Kashish Shah, Research Analyst
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A Renewed Push on Solar-Powered Irrigation Would Accelerate India's Energy Transition

Lessons Learned Can Help States Overcome Hurdles to Deployment of Solar Irrigation Pumps

Introduction

India is the world's third-largest electricity market after the U.S. and China and also one of the fastest growing electricity markets. Under the Paris Climate Agreement India set ambitious targets to reduce its emission intensity and decarbonise its electricity sector through large-scale deployment of renewable energy.[1]

The Government of India's ambitious target to install 450 gigawatts (GW) of renewable energy capacity by 2030 has drawn enormous interest from global investors, developers and energy companies with the ability to deploy capital at an unprecedented scale. The majority of capacity additions have come in the form of utility-scale solar and wind projects on the back of favourable economics and ultra-low wholesale tariffs. However, similar momentum has yet to be seen in distributed solar energy capacity.

India's distributed solar capacity is lagging significantly behind its near-term target of 40GW by 2022. This is an important sub-target of the 100GW of solar capacity which is in turn part of the target to install 175GW of renewable energy capacity by 2022.

India's current total distributed solar capacity is 7.8GW. The Ministry of New and Renewable Energy (MNRE) reports on-grid rooftop solar capacity reached 4.3GW as of February 2021, while Bridge to India reports an additional 2.2GW of rooftop solar capacity as of December 2020, making the total rooftop solar capacity ~6.7GW.[2] Bridge to India also reports additional off-grid solar capacity of ~1.1GW as of December 2021.

India's agricultural sector accounts for about 20% of electricity consumption.

In agriculture, electricity plays a crucial role in meeting irrigation requirements. Power consumption by the agricultural sector in India grew at a compound average growth rate (CAGR) of 7.1% between FY2008/09 and FY2018/19. This is in line

[1] IEEFA. India on track to meet majority of Paris goals. 3 December 2018.
[2] Bridge to India. India Solar Compass Q42020.

with India's overall growth in electricity demand of roughly 6-7% over the last decade. As per FY2018/19 data, roughly 20% of India's electricity consumption was in the agricultural sector.[3]

Successful farming in India typically requires irrigation. However only 48% of the country's "net sown area" is irrigated while the rest is dependent on the vagaries of nature.

As per Ministry of Statistics and Programme Implementation (MoSPI) data from FY2017/18, 62% of the country's net irrigated land is watered either by relatively deep tube wells or other, shallower types of wells. Most of these wells are reliant on electric or diesel pumps.[4]

To support India's vast agricultural demand, power is provided to farmers at subsidised rates. The state power distribution companies (discoms) finance these subsidies either through state government budgetary support for subsidies or higher power tariffs for their commercial and industrial (C&I) customers and residential customers.

In a study from 2019, the Indian Statistical Institute estimated that Rs90,000 crore (US$12bn) was directed towards subsidising power supplied to the agricultural sector in FY2015/16.[5]

Also, power at free or subsidised rates does not encourage efficient use of water, resulting in exploitation and depletion of extremely valuable groundwater resources.

Solar irrigation pumps have been identified as an extremely effective way of supporting expansion of distributed solar generation whilst supporting India's vast power demand in the agricultural sector. In IEEFA's view, solar irrigation pumps when implemented sustainably are a key instrument to tackle the growing challenges of the nexus between food, water and energy in India.

Solar pumps help expand distributed solar generation while catering to agriculture's vast power demand.

Additionally, we note that significant up-scaling of solar irrigation pump deployment would provide multiple benefits to India in terms of:

- reducing the need for heavily subsidised electricity to the agricultural sector, which would help to alleviate discom financial distress;
- aligning solar generation with irrigation time of use;

[3] CEIC.
[4] MoSPI.
[5] Indian Statistical Institute. Agriculture Subsidies. March 2019.

- replacing subsidised, imported diesel, with the associated foreign exchange and reduced current account drain;
- significantly contributing to the nation's carbon emissions reduction efforts;
- expanding and diversifying farmer incomes; and
- providing a sustained domestic and even export opportunity for system manufacturing under the Centre's 'Make in India' campaign.

