Implementing Solar Irrigation Sustainably

A guidebook for state policy-makers on maximizing the social and environmental benefits from solar pump schemes

ANNEX

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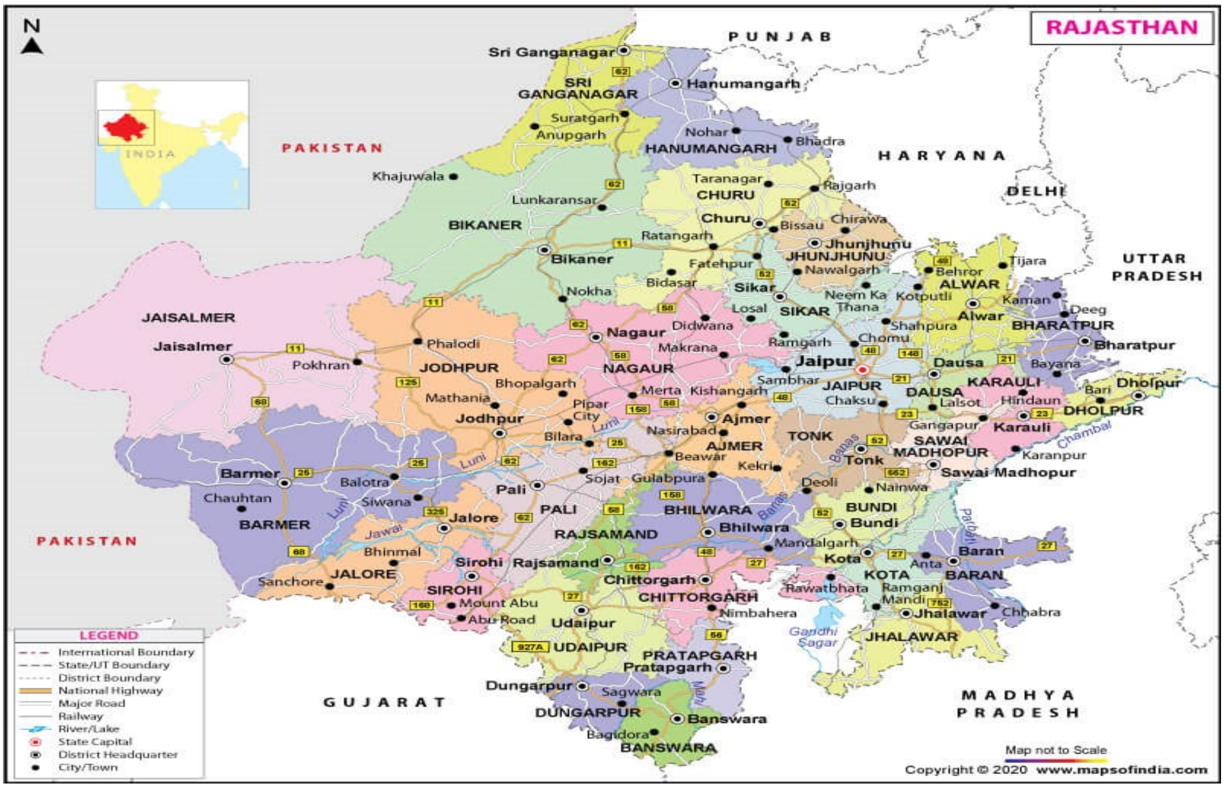
Annex A. List of Organizations Consulted during the Project

Distribution companies (DISCOMs)	• Ajmer Vidyut Vitran Nigam Ltd • Chhattisgarh State Power Distribution Company Limited • Dakshin Haryana Bijli Vitran Nigam • Jharkhand Bijli Vitran Nigam Limited • Gujarat Urja Vikas Nigam Limited
State renewable energy development agencies	• Chhattisgarh Renewable Energy Development Agency • Haryana Renewable Energy Development Agency • Jharkhand Renewable Energy Development Agency • New & Renewable Energy Development Corporation of Andhra Pradesh Limited
Central ministries and public sector undertakings (PSUs)	• Ministry of Agriculture • Ministry of New and Renewable Energy • Ministry of Power • Central Ground Water Board, Ministry of Jal Shakti • Energy Efficiency Services Limited • NITI Aayog
State departments and regulatory bodies	• Department of Agriculture, Jharkhand • Department of Horticulture, Rajasthan • Groundwater Department, Andhra Pradesh • Haryana Electricity Regulatory Commission • Gujarat Green Revolution Company • Irrigation and Water Resources Department, Haryana • Jharkhand State Electricity Regulatory Commission • Jharkhand State Livelihoods Promotion Society • Rajasthan Agriculture Competitiveness Project • State Water Resources Planning Department, Rajasthan
Research, private sector, and consulting organizations	• Bask Research Foundation • Centre for Economic and Social Studies • Centre for Policy Research • Centre for Research in Rural and Industrial Development • Consumer Unity & Trust Society • Gujarat Energy Research and Management Institute • Deloitte • International Water Management Institute • Koan Advisory • PRAYAS • KPMG • Indian Council of Agricultural Research • Aga Khan Development Network • Switch On Foundation • The Clean Network
Banks and multilateral organizations	• National Bank for Agriculture and Rural Development • State Bank of India • World Bank • United Nations Development Programme

Annex B. Case Studies in Rajasthan, Gujarat, and Andhra Pradesh

Rajasthan Case Study



Introduction

Rajasthan has been a pioneer in the implementation of standalone solar pumps in India. Being mostly arid and water constrained, the state has been enterprising in combining interventions for water conservation with solar pump schemes. The state's agriculture sector is a significant contributor to its economy (~30% of the state gross value added in 2020/21) and an important livelihood source for its rural population (Rajasthan Directorate of Economics and Statistics, 2021). The Rajasthan Horticulture Development Society (RHDS) launched a scheme called the Solar Pumping Programme in 2011. The scheme mandated that beneficiary farmers install a drip irrigation system and create a water storage mechanism (*diggi*) to be eligible for standalone solar pumps (Kishore et al., 2014). The scheme aimed to increase horticulture production and addresses several issues concerning the water–energy–food (WEF) nexus. Solar pump schemes in Rajasthan, including Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahaabhiyan (PM-KUSUM) component B, are being implemented by the RHDS, unlike most states which are relying on renewable energy development agencies (REDAs). The advantages and drawbacks of this institutional setup are also outlined in this case study.

The WEF Context in Rajasthan

Scanty and erratic rainfall, periodic droughts, and limited perennial water sources have made Rajasthan a water-scarce state. It has only 1% of India's surface water resources and 5.6% of its population, thereby creating stress on water resources (Water Resources Planning Department, 2014).

The agricultural sector depends heavily on rainfall, with around 66% of the cultivated area in the state being rainfed (Ministry of Agriculture and Farmers Welfare, 2021). Of the gross irrigated area (around 10 million ha), 67% is dependent on groundwater (tube wells and other wells) (Commissionerate of Agriculture, Rajesthan, Jaipur, 2018). Subsidized electricity and procurement price incentives have recently encouraged farmers to cultivate water-intensive crops, adversely affecting the state's groundwater resources. Overall, the agriculture sector consumes around 86% of the available water in India's western region, including the state of Rajasthan, underlining the importance of promoting water conservation in the sector (The Energy Resources Institute, 2017).

