Evaluation and Impact Assessment of the Solar Irrigation Pumps Program in Andhra Pradesh and Chhattisgarh

Report prepared for

Shri Shakti Alternative Energy Limited

By

Dr Shikha Suman
987-175-6326 | samplingresearch@gmail.com

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Cover Photo:

This is a solar powered farm spread over 2 acres in Kurnool District of Andhra Pradesh. This farm was transformed when the farm owner realized that with the on-demand availability of water, he could start planting Red Chillies instead of Tobacco (during monsoon) and Bengal gram (in the winter); the typical cropping pattern of most farmers in that area who do not have an electrical connection to pump ground water. Now, the farmer is getting substantially higher cash-per-acre and has not only recovered his extra cost of inputs, he's on the path to surplus income as well.

This report has been commissioned by Shri Shakti Alternative Energy Limited (SSAEL), Hyderabad.
The report has been prepared by Dr Shikha Suman of Sampling Research, New Delhi.

Contents

Preamble

Why this Report?

This report has been prepared to facilitate the Ministry of New & Renewable Energy (MNRE), Government of India, to ascertain the impact of the Solar Irrigation Pumps Program in select districts of the States of Andhra Pradesh and Chhattisgarh.

MNRE, together with the US State Department have founded a grant program called PACESetter Fund (PSF). Under PSF, Shri Shakti Alternative Energy Limited (SSAEL) has been awarded a grant for ***"Remote Performance Monitoring & Outsourced Service Management of Solar Pumps through an online portal with pilot demonstration projects in Andhra Pradesh and Chhattisgarh States"***. This study was initiated to evaluate the solar pumping program at the start of this project.

Limitations of the Report

1. The geographies and numbers of pumps to be covered under the grant were decided based on the proposal submitted by SSAEL to the PACESetter Fund, to have reasonable quantity and diversity to achieve the objectives of the project. The same was later fine-tuned in consultation with MNRE based on the feedback received from the Techno-Financial Committee of PSF.

2. The research was conducted to study the operating solar pumps and their financial, environmental and social impacts, besides other changes brought about by solar pump installation over the last 10 to 40 months of installing them in these States/districts.

3. **The findings stated in this report are intended for use in the Project**. They are not meant to serve as an authoritative syndicated research or quoted in reference to statewide impact of solar pumping.

4. The 7 defined objectives were laid out in discussions between MNRE and SSAEL and no formal Terms of Reference (ToR) has been issued by MNRE to take up this study. It is a subset and part of the PSF grant project and covered within the sanctioned funding for the project.

5. Averages for AP and Chhattisgarh have been used for analysis of most parameters, except where stated specifically. The installations in Chhattisgarh are more recent and therefore the economic impact is not as pronounced – but the trend is similar to AP.

Solar Pump Installations

A total of 142,000 Solar Pumps have been installed in the Country as on 30.11.2017 including 131,000 during the last three and half years.

Since 2014-15, in the State of Andhra Pradesh 16,725 solar irrigation pumps have been installed. Of these, the distribution in the target districts of this study is:

Krishna	1562
Kurnool	468
Ananthapur	559

In Chattisgarh, the aggressive Saur Sujla program resulted in 12,080 solar irrigation pumps getting installed and operational between Nov 2016 and March 2017. In the districts targeted:

Raipur	353
Bematara	116

Acknowledgements

This study would not have been possible without the cooperation and support received from several officials of the State Nodal Agencies involved; CREDA and NREDCAP. Also the MNRE, US State Department and the Indo-USSTF, who have been instrumental in helping structure the call for the proposals and supporting SSAEL from time to time.

Study Objectives

This study has been conducted to arrive at answers to the following points relating to solar pumps operational in the farms. The same will be recorded at the end of the PSF grant project (May 2019) for evaluating the difference created by SSAEL's intervention in the target farmer group.

1. Quantum of additional income to the farmer (before and after solar pump)
2. Cost benefit analysis of the solar pump (from farmer point of view)
3. Usage of water - judicious or indiscriminate
4. Any change in cropping pattern
5. Possibility to connect to grid to export surplus power
6. Any socially / commercially beneficial applications of excess power
7. Overall impact analysis and program effectiveness

The first and second points are especially significant given the fact that the MNRE through State Nodal Agencies (SNA) is providing subsidy to the farmers / beneficiaries to an extent of as much as 95% under certain programs in India, including the Saur Sujla program studied (refer 'Saur Sujla Poster' in this report). Given this, if the financial impact of the solar pump is substantial, subsidies can be reviewed and new financial models could be evolved to create win-win scenarios for Government and beneficiaries.

