WRI INDIA

WORKING PAPER

LEARNINGS FOR TAMIL NADU FROM GRID-CONNECTED AGRICULTURAL SOLAR PHOTOVOLTAIC SCHEMES IN INDIA

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EXECUTIVE SUMMARY

Highlights

- Eighteen percent of the electricity consumption in India powers the agricultural sector and is subsidized (fully or partially). Electricity distribution companies (discoms) bear the brunt of supplying subsidized power as the rate of cost recovery from farmers is low, with delayed/ inadequate payments from the government.
- Reducing the need for subsidized electricity by solarizing irrigation pumpsets can decrease the burden on discoms and government, prevent wastage of energy and water resources, and incentivize efficient use. The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM KUSUM) scheme was launched by the Government of India to solarize agricultural activities in all states and to drive the change toward economic and environmental sustainability.
- Tamil Nadu has issued an order to implement Component C (focused on solarization of grid-connected pumpsets at the individual farm level) of KUSUM. We reviewed schemes similar to Component C that were piloted in Karnataka, Andhra Pradesh, and Gujarat, to share learnings with Tamil Nadu.
- We propose recommendations that could facilitate successful implementation in Tamil Nadu: assess the adequacy of the feed-in tariff, work with the local population to avoid water-inefficient agriculture, and develop a robust monitoring and evaluation framework to periodically assess and plan for course correction and improvements.

CONTENTS

Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback and to influence ongoing debate on emerging issues. Most working papers are eventually published in another form and their content may be revised.

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The numbering system followed in this working paper is the Indian numbering system. Typical values that are used are Lakhs (1 Lakh = 100,000) and Crores (1 Crore = 10 million).

Context

Agriculture, the source of livelihood for 58 percent of India's population, depends heavily on the availability of reliable irrigation facilities. Irrigation in India draws from surface water replenished by rainfall, canal irrigation from rivers, or tubewell/borewell irrigation from underground aquifers.

The electricity supplied to the agricultural sector is either free or heavily subsidized. Cost recovery from the agricultural sector proves challenging for discoms. Where it is possible at all, cost recovery from this sector averages around 30 percent, as seen in Figure ES-1 (taken across all states) (CEA 2020c).

The revenue health of many discoms is further imperiled by the fact that they are often not compensated adequately or in a timely manner by the government (Chatterjee 2020a; Bhaskar 2020). Discoms recover these costs by charging higher rates for commercial and industrial electricity consumers, which in turn weakens the competitiveness of the economy.

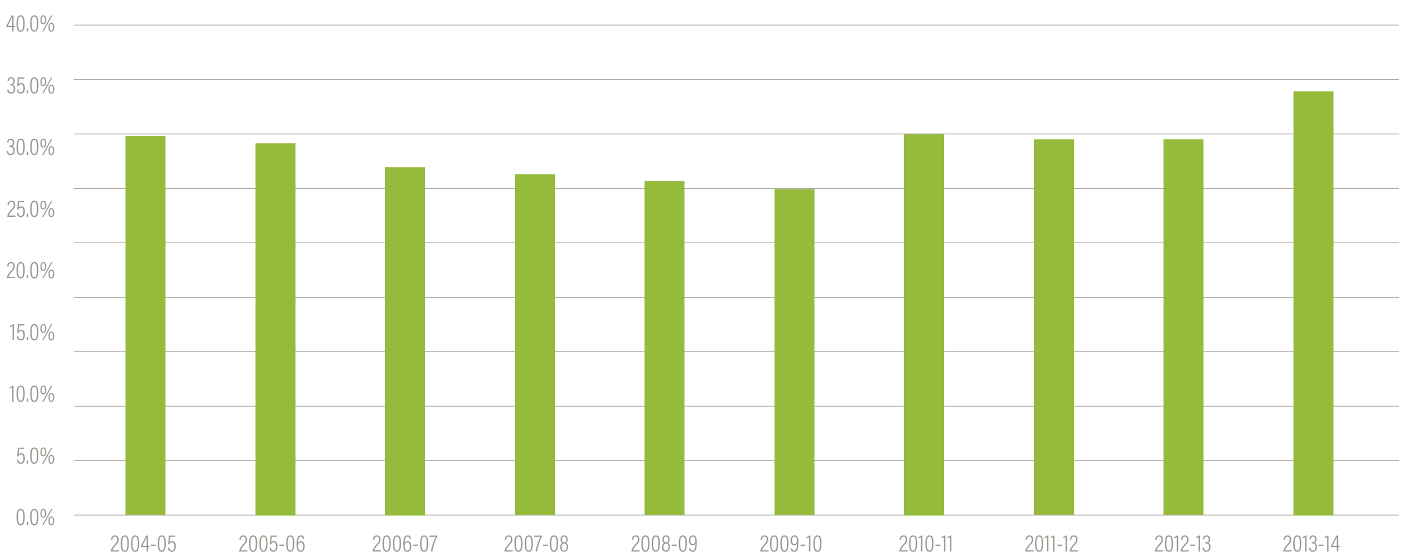
The current scenario in India is difficult to change since subsidized electricity is crucial for keeping the cost of agricultural production low.

Electricity that powers irrigation is delivered to farmers mostly at odd hours during the night. Not only does this cause hardship to the farmers, but it also poses a safety hazard. Farmers try to get around the problem by setting their pumps to auto-start when the supply of electricity commences and leave them running for the entire duration of the supply period. Free or low-cost electricity absolves users of the need to monitor and use energy and water resources effectively, which leads to wastage. One approach to overcoming this problem is to achieve more consistent daytime supply without increasing the discoms' production cost. Solarization of agriculture offers a viable solution that ensures clean, low-cost energy is generated locally and when it is most needed. It can also reduce both the subsidy burden on discoms and transmission and distribution (T&D) losses, and can potentially mitigate capital expenditures (Patel and Patel 2019).

With these goals in view, the Ministry of New and Renewable Energy introduced the KUSUM scheme in 2019 to solarize irrigation across India. The scheme has three separate components: Component A, Component B, and Component C.

Component C, which is our focus in this paper, is the component that deals with solar plants to power grid-connected, individual irrigation pumps. The Government of Tamil Nadu (GoTN) decided to roll out KUSUM's Component C for 20,000 pumps and issued a Government Order (GO) to that effect in 2020. On November 10, 2020, the Tamil Nadu Electricity Regulatory Commission (TNERC) passed an order approving the scheme. Installation of the solar photovoltaic (PV) pumpsets and other operational procedures are expected to commence in the first half of 2022.

Figure ES-1 | **Ratio of Recovery from Agricultural Sector to Cost of Supply**



Source: CEA 2020c.

Table ES-1 | **Summary of the Schemes Reviewed**

STATE/UT	SCHEME NAME	SCHEME LAUNCH YEAR	SCHEME GOALS	SCHEME PERFORMANCE
Gujarat	Suryashakti Kisan Yojana (SKY)	2018	The SKY Scheme had the target of solarizing 137 feeders covering approximately 12,000 consumers and aimed to add 175 MW of distributed solar power.	Against an original target of 137 feeders, 11,993 consumers, 175 MW, and 139,965 horsepower (hp), we observed that the progress has been 68.6%, 37.6%, 46.2%, and 56.8%, respectively. An additional injection of 28.5 MU (million units) of clean energy at the farm level was recorded.
Karnataka	Surya Raitha Scheme	2014	Karnataka's Surya Raitha Scheme targeted solarizing 310 individual pump connections at 5/7.5 hp levels across 11 villages.	The scheme enabled the installation of 310 solar PV pumpsets with a cumulative capacity of 2.68 MW and 2.64 MU of annual generation.
Andhra Pradesh	Solar Brushless Direct Current (BLDC) Pump Pilot	2018	Andhra Pradesh's Solar BLDC Pump Scheme targeted solarizing 216 individual pump connections at 3/5 hp levels across 32 villages.	As of November 2020, the implementation of the pilot was complete, covering 216 irrigation pumpsets against a target of 250. An installed capacity of up to approximately 1,080 kW of distributed grid-connected solar capacity was added.

Source: Publicly available information compiled by WRI India researchers.

For this paper, we identified and reviewed schemes similar to Component C that predated KUSUM in three states (Gujarat, Andhra Pradesh, and Karnataka), which would help Tamil Nadu and potentially other states to effectively implement KUSUM's Component C.

Table ES-1 shows a snapshot of the schemes we have reviewed.

About This Paper

Our paper studies the design and performance of three schemes—Suryashakti Kisan Yojana (SKY) in Gujarat, Surya Raitha Scheme in Karnataka, and the Solar BLDC Pump Pilot in Andhra Pradesh—that predated the launch of KUSUM's Component C in Tamil Nadu.

The objective of this paper is to highlight the learnings from the schemes in these three states, which could prove useful to stakeholders in Tamil Nadu, especially discoms and the state's Renewable Energy Development Agency in the lead-up to operationalizing Component C. This evaluation would also be a useful addition to the growing body of literature on the KUSUM scheme and help other states improve their design and implementation strategy.

Our review was based on the following key criteria:

- The design characteristics of these schemes with their commonalities and unique features
- Challenges faced in implementing these schemes
- Key outcomes of such schemes

For this review, we analyzed documentation related to the schemes, such as GOs, impact reports prepared by the government or other agencies, and articles in the media. We also conducted interviews with key stakeholders in Andhra Pradesh, Karnataka's state nodal agencies, and other implementation organizations that were involved through the life cycle of the scheme. However, we have not conducted field assessments with beneficiaries on account of COVID-19 - related restrictions.

It must be noted that this paper is not intended to be a cost-benefit or a comparative analysis of the schemes reviewed in this study.

Insights from Solarization of Pumpsets in Three Indian States

Scheme Design: The schemes across the states worked with a net-metered solar-PV-based pumpset installed on a farmer's field. The solar capacity of the installed system (in kilowatts, kW) was permitted to be greater than or equal to the installed capacity of the pump (in horsepower, hp). The actual permitted value varied across the three states.

Feed-in tariff (FiT) is also an important part of the scheme. It has the potential to decide the additional income that farmers can earn by exporting excess electricity into the grid and their potential behavior toward water conservation. In general, a value lower than the average cost of supply (ACoS) for the discom was considered.

Financing for the scheme was initially envisaged as a combination of government (union and state) subsidies and farmer investments, but the latter ended up being taken up by the state itself.

Key Challenges: Raising financial contributions from farmers was a major challenge across all states. As mentioned earlier, these were subsequently taken up by the state. Winning the confidence of farmers in solarization was challenging considering the politics around metering of irrigation pumpsets. Another challenge was the lack of confidence in solarized pumpsets due to observation of poor or failed experiences with earlier attempts to deploy off-grid solar PV pumpsets. Monitoring and evaluation (M&E) of the scheme was a challenge due to non-standardization of the equipment and the lack of training given to farmers to read the meters. In the case of Karnataka in particular, one of the major challenges was the selection of the wrong target region to implement the scheme. The Harobele region, which falls under the Arkavathy river/dam area, has no groundwater scarcity and belongs to the water-intensive sericulture belt, where the value generated by irrigation is high. The FiT offered to the farmers through the scheme was, therefore, not enough for farmers to change their water extraction patterns.

Key Recommendations

Based on our assessment and the findings, we arrived at the following recommendations, which have the potential to inform and aid the design and roll-out of KUSUM's Component C in Tamil Nadu:

- Determine the appropriate level of the FiT to incentivize the use of solar panels to power the irrigation pumpsets and incentivize groundwater conservation.
- Ensure timely and full payout of subsidy and incentives to facilitate farmers' participation and enhance trust.
- Ensure that there are adequate operational and maintenance provisions for the solar PV systems and pumpsets, including training programs for farmers, as part of the tender documents. Poor performance of the equipment and malfunctions erode the farming community's trust in solarization.
- Maintain regulatory certainty by consistently adhering to the scheme parameters, except when major course corrections are required. The signals for this can come from a good M&E framework. Therefore, capacity development and institutionalizing a robust M&E framework can help assess the scheme's performance and plan for course correction if it becomes necessary.

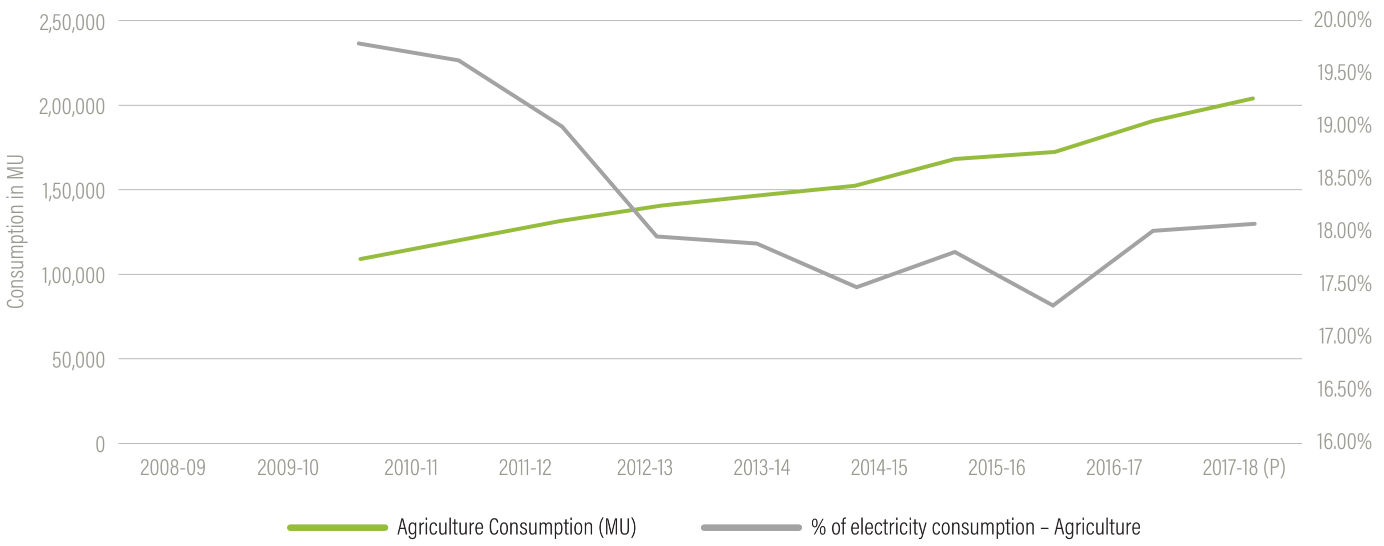
1. INTRODUCTION

The supply of electricity for irrigation needs is a crucial factor in agricultural production. The electricity demand from India's agricultural sector has grown at a compounded average growth rate of 6.42 percent since 2008–09 and accounted for 18 percent of the country's electricity consumption in 2018–19 (MoSPI 2019). Though the share of electricity supplied to the agricultural sector has decreased in comparison to other sectors, its total consumption of electricity has increased over the past 10 years (Figure 1).

The increase in electricity consumption is directly proportional to the growing trend of tubewell irrigation in India, as seen in Figure 2. India has electrified over 2.13 crores of pumpsets/tubewells as of March 2020. Of these, 2.82 lakh pumpsets/tubewells were electrified in 2019–20 (CEA 2020a).