Excessive use of groundwater has led to its depletion in several parts of the state. As per the block-wise groundwater resources assessment done in 2017, there are 295 groundwater development blocks in the state, of which 185 are overexploited, 33 are critical, 29 are semi-critical, and three are saline (Central Ground Water Board, 2019). The depletion of groundwater reserves disproportionately impacts poor and marginalized farmers since they are unable to invest in capital-intensive water extraction methods like bore wells or high-capacity pumps (Kumar et al., 2013). Their dependence on water markets could also increase with lower water tables (Sarkar, 2011). As a result, the Rajasthan government has adopted several policies and programs to promote water conservation and groundwater monitoring, such as the installation of piezometers and digital water level recorders under the National Hydrology Project and water conservation under the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) (World Bank, 2020). For the conservation of surface water sources, the state has undertaken several major, medium, and minor irrigation projects.

Table B1. Supportive state schemes and policies

Policy name	Features relevant to the WEF nexus and solar pumping
Solar Pumping Scheme 2011	• Launched by the RHDS. • Mandated micro-irrigation systems and water storage as eligibility criteria for the scheme. • Initial subsidy of 86% provided on system cost. • Planned outlay of INR 5.15 billion to install 10,000 standalone solar pumps. • 45,000 solar pumps have been installed so far.
Rajasthan Solar Policy, 2019	• Target of 1,000 MW capacity from solar pumps. • Promotes solar pumps for pressurized irrigation. • Promotes solarization of grid-connected pumps.

Policy name	Features relevant to the WEF nexus and solar pumping
	• Rajasthan Renewable Energy Corporation Limited (RRECL) is the implementing agency.
State Water Policy, 2010	• Calls for proper planning, public participation, use of technology, and regular evaluation of groundwater resources. • Builds capacity for water-use efficiency in agriculture. • Creation of a water resources database.
Mukhyamantri Jal Swavlamban Abhiyan (MJSA), 2016	• Objectives: improve groundwater availability, reduce depletion, increase cultivable and irrigated area. • Converges all schemes of water conservation and water harvesting. • Involves state departments, non-governmental organizations (NGOs), and public participation. • Renamed as the Rajiv Gandhi Jal Sanchay Yojana (RGJSY) in 2019. • 1.8 lakh interventions have been planned in 3,900 villages across the state.

Table B2. Status of PM-KUSUM in the state

Component of PM-KUSUM Scheme	Progress
KUSUM-A	• Rajasthan Urja Vikas Nigam Limited (RUVNL) is the nodal agency. • Rajasthan is the first state to complete the selection of farmers. • Allotted 722 MW of capacity to 623 farmers. • Targets revised from 325 MW to 725 MW. • Details of rural 33 kV sub-stations released. • Tariff fixed at INR 3.14 per unit.
KUSUM-B	• RHDS is the nodal agency. • Target: 25,000 standalone pumps of 7.5-Hp capacity. • Centralized tender floated by Energy Efficiency Services Ltd.
KUSUM-C	• Jaipur Vidyut Vitran Nigam Limited (JVVNL) is the implementing agency. • Bids invited for 1,707 grid-connected pumps.

Sources: Iqbal, 2020; Ranjan, 2020.

Key Issues Related to Solar Pumping in the State and How They Are Addressed

1. Coordination

The Solar Pumping Scheme implemented by the RHDS from 2011 received technical and financial support from the Ministry of New and Renewable Energy (MNRE) and coordinated with RRECL in implementation. Vendor selection was based on MNRE guidelines and was overseen by RRECL and RHDS. Awareness generation, advertising, and public outreach were undertaken by RHDS in collaboration with vendors. RHDS was successful in converging its 2011 solar photovoltaic (PV) pumping scheme with the Rashtriya Krishi Vikas Yojana (RKVY) and the Jawaharlal Nehru National Solar Mission (JLNNSM). However, the state's groundwater department was not involved in the scheme's implementation.

Interviewed officials from the RHDS confirmed that they had cultivated well-defined relationships with the agriculture, horticulture, and renewable energy departments. They involved officials from these departments at the scheme's outset in planning meetings and field visits to ensure equal ownership between different departments. This was partly driven by strong backing from the state's political leadership as well as a clear understanding of the scheme's benefits among senior officials. They also suggested that a working relationship between secretary-level officials of relevant state agencies is essential to tackle any coordination challenges and ensure seamless implementation of the scheme at the ground level. They also highlighted the limitation of REDAs and energy departments to engage with farmers and understand their concerns. However, for grid-connected solar pumps, they recommended the close involvement of DISCOMs, REDAs, and energy departments in the implementation process.

An interesting case study on solar pumps is the Rajasthan Agriculture Competitiveness Project (RACP), a World Bank-supported project. Its objective was to improve agricultural productivity and farmers' income, in addition to promoting sustainable agriculture practices and water-use efficiency. Launched in 2012, the RACP was steered by a consortium of officers from various state departments like agriculture, horticulture, water resources, and energy. The RACP conducted pilot studies for PM-KUSUM component C on two feeders—Ajairajpura and Mohabatpura—in Jaipur district (RACP, 2021). A cost-sharing model was devised, with 90% borne by RACP and 10% paid by farmers. However, due to restrictions placed during the COVID-19 pandemic, the study could not be completed (RACP, 2021). Interviews with RACP team members revealed that for a scheme of this scale, a dedicated working unit under any state department with special officers on deputation could ease the implementation process with better coordination, targeting, time management, and grievance redressal. Having a secretary-level state official heading this body could greatly benefit decision making, getting approvals, and enlisting the support of other departments and financial institutions.

The Mukhyamantri Jal Swavlamban Abhiyan (MJSA) is a successful example of coordination among different government departments, particularly at the district and Gram Panchayat levels. The scheme also involved NGOs and citizen groups in the planning and implementation process. Under the scheme, district collectors are authorized to sanction the District Mission Plans with inputs from the Gram Sabha, after getting approved by the District Level Committee (Government of Rajasthan, n.d.). One study highlights the creative combination of resources used under the MJSA and notes that it offers scope for integrating interventions like micro-irrigation (PMKSY), solar pumps (PM-KUSUM), and groundwater conservation (Atal Bhujal Yojana) for enhanced drought resilience (Alam et al., 2020).

2. Financing and Affordability

The 2011 solar PV pumping scheme involved a significant capital subsidy of 86% on the solar pump. This was creatively financed by combining subsidies provided under the RKVY (56%) and the National Solar Mission (30%). The remaining 14% of the pump cost was to be paid by farmers (Department of Energy. n.d.).

Over time, the subsidy figure was reduced from 86% to 70% and finally to 60% (cKinetics & Climate Policy Initiative, n.d.). Officials from the state's Horticulture Department suggested that the reason for this was the rapid fall in prices of solar pumps and the growing acceptance of farmers of the new technology. The officials also claimed that the reduction in subsidy did not dampen the enthusiasm of farmers and helped bolster the financial sustainability of the scheme from the state's perspective.

Interviewed state officials suggested that a potential constraint in the scale-up of PM-KUSUM will be the ability of farmers to afford 40% of the capital cost of solar pumps. While RHDS officials were optimistic about farmers' willingness to adopt solar pumps under PM-KUSUM, other stakeholders expressed apprehensions. Consultations with officials on the RACP pilot project revealed that farmers were willing to pay the upfront 10% cost of the pumps but struggled to obtain loans from financial institutions for the remaining amount. According to a policy expert based in the state, farmers can avail of a loan at a 7% interest rate under the NABARD Kisan Credit Card scheme; however, commercial banks are charging a steep 10–12% interest rate for solar pumps. He also suggested that it is unclear if the recent announcement by the Reserve Bank of India to include solar pumps in priority sector lending targets for banks will address this challenge.