In our note from August 2018, we estimated a total saving of US$7.6bn in subsidies for the government if the targets under the Indian central government's Prime Minister Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) scheme are met.[6]

At President Biden's Leaders' Summit on Climate in April 2021, the U.S. and India launched the 'U.S.-India Climate and Clean Energy Agenda 2030 Partnership'.[7] The partnership will aim to mobilise finance to speed up clean energy deployment and demonstrate and scale innovative clean technologies to reduce greenhouse gas emissions across various sectors. In our view, scaling, developing and financing solar irrigation in India could be an area of focus under this program.

In this note we review the progress of the PM-KUSUM scheme which has a target of deploying a total of 30.8GW of capacity through various modes of solar irrigation pump systems.

PM-KUSUM Scheme

The PM-KUSUM scheme has a total central financial assistance budget of Rs34,422 crore (US$4.7bn) for the states to deploy solar irrigation pumps by March 2022. The scheme comprises of three components in terms of modes of solar irrigation pump systems.

Component-A: Setting up of 10GW of decentralised grid-connected solar or other renewable energy power plants on barren/fallow land.

The power generated from the grid-connected capacity is to be purchased by the discoms at feed-in-tariffs determined by respective State Electricity Regulatory Commissions (SERCs). Rural landowners benefit as it creates an avenue for a stable and continuous source of income. The discoms have been allowed a performance-based incentive of Rs0.40/kWh for the first five years of the scheme.

Component-B: Installation of 20 lakh (2 million) standalone solar pumps.

Under this mode, individual farmers are supported to install standalone

[6] IEEFA. Vast potential in India for solar-powered irrigation. August 2018.
[7] The White House. FACT SHEET: President Biden's Leaders' Summit on Climate. 23 April 2021.

solar pumps of up to 7.5 horsepower (HP) capacity. Higher capacity pumps can be installed but are not subsidised.

Component-C: Solarisation of 15 lakh (1.5 million) grid-connected agriculture pumps.

Under this component of the scheme, individual farmers are supported to solarise pumps of up to 7.5HP capacity. Solar PV capacity up to twice the pump capacity in kW is allowed under the scheme. Farmers are able to use the generated energy to meet their irrigation needs and sell excess available energy to the discoms, creating extra income for the farmers while supporting the states to meet their Renewable Purchase Obligation (RPO) targets.[8]

Under the umbrella scheme the state governments and the state-level power ministries are leading the deployment of solar irrigation pumps. We note that the approach to deploying solar pumps varies across different states depending on the dynamics and challenges of agricultural economies, agricultural power tariff structures and other state-level subsidy support.

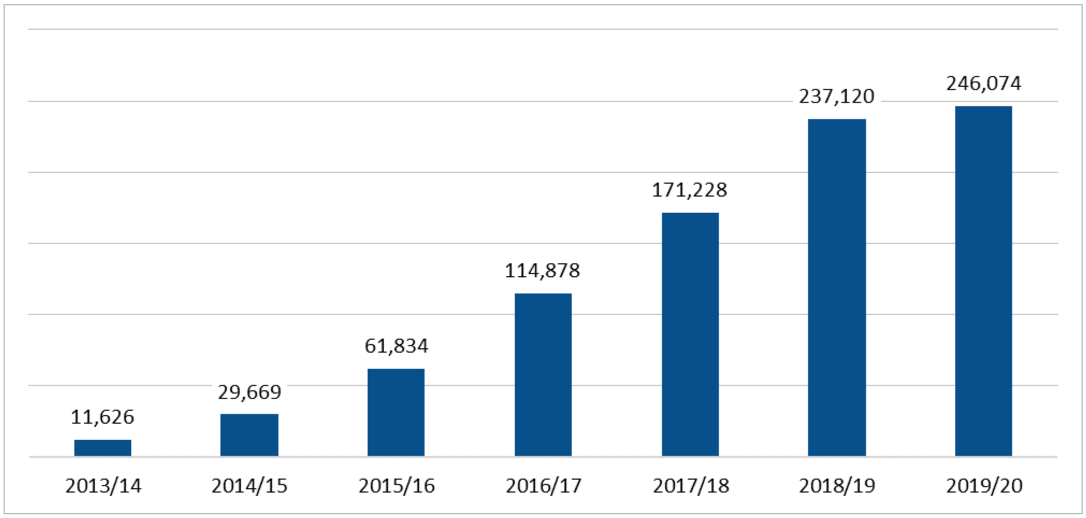
Solar irrigation pumps are a key instrument to address the issues pertaining to the food-water-energy nexus. Therefore, various state-level bodies related to agriculture, water and power are rightly involved in implementation and coordination of this important scheme.

