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Business models and strategies for large scale uptake of Universal Solar Pump Controller (USPC)

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Acronyms

3-D	Three Dimension
AC	Alternate Current
AED	Agricultural Engineering Department
CCAFS	Climate Change, Agriculture and Food Security
CEEW	Council on Energy, Environment and Water.
CEO	Chief Executive Officer
CFA	Central Financial Assistance
COP	Conference of the Parties
CPSU	Central Public Sector Undertaking
CUF	Capacity Utilization Factor
DC	Direct Current
DDU-GKY	Deen Dayal Upadhyaya - Grameen Kaushalya Yojana
FPO	Farmer Producer Organisations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOI	Government of India
GW	Gigawatt
HP	Horse Power
ICAR	Indian Council of Agricultural Research
IGEN	Indo-German Energy Programme
INR	Indian Rupee
IWMI	International Water Management Institute
JLG	Joint Liability Groups
KUSUM	Kisan Urja Suraksha evam Utthan Mahabhiyan
KVGB	Karnataka Vikas Grameena Bank
MNRE	Ministry of New & Renewable Energy
MPPT	Maximum Power Point Tracker
MS	Microsoft
MW	Mega Watt
NABARD	National Bank for Agriculture and Rural Development.
NISE	National Institute of Solar Energy
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
PACS	Primary Agricultural Credit Societies
PM	Pradhan Mantri
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PMKVY	Pradhan Mantri Kaushal Vikas Yojana

PSWP	Promotion of Solar Water Pumps
PV	Photovoltaic
PWM	Pulse-Width Modulation
RE	Renewable Energy
RMS	Remote Monitoring System
RTS	Grid Connected Rooftop Solar
SHG	Self Help groups
SIA	State Implementation Agency
SIPS	Solar Irrigation Pump Sizing
SMAM	Sub-Mission on Agricultural Mechanization.
SPV	Solar Photovoltaic
SWISM	Single Window Information and Support Mechanism
SWP	Solar Water Pump
THD	Total Harmonics Distortion
TV	Television
USPC	Universal Solar Pump Controller
VFD	Variable Frequency Drive
VMin	Minimum Voltage
Voc	Open Cicuit Voltage
VP	Vice President
VR	Virtual Reality
WUA	Water User Association

Executive Summary

Solar Water Pumps (SWPs) have now become an integral part of the agriculture and irrigation ecosystem in the country. Once a novelty, SWPs are emerging as an effective alternative to traditional options such as diesel and electric pumps.

Solar energy product prices have declined sharply over the last decade, thereby enabling innovation even outside the traditional grid-connected electricity industry. In recent times, policy makers have framed suitable policy mechanisms to facilitate these innovations to be more scalable. Solar Water Pumps have emerged as one of the key applications of such cross-sectoral innovation.

The Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM KUSUM) scheme have seen varying levels of success, with installations scaling up but asset utilization remaining low primarily due to lack of awareness and knowledge, technological issues and lack of supporting infrastructure.

However, the SWPs deployed at a high cost are currently utilized only for half of the days in a year (around 150 days per year) on average. To optimally utilize the solar PV system, the SWP controller should be able to perform other rural and agricultural activities. This will increase the productivity of the agricultural sector and the income of the farmers. With the use of Universal Solar Pump Controllers (USPC) the solar system could be used effectively throughout the year and help in improving the living conditions of small and marginal farmers.

The Government of India (through the Ministry of New & Renewable Energy (MNRE)) has introduced technical specifications for USPC, a controller with multiple outputs giving farmers the opportunity for utilizing the excess energy generation for other applications such as flour mills, grinding, battery storage, drying, washing, heating. The Government of India (GoI) also announced the approval of the PM-KUSUM scheme in the country on 19th February 2019. Under Component-B of this scheme, the government aims to install 2 million off-grid solar pumps. Though USPC have also been integrated in the PM-KUSUM scheme, there is only limited information on the uptake and use of USPCs. Despite the advantages offered by USPC, uptake remains limited due to high costs, non-provision of subsidy, limited knowledge about the benefits and lack of a supporting ecosystem constraining the demand and thus income generation potential for other end-use applications. The success or the failure of the USPC will depend on both demand and supply side factors as well as implementation mechanisms. This includes USPC potential, economic and commercial viability, additional income generation opportunity, availability of affordable financing, government subsidies and incentives, USPC costs, business models, on-ground acceptability and demand for end-use applications.

This study intends to assess the existing USPC ecosystem, identify gaps and challenges and draw out possible strategies and mechanisms for increasing USPC acceptability and its deployment. The report captures the details on the assessment of key parameters impacting the adoption of USPC, the development of a framework for the selection of relevant states and districts, across which excess energy generated during non-irrigation hours of SWP will be estimated. Subsequent sections of the report disclose key challenges in the adoption of USPC from the perspective of both USPC/SWP/Agri manufacturers and farmers.

Some of the key highlights of the study comprising consultations with various stakeholders, issues faced and suggested potential measures/interventions are given below:

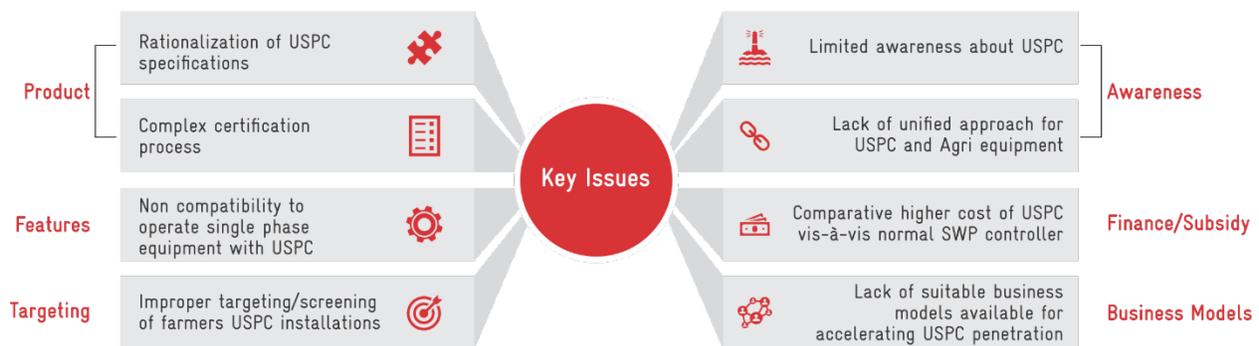
- **Consultations with SWP/USPC/Agri equipment manufacturers:** During consultations with the USPC manufacturers, the issue of awareness among stakeholders regarding the product, PM-KUSUM scheme has been highlighted. Further, the issue of the higher price of USPC compared to normal controllers and lack of additional subsidy on USPC has been mentioned as key reasons for limited penetration of USPC. Manufacturers cited the need for credible demonstrations, financial measures/technological initiatives to

reduce the cost differential between the price of normal controllers and USPC and adding compatibility to operate single phase equipment. Some of the respondents outlined that the emphasis of the government policies and guidelines should be more on increasing awareness amongst farmers regarding the potential applications that can be operated with USPC and associated benefits. This may result in upscaling the market and making space for more variants in the near future.

- Consultations with USPC Beneficiaries:** Consultations with farmers provided insights related to the level of awareness among farmers and key factors attributing to low uptake of USPC. It was observed that most farmers did not know about the USPC functionalities, including the various agri equipment that can be operated in addition to the irrigation pump. Even though some were aware of the functionalities of USPC, they do not want to use the SWP for any other purpose as they do not have the need to operate agri-equipment with USPC. This indicated that targeting may be improved to ensure that farmers having needs for operating additional Agri equipment with USPC can be identified. The interactions with farmers have also revealed that most farmers also want USPC to support single phase equipment so that they can operate single phase commercial as well as domestic loads.

The report suggests some potential measures/recommendations for addressing the key issues highlighted by all stakeholders:

Key issues perceived to be hindering USPC penetration.



Key Solutions/Mitigation measures



Further, to accelerate USPC penetration, business models are proposed as highlighted below:

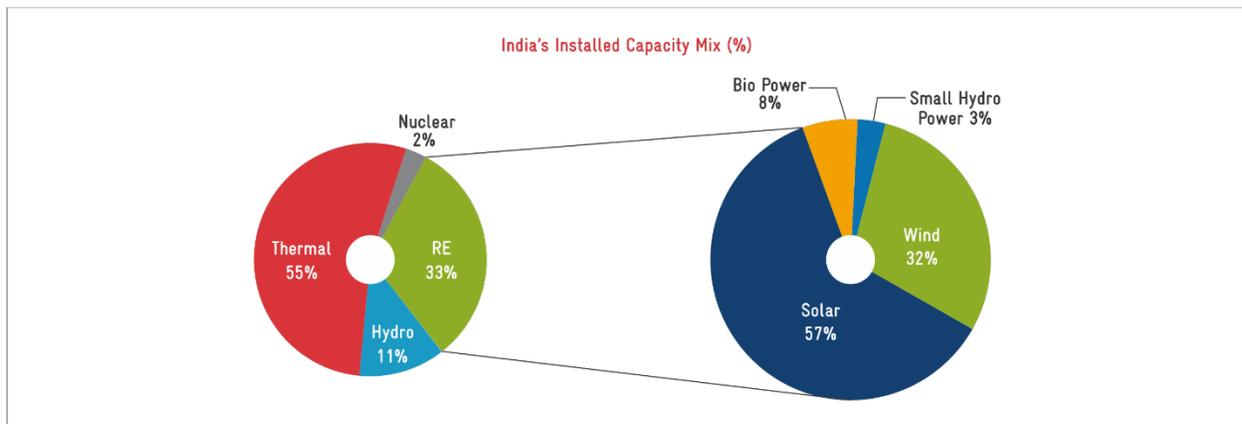
1. Farmer currently owning neither USPC nor grid powered Agri equipment shall purchase both from respective vendors
2. Farmer already owns grid power agri equipment but doesn't own USPC. Farmer purchases USPC through PM-KUSUM scheme
3. Farmer turns to be an agri-entrepreneur providing services to neighboring farmers
4. Farmer switches to USPC to make commercial products to be sold in the market (E.g. Flower pots etc.)
5. Community based farming using Solar pump, USPC and compatible agri-equipment

These models align with the preferred business practices of farmers using USPC to operate both SWP and grid-powered agricultural equipment.

1. Background

During the Conference of the Parties on Climate Change (COP 27), India submitted its ‘Long-Term Low Emissions Growth Strategy’ indicating low carbon transition pathways in key economic sectors. India has targeted to raise the non-fossil fuel capacity to 500 GW by 2030 while meeting 50% of its demand through renewables. As of 31st March 2024, the total installed capacity of RE stood at ~190.5 GW, which constituted ~43% of the total installed capacity in the country¹. The [Figure 1](#) presents an overview of the country’s installed capacity mix, including specifically that of RE.

Figure 1: India's Installed Capacity Mix (in %)



As illustrated in the figure, solar energy is a vital part of India's renewable energy (RE) ambitions, commitments, and scale-up strategy. Solar power accounts for approximately 19% of the total installed capacity and ~57% of the total installed RE capacity (excluding Hydro). It has become central to driving non-fossil fuel initiatives, with the government aiming to harness the country's extensive solar potential in various applications, including rooftop solar, ground-mounted solar, and solar water pumps, to meet its international commitments.

1.1 Solar powered irrigation system Technology in India – Current scenario and key measures undertaken

Solar energy can be used both for thermal and electric applications such as drying, heating, cooling, cooking, lighting, pumping, etc. Standalone solar pump has been one of the major applications of solar technology that has potential to reduce carbon emissions locally. There were close to 10 million² diesel-based pump sets in India in 2022, amounting to one third of all water pumps that were being operated in the country. Due to this widespread use of diesel pumps, the dependency on oil imports is increasing resulting in a significant carbon footprint within the agriculture sector, thereby becoming a great barrier towards achieving sustainability and carbon neutrality. Furthermore, diesel imports are significantly impacting India’s forex reserves. As a measure to address these issues, both the central and state governments have acknowledged SWP as a possible medium for decarbonization and energy sustainability while reducing the fuel imports. The only technology difference between the solar and diesel pumping is the source of power and controller. In solar and diesel pumping, solar PV panels and diesel are used to generate the requisite power to pump the water. These systems harness solar energy to power water pumps, providing a sustainable alternative to traditional diesel and electric pumps. A typical SPIS consists of the following:

¹ IC.Mar-2024 (allocation-wise).xlsx

² [How can India Scale Up Solar Pumps & Make Farms Diesel Free by 2024?](#)

- **Solar Panels:** These panels produce DC electricity through the photovoltaic effect, with the array size dependent on pump size, water requirements, and available solar irradiance.
- **Module mounting structure:** Provides stability and protection for the solar panels, offering both fixed and tracking options.
- **System Controller:** Acts as a buffer between the pump and solar array, optimizing performance and providing low voltage protection.
- **Electric Motor:** Either DC (BLDC) or AC motors are used, with DC motors generally being more efficient.
- **Remote Monitoring Unit (RMU):** Allows efficient management and monitoring of the solar water pumps.
- **System Wiring:** Connects all components to ensure proper functioning.