In the implementation of PM-KUSUM component C, officials from the Ajmer Vidyut Vitaran Nigam Limited (AVVNL) were unclear about farmers' ability to pay for the upfront cost as well as avail financing for grid-connected pumps. They suggested that their proposed net metering tariff rate was yet to receive approval from the Rajasthan Electricity Regulatory Commission. They revealed that that in a recent meeting held with the Ministry of Power, they had discussed the possibility of receiving loans from NABARD to finance 70% of the pump cost.

3. Targeting

The RHDS advertised the solar PV pumping scheme through newspapers, while vendors and their representatives on the ground would reach out to farmers to create awareness and generate demand (Kishore et al., 2014). Interested farmers applied to the RHDS with payment of the first instalment. Farmers owning up to 2 ha of land could apply for 2.2-kWp systems, while those with farms of sizes greater than 2 ha could apply for 3-kWp systems. Interviewed officials suggested that farmers practising high-tech horticulture and micro-irrigation were given preference in the allotment of pumps. Initially, only 3-HP and 5-HP capacity pumps were allocated, but growing farmer demand led to an increase in permitted pump capacities. However, the RHDS allotted pumps based on the total irrigated area to ensure that higher-capacity pumps were not allocated to small farms. Interviewed officials also suggested they have recently been considering providing subsidized universal solar pump controllers (USPC), which can enable farmers to operate other power equipment on farms along with solar pumps.

A 2014 survey in Rajasthan found that small and marginal farmers did not initially benefit from the scheme (Kishore et al., 2014). The high upfront cost of the system (even after 86% subsidy) and of constructing *diggis* (an eligibility criterion) constrained small and marginal farmers from applying for the scheme. However, RHDS officials suggested that following the scheme's initial success, small and marginal farmers became increasingly interested in participating, and at present, around 60%–65% of beneficiaries of the scheme are small and marginal farmers. A more recent study found that 72% of solar pump beneficiaries in the state were small and marginal farmers, indicating the state's subsequent success in targeting smallholders (Shakti Sustainable Energy Foundation, 2018).

Under MJSA, well-defined selection criteria for targeting low-income farmers were incorporated into the scheme's mission plan. Interviews with multiple officials suggest that the convergence of MJSA with PM-KUSUM in the state might help to leverage the best practices adopted by the former to reach PM-KUSUM's intended beneficiaries.

Under PM-KUSUM component C, consultations with AVVNL officials suggested that the targeting of specific feeders is determined by the maximum pump capacity. Only agricultural feeders where the maximum pump capacities are 7.5 HP or lower are chosen for the implementation of PM-KUSUM component C to meet MNRE's guidelines. Solar panels with twice the capacity of existing pump sets are being installed.

Many officials have suggested that targeting Farmer Producer Organizations (FPOs) is relatively easier than reaching individual farmers. The advantage of involving FPOs is demonstrated by a recent study by the World Bank in Rajasthan, which found that the maintenance costs of common grid infrastructure can be shared collectively by an FPO (Gulati et al., 2020). Further, the study suggests that those farmers in the vicinity of a feeder who have been awaiting electricity connections, especially small and marginal farmers, can be encouraged to join the FPO. The challenge for states is to collectivize farmers and create standard procedures and governance mechanisms for an FPO. The study stresses the importance of involving the private sector in mobilizing farmers, creating FPOs, facilitating borrowings from banks, and the supply and installation of solar systems, among others (Gulati et al., 2020).

Consultations with RHDS officials suggest that low-income and marginal farmers are receiving priority access to solar pumps in Rajasthan under the PM-KUSUM scheme, with better-off and well-connected farmers further down the waiting list in the distribution of solar pumps. This has been facilitated by a transparent application process, with digital registration forms being mandated since 2020.

4. Infrastructure Support

Multiple officials and policy experts raised concerns over the ability of Rajasthan's financially stressed DISCOMs to set up a net metering framework in its rural districts. A lack of metering and trained manpower poses significant constraints in the state. They highlighted that DISCOMs' institutional expertise in implementing rooftop solar could be leveraged and adapted to solar pump schemes.

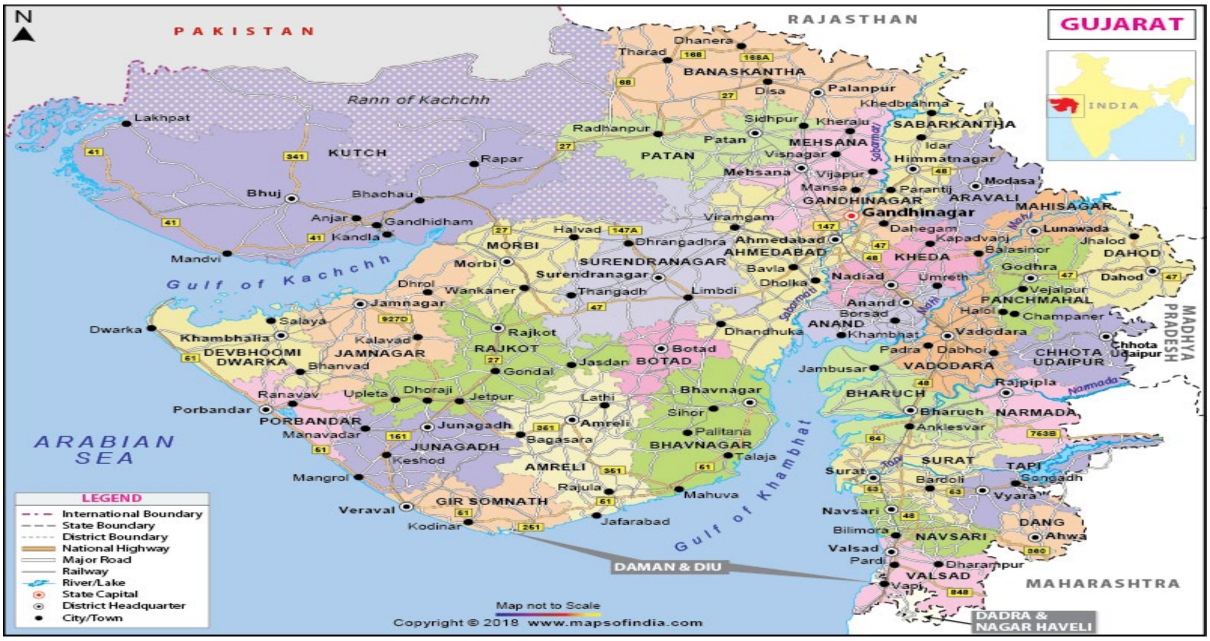
AVVNL has reported facing grid-integration issues, mostly around voltage deviations, following the integration of grid-connected solar pumps. They mentioned that when voltage variations go beyond the permissible limits, inverters are programmed to disconnect the grid from solar pumps.

5. Monitoring and Evaluation

In the 2011 solar PV pumping scheme, the RHDS received regular feedback on the performance of solar pumps through district-level meetings. All pumps were equipped with radio frequency chips that recorded parameters such as hours of operation. According to the head of an FPO in Rajasthan, the monitoring of water usage has improved under solar pumps, since farmers can now track the total water consumed during daylight hours. This contrasted with the earlier provision of night-time supply of grid electricity, which had made it challenging for them to monitor groundwater withdrawals.

