	0.0	0.00
Total	13.17	1.42	2.56	1.97	0.11	0.03	5.58	2.78

Annexure 3: List of stakeholders

Organization	Contact person
CEEW	Mr Bharat Sharma
GIZ	Mr Nilanjan Ghose, Ms Ruchi Gupta
ICRIER	Mr Subhodeep Basu
CSEP	Mr Sharath Chandra Rao
Khare Energy	Mr Manish Khare
IWMI	Mr Shilp Verma
DISCOM-Jaipur	Ms Deepti Mathur

Annexure 4: Coding interview – PM-KUSUM (example interview: GIZ)

Criterion	Category	Interview excerpt and source	ICAT dimension - renewable energy methodology	ICAT dimension - sustainable development methodology
Alignment with RPO	Policy and regulatory	Interview (GIZ): What is the RPO obligation of that state is also very important. What is the exposure of the state? Is the nation geared towards this kind of intervention? There are states which are used to dealing with utility scale solar.	1. Electric utility quota obligation and renewable portfolio standards as a policy instrument in the energy supply sector. 2. Utility purchase obligation as a critical element in feed-in tariff and premium policies that contributed to their success globally.	No evidence
State regulatory support for tariffs	Policy and regulatory	Interview (GIZ): Highlighted state-specific variations in land leasing policies and tariff regimes affecting the uptake.	1. Implementing agency or entity - Ministry of Energy/Energy Regulatory Commission 2. Depending on the country circumstances, regulatory agencies and public utilities may be responsible for designing and implementing RE policies. Barrier insufficient clarity and transparency in existing regulations or in the development of new	No evidence

Criterion	Category	Interview excerpt and source	ICAT dimension - renewable energy methodology	ICAT dimension - sustainable development methodology
State regulatory support for land policy	Policy and regulatory	<p>Land aggregation in some states has begun through dedicated land aggregation portals. However, such systems are not yet available across all states in the country. Expanding these portals nationwide could significantly accelerate project uptake and streamline land identification and allocation processes. A second key issue relates to land lease rates. While lease rates cannot be fully</p>	<p>policies. Lack of transparency in policy set-up of feed-in tariff policy and history of ad-hoc changes in regulation increase uncertainty, which discourages market actors from participating in the policy. No evidence</p>	

Criterion	Category	Interview excerpt and source	ICAT dimension - renewable energy methodology	ICAT dimension - sustainable development methodology
		<p>uniform across states due to differences in land values and local market conditions, states should develop transparent formulas or standardized methodologies for determining fair lease rates for farmers. This is important because leasing land provides compensation to farmers for land that was previously used for agricultural purposes. If farmers do not receive reasonable and attractive returns, they may be reluctant to lease their land for project development. Some states, such as Maharashtra, have taken steps to establish land lease rate mechanisms, while many</p>		

Criterion	Category	Interview excerpt and source	ICAT dimension - renewable energy methodology	ICAT dimension - sustainable development methodology
		<p>others are still in the process of developing an approach. Greater consensus is therefore needed on how lease rates should be calculated, including the appropriate formulas and parameters to be considered. At present, some states are actively addressing this issue, while others are yet to prioritize it.</p>		
Ease of permitting and clearances	Policy and regulatory	<p>Interview (GIZ): Identified bottlenecks in permitting and clearance processes across the states.</p>	<p>1. Permits for new RE plants are difficult to obtain, approval procedures are lengthy and cumbersome, or there is a lack of spatial planning for RE.</p>	<p>Programmes that establish a limit on aggregate emissions of various pollutants from the specified sources require sources to hold permits, allowances or other units equal to their actual emissions; and allow permits to be traded among</p>