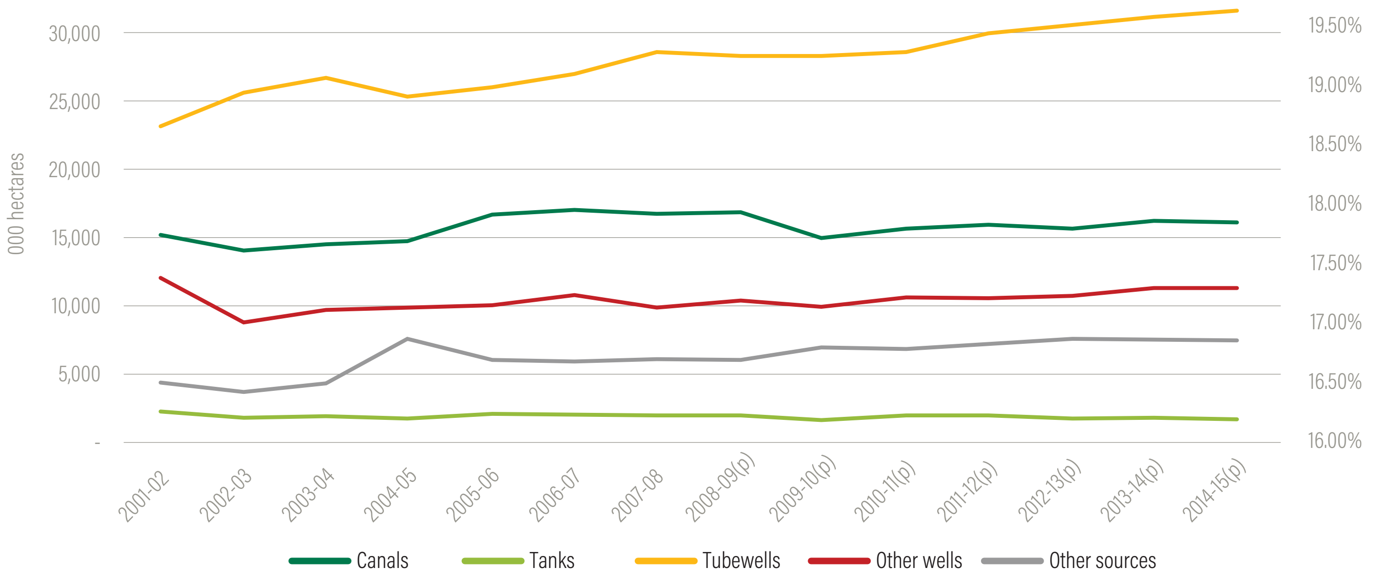
Electricity for irrigation in the agricultural sector is either supplied free of charge or is subsidized by most state governments across India. This policy is largely driven by political compulsions. With the quantum of electricity supply to the sector going up, subsidy disbursements by the state government have also risen proportionally. Electricity subsidies pose a paradox: they are viewed as a fiscal measure to boost the agricultural sector's profitability/productivity, but they impose

Figure 1 | **Share of Agriculture in India's Electricity Consumption**



Note: MU = million units.
Source: MoSPI 2019.

Figure 2 | **Irrigated Area by Source in India**

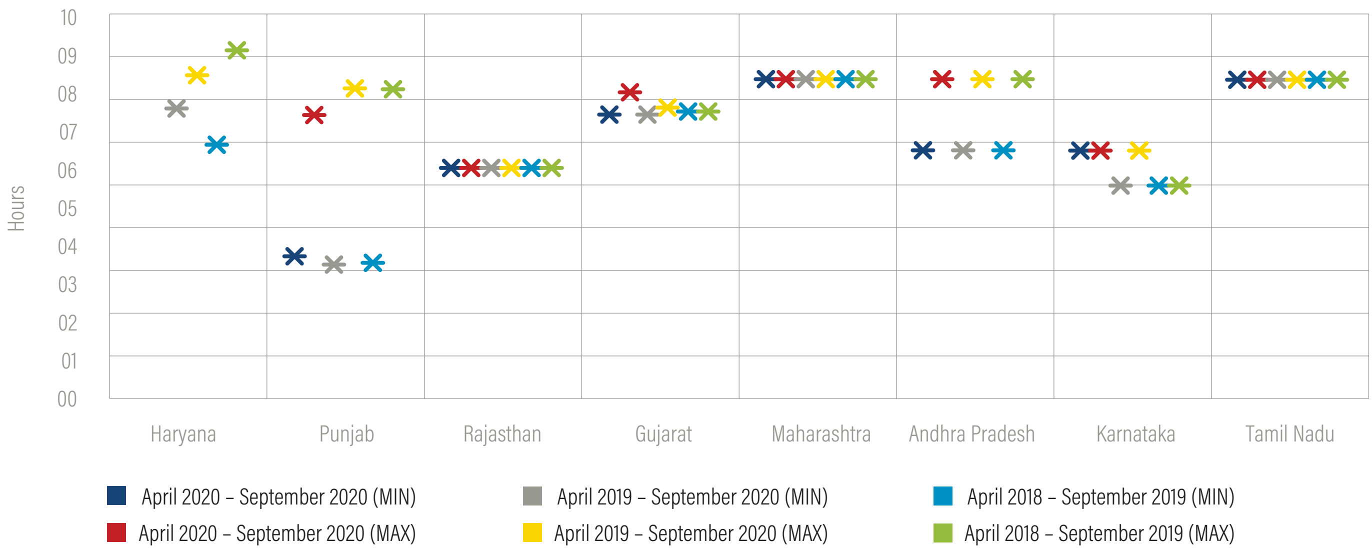


Note: The "(p)" next to some years denotes "provisional."
Source: MoSPI 2018.

a heavy burden on the state's finances (Singh 2012; Rao 2017). An estimated ₹90,000 crores was allocated to subsidizing power supplied to the agricultural sector in 2015–16 (Ramaswami 2019). The subsidy disbursed by state governments in India accounts for a significant proportion of a state's budget. Power subsidy for the agricultural sector ranges from 3.8 percent of the state budget in Andhra Pradesh (Chatterjee 2020b; AP Government 2020) to 10 percent of the state budget in Punjab (Rambani 2020).

Our research found that subsidized power supplied to the agricultural sector in Gujarat, Andhra Pradesh, and Karnataka is often unreliable. Most subsidized power is provided during nighttime hours, causing great inconvenience and posing safety risks to the farmers.

Figure 3 | **Average Daily Hours of Supply to Agriculture Consumers**



Source: CEA 2019, 2020b, 2020c.

It is a common practice for farmers to use auto-starters on their pumpsets that are configured to switch pumps on as soon as electricity supply commences at night. With the cost of electricity being nil to minimal, farmers often neglect to monitor their pumpsets at night. This practice results in both inefficient use of electricity and overextraction of water (Gill 2019). In the case of Tamil Nadu, the practice is to provide six hours of supply during the daytime and three hours during the night (Figure 3).

One of the major fallouts of the injudicious use of irrigation pumpsets is an increase in carbon emissions. A recent study estimated that groundwater irrigation emits 45.3–62.3 million metric tons of carbon annually, contributing 8–11 percent of India's total carbon emission (Rajan et al. 2020). This growing carbon footprint contributed by tubewells highlights the serious environmental concerns that could impact society and the wider economy.

Solarization of Irrigation

Supplying power through solar PV has the potential to address the challenges concerning reliability of power and rising subsidy payments by state governments. It can also offer a climate risk mitigation strategy. Several states in India have launched regional schemes, at a pilot scale, to solarize irrigation with varying degrees of success. The central government, with a view to strengthening and streamlining such sub-national efforts, launched the KUSUM national scheme, which is led by the Ministry of New and Renewable Energy (MNRE). The KUSUM scheme has three distinct components (see Figure 4).

Figure 4 | **KUSUM Component Description and Targets**

Component A	Component B	Component C
Setting up of 10,000 MW of decentralized ground-level/stilt-mounted grid-connected solar or other renewable-energy-based power plants	Installation of 17.50 lakh stand-alone solar agriculture pumps to replace existing diesel pumps	Solarization of 10 lakh grid-connected agriculture pumps

Note: KUSUM = Kisan Urja Suraksha evam Utthaan Mahabhiyan; MW = megawatts.
Source: MNRE 2019.

Component B and C targets have been revised from those announced at the original launch of the scheme: 20 lakh pumps, up from 17.5 lakh pumps for Component B; and 15 lakh pumps, up from 10 lakh pumps for Component C (MNRE 2020b). Revised guidelines for the implementation of feeder-level solarization under Component C were issued on December 4, 2020 (MNRE 2020c). Component C can now be implemented either at an individual irrigation pumpset level or at a feeder level, where a larger solar power plant would cater to the total annual power requirement of the feeder.

The target of the KUSUM scheme is to add 30.8 gigawatts (GW) of solar power to India's overall goal of 100 GW by 2022 through three specific intervention components. A total outlay of ₹34,035 crores (MNRE 2020b) has been provisioned to finance the capital expenditure required to install grid-connected solar panels for agricultural purposes. Although KUSUM is a central government scheme, every state is expected to achieve a share of the 30.8 GW target (MNRE 2020a). Figure 5 details the state-wise breakup of the target.

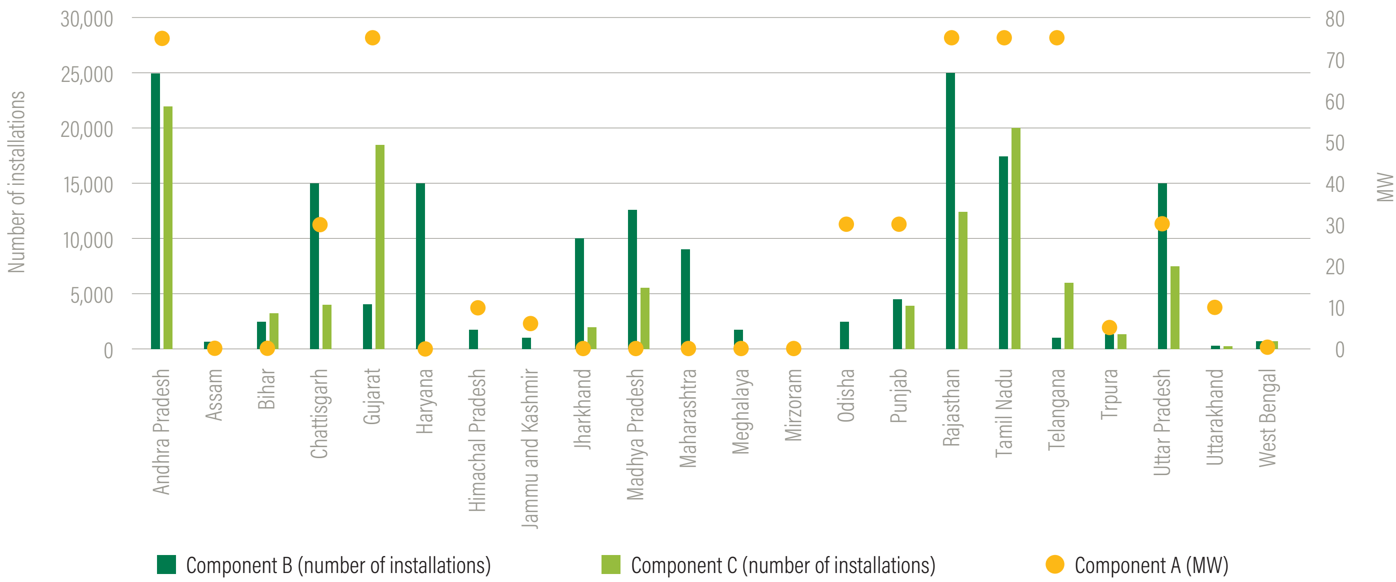
The Case in Tamil Nadu

Tamil Nadu has opted to implement all three components of the KUSUM scheme (MNRE 2020a). Tamil Nadu Electricity Generation and Distribution Company Limited (TANGEDCO), Agriculture Engineering Department, and Tamil Nadu Energy Development Agency (TEDA) have been identified as the implementation agencies for Components A, B, and C, respectively.

The GoTN issued its order for the implementation of KUSUM-C Scheme on August 18, 2020, by sanctioning ₹316.80 crores as a share of the state's subsidy to solarize 20,000 grid-connected pump sets (Energy Department, GoTN 2020). On November 10, 2020, the TNERC passed an order approving the scheme with a ceiling solar FiT order of ₹2.28/kilowatt-hour (kWh) and a generation-based incentive for the farmer starting at ₹0.5/kWh and going up to ₹1/kWh (TNERC 2020). Some of the key highlights of the order are shown in Figure 6.

According to the MNRE guidelines on the scheme, the capital expenditure to procure and install such systems is intended to be financed by subsidy assistance from the MNRE (30 percent) and the state government (30 percent), and the rest through farmers' contribution (40 percent equity) paid to the nodal agency operationalizing the scheme. It is expected that only 10 percent of the equity cost needs to be paid up front by the farmer, and

Figure 5 | **State-Wise Split of KUSUM Targets**



Note: KUSUM = Kisan Urja Suraksha evam Utthaan Mahabhiyan; MW = megawatts. The state-wise breakup has not been revised along with the overall target. Also, though the Ministry of New and Renewable Energy (MNRE) has not listed Karnataka as part of the new scheme targets, the state has issued Government Orders (GOs) for Components A and B, for reasons unspecified.
Sources: MNRE 2020a.

Figure 6 | **Key Highlights of Tamil Nadu KUSUM C Order 2020**

1. Solar power capacity up to 2 times the pump capacity to be allowed
2. 7.5 hp is the chosen pumpset load, implying a maximum solar capacity of 11 kW
3. Two models for implementation: the Capex model (TEDA implements the project and enters into a PPA with TANGEDCO) and the RESCO model (a private developer implements the project). In both cases, there is no requirement for capital investment from farmers.
4. A levelized ceiling tariff for 25 years of ₹2.28/kWh that will be paid to the RESCO
5. Farmer's incentive of up to ₹1/kWh for net export and a maximum annual incentive of ₹15,000 for a 7.5 hp pump and 11 kW solar system combination

Note: KUSUM = hp = horsepower; KUSUM = Kisan Urja Suraksha evam Utthaan Mahabhiyan; kW = kilowatt; kWh = kilowatt-hour; PPA = power purchase agreement; RESCO = renewable energy service company; TANGEDCO = Tamil Nadu Electricity Generation and Distribution Company Limited; TEDA = Tamil Nadu Energy Development Agency.
Sources: TNERC 2020.

the remaining 30 percent will be financed by a bank loan (MNRE 2020c).