For the RACP pilot project, groundwater levels were recorded through piezometers by the State Groundwater Department, along with overall monitoring of the project by the State Water Resources Planning Department. Under the National Hydrology Project, all piezometers would be upgraded to online systems for data recording in the next 2 years. In addition, RHDS officials suggested that an independent third-party evaluation was done by a World Bank-appointed agency. However, recommendations from the study were not implemented by the RHDS due to cost constraints.

Gujarat Case Study



Introduction

Gujarat has been an early adopter of innovative solar irrigation schemes and pioneered the installation of grid-connected solar pumps as well as the solarization of agricultural feeders. Gujarat experimented in 2015 with the world's first solar irrigation cooperative model in Dhundi (Shah et al., 2016). The state also launched its flagship Suryashakti Kisan Yojana (SKY) scheme in 2018, merging elements of agricultural feeder solarization, farmer cooperatives, net metering, and water-use efficiency to address concerns related to the WEF nexus.

Consultations with state officials revealed that the SKY scheme eventually contributed to the design of the PM-KUSUM scheme. A critical analysis of SKY as provided in this case study can provide useful lessons for other states in the sustainable implementation of PM-KUSUM. This study draws on the state's groundwater management practices, which can also provide useful lessons for other states.

The WEF Context

The water resources in Gujarat are mostly concentrated in the central and southern regions. The regions of Saurashtra and Kutch face shortages of both surface as well as groundwater (Swain et al., 2012). The annual replenishable groundwater volume is 15.81 BCM, and the annual groundwater draft is 11.5 BCM, around 76% of the groundwater volume (Central Ground Water Board. n.d.). However, groundwater levels have been declining in specific regions. Of the 184 taluks, around 31 taluks are overexploited, followed by 12 and 69 taluks, respectively, in the critical and semi-critical categories. Notably, the water levels are declining in the aquifers of North Gujarat at a rate of 2 m per year (Central Ground Water Board, 2016). While surface water remains an important water source, with around 185 river basins, the distribution of surface water sources disadvantages the state's northern regions.

Although agriculture continues to be mainly rainfed, both surface water and groundwater resources are being increasingly utilized. Several state initiatives have been undertaken to conserve and recharge groundwater sources. It has resulted in Gujarat being ranked highest among all states in the Composite Water Management Index, released in 2019 by the NITI Aayog.

The Gujarat Green Revolution Company (GGRC), a PSU created by the state government, has been undertaking micro-irrigation schemes in the state since 2005. Until 2021, around 7,74,953 ha of land has been brought under micro-irrigation technologies under the PMKSY – Per Drop More Crop scheme (Jadhav, 2021). Furthermore, GGRC has also undertaken a solar pump program to provide 400 standalone solar pumps to farmers along with micro-irrigation systems.

Solar Pumping in Gujarat

According to the MNRE's annual report for 2020/21, a total of 11,522 standalone solar pumps have been installed in Gujarat (MNRE, 2021).

PM-KUSUM

The Gujarat government allotted INR 1.25 billion for the state's subsidy contribution under PM-KUSUM in its annual budget for 2020/21. INR 250 million was earmarked for the implementation of component C and INR 1 billion for installing standalone solar pumps under component B (Prasad, 2020b). For PM-KUSUM components B and C, the Gujarat Urja Vikas Nigam Limited (GUVNL), a holding company for all four state DISCOMs, was appointed as the state's nodal agency (GUVNL, 2019).

As of December 31, 2020, a total of 2,199 standalone solar pumps had been installed under PM-KUSUM component B, and 7,000 electric pumps had been solarized under PM-KUSUM component C (MNRE, 2021). Gujarat has also set up the Solar Energy Data Management (SEDM) online monitoring portal for tracking the scheme's progress in the state.

Table B3. Supportive policies and schemes on solar pumping in Gujarat

Policy name	Features relevant to the WEF nexus and solar pumping
GGRC Solar Water Pumping Scheme, 2014–15	• Provision of standalone solar pumps of 3-HP and 5-HP capacity. • Drip irrigation systems were a necessary condition for availing the scheme. • Central Financial Assistance of INR 40,500 per HP for DC pumps and INR 32,400 per HP for AC pumps. • The remaining cost was borne by farmers through loans from state-owned or commercial banks. • Provision of 5 years of system maintenance. • Interviews with officials revealed that 400 standalone solar pumps (both AC and DC) were installed but discontinued due to a lack of funds.

Policy name	Features relevant to the WEF nexus and solar pumping
GUVNL standalone solar pumps, 2014	• Scheme was implemented by the four DISCOMs under GUVNL. • Initial target of 1,000 solar pumps with capacities between 3 HP and 5 HP. • Cost of INR 600,000 per pump set (INR 1,000 per HP for tribal farmers; INR 5,000 per HP for others). • Pumps were given to farmers who applied for electricity connections. • Free maintenance for 5 years. • Interviewed officials confirmed that around 12,500 standalone pumps were installed under the scheme.
GGRC Sardar Krushi Package, 2015	• Jointly launched by GGRC and Gujarat State Fertilisers & Chemicals Ltd. • It aims to initiate a "Second Green Revolution" in the state. • Promotes smart agriculture technologies, including micro-irrigation and solar water pumps. • Solar pumps may be availed through GGRC under a NABARD scheme.
Gujarat Solar Policy, 2015	• Promotes solar pumps for agriculture through subsidy support. • Enables DISCOMs to buy surplus power generated from solar pumps.
Gujarat State Water Policy, 2015	• Calls for the regulation of electricity supply to agriculture, by segregating agriculture feeders for pumping groundwater. • Encourages the use of drip and sprinkler irrigation systems.

Sources**:** Economic Times, 2014; Energy and Petrochemicals Department, 2015; GGRC, n.d.-a, n.d.-b

SKY

The SKY scheme was launched by Gujarat in 2018 with the aim of meeting energy demand and augmenting farmers' income, as well as improving the financial health of state DISCOMs (GUVNL, 2018). The scheme provides daytime power supply to farmers through the installation of solar pumps and enables farmers to sell surplus power. Only consumers with designated agriculture connections were eligible for the scheme. The DISCOM selected feeders for the implementation of SKY based on the following criteria:

- Minimum 70% of farmers should agree to join on a specific feeder.
- 1000 hp per year consumption.
- Capability of farmers to join the scheme.
- Transmission and distribution losses in agriculture dominant feeders from different districts.

SKY was meant to be initially implemented as a pilot and aimed to cover 137 agriculture feeders encompassing 12,400 connections in 33 districts of Gujarat. The implementing agencies mandated that the feeder remain live for 12 hours during the daytime. There was also a provision to enable farmers to utilize land on which the system is installed for other purposes by increasing the height of the panels (Kanoda Energy Systems Pvt. Ltd., 2018). Interviewed officials from GUVNL revealed that SKY had installed 97 MW of capacity (as of October 2020) covering 91 feeders and benefiting 4,200 farmers before it was discontinued. Under SKY, solar systems were sized (in kW) at 1.25 times the contracted load of the agriculture pump set (in HP). This was done to ensure that farmers could inject surplus power into the grid. An official from Gujarat Energy Research and Management Institute (GERMI) suggested that the DISCOM initially mandated that all farmers in a particular feeder need to participate, but this was revised to 70%, and in some cases, even 50% was considered sufficient due to the difficulty in convincing farmers to participate.