Extremely Slow Progress

Despite the clear benefits, the deployment of solar irrigation pumps in India has been extremely slow. According to the MNRE data,[9] against the ambitious target of installing two million off-grid solar pumps, only ~246,000 pumps were installed by the end of FY2019/20. The PM-KUSUM scheme should have accelerated the process of pump deployment, however we note only 8,900 pumps were deployed in the 12 months after the formalisation of the scheme.

[8] MNRE. Scale-up and expansion of Padhan Mantri Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme.4 November 2020
[9] MNRE. Annual Report FY2019/20.

Figure 1: Number of Off-Grid Solar Irrigation Pumps Installed



Source: MNRE Annual Report FY2019/20.

Based on a literature review of various studies by electricity-related research groups[10] on the implementation of solar irrigation pumps in India, we note some of the key bottlenecks slowing the uptake of solar pumps:

- **Coordination among state-level bodies:** As discussed earlier, solar irrigation pumps can help in resolving the challenges pertaining to the water-energy-food nexus. Information asymmetry across various state government bodies regarding farming issues makes the process slower. There is also a lack of coordination among the various government bodies and mismanagement of the sharing of subsidies.

  For example implementation of components A and C requires coordination between the state discoms, agricultural department, minor irrigation department and any other department designated by the state government.

- **Affordability:** For components B and C of the scheme, the central and state governments provide financial assistance for 30% of the cost, the farmer pays 40% and bank financing is available for the remaining 30%.

  Even then, investing in the upfront cost of the pump and accessing formal bank credit remains a challenge for small and marginal farmers.

  The difficulties farmers have in accessing financing for pumps is evident in the state of Rajasthan. Reportedly, out of 623 farmers shortlisted based on their applications, 201 have deposited security money of Rs5 lakh/MW for grid-connected solar plants to power irrigation pumps. However, only 170

[10] CEEW, Prayas, IISD, Dalberg.

have signed agreements with the state discoms.[11]

Further, out of the 170 farmers who have signed agreements with discoms to set up solar plants, only around 15 have started working on these projects. The rest have yet to tie up bank funding.

Reportedly, the discoms' weak financial position and poor track record on payments are a major obstacle to banks lending for these projects. In addition, banks do not consider farmers' land to be strong collateral against the loan due to the politically sensitive nature of agriculture issues in India. Also, administrative delays could be contributing to the sluggish implementation of this pilot.

The irrigation pumps could also be used for drawing excess water and provide water-as-a-service, allowing additional revenue for the pump owner.

The assumed financial benefits of additional revenue for the pump owner from water-as-a-service has not worked out as the irrigation (water) needs are seasonal. Also, underutilisation and frequent breakdowns of the pumps further deteriorate their economic viability.

- **Asset ownership:** The different models of asset ownership – farmer, discom or developer – can play a big role in the resulting viability of the pump sets.

  Also, these models could control the negative externalities such as depletion of ground water, land as well as power usage (allowing free-rider behaviour).

  The International Institute for Sustainable Development (IISD) has identified four key models of asset ownership of solar irrigation pumps or solarised agricultural feeders. We list some of the key features, benefits and drawbacks of these models in the following table:

[11] ET Energy World. Rajasthan: Banks' refusal to fund hits solar scheme for farmers. 13 April 2021.