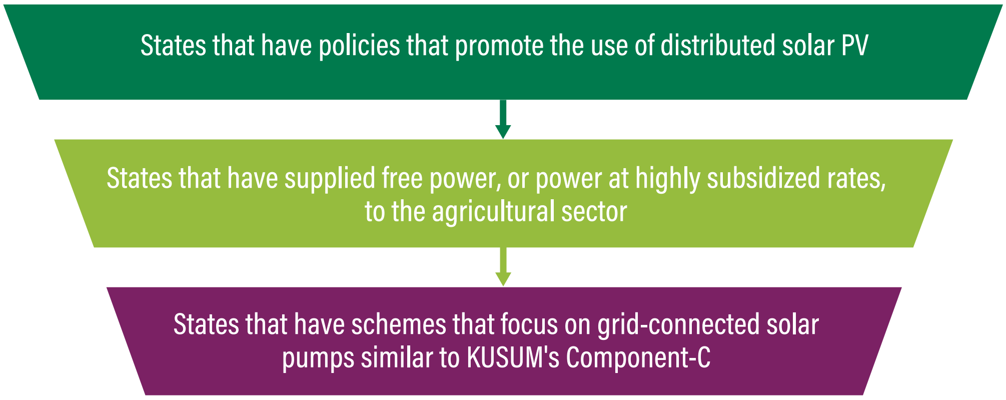
We focused our attention on deriving learnings to help operationalize Component C, as it is the first of the three components that the GoTN has decided to move ahead with.

There are two key challenges the GoTN will need to consider when implementing Component C: water scarcity and financial viability for the farmer.

- Nearly 49 percent of the administrative blocks in Tamil Nadu are categorized as critical, overexploited, or saline (MoJS 2019). When the condition of all the administrative blocks was compared with a previous assessment carried out in 2013, 68 percent of them exhibited deterioration. Many of these blocks are part of the agricultural belt in the state. Under these critical conditions, the implementation of Component A takes away the ability of an individual farmer to moderate his/her water table extraction, because Component A essentially targets setting up an aggregated solar plant for the entire feeder. Component C, on the other hand, is geared toward setting up solar plants for individual pumpsets. The implementation of Component C can potentially help save water and help avoid stranded capacity (where there is insufficient uptake for the generated power) challenges with the existing generation fleet of the discom (Gulati et al. 2020).

- Although Component C could contribute to energy and water conservation efforts, there are associated financial challenges for the farmer. According to the 2019 KUSUM guidelines, 40 percent of the capital cost of the solar PV pump will have to be borne by the farmer. Reports suggest that rural agricultural households in Tamil Nadu have one of the highest incidences of debt in the country. It is estimated that 60–80 percent of rural agricultural households in the state have some form of debt or borrowing that is yet to be repaid. Therefore, incurring further debt would not be viable and could even be detrimental (NABARD 2018).

Figure 7 | **Criteria for Selection of States**



Note: KUSUM = Kisan Urja Suraksha evam Utthaan Mahabhiyan; PV = photovoltaic.

Methodology

We looked at several other states across all the regions in India to check if any of them have explored or initiated the process of implementing the KUSUM scheme or similar schemes in the past. We tabulated the details of various solar PV irrigation schemes (SPIS) across India and classified them as shown in Figure 7.

Based on this classification, we looked at the renewable energy (RE) policies of different states along with the tariff orders passed by regulatory commissions for supplying power to the agricultural sector in each state. We identified the schemes rolled out in Gujarat, Andhra Pradesh, and Karnataka as the focus of our evaluation based on their similarity to the structure of KUSUM's Component C. Though the schemes are similarly designed—particularly around their FiT mechanism—the management structure and implementation strategies of each scheme are unique, as described in the subsequent sections. For a detailed list of the schemes and other information on the top 10 states, see Appendix A, Table A1.

Limitations of the Study

Field research posed a challenge owing to the travel restrictions imposed by the pandemic. We were unable to conduct face-to-face interviews with farmers who have adopted these schemes. As a result, we had no means of obtaining independent on-ground assessments of the outcomes of the schemes.

Process

The primary research method we adopted for this paper is the analysis of documentation related to the schemes. This included Government Orders (GOs), Measurement and Evaluation (M&E) reports prepared by government or other agencies, and articles in the media.

We also conducted interviews with key stakeholders in Andhra Pradesh and Karnataka's state nodal agencies and other implementation organizations that were involved through the life cycle of the scheme. One of the coauthors of our paper is a part of Gujarat Energy Research & Management Institute (GERMI) and supported conceptualization of the Suryashakti Kisan Yojana (SKY) scheme in Gujarat. We assessed each case state-wise, along a uniform set of parameters as detailed in the following sections.

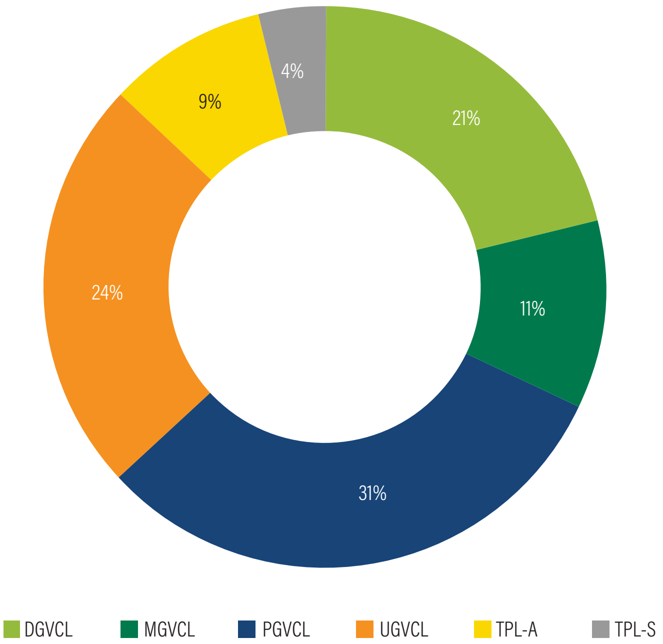
2. GUJARAT

Overview of the Power Sector and Agricultural Demand in the State

Gujarat has four government-owned electricity distribution companies—Uttar, Dakshin, Paschim, and Madhya Gujarat Vij Corporation Limited (U/D/P/M GVCL)—that were formed post the unbundling of the power sector in 2005 and the reforms under the Electricity Act 2003. These discoms are responsible for distributing power to various consumer categories, while the parent holding body—that is, Gujarat Urja Vikas Nigam Limited (GUVNL)—is responsible for power purchase. In addition to the government-owned discoms, Torrent Power Distribution Limited operates the distribution network in a few cities.

Figure 8 lists discom-wise sales in the state of Gujarat (GERC 2020). Paschim Gujarat Vij Corporation Limited (PGVCL) is the largest discom (in terms of sales),

Figure 8 | **Discom-Wise Sales (in MU) in Gujarat**



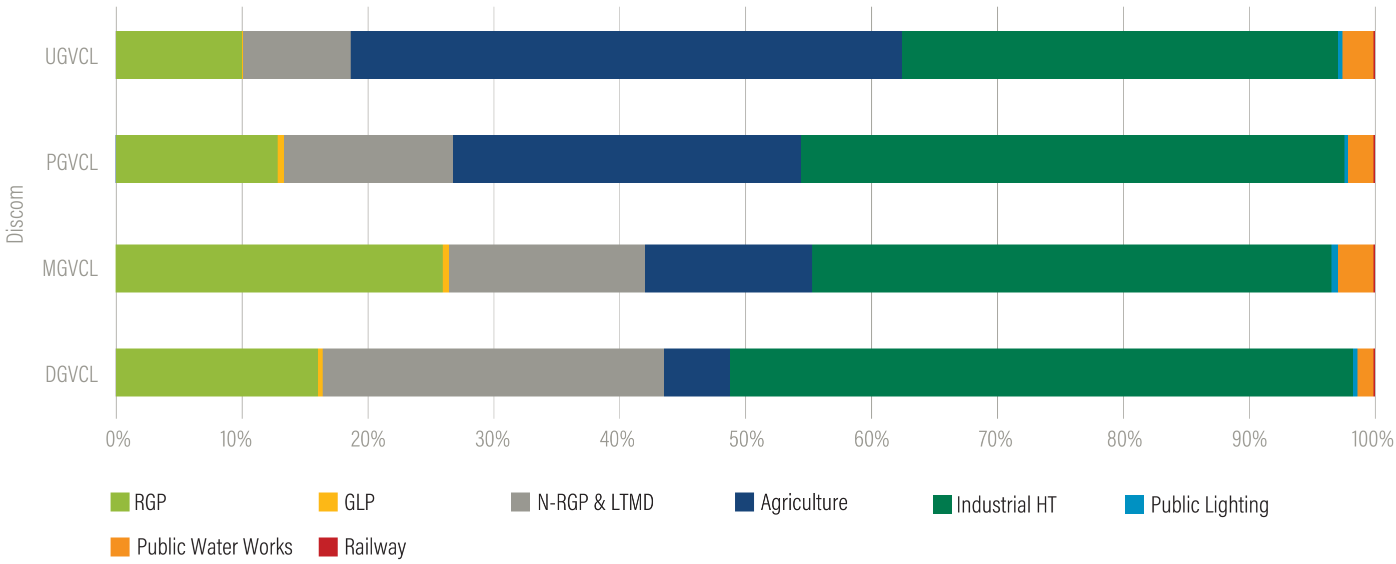
Note: DGVCL = Dakshin Gujarat Vij Corporation Limited; discom = distribution company; MGVCL = Madhya Gujarat Vij Corporation Limited; MU = million units; PGVCL = Paschim Gujarat Vij Corporation Limited; UGVCL = Uttar Gujarat Vij Corporation Limited; TPL-A = Torrent Power Limited–Ahmedabad; TPL-S = Torrent Power Limited–Surat.
Source: GERC 2020.

followed by Uttar Gujarat Vij Corporation Limited (UGVCL), Dakshin Gujarat Vij Corporation Limited (DGVCL), Torrent, and Madhya Gujarat Vij Corporation Limited (MGVCL). Whereas Torrent Power caters to urban centers, the other discoms cater to significant agricultural demand, making them the prime movers for agricultural solarization interventions.

Figure 9 shows the share of agriculture sales in the four discoms of GUVNL. UGVCL and PGVCL have a more significant share of agricultural consumers compared to DGVCL and MGVCL. Consequently, the former two face greater revenue stress. The agricultural tariff structure in Gujarat, shown in Table 1, highlights the extent of subsidy provided by the state government to the agricultural sector.

The state and discoms needed to come up with a strategy to address the concerns over rising expenditure on account of subsidized power delivered to the agricultural sector. Therefore, the state announced the SKY scheme in 2018 (Energy & Petrochemicals Dept., Govt. of Gujarat 2018).

Figure 9 | **Share of Agriculture Sales for Discoms**



Note: discom = distribution company; GLP = General Lighting Purpose; HT = High Tension; LTMD = Low Tension Medium Demand; N-RGP = Non-Residential General Purpose; RGP = Residential General Purpose.
Source: GERC 2020.

Table 1 | **Gujarat Agricultural Consumer Tariff**

CATEGORY	TYPE OF CONSUMERS COVERED	ALLOWED LOAD (KW)	FIXED CHARGE (₹/KVA OR KW)	ENERGY CHARGE (₹/KWH)
Agriculture	Metered and unmetered agricultural consumers	No restrictions	Unmetered: ₹200/ hp/month Metered: ₹20/hp/ month	Unmetered: ₹0/kWh Metered: ₹0.60/kWh

Note: hp = horsepower; kVA = kilovolt-ampere; kW = kilowatt; kWh = kilowatt-hour.
Source: Gujarat Electricity Regulatory Commission (GERC) Truing up for FY 2019-20, Determination of ARR and Tariff for FY 2021–22 of Gujarat discoms.

SKY Scheme: Introduction

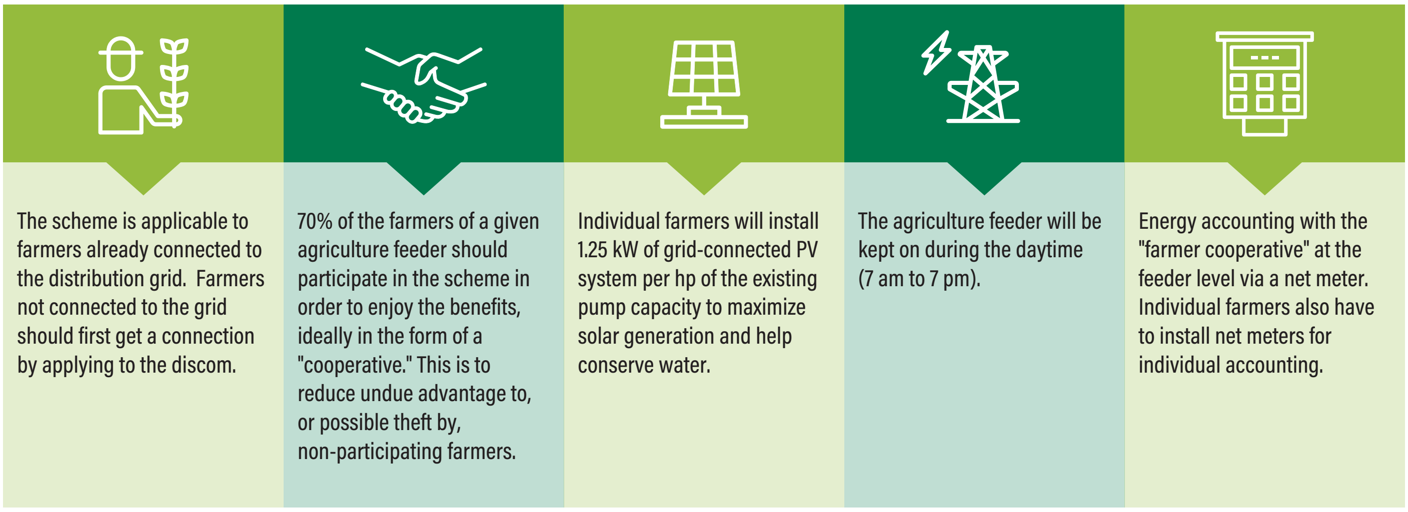
Under SKY, the Government of Gujarat piloted a scheme projected to reach 137 feeders across several districts of Gujarat. Each feeder has several farmers connected to it. The scheme essentially operates with net-metered solar-PV-based pumpsets installed in the farmers' fields. The aim was to help farmers (individuals as well as groups) form collectives/cooperative societies that could help implement the scheme. Financing for this pilot project was apportioned as follows: investment by the farmer (5 percent equity), subsidy assistance from the MNRE (30 percent), and the remaining 65 percent to be obtained as a loan taken by the state government on behalf of the farmer. The total project cost was estimated to be ₹900 crores, of which the estimated debt required for the entire project was ₹585 crores.

Objectives and Technical Provisions of Scheme

The key technical provisions of SKY are shown in Figure 10. The key objectives of SKY were the following:

- Provide adequate and reliable daytime power to farmers by installing solar PV panels
- Provide a secondary source of income to farmers through sale of surplus solar power to discoms, thus incentivizing efficient utilization of power and water
- Help farmers become self-reliant for their electricity requirement
- Create employment opportunities in rural areas, particularly around the operation and maintenance of solar PV systems

Figure 10 | **Technical Provisions of Suryashakti Kisan Yojana (SKY) Scheme**



Note: hp = horsepower; kW = kilowatts; PV = photovoltaic.
Source: GERC 2018.