Key Issues Related to Solar Pumping and How They Are Addressed

1. Coordination

An official from GERMI suggested that political will and bureaucratic alignment helped facilitate coordination between different departments in the SKY scheme's implementation. According to the Gujarat Power Research Development Cell (GPRD), there were three agencies involved in the design and implementation of SKY—GPRD, GERMI, and GEDA—all of which fall under the purview of the state Energy and Petrochemicals Department. The oversight of this department helped them address any coordination challenges. However, an official from GERMI revealed that they struggled to get farmer buy-in for the scheme. He also suggested that, in hindsight, the involvement of the agricultural and rural development departments could have improved the state's outreach efforts to farmers.

In the implementation of the GGRC solar water pumping scheme as well as the standalone solar pumping scheme, coordination among various agencies was based on the assignment of well-defined roles to each agency. Interviewed state officials suggested that the nodal agency for micro-irrigation schemes in Gujarat is the Narmada Water Resources and Water Supply Department, whose role is to channel funds from the state government and the Ministry of Agriculture and Farmer's Welfare to specific schemes. The GGRC has the responsibility of scheme implementation. This involves engaging with farmers and connecting them with vendors and manufacturers. GGRC also coordinates with state-level banks and bankers' committees to provide loans to farmers.

GUVNL stated that there have been no coordination issues between them and DISCOMs in the implementation of PM-KUSUM. An official from GERMI recommended that the top-down implementation of PM-KUSUM must be complemented with a bottom-up engagement of farmer communities. For this, states should work with civil society organizations to understand the socio-economic conditions and ground-level situation of farmers and accordingly implement appropriate measures. The interviewed officials also highlighted the need for targeting, awareness generation, and capacity-building activities for the better implementation of PM-KUSUM.

There should be **PM-KUSUM Cells** in DISCOMS and state renewable energy development agencies with staff trained in all aspects related to PM-KUSUM [that] are able to engage with farmers and other stakeholders. Investment from state governments need to be made in this direction.

—Stakeholder consultation with GERMI

2. Financing and Affordability

Farmers were required to pay 5% of the system cost under SKY, while the remaining 95% was covered through a combination of central and state subsidies as well as loans from financial institutions (Gujarat Power Research Development Cell, n.d.). The state adopted a similar model for PM-KUSUM (The Hindu BusinessLine, 2018). Gujarat received support from NABARD's Rural Infrastructure Development Fund to sponsor the loan component of the SKY scheme (Rahman et al., 2021). Officials suggested that the state is looking for similar support from NABARD under PM-KUSUM. Under SKY, farmers could opt for a power purchase agreement (PPA) with the DISCOM for a period of 25 years. The DISCOM was mandated to pay a feed-in tariff rate of INR 3.50 per unit for surplus power injected into the grid, and the state government would pay INR 3.50 per unit as an Evacuation Based Incentive (EBI). However, the EBI was valid for only 7 years of the loan repayment period. The scheme required all participating farmers in a specific feeder to form a committee for the efficient implementation of the scheme. Until the loan period elapsed, the system's ownership remained with the state; it was then transferred to the farmers' committee.

A major challenge encountered in Gujarat was farmers' reluctance to participate since agricultural power supply in the state is heavily subsidized. In addition, actual feeder losses for most DISCOMs are much higher (around 15%) than the anticipated feeder losses (5%) in the scheme, which may impact DISCOMs income (Saur Energy, 2019). In the GGRC solar pumping scheme, officials revealed that the high upfront cost of the pumps, along with the mandatory installation of a micro-irrigation system, was found to be a major barrier for farmers and resulted in poor uptake of the scheme. This challenge persisted despite regular farmer awareness and outreach programs conducted by state agencies.

Under PM-KUSUM, the farmers' contribution of 40% of the pump cost is viewed by state officials as a challenge. As per GUVNL, the Agriculture Infrastructure Fund, which includes a provision of 3% interest subvention on loans, could be a solution to address this challenge. They also suggested that NGOs could provide corporate social responsibility support and help collectivize farmers in cooperatives under the PM-KUSUM scheme.

3. Targeting

Stakeholder consultations with GGRC revealed that they had formulated a Decision Support System to indirectly target beneficiaries. They generated awareness among farmers using various communication channels like print/electronic media, meetings, and farmer interactions to help farmers independently take a decision on adopting micro-irrigation and solar pumping systems. Moreover, many of the vendors of micro-irrigation systems also dealt with solar PV systems, which made it easier for them to target and engage with farmers to promote solar pumps. Officials claimed that small and marginal farmers responded better than large farmers since the requirement of micro-irrigation systems was more aligned with their cropping practices. They suggested that low-income farmers who practised rainfed farming were able to diversify their crops using solar and micro-irrigation systems. Based on the lessons from the GGRC project, the state is considering the convergence of micro-irrigation, under the Per Drop More Crop component of PMKSY within the PM-KUSUM scheme.

4. Infrastructure Support

Under the Dhundi pilot project (Box A1), a PPA was signed between the Madhya Gujarat Vij Company Limited (MGVCL) and the Dhundi Saururja Utpadak Sahakari Mandali (DSUUSM), a solar pump cooperative, to provide legal recognition for the sale of electricity to the grid by the cooperative. The agreement required cooperative members to give up their right to apply for electricity connections for the 25-year PPA period. MGVCL developed the required infrastructure for injecting electricity from the solar micro-grid (56.4 kWp) to its distribution network at the interface point of the 11 kV Kotaria Feeder (DSUUSM, 2018).

Box B1. Solar energy cooperative model at Dhundi

The world's first solar irrigation cooperative model was created in 2015 in Gujarat's Dhundi village (DSUUSM, 2018). The initiative was conceptualized by the International Water Management Institute (IWMI) with support from Tata Trusts. Six farmers were provided solar irrigation systems with a total panel capacity of 56.4 kWp, forming a micro-grid arrangement. The micro-grid was connected to the grid at a single metered point. MGVCL signed a PPA with DSUUSM at a tariff of INR 4.63/kWh for a period of 25 years, in return for the cooperative giving up their right to apply for grid connections. The cooperative was offered additional bonuses in the form of a Green Energy Bonus (at INR 1.25/kWh) and a Water Conservation Bonus (INR 1.25/kWh), bringing the total tariff to around INR. 7/kWh. The initial investment was around INR 6.9 million, with a combined farmers' contribution of around INR 840,000 and the rest supported by IWMI (DSUUSM, 2018).

The Dhundi project made use of the available grid infrastructure. Its concept of injecting power into the grid at a single location was found to be more cost effective and accrued less technical losses for the DISCOM compared to net metering and monitoring individual farmers supplying to the grid. Although the SKY scheme, which drew inspiration from the Dhundi project, did not mandate that only cooperatives or groups could apply, it stipulated that transmission and distribution losses greater than 5% were to be distributed pro-rata among all solar-generating farmers on a feeder.

Under the SKY scheme, a GERMI official suggested that the DISCOM's capabilities were bolstered through the training of its engineers and conducting baseline studies for feeder segregation. DISCOM staff was trained using videos on system installation and maintenance at the GPRD Baroda training centre. GPRD officials stated that in order to prepare the grid for SKY, rigorous maintenance of the transformer and distribution lines was carried out in coordination with the DISCOM. They suggested that strengthening DISCOM capabilities is vital for implementing grid-connected pumps, and international agencies can be invited by states to conduct evaluations and undertake capacity-building activities.