PM-KUSUM Scheme

The Cabinet Committee on Economic Affairs approved the PM-KUSUM scheme in its meeting held on 19th February 2019³. The key objective of the scheme is to provide clean and sustainable energy while creating opportunities for additional income for farmers through the use of fallow land. The scheme envisages the use of renewable energy in uplifting the livelihood opportunity of farmers while ensuring them a green and reliable supply of power. The scheme comprises of three major components:

- **Component-A:** 10,000 MW of Decentralized Ground Mounted Grid Connected Solar Power Plants
- **Component-B:** Installation of 1.4 Million standalone Solar Powered Agriculture Pumps
- **Component-C:** Solarisation of 3.5 Million existing Grid-connected Agriculture Pumps along with agricultural feeder level solarization.

Under Component B of the PM-KUSUM scheme, individual farmers will receive financial assistance to install standalone SWPs or replace existing diesel Agriculture pumps / irrigation systems in off-grid areas, where grid supply is not available. The scheme has a target of 1.4 Million standalone SWPs installations throughout the country. As on 30th September 2024, 0.49 Million⁴ standalone solar pumps have been installed in the country under component B of the PM-KUSUM scheme⁵.

The scheme offers flexibility through two implementation modes: with and without state share. In the state-share model, the Central Government provides 30% financial assistance, while states contribute at least 30%, leaving farmers to cover the remainder. Without state participation, farmers bear a larger portion (the remaining 70%) of the cost but still benefit from substantial central assistance. The CFA will be increased to 50% for North-Eastern, Hilly, and Island regions for both the implementation modes. To ensure widespread accessibility, the CFA is typically capped at 7.5 HP pump capacity, with special provisions⁶ allowing up to 15 HP in specific regions for 10% of installations. The remaining amount (up to 30%) will be financed by banks or other financial institutions.

Prior to PM-KUSUM scheme, Off-grid Solar PV Programme was operating to promote off-grid SWP adoption, wherein, as per MNRE Annual Report for FY2021, 272,000 off-grid solar powered irrigation systems have been installed across India⁷ till 31st March 2020. Despite long and continuous policy support, the penetration of solar pumps in India has been low till date. The total standalone SWP installations till date has been shown in Figure 2. The state-wise cumulative installations of SWP under the Component B of PM-Kusum Scheme is illustrated in [Annexure-1](#):

³ <https://mnre.gov.in/img/documents/uploads/8065c8f7b9614c5ab2e8a7e30dfc29d5.pdf>

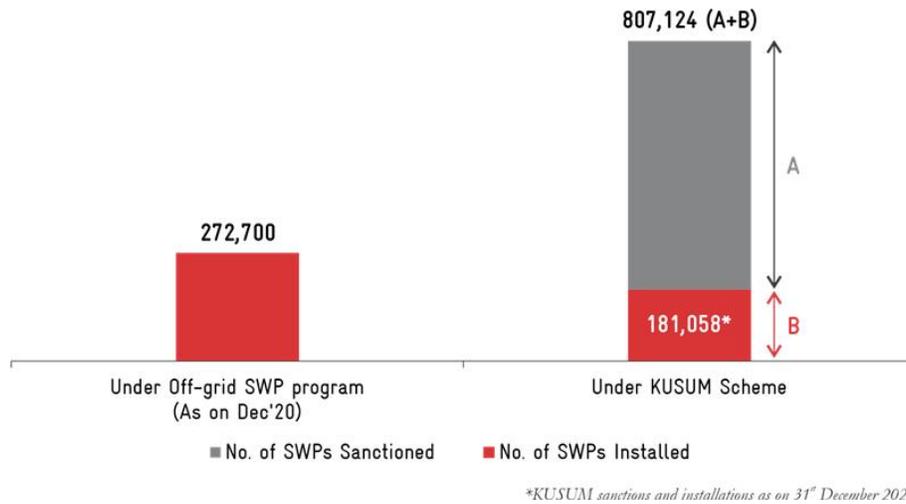
⁴ <https://pmkusum.mnre.gov.in/#/landing>

⁵ RTS Workshop held on 24th September 2021, MNRE

⁶ For the individual farmers in the NER; Hilly region (Jammu & Kashmir, Ladakh, Uttarakhand and Himachal Pradesh) and Islands (Andaman & Nicobar, Lakshadweep), the CFA will be available for pump capacity up to 15 HP, however the CFA for pumps up to 15 HP will be restricted to 10% of total installations

⁷ MNRE Annual report 2022-23

Figure 2: Progress in Off-grid SWP in India



1.2 Current utilization of SWP in India and need of USPC

Once a novelty, the SWPs are now emerging as an effective alternative to traditional options such as diesel pumps. Many new business models of SWPs have emerged, facilitated in part by the varying on-ground conditions and irrigation needs of the farmers. The central government as well as various state governments have been pushing the large-scale deployment of Solar Water Pumps for solarizing the agriculture sector, reducing agriculture subsidies and for enhancing the income of farmers in a sustainable manner.

The efforts till now have been focused on pushing the demand through policy support and financial incentives whereas creating demand from the farmers' end has been given only limited importance. The PM-KUSUM scheme has seen varying levels of success, with installations scaling up but SWP utilization remaining fairly low primarily due to absence of a viable ecosystem, technological issues and the lack of supporting infrastructure. It has been observed that optimum utilization of SWPs leads to greater income generation for farmers thereby increasing the financial and commercial viability of the system. The utilization of the SWPs can be optimized in two ways: firstly, aligning the cropping pattern and thus the irrigation requirement as per SWP operation and secondly, by utilizing the excess energy for other income generating end-use applications. It is challenging to convince farmers to change/ align their cropping pattern since cropping patterns are associated with traditional farming practices passed on from one generation to another. Additionally, many a times, a change in cropping is not feasible considering climate, temperature, type of soil and crop water requirements. A more sustainable method of increasing SWP utilization is thus to explore other applications which can be powered by electricity generated by SWP systems during non-pumping hours.

In the above context, the MNRE has introduced technical specifications for Universal Solar Water Pump Controllers (USPC), a controller with multiple outputs giving farmers the opportunity to utilize the excess energy generation during the non-irrigation hours for operating other applications such as Atta Chakki, Chaff Cutter etc. However, there are some challenges in adoption and hence, despite encouragement from MNRE to use USPC (including in PM-KUSUM scheme), till date there are very few installations on ground. A detailed analysis on different aspects of USPC that would aid in understanding the bottlenecks and identify probable solutions and directions for large scale uptake of USPC is missing?

With this objective, this study has been conducted to assess the existing USPC ecosystem, identify gaps and challenges and draw out possible strategies and mechanisms for increasing USPC acceptability and its deployment.

2. Project Framework

The project intends to study the existing USPC ecosystem and technological landscape. Further, on basis of the same, draw feedback and responses from various stakeholders such as USPC/SWP/agri/food-processing equipment manufacturers, State Implementation Agencies (SIAs) of the PM-KUSUM scheme, researchers, testing laboratories and the farmers to identify key issues deterring the USPC penetration while also identifying potential solutions for the penetration of USPC.

As part of the efforts to assimilate accurate and meaningful responses from key stakeholders, a comprehensive action plan was developed. As part of the project framework, the following activities were undertaken:

- Literature Review and Desktop Research
- Market Scanning and supply side analysis
- Selection of States and Districts
- Estimation of excess energy generation
- Mapping of key stakeholders
- Questionnaire for primary consultations
- Stakeholder consultations
- Analysis and insights from secondary research and primary consultations - Key issues, solutions and business models for USPC penetration
- Dissemination workshops, case studies and infographics on USPC have been carried out

2.1 Literature Review and Desktop Research

The first step involved undertaking a comprehensive literature review for the study of existing use-cases and end-use applications of USPCs. Under the literature review, we had encompassed a study of existing research reports, journals, publications etc. and documented key learnings and findings relating to USPC and its adoption. Some of the key sources referred to for literature review included the MNRE Technical Specifications, International Water Management Institute (IWMI-TATA policy paper “Har Khet Ko Pani - Rethinking Pradhan Mantri Krishi Sinchai Yojana (PMKSY)” etc.

Additionally, we had also undertaken secondary research to map the average usage of solar pumps across various states and for different configurations, the average solar irradiation across different districts. This served as a key input for determining the average excess energy generated for various solar pumping systems during the assignment.

2.2 Market Scanning and supply side analysis

Building upon the insights and information from literature review & desktop research, a detailed analysis was undertaken to analyze the USPC ecosystem for a product point of view. In this respect, the suppliers, key manufacturers and integrators of USPCs were identified.

Additionally, a detailed catalogue is created outlining the key information of various USPC models available with the respective manufacturers/suppliers such as costs, technical specifications, no. of outputs, supported end-use applications etc. The insights and data collected for the catalogue are used for the validation of the responses received from farmers on ground.

2.3 Selection of States and Districts

Estimating excess generation is critical for getting the range of average SWP utilization across various states and districts across the country.

Since the surplus energy needs to be estimated across various states and districts, ensuring uniform representation, a framework/methodology for selection of states and districts based on various parameters/criteria has been created. The methodology for the selection of states and districts has been carried out in two modules.

- Selection of districts from the cluster combination as defined in the IWMI-Tata Policy Paper based on high level of farm mechanization.
- States with a higher number of SWP Installations and demand as submitted for Component B of PM KUSUM scheme.

The purpose of shortlisting selected districts and states is to ensure that the selected districts represent the varied geographical, geological, and climatic conditions across India. Accordingly, 50 districts in 15 states across the country were selected for the estimation of the excess energy unutilized by SWPs across the country.

The detailed framework for the selection of states and districts for the estimation of excess energy unutilized by SWP's across India has been given in [Annexure-2](#).

2.4 Estimation of excess energy generation

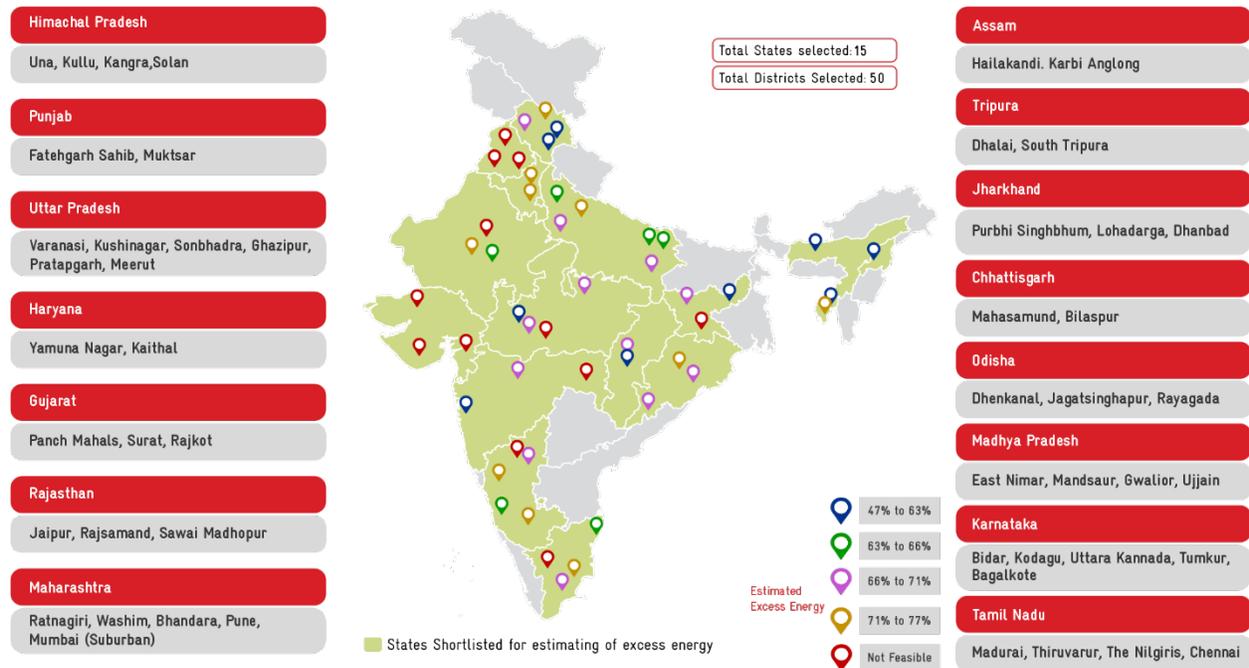
The Solar Irrigation Pump Sizing (SIPS) Tool is a excel based tool developed by the Indian Council of Agricultural Research (ICAR), GIZ, the Climate Change, Agriculture and Food Security (CCAFS) and IWMI to help estimate the optimal solar pump capacity at a given location in India. The tool intends to increase the understanding of factors that drive farmers' irrigation demand, pumping behavior, and ultimately recommends 'pump size' and monthly irrigation requirement based on the various factors, such as:

- Location: Longitude, elevation, latitude
- Climate data: Maximum temperature, Minimum temperature, Rainfall
- Crop data: Type of crop, cropped area, planting date, planting month
- Irrigation System: Type of water source, Depth of water table, Depth of the water level, Type of irrigation system, Number of days for irrigation in a month
- Irrigation System: Operating heads for different irrigation methods

Based on the output of the tool, the excess energy un-utilized by SWP across the selected states and districts can be estimated using an 'Excess Energy Computation Tool'. The excess energy is calculated by subtracting the energy consumed by solar water pump for irrigation purposes from the energy generation by solar panels during a year.

Basis upon the methodology that has been highlighted in Annexure-3 the corresponding excess energy (in %) generated across each district has also been shown in Annexure-4.