The third point is critical in understanding the impact of the solar pump on ground water. Ground water monitoring could be included as a data point in the GIS-based remote monitoring systems being developed by SSAEL. Doing so will ensure future pump site selection (for subsidy issuance or otherwise) is validated by water availability for at least the operating period of the solar installation.

The fourth point helps determine the impact on farm productivity. Whether any increase in number of crop cycles is recorded. Or whether new farm techniques have been adopted. Or whether there is any change in the cropping pattern / crop types planted grown. All of which would result in more earnings.

Points five and six are concerned with additional income streams for the beneficiary. Once remote performance monitoring for all pumps – any make, type, manufacturer, size, capacity, AC or DC – becomes a reality through this project, each off-grid mini installation can have the requisite controls to be monitorable. With net metering and requisite clearances, it can become a feeder to the transmission grid. It can also become a source of energy for domestic and other applications, during non-irrigation periods. Or it can be a source of extra water for diversification into fish/duck-farming etc.

Through the last point, it is aimed to conclude how tangibly the impact of the program (so far) has been felt by the beneficiaries. We seek to find any indicators to where the program could go to benefit all concerned more effectively.

Sample Size and Methodology

As defined by the PSF grant, a plan was formulated for monitoring 400 solar irrigation pump sites in AP and 50 in Chhattisgarh under pilot project over an 18-month period, through a web based GIS (Geographical Information System) and MIS (Management Information System) portal. The idea is to bring the solar pumps of various manufacturers under a common web based portal provide real-time MIS reports to State and Central Agencies and to arrive at the incremental impact of the intervention.

Study Sample

Given the project needs, it was decided to survey 150 sites in AP and 50 sites in Chhattisgarh in the defined districts. To have an even sample base, 50 beneficiaries were interviewed in each district.

Chhattisgarh
This sample size of 50 constitutes 100% of the project-defined sample in Chhattisgarh. Moreover, it constitutes 10.7% of the installed base in Raipur+Bematara and 0.41% of the entire installed base of the State. Since the installations in Chhattisgarh are fairly homogenous and contemporary, it is statistically a good sample to extrapolate quantitative aspects State-wide, although extrapolation is not the intent.

Andhra Pradesh
This sample size of 150 over 3 districts constitutes 37.5% of the project-defined sample in AP. Moreover, it constitutes around 10% of the installed base in each district Ananthapur and Kurnool, which is considerably larger than the statistically extrapolatible sample of 1%. In Krishna, the sample of 50 is 3%. Overall for AP, the sample base is 0.9% but this fact is not of much significance by itself.

What is important is that together with the decision makers of the SNA and their District Managers, the districts Krishna, Ananthapur and Kurnool were chosen as they represent the diversity of land and water conditions across the State. Krishna is in a river basin, hence its findings could apply all over the Andhra belt. Ananthapur is dry and hot, typical of the Rayalseema belt. And Kurnool is a non-coastal green area.

District	Sample Surveyed	%age of installed base	Remarks
Krishna, AP	50	3.2%	Rep. coastal districts
Kurnool, AP	50	10.7%	Rep. of central AP
Ananthapur, AP	50	8.9%	Rep. of Rayalseema
Raipur+Bematara	50	10.7%	Total CHG sample

The field work was conducted in the local language in Nov-Dec 2017. Findings were collated, ratified and reported in Jan 2018.

Methodology

A questionnaire-led quantitative approach was adopted for objectivity. Generally closed-ended questions were used. Care was taken to validate factual correctness of answers within the questionnaire itself using the content and sequence of questions as the means. Further, 20% forms were back-checked randomly over the phone and 5% of the interviewees were met by a more senior team one-on-one while the data-entry process was being completed. This was for ratification and gaining qualitative inputs.

