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CEEW Policy Brief

Solar Pumps for Sustainable Irrigation

A Budget Neutral Opportunity

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A policy brief on 'Solar Pumps for Sustainable Irrigation: A Budget-Neutral Opportunity'.

Editor: Dr Arunabha Ghosh

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The Council on Energy, Environment and Water (http://ceew.in/) is an independent, not-for-profit policy research institution. CEEW addresses pressing global challenges through an integrated and internationally focused approach. It does so through high quality research, partnerships with public and private institutions, and engagement with and outreach to the wider public. CEEW has been ranked best in India (and South Asia) in several categories two years running in the Global Go To Think Tank Index. CEEW has also been rated as India's top climate change think-tank in 2012 and 2013 as per the ICCG Climate Think Tank's standardised rankings.

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About CEEW

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About the Authors

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As a researcher at CEEW, Shalu has worked on a diverse range of research projects in collaboration with international associations with a focus on energy access and sustainability. These include efficacy analysis of LPG subsidy policy in India, impact assessment of DBTL scheme, roadmap to realise 100 GW of solar and re-energizing India's solar energy market through financing. She has been working with the modelling team at CEEW to explore cost effective solutions for meeting India's energy demand by 2050.

Prior to joining CEEW, Shalu completed a course on 'policies, politics and practices of environmental management in developing world' at the Centre for Science and Environment (CSE), when she also served as the editor of the participants' environment magazine.

Shalu also had short term project stints with organisations such as Schlumberger Asia Services Ltd. (Wireline segment) and Control & Switchgears Ltd (low voltage protection elements, assembly line).

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Executive Summary

Rising demand for food, stressed water resources and poor water use efficiency in agriculture coupled with fiscally unsustainable subsidies, call for a need to rethink the approaches adopted to facilitate irrigation services in India. It has become increasingly challenging to facilitate affordable irrigation service through conventional irrigation technologies, from both fiscal and environmental perspectives.

With this backdrop, solar pumps are increasingly been seen as an alternative irrigation technology and are being promoted through the provision of high upfront subsidy on their capital costs. However, the current incentive strategy would not be amenable to scale up due to fiscal constraints. This study asks: Are there budget-neutral opportunities to incentivise solar pumps, such that they can be scaled up without challenging the fiscal limits?

KEY FINDINGS OF THE STUDY

In order to facilitate affordable irrigation through ground water sources, state governments bear significant expenses as subsidy on both initial connection costs and recurring power consumption during pumping. State governments typically incur ~INR 2,27,000 (USD 3,783) on every new agriculture connection (average 5 horsepower size), over a 15 year period (NPV basis). This subsidy could range from INR 3,13,000 (USD 5,217) to INR 1,50,000 (USD 2,500), across the states, depending upon power tariffs and collection efficiencies for agriculture sector.

Scaling up the deployment of solar pumps through incentives such as capital subsidy would need high fiscal expenditure. In order to increase the penetration of solar pumps from the current 0.1% to 1% (of total pump sets in the country), 0.3 million units would need to be deployed, requiring subsidies of the order of INR 7,500 crore (USD 1.25 billion).

Can the government promote solar pumps without incurring additional fiscal expenditure? The state governments could incentivise solar pumps in lieu of awarding new agriculture connections, to the extent of the expenses, which it will likely incur on the latter. Such a budget-neutral approach would enable them to subsidise capital cost of solar pumps by up to 63%, 45% and 23% in states with high, moderate and low levels of agriculture power subsidy, respectively

How does the choice between a solar pump and an electric pump play out for the farmer? In the current scenario of high subsidies on power for agriculture, despite a subsidy on solar pumps, farmers might still find electric pumps more economic than using solar pumps. However, high waiting time for new connections, poor quality of agricultural power supply and the costs associated with both could tilt the balance in favour of solar pumps.

1 Introduction

Provision of energy for irrigation at affordable prices, is one of the biggest challenges facing the country today. Only around 45% of net sown area in India is under irrigation cover (Department of Agriculture and Cooperation, 2014). Historically, food-grains production has shown a linear increment with the net irrigated area (NIA) (Mcneil & Sathaye, 2009). A simple projection of the past trends indicate that around 104 million ha of NIA would be required to meet the food-grains requirement of around 460 million tonnes by 2050, implying a net irrigation cover of ~ 74% of net sown area. However, NIA saw an increase of only 1.4% between 2006 and 2011 (IASRI, 2014). Thus, even as attempts are made to increase water use efficiency and 'crop per drop', there is also a need to expand the irrigation cover in the country at a significantly higher rate. Consequently, the provision of energy for irrigation at affordable prices becomes the necessity.