- Reduce the financial burden on discoms and government, and lessen the need for other sectors to cross-subsidize power to farmers
- Promote RE and meet the solar renewable purchase obligation of discoms

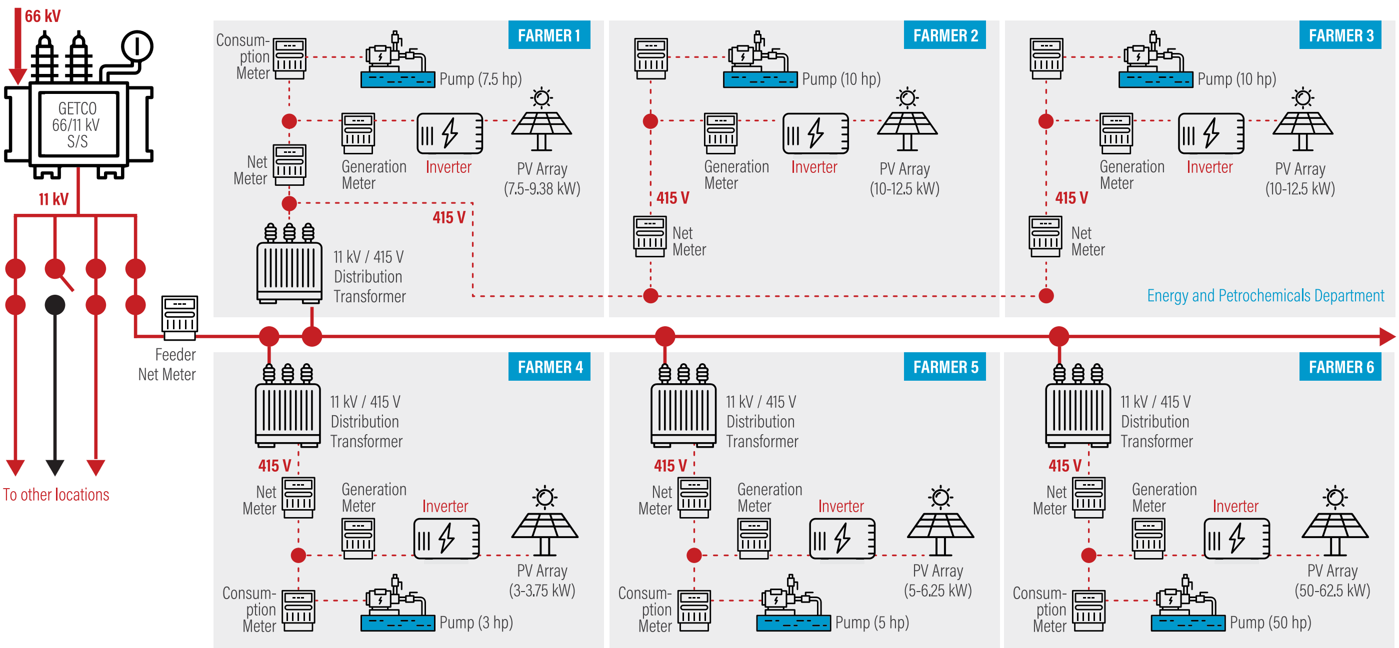
Figure 11 provides the schematic line diagram of the technical system. The figure indicates a substation from which 11 kV feeders emanate, some of which are earmarked as agriculture feeders to supply electricity to farmers. All financial settlements from the discom are reconciled with the net meter at the substation to discourage theft along the feeder.

Farmer Economics

Capital Investment

In addition to the 30 percent of capital cost received as subsidy from MNRE, the farmer is expected to contribute at least 5 percent of the solar PV system cost, and the remaining 65 percent is raised as a loan facilitated by the state government through an escrow involving the discom at the rate of ≤6 percent (Jani 2018). The project parameters are summarized in Figure 12.

Figure 11 | **Line Diagram for Suryashakti Kisan Yojana (SKY) Scheme**



Note: GETCO = Gujarat Energy Transmission Corporation Limited; hp = horsepower; kV = kilovolt; kW = kilowatt.
Source: Jani 2018.

Figure 12 | **Suryashakti Kisan Yojana (SKY) Scheme Capital Investment**

Total targeted pump capacity under project: 139,965.5 hp

Corresponding solar PV capacity: 175 MW

Per kW capital cost: ₹50,000/kW

Total capex under the project: ₹875 crores

Farmer's equity contribution (5%): ₹43.75 crores

Total debt required (65%): ₹568.75 crores

Note: hp = horsepower; kW = kilowatts; MW = megawatts; PV = photovoltaic.
Source: Jani 2018.

Table 2 | **Return on Investment in Suryashakti Kisan Yojana (SKY) Scheme**

	PROVISION	JUSTIFICATION/REMARKS
1	FiT: ₹3.50/kWh The discom's rate of purchase of net surplus power generated by the farmer at the end of the billing cycle. Purchase period: 25 years.	In line with (a) Gujarat's average power purchase cost, and (b) the cost of bulk solar power transmitted to the distribution end.
2	EBI: ₹3.50/kWh By the Government of Gujarat, in addition to the FiT, up to a maximum of 1,000 kWh per kW of solar system per year. EBI to be provided up to the completion of loan repayment by farmer; that is, for 7 years.	Equivalent to the Government of Gujarat's 30% subsidy (net present value of the cash flows for 7 years).

Note: kWh = kilowatt-hour.
Source: GERC 2018.

Return on Investment: Feed-in Tariff (FiT) and Evacuation-Based Incentive (EBI)

FiT and EBI are two specific sources of cash flow that are expected to pay back the investment incurred on the solar systems.

Farmer's Investment and Payback

Table 3 lists the costs that farmers would incur and the projected payback, which could justify investment decisions. Table 4 shows the assumptions and calculations used to design the evacuation-based incentive (EBI) and feed-in tariff (FiT).

The capital cost of a grid-connected PV system is assumed to be ₹50,000/- per kW. This price is based on the current market trends and the latest tenders for distributed PV systems in India. However, this is only an estimate. The subsidy contribution of MNRE is subject to approvals. The state government bears this subsidy component until such approvals are received.

The scheme assumed that efficiency improvements would arise from improved irrigation practices due to the incentives for the export of energy to the grid. Moreover, energy-efficient pumps could be adopted to maximize energy export.

Table 3 | **Farmer Investment and Payback in Suryashakti Kisan Yojana (SKY) Scheme**

PER HP CAPITAL COST COMPONENT	FRACTION OF TOTAL CAPITAL COST	AMOUNT (₹)
Farmer's up-front payment	5%	3,125/-
MNRE's capital subsidy	30%	18,750/-
Farmer's loan amount	65%	40,625/-

Note: kWh = kilowatt-hour; MNRE = Ministry of New and Renewable Energy.
Source: GERC 2018.

Table 4 | **Energy Balance for the Farmer in Suryashakti Kisan Yojana (SKY) Scheme**

SL NO.	ENERGY COMPONENT PER HP	ENERGY (kWh/year)
1	Energy generated "per 1.25 kW" of PV system (@CUF 18.30%)	2,000
2	Energy utilized "per hp" of pump (Less:)	800
3	Efficiency Improvements due to incentives	200
4	Farmer's net energy injection to the grid (1–2+3)	1,400

Note: hp = horsepower; kW = kilowatt; kWh = kilowatt-hour.

Table 5 | **Farmer Revenue in Suryashakti Kisan Yojana (SKY) Scheme**

SL NO.	FARMER'S REVENUE COMPONENT PER HP	DURING THE LOAN TERM (YEAR 1 TO 7) (₹/YEAR)	AFTER LOAN TERM (8-25 YEARS) (₹/YEAR)
1	Sale of power to discom (@ ₹3.50/kWh)	4,900/-	4,900/-
2	EBI from Govt. of Gujarat (@ ₹3.50/kWh, max. 1,000 kWh/kW/yr)	4,375/-	-
3	Savings in electricity bill (@ ₹0.60/kWh)	480/-	480/-
4	Gross benefit to farmer	9,755/-	5,380/-
5	(Less: loan repayment)	6,574/-	-
6	Net annual income	3,181/-	5,380/-

Note: discom = distribution company; EBI = evacuation-based incentive; hp = horsepower; kW = kilowatts; kWh = kilowatt-hour; yr = year.
Source: Authors.

State Government's Economics

Gujarat has over 15 lakh farmers connected to its distribution grid with an average individual pump capacity of 11.4 hp. Further, the number of connections has been increasing by 1–2 lakhs each year. In 2017–18, the agricultural sector consumed 27 percent of GUVNL's electricity supply.

The cost incurred by GUVNL to serve electricity is ₹6.00/kWh, while the recovery from farmers is only about ₹0.62/kWh. This shortfall is met through subsidy from the state government and cross-subsidy, mainly from industrial and commercial consumers. In 2017–18, GUVNL sought from the Government of Gujarat a subsidy of ₹5,370 crores for the deficit caused by the agricultural sector.

Once a farmer is provided with a solar PV system, the state's power subsidy obligation toward that farmer is revoked. However, the government continues to contribute under the SKY scheme in the form of the farmer's EBI for seven years. This period is the farmer's expected loan repayment term.

Key Stakeholders and Transaction Relationships

Figure 13 describes the key stakeholders and the transactions between each stakeholder in the scheme.

- Farmers are the beneficiaries of this project. They own and operate the grid-connected solar pump. The loan taken by the Government of Gujarat on behalf of farmers will be routed through GUVNL.
- The concerned discom is responsible for signing the power sale agreements with the farmers.
- The Government of Gujarat Energy and Petrochemical Department is responsible for steering the project, taking the loan from NABARD, and disbursing the EBI for seven years to the farmers.
- NABARD will syndicate the loan to the Government of Gujarat.

Social and Environmental Benefits

This project was designed with the objective of offering the social and environmental benefits shown in Figure 14.

Stakeholder Benefits and Challenges

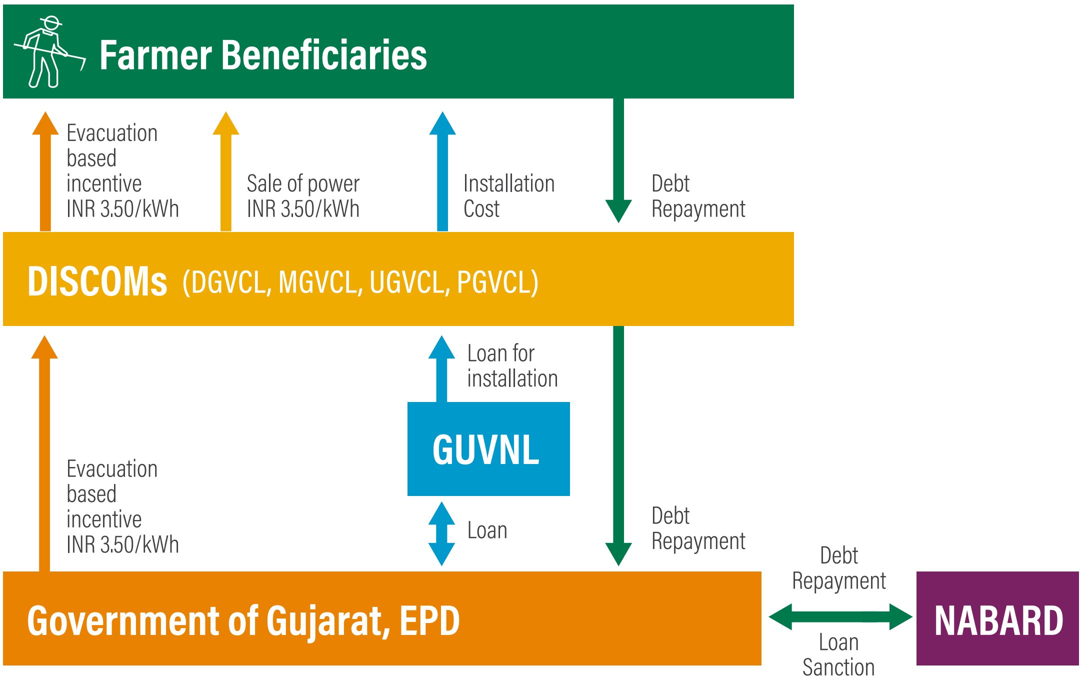
The stakeholder benefits and challenges are presented in Table 6.

Current Status and Deviations from Plan

Against an original target of 137 feeders, 11,993 consumers, 175 MW, and 139,965.5 hp, we observed that the progress has been 68.6, 37.6, 46.2, and 56.8 percent, respectively. The additional injection of 28.5 MU of clean energy from farmers into the grid is also a positive contribution. An investment of approximately ₹536 crore, which included the farmer contribution, funded the program to achieve the outcomes highlighted in Table 7.

The state government has decided to put SKY on hold due to the announcement of KUSUM. Any further solarization will occur under the aegis of the KUSUM

Figure 13 | **Stakeholders and Flow of Funds**



Note: DGVCL = Dakshin Gujarat Vij Corporation Limited; EPD = Energy & Petrochemicals Department; GUVNL = Gujarat Urja Vikas Nigam Limited; kWh = kilowatt-hour; MGVCL = Madhya Gujarat Vij Corporation Limited; NABARD = National Bank for Agriculture and Rural Development; PGVCL = Paschim Gujarat Vij Corporation Limited; UGVCL = Uttar Gujarat Vij Corporation Limited.
Source: Authors.

Figure 14 | **Suryashakti Kisan Yojana (SKY) Scheme: Social and Environment Benefits**

JOB CREATION AND SKILL DEVELOPMENT	IMPROVEMENT IN HUMAN DEVELOPMENT INDICES	WATER CONSERVATION BENEFITS	RENEWABLE ENERGY GENERATION AND CLIMATE CHANGE
The project is expected to achieve job creation and skill development in rural areas, particularly around the operation and maintenance of the PV systems. For the purpose of this study, we have been able to get only anecdotal evidence regarding this. These benefits are yet to be formally validated through a rigorous methodology.	Access to energy improves human development indices. In this project, it is expected that the energy generated from the solar systems will increase incomes and in turn improve human development indices.	Based on the experience in Dhundi, this project envisions that the farmers will use groundwater more efficiently. It is estimated that a water-saving benefit of 15-30% can be expected (DSUUSM 2018).	The deployment of renewable energy, especially in a distributed form, has several benefits. In terms of averted CO2 equivalent emissions, the Central Electricity Authority (CEA) measures the carbon intensity in electricity generation at 0.80 metric tons of CO2 per MWh per year. The 175 MW that is scheduled to be installed under this project can generate an overall 2.8 million MWh/year. This can avert a total carbon emission of 232,556 metric tons of CO2 per year. There are also multiple system benefits in terms of avoided T&D losses and voltage improvements.

Note: CO2 = carbon dioxide; MW = megawatts; MWh = megawatt-hour; T&D = transmission and distribution.
Source: WRI analysis.