Findings Summary

These findings will serve as the baseline to study how these impacts change once a comprehensive remote performance monitoring system, on a web based GIS and MIS platform, with centralized service management is deployed for all pumps. The intent is to measure the parameters again after 18 months. In order of the objectives, the principal findings at the start of this project are:

1. **Additional income to the farmer**
   - As a consequence of having solar irrigation pumps, *the number of farmers that earn more than Rs 100,000 per annum has more than doubled, from a mere 26% to a strong 58%.*
   - On average, *45% farmers saw an increase of 50% or more in their annual incomes and 70% farmers began to earn 25% extra*.

2. **Cost benefit analysis of solar pump**
   - Owing to the availability of subsidy across the board, the price paid by farmers has been between Rs 7000 and Rs 80,000 depending on the size/capacity of the pump, district and scheme of purchase. This is lower than the annual cost of irrigation water from direct purchase or from installing a diesel pumpset. Electric pump is still a cheaper option at prevailing rates.
   - *The added benefits of selling water, using water for diversifying, using panels for commercial purposes or exporting power to the grid have not been explored*.

3. **Usage of water – judicious or indiscriminate**
   - It is generally observed that water is being used judiciously. *Wastage is not observed. Farmers are conscientious about on and off timings for different types of crops.*
   - The use of water for purposes such as aquaculture, duck rearing was not evidenced in the sample. Sharing of water with neighboring farms was also negligible.

4. **Change/s in cropping pattern**
   - As they say, necessity is the mother of invention. *Districts that have relative water scarcity have a marked increase in shift of cropping practices whereas a water-rich district like Krishna demonstrates zero change in cropping mindset.*
   - *The cropping changes include starting of fruit orchards, drip irrigation, greenhouses for floriculture and growing vegetables or cash crops like chillies* that require steady control over water. An increase in crop cycles, upto 3 cycles per year, has also been observed.

5. **Export surplus power to grid**
   - So far, in the sample considered, nobody has connected their SWP to the grid. *As many as 73% of the systems are underutilized since the farmer's own water requirements are being met*, but the panels are lying unused thereafter. For perspective, in a district with 500 SWPs on average, that is about 5.84 MWh available every day (1752 MWh per year), considering an average of 4 hours of unused availability for each pump.

- 98% of the pumps were AC in nature. Secondary research and qualitative findings indicate that there is a grid line passing in the vicinity of over 90% of them. *Therefore there is the potential for net-metering and grid interconnection to export the surplus power, however there is practically no awareness* about both, the possibility and the complexity of doing it. Even the AP and Chhattisgarh Electricity Regulator's documents are silent on the subject of agri-feeders.

6. **Other social / commercial applications of excess power**
   - An abysmally low 1% of beneficiaries have attempted to use their panels for other village productivity enhancing measures such as operating small DC motors, household electrification or charging batteries. Strict warranty conditions prohibit such applications, it was said.
   - *The use of water for drinking, sanitation or even irrigation in other farmlands was not observed. The laying of additional pipes and recovery of money basis usage could be impediments*.

7. **Overall impact analysis and program effectiveness**
   - The solar irrigation pumping program in the districts studied in both States has been a success in the context in which it has been conceived. *Farmer incomes and farm productivity is on the rise.*
   - *Education about profitable farm-practices is notably missing, which could increase cash-per-acre substantially in future*. Lack of education on solar maintenance is also thwarting productivity.