As of March 2015, India had around 19 million agriculture connections for irrigation through electric pumps (CEA, 2014), which reportedly consumed 166 billion units of power (~22% of total sales) in 2013-14 (Planning Commission, 2014). On the one hand, power for agriculture connections is heavily subsidised, leading to poor returns for utilities and wasteful consumption; on the other hand, even the existing connections face the challenge of unreliable and limited supply. Adding to the problem, lakhs of farmers are in waiting across the country to get their agricultural electricity connection (Iyer, 2013). Due to the unavailability of electricity or connection, a sizeable number of farmers rely on diesel pumps, which are considerably expensive to run. Diesel is the major source of energy for irrigation in 12 Indian states, 11 of which are in eastern and north eastern India.[1] In addition to the 19 million electric pump sets, there are almost 9 million diesel irrigation pump sets in the country (Raghavan et al., 2010).

Against this background, solar pumps have emerged as an attractive alternative technology for irrigation. They can serve as a cost effective mode of irrigation with low maintenance requirements, and help address the farmers' concerns associated with erratic power supply and high recurring expenditure on diesel. Recognising the opportunity of promoting irrigation across the country and simultaneously reducing power subsidy, improving grid stability and reaping environmental benefits, both central and state governments have started promoting solar pumps in the recent years.

The central government has set the target of incentivising 100,000 solar pumps (MNRE, 2014), while the state governments of Maharashtra, Gujarat etc. are pursuing individual targets of facilitating adoption of solar pumps (Kulkarni, 2015). The incentives are in the form of capital subsidy ranging from 30% to 86% (from both central and state government) of the upfront cost and long terms loans (for 10 year period) by the National Bank for Agriculture and Rural Development (NABARD).

As of August 2015, India has ~35,000 solar pumps, against a total of ~28 million irrigation pump sets. In order to increase the penetration of solar pumps from the current 0.1% to 1%, 0.3 million units would need to be deployed. Incentivising these pumps through capital subsidy mechanism (say 50% of the upfront costs) would require a fiscal expenditure of the order of INR 7,500 crore (USD 1.25 billion). Given the limited fiscal resources, such levels of expenditure would make it difficult to scale up the deployment of solar pumps.

This study asks: Are there budget-neutral opportunities to incentivise solar pumps, such that they can be scaled up without facing fiscal constraints?

1 CEEW analysis based on data from Minor Irrigation Census, 2006

2 Budget-Neutral Opportunity
Incentivise Solar Pumps in Lieu of Awarding new Agriculture Connections

State governments heavily subsidise power consumption in agriculture for irrigation purposes. At pan India level, INR 66,324 crore (USD 11.05 billion) was spent as subsidy on agricultural electricity sales in 2013-14, an 8% increase over the previous fiscal year (Planning Commission, 2014).

Besides the subsidy on power consumption, state governments also subsidise the capital costs incurred in providing new agriculture connections. These costs vary significantly with the type of feeder line (high tension or low tension), the distance from the nearest substation and the need for a new substation or a transformer. Governments typically incur a cost of INR 70,000 to INR 150,000 (USD 1166 to USD 2500) for every agriculture connection, while only a small connection fee of ~INR 12,000 (USD 200) is charged from the farmers (Gopal B Kateshiya, 2014; Iyer, 2013).

Overall, governments bear significant expenses to facilitate irrigation through electric pumps, which can be alternatively used to subsidise solar pumps. In order to assess the feasibility of such an approach, we conducted a discounted cash flow analysis of the expenses likely to be incurred by state governments in installing and servicing an agriculture connection.

The analysis was conducted for a representative pump size of 5 HP (Saini, 2011) for a 15 year period. It was assumed that solar pumps would have an effective life of 15 years under field conditions.[3] Initial expenditure on new agriculture connection and the corresponding connection fees were assumed to be INR 100,000 and INR 12,000, respectively. The cost of power supply was assumed to be INR 6/kWh, rising at a CAGR of 5%.[4] The average tariff for agriculture was assumed as INR 2 /kWh, rising at a CAGR of 8%.[5] It was assumed that a pump would run for 1000 hours/annum on average (5 hours*200 days).

As per the analysis, state governments would typically incur ~INR 227,000 or USD 3,783 on every new agriculture connection (Net Present Value of expenses over 15 years). This amount, if diverted towards a solar pump of equivalent rating i.e. 5 HP, could subsidise the capital cost of the pump (~INR 500,000 or USD 8,333) by up to 45%.