Figure 3: States and districts shortlisted for estimating of excess energy (Each location icon represents a different district and colors represent the corresponding range of excess energy)

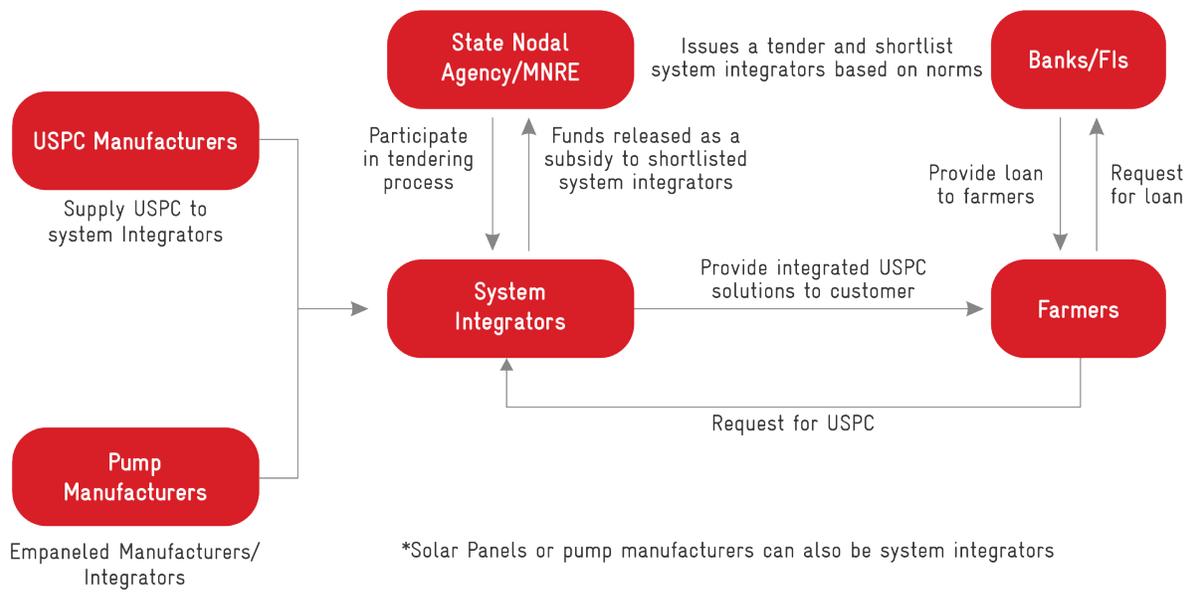


The detailed methodology finalized based on inputs from MNRE and GIZ has been provided in greater detail in [Annexure-3](#):

2.5 Mapping of key stakeholders

The Figure 4 gives an overview of the major stakeholders involved in the off-grid standalone solar water pumping system with USPC.

Figure 4: Overview of key participants in the USPC ecosystem



The key stakeholders in a SWP with USPC ecosystem include:

- **Farmers:** The end-users of solar pumps who use the technology to irrigate their crops and also operate their agri equipment using USPC.
- **State nodal agency/MNRE:** Responsible for creating policies and regulations that support the use of solar pumps, as well as providing funding and incentives for their adoption.
- **Solar Pump/USPC manufacturers:** Companies that design & manufacture SWP/USPC and supply to system integrators.
- **System Integrators:** Companies that provide and install integrated SWP with USPC solutions to the end users. SWP manufacturers can also act as system integrators.
- **Banks/Financial Institution (FIs):** Provide loans for the purchase and installation of solar pumps to farmers and other end-users.

2.6 Questionnaire for primary and secondary consultations

The questionnaires for SWP/USPC/Agri equipment manufacturers and farmers have been framed to capture responses and understand the key issues faced by stakeholders affecting the USPC penetration across the country. The questionnaires were designed to understand the USPC technology, its cost and benefits, and identify bottlenecks, if any, affecting the USPC adoption by farmers. The questionnaires for the equipment manufacturers were carefully framed according to various factors such as potential applications that can be operated with USPC, awareness and understanding of USPC technology, measures to be undertaken to increase the penetration etc. Similarly, the questionnaires for the farmers were framed to capture the farmers' motivation for the use of USPC, their experience while applying for USPC and while using USPC, information on subsidy availed by farmers for the purchase of SWP with USPC, key issues (if any) faced while using USPC, usage pattern of USPC, etc. All the questionnaires for the respective stakeholders were finalized based on inputs and suggestions from MNRE and GIZ. Detailed questionnaires have been given in [Annexure-4](#).

2.7 Stakeholder consultations, analysis and dissemination of findings

The team conducted stakeholder consultations to assess the USPC technological landscape, adoption challenges, and potential solutions. The process involved three phases:

Preparatory Phase

The research team initiated the process by identifying and contacting relevant stakeholders. Customized questionnaires were developed and where possible, disseminated to participants prior to consultations. Subsequently, meetings were arranged in various formats, including in-person, virtual, and telephonic, based on stakeholder availability and preferences.

Interaction with Stakeholders

Structured discussions were conducted with a diverse range of industry participants, including USPC manufacturers, agricultural equipment producers, and farmers. These interactions were guided by pre-planned agendas to ensure thorough coverage of relevant topics.

Documentation and Reporting

The interactions with the respondents were documented accurately. All these consultations were documented and shared with all interviewees and other relevant stakeholders to solicit feedback and any further inputs. The documented information from the meeting were shared with GIZ and MNRE. This was followed by a detailed analysis of key discussion points which were presented to GIZ on a fortnightly basis.

The key findings of the secondary research and primary consultations are highlighted in subsequent sections of this report.

3. Stakeholder Consultations

3.1 Consultations with SWP/ USPC/ Agri equipment manufacturers/ Researchers/ Technical institutions

The project team conducted consultations with various SWP/USPC/Agri equipment manufacturers, researchers, technical institutes such as NISE, and SIAs such as Tamil Nadu AED in the country. The discussions were focused on understanding the challenges vis-à-vis technical requirements of the equipment and excess energy produced from SWPs (e.g., electrical compatibility, O&M requirements, etc.) in promoting USPCs. The list of stakeholders with whom the consultations have been conducted are highlighted in [Annexure-6](#).

a) Objectives of Consultations

The project team sought to achieve following objectives from the consultations with the above stakeholders:

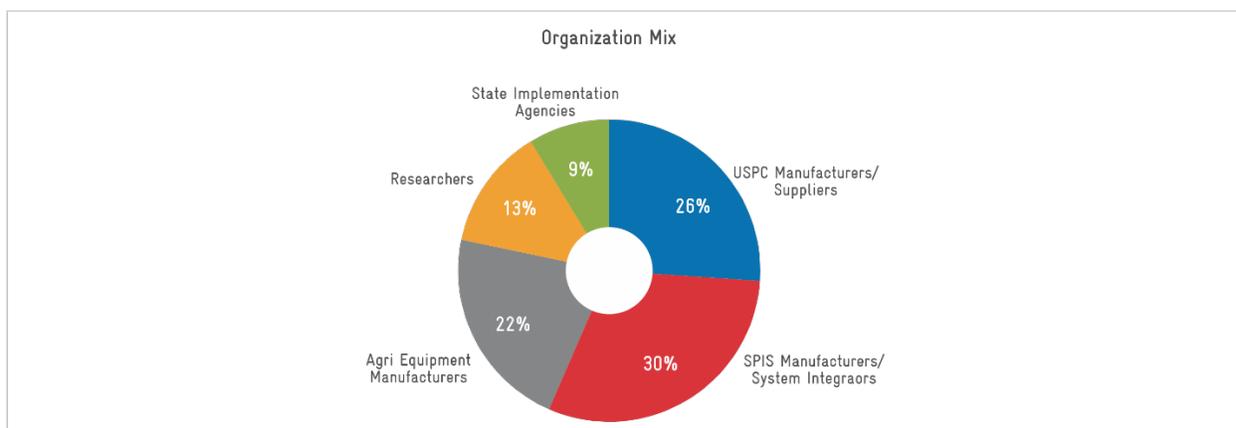
- i. Understand the USPC technology, its costs and benefits
- ii. Understand the technical requirements of the agri equipment to be compatible with USPC
- iii. Evaluation of awareness level among manufacturers regarding various central and state sponsored SWP schemes including PM-KUSUM scheme
- iv. Gain insights about the existing cost contribution for SWPs (including availability of subsidy/CFA for USPC under the PM-KUSUM scheme)
- v. Identification of existing bottlenecks and issues affecting adoption of USPC by the farmers (as part of PM-KUSUM scheme or otherwise)
- vi. Identification of list of potential applications that can be powered using USPC
- vii. Feedback/suggestions on potential measures to be undertaken by various stakeholders (MNRE, State Implementation Agencies, etc.) for accelerating the penetration of USPC

With the above stated objectives, the project team conducted in-person and virtual consultations with stakeholders as highlighted below to seek their inputs & feedback on key issues and mitigation measures to be undertaken for accelerating the adoption of USPC.

b) Coverage

As part of our consultations with manufacturers/system integrators of SWPs, USPCs, and agri machinery equipment, interaction has been conducted with around 20 stakeholders including Mechair, Shakti Pumps, Kisan Solar, Able Manufacturers, etc. The organization mix of the consulted stakeholders is shown in Figure 5.

Figure 5: Organization Mix of Consulted Stakeholders



c) Key inputs from discussion

Meaningful insights were received from all the participants during the consultations to understand the challenges vis-à-vis technical requirements of the equipment and identify the potential applications that can be operated using USPC.

Following are the key inputs of our consultations with representatives of various stakeholders:

Key Insights

- (i) Rotomag, Jain Irrigation, Mahindra and Shakti Pumps emphasized that the current USPC technical specification is quite stringent and suggested the simplification of specifications to make it more 'practical'.
- (ii) The majority of USPC suppliers suggested the compatibility of single-phase applications to power the normal household equipment with USPC should be added to increase the demand among farmers.
- (iii) The high cost of USPC compared to normal SWP controllers is one of the plausible reasons due to which USPC is not so successful/popular in the solar pumping ecosystem and amongst the farmers.
- (iv) It was suggested that the current USPC testing procedure defined by MNRE is complex, requiring actual farm equipment to be operated with USPC. Hence, simplification of testing norms is suggested.
- (v) Both Kisan solar and Rotomag suggested the need to set up communication campaigns and demonstration sites for farmers to increase the awareness and build trust related to USPC to increase the uptake of USPC.
Most of the USPC manufacturers have stated that the emphasis of the regulations and policies should be more on increasing awareness amongst farmers. This may result in upscaling the market and making space for more variants in the near future.
- (vi) USPC mfgs. viz. Shakti Pumps and Kisan Solar highlighted that commercial assistance in the form of subsidies/CFA on the price of USPC will assist in providing relief to farmers and result in increasing adoption of USPC.
- (vii) On the financing mechanism, Rotomag suggested the need for concessional financing from Banks/FIs to farmers for covering the USPC upfront cost and encouraging farmers participation.
- (viii) Tamil Nadu AED suggested that there is a need for pilot units to be installed across the country that will stimulate the adoption of USPC.
- (ix) HP Agri department stated that they had taken multiple steps to increase public awareness regarding the PM KUSUM scheme and SWPs among farmers such as advertisement through Radio, Television, pamphlet, and public hoardings/Posters/Banners (situated in areas of high footfall). It was suggested that there is the need to increase awareness regarding USPC and its potential benefits among the end users.
- (x) NISE stated that in the future they will also be focusing on the development of USPC providing support for operating multiple equipment at the same time

3.2 Farmer Consultations

Despite the efforts of government agencies to increase USPC penetration, SWP schemes with USPC such as PM-KUSUM (component B) and States schemes such as Himachal Pradesh's 'Kisan Sinchayi Yojna' have witnessed limited progress so far with only a few USPCs installed across the country. In view of this, the project team has conducted a consultation with USPC beneficiaries in Himachal Pradesh with the objective to understand the common uses of excess energy from SWPs, and challenges and benefits of the adoption of USPCs.

a) Objectives of Consultations

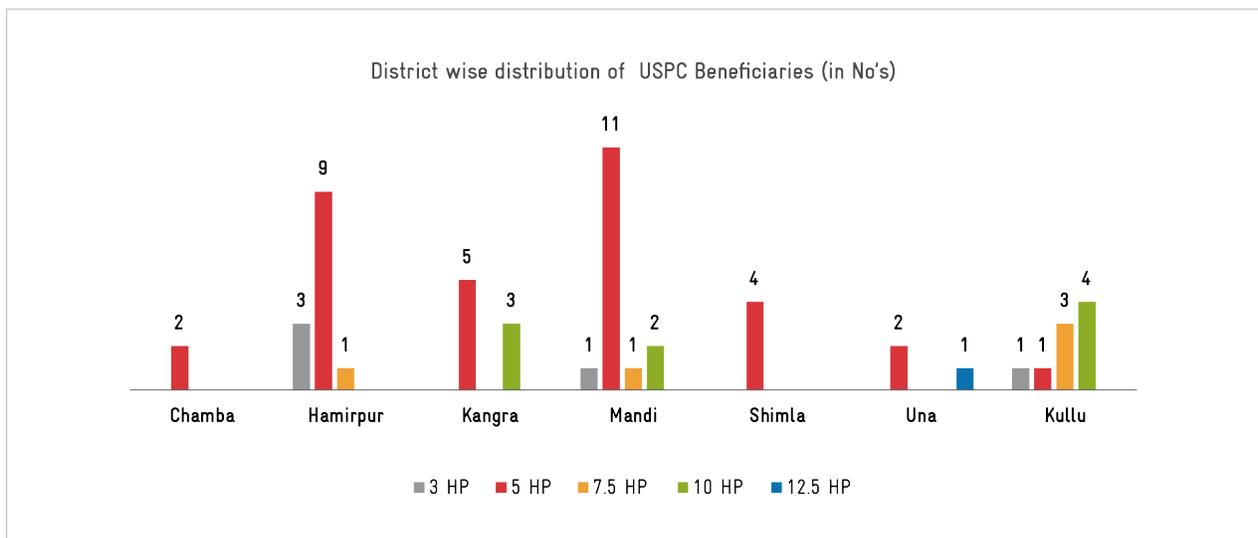
The objectives of farmer consultations are highlighted below:

1. Understand the common uses of excess energy from SWPs, Challenges and benefits of the adoption of USPCs.
2. Assess awareness level among farmers regarding USPC technology, SWP technology, PM-KUSUM scheme and various agri applications being used by them.
3. Understand famers experience while using USPC.
4. Identify potential applications for which farmers are utilizing USPC apart from lifting water.
5. Identify factors affecting the farmers' decision for not using USPC functionality.

b) Coverage

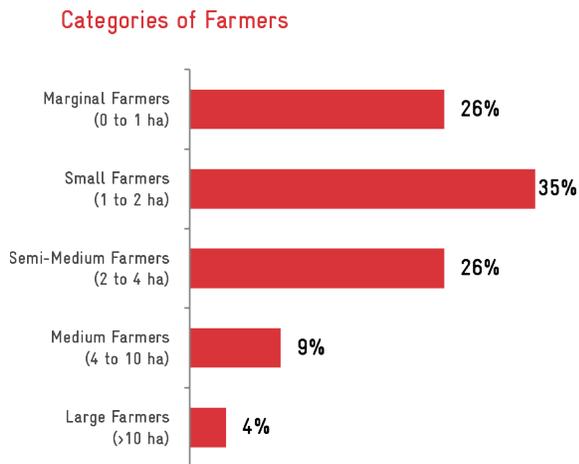
The project team conducted farmer consultations with 54 farmers across 7 districts in Himachal Pradesh. The district wise distribution of USPC beneficiaries has been illustrated in [Figure 6](#). The detailed approach for the selection of farmers for the primary survey is provided in [Annexure-7](#). The exhaustive list of the surveyed farmers is provided in [Annexure-6](#).

Figure 6: District Wise USPC Installation to be considered for the primary survey

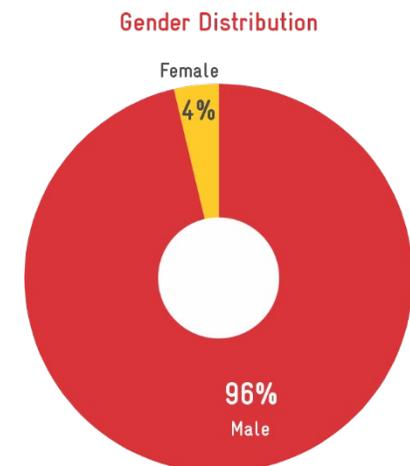


Some of the insights from the survey sample are illustrated below:

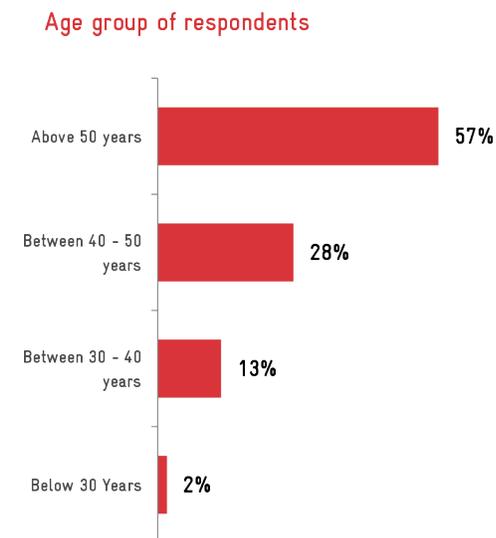
Figure 7: Farmer Coverage



As per interaction with farmers during the consultations, it was observed that 61% of small and marginal farmers owned SWPs with USPC. This can be substantiated by the fact that the distribution of land holdings according to the 2010-11 Himachal Pradesh Agricultural Census shows that 87.95 percent of the total holdings are owned by Small and Marginal farmers.



Less than 4% of SWP Owners from the consultations are female farmers. This can be substantiated by fact that land ownership is a prerequisite for applying for SPIS and the majority of women farmers do not have land in their name.

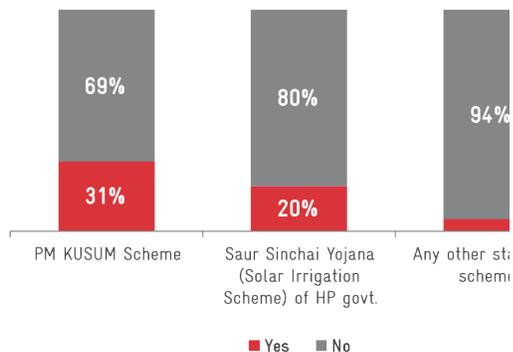


Only 2% of SWP Owners from the consultations are below 30 years of age whereas about 85% of SWP Owners are above the age of 40. Since SWP ownership is dependent on land ownership, which is highly correlated with legal age, the higher age groups seem to own more SWPs. Usually, senior members of family are the decision makers of the family and have land on their name, due to which higher age groups seem to own more SWPs.

c) Key inputs from the discussions/consultations?

The consultations were intended to ensure district wise diversity among farmers for a better coverage of challenges faced by farmers across the state.

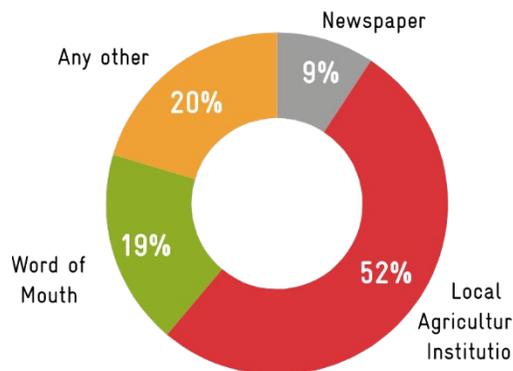
Scheme Awareness among Farmers



It was observed that awareness among farmers regarding state and central schemes is very limited.

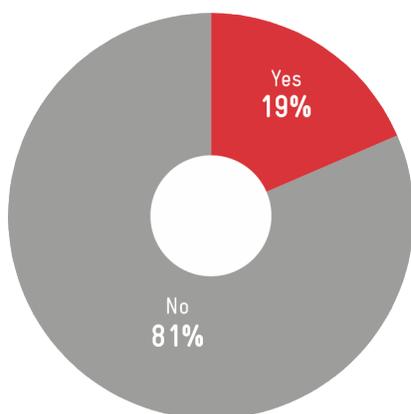
Further, it was revealed during the survey that the majority of farmers were unaware of key aspects of the PM-KUSUM scheme such as who is the State Implementation Agency (SIAs), their (SIA's) role, subsidy contributions of state and central governments, etc.

Source of SPIS information



Local agricultural institutions such as the State Implementation Agency (SIA) of HP viz. Himachal Pradesh Agriculture Department, etc. seem to have a good reach amongst the farmers in providing credible information related to USPC. While these sources are to be leveraged further, other sources such as social media, pilot demonstrations etc. should be tapped to motivate farmers to use USPC gainfully by creating awareness.

Farmers witnessed demonstrations of SWP/SWP with USPC



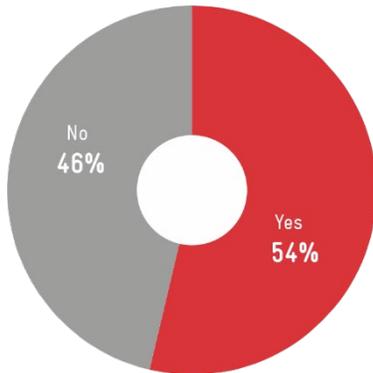
10 out of 54 farmers have stated that they had witnessed the visual operation of SWP/USPC prior to purchasing the system.

Some of the places where they had witnessed the demonstration units are:

- Nearby village,
- Panchayat office,
- Installations by other farmers

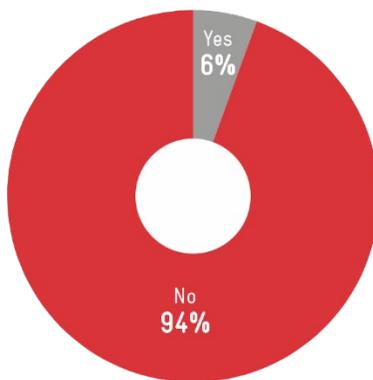
Demonstrations play a critical role in creating awareness and addressing the apprehensions farmers may be having regarding SWP/USPC. Hence there is the need to further enhance the demonstrations on ground across India.

Water shared with neighboring farmers



While ~50% of farmers are sharing water with neighbors, only one farmer stated that he is selling water to the neighboring farmers to generate extra income. This highlights that farmers are primarily using SWP for captive irrigation or sharing water with neighboring farmers on goodwill and not necessarily as a revenue source.

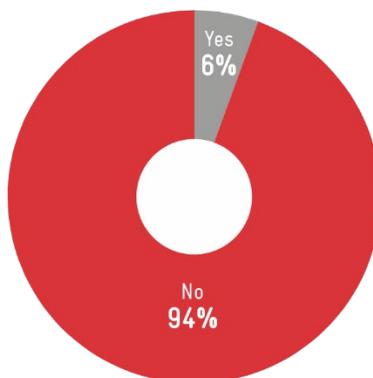
Grid Connected SWPs



3 farmers stated that their SWP are connected to the grid and can be operated with the grid power. Discom has not permitted the injection of energy back to the grid. Therefore, the farmers were only utilizing it to operate SWP during non-solar hours.

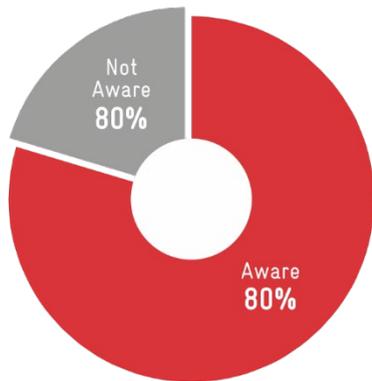
A few farmers stated that the discom has now discussed the sale of power to the grid.

Loan taken for purchasing SWP/USPC



Only 3 out of 54 farmers cited that they had availed a loan for the purchase of SWP/USPC. The rest of the farmers have not availed any financing from banks/financial institutions and have availed the SWP only through equity contribution.

Awareness regarding Subsidies provided for purchasing SWP/USPC

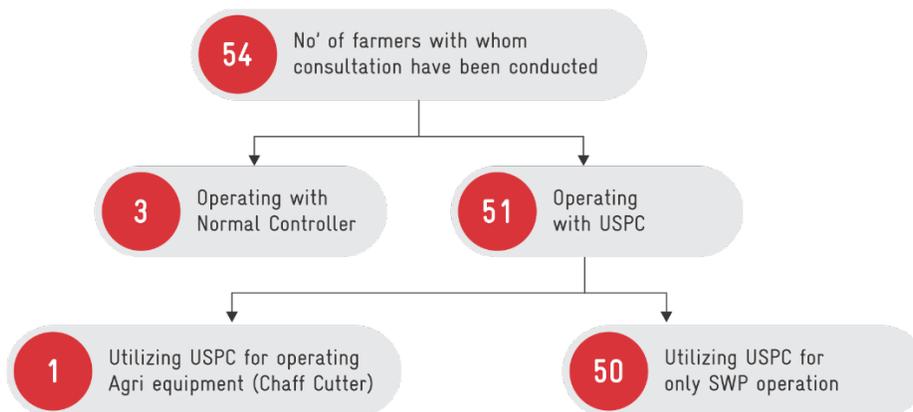


11 farmers stated that they are not aware of the details of whether any subsidy had been provided to them or not. Thus, indicating a major awareness gap.

However, the discussion with SIA revealed that all the SWPs were installed under the state scheme titled 'Himachal Pradesh Saur Sinchai Yojna'. Further, it was cited that farmers had paid the effective price after subsidy, followed by some of the farmers citing the lack of awareness regarding the subsidy contribution being availed by them.

Usage of SWP/USPC

Figure 8: Breakup of USPC Beneficiaries



Out of the 54 farmers with whom consultations have been conducted, it was identified that 3 of the farmers were using normal controllers and the rest (51 farmers) were using USPC. However, based on consultations with the 51 USPC beneficiaries, it was revealed that only 1 out of those was utilizing USPC for operating Agri equipment (Chaff Cutter) apart from operating SWP, while the rest (50) were utilizing USPC only for SWP operation (as illustrated in Figure 8). This indicates serious un-utilization of USPC. Some of the reasons attributed by farmers for the low utilizations are as follows:

- **Incorrect targeting of farmers:** 15 out of the 54 farmers stated that even though they were aware of the functionalities of USPC, they do not want to use the SWP for any other purpose as they do not need to do so. Some of the reasons cited for not using were as follows:
 - They don't have any additional usage of Agri equipment on their farm and only require SWP for irrigation.
 - They own grid powered equipment which can be operated any time contrary to USPC, which can only be operated during solar hours.
 - Some cited the lack of capital as issue for not opting for any Agri equipment.