Concern areas evaluated

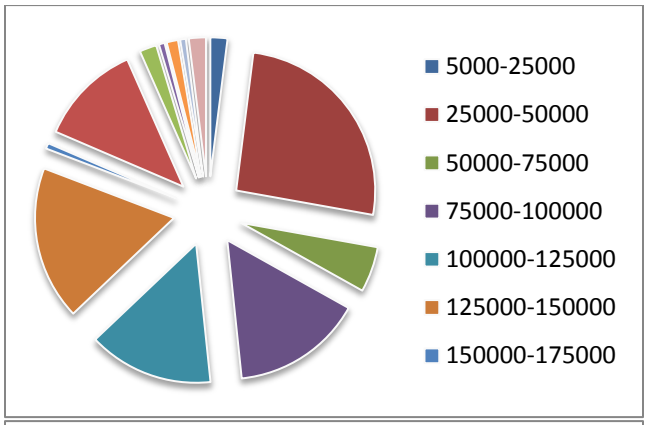
1. Farmers are unable to progress beyond flood irrigation / rice cultivation because of:
   - Lack of cashflow availability – but they are excited at the prospect of doing so next year.
   - Concerns about muti-cropping – though due to solar water pumps around 10% have started cultivating vegetables. Earlier they were using it only for rain fed crops like gram, wheat.
   - Concerns about theft and damage of pipes – this also is one reason drip irrigation is a slow starter. And nobody is selling water to others, even when their pumps are lying idle.
   - Safety and security; they want to protect crops like vegetables and wheat from wild animals and think fencing must be done first.
2. *Theft of panels and missing wires, damage to the system has been experienced by as many as 12 out of 50 users in Chhattisgarh.* Where pumps are not working at all a few claim to have reported about the faulty system but they have not got the service. They are expecting CREDA to be their point of service and have no knowledge of any other Engineers/Technicians.
3. *There is very limited understanding of the impact of dust on panels and other aspects of operating efficiency.* No sustainable attempt has been made proactively to address the same. Even at the time of installation, high panel height from the ground prevents ease of cleaning.

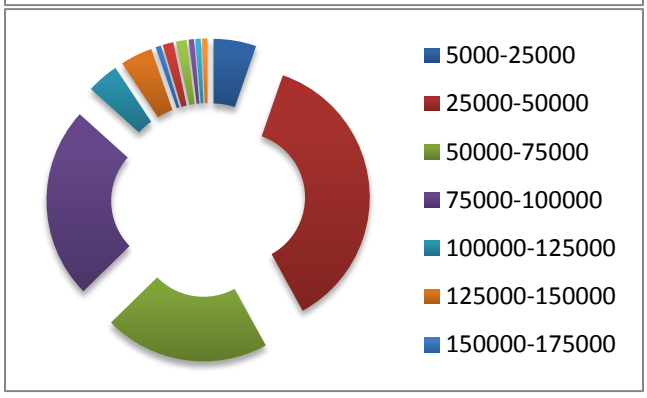
The success of Solar Water Pumps (SWPs) however will depend on the selection of the cropping pattern and efficient irrigation practices. Based on food habits and traditional cultivation practices people are still using SWPs for flood irrigation. Used in line with scientific agricultural practices in parallel with the traditional approach can help increase the yield and the income of the farmers.

Findings/Impact

Economic impact

In the sample interviewed, 52 farmers were earning above Rs. 100,000 per annum before the pump installation. 116 farmers report to be earning above Rs. 100,000 per annum after the solar pump has been operational.





123% increase in income over Rs 100,000 reported. More than 58% of the farmers across districts now earn over Rs 100,000 per annum

Incomes across categories have increased. The charts alongside show the breakup Before (above) and After (below) solar pumps were installed

- *As a consequence of having solar irrigation pumps, the number of farmers that earn more than Rs 100,000 per annum has more than doubled, from a mere 26% to a strong 58%.*
- On average, 45% farmers saw an increase of 50% or more in their annual incomes and 70% *farmers began to earn 25% extra.*

Observations/Comments

- Owing to the availability of subsidy across the board, the price paid by farmers has been between Rs 7000 and Rs 80,000 depending on the size/capacity of the pump, district and scheme of purchase. This is lower than the annual cost of irrigation water from direct purchase or from installing a diesel pumpset. Electric pump is still a cheaper option at prevailing rates.
- The added benefits of selling water, using water for diversifying, using panels for commercial purposes or exporting power to the grid have not been explored.

Environmental impact

The average number of hours water is being used for the major 5 crops is as below. This is commensurate with the crop-need and the pumpsets are being switched off in 86% cases immediately after the irrigation is completed. Therefore, prima facie, groundwater levels are not being compromised by indiscriminate wastage of water, merely because it is available freely.

Crop	Irrigation hours / day
Rice	8
Black / Red Gram	7.5
Changakaya	6.2
Maize	4
Mango	7

Furthermore, the farmers currently appear very conservative in their usage of water for other purposes. Only 1 farmer has actually used it for water-intensive farming (Sapota). The shift is rather to cash-crops which require controlled water availability, which is better for the economy as well as the environment.