Although the SKY scheme mandates that DISCOMs must pay a feed-in tariff to farmers, a GERMI official suggested that there appears to be some mistrust among farmers in receiving payments, and there is a need for sustained political will to ensure that DISCOMs honour their PPA commitments. Officials suggested that the SKY model may not work in all states, given their different political economies. Mandating the installation of meters was not an obstacle in Gujarat but could be in other states.

Consultations with GUVNL officials revealed that the state is providing USPC to interested farmers by accepting additional payments under PM-KUSUM. They also suggested that they have not encountered any grid-integration challenges but anticipate them in the future as renewable energy capacity increases in the grid.

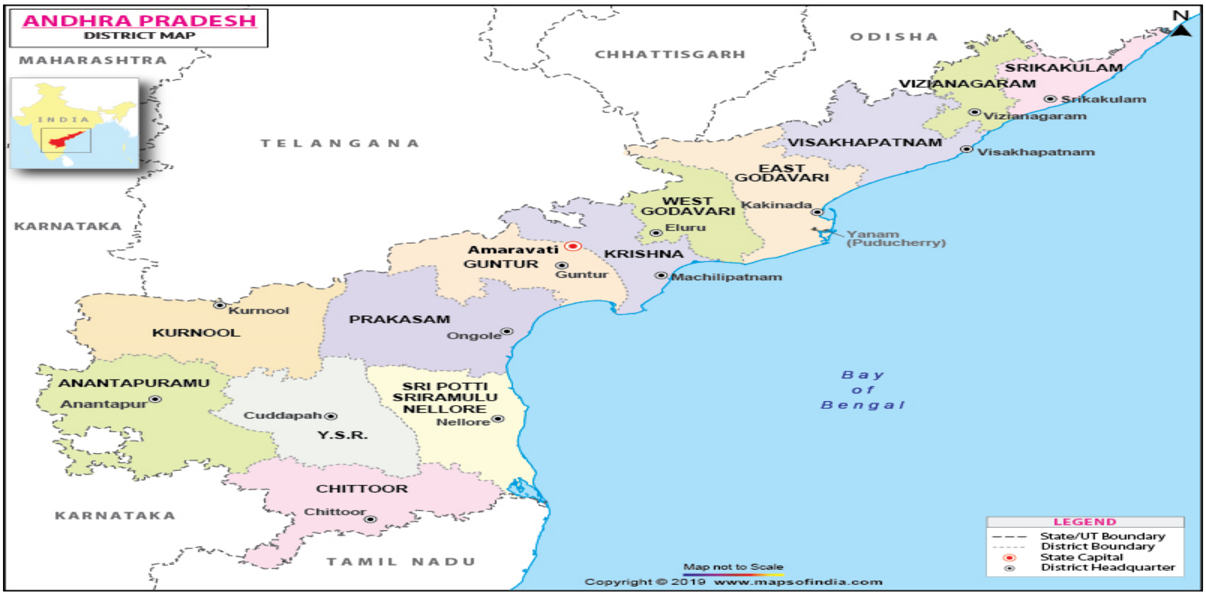
5. Monitoring and Evaluation

Gujarat was one of the first states to develop an online platform for monitoring solar pump installations. Interviewed officials suggested that the formation of farmer cooperatives helped officials manage and monitor the system's performance. SKY also introduced the concept of Smart Energy Management by using the Internet of Things for monitoring energy consumption, evacuated energy, billing, and recording feeder-level losses. The major components of the Smart Energy Management mechanism consisted of (a) remote metering for prosumers, (b) WatchDog Transformers for non-participating agriculture consumers, (c) remote metering solutions for non-agriculture consumers, and (d) remote-monitoring SEDM software (Upadhyay et al., 2019). WatchDog Transformers were utilized to address the "free rider" issue and prevent a spike in power consumption from non-SKY agriculture consumers. The transformers were equipped with Internet of Things-based programmable watchdog devices (WDD) mounted on the distribution transformer at the low voltage side to limit access to the transformer from the WDD and not through the distribution transformer (Patel & Patel, 2019). This limited the duration of 3-phase power supplied to non-SKY consumers to 8 hours while continuing to supply single-phase power for residential purposes. The energy consumed by non-SKY consumers was also recorded in the system. Further, acting as an energy audit device, the WatchDog Transformer monitors the difference between energy generated and consumed every 15 minutes and raises an alarm if the difference deviates from the defined values (Upadhyay et al., 2019). Officials suggested this information be uploaded and monitored on the SEDM.

Interviewed officials suggested that the GGRC scheme also employs a robust monitoring mechanism. After installing the micro-irrigation system, vendors have to conduct trial runs, which are followed by a third-party inspection, verification, and random checks. The results of these checks are then recorded on an online portal. The subsidy component is disbursed to the vendor only after successful verification. Moreover, the use of information technology at every stage of the implementation process—registration, geo-survey, trial run, system performance—has improved the scheme's implementation and monitoring.

Building on the state's experience of developing robust monitoring mechanisms in state-level schemes, Gujarat became one of the first states to implement the SEDM platform under PM-KUSUM.

Andhra Pradesh Case Study



Introduction

Andhra Pradesh (AP) implemented the Solar PV Water Pumping Programme in 2014/15 and the Solar Brushless Direct Current (BLDC) pump pilot in 2018. The New & Renewable Energy Development Corporation of Andhra Pradesh (NREDCAP), the state's renewable energy development agency, implemented the Solar PV Water Pumping Programme. NREDCAP targeted the deployment of standalone solar pumps in areas where grid connectivity was poor or absent and where the state DISCOM did not have plans for grid expansion in the near term. NREDCAP successfully installed 34,045 standalone solar pumps, the second highest in the country (MNRE, 2021). Providing standalone solar pumps helped clear the state's pending agricultural electricity connections and assisted in reducing its agricultural electricity subsidies. The Andhra Pradesh Eastern Power Distribution Company Ltd (APEPDCL) was the implementation agency for the BLDC pumps program. The BLDC pump scheme aims to provide enhanced daytime electricity supply to farmers and creates a framework that enables them to sell excess electricity back to the grid. The scheme therefore has the potential to simultaneously bolster farmer incomes and curb excessive groundwater extraction.

Agriculture plays an important role since 62% of the state's population lives in rural areas and depends on agriculture and allied activities for their livelihoods. Rising groundwater depletion and frequent droughts have led to growing urgency among policy-makers to implement water conservation and efficiency measures. Interviewed officials also revealed there is a desire to extend the use of clean energy sources, like solar power, to agriculture. These factors have been drivers of the state's innovative programs in agriculture, water management, and renewable energy. This case study draws lessons from AP's solar pump schemes and highlights how they affect the water–energy–food (WEF) nexus.

The WEF Context

Agriculture in AP is largely dependent on rainfed irrigation (Government of Andhra Pradesh, 2017). Erratic rainfall patterns and consecutive droughts in the state have compelled farmers to depend on groundwater irrigation. The western region of the state (the Rayalaseema region) encountered nearly 15 drought years between 2000 to 2018 (Rao, 2019). The most important crop in the state is rice, with an area of 21.06 lakh hectares covered under paddy cultivation in the state (Government of Andhra Pradesh, 2017).