Criterion	Category	Interview excerpt and source	ICAT dimension - renewable energy methodology	ICAT dimension - sustainable development methodology
Capacity of state implementing agencies	Institutional	Interview (GIZ): Noted disparities in technical and administrative capacity of SIAs to implement PM-KUSUM	Lack of strong and dedicated institutions to carry out policies. Several institutions claim responsibility for implementation of the policy. Procedures on how to participate in, or receive assistance from, the policy is unclear, which discourages market actors.	sources. These programmes are also referred to as emissions trading systems or cap-and-trade programmes. Other enabling actions under the policy: Training and capacity-building of stakeholders involved in the Scheme, such as government staff, utilities, regulatory commissions, banks and workers.
Coordination between MNRE, DISCOMs and Agriculture Department	Institutional	Interview (GIZ): Emphasized the need for better coordination mechanisms among implementing agencies	Institutional and administrative: Unclear procedures and responsibilities, and/or complex interactions and lack of coordination between various authorities involved. No evidence of	Policies that interact with each other and when implemented together, have a combined effect that is less than the sum of their individual effects when

Criterion	Category	Interview excerpt and source	ICAT dimension - renewable energy methodology	ICAT dimension - sustainable development methodology
Monitoring and reporting systems	Institutional	Interview (GIZ): Pointed out inconsistencies between reported data and field realities	coordination between the stated agencies.	implemented separately. Energy (SDG 7) - Solar capacity installed (MW) Electricity delivered from solar PV installations (MWh). These indicators will track the quantity of renewable energy installed and generated from the solar PV incentive policy.
Training and outreach mechanisms	Institutional	Interview (GIZ): Discussed the limited reach of farmer awareness programmes and suggested improvements	<ol style="list-style-type: none"> 1. Insufficient knowledge about availability, benefits and performance of RE. 2. Insufficient number of skilled workers, and lack of training and education. Insufficient skilled workers are available for installation of wind turbines. 3. Lack of experience and expertise among the 	<ol style="list-style-type: none"> 1. Increase in training for skilled workers in the solar-relevant sectors (mentioned as an example of reporting impacts for a solar PV incentive policy). 2. For this, the indicator to quantify: Number of new

Criterion	Category	Interview excerpt and source	ICAT dimension - renewable energy methodology	ICAT dimension - sustainable development methodology
Grid infrastructure readiness	Technical	Interview (GIZ): Grid readiness challenges in the implementation of Components C and A.	<p>relevant stakeholders, including project sponsors and power producers, investors and financiers, and regulators and authorities.</p> <ol style="list-style-type: none"> 1. Lack of flexibility of the energy system (i.e., of the electricity grid to integrate or absorb RE). 2. Energy markets are not prepared for RE (e.g., integration of intermittent energy sources, grid connection and access are not fairly provided). 3. Higher grid connection costs for RE. 4. History of technical problems with grid infrastructure prevents decentralized access of RE to the grid. 	skilled trainees and workers on the ground.

Annexure 5: Excerpt from interviews with several stakeholders

Criterion	GIZ	CSEP	CEEW	ICRIER	Developer - Khare Energy	DISCOM - Jaipur	IWMI
Alignment with RPO targets	What is the RPO obligation of that state is important. What is the exposure of the state? Is the nation geared towards this kind of intervention, right There are states which are used to dealing with utility scale solar.	Components A and C are scalable and have larger potential to impact the grid.	No evidence	PM-KUSUM targets solarizing agriculture; states like Rajasthan/MP/Telangana quickly adopted capacity.	No evidence	RPO compliance remains behind; PM-KUSUM capacities are now considered in planning, but a shortfall (~25%) persists.	No evidence
State regulatory support for tariffs	Highlighted state-specific variations in land leasing policies and tariff regimes affecting the uptake.	Different states have different land leasing provisions and periods.	Different states have different land leasing provisions and periods.	State nodal agencies, DISCOMs and banks need stronger coordination; staff turnover hampers continuity.	Land acquisition has become a major problem.	Tariff discovery proceeds via competitive tenders and committee negotiations, then approval by the regulator	No evidence