Table 6 | **Stakeholder Benefits and Challenges**

STATE GOVERNMENT—BENEFITS	STATE GOVERNMENT—CHALLENGES	FARMER—BENEFITS	FARMER—CHALLENGES	GUVNL—BENEFITS	GUVNL—CHALLENGES
▪ Reduction in electricity subsidy ▪ Potential improvement in water usage efficiency ▪ Improved rural development indicators: income and employment ▪ Ability to meet renewable energy goals	▪ Significant up-front capital subsidy and risk of loan default by farmers ▪ Requires extensive planning given the distributed nature of farms	▪ Daytime power supply ▪ Additional earnings through sale of power to the grid ▪ Potential long-term water security	▪ Raising equity is difficult for small farmers ▪ Achieving minimum mandated level of farmer participation	▪ Reduction in cross-subsidy due to reduction in agricultural consumption ▪ Potential to meter previously un-metered connections ▪ Fulfillment of Renewable Purchase Obligation	▪ Coordinating installation of distributed generation, especially as farmers are deemed to be a politically sensitive group ▪ Metering- and payment-related issues, especially in case of net imports of electricity by farmers

Note: GUVNL = Gujarat Urja Vikas Nigam Limited.
Source: WRI analysis.

Table 7 | **Status of Suryashakti Kisan Yojana Scheme**

NO. OF FEEDERS	NO. OF CONSUMERS	CONTRACTED LOAD (HP)	SPV AC CAPACITY (MW)	CURRENT GENERATION (MW) AS OF NOV 5, 2020	CUMULATIVE SOLAR GENERATION SINCE APRIL 1 2019 (KWH)	CUMULATIVE PUMP CONSUMPTION SINCE APRIL 1 2019 (KWH)	NET INJECTION (-) OR DRAWAL (+) (KWH)
94	4,506	79,568	80.84	96.61 MW	315,981,612	99,592,063	86,964,228

Note: hp = horsepower; kWh = kilowatt-hour; MW = megawatts; SPV = solar photovoltaic.
Source: From the Gujarat Energy Research and Management Institute (GERMI) records.

scheme. The pilot for 137 feeders could not be completed. Further, the 30 percent subsidy from MNRE for the SKY scheme was not disbursed to GUVNL.

Although a fair number of farmers have participated in the SKY scheme (see Table 7), the 30 percent subsidy from MNRE acts as an incentive for Gujarat to align their state scheme with the KUSUM scheme. Existing SKY participants will not be ported to KUSUM.

3. ANDHRA PRADESH

Overview of Agriculture Electricity Demand

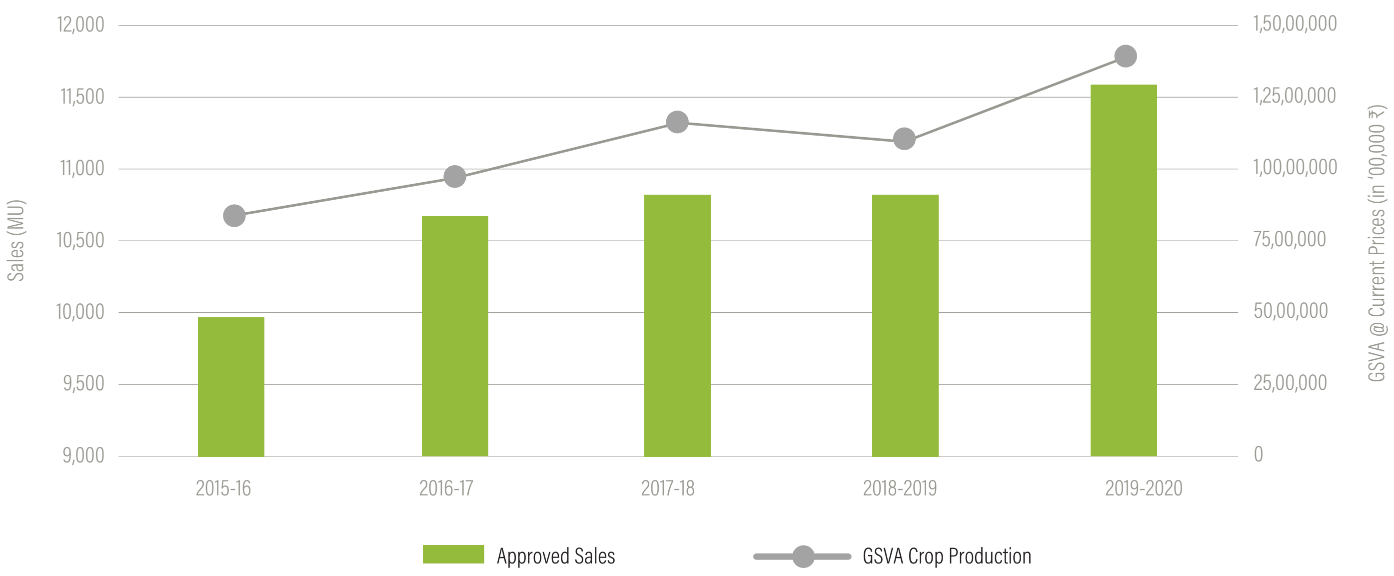
In 2019–20, Andhra Pradesh (AP) had approximately 17.85 lakh grid-connected irrigation pumpsets that accounted for 11.57 MU in electricity sales (APERC 2020). One in five units of electricity supplied in AP is consumed by the agricultural sector. With the Energy Department expecting to add over 50,000 new connections, the total number of agricultural service connections was expected to exceed 18 lakhs by the end of 2020–21 (*The Hindu* 2020a).

Although electricity is free for farmers, it was limited to seven hours per day split as three hours of daytime supply and fours of nighttime supply. In 2019, the newly elected government ordered an increase in the supply of free daytime power to nine hours to improve productivity and reduce farmers' debt (*The Hindu* 2020b). The split of day/night distribution of these nine hours has not been clarified yet. As a result of the announcement and other favorable conditions in the state brought about by the new government (Agarwal 2020; The New Indian Express 2019), the value of crop production in FY2020 grew by 26 percent from the previous year, which was higher than growth rates in the previous five years. In addition, the share of crop production of the state's total gross value add (GVA) grew from 14.0 percent in FY2019 to 15.7 percent in FY2020 (Figure 15)

However, these changes have come at a cost to the discoms. Before the 2019 announcement, the subsidy borne by the discoms to support electricity supply to the agricultural sector amounted to approximately ₹6,000 crores per year. With the announcement granting nine hours of free daytime supply, the subsidy allocation is expected to go up by another ₹1,000 crores per year (Raghavendra 2019). According to the AP Electricity Regulation Commission's (APERC) Tariff Order 2020-21, the state's subsidy contribution has grown to ₹7,462.8 crores (APERC 2020). APERC's approved subsidy per unit has also risen annually by 15.3 percent on average since 2014 and is expected to grow further given the current trajectory.

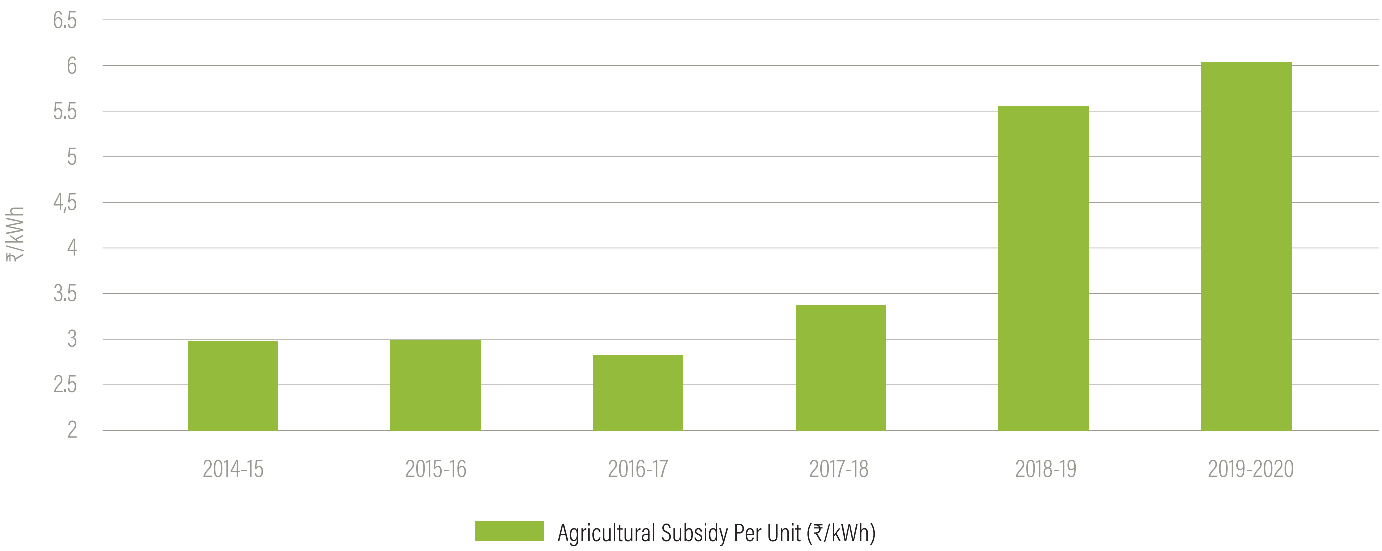
Although such subsidies are usually met by the state exchequer, the working capital of the discom and its ability to raise credit is severely impacted if there are

Figure 15 | **APEPDCL Irrigation and Agricultural Sales and Gross State Value Add (Crop Production) 2015-2020**



Note: APEPDCL = Andhra Pradesh Eastern Power Distribution Company Limited; GSVA = gross state value add.
Source: APERC 2020, MoSPI 2020.

Figure 16 | **Agricultural Subsidy Per Unit, Andhra Pradesh, 2014-2020**



Note: kWh = kilowatt-hour.
Source: APEPDCL 2019.

delays and deficits in subsidy transfers. However, the current government has now notified and approved direct benefit transfers (DBT) to the farmer in line with the central government's recommendation, negating the need for subsidy transfers to the utility (Nair 2020).

Grid-Connected Solar BLDC Pump Scheme

In anticipation of such challenges, the Andhra Pradesh Eastern Power Distribution Company Limited (APEPDCL) launched a pilot program in 2018 to replace the existing irrigation pumpsets with grid-connected solar brushless direct current (BLDC) pumpsets. It must be noted that the DBT scheme was not in effect when this pilot was rolled out. In the current context, this scheme will aim to reduce the DBT payouts by the government to eligible farmers. The entire capital expenditure of this program, which covered 216 agricultural service connections across 32 villages, was borne by APEPDCL. Based on feasibility and system analysis studies, APEPDCL identified one agriculture feeder in Vizianagaram district that would support the solar-PV-powered BLDC irrigation pumpsets (APEPDCL 2019).

The scheme encouraged farmers to export surplus energy generated from solar panels after consumption by the pumpsets at a predetermined FiT. The FiT, at the time of implementation, was fixed at ₹1.50/unit.

About the BLDC Scheme

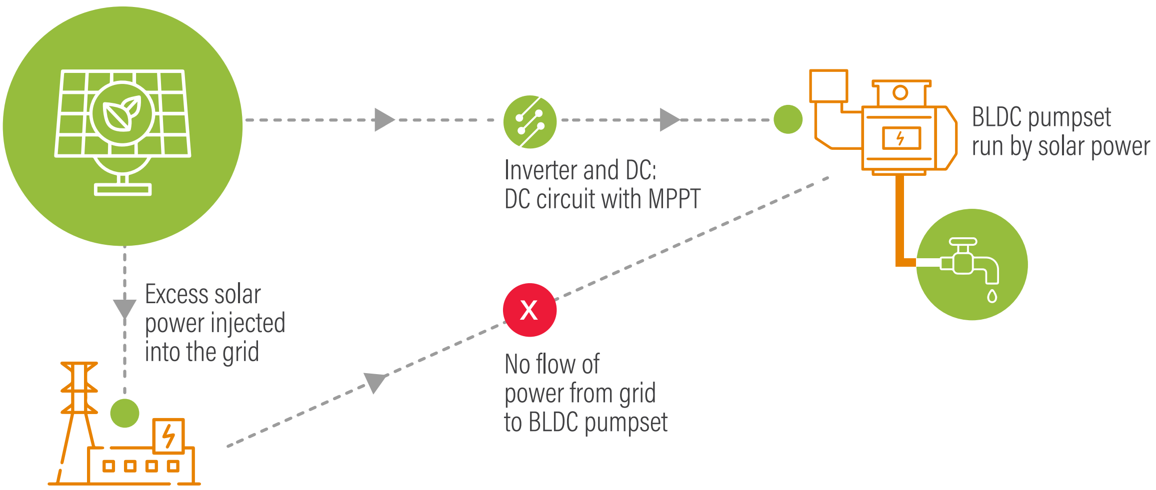
APEPDCL spent approximately ₹9.30 crores on implementation of the pilot by replacing 216 existing 3 hp and 5 hp AC pump sets with 3 hp and 5 hp grid-connected solar-PV-powered BLDC pumpsets at discovered prices of ₹3.30 lakhs and ₹4 lakhs, respectively (APEPDCL 2019). According to the scheme, the solar panels were permitted to be sized on a 1:1 basis. This means that a 3 hp pump would be allowed a corresponding solar PV capacity of 3 kW. Although APEPDCL bore the entire capital investment for each solar PV BLDC, which included the maintenance expenditure under the warranty period, the ownership is vested with the farmer.

APEPDCL specifically chose BLDC pumpsets as they have a 20–25 percent higher operating efficiency than AC pumpsets (BARC n.d.). As the scheme allows the pumpset to draw power only from the solar panel, BLDC systems are more suitable as they prevent power from being drawn directly from the grid. Solar-powered BLDC pumpsets were originally intended for off-grid applications, but this was among the first attempts to use them as part of a grid-connected system.

Any excess power generated by the solar panel that is not consumed for the pump's operation is converted back to AC power using an inverter and injected into the grid.

As this was a proof-of-concept pilot, APEPDCL needed to ensure that the risks were low and success rates were high to maximize stakeholder confidence in the scheme. An agricultural feeder in Vizianagaram district supporting 250 irrigation pumpsets was chosen by APEPDCL primarily because of the low load across that

Figure 17 | **Schematic Representation of a Grid-Connected BLDC Pumpset**



Note: BLDC = brushless direct current; MPPT = maximum power point tracking.
Source: APEPDCL 2019.

feeder and its accessibility. Two hundred and sixteen pumpsets were selected for participation in the scheme. The feeder supported pumpsets that were predominantly 5 hp or less in capacity. This would allow the discom to pilot the scheme without jeopardizing grid stability. As a further advantage, the feeder is close to a highway, making transportation of components and access to services easier.

APEPDCL also deliberately capped the pump capacity to 5 hp as they did not want to install oversized panels on the farmlands and were also limited by the allocated budget. Industry estimates suggest that the land requirement is approximately 100 square feet per kilowatt installed (Ghose et al. n.d.). Larger pumps needing larger solar panels require more land. In the Vizianagaram case, the state and the discom found that farmers were willing to forgo the required land for up to a 5 kW solar PV system. Anything more than 5 kW was objected to by the local farming groups. Farmers were not willing to give up more land because it is directly linked to their agricultural revenue.