Table 1: Models of Solar Pump Ownership

Solar Ownership Model	Key Feature	Benefits	Drawbacks
Individual Farmers			
A farmer or a group of farmers to purchase, finance, and operate and maintain a grid-connected solar pump with state subsidy support under PM-KUSUM	The Discom would sign an agreement with the farmer/group of farmers and pay the farmer directly for the excess power supplied to the electricity grid under the state's net metering policy	Owning the solar pumps would create a strong incentive for the farmer/group of farmers to maintain and protect the solar pumps	The operational and transactional costs of signing and sustaining PPAs with a large number of farmers could create an additional burden on financially-stressed Discoms
Farmer Enterprise (FE)			
An organisation led by a managing committee or board of directors, the enterprise will be responsible for the implementation of KUSUM and the distribution of solar pumps among its members	The FE could approach the state nodal agency for solar pumps and could approach financial institutions for financing	Lower credit risk for the financial institutions; lower risks for the discom as it would have to manage fewer PPAs; low-income and marginal farmers could participate in FEs through awareness creation	Requires time and resources for the state nodal agency to mobilise and organize farmers into an enterprise
Discom Model			
Discom to segregate and solarise agricultural feeders	Two financing models - a) Capex Model - Discom to organise financing for the solarisation of feeders with the upfront capital investment b)RESCO model - solar developers to participate in solarising the feeders and signs a PPA with the discom to provide solar power from a solar asset owned by the developer	This would provide day-time cheap solar power to farmers without the capital investment from low-income farmers	The Discom could be further burdened by taking a loan for solarising agri-feeders; interest payments could further deteriorate its finances if agricultural subsidies aren't phased out by the state
Private Developer Model			
Under a RESCO model, private players can be invited by a Discom to install a solar power plant, which would supply electricity to the Discom	Farmers will benefit by availing rental payments on barren land (under component A of PM-KUSUM) and by receiving access to reliable electricity under component C (feeder-level solarisation)	A private-public partnership model can be readily deployed at scale and obtain competitive rates for solar installation	It does not create any incentive for farmers to use electricity efficiently and conserve water, and may lead to further exploitation of groundwater resources

Source: IISD, drawing on joint work with TERI, CEEW & ISEP.

- **Technology:** There is also the challenge of getting things right from the technological point of view. For example, AC vs DC pumps, correct pump sizes in different cases (5HP or 7.5HP) and selection of the pump sizes based on the water table levels. Smaller pumps could be inefficient for deeper water tables and bigger pumps could increase the risk of depleting water tables.

Renewed Impetus from the Centre

In order to overcome some of these challenges, the MNRE opted for bulk sourcing of solar irrigation pumps to bring the costs down as well as provide necessary momentum for uptake of pumps.

In January 2021, Energy Efficiency Services Limited (EESL), a government-owned entity, issued a tender to source ~318,000 off-grid solar irrigation pumps in selected states under component-B of the PM-KUSUM scheme.[12]

[12] Mercom India. EESL Issues Tender for 317,975 Solar Pumps Across India. 15 January 2021.

The tender's scope of work included design, manufacture, supply, transport, installation, testing, and commissioning of off-grid solar irrigation pumps of 1-10HP, including complete system warranty, repair, and maintenance for five years.

The tender mandated usage of indigenously manufactured modules to promote the 'Make in India' program of boosting local manufacturing.

The following table provides the tendered cost of the solar irrigation pumps in the EESL tender.

Table 2: Cost of Solar Irrigation Pumps from the EESL Tender

Pump Type	Cost Range (Rs)
1HP DC	20,000 - 80,000
2HP DC	20,000 - 80,000
3HP DC	27,000 - 80,000
5HP DC	28,500 - 84,000
7.5HP DC	50,000 - 96,000
10HP DC	412,500 - 419,600
1HP AC	20,000 - 80,000
2HP AC	20,000 - 80,000
3HP AC	27,000 - 80,000
5HP AC	29,000 - 84,000
7.5HP AC	50,000 - 96,000
10HP DC	401,900 - 414,700

Source: MNRE.

Experiences in States

Different states have adopted different modes and strategies to solarise their agricultural demand. We discuss the experiences and progress of solar pump deployment in various states.

Gujarat

In June 2018, the Gujarat government launched the Suryashakti Kisan Yojana (SKY) scheme. The scheme was designed to set up 137 new agricultural feeders to cover 12,400 farmers.

Farmers with an existing electrical connection were to be provided solar panels as per their load requirements, with separate feeders for the power generated from solar energy. The cost was pegged at Rs870 crore (US$118m), with an expected production of 175MW.