This indicates that targeting may be improved to ensure that farmers having needs for operating additional Agri equipment with USPC can be identified.

- **Planning to buy three phase compatible equipment with USPC:** 9 out of 54 farmers had cited that they are interested in purchasing the additional Agri equipment for operating it with USPC. However, they

are currently using it for SWP operation only. Some of the reasons due to which farmers have not purchased any equipment till date are as follows:

- Lack of awareness regarding the alternate use of USPC.
- Limited accessibility of three phase equipment in local market.
- Lack of motivation due to availability of subsidized electricity (Free electricity up to 125 units for domestic consumers in Himachal Pradesh).

➤ **USPC is installed far from the farm:** 8 out of 54 farmers had stated that that the USPC is installed in areas far off from their houses where agri equipment is installed i.e. located more than 1 km away from their premise. Therefore, they were utilizing it only for lifting water as the farmers have very few or nil options to operate any Agri equipment with USPC.

➤ **Connection to local grid:** 8 out of 54 farmers cited interest to connect the SWP/USPC system with the grid. Some of the reasons stated by the farmers for the above is as follows:

- Utilize grid power for operating single phase equipment and even domestic load.
- Aid in gaining extra revenue by selling their excess solar power to the grid.
- Excess energy exported to grid can be adjusted from the net billing.

It was revealed during the survey that out of 54 farmers, 3 of the farmers had connected USPC with the grid power for operating the SWP during non-solar hours. However, none of the farmers were injecting excess energy back to the grid.

➤ **Currently owners of single phase equipment:** 5 out of 54 farmers were found to be using single phase equipment which was incompatible with USPC. The majority of these farmers had single phase chaff cutters and wheat grinding machines for meeting their daily agri needs.

All those farmers, as well as farmers whose houses were close to the field, suggested/desired that USPC should support single phase equipment so that they can operate single phase commercial as well as domestic loads. The major reason attributed by some of the farmers for this is that single phase equipment is easily available in the market contrary to the three-phase equipment.

➤ **Inadequate or incorrect communication by the installation/ service team:** Typically, it has been observed that local technicians and service providers are the primary medium for spreading awareness regarding the product/technology among the end users.

However, during the survey, 3 farmers cited that the installation team asked them not to use the USPC for operating any other device apart from lifting water viz. operating SWP. As a result, farmers cited to have not utilized USPC for operating any other agri equipment with USPC as they fear that warranty would be null & void if they use it for other purposes. Thus, indicating inadequate or incorrect communication by the installation/ service team.

➤ **Educating farmers about alternate USPC usage was not done by either service provider or SIA:** During the survey, it was observed that in general most farmers did not know about the alternate use/functionality of USPC. Even those who knew, had very limited knowledge. Also, all farmers have admitted having limited awareness regarding PM-KUSUM and state-sponsored SWP schemes.

This indicates the lack of effort by service providers and even by respective implementation agencies of the state for spreading awareness among farmers.

➤ **Other reasons:** In addition to the above reasons, some additional reasons cited by farmers for the low utilization of USPC are as follows:

- The original owner died during COVID, resulting in utilizing USPC by owner's brother for operating only SWP.
- One farmer cited that installed SWP is not powerful enough to lift water. Therefore, the farmer was skeptical about alternate use of USPC. This resulted in the farmer not using the USPC for any other need.

4. Key Issues and Potential Solutions

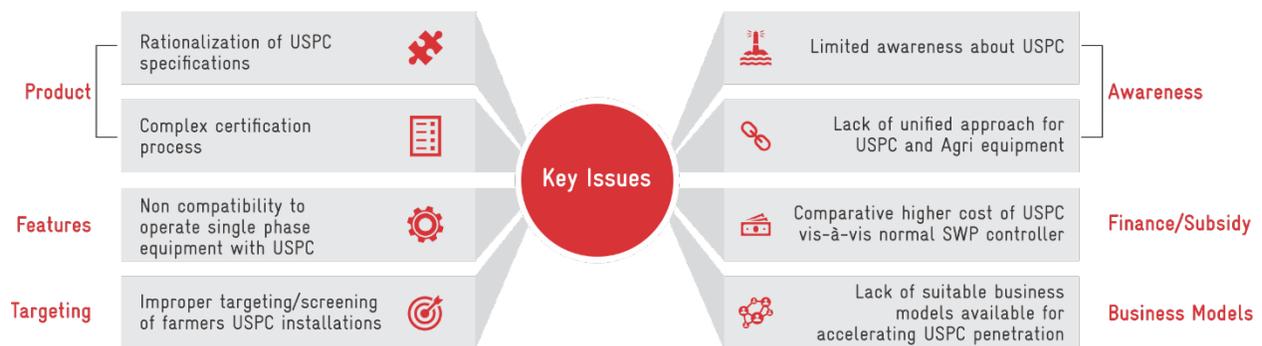
The consultations have presented critical observations and perspectives of various stakeholders viz. USPC/SWP/agri/food-processing equipment manufacturers, State Implementation Agencies (SIAs) of PM-KUSUM scheme, researchers, testing laboratories etc. Based on insights shared by stakeholders, key issues deterring the USPC penetration were identified. Further, one-on-one consultations with stakeholders have also led to the identification of some potential solutions that would aid in addressing the issues and make the USPC accessible and affordable to farmers.

Further to this, some probable business models were developed (Detailed out in [Section 5](#)) that could lead to accelerating the adoption of USPC.

4.1 Key issues identified based on the consultation with various stakeholders

The [Figure 9](#) illustrates category wise key issues identified by the project team.

Figure 9: Key Issues identified during project (?) consultation?



Product

Issue 1: Stringent USPC specifications

During consultations with the USPC manufacturers, stakeholders stated that the current technical specifications of USPC issued by MNRE are quite stringent and complex in nature resulting in the increasing cost of USPC. Some of the measures suggested by stakeholders cited for non-standardized specifications are:

- **Revising input voltage range:** The input voltage range as defined in the specifications may needs to be revised based on the suitable scientific methodology, since such a surge is not achievable. It was mentioned that the temperature coefficient of the module is around 0.3% per °C. Considering this as a thumb rule, the input voltage can also be defined based on the temperature coefficient rather than defining it arbitrarily.
- **Revising Total Harmonics Distortion (THD) levels:** The document currently specifies THD levels in the range of 3%-5%. However, many developers have noted that THD levels can go upas high as 20%-30% in practical scenarios.
- **Reduction in output ports:** The specification mandates USPC having switch based selection for the five output ports, one dedicated for solar water pump and the remaining for operating other agricultural applications such as Chaff Cutter, Atta Chakki, etc. However, many manufacturers outline that since no concurrent operation is permissible with USPC, it was suggested to review the multi output functionality and reduce the USPC output ports.
- **Eliminating use of Sine Wave Filter:** Many developers cited that most of the conventional agri equipment was not Variable Frequency Drive (VFD) compatible hence a bulky and costly sine filter consisting of expensive ‘Sand Dust’ coils is needed with the USPC to drive such equipment. The purpose of sine wave

filters is to convert the rectangular Pulse Width Modulation (PWM) output signal of the motor into smooth sine wave filter and eliminating the Total Harmonic Distortion (THD). It was suggested that since most of the modern equipment can withstand the Total Harmonic Distortion (THD) generated by the Variable Frequency Drive (VFD), the use of the sine wave filter can be eliminated where equipment is installed at a distance of within 10-20 meters from the USPC.

- **Restricting energy export to the grid:** At present, it was specified that USPC should have features to export power to the grid when pumping is not in operation. The objectives and the purpose of the USPC are to utilize the 'wasted' power of pumps installed in OFFGRID mode. Adding too many features will not only complicate the whole controller and increase its cost but also make it less reliable.

Issue 2: Complex Certification Process

During consultations with stakeholders, one of the major reasons cited by stakeholders is that Testing norms of USPC are not standardized by the certification labs across the country. This is acting as a hurdle in getting the certification for the USPC.

In addition, the current testing procedure requires it to perform the functional test analysis of USPC by using actual defined three phase farm equipment such as Atta Chakki, Chaff Cutter, Bulk Milk Chiller, etc. However, it makes it difficult for vendors to carry the actual farm equipment to the testing centers.

Considering the variety of farm equipment, including models and brands, it is impossible to achieve any degree of consistency in results either in the test center or in the field. In addition, it makes the test analysis time consuming (taking around 15 days to conduct the testing procedure). Further, it would also be logistically difficult for manufacturers to bring the required equipment to the testing centers.

In addition, the current technical specifications are detailed about intermediate conditions such as Maximum Power Point Tracker (MPPT) efficiency, number of ports, etc. but the 'real' output of the core performance test is unclear.

Hence, there is a need to simplify the certification process, where the number of equipment to be tested and the testing procedure are to be streamlined.

Features

Issue 3: Lack of technical specifications for operating single phase equipment with USPC

USPC is perceived as a tool to utilize the excess energy generated by the solar panels of SWP in off-grid applications such as Atta Chakki, Chaff Cutter, Shredder, etc. However, the current technical specifications permit only the use of three phase agri equipment with USPC and not the single phase equipment.

Primary consultation with USPC beneficiaries across HP revealed that 45% of the farmers were using single phase equipment for their daily needs and indicates an inclination/demand to operate both single phase and three phase equipment using USPC. Also, many farmers cited that single phase agri equipment are easily accessible in the local market in contrast to the three phase agri equipment, which were stated to be available only in far-off big cities.

Further, there might be high probability of damage/tampering of the equipment/USPC by farmers as farmers due to lack of technical knowledge might connect the single-phase equipment with USPC.

Hence, it was suggested that enabling the provision of operating single-phase equipment with USPC may be evaluated due to their wide availability.

Targeting

Issue 4: Lack of suitable criteria for selection of farmers for USPC installations

We observed during the survey that 28% of the farmers, despite knowing the functionalities of USPC, they do not intend to use the SWP for any other purpose. Some of the reason cited for not using were as follows:

- 11 of the farmers cited that they don't have any additional usage of Agri equipment in their farm and only require SWP only for the irrigation purpose.
- 3 of the farmers stated to be having grid connectivity, making it less attractive for farmers to shift to USPC as they can operate agri equipment 24 X 7, which is not possible while operating with USPC
- Some of the farmers even cited lack of capital as issue for not opting any three phase Agri equipment.

Also, 15% of farmers cited that USPC is installed in the area far off from their houses i.e. located at a distance of more than 1 km away from their premises. Following which they were utilizing it only for lifting water and has very few or nil options to operate any Agri equipment with USPC.

Thus, indicating that there is a need for criteria to be adopted for allocating the USPC to farmers to improve the targeting and enhance utilization.

Awareness

Issue 5: Limited awareness amongst stakeholders regarding benefits and applications of USPC

As of now, USPC has limited penetration in the country. During a virtual workshop, discussions with various stakeholders revealed two main barriers to its adoption. Firstly, about half of the participants believe that a lack of awareness about USPC benefits among farmers is a significant obstacle. Secondly, 48% of the participants pointed out that limited information on the agricultural equipment compatible with USPC further hinders its uptake in India.

Additionally, a survey was conducted with representatives from various State Implementation Agencies (SIAs) to seek their viewpoints on the factors impacting the USPC penetration. Around, 70% of SIAs identified limited awareness of USPC benefits among end users as key issue deterring its penetration. In addition, 80% of the SIAs highlighted a lack of information on potential applications that can be operated using USPC as another factor hindering adoption.

Our consultation with farmers in Himachal Pradesh, Rajasthan, and Haryana revealed that most of farmers had limited awareness regarding PM KUSUM and state sponsored scheme. In general, most farmers did not know about the intended purpose of USPC apart from lifting water. Even those who knew, had very limited knowledge regarding the functionality. Out of those using USPC for intended purpose, majority of farmers are utilizing USPC for operating only one equipment other than SWP such as Chaff Cutter, Atta Chakki, etc., and very few farmers are utilizing it for driving wide range of applications.

This reflects that farmers have fair understanding regarding the SWP usage, but they have limited awareness regarding USPC, its benefits, potential list of applications that can be operated using USPC, etc. Therefore, stakeholders across the value chain, from farmers to officials from SIAs have limited knowledge regarding the benefits and applications of USPC.

All 54 farmers have admitted in our survey have stated that they have little to no knowledge regarding PM-KUSUM and state-sponsored SWP/USPC schemes.

Hence, this indicates that there is a need for steps to be taken to increase awareness among farmers and SIAs regarding USPC benefits and potential list of equipment that can be operated with USPC.

Issue 6: Lack of unified approach for USPC and Agri equipment

One of the major reason for limited awareness among stakeholders is that any consumer who wishes to install the SWP with USPC system, may not have the detailed information available at one place viz., information related to

PM KUSUM scheme, Agri related schemes (both at state and central level), processes/procedures to be followed for new applications, availability of subsidy and finance, etc. Currently, multiple departments such as Renewable Energy Development Agency (REDA), agri departments etc. are involved in overseeing implementation of SWP/USPC, whereas the agri equipment is overseen by other ministries and departments in silos. This is resulting in beneficiaries to reach out to multiple departments for seeking information/applying for SWPs/agri equipment making the process complex.