Stakeholder Benefits

Farmers

- Revenue to farmers: BLDC pump sets are 20-25% more energy efficient than AC-powered ones. This allowed farmers to use fewer units of electricity for their irrigation needs and export more power back to the grid, thus increasing their revenues. The payback period of farmers who will invest their funds in the system will be shortened. Based on APEPDCL's calculations, each farmer with a single solar-powered BLDC pumpset could earn anywhere between ₹3,000 to ₹6,000 as additional income per year depending on the number of units exported back to the grid. R.B. Patel and R.D. Patel (2019) give an example where excess energy exported by the farmer is based on a 5 HP grid-connected pumpset with a 5 kW solar panel operating at a CUF of 15% and generating approximately 6,720 units annually. In reality, a 5 kW system can produce up to 7,000 units if the conditions are favorable.
- Grid Independence: Farmers enjoyed longer hours (>7 hours) of daytime operation compared to grid-operated power.

Discoms

Using solar-PV-powered BLDC pumpsets gave APEPDCL two advantages:

- Incentive for farmers to protect and maintain their solar PV systems: From previous experiences and trials in the state, it was found that if farmers had access to both solar PV and the grid, the panels were poorly maintained. Farmers simply switched back to the grid when it was convenient, which negated the solarization of irrigation pumps and resulted in a sunk investment for the discom. But through this pilot, when farmers were given the option to draw power from only the PV panels, field studies have reportedly shown better operation and maintenance of the solar panel systems.
- Grid independence: It eliminated the need for the grid to power the agricultural pumpsets. On average, APEPDCL supplies 6,650 units of non-revenue electricity to a single agricultural pumpset per year.

Through this pilot, APEPDCL reduced the need for state subsidies as well as cross-subsidy from other consumers.

APEPDCL was able procure the surplus energy produced by the solar PV panels at ₹1.50 from farmers. Compared to the levelized (cost adjusted for inflation) marginal cost per unit in FY2020, APEPDCL saved ₹4.19 for every unit of electricity procured from these systems, as illustrated in Table 8.

State Government

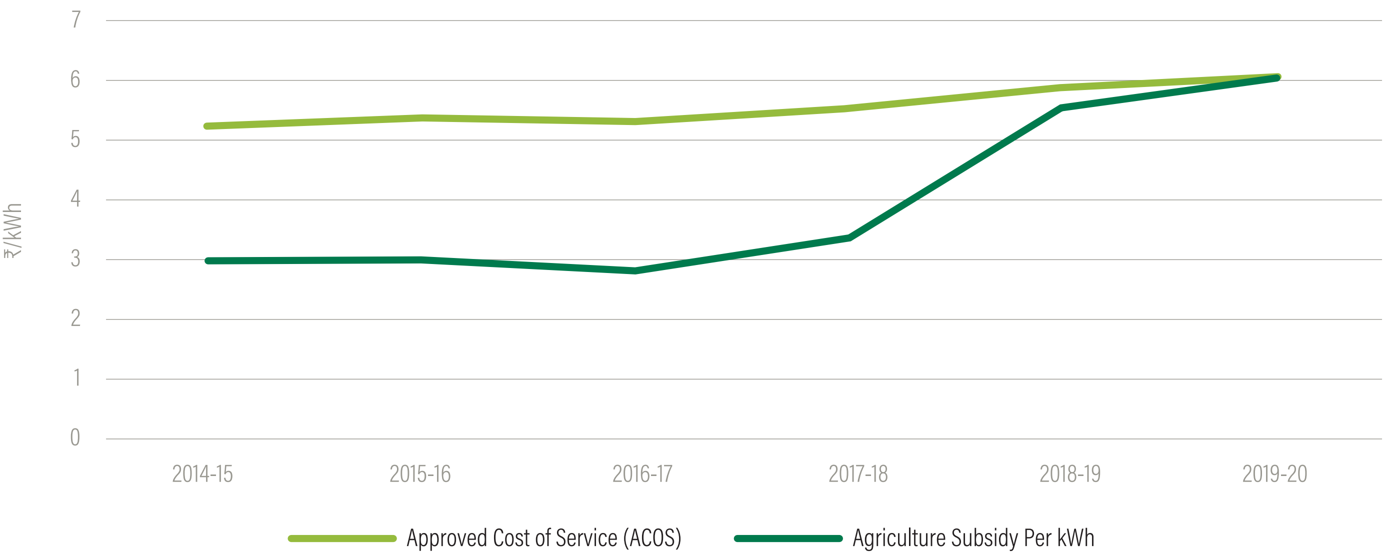
Reduced subsidy: Every grid-connected solar PV BLDC pumpset that is part of this scheme reduces the burden of subsidy on the state. Agricultural subsidy per unit provided by the Government of Andhra Pradesh has approximately doubled over the previous 5 years and, as of FY2020, has equaled the current cost of service (CoS) by the discom (APEPDCL 2019) as shown in Figure 18.

Table 8 | **Cost-Benefit Analysis to the Discom**

PARAMETER	UNIT	VALUE
Marginal variable cost in FY2019–20	₹/Unit	3.58
Year-on-year escalation in variable cost	%	4.00
Levelized variable cost for 25 years	₹/Unit	4.96
Transmission loss per Tariff Order FY2019–20	%	3.03
Distribution loss per Tariff Order FY2019-20	%	10.11
Levelized marginal cost including T&D losses	₹/Unit	5.69
Power purchase cost for excess energy injected into grid by farmers (25 years)	₹/Unit	1.50
Levelized savings to APEPDCL for excess energy injected into grid	₹/Unit	4.19

Note: discom = distribution company.

Figure 18 | **Approved Cost of Service versus Agricultural Subsidy Per Unit**



Note: kWh = kilowatt-hour.
Source: APEPDCL 2019.

The state has estimated the levelized cost of supply over the next 25 years to be ₹7.64/kWh. At this rate, and assuming the annual consumption per pumpset to be 6,650 units, the annual subsidy per pumpset borne by the government equals ₹50,806. Therefore, through this scheme, the government was able to save ₹50,806 per pump in annual subsidy disbursement.

Stakeholder Challenges

Farmers

BLDC irrigation systems: Incorporating a BLDC pumpset has benefited the discom and state by ensuring non-reliance on the grid for agricultural demand and ensuring higher accountability by farmers to maintain and operate their system effectively, although the regular maintenance costs are underwritten by the discom. However, farmers did face some challenges.

- BLDC Pump Durability and Maintenance: If a BLDC pump system fails, it is particularly difficult to repair owing to the limited technical know-how and availability of spare parts in rural and remote locations. Although the failure rate has been low, the financial implications for the farmer if a failure does occur is significantly high, especially outside the warranty period. The components of a DC pumpset are usually imported, and the cost of transportation and customs duty further add to the price. Extending the O&M contract covered under warranty, designing an affordable insurance scheme that would help cover any repair/replacement outside of the warranty, improving the local supply chain of spare parts, and capacity training are some ways to overcome this challenge.

- Lack of Grid Back-Up: During days of lower solar irradiation, farmers may experience reduced energy production, which may be insufficient to meet their irrigation needs. In such cases, farmers cannot switch back to the grid as the design of the BLDC system does not permit this.

In areas where water stress was high, higher-powered pumpsets were required to lift water up from greater depths. Solar-powered BLDC irrigation pumpsets, usually designed for low horsepower, are not the ideal system to use when pumping requirements are higher. If the farmers resorted to an alternative AC-powered pumpset, they stood to lose the benefit from exporting excess energy because of the higher energy requirements of AC-powered pump operation.

Discom

- Farmer confidence: Low confidence in solar-powered pumpsets among farmers was another problem that had to be swiftly resolved for the pilot to take off. Farmers have often cited cases of neighboring farmers with off-grid solar PV pumpsets that have failed often because of inferior component quality or the lack of any O&M support by the developer after installation. In addition to this, farmers were also apprehensive about surrendering not just their existing grid connections but their irrigation pumpsets as well. Without farmers' buy-in, the probability of non-implementation of the scheme was high. Therefore, in order to overcome the initial inertia in adoption and instill a certain level of trust among the farming community, APEPDCL, in collaboration with local panchayat and village heads, installed the first few systems.

- End-Voltage Fluctuation: APEPDCL found significant end-voltage fluctuations, particularly when the BLDC pump was not operational, preventing the solar PV panels from injecting power back into the grid (Woyte et al. 2006) and damaging the inverters, resulting in disruptions to power injection. Any disruption in power flow back to the grid, will directly impact the beneficiary's financials and may cause the program to fail.

State Government

- Data for Measurement and Evaluation: As the pilot was a proof of concept, the government invited limited tenders from only the developers who had participated in the stakeholder consultations the department had organized. The state granted all developers present an equal opportunity to deploy the system. A critical challenge with having multiple vendors installing these systems was data integration. A key lesson here for APEPDCL and the Energy Department was to ensure standardization of the remote monitoring unit's (RMUs) specification to maintain consistency in data transfer to the central server and deliver robust analysis and evaluation to all the stakeholders.

Current Status and Deviations from Plan

As of November 2020, the implementation of the pilot was complete and covered all 216 irrigation pumpsets originally targeted. An approximate installed capacity of up to 1,080 kW of distributed grid-connected solar capacity was added because of this pilot.

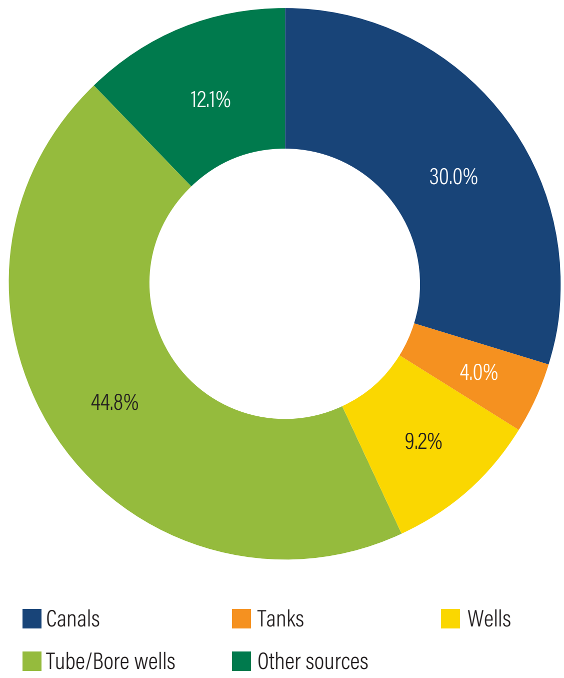
4. KARNATAKA

Overview of Agriculture Electricity Demand

For several consecutive years, Karnataka's agricultural sector has accounted for the highest share of the electricity consumption of the state. In 2018–19, the electricity consumption of irrigation pumps alone accounted for 39 percent of the total consumption (Figure 21) with an annual sale of 58,609 MU. With more than eight lakh new irrigation pumps added over the previous six years (Figure 19), the state is witnessing an upward trend in electricity demand for irrigation. It has been reported that tubewells/borewells (44.8 percent) account for the highest proportion of the net irrigated area, followed by canals (29.95 percent) and wells (9.16 percent) (Govt. of Karnataka 2020). See Figure 20.

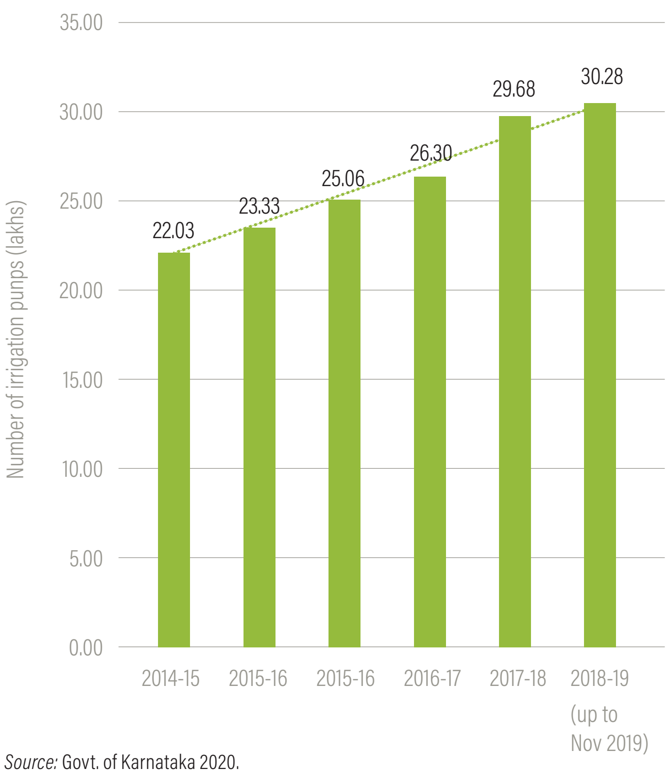
With the demand for electricity in the agricultural sector going up, subsidy disbursements by the state government have grown apace. Figure 22 illustrates the growth in subsidy provided by the government toward electricity supply for the agricultural sector between 2014 and 2019.

Figure 20 | **Sector-Wise Irrigation in Karnataka (2017-18)**



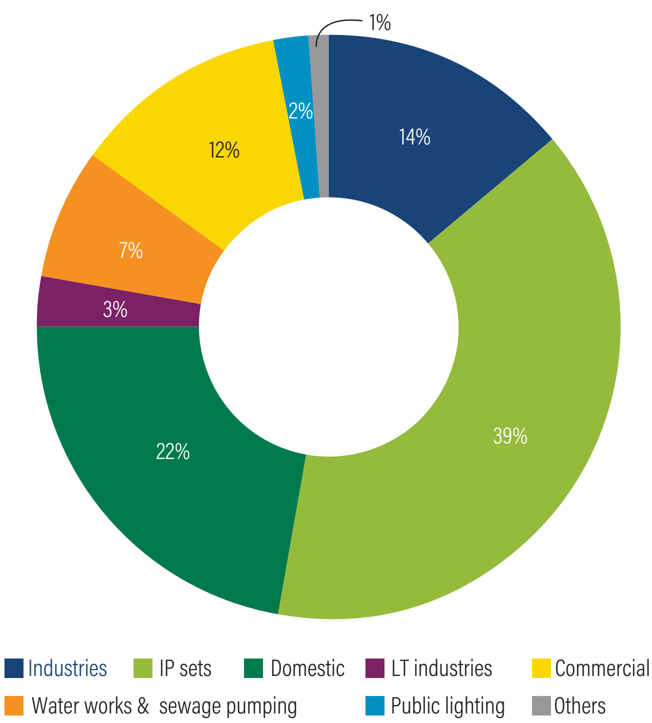
Source: Govt. of Karnataka 2020.