Criterion	GIZ	CSEP	CEEW	ICRIER	Developer - Khare Energy	DISCOM - Jaipur	IWMI
State regulatory support for land policy	Addressed compatibility of agrivoltaics with existing land and water policy frameworks	Productive land can primarily be used in agrivoltaics format	Productive land can primarily be used in agrivoltaics format	600 kW ground-mounted plant in Rajasthan being retrofitted to agrivoltaics (panels ~4m high)	No evidence	under Section 63. Open tenders allow broad participation; land availability (especially barren land) has been a practical enabler. Initial preference for barren land shifted as agricultural land also came into use. There is support for introducing agrivoltaics to balance energy generation with continued cultivation	No evidence

Criterion	GIZ	CSEP	CEEW	ICRIER	Developer - Khare Energy	DISCOM - Jaipur	IWMI
Capacity of State Implementing Agencies (SIAs)	Noted disparities in technical and administrative capacity of SIAs to implement PM-KUSUM	Provided need-based support to MP, Karnataka, Telangana; SNA capacity varies	Provided need-based support to MP, Karnataka, Telangana; SNA capacity varies	Reported tariffs ~₹ 3.04; some contracts show ₹2.6-2.78 which undermines investor returns	No evidence	Rajasthan's prior experience with large backlogs of agricultural connections and diesel dependence aided quick uptake, particularly in off-grid pumps. Abundant barren land in western districts facilitated siting for decentralized plants	State capacity is critical in implementation of policy. Electricity nodal agency needs to have experience working with farmers
Coordination between MNRE, DISCOMs and agriculture department	Emphasized the need for better coordination mechanisms among the	MNRE, DISCOMs, Agriculture, And Revenue departments need coordination	MNRE, DISCOMs, Agriculture, And Revenue departments need coordination	Large farmers can self-develop; small/marginal farmers need grants, FPO support or leasing revenue	Better policies need to be designed for FIs for lending of loans.	Regular central monitoring; unsigned PPAs are surrendered for	MNRE, DISCOMs, agriculture, and revenue departments need coordination

Criterion	GIZ	CSEP	CEEW	ICRIER	Developer - Khare Energy	DISCOM - Jaipur	IWMI
	implementing agencies				Second thing, at the state level, there are several challenges related to leasing	reallocation. Timely farmer payments and clear agreement mechanisms were noted as strengths	
Monitoring and reporting systems	Pointed out inconsistencies between reported data and field realities	PM-KUSUM portal shows sanctioned vs commissioned ; gap exists in intermediate data.	PM-KUSUM portal shows sanctioned vs commissioned ; gap exists in intermediate data.	Component B pump solarization replaces diesel pumps (8,50,000 pumps figure referenced) – clear GHG benefit	No evidence	No direct evidence	No evidence
Training and outreach mechanisms	Discussed the limited reach of farmer awareness programmes and suggested improvements	Awareness low among small farmers; uptake skewed to well-to-do farmers	Awareness low among small farmers; uptake skewed to well-to-do farmers	No evidence	No evidence	No direct evidence	No evidence
Grid infrastructure readiness	Grid readiness challenges in the implementation of	Odisha grid unprepared; feeder segregation	Odisha grid unprepared; feeder segregation	Rajasthan's PPAs and feeder segregation aid grid integration; other states lack readiness	No evidence	Agricultural load is highly seasonal; plants are sized to peak	No evidence

Criterion	GIZ	CSEP	CEEW	ICRIER	Developer - Khare Energy	DISCOM - Jaipur	IWMI
	Components C and A	required for Component C	required for Component C			seasonal demand. Surplus outside peak months indicates a need for storage to manage evening peaks and seasonal variation	
CAPEX and OPEX affordability for farmers	Broke down capital and operating cost implications for farmers in different states.	1 MW plant ~₹3 crore; margin money ~30% → ₹90 lakh upfront unaffordable for most farmers.	1 MW plant ~₹3 crore; margin money ~30% → ₹90 lakh upfront unaffordable for most farmers.	Risks include land status uncertainty, and weak grievance mechanisms.	No evidence	Under Component B, a 40% share of the farmer was considered acceptable given diesel savings. For grid-connected plants, very low bid tariffs undermine financial viability.	No evidence