Hence, to improve overall approach for benefiting farmer with USPC, it is important to devise collaborative strategies to target these various domains. The benefits of standalone SWP scheme have been minimal and convergence with state and central level farm mechanization schemes can help diversify the multiple areas of impact.

Finance/Subsidy

Issue 7: Comparative higher cost of USPC vis-à-vis normal SWP controller

In the survey conducted with various stakeholders during the virtual workshop, 11 out of the 21 participants cited that cost differential between the price of regular controller and USPC is one of the major reason affecting the USPC adoption.

A detailed discussion with some of the USPC manufacturers revealed that , While CFA and capital subsidies could help reduce that barrier, the gap between the cost of regular controller and USPC prevailing market price remains very wide. Presently, CFA is capped at 30% of benchmark price for normal controller or discovered cost for USPC, whichever is lower. It was emphasized by stakeholder for including the provision for subsidy/CFA on the price of USPC discovered in the tender (or the USPC benchmark price declared by MNRE, whichever is lower). This will aid in creating demand from farmers and results in lowering the cost of USPC making it affordable to farmers. It was highlighted that gradually with increase in demand of USPC, the production volumes will be increased, resulting to lowering the cost of USPC in line with the cost of SWP at present.

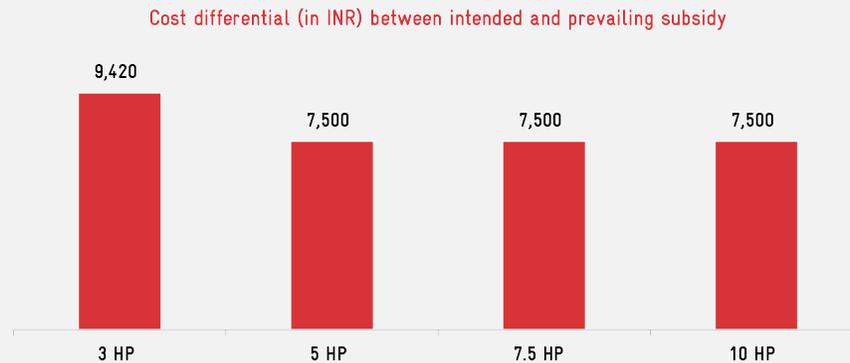
The tabular representation outlining the cost differential between the prevailing and intended subsidy scenario for a 5 HP Submersible water filled pump sets, is illustrated in the [Table 1](#):

Table 1: Cost differential between intended and prevailing subsidy scenario

Details	Discovered price	Benchmark price	Prevailing Subsidy (CFA and state subsidy)	Intended Subsidy	Cost Differential
5 HP SWP with Regular Controller	INR 2,27,500/- (A)	INR 2,36,500 (B)	INR 1,36,500 (E) 60% subsidy on minimum of A or B		
5 HP SWP with USPC	INR 2,49,000 (C)	INR 3,06,600 (D)	INR 1,41,400 (F) 60% subsidy on minimum of B or C	INR 1,49,400 (G) 60% subsidy on minimum of C or D	INR 7,500 (G-F)

The above cost differential for all the pump capacity range is shown in [Figure 10](#):

Figure 10: Cost differential (in INR) between intended and prevailing subsidy



Business Models

Issue 8: Lack of suitable business models available for accelerating USPC penetration

SWP with USPC has proven to be a technically viable option for the utilizing the excess energy generated during the SWP off-days for operating the compatible agri equipment. However, the high upfront capital cost of USPC (compared to normal controller) acts as a hurdle in the adoption of USPC as highlighted by various stakeholders during the primary consultations.

During the virtual workshop,⁹ of the 21 participants cited lack of availability of suitable business models in the market for accelerating the USPC penetration. It has been emphasized that, the robust delivery (or business) model is a key determinant for accessibility of USPC for farmers, whether they are smallholder or commercial and increasing its uptake.

At present, very limited business models being deployed on ground by farmers for use of agri-equipment such as Atta Chakki, Chaff Cutter, etc. with USPC. Also, among the surveyed farmers, none of the communities or group farmers were found to be utilizing USPC for operating any Agri equipment apart from lifting water.

Hence, there is a need to develop suitable business models for both Individual/group of farmers for better utilization of USPC, better payback period and maximization of revenue. A suitable delivery model should closely resemble local conditions, often requiring multiple approaches to cater to needs of the farmers.

4.2 Key Solutions based on the consultation with various stakeholders

In view of the issues highlighted by stakeholders during consultations, following solutions have been proposed:

Figure 11: Proposed Solutions



Solution 1: Simplification of specifications and testing procedures:

During the consultation with various stakeholders such as USPC Manufacturers (Rotomag and Kisan Solar) and research labs (National Institute of Solar Energy (NISE)), it was highlighted that the current testing procedure specified by MNRE is quite labor-intensive. It requires real-time testing of multiple types of farm equipment, such as Atta Chakki, Chaff Cutter, and Cold Storage.

The current testing procedure specified by MNRE in the technical specification⁸ requires testing of USPC in two principal modes:

- a) As an off-grid solar pump controller: the testing should be as per MNRE specifications and Test procedure.
- b) As a controller to operate motorized farm equipment: The testing should be performed on standard actual motors suitable for 4 loading modes. The input to the USPC must be from a solar PV simulator using the hot and cold profiles issued by MNRE. Tests are performed on USPC driving agrarian loads like Atta Chakki, Chaff Cutter and Deep Freezer under test. The USPC must be able to operate these motors of the attached agrarian load, so that they deliver the rated torque and are able to also operate till 150% of the rated torque for 30 seconds.

Further, expected output of individual applications must be specified as per their power rating and SPV capacity, such as:

- a) kg/hour grinding of atta chakki, and granularity.
- b) Volumetric Icing of cold storage in x hours.
- c) Output in terms of kg/hours for a specific capacity grass-cutter.
- d) Output must be quantified in terms of rate of volume or weight as above for any other applications.

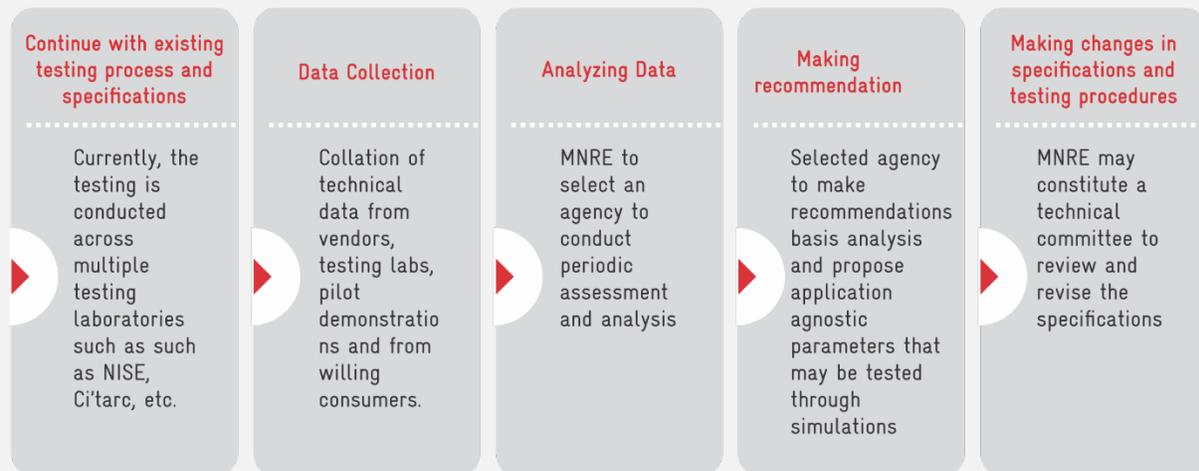
This means that each test Centre must have such equipment viz, Atta Chakki, Cold storage, Grass cutter, etc. and all the test centers must have the same brand/rating of Atta Chakki. And then must conduct the tests of each of these equipment using an UPSC controller. Also, clear norms will then have to be established about the ‘quality’ and ‘specifications’ of the grains (for atta chakki), quality of water and storage capacity (for cold storage), type of grass and its moisture content (for grass cutter). It is therefore evident that such an approach to testing the UPSC is difficult to implement.

Furthermore, USPC is currently in nascent stage across the country. Hence, an adaptive approach is suggested involving gradual simplification/easing up of testing process, resulting in making the testing procedure more simplified, and streamlined. Hence, appropriate feedback may be sought from the various vendors, testing labs and willing consumers, so that variety of new issues can be identified, recorded and analyzed to minimize their impact.

⁸ Ministry of New and Renewable Energy, Government of India. (Feb 2023). Updated Specification and Testing procedure for the Solar Photovoltaic Water Pumping System and USPC. [Online]. Available: <https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/02/2023020342.pdf>

The brief of the adaptive approach of simplification of testing procedures/specification is illustrated in [Figure 12](#):

Figure 12: Approach for simplification of specifications



Proposed Next Steps:

- Proactive approach from industry is required so that a unique platform/entity for reviewing the specifications & testing procedures can be created.
- The entity may collect data from willing consumers and submitting the draft recommendations to MNRE basis the analysis.

Solution 2: Awareness Campaigns

1. Various modes of disseminating information

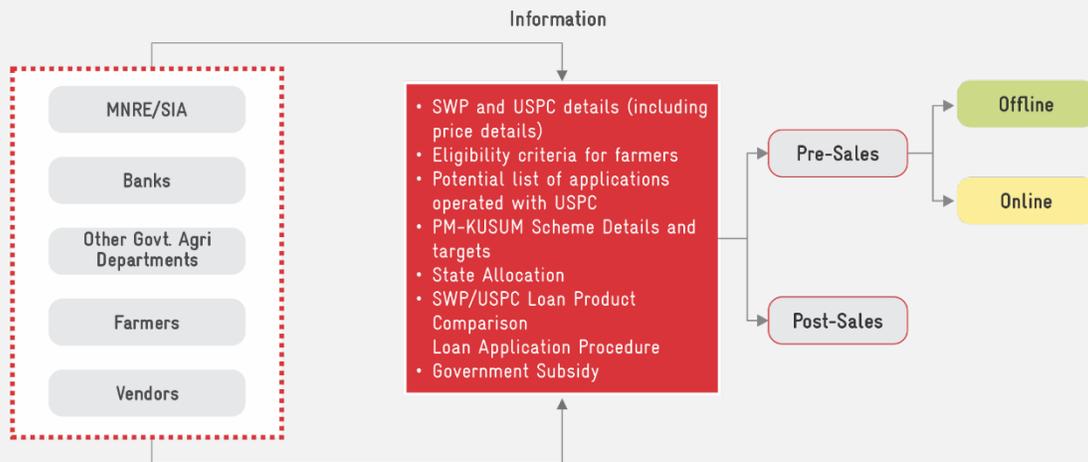
During the market scanning, it was observed that various stakeholders were involved in the USPC and solar pumps ecosystem, including MNRE/ SIAs, Banks, other Government agriculture departments, Farmers, and Vendors.

Based on the consultation with above mentioned stakeholders, the lack of awareness about USPC and benefits among farmers was cited as the major bottleneck in accelerating the adoption of USPC.

New technologies require awareness generation and capacity building for various stakeholders to understand, assess, deploy, and support them. Respondents emphasized that the SWPs and USPCs are no different. It is important for farmers in particular to understand the benefits of USPC as well as the supporting applications that enable the deployment of USPC and the subsidy schemes available to make the technology more accessible. A comprehensive approach to disseminating information to all stakeholders is required. This should include awareness campaigns, pilot demonstrations, knowledge materials, capacity building, and engagement with farmers to educate, address their concerns and offer guidance on the subsidy application process. This would aid in enhancing USPC demand among farmers and would ensure disseminating benefits & applications of USPC among end users and the accelerating adoption of USPC at scale.

The brief of the approach of imparting information related to SWP/USPC and subsidy related details among various stakeholders is illustrated below:

Figure 13: Approach of imparting information to various stakeholders



Pre-Sales Potential Solution:

Online Medium

- Creating bottom-up demand by focusing on pilot demonstration and raising awareness levels among farmers
- Increase public awareness regarding the PM KUSUSM scheme and SWPs/USPCs among farmers through advertisements on Radio, and Television
- Conduct Pilot demonstration using Virtual Reality (VR) based solutions (discussed in detail below)

Offline Medium

- Distribute Brochures, pamphlets, and Hoardings in high footfall areas such as Markets, touristic places, etc.
- Capacity building to ensure long term operability, and targeting of various stakeholders across the value chain, including those involved in policy and program formulations, and financing
- Nurture interest and solicit application through field staff and Kisan Mela
- Pilot Demonstrations (Discussed in subsequent sections)

Post-Sales Potential Solution:

After the installation of USPC at the farmers sites, SIA officials/local representatives must conduct periodic field visits:

- Disseminate information on potential applications such as Chaff Cutter, Atta Chakki, etc., which can be operated with USPC
- Ensure that farmers are aware of the benefits of USPC
- Check whether the farmer is utilizing the excess solar energy in an optimal manner using Remote Monitoring System (RMS) (Discussed in subsequent section)

2. Pilot Demonstrations

Based on our consultation with various stakeholders including SIA's officials, Vendors and Farmers, it was outlined that one of prominent reasons for slow uptake of USPC is the reluctance among the end users regarding new technology. It was emphasized that pilot demonstrations are an efficient way to illustrate the benefits that solar power generated from panels can be used for other things like operating three phase agri equipment such as Chaff Cutter, Atta Chakki, etc. using USPC. Respective stakeholders, particularly the farmers awareness of USPC needs

to be enhanced to help building trust and confidence in the technology. Such efforts can increase the awareness of the technology, the financial support on offers, and economic benefits that can accrue over time.