Figure 19 | **Increase in the Number of Irrigation Pumps in Karnataka**



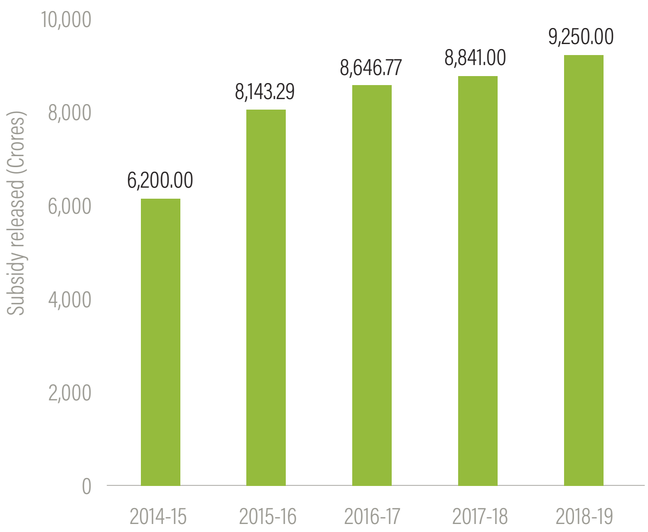
Source: Govt. of Karnataka 2020.

Figure 21 | **Sector-Wise Electricity Consumption in Karnataka**



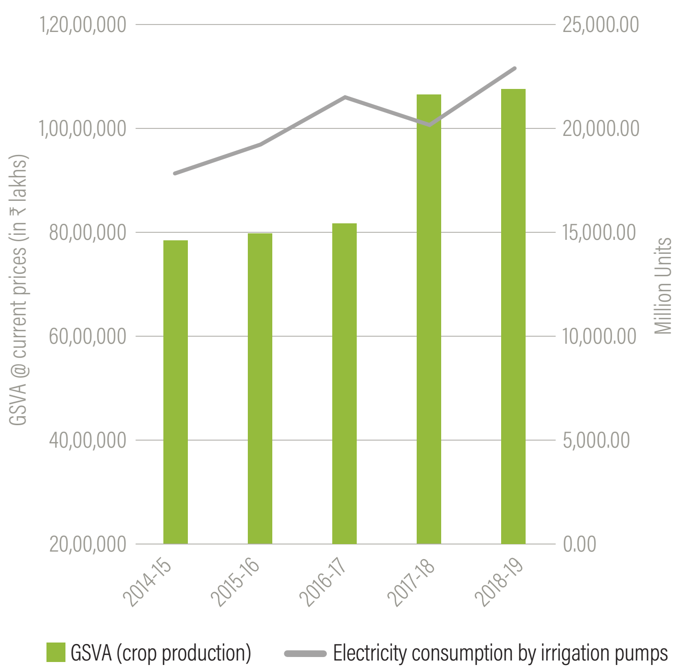
Notes: IP = irrigation pumpsets; LT = Low Tension.
Source: Govt. of Karnataka 2020.

Figure 22 | **Subsidy Released by the State Government**



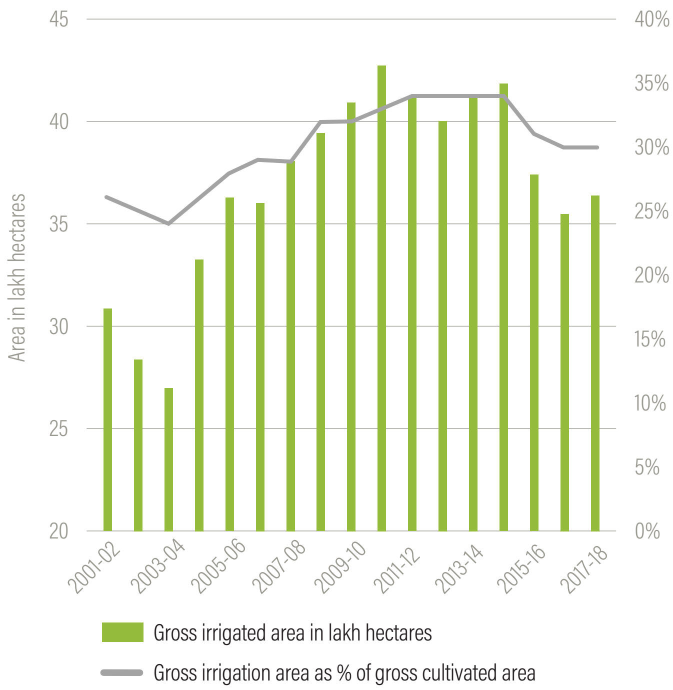
Source: Govt. of Karnataka n.d.

Figure 23 | **Agriculture Productivity and Electricity Consumption**



Notes: GSVA = gross state value add.
Sources: MoSPI 2020.

Figure 24 | **Irrigation Trends in Karnataka**



Source: Govt. of Karnataka 2020.

Figure 23 traces how the sector's productivity has improved alongside electricity consumption. Before the provision of free electricity supply in 2008, the average gross irrigated land in the state was 32.8 lakh hectares. After 2008, when power supplied to the sector was provided free of cost, the average gross irrigated land increased to 39.7 lakh hectares (Govt. of Karnataka n.d.). See Figure 24.

Although the agricultural sector benefited from free power supply in terms of increased output, the discoms and the state government continue to bear a heavy subsidy burden. Agricultural sector power subsidies have made groundwater accessible for irrigation, but have depleted groundwater aquifers in the state. This, in addition to the growing demand for electricity from the sector, has prompted the state to look at strategies that could address environmental as well as economic challenges. The Surya Raitha scheme was launched to safeguard the interests of the state exchequer, the discom, and the farmer.

Surya Raitha Scheme

Surya Raitha is Karnataka's solar PV irrigation scheme. It enables farmers to harness solar energy by installing solar irrigation pumps (SIPs). Although the scheme was announced in 2014 by the Karnataka Renewable Energy Development Limited, it was launched only in January 2018 in Kanakapura taluk in Ramanagara district on a pilot basis. The scheme sought to replace 310 irrigation pumpsets (cKinetics and CPI n.d.). Before the scheme was launched in 2018, the farmers who had borewells and faced unreliable electricity supply issues were identified and convened under the Surya Raitha Agricultural Electricity Consumer Cooperative Society in August 2015 (KERC 2017). They were then provided interest-free loans of up to ₹7.35 lakhs and ₹11.35 lakhs to erect solar panels for 5 hp and 7.5 hp pumps, respectively.

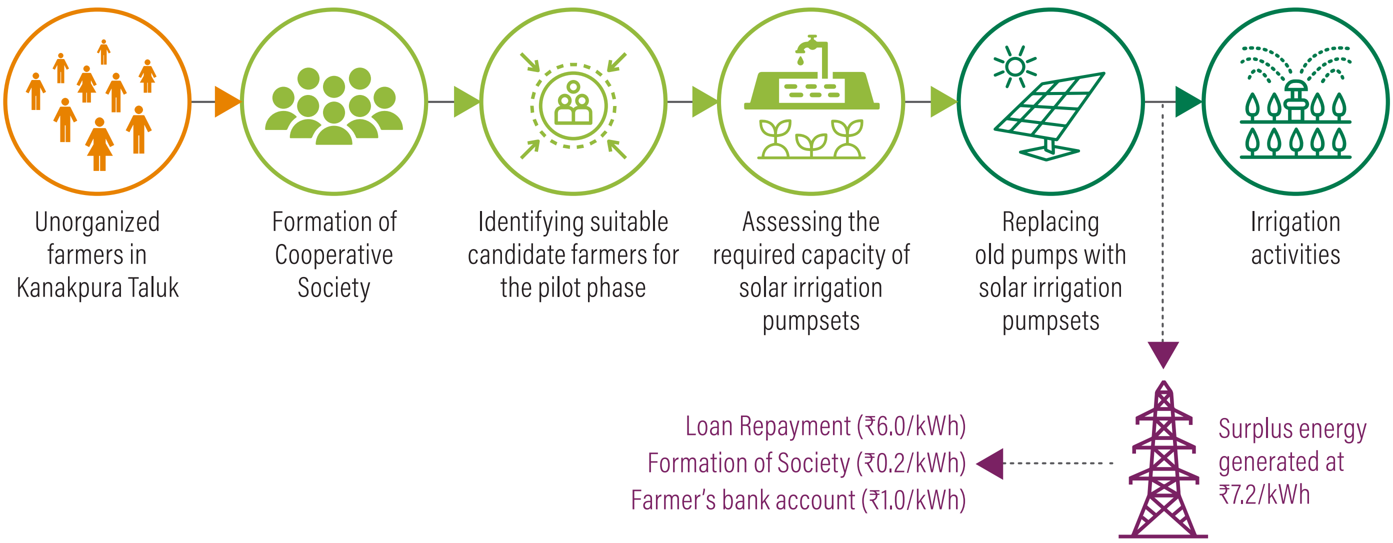
The scheme was financed jointly by the state government, MNRE, and the discom Bangalore Electricity Supply Company Limited (BESCOM) covering 310 beneficiaries across 11 villages of Kanakapura taluk. To enable a self-sufficient system and shorten the loan recovery period, the PV panels were oversized by 50 percent and the feeder was kept on from 6 AM to 6 PM to facilitate injection of surplus power into the grid. Typically, 67 percent of the energy was used for irrigation, and the rest was exported back to the grid (KERC 2017).

Farmers benefited from the scheme through the additional stream of income generated by exporting excess energy. A power purchase agreement was signed between the farmers and BESCOM for a 20-year period, to sell surplus electricity at ₹7.20/kWh escalating at 3 percent per annum for 20 years. Of this, ₹1/kWh was to be directly credited to the farmers' bank accounts as a generation-based incentive (GBI), ₹0.20/kWh was to be used for running the cooperative society, and the rest was to be used for repaying the bank loan. The opportunity to evacuate the surplus solar power to the grid was aimed at motivating the farmers to utilize groundwater more judiciously. However, evidence indicates that the GBI offered to the farmers proved insufficient for them to change their water extraction practices. (See the section on stakeholder challenges for more details.) (Shirsath et al. 2020).

Financial Model of Surya Raitha

The scheme was designed such that 90 percent of the initial capital investment was raised through subsidy support from MNRE and the Government of Karnataka, and the rest was expected to be contributed through farmers' investments (about ₹50,000 for 5 hp and

Figure 25 | **Program Design of Surya Raitha**



Notes: kWh = kilowatt-hour
Source: WRI analysis.

₹75,000 for 7.5 hp) and an interest-free loan from BESCOM. However, owing to financial constraints, the farmers' share was later partly funded by the government as a one-time subsidy and partly by BESCOM, by raising the agreed loan amount. The total cost of the project was ₹23.8 crores, and the cost breakdown is shown in Table 9 (KERC 2017).

Major Stakeholders: Roles and Responsibilities

Figure 26 shows the roles and responsibilities of the key stakeholders of the Surya Raitha Program.

Table 9 | **Surya Raitha Project Cost Break-down**

PARTICULARS	5 HP CAPACITY	7.5 HP CAPACITY
Total cost of system (₹)	6,78,342	9,08,342
Number of pumps installed (Nos)	223	87
GoK contribution (₹)	58,000	1,69,000
MNRE contribution (₹)	1,62,000	1,62,000
Interest free loan from BESCOM (₹)	4,08,342	5,02,342
Farmer contribution	50,000	75,000

Notes: BESCOM = Bangalore Electricity Supply Company Limited; GoK = Government of Karnataka; hp = horsepower; MNRE = Ministry of New and Renewable Energy.
Source: KERC 2017.

Figure 26 | **Key Stakeholders of the Surya Raitha Program: Roles and Responsibilities**

Karnataka Renewable Energy Development Limited (KREDL)	Nodal agency that supervised and coordinated the overall working of different stakeholders involved in the program
BESCOM	▪ Financial support to the farmers through interest-free bank loans ▪ Installation and maintenance of solar irrigation pumps (SIPs) at farmers' premises ▪ Purchase of surplus solar energy generated by the farmers at a fixed rate
MNRE	Provide financial support to the farmers
Surya Raitha Agricultural Electricity Consumer Cooperative Society	▪ Identify on-the-ground problems and communicate them to the relevant authority ▪ Work for the welfare of farmers in the region
Farmers	Generate solar energy for irrigation and sell surplus energy to the BESCOM to repay the loan and earn extra revenue

Notes: BESCOM = Bangalore Electricity Supply Company Limited.
Source: KERC 2017.

Stakeholder Benefits

Farmers

- As the operational and maintenance expenditures for the solar irrigation pumps (SIPs) are covered for 10 years under the scheme, farmers bear a minimal risk in the event of system failure.
- Farmers do not have to make a capital investment, and the availability of interest-free bank loans with long-term repayment options has helped them.
- As the scheme enabled PV panels to be oversized by 50% to ensure electricity generation even while the pump is working, it has helped farmers gain additional revenue through export of surplus solar energy.
- The quality of irrigation has been improved with reliable and uninterrupted power supply.

Discom

- The scheme has helped the discom reduce its financial distress caused by electricity subsidies.
- The reduced energy consumption led to voltage improvement and reliable supply. As farmers produce electricity at the source of consumption and export the excess locally, discoms benefit from a reduction in transmission and distribution (T&D) losses.

State Government

The scheme has decreased the the carbon footprint of groundwater irrigation by reducing the usage of electricity and diesel for pumping water.

Stakeholder Challenges

Farmers

- Although the formation of the Surya Raitha Agricultural Electricity Consumer Cooperative Society was intended to galvanize the efforts of solar irrigation pump (SIP) owners to maximize their income, it ended up being ineffective (Shirsath et al. 2020). This could be treated as a missed opportunity that could have otherwise offered institutional support to operationalize the sale of electricity.
- Farmers were not adequately trained to read the meters or adjust the control devices to regulate the share of surplus solar electricity evacuated to the grid. As a result, they were not aware of the electricity generated, used, and sold by them.

Discom

- As BESCOM led the implementation of this scheme as a part of their demand-side management (DSM) activities, the high investment has limited the discom's ability to further invest in other DSM programs (KERC 2017).
- Ensuring the effectiveness of the O&M by third parties is an additional responsibility for the discom.
- Because the major share of the capital investment comes from the discom, it can be financially unviable for the discom to invest proportionally as the program scales.

State Government

- The large-scale implementation of this model will create a less competitive market for solar irrigation pumps (SIPs) if the program continues to focus on providing subsidies as a certain percentage of the rated price of SIPs rather than as a flat subsidy per kW model, which will, on the other hand, encourage suppliers to focus on a low-margin high-volume business model to remain viable in the market.
- The scheme, with its goal of promoting sustainable use of ground water resources, has chosen the wrong pilot location. The Harobele region, which falls under the command area of Arkavathy river/dam, has no groundwater scarcity. Furthermore, the region under the Harobele feeder belongs to the water-intensive sericulture belt, where the value generated by the irrigation is high. In this setting, the incentive offered to the farmers (₹1/kWh) was not significant enough for them to change their water use behavior, and the program could not deliver the anticipated impact (Shirsath et al. 2020).