Criterion	GIZ	CSEP	CEEW	ICRIER	Developer - Khare Energy	DISCOM - Jaipur	IWMI
Community ownership models	Reviewed cases of FPO participation in PM-KUSUM projects and lessons learnt	Few FPO examples; one FPO project became NPA and failed to scale	Few FPO examples; one FPO project became NPA and failed to scale.	Decentralized SNA models (e.g., Rajasthan) show faster approvals and better developer support.	Farmers should get benefit from land.	No direct evidence	No evidence
Availability of concessional finance and credit (all components)	No evidence	FPO loan turned into NPA; bank financing and margin requirements are barriers	FPO loan turned into NPA; bank financing and margin requirements are barriers	Banks/microfinance active in some states; interest subvention or credit guarantees suggested for small farmers		Bank lending depends on realistic IRR assumptions; projects quoted at very low tariffs face financing challenges. No concessional lines were specifically mentioned	No evidence
Payment reliability from DISCOMs	Noted DISCOM payment delays and suggested assurance mechanisms	DISCOM visibility and payment assurance important, district-level funds may reduce	DISCOM visibility and payment assurance important, district-level funds may reduce	Payment can be unreliable, but evidence from states can vary	No evidence	Payment systems to farmers were described as efficient and timely, cited as a key driver of the Scheme's	No evidence

Criterion	GIZ	CSEP	CEEW	ICRIER	Developer - Khare Energy	DISCOM - Jaipur	IWMI
Impact on water use efficiency	Raised concerns about groundwater over-extraction risks with solar pumping.	DISCOM visibility Risk of over-extraction of groundwater with unmetered solar pumps (implied concern)	DISCOM visibility Risk of over-extraction of groundwater with unmetered solar pumps (implied concern)	Questions on 25-year land use, asset handover, and long-term farmer benefits	Actually conserve water with minimum 30% savings	success in Rajasthan No direct evidence	No evidence

Annexure 6: Questionnaire for various stakeholders for evaluating the PM-KUSUM Scheme

A. Developers

1. Which component(s) of PM-KUSUM have you been involved in—Component A, Component B or Component C?
2. How many MW pumps have you installed so far under the Scheme?
3. How long does it take from project sanction to commissioning? What causes probable delays?
4. Was it easy to get empanelled or approved as a vendor by MNRE/state agencies?
5. Does getting approved also imply meeting MNRE's technical standards while staying cost-competitive?
6. Have you faced issues related to delayed payments by farmers?
7. Have you used innovative land-use models like agrivoltaics (dual use of land)?
8. How do you typically partner with landowners or farmers? Please state the applicable model - lease models; revenue sharing
9. Do you face delays in land aggregation, DISCOM approvals?
10. What support do you receive from state-level nodal agencies or MNRE. Is it timely and adequate?
11. Do you provide operations and maintenance (O&M) services beyond the installation period?
12. Have you faced any legal or land-related disputes while implementing the projects?
13. Are you able to raise debt or equity financing easily for these small-scale projects?
14. What kind of blended finance or guarantees would help de-risk instruments?
15. Are there any region-specific challenges, e.g., water table depth, crop type?

B. Individual Farmers/Water Use Associations/Farmer Associations

1. Which component (A, B, or C) were you involved or interested in?
 - a. If Component A: Did you set up a solar plant yourself or lease your land to a developer?
 - b. If Component B: Was the pump installed directly by you or through a government vendor?
 - c. If Component C: Are you exporting electricity to the grid?
2. How did you first hear about the PM-KUSUM Scheme? Did you face any difficulty in understanding eligibility or accessing the application process?
3. How much did you have to bear as upfront cost? Is the subsidy provided by the government enough or do you have to take a loan over and above that?
4. For Component A (SPPs):
 - a. How much income are you generating by selling power?
 - b. Did the process of dealing with DISCOMs (metering, payment) work smoothly?
 - c. How has the project affected your land use or productivity?