A notable business opportunity with an environmental benefit which is missed is that of water sharing or sale of surplus water. Only 4 farmers across all districts have begun to engage in this. Across all districts only 3 HP and 5 HP pumps have been installed, both of which provide larger coverage than typical farm sizes (more than 80% are less than 5 acres).

Observations/Comments

- It is generally observed that water is being used judiciously. Wastage is not observed. Farmers are conscientious about on and off timings for different types of crops.
- The use of water for purposes such as aquaculture, duck rearing was not evidenced in the sample. Sharing of water with neighboring farms was also negligible.
- Krishna and Ananthapur are the top water consuming districts.

Farm-practice impact

36%
Increased crop quantity (more yield)

29%
Improved crop quality (more cash)

66%
Increased crop cycles

Observations/Comments

- Qualitative evaluations reveal how several farmers have started increasing cash per acre. *A Sweet Lime orchard stands in a five acre farm that had no power earlier; Red Chillies abound in a farm that was rain fed to grow tobacco and Bengal gram earlier*.
- Since Krishna District grows paddy, no other crop has been tried there, whereas farmers are hungry for increasing yield in other districts. In fact district-wise skews are evident as Ananthapur has 100% increase in crop cycle while Krishna reported as no increase.

- The cropping changes include starting of fruit orchards, drip irrigation based greenhouse for floriculture and changes in land use, to grow cash crops that require steady control over water. An increase in crop cycles, upto 3 cycles per year, has also been observed.

Earlier, this land was rain-fed only; had only rice cultivation. For the first time, after installing the solar pump Wheat/ Mustard/ Bengal Gram / Masoor (multi crops) were grown on this farmland. The green background indicates wheat cultivation.

Social impact

An abysmally low 1% of beneficiaries have attempted to use their panels for other village productivity enhancing measures such as operating small DC motors, household electrification or charging batteries. Strict warranty conditions prohibit such applications, it was said.

Likewise, the use of water for drinking, sanitation or even irrigation in other farmlands was not observed. The laying of additional pipes and / or recovery of money on a pay-by-use basis could be impediments; not studied.

However, one beneficiary was using the solar pump for brick making, captured in the photo above.

So far, in the sample considered, nobody has connected their SWP to the grid. *As many as 73% of the systems are underutilized since the farmer's own water requirements are being met*, but the panels are lying unused thereafter. For perspective, in a district with 500 SWPs on average, that is about 5.84 MWh available every day (1752 MWh pa), considering an average 4 hrs of unused availability for each pump.

Observations/Comments

- 98% of the pumps were AC in nature, operable using solar and electricity.
- With the exception on 1 surface pump, all pumps surveyed were submersible.
- There is the potential for net-metering and grid connectivity, however there is practically no awareness about both, the possibility and the complexity of doing it. Even the AP and Chhattisgarh Electricity Regulator's documents are silent on the subject of agri-feeders.

Service level

According to the recent Dalberg Report on "Impact assessment of the National Solar Pumps Programme" one of the main challenges in the Solar Pumping program in Bihar is:

“A weak after-sales service network for SWPs as compared to diesel pumps, and a long application process. Most solar pumps must be taken to the installer for repair, and take more than a week for repairs, while diesel pumps can be repaired by a local mechanic within a day. The process of acquiring solar pumps takes 10-11 weeks in the state, and anecdotal evidence suggesting even longer timelines, with a farmer saying “The approval sometimes takes a lot of time. It took 6-8 months to get the approval as the pump was not available.”

Likewise in UP:
“A weak after-sales service network for SWPs as compared to conventional pumps, and a long application timeline. ~70% of solar pumps have to be taken to the installer for repair, while most conventional pumps have local repair networks. This has resulted in 12% of SWPs being unoperational for more than a month, while >95% of other pumps are repaired within a week. Further, it takes the median farmer 10-11 weeks to receive a solar pump, while electric and diesel pumps can be purchased immediately.”

Why was the Service Level Study important?

The vision of SSAEL behind the PSF grant project is to implement a singular service management system that is driven by technology, remote performance monitoring and delivered by a fleet of technicians and engineers who interface with the farmer / pump owner with a regularity that is uncommon.

For doing so, they will be trained in water-use aspects in order to advise the farmer on better farming practices and show him the impact of well-informed energy and water-use decisions. This fleet will be trained and empowered to address issues of any pump; AC / DC / Surface / Submersible / Hybrid / any make / any capacity / any integrator.