Pilot Demonstration (Through offline medium)

- **Organize Demonstration Camps and Exposure Site Visits:** The SIA should organize demonstration camps and arrange exposure site visits in target districts to showcase USPC and highlight key benefits and applications such as Chaff Cutter, Shredder, and Compressed Cow Dung Wood making machine.
- **Data Collection:** Data from these pilot demonstrations can be collected by the agency identified by MNRE for periodic assessment and analysis over time.
- **Allocation to New Technologies:** A portion of the above pilot units can be allocated to new technologies that have similar outputs but do not necessarily meet the MNRE's technical specifications.

Pilot Demonstrations (Through both online and Offline Mediums)

- **Showcase Recordings:** Recordings of pilot demonstrations can be showcased through TV programmes (offline) and video clips, which can be circulated via social platforms such as WhatsApp, Facebook, and YouTube (online).
- **Virtual Reality (VR) Solutions:** Virtual Reality (VR) based solutions can be used to demonstrate the pilot (discussed in the subsequent section).

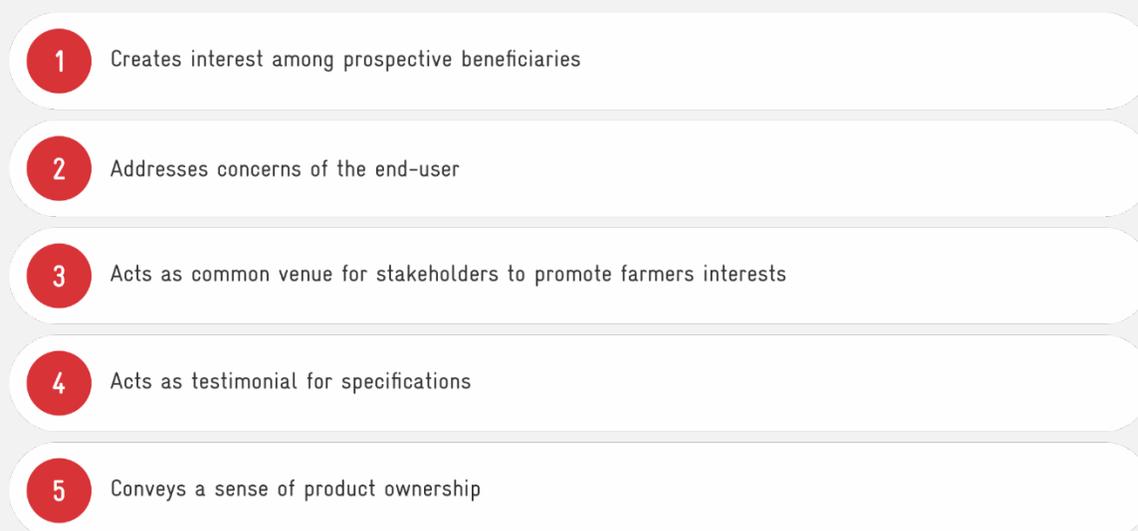
These measures could help generate interest & build confidence among farmers and in turn generate demand leading to an increase in the uptake of USPC. This is also likely to increase the farmer's willingness to spend on the system and reduce subsidy dependence in the longer term.

Key Benefits of Pilot Demonstrations

Pilot demonstrations are expected to stimulate considerable interest among prospective buyers (farmers), conveying a sense of product ownership while substantiating product claims and addressing key concerns of the targeted consumer base.

Due to these inherent benefits of live demonstrations of products such as SWP, MNRE/SIAs may set up similar demo units with the help of Joint Liability Groups (JLGs), Farmer Producer Organisations (FPOs), WUAs and SHGs to promote SWP/USPC. Demonstration units may also be set up at various locations (kisan melas, near banks, panchayat offices, farm fields etc.) by various stakeholders such as financial institutions (Banks, PACS etc.), FPOs, SIAs, Developers etc.

Figure 14: Key benefits of pilot demonstrations



3. Virtual Reality (VR) Solutions

As discussed in the above section, pilot demonstrations play a significant role in increasing awareness among farmers regarding solar water pumping systems, USPC and associated agricultural equipment. However, it may be challenging to conduct pilot demonstrations across the country as it requires high capital costs and the reach may also be geographically restricted. The new immersive VR technology applied to various sectors such as Gaming, Health, etc., can offer significant support to the agricultural sector particularly increasing the awareness regarding solar water pumping and USPC amongst various stakeholders.

Virtual reality creates an artificial environment which can be explored in 360 degrees, providing an immersive and interactive experience. Using the VR headset, the immersive experience can be given to farmers in Kisan Melas, at the Panchayat office or even at their homes. Farmers can even interact with the pilot demonstrations using the supportive motion controllers.

Mode of Implementation:

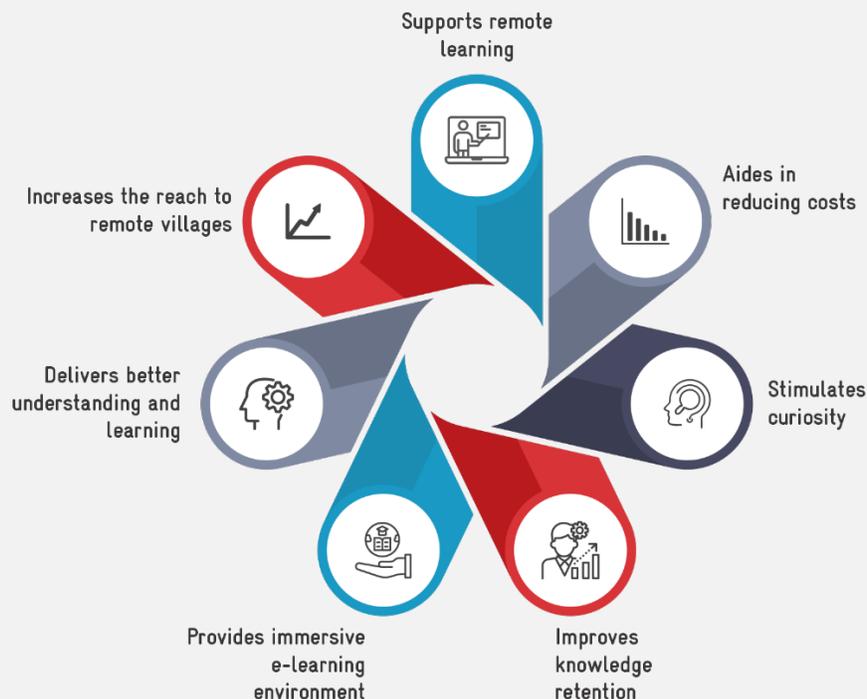
This immersive experience can be imparted to the end users, particularly farmers, using three levels:

- **Level 1:** Immersive 360° VR navigation can be recorded through the help of VR Headsets and can later be showcased as a video to other farmers to share the immersive 3D experience. This experience is comparatively much better than the normal video.
- **Level 2:** The farmer himself can wear the VR Headset to experience, interact and navigate through the virtual immersive Three Dimension (3-D) simulation
- **Level 3:** Persons (SIA representative/farmer) can wear and operate the VR Headset to experience 3-D immersive environment, while the same thing can be experienced by a group of other farmers in real time in 2-D.

Benefits for Stakeholders

Some of the major benefits of adopting VR based solutions for increasing awareness regarding SWP & USPC systems and showcasing demonstrations is shown in *Figure 15*:

Figure 15: Benefits of VR based Solutions for showcasing pilot demonstrations



4. Post installation monitoring using Remote Monitoring Sensors (RMS) data to improve utilization

Based on the on-ground survey conducted with USPC beneficiaries across 7 districts in Himachal Pradesh, it was observed that 98% of farmers were utilizing USPC for other applications/agri needs apart from lifting water using solar water pumps. Also, it was observed that no post installation training/inspection was conducted by SIA's/USPC manufacturers to check for utilization. Hence, RMS data can be utilized to monitor the utilization of USPC.

As per the KUSUM website and the discussion with various USPC manufacturers, it was outlined that the RMS data captures the usage of each output port/channel. Thus, the monitoring system usage through RMS can aid in detecting low USPC utilization and facilitate proactive management viz. with the help of RMS, farmers with low utilization should be approached and necessary advice should be given for increasing USPC utilization.

Some of the key parameters captured by RMS for each output channels are as follows:

Figure 16: Key Parameters captured by RMS for each output channel.

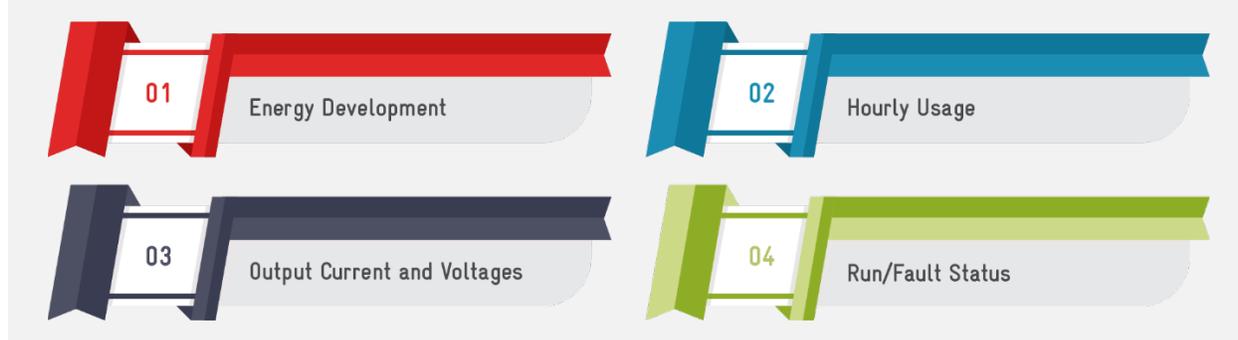


Figure 17: Representation of info captured by RMS

Parameter	Description	Unit
"UDHR2": "4.78",	Channel 2 USPC Day Run Hours	Hrs.
"UTOTHR2": "13.94",	Channel 2 USPC Cumulative Run Hours	Hrs.
"UOPI2": "0.00",	Channel 2 Output Current	A
"UOPV2": "230.00",	Channel 2 Output Voltage	V
"UOPKW2": "45.00",	Channel 2 Output Active Power	kW
"URUNST2": 1	Channel 2 Run Status 1 – ON, 0 – OFF	
"UFLST2": 1	Channel 2 Fault Status 1 – Fault, 0 – No Fault	
"UDKWH3": "35.00",	Channel 3 Today's Generated Energy by USPC	KWH
"UTOTKWH3": "120.00",	Channel 3 Cumulative Generated Energy of USPC	KWH
"UDHR3": "4.78",	Channel 3 USPC Daily Running Hours	Hrs.
"UTOTHR3": "13.94",	Channel 3 USPC Cumulative Running Hours	Hrs.
"UOPI3": "20.00",	Channel 3 Output Current	A
"UOPV3": "230.00",	Channel 3 Output Voltage	V
"UOPKW3": "45.00",	Channel 3 Output Active Power	kW
"URUNST3": 1	Channel 3 Run Status 1 – ON, 0 – OFF	
"UFLST3": 1	Channel 3 Fault Status 1 – Fault, 0 – No Fault	
"UDKWH4": "35.00",	Channel 4 Today's Generated Energy of USPC	KWH
"UTOTKWH4": "120.00",	Channel 4 Cumulative Generated Energy by USPC	KWH
"UDHR4": "4.78",	Channel 4 USPC Daily Running Hours	Hrs
"UTOTHR4": "13.94",	Channel 4 USPC Cumulative Running Hours	Hrs
"UOPI4": "20.00",	Channel 4 Output Current	A

Parameter	Description	Unit
"UOPV4":230.00",	Channel 4 Output Voltage	V
"UOPKW4":45.00",	Channel 4 Output Active Power	kW
"URUNST4":1	Channel 4 Run Status 1 – ON, 0 – OFF	
"UFLST4":1	Channel 4 Fault Status 1 – Fault, 0 – No Fault	
"UDKWH5":35.00",	Channel 5 Today's Generated Energy by USPC	KWH
"UTOTKWH5":120.00",	Channel 5 Cumulative Generated Energy by USPC	KWH
"UDHR5":4.78",	Channel 5 USPC Daily Running Hours	Hrs.
"UTOTHR5":13.94",	Channel 5 USPC Cumulative Running Hours	Hrs.
"UOPI5":20.00",	Channel 5 Output Current	A
"UOPV5":230.00",	Channel 5 Output Voltage	V
"UOPKW5":45.00",	Channel 5 Output Active Power	kW
"URUNST5":1	Channel 5 Run Status 1 – ON, 0 – OFF	
"UFLST5":1	Channel 5 Fault Status 1 – Fault, 0 – No Fault	

These measures should be mainstreamed into relevant policy/programmes in an effort to standardize identification of beneficiaries with low utilization and can be approached for understanding the reason behind the same and providing them with the necessary advise.