State and central government subsidies supported 60% of the pump cost, with the farmer paying just 5% upfront and the remaining 35% was a loan at a subsidised interest rate. The scheme was to run for 25 years, with the farmer getting Rs7.00/kWh of production in the first seven years, and Rs3.50/kWh subsequently.

According to reports from March 2019, the plan was scaled down to just over 2000 farmers and limited to 50 exclusive feeders.[13]

Reportedly, the biggest obstacle was the refusal of farmers to shift, since the agricultural power tariffs were around Rs0.60-0.50/kWh. On top of that, the average assumed feeder losses were kept at 5% when actual losses for most discoms were well over 15%, lowering farmers' expected revenues from selling the power back to the grid.[14]

Moreover, farmers opting for a central government subsidy had to forego the Rs7.00/kWh feed-in-tariff for power sold back to the grid – another dent in the attractiveness of the scheme.

Currently with no updates on the scheme on the Gujarat Power Ministry's public portals, we note that it appears to have made little progress.

Maharashtra

Maharashtra's model for grid-connected solar irrigation pumps has had tangible success in solarising agricultural feeders to support marginal farmers with no grid connection.

In 2018, the Maharashtra government launched its solar irrigation pumps scheme with a target to deploy a total of 125,000 solarised pumps in a phased manner in the three years to FY2021/22.[15]

The scheme offered solarised power for irrigation to farmers with no existing power connection. A farmer or a group of farmers with land available for deployment of solar panels could apply for the scheme. The beneficiary farmer paid an up-front cost of Rs165,594 (US$2,256) for a 3HP pump and Rs247,106 (US$3,367) for a 5HP pump. Apart from the up-front cost of the solar pump, the farmers did not have to pay any charges for the power, making it cheaper than diesel pumps with high operational cost.

The Maharashtra state-owned discom, Maharashtra State Electricity Distribution Company Ltd (MHEDCL), and Maharashtra State Power Generation Corporation Ltd (MHPGCL) are the implementing agencies for the scheme. MHEDCL and MHPGCL would empanel solar developers to deploy grid-connected solar pumps and the discom would sign a power purchase agreement (PPA) for 25 years.

Prayas, a Maharashtra-based public interest research group, estimates a saving of Rs4.5 crore per feeder over life (NPV @ 10% discount rate), an equivalent saving of

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[13] Saur Energy. Gujarat's Troubles with SKY Scheme a Lesson For all State Governments. 15 March 2019.

[14] The Indian Express. Suryashakti Kisan Yojana: Solar power scheme to boost farm income faces 'risk of withering away'. 7 December 2018.

[15] Maharashtra State Electricity Distribution Company. Mukhyamantri Saur Krushi Pump Yojana (Mskpy).

Rs10,500 per pump per year.[16]

The state continues to solarise its agricultural demand under the Mukhyamantri Saur Krushi Pump Yojana (MSKPY). In October 2020, MHEDCL sought approval from the state's electricity regulatory commission to float tenders to source solar power capacity to solarise irrigation pumps.[17]

Andhra Pradesh

With a mega 6.4GW of solar capacity auction to provide free power to farmers for 9 hours during daytime, Andhra Pradesh has taken a route to solarise its entire agricultural demand.[18]

This auction from February 2021 resulted in tariffs in the range of Rs2.47-2.58/kWh from developers including Torrent Power, NTPC, Adani and Shirdi Electricals.

As daytime provision of solar would not incur any firming cost, in IEEFA's view this would reduce the cross-subsidy burden on the Commercial & Industrial (C&I) and residential customers who pay higher tariffs to subsidise the agriculture consumers. Eventually this cost of free power will be passed on to other customer segments but the cross-subsidy burden will be still much lower than thermal power tariffs with a high sunk cost of capital charges.