The Remote Transmission Units (RTUs – to move data from the pump to the cloud), if installed by the integrators will be accessed through their Application Programming Interfaces (APIs) to collate and analyze Big Data on a cloud for the benefit of all concerned – especially the various manufacturers for service quality measurement, and the MNRE / SNAs for effective understanding of how their subsidized assets are performing. In the cases where RTUs/APIs are not available, the project envisages installing or developing them.

The best part is that the common GIS and MIS platform for monitoring the solar pumps will be a social, open portal available on a SaaS (Software as a Service) model, which will enable access to all related parties at zero cost to the farmer. Big Data (linkage to the Aadhaar Card and Soil Health Card) will be portable to other apps of social / agri-nature to benefit the users further. Commodity markets, insurance companies and other commercial establishments can use it to improve their forecasting for crop yield estimation or for deciding insurance premiums.

The key is to bring the manufacturers and system integrators on the same page with regard to AMC service, warranty management and turnaround time. This is a matter of aggregation under the aegis of the MNRE. The outsourced service management model is similar to that which is already in use by

consumer durable, IT and elevator companies. Solar pump manufacturers will gain also from scale-based economies of data transfer and cloud hosting costs, besides not having to afford and train specialist manpower. Service availability, as it stands in the target districts, was covered in this study as below.

District	Service Provider/s	Avg Distance of Technician	Easy access to Service	Pumps non-operational
Krishna	16 unique providers in 50 surveyed	39 kms	74% yes	1 (choked pipe)
Kurnool	9 different providers in 50 surveyed	21 kms	N/A	0
Ananthapur	5: Akshaya, Microsun, Navitas, Premier, PV Power	66 kms	N/A	0
Raipur+B'tara	4: Cosmo, Ecozen, Shakti, SolarAqua	56 kms	32% yes	6 (wire damage)

The Education aspect of Service

Service does not only mean fault repair. Service, when provided for pro-actively, say as in AMC, with adequate budgets (through aggregation, economies of scale and the SaaS revenue stream, as in the case of this project), will result in higher output.

The picture on the left shows a Sweet Lime farmer who could capitalize the land that was lying vacant without electric supply. But with so much dust on his panels, is he effectively capitalizing the resource? Service therefore means advice on panel efficiency, irrigation methods, seeds and other issues that have been identified earlier in this report. This nature of service is not what a pump service technician is generally mandated to give. But with a holistic view, as in this project, it is a value gap being fulfilled.

The picture on the right shows how wiring can become defective / damaged by animals, leading to breakdown. This is preventable with routine, pro-active service processes.

Observations/Comments

- Education about profitable farm-practices is notably missing, which could increase cash-per-acre substantially in future. Lack of education on solar maintenance is also thwarting productivity.
- The beneficiary's ability to enhance income beyond his own farm is restricted by service considerations and entrepreneurial thinking. This is analogous to having a Ferrari but being constrained to drive only on the streets of Old Delhi.
- Availability of performance data on cloud (as envisioned in the project) will also help provide a feedback system to the farmer to enhance productivity as he would know over a phone call (or app), how much below the benchmark he is producing. The Mobile App can be used by the Farmer to requisition Service for the pump and the resolution of the issue can be monitored by the State Agency and MIS reports can be generated by MNRE besides real time monitoring if all the manufacturers are brought on to the common web based GIS and MIS portal.

Conclusions/Next Steps

According to a recent study by CEEW, solarizing individual grid-connected pumps is the costliest approach for the government to expand irrigation cover, while not being the most attractive option for farmers. In regions with prevailing local water markets, it recommends to promote community-owned solar pumps. *While joint ownership drew interest from 20% of farmers, close to 80% of them were interested in buying water from a community-owned or enterprise-owned solar pump at competitive prices.* The report also encourages sharing of solar pumps among farmers through farmer extension programmes. Given zero marginal cost of pumping with solar, water sharing, already a prevalent practice in many parts of the country, helps put a marginal price to the water.

The context of the above reference is that two things emerge strongly, which are proposed to be addressed by SSAEL's project:

1. *There is a strong need for entrepreneurship and community mobilization for the above recommendations to fructify.* So far that does not lie as a key deliverable in the purview of any single player in the farm / water sector. SSAEL's project is designed to play that role by coopting pump maintenance providers, Government bodies, village entrepreneurs and technologists.