5. For Component B (Standalone Pumps):
 - a. Has the solar pump replaced diesel use completely?
 - b. Have you noticed changes in irrigation patterns or cropping cycles?
6. For Component C (Grid-connected Pumps):
 - a. Are you able to export excess energy back to the grid?
 - b. Have DISCOMs paid you promptly in the past?
7. Do you feel your income has increased as a result of PM-KUSUM?
8. Has the Scheme reduced your dependence on diesel or unreliable electricity?
9. Have you experienced better crop yield, irrigation access, or water use flexibility?
10. Was there any delay or confusion in subsidy release, installation, or operation?
11. Do you record how many hours the pump is used or how much electricity is produced?
12. Would you recommend any changes to the PM-KUSUM Policy?

C. State Electricity Regulatory Commissions (SERCs)

1. How do you set tariffs, considering developers and farmers often complain about existing sub-optimal tariffs?
2. Is there any reluctance from DISCOMs to sign PPAs with the developers?
3. How closely do you coordinate with the state nodal agencies, MNRE, and DISCOMs in tariff-related issues under the Scheme?
4. What challenges have you faced in the implementation of KUSUM projects?
5. Is the SERC considering aligning PM-KUSUM outcomes with the state's renewable purchase obligation (RPO) targets?
6. Are there lessons learnt from other states that you think can help harmonize tariffs or improve the uptake?

D. DISCOMs

1. How has the company engaged with the implementation of PM-KUSUM in the state so far?
2. Which components (A, B, C) has the company actively participated in, and in what capacity (PPA, facilitation, technical approvals, etc.)?
3. What are the key challenges the DISCOM faces in integrating decentralized solar under PM-KUSUM into its distribution network?
4. How do you see the role of PM-KUSUM in meeting your RPOs?
5. What is the typical payment timeline for developers or farmers after the injection of solar power into the grid?
6. How can the DISCOM's involvement be strengthened – through better tariffs, faster approvals, or infrastructure support?

E. Banks and Other Financial Institutions

1. Is your institution formally participating in PM-KUSUM (e.g., through MoUs, RBI circulars, state directions)?
2. Which components are you financing the most? How is financing structured (interest subvention, collateral requirements, etc.)?
3. Do you face challenges verifying farmer eligibility or land ownership?
4. Are there any guarantees that are provided by the government to mitigate bank risk?
5. What are the most common challenges faced in loan sanctions and loan disbursement under PM-KUSUM?
6. Is there a need for a specialized re-finance window (e.g., NABARD/SIDBI line of credit) to scale this effort?
7. Do you see PM-KUSUM related lending as a scalable product line for rural and agri-lending portfolios?

Questions for General Stakeholders

Component A

1. Is a sub-optimal tariff the key reason for the slow uptake of Component A of PM-KUSUM?
2. Can the state government provide a guarantee?
3. Do more PPAs need to be signed with non-DISCOMs, and hence not limiting the sale of power to DISCOMs?
4. How do state policies differ from the policies of the Centre?
5. Does the financial health of DISCOMs impact PPA with developers?
6. How does land rent impact the implementation of Component A?

Component B

1. How does the lack of availability of water pumps of all sizes impact the implementation of Component B?
2. How does the governance model impact the implementation of Component B?
3. How does linking of subsidy with the capacity of the pumps impact implementation of the Scheme?
4. How does state policy on subsidies impact implementation of Component B?

Component C

1. How does tariff setting impact the implementation of Component C?
2. How are Centre and state governments' policies aligned?