As per the 2017 Central Ground Water Board block-wise groundwater assessment data, of a total 670 blocks in the state, 24 are in a critical state, 60 are semi-critical, and 45 are overexploited (Central Ground Water Board, 2019). Through the command area development project, AP has implemented measures to increase the state's irrigation potential while adopting effective water management and conservation practices. As per the 2019 *Composite Water Management Index* report published by NITI Aayog, AP ranked second among all states in water management.

The state government budgeted INR 7,064.27 crore in 2019/20 to provide free power to all non-corporate farmers for 9 hours a day (Andhra Pradesh Electricity Regulatory Commission, 2019). The number of agricultural connections in the state is around 17.55 lakh (Apparasu, 2020). Interviewed officials suggested that there are 1.5 lakh farmers waiting for connections, and solarizing these pending connections might help the state avert a recurring subsidy for agricultural power supply in the long run.

Table B4. Relevant policies/schemes in the context of WEF and solar pumping

Policy name	Features relevant to the WEF nexus and solar pumping
Andhra Pradesh Solar Power Policy 2018	• Target of installing and operationalizing 50,000 solar pump sets in 5 years (by 2023)
Andhra Pradesh Water, Land and Trees Act, 2002	• Groundwater conservation is the key objective. • Assistance for new borewell applications–single-window clearance. • Compensation for failed borewells up to INR 10,000. • Notified villages where groundwater withdrawal is banned. Penalties for violators.
YSR JALA KALA Scheme (free borewell Scheme), 2020	• Small and marginal farmers targeted. • Free borewells to beneficiaries. • Financial assistance to establish cold storage.
Neeru Chhetu Scheme, 2014	• Objective of water management and conservation. • Micro-irrigation encouraged. • Recognized by NITI Aayog's *Composite Water Management Index, 2019* as best practice.

Sources: Energy, Infrastructure & Investment Department, 2018; Government of Andhra Pradesh, n.d.; The Hindu, 2020; Water Resources Department, n.d.

Solar PV Water Pumping Programme

The Solar PV Water Pumping Programme was jointly implemented by NREDCAP, AP DISCOMs, and the agricultural and fisheries departments. The project was initiated in 2014/15 and ran until 2018, supported by an MNRE subsidy (30%), a state subsidy (30%), and a beneficiary contribution (40%) (NREDCAP, 2014). Around 31,275 standalone solar pumps of 3-HP and 5-HP capacities were installed by September 2020 (Transmission Corporation of Andhra Pradesh, 2020).

After the DISCOM identified beneficiaries, NREDCAP and the DISCOM conducted field inspections to check the water source and to develop a feasibility report. The MNRE subsidy and farmer contribution was deducted from the total cost of the system, and the balance amount was paid by the DISCOM to the vendor.

Interviewed officials revealed that the failure of borewells and pumps due to the sudden collapse of sandy soil into the bore (which blocks the pumps) was a challenge in implementing the scheme in coastal areas. In these situations, desilting and construction of a new borewell had to be undertaken.

Following the successful installation of solar pumps by NREDCAP and the promising response of farmers, the MNRE allotted 25,000 pumps for 2019/20 under PM-KUSUM component B. However, officials suggested that due to limited interest in implementing standalone pumps, the state did not allocate the required budget for the scheme, leading to its discontinuation.

Grid-Connected, Solar-Powered BLDC Pumping Pilot Project

The BLDC Solar Pump pilot project was launched in 2018 to address a lack of daytime electricity supply for farmers, over-extraction of groundwater resources, transmission and distribution losses, and the growing subsidy burden faced by DISCOMs. The scheme aimed to replace inefficient pump sets with energy-efficient pump sets to reduce the total energy consumption and thereby DISCOM losses.

The pilot project was implemented by APEPDCL in the Savaravilli feeder in Bhogpuram Mandal, Vizianagaram district, covering 250 agricultural connections over 32 villages. Around 216 pumps were replaced by grid-connected BLDC pumps. The total expenditure for the pilot was approximately INR 93 million, which was borne entirely by APEPDCL (2019).

The key findings from the project, as reported by APEPDCL, are listed below (not independently verified):

- Uninterrupted 8–10 hours of daytime power supply provided to farmers.
- Higher output for the same size of pump set.
- 30–40% of the solar power generated was injected into the grid.
- Additional income in the range of INR 3,000–6,000 for farmers through incentive mechanisms.
- Reduction in transmission and distribution loss due to decentralized generation.
- 5-HP capacity BLDC pumps are effective up to water levels of 150 ft—prevents over-withdrawal.

- Based on the DISCOM's estimates, the entire cost was estimated to be recovered in 2 years.

As per APEPDCL officials, the pilot BLDC program (which is 100% subsidized) could not be scaled up under PM-KUSUM, as it would require a 40% farmer contribution of the system cost, which the state government did not find feasible given the political economy of free power supply in the state.

Status of PM-KUSUM in AP

The state is planning to build grid-scale 10 GW of solar capacity for agriculture power supply (Prasad, 2020a). Interviewed officials from NREDCAP and APEPDCL suggested that with falling costs of solar power, it would be more cost effective and easier to implement the 10-GW project. They also hoped that going for grid-scale solar would avoid the need for time-consuming outreach efforts undertaken during the implementation of the BLDC solar pumps scheme. According to media reports, the state sent a formal proposal to MNRE for the inclusion of this project under component A of PM-KUSUM (New Indian Express, 2020).

Box B2. Grid-scale solar plants for agriculture in AP

The Andhra Pradesh Green Energy Corporation Ltd (APGECL), a 100% subsidiary of the state generation company, was designated as the nodal agency for the implementation of this project.

- APGECL will procure solar power under a build-operate-transfer (BOT) model for 30 years.
- The tariff decided by competitive bidding will be applicable for the first 15 years.
- Prefixed operation and maintenance (O&M) charges from the 16th year onwards, escalating annually at 4% till 30th year.
- Agriculture feeders will be initially segregated and then connected with solar plants (NREDCAP).
- Wastelands are being identified for solar power projects.

Source: Prasad, 2020a.

Key Issues Related to Solar Pumping and How They Are Addressed

1. Coordination

The standalone solar pumping scheme was implemented by NREDCAP in collaboration with the state DISCOMS (APEPDCL and APSPDCL) as well as the departments of agriculture and fisheries. DISCOMs were responsible for identifying farmers and selecting beneficiaries. Joint inspections by NREDCAP and DISCOM officials helped check if farmers had a proper source of water supply and verify the pumps' operational performance. Interviews with state officials revealed that subsidies were released to vendors by NREDCAP, while DISCOMs retained 10% as the security deposit and only released it to vendors in yearly instalments to ensure they provided O&M services throughout the 5-year duration.

The BLDC pilot scheme was solely implemented by APEPDCL. DISCOM officials interviewed by the project partner Council on Energy, Environment and Water during a separate study revealed that the main hurdle they faced was convincing farmers to participate due to the free agricultural electricity supply in the state. They suggested this could have been tackled by involving the agriculture and irrigation departments since they have long-standing relationships with farmers and may have been better placed to convince them to participate.