2. The more the sources of water are aggregated, the greater the need for aggregated services and performance monitoring. However, this is a critical need in the present context as well since lack of Big Data in this sector limits the basis of decision making as India plans to leap into the vision of 1,000,000 pumps by 2022, through SNAs under the National Solar Mission (NSM) and the same should align with the Honourable Prime Minister's vision for "more crop per drop" and the target to double farmers income by 2022.

Further, the following will help to improve farm productivity and spur the adoption of solar systems:

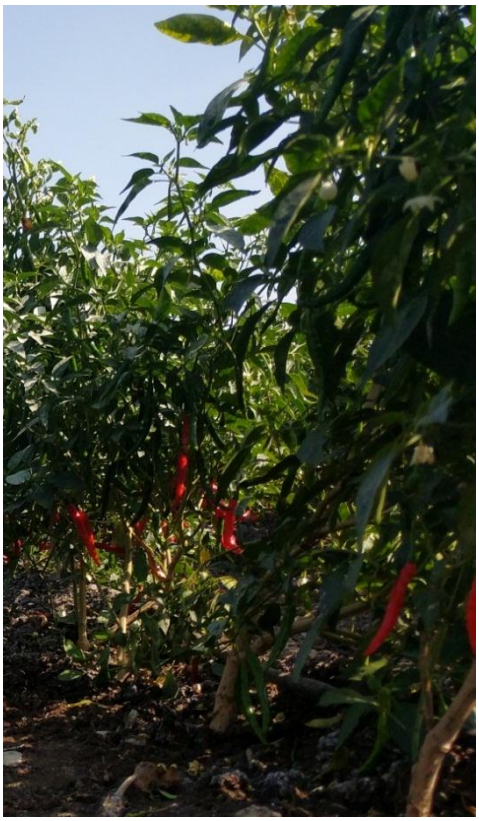
1. Hand-holding on how to integrate various technologies. Farmers we interviewed have got irrigation pipes, sprinklers, drip irrigation pipes from the department at attractive rates but the technical guidance on ground may not be adequate.

2. Relook at warranty management terms in view of increasing utilization of installed panel capacity, thereby increasing revenue and social benefit.

3. Education on cost-benefits of technology and refinance. Farmers have understood this for seeds; unhappy with the quality of seeds from the Government, which result in non-uniform cultivation on the ground, they are willing to buy good quality seeds at more than double the rate to get better yield.

4. Relook at the procurement process of individual solar pumps and bank financing options. In the light of very positive feedback on increased income, the paradigm on this could well be changed.

5. Keeping in view the increased cropping and bullishness that would soon set in, GIS mapping of groundwater for controls and balances will become critical. SSAEL is incorporating the same in the design of the project, though not envisaged in the scope of the original project proposal.



As concluded from the findings in this report, the missing link for farmers is holistic on-ground technical support; which goes way beyond pump repair… into preventive maintenance into proactive service, education on farming and cropping practices, integration and use of technologies and interpretation of agri-environmental parameters to provide critical inputs to farmers and linkages to supply chains.

The missing link for MNRE, SNAs and Pump Service Providers is big data and cloud-based monitoring that is agnostic of pump types, manufacturers and installers. Also, the costs of retaining manpower to service warranties and to upload and mine data may not have been adequately provided for in the tender bids.

Furthermore, we envisage that the following can be logical extensions to the present project, which fit directly with National Priorities of “doubling of farmer income by 2022” and “more crop per drop”:

- The common GIS and MIS platform envisaged for monitoring the solar pumps remotely could be augmented by monitoring agri-environmental parameters and providing necessary inputs to the farmer for sustainable extraction of groundwater and increased productivity.
- Environmental parameters for agriculture can be monitored, such as ambient temperature, rainfall, soil moisture content, besides solar pump operation to estimate water flow and thus work towards climate resilient agriculture.
- Based on monitoring of agri-inputs to farmers, yield estimation by experts can be shared with Banks, Insurance companies and commodity buyers.
- Assistance to the Farmers to facilitate net metering to export the surplus power to the power grid.