In the states where the agriculture tariff is even lower or the connection cost is higher, subsidising a solar pump would make a stronger economic case. For instance, the states such as Andhra Pradesh, Punjab and Haryana, where the average tariff for agriculture is negligible, say ~INR 0.30 /kWh and likely to rise at a CAGR of 4%[6], the state government expenses on an agriculture connection could be

2 This study focuses on comparative analysis of solar pumps against electrical connections only, as (i) the economic benefits of shifting from diesel pumps to solar pumps are already well established in the literature; (ii) after the removal of subsidy from diesel in Oct, 2014, there is no fiscal expenditure on that account which could be diverted to promote solar pumps

3 Based on CEEW interviews with technical experts at the SELCO foundation

4 For Indian states, the unit cost of supply in 2013-14 was INR 5.9 /kWh (median value) and it grew at a CAGR of 5.7% (median) over 2009-10 and 2013-14 (Planning Commission, 2014).

5 For Indian states, the average tariff for agriculture in 2013-14 was INR 1.8 /kWh (median) and it grew at a CAGR of 7.3% (median) over 2009-10 and 2013-14 (Planning Commission, 2014).

6 In six Indian states (Andhra Pradesh, Haryana, Himachal, Jharkhand, Punjab and Tamil Nadu), average agriculture tariff in 2013-14 was INR 0.27 / kWh, which has been growing at an average CAGR of 3.4% in between 2009-10 and 2013-14 (Planning Commission, 2014).

Table 1: Expenses incurred by state governments on an agriculture connection and extent of budget-neutral subsidy for solar pumps

Category of states	Assumptions for tariff and connection cost	NPV of expenses incurred over 15 year period	Extent of budget-neutral subsidy for solar pumps
Category 1 (high subsidy on power)	Connection cost (INR 100,000), agriculture tariff of INR 0.30/kWh (CAGR 4%), power supply cost of INR 6/kWh (CAGR 5%)	INR 313,000 (USD 5,217)	63%
Category 2 (moderate subsidy on power)	Connection cost (INR 100,000), agriculture tariff of INR 2/kWh (CAGR 8%), power supply cost of INR 6/kWh (CAGR 5%)	INR 227,000 (USD 3,783)	45%
Category 3 (low subsidy on power)	Connection cost (INR 100,000), agriculture tariff of INR 4/kWh (CAGR 10%), power supply cost of INR 6/kWh (CAGR 5%)	INR 115,000 (USD 1,917)	23%

Source: CEEW Analysis

as high as ~INR 313,000 (USD 5,217). Such amount could be sufficient to subsidise the capital cost of solar pumps by up to 63% (refer to category 1 in Table 1).

On the other hand, states with high average tariff for agriculture, say INR 4/kWh[7] (as shown in Category 3 in Table 1) would incur less expenses on an agriculture connection and thus would be able to provide only 23% capital subsidy for solar pumps, in a budget-neutral manner.

For the purpose of this study, only representative cases have been analysed. However, the agriculture tariffs and their growth trends vary widely across the states and so does the cost of the initial connection for electric pumps. For instance, Table 2 illustrates the broad categories, which each Indian state would fall into.

Further Annexure 1 provides details on the likely trajectories of cost of power supply and average agriculture tariff in category 1 states, as per the current trends (aggregate over 2009-2014). It also projects annual power subsidy burden against every agriculture connection in the state, for a repre-

Table 2: Categorisation of Indian states by levels of subsidy to agriculture power

Category of states	Name of the states
Category 1 (high subsidy on power)	Andhra Pradesh, Haryana, Himachal, Jharkhand, Punjab, Tamil Nadu (North eastern states: Arunachal Pradesh, Mizoram, Nagaland, Sikkim)
Category 2 (moderate subsidy on power)	Chhattisgarh, Delhi, Gujarat, Goa, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan, Uttar Pradesh, Uttarakhand (North eastern states: Manipur, Meghalaya)
Category 3 (low subsidy on power)	Assam, Bihar, Madhya Pradesh and West Bengal (North eastern states: Tripura)

7 Assam, Bihar, Madhya Pradesh and West Bengal have average agriculture tariff of ~ INR 4/kWh and they have shown a high CAGR of ~20% in past five years (2009-10 to 2013-14) (Planning Commission, 2014).

sentative pump of 5HP size, running for 1000 hours every year. Annexure 2 and Annexure 3 provide similar details for category 2 and category 3 states.

Each state government would have to conduct an exercise, to estimate the expenses it is likely to incur on an agriculture connection, over the expected life of solar pumps, keeping in mind the likely trajectory of agriculture tariffs, using the methodology employed in this study. The amount, thus arrived at, could be used for incentivising solar pumps, which would be a budget-neutral expenditure over a 15 year timeframe.