Whilst catering for agriculture demand with utility-scale solar projects has its merits – lower cost, rapid upscaling and reliability of service – it does not serve the purpose of expanding India's distributed solar generation fleet. It also requires investment into new transmission infrastructure and separating agricultural feeders.[19]

The Government of India's national-level scheme Deendayal Upadhyay Gramin Jyoti Yojana (DUGJY) involves feeder separation of agricultural and non-agricultural feeders, rural electrification and strengthening of the distribution network.[20]

Feeder separation allows the distribution company to regulate power supply to agricultural consumers as and when needed for effective demand-side management (DSM). The separation of feeders helps flatten the load curve by shifting the agricultural load to off-peak hours and thus facilitates peak load management. The core objective of separation of feeders is to provide a regulated supply to agricultural consumers and a continuous power supply to non-agricultural consumers in rural areas.

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[16] Prayas. Solar Agricultural Feeder.
[17] Maharashtra Electricity regulatory Commission. Case of Maharashtra State Electricity Distribution Company Limited seeking approval to float Open tenders under Mukhyamantri Saur Krishi Vahini Yojana. 18 December 2020.
[18] Mercom India. Torrent Power Quotes the Lowest Bid of ₹2.47/kWh in Andhra's 6.4 GW Solar Auction. 3 February 2021.
[19] PV Magazine. Debunking feeder segregation. 29 December 2020.
[20] Deendayal Upadhyay Gram Jyoti Yojana.

In an effort to aid its distributed solar capacity for agriculture, this year Andhra Pradesh launched a pilot scheme to install 3HP and 5HP grid-connected solar pumps sets. In the initial phase, 250 pump sets were installed in the district of Vizianagaram. The scheme is also set to be implemented in the districts of Vishakhapatnam and Srikakulam.

The approach by Andhra Pradesh to solarise the state's entire agricultural demand, either through utility-scale or distributed solar, exhibits the dynamicity required to transition the agricultural sector to a cleaner and cheaper power supply.

Conclusion

Solar irrigation pumps are an excellent technology solution for India to provide clean power to the agricultural sector whilst also improving the discoms' financial situation. Distributed solar power generation reduces the pressure to expand transmission capacity as well as the need for large areas of land (unlike in the case of utility-scale projects). It also allows for the replacement of massive fleets of diesel gensets in the agricultural sector. This would boost India's efforts to reduce air pollution and reduce the need for imported diesel.

However, India's solar irrigation pump mission has had a sluggish run. The varying structures and dynamics of agriculture, power and water across states pose huge challenges to its implementation.

It is now very clear that one particular scheme or solution does not fit all states. Although to its credit, the PM-KUSUM scheme does provide flexibility (with three components to the scheme) and the budgetary support required to solarise India's agricultural demand.

To begin with, each state needs to zero in on which mode of solarising its agricultural power demand (off-grid vs on-grid) works best. States then need to improve cooperation between the various governmental bodies involved.

The states need to address the challenges of coordination, affordability, business models, technology and awareness creation.

There are different models of pump ownership that could work for different states or even for different districts of a state, depending upon the agricultural and power-related dynamics of the region.

A massive part of the Indian power distribution sector's woes stem from the burden of subsidies to agricultural consumers. This also impacts India's industrial and manufacturing sector as C&I tariffs remain high due to the heavy cross-subsidy burden on C&I customers. As a result, high power costs continue to inhibit India's industrial and manufacturing growth.

Solar irrigation pumps have massive potential to reduce discoms' power procurement costs, in turn reducing subsidy costs.

Solar irrigation pumps have massive potential to reduce discoms' power procurement and subsidy costs.

There is also a substantial opportunity to build Indian manufacturing of solar irrigation pumps to cater to local and international demand (in markets such as Bangladesh and Africa), which would help further the government's aim of a 'self-reliant' India and drive a greener economic recovery.

The state governments must now build on the learnings of the past few years to accelerate the deployment of solar irrigation pumps. They are key to expanding India's distributed solar generation capacity and in turn its power market transition.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

About the Author

Kashish Shah

Kashish Shah, a Research Analyst at IEEFA, has a master's degree in economics from the University of Sydney and an engineering degree from NMIMS University in Mumbai. Kashish has worked in the Global Analytics Division of the Royal Bank of Scotland with a focus on regulatory policies. He has research experiences in India's public sector in his work for a member of the Indian Parliament and a University of Sydney-based research group.
kshah@ieefa.org