In conclusion, currently the impact of the solar irrigation systems has been encouraging, as also the maintenance. Crop Yield and incomes have increased. Water usage is optimal. Other social and business benefits are yet to be fully explored.

Given emerging trends (CEEW recommendations), imminent expiries of warranties and ageing of panels, outsourcing service and hand-holding farmers will lead to sustainable growth into the future as well.

Addendum: Impact of Central Financial Budget 2018

In his Budget 2018 speech in the Parliament on 1st February, the Honourable Finance Minister, Government of India made direct references to the following aspects that have deep relevance to this project and its outcomes over the next year or so:

1. The need for net metering for export of surplus power generated by solar irrigation pumps. The Power Minister further stated that "under the scheme, farmer would be able to use solar power and sell excess generation which makes it very attractive proposition". *However, the Honourable Minister pointed to the need to set up processes and regulations with Discoms and State ERCs (gaps in the regulatory mechanisms for the same) and there is an imminent need to monitor the pumpsets, which will be fulfilled by this project.*

2. The revised KUSUM (Kisan Urja Suraksha Utthaan Maha Abhiyaan) Scheme with an outlay of INR 48,000 crore will result in installation of 17.5 lakh off grid solar farm pumps. *This is more than 10 times the current base and a robust universal monitoring platform (to record performance data of any make, type, manufacturer, size, capacity, AC or DC pump) is of critical importance.*

3. *Implementation of new a financial model wherein State and Centre collectively provide for 60% of cost of solar pumps as subsidy while banks provide a loan of 30% and remaining 10% is paid by farmers.* Such implementation increases the base of financial partners (Banks) whose confidence can be enhanced with real-time monitoring of their financed assets. It also compounds service aspects, which this project aggregates.

Annexure 1: Abbreviations Used

AMC	Annual Maintenance Contract
AP	Andhra Pradesh
CEEW	Council on Energy, Environment & Water
CREDA	Chhattisgarh State Renewable Energy Development Agency
GIS	Geographical Information System
Indo-USSTF	Indo-US Science & Technology Foundation
MIS	Management Information System
MNRE	Ministry of New & Renewable Energy
NREDCAP	New & Renewable Energy Development Corporation of Andhra Pradesh
NSM	National Solar Mission
PSF	PACESetter Fund
ToR	Terms of Reference
SaaS	Software as a Service
SNA	State Nodal Agency (viz CREDA/NREDCAP)
SSAEL	Shri Shakti Alternative Energy Limited
SWP	Solar Water Pump
US	United States

Annexure 2: Saur Sujla Poster

Annexure 3: Questionnaire

Solar Pump Survey Form No: _____ / _____

Latitude: _____ Longtd: _____

Village : _____

Blk/Mdl/Teh: _____

User name: _____

Mob No.: _____

Pump HP & Make: _____

Pump controller make: _____

Has RTU: YES / NO

Mobile Signal Co.: _____

Type : AC / DC / Electric / Hybrid / Surface

Irrigation: Flood / Drip / Other _____

Soil type: _____

Depth of bore: _____(mt) Dia: _____

When installed: _____

Seasonal perf variation observed? YES / NO

Acreage under pump: _____

Acres owned by user: _____

- ☐ Pump not at specified location / Where
- ☐ User not at pump location / Where
- ☐ Pump not operational / Since
- ☐ Pump not seen / Why

Pump output photo ref / User Statement(s):

1. Before pump, Rs/yr earned from farming

   _____

2. Crops grown before and after pump

   OLD: _____

   NEW: _____

3. a. Increased crop cycles after installing?
   YES NO
   b. If no, do you think it can be done?
   YES NO

4. Do you use the solar panels from your pump for anything else (eg electrification)?
   YES NO
   If yes, what? Any business benefit?

   _____

   Do you give water to neighbor's farm if surplus
   YES NO

5. Do you close the pump immediately after finishing irrigation? (NO if it runs longer)
   YES NO

6. No. of hours water runs currently _____

   Crop 1 _____No. of hrs _____
   Crop 2 _____No. of hrs _____

7. Is your pump connected to the supply grid?
   YES NO

8. When pump stops, do you get service easily
   YES NO

9. How far is the service provider? ____km

10. How much do you earn from the farm now?

    _____

_____ Date_____ Time_____ _____