The AP state government has brought all water-related agencies under a single department, the Andhra Pradesh Command Area Development Authority (CADA). Interviews with the department revealed that they had developed good coordination mechanisms with other departments like agriculture, horticulture, and energy. The secretary of the state water department holds the charge of Commissioner of CADA and is assisted by an additional commissioner. CADA also conducts capacity-building activities with local water user associations (WUAs) to enhance their water management practices and maintenance of command area activities.

2. Financing and Affordability

The MNRE provided Central Financial Assistance of 30% of the capital cost of the pumps in the Solar PV Water Pumping Programme. Sixty percent of the total cost was borne by DISCOMs and agriculture and fisheries departments through loans from NABARD. Farmers' contribution for a 5-HP pump was INR 55,000; for a 3-HP pump, it was INR 40,000 (NREDCAP, n.d.). NREDCAP acted as the nodal agency for the scheme and disbursed the subsidy from the MNRE. Financial assistance was provided to farmers belonging to Scheduled Caste and Scheduled Tribe (SC/ST) categories by SC/ST development agencies.

The entire cost of the BLDC pumps project was borne by APEPDCL.

Box B3. Cost-benefit analysis of BLDC pumps scheme as estimated by APEPDCL

- After the loan tenure of 15 years, APEPDCL will accrue annual savings of INR 50,000 per 5-HP pump for a period of 10 years.
- Annual estimated energy savings: 2,000 to 4,000 units.
- Farmers' income from selling excess energy: INR 3,000 to INR 6,000 per year.
- APEPDCL savings on power purchase costs at Net Present Value: INR 75,000 to 150,000.

Source: APEPDCL, 2019.

In the solar PV pumping scheme, preference was given to farmers in areas where grid connectivity was poor or absent. Interviewed state officials suggested that farmers found the scheme profitable, as the total expenditure incurred for installation of a new electric AC pump was nearly equal to the farmers' share defined by NREDCAP. However, in the pilot BLDC pumping scheme, as agricultural electricity supply is free in AP, existing grid-connected farmers were reluctant to switch to BLDC pumps. Officials revealed that farmers eventually understood the benefits of this scheme, and they received positive responses toward the end of the project.

3. Targeting

- Farmers were selected based on the following criteria in the solar PV pumping scheme:
- Farmers residing in locations where the grid extension was not feasible or power supply is erratic.
- Farmers who did not have an agricultural connection and were using diesel pumps.
- Farmers who had a borewell or open well.
- The permissible limit of groundwater depth was 200 ft.

As the permitted capacity was only up to 5 HP, officials suggested that small and marginal farmers benefited from the scheme.

Under the BLDC pilot project, APEPDCL was looking to identify a feeder with a maximum pump capacity of 5 HP and no more than 250 agriculture connections. The Savaravilli feeder satisfied these conditions and was chosen for implementation. APEPDCL organized several meetings with farmers to educate them about BLDC pumps and to highlight the financial gains of exporting surplus energy to the grid.

According to several stakeholders, effective communication and farmer outreach are essential for any scheme to be successful in targeting the right beneficiaries. During the interviews, an official from the National Institute of Rural Development highlighted the lack of data use by state agencies to improve targeting. He claimed that AP has very robust databases on its water resources and crop conditions, right up to the village and individual pump levels. According to the stakeholder, these databases are rarely utilized, and targeting would be improved if state policy-makers relied on the use of scientific data.

4. Infrastructure Support

In AP, NREDCAP has branches and headquarters in every district with technical and non-technical personnel. Their human resources, coupled with the vast network of technical staff and field staff of DISCOMs, helped ensure the smooth implementation of the solar PV pumping scheme. For the selection of vendors, tenders were called on an all-India basis. Only well-established companies that could set up district-level service centres were selected. NREDCAP stored solar pump components and materials at their district headquarters for easy replacement in case of damage. During installation, vendors were required to educate farmers about the basic operation and maintenance of the system.

The BLDC pilot project offered farmers daytime power supply in addition to the opportunity to sell excess power generated into the grid. The state regulatory commission, APERC, approved a tariff of INR 1.50/kWh for each unit injected into the grid. Interviewed APEPDCL officials revealed that they decided to settle the payment every quarter but faced initial obstacles in convincing farmers to share their bank account number, which demonstrated a trust deficit between farmers and the DISCOM.

A key technical challenge initially faced by farmers in the BLDC pilot project was that the inverter tripped when there was no grid power supply. APEPDCL officials highlighted that in order to address this problem, vendors experimented with the use of a simple manual changeover switch, which allowed the system to be disconnected and operate as a standalone system during the non-availability of the grid. They also revealed that another advantage of

BLDC pumps was that they provided extended electricity hours since they started operating at a low initial torque (around 90 V) from daylight till late afternoon. This duration of reliable daytime power matched the supply of grid power in the state.

5. Monitoring and Evaluation

A proper monitoring framework was not planned as part of the NREDCAP solar pumping scheme. An independent evaluation and impact assessment of the scheme (Suman, 2018) found the following:

- An increase in crop productivity and farmers' income. The annual income of farmers nearly doubled after installing solar pumps.
- Judicious use of water was observed due to the manual operation of pumps. Due to reliable daytime power supply, farmers had stopped using auto starters. Districts with relative water scarcity experienced changes in cropping patterns like increases in horticulture, floriculture, fruit orchards, and drip irrigation. The cropping cycle improved to three cycles per year.
- There is a lack of awareness among farmers about profitable farm practices.
- There is a lack of awareness about how the optimum use of solar panels affects energy production.
- Utilizing energy for other productive purposes (solar cold chain or primary food processing plants) or selling the energy to improve farmers' income is recommended.

Officials from the State Groundwater Department revealed that the monitoring of water levels is being done at numerous locations across the state using piezometers. The data is assessed every 3 years, and at present, monitoring is being done while keeping 2019 as the base year. The monitoring data is used by the groundwater department to plan schemes and proposals for groundwater management. The groundwater department also stated that new borewells are not allowed in blocks that are overexploited. As water levels have been declining in several places, the state government has constituted a committee to reassess the existing norms for borewell depth and spacing.

Other Issues

The need for raising awareness

All stakeholders consulted in AP spoke about the need for state agencies to create awareness of any new technology and scheme before implementation to ensure its wider acceptance. It was suggested that small and marginal farmers may be encouraged to grow fodder crops along with high-value horticulture crops as an additional source of income. They suggested that awareness measures must also discourage the competitive digging of borewells, which can result in groundwater depletion and contributes to farmers being burdened by debt due to the costs incurred in digging them.

Using water level instead of borewell depth to allocate solar pumps

Officials from the AP State Groundwater Department suggested that bore-\well depth should not be taken as the criterion for sanctioning solar pumps. Instead, the level of water in the well should be considered since the total depth of the borewell may be more than the undisturbed static level of water that flows into the well as it is being drilled (which is less than the total borewell depth). Once a pump is installed and starts operating, this water level starts declining and reaches an equilibrium level called permanent sustainable water level. The groundwater department suggested that solar pumps should be placed beyond this sustainable water level to prevent the solar pump from running dry.

The need for comprehensive planning

According to an official from the National Institute of Rural Development, a three-stage planning approach must be adopted by state implementing agencies for solar pump schemes. First, land parcels need to be identified based on the available water resources and water-use characteristics. Second, all institutions present in that area must be identified, including self-help groups, FPOs, and water user associations. Third, state agencies need to review all schemes that are active in the area, such as Gram Panchayat development plans, perspective plans, and district irrigation plans, and focus on integrating them with PM-KUSUM.

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