Current Status and Deviations from Plan

Table 10 | **Surya Raitha Program Outcomes**

NUMBER OF SIPS INSTALLED	SIZES OF INDIVIDUAL ENERGY SYSTEMS (KWP)	TOTAL INSTALLED PVS (KWP)	ANNUAL GENERATION OF SURPLUS SOLAR ENERGY (MU)
310	5.6 and 8.4	2,681	2.64

Notes: kWp = kilowatts peak; MU = million units; SIPs = solar irrigation pumps.
Average annual generation of surplus solar energy has been back-calculated under the assumption that the farmers would be able to repay the loan in 15 years by selling surplus energy at Rs. 7.2/kWh.
Source: WRI analysis.

5. CONCLUSIONS AND LEARNINGS

Our recommendations for the state of Tamil Nadu are derived from our analysis of the design, performance, and challenges of each of the three state-level schemes. These critical challenges and key outcomes are summarized as follows.

Sizing of the solar PV system vis-à-vis the irrigation pump size: In all three states, the sizing of the solar system (measured in kW) was permitted to be greater than or equal to the size of the irrigation pumpset (in hp). This was done to ensure that farmers can irrigate their fields by using solar energy, and subsequently export any excess energy to the grid. Farmers gain a revenue stream, and extraction of water is limited to only what is required.

Feed-in Tariff (FiT): The three states have adopted differing levels of FiT. This is because they have differing cost structures for the power sector. Gujarat has introduced an FiT of ₹3.5/kWh and an additional time-bound EBI of ₹3.5/kWh for the duration of loan repayment. By way of comparison, its cost of supply for irrigation is ₹6/kWh. The corresponding numbers for the FiT and the cost of supply in AP were ₹1.5/kWh and ₹5.69/kWh, respectively. For Karnataka, they were ₹7.2/kWh and ₹6.8/kWh (KERC 2018). We were not independently able to verify the net additional income to farmers or the subsidy savings for the discoms. But information available about the scheme results in each state indicates that export of excess electricity to the grid has taken place, which could indicate a certain amount of earnings for farmers. This suggests that pricing the exported solar electricity at a suitable level acceptable to farmers below the cost of supply could be a win-win situation for both farmers and the discom.
Except for Karnataka, we have not come across information that conclusively establishes the impact of energy pricing on water conservation.

Subsidy: All the schemes in the three states have relied on government subsidy to enhance adoption by farmers. In addition, even in cases where some portion of the cost was expected to be contributed by the farmer, we have seen that the state stepped in to take on some or all of the financial burden. All the data we assessed seem to indicate that subsidy contributions were timely and honored in full.

Operations and Maintenance (O&M): In the case of AP and Karnataka, the responsibility for O&M was taken up by the discom. O&M issues had initially created hesitancy among farmers in AP due to equipment failures in previous projects. Even the current rollout of BLDC pumpsets saw a few instances of equipment failure due to poor O&M.

Monitoring and Evaluation (M&E): The only M&E information available for the scheme was in connection with the installed capacity of solar PV, and for Gujarat and Karnataka, the amount of solar energy injected into the grid. We did not find evidence of an M&E scheme in the design or operation stage to capture related parameters such as the impact of the scheme on the water table and impacts on farmer income, except for a pilot project in Dhundi (DSUUSM 2018).

6. WAY FORWARD FOR TAMIL NADU

Component C proposed in Tamil Nadu incorporates some of the design features described earlier. In particular, the solarization system associated with the pumpset is oversized vis-à-vis the pumpset's hp rating. The state has also calculated a FiT that is lower than the average cost of supply (ACoS) for the state and involves an incentive for the farmer. The state has also committed to certain levels of subsidy to reduce the financial burden on the farmer.

However, there are two points where Tamil Nadu differs from the other states. One, the state has not segregated its feeders into agricultural and non-agricultural feeders. This means that the state will have to adopt extra filtering and scrutiny when assessing the impacts of the project. Two, the state has elected to proceed with the implementation of its complete assigned quota under the KUSUM Component C Scheme instead of launching a pilot. Pilot projects have the advantage of providing an opportunity for course correction in the event of unintended consequences.

Drawing from the lessons derived from the study of schemes in Gujarat, Karnataka, and AP, the relevant agencies in Tamil Nadu—TEDA, TANGEDCO, TNERC, and GoTN—need to assess the following parameters and be ready for fine-tuning to ensure the success of the scheme:

- Appropriate pricing of the FiT to encourage solarization of the agricultural pumpsets and conservation of underground water by incentivizing farmers to supply extra energy to the grid—We have seen earlier how the FiT level plays a role in increasing farmers' income levels, and it can potentially also play a role in promoting water conservation. Currently, in the case of Tamil Nadu, since TEDA is raising capital to also meet the farmers' share of the capital cost, the role of the FiT is only to provide additional income. However, if this model changes in the future, investment attractiveness to recover the amount invested by the farmer will also have to be factored in.

- Historically, the availability of electricity and water for irrigation has decided what farmers grow. Now that electricity is not likely to be a problem with the advent of solar-PV-enabled irrigation and with farmers now being able to ostensibly access markets facilitated by the new farm laws (Chand 2020), water could become the limiting factor. There is a need to develop regulatory frameworks for water resource governance in tandem with KUSUM. For instance, states such as Maharashtra, AP, and Gujarat have implemented a participatory approach of "aquifer-based, common pool resource" for groundwater management (Kulkarni et al. 2015).

- Ensure timely and full payout of the subsidy to establish trust with different stakeholders—As mentioned earlier, we did not find specific instances of subsidy payout commitments not being honored in any of the three pilot schemes. State governments have also been handling much larger volumes of subsidy for electricity supply, and hence there should not be significant issues on this count.

- Ensure that the scheme has adequate provisions for maintenance of the installed solar systems—The importance of good-quality systems has been highlighted (Hystra 2020) as being vital to retain and enhance customer confidence. In addition, farmers who have adopted solar PV systems could be made more self-reliant through maintenance training programs.

- Develop capacity and institutionalize a strong M&E framework; empower a team in TEDA to continually track and evaluate the scheme performance—This is a great opportunity for TEDA to put in place a robust Monitoring, Evaluation and Learning framework that will encompass the following (Reytar et al. 2014):
    - Selection of the right thematic areas for the indicators—For instance, the area under specific crops and environmental indicators such as sector greenhouse gas emissions could be tracked in addition to energy, water, and livelihood.
    - Identify the indicators through the "causal chain" approach—This would mean identifying whether the indicators are policy-level indicators, practice-level indicators, or on-ground performance indicators.
    - Finalize the indicators through a screening criterion—This would help grade indicators based on characteristics such as data availability, data accuracy, consistency, frequency, relevance, and proximity.
    - Identify data repositories/sources to collect primary and secondary data.

TEDA could then build on the proposed framework to develop the baseline, collect data, and conduct spatial and/or temporal evaluation of the scheme. The learnings from this need to be disseminated widely to ensure a transparent assessment of the scheme.

It is also important to rightsize irrigation systems, with an emphasis on equitable distribution of pumps to marginal farmers in the state. There are several governance-related issues around equity, livelihoods, participatory decision-making, water sharing, and crop substitution that need to be closely monitored, so that they can be mitigated through a robust and responsive M&E framework.

Lastly, the state should also maintain regulatory certainty by not changing the scheme parameters except in situations when major course corrections are required. In the three examples that we have studied, we have not come across an example of the scheme parameters being changed midway. Whatever be the outcome of the pilot, the states have stuck with the initial design. Only a very significant change in the ecosystem prompted Gujarat to merge its own scheme with KUSUM.

APPENDIX A

We tabulated the details of various solar PV irrigation schemes (SPISs) across India and classified them as shown in Table A1.

Based on this classification, we looked at the different state renewable energy (RE) policies that promoted the solarization of irrigation pumpsets and agricultural sector tariff orders passed by regulatory commissions. Table A1 provides a snapshot of the selection criteria used by some of the most important states in India in their efforts to solarize the agricultural sector. It also describes the schemes rolled out in Gujarat, Andhra Pradesh, and Karnataka that we focused on in this research, because of their similarity to the structure of KUSUM's Component C.

Table A1 | **Summary of Solar Photovoltaic Agriculture Schemes in India**

STATE	REGION	OFF-GRID SOLAR PUMPS INSTALLED	AGRICULTURAL ELECTRICITY TARIFF (ENERGY CHARGE) IN ₹/KWH	FEEDER SEPARATION FOR SECTOR (KM)	HOURS OF SUPPLY TO SECTOR (HR:MIN)	WATER STRESS (CATEGORIZATION PER WRI AQUEDUCT[a])	AGRICULTURAL GRID CONNECTIONS (IN LAKHS)	IMPLEMENTED SCHEMES
Chhattisgarh	Central	61,970	4.4–5.2 (LV)	Yes (3,181)	18	Low to Medium	4.22	Saur Sujala Yojna: The purpose of the scheme is to provide solar pump capacity of 2, 3, and 5 hp with 90–95% subsidy.
Rajasthan	Northern	48,175	5.5–7.1	Yes (5,659)	06:30	Extremely High	12	The Rajasthan Solar Water Pumping Project: The scheme provides farmers with 86% subsidy on the capital cost of the pump. The subsidy comes from two sources: 56% from the Rashtriya Krishi Vikas Yojana implemented by the state government with funds allocated by the Government of India (GoI), and 30% from the Ministry of New and Renewable Energy (MNRE) of the GoI under the Jawaharlal Nehru National Solar Mission.
Andhra Pradesh	Southern	34,045	0–5 (LT); 0 - 7.15 (HT)	No (0)	9	Extremely High	17.67	Solar PV Water Pumping Programme: The off-grid solar photovoltaic (PV) scheme provided beneficiaries MNRE subsidy (30%) and state govt subsidy (30%). The state launched the BLDC Solar PV Pump scheme in 2018 that covered 250 agricultural service connections across 32 villages. The scheme encouraged farmers to export surplus energy generated from solar panels after consumption by the pumpsets at a pre-determined feed-in tariff (FiT), similar to how Component C is designed.
Uttar Pradesh	Northern	20,546	LMV-5: 0–6	Yes (35,225)	17:51	Extremely High	12.21	Solar PV irrigation pump scheme: Supports 2–5 hp pumpsets. Subsidy ranges from 56% to 88% depending on the pump.

STATE	REGION	OFF-GRID SOLAR PUMPS INSTALLED	AGRICULTURAL ELECTRICITY TARIFF (ENERGY CHARGE) IN ₹/KWH	FEEDER SEPARATION FOR SECTOR (KM)	HOURS OF SUPPLY TO SECTOR (HR:MIN)	WATER STRESS (CATEGORIZATION PER WRI AQUEDUCT[a])	AGRICULTURAL GRID CONNECTIONS (IN LAKHS)	IMPLEMENTED SCHEMES
Madhya Pradesh	Central	17,813	LV-5: 4.5–5.9	Yes (7,932)	09:56 (Irrigation); 23:46 (Mixed)	High		Madhya Pradesh (MP) Mukhyamantri Solar Pump Yojana: MP Urja Vikas Nigam is the nodal agency that will make the solar pumps available to farmers. In this scheme, the MP government will provide solar pumps for irrigation to farmers. The government has set a target to install 2 lakh solar pumps in the state over the next 5 years. The farmers of the state will get 80% subsidy to install solar pumps in their fields.
Gujarat	Western	11,522		Yes (1,512)	08:12	Extremely High		Suryashakti Kisan Yojana: The 60% subsidy on the cost of projects will be given by the state government and the GoI, 35% of the project cost will be provided through a loan with interest rates of 4.5% to 6%, and the remaining 5% of the project cost will be borne by the farmers. The scheme incentivized farmers (through a pre-determined FiT and EBI) to sell surplus solar power to discoms. The design of this scheme is similar to KUSUM's Component C.
Orissa	Eastern	9,551	LT/HT Irrigation, Pumping and Agri: 1.50	Yes (1,003)	24	Medium to High	NA	Orrisa launched the Soura Jalanidhi scheme, which aims to increase the use of solar energy through solar PV pumpsets for irrigation activities. The scheme aimed to install 5,000 solar pumps by providing a subsidy of 90% of the capital cost to the beneficiaries to irrigate 2,500 acres of land.
Maharashtra	Western	9,337	LT IV (2020–21 Metered): 3.71	Yes (7,925)	9	Medium to High	230.76	Mukhyamantri Saur Krushi Pump Yojana: Subsidy of up to 90% via "Chief Minister's Solar Agriculture Feeder Programme": As of December 2018, nearly 10,000 farmers are already getting reliable daytime power under this scheme, and the discom is planning to scale this significantly beyond initial target of 7.5 lakh in the next three to five years.

STATE	REGION	OFF-GRID SOLAR PUMPS INSTALLED	AGRICULTURAL ELECTRICITY TARIFF (ENERGY CHARGE) IN ₹/KWH	FEEDER SEPARATION FOR SECTOR (KM)	HOURS OF SUPPLY TO SECTOR (HR:MIN)	WATER STRESS (CATEGORIZATION PER WRI AQUEDUCT[a])	AGRICULTURAL GRID CONNECTIONS (IN LAKHS)	IMPLEMENTED SCHEMES
Karnataka	Southern	7,420	0 (up to 10 hp)–3.95 (above 10 hp)	Yes (11,595)	7	Medium to High		Karnataka Surya Raitha Scheme: Two-thirds of the electricity generated through solar panels has to be used by farmers, and the balance can be sold to the discom at a proposed rate of Rs. 7.50/kWh. It is financed by a combination of farmer investment, state government subsidy, and investment from BESCOM as an interest-free loan. The design of this scheme is similar to that of KUSUM's Component C.
Tamil Nadu	Southern	5,459	0	Yes (672)	9	Extremely High	21.4	Tamil Nadu previously rolled out a Solar Powered Pumping System scheme through the state Agricultural Engineering Department that provided 90% subsidy (20% – MNRE, 40% – the state government, 30% – TANGEDCO). The scheme was designed for off-grid solar-PV-powered irrigation pumpsets of 5, 7.5, and 10 hp motors.

Note: [a] Aqueduct is a data platform run by World Resources Institute (WRI): https://www.wri.org/aqueduct.
EBI = evacuation-based incentive; FiT = feed-in tariff; HT = High Tension; LMV = Low Medium Voltage; LT IV = Low Tension; MNRE = Ministry of New and Renewable Energy; TANGEDCO = Tamil Nadu Electricity Generation and Distribution Company Limited.

ENDNOTES

[i] In this working paper, the agricultural sector broadly refers to irrigation-related activities at the farm level.

[ii] Based on the administrative structure, a block or a community development block is a district subdivision for the purpose of rural development departments and Panchayati Raj institutes, consisting of a cluster of villages. The villages come under the block category for planning and development purposes only; for the administration of land and the
revenue department, they come under a tehsil/taluk. A tehsil/taluk may consist of one or more blocks.

[iii] Gujarat Energy Research & Management Institute (GERMI) analysis based on data provided by Uttar Gujarat Vij Corporation Limited (UGVCL).

[iv] Dhundhi Project: Dhundi Saur Urja Utpadak Sahakari Mandali (DSUUSM) was formed in June 2015 as a cooperative with six farmer members who acquired solar irrigation pumps with a total panel capacity of 56.4 kWp (IWMI 2018).

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ABOUT WRI INDIA

WRI India is a research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure that our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.