The main purpose of the study was to estimate the resources available to state for incentivising solar pumps, in lieu of awarding new agricultural connections. Capital subsidy is one of the most commonly used incentives, and is used here as a means to illustrate the magnitude of support that can be redirected towards deployment of solar pumps. However, other means of incentivising solar pumps can be explored as well, for instance, a combination of capital subsidy and low interest long term loans, which might better suit the government as well as the farmers' needs.

3 Economic Rationality for the Farmers

Solar vs Electric Pumps

Budget-neutrality could be a sound policy objective, but how does the choice between a solar pump and an electric pump plays out for the farmer? In order to answer this question, we conducted a comparative analysis of the cash flows for both choices. The cash flow analysis was conducted for a representative pump size of 5 HP for a 15 year period for all three categories of states, discussed in section 2. Further, we complement the analysis by also looking at opportunity cost associated with the choice of electric pumps.

Farmers using electric pumps incur expenses on purchase, installation and/or replacement of the pump, power bills (though subsidised), maintenance and repairs. We assumed an initial cost of electric pump at INR 30,000 (Saini, 2011), pump life of 7 years, annual maintenance costs at 7% of the capital costs and rising at 5.72% per annum (on account of inflation). Farmers using solar pumps would incur the capital cost (net of subsidy) as upfront investment or loan payments, maintenance expenses and pump repair/replacement costs. For these, we assumed a pump life of 7 years, maintenance costs at INR 1000/year[8] and rising at the CAGR of 5.72% (accounting for inflation).

Table 3 below highlights the NPV of the total expenses to be borne by farmers' using electric and solar pumps across the three categories of states, as identified in the previous section.

Table 3: Expenses (NPV) to be incurred by farmers over 15 year period

Category of states		Expenses incurred	
By type of subsidy on power	Budget-neutral capital subsidy on solar pumps	Farmer using electric pump	Farmer using solar pump (with subsidy)
Category 1 (high levels of subsidy)	63%	INR 92,400 (USD 1,540)	INR 218,000 (USD 3,633)
Category 2 (moderate levels of subsidy)	45%	INR 178,000 (USD 2,967)	INR 304,000 (USD 5,067)
Category 3 (low levels of subsidy)	23%	INR 291,000 (USD 4,850)	INR 416,000 (USD 6,933)

Source: CEEW Analysis

In all three categories of states, despite getting a capital subsidy, to the extent of maximum possible in a budget-neutral manner, a farmer using a solar pump would be spending ~INR 125,700 (USD

8 A conservative estimate, as maintenance costs are often cited to be negligible. One such study uses a maintenance cost of INR 500/annum (Pullenkav, 2013).

2,095) more than the farmer using an electric pump. This is equivalent to 25% of the capital cost of the solar pumps.

Considering only these cash flow numbers, **it appears that in the current power tariff regime, there would be inequity between farmers using the solar and electric pumps, despite the solar pumps receiving capital subsidy, as proposed above. However,** ***in reality, farmers' preference for solar or electric pumps would also be affected by aspects such as waiting time for new connections, reliability and quality of power supply as well as cost of repair and maintenance.***

The waiting-time for new agriculture connections runs into years across many states, which imposes a cost on farmers in the form of loss of crop productivity, the cost of using diesel pump set or the cost of obtaining tatkal (immediate) agriculture connections with full initial connection cost. To quantify the cost of waiting time, a delay of two years in getting an electric connection would have an opportunity cost of INR 100,000-150,000[9]. Thus, in states with high waiting time for new connections, solar pumps might be economically more attractive to the farmers as compared to tatkal connections or using diesel pumps. Moreover, the farmers using solar pumps would benefit through enhanced yields, due to assured supply of water.

Similarly, the costs associated with unreliable and poor quality of agricultural electricity supply could also tilt the balance in favour of solar pumps. Agriculture power supply is often erratic and of poor quality across most states. This results in frequent damages to the pumps and increases the cost of repair and maintenance for the farmers. A field study in Karnataka and Tamil Nadu revealed that farmers incur average repair cost of INR 6,000 per year, due to heavy voltage fluctuations as well as poor quality pump sets (Kannan, 2013).

Such costs associated with the choice of electric pumps as against the benefits of assured power supply from solar pumps, make an economic case for using solar pumps for irrigation.

9 Assuming that in absence of electricity connection, similar levels of irrigation service is achieved either by getting a tatkal electricity connection or by using a diesel pump.

4 Concluding Remarks

This study puts forward a budget-neutral approach for incentivising the adoption of solar pumps in India. The study also looks at parity between solar and electric pumps from economic perspective, i.e. NPV (net present value) of the expenses to be incurred by the farmer on either option. It further discusses that the farmers' preference for solar or electric pumps would also be affected by aspects such as waiting time for new connections, reliability and quality of power supply, and availability of repair and maintenance services..

Even as the study proposes mechanisms for promoting the deployment of solar pumps, it is also necessary to assess the suitability of solar pumps in providing sustainable irrigation, before they are scaled up. Exploring the context under which solar pumps would be technically, economically, operationally as well as environmentally sustainable would help different stakeholders identify and prioritise potential areas for deploying solar pumps through effective promotional policies and strategies.

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Annexure 1

Table 4: Proposed Agriculture Tariff and expected savings on power subsidy in Category 1 states

Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Unit cost of supply (INR/kWh)	6.0	6.3	6.6	6.9	7.3	7.7	8.0	8.4	8.9	9.3	9.8	10.3	10.8	11.3	11.9	12.5
Average agriculture tariff (as per current trends) (INR/kWh)	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
Per unit subsidy to agriculture (INR/kWh)	5.7	6.0	6.3	6.6	6.9	7.3	7.7	8.0	8.5	8.9	9.3	9.8	10.3	10.8	11.4	11.9
Cost of power supply per agriculture connection (INR/year)	23,380	23,499	24,674	25,908	27,203	28,563	29,991	31,491	33,065	34,719	36,455	38,277	40,191	42,201	44,311	46,526
Revenue recovered from farmers per agriculture connection (INR/year)	1,119	1,164	1,210	1,259	1,309	1,361	1,416	1,473	1,531	1,593	1,656	1,723	1,792	1,863	1,938	2,015
Annual subsidy per agriculture connection (INR/year)	22,261	22,335	23,464	24,649	25,894	27,202	28,575	30,018	31,534	33,126	34,798	36,555	38,400	40,338	42,373	44,511

Source: CEEW Analysis

Annexure 2

Table 5: Proposed Agriculture Tariff and expected savings on power subsidy in Category 2 states

Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Unit cost of supply (INR/kWh)	6.0	6.3	6.6	6.9	7.3	7.7	8.0	8.4	8.9	9.3	9.8	10.3	10.8	11.3	11.9	12.5
Average agriculture tariff (as per current trends) (INR/kWh)	2.0	2.2	2.3	2.5	2.7	2.9	3.2	3.4	3.7	4.0	4.3	4.7	5.0	5.4	5.9	6.3
Per unit subsidy to agriculture (INR/kWh)	4.0	4.1	4.3	4.4	4.6	4.7	4.9	5.0	5.2	5.3	5.5	5.6	5.7	5.9	6.0	6.1
Cost of power supply per agriculture connection (INR/year)	22,380	23,499	24,674	25,908	27,203	28,563	29,991	31,491	33,065	34,719	36,455	38,277	40,191	42,201	44,311	46,526
Revenue recovered from farmers per agriculture connection (INR/year)	7,460	8,057	8,701	9,397	10,149	10,961	11,838	12,785	13,808	14,913	16,106	17,394	18,786	20,288	21,911	23,664
Annual subsidy per agriculture connection (INR/year)	14,920	15,442	15,973	16,510	17,054	17,602	18,153	18,706	19,258	19,806	20,349	20,883	21,406	21,912	22,399	22,862

Source: CEEW Analysis

Annexure 3

Table 6: Proposed Agriculture Tariff and expected savings on power subsidy in Category 3 states

Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Unit cost of supply (INR/kWh)	6.0	6.3	6.6	6.9	7.3	7.7	8.0	8.4	8.9	9.3	9.8	10.3	10.8	11.3	11.9	12.5
Average agriculture tariff (as per current trends) (INR/kWh)	4.0	4.4	4.8	5.3	5.9	6.4	7.1	7.8	8.6	9.3	9.8	10.3	10.8	11.3	11.9	12.5
Per unit subsidy to agriculture (INR/kWh)	2.0	1.9	1.8	1.6	1.4	1.2	1.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cost of power supply per agriculture connection (INR/year)	23,380	23,499	24,674	25,908	27,203	28,563	29,991	31,491	33,065	34,719	36,455	38,277	40,191	42,201	44,311	46,526
Revenue recovered from farmers per agriculture connection (INR/year)	14,920	16,412	18,053	19,859	21,844	24,029	26,432	29,075	31,982	34,719	36,455	38,277	40,191	42,201	44,311	46,526
Annual subsidy per agriculture connection (INR/year)	8,460	7,087	6,621	6,049	5,359	4,534	3,560	2,416	1,083	-	-	-	-	-	-	-

Source: CEEW Analysis

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