Solution 3: Offering optimal/customized solutions to the farmer

1. Offering optimal/customized solutions to the farmer

Based on consultations with the Tamil Nadu Agricultural Engineering Department (AED), it was revealed that the current tendering process by MNRE follows a top-down approach. MNRE aggregates demand and calls for submissions from all implementation agencies. Based on the annual target and the demand received from these agencies, MNRE allocates the quantity of pumps to the implementation agencies in each state.

For centralized tendering, the designated Central Public Sector Undertaking (CPSU) issues region-wise or state-wise tenders. Bidders are requested to quote based on region, technology (submersible or surface pumps), pump type (Alternate Current (AC) or Direct Current (DC) pumps), and capacity. Separate additional quotes are required for USPC.

Typically, three bidders are selected, and they must match the L1 price (the lowest price). The quantity allocated to those who agree to match the L1 price is distributed as follows: 50% to the lowest bidder, 30% to the second lowest, and 20% to the third lowest, based on the rates they quoted.

- After the vendors are selected, MNRE may communicate the price to respective SIA that are discovered for SWP with USPC through centralized tenders.
- Under the market mode, the respective implementation agency of the state offers willing farmers a chance to select his/her choice of vendor by providing them with the list of MNRE empaneled vendors and the corresponding price quotations of the respective vendors.
- Subsequent to the vendor selection by farmer, the selected vendor along with the respective implementation agency of the state, jointly conducts field inspection to perform a technical feasibility analysis and seeks to validate information from farmers on water tables in the area, land covered, quantity of water required for irrigation, etc. to identify the suitable size of the pumps
- Post field inspection, a **standard variant** of pump capacity is sanctioned, after which the respective vendors will install the SWP at the farmer's site.

Drawbacks of the current scenario

- While the standardization of the solar water pumps is important, the product should be suited to customer needs.

- One of the major issues with the existing scenario is that the ‘one-size-fits-all’ approach fails to meet the specific needs of the end users (the farmers).

Hence, there is a need for amendment/enhancement in offering optimized/customized pumping solutions to the farmers.

- Technology providers need to standardize products to minimize failures to an extent.
- Yet, they also need to offer/suggest **optimal/customized solutions** to the end user to meet their requirements as gathered during the field visit, such as high solar panel capacity for farmers who want to store and utilize the excess energy into battery for meeting their needs during non-solar hours.

Thus, based on the information gathered during field visits and on farmer requirements, the vendor shall suggest a customized solution to cater to the farmers’ requirements. SIA is to provide Central and state subsidy applicable for the nearest standard variant in terms of Solar capacity and balance cost that is to be borne by the farmer.

Benefits of customized solutions to the farmer:

Offering customized solutions to farmers, will help farmers in optimally utilizing the excess energy generated for meeting their needs and also for operating agri equipment using USPC.

2. Mandating the facilitation of operating manual

Local technicians and service providers are the primary medium for spreading awareness amongst the end users regarding the benefits and applications of the product, i.e. USPC. However, during the survey conducted with USPC beneficiaries across Himachal Pradesh, 6% of the farmers have cited that the installation/service team had asked them not to use USPC for operating any other equipment apart from SWP. As a result, farmers were skeptical regarding using USPC for driving any other load, as they fear that warranty would be null and void if they use it for any other purpose. This indicates inadequate communication by the service team.

Thus, in order to ensure clear operating procedures, MNRE may mandate designing a standard operating/communication manual for facilitating farmers with the comprehensive guide for overall USPC operations. It should be provided preferably in both English and the local language to the beneficiary.

At present, centralized tenders for standalone pump sets under PM KUSUM scheme mandate that the following information is to be captured in the O&M Manual as shown in [Figure 18](#):

Figure 18: Information mandated to be captured in O&M Manual

Vendor must submit an O&M manual in both English and local language should be provided with each SPWPS to the beneficiary. The following minimum details must be provided in the manual:

- Basic principles of PV system
- A small write-up (with a block diagram) on SPWPS- its components, PV module, electronics and expected performance
- A simple single line diagram (SLD) depicting the electrical circuits and control mechanism
- Type, model number, voltage and capacity of the motor used in the system
- The make model number and country of origin of each component
- Significance of indicators
- Clear instruction on regular maintenance and troubleshooting of the SPWPS
- Preventive maintenance schedule
- Detailed information about warranty coverage
- Dos and Don'ts
- Name and address of the contact person for repair and maintenance in case of non-functionality
- Description of frequent faults of PV module and pump and its remedies
- Minimum 10 hard copies in (booklet form kept at each service center also to be provided to SIA as and when required.

Some of the additional information to be provided in the operating/communication manual related to USPC are:

- **Operating Instructions and use cases**
 - Potential List of Agri equipment compatible (with corresponding capacity) with USPC
 - Showcasing technology through excellent examples and cases using Snippets
- **Dos and don'ts for regular maintenance**
 - SOPs for routine maintenance and other daily operations
 - Necessary safety precautions are to be taken
- **Troubleshooting Procedure**
 - Brief description on USPC troubleshooting procedures
 - Protocols to be followed in case of emergency
- **Problem Reporting/Escalation Procedure**
 - Escalation matrix for problem solving

These booklets should be provided to each beneficiary and also hard copies should be kept at the service centers and provided to SIAs as and when required.

Solution 4: Developing selection criteria for better targeting

Developing selection criteria for better targeting:

With the growing adoption of solar powered irrigation technology in India, many vendors have outlined the need for a dedicated framework/methodology for the identification of farmers for USPC installations, so that it can be allocated to the right people in the right way. Targeting farmers is essential since it involves the subsidy part from the government in addition to their own contribution, and efficient allocation ensures optimal use of public resources. Some of the criteria suggested for allocating USPC is defined in Table 2. These criteria are particularly relevant in the context of subsidy allocation but can also guide farmers in their decision-making process even without subsidies.

Table 2: Criteria proposed for allocating USPC

Criteria	Details
Availability of diesel pumps	For USPC, the states may formulate clear guidelines to prioritize farmers using diesel pumps and without agricultural connections for allocating USPC, with an intention to de-dieselize the farming sector. This approach has already been adopted by the PM-KUSUM scheme and would be important for the USPC allocation as well. The absence of such criteria can result in grid-connected farmers cornering subsidy benefits. Giving up their agricultural connection could be a pre-condition for grid-connected farmers to access subsidies for standalone solar pumps.
Intend/availability to operate Agri equipment:	Implementation agencies of states prioritize farmers having three phase agri equipment to be operated with USPC or having intentions to operate three phase agri equipment in the near future, for allocating USPC. This approach will enable identifying farmers who can utilize USPC for operating agri equipment apart from driving solar water pumps.
Proximity of Agri equipment with USPC	Also, while allocating USPC to farmers, it may be ensured that the USPC should be located close to the farm where the agri equipment is installed. Installing USPC in close proximity to the agri equipment will enable farmers to operate the equipment with USPC, which is difficult in cases where farm equipment is installed far from the USPC location.
Geographical Locations	While allocating USPC to farmers, another prominent factor to be considered is farmers residing in locations where the grid extension is not feasible, or power supply is erratic.
Availability of reliable water source	Availability of reliable water sources such as borewells or open wells, check dams, etc. shall also be considered while allocating USPC.

Hence, for allocating USPC to farmers the appropriate weightage may be assigned to each parameter discussed above and depending upon their relative importance, a passing/selection score can be determined for the selection of farmers for allocating USPC.

Solution 5: Enhance synergy and access to information

1. Facilitating USPC penetration through convergence

One of the major reasons for limited awareness among stakeholders is that consumers who wish to install the SWP with USPC system, may not have the detailed information available at one place viz., information related to the PM KUSUM scheme, Agri equipment related schemes (both at state and central level), processes/procedures to be followed for new applications, availability of subsidies and finance, etc.

Currently the state and central portals of PM-KUSUM Scheme are linked and capture the following key information regarding 3 components:

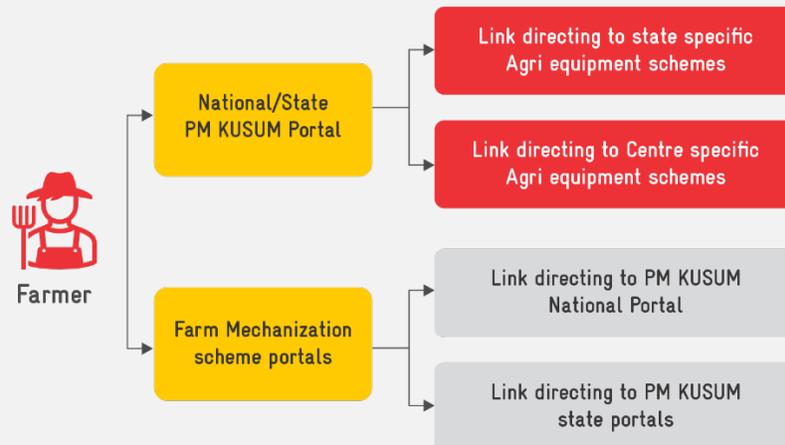
- Beneficiary list
- Application status tracker
- Complaint registration
- Vendors' contact details
- Prices discovered for various capacities of SWPs and USPC
- Test reports
- Details of SIA etc.

However, state and central portals don't capture information regarding prevailing schemes for the purchase of agri-equipment compatible with USPC.

Similarly, portals state and central schemes for farm mechanization don't capture information related to the PM-KUSUM scheme.

As a result, there is a need for convergence of the PM KUSUM portal with the farm mechanization scheme, which may facilitate the user to entail all the information related to agri equipment such as subsidies available, etc.

Figure 19: Schematic diagram illustrating the integration of relevant information sources



Farmers can either visit the respective portal of the state implementation agency or the National PM KUSUM portal for seeking the details related to the PM KUSUM scheme & agri related scheme and vice versa.

It is anticipated that convergence of the PM-KUSUM scheme with Farm Mechanization schemes such as the Centrally sponsored Sub Mission of Agricultural Mechanization (SMAM), Pradhan Mantri Krishi Sinchayi Yojana (PMKSY) and various state sponsored schemes such as HP's Rajya Krishi Yantrikaran Scheme etc. shall assist in increasing the traction among farmers regarding both USPC and Agri equipment.

2. 'Single-window' Information and Support Mechanism (SWISM)

Based on the survey conducted with farmers in HP, it was found that majority of farmers were not aware of a potential list of equipment that can be operated with USPC and also not aware of any financial assistance being provided on the purchase of Agri /irrigation equipment. Also, multiple departments and ministries are involved in the SWP/USPC ecosystem at present. Thus making it difficult for farmers to gather all the required information/clarification before making their decision for opting for SWP/USPC.

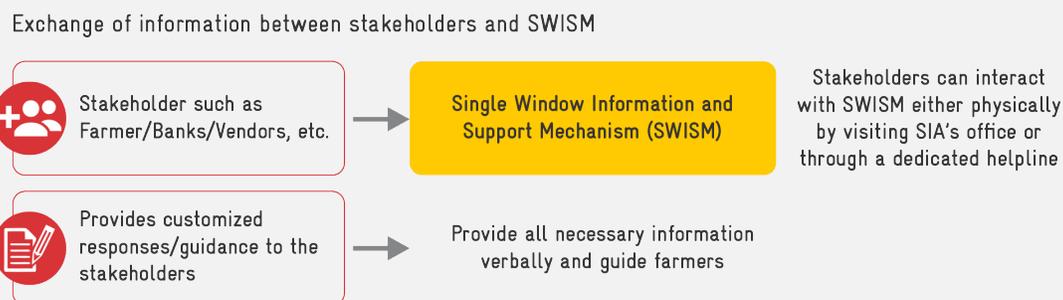
Hence, there is a need for a Single Window Information and Support Mechanism (SWISM) for all aspects related to Agriculture equipment, solar water pumping systems and USPC, which shall be beneficial for all the concerned stakeholders.

The function of SWISM will be to facilitate farmers with all the necessary/required information verbally and guide farmers with customized information such as which banks can provide loans, which agri equipment can be connected with USPC, subsidy availability, process for availing subsidies, etc. Stakeholders can interact with SWISM either physically by visiting SIA's office or through a dedicated helpline imparting all the necessary information to guide the stakeholder.

Stakeholders can visit SWISM for the following additional information viz.

- Information on schemes (PM KUSUM/Agri equipment)
- Potential equipment compatible with USPC
- How to avail subsidies
- Which banks can provide loans and corresponding interest rates
- Feed-in-Tariff details, etc.

Figure 20: Exchange of information between Stakeholders and SWISM



All the existing offices of respective implementation agencies of the states should preferably have SWISM trained officials. However, capacity building of SWISM staff/agents is critical to enhance the knowledge/skills required for the role and increase their proficiency. Further, it is necessary to have a proper monitoring process in place for evaluating the performance and effectiveness of the staff/agents of the SWISM. This shall benefit all involved stakeholders viz SWP developers/vendors, farmers and local youth.

Solution 6: Other Recommendations

1. Farmers seeks low payback period while investing

The benefits of USPC are not purely limited to economics of avoided diesel cost/electricity tariff. There are additional benefits such as improved energy access and livelihood in rural areas. A farmer, however, would not look at the benefits. While solar based pumping solutions with USPC for operating agri equipment is economically more advantageous to the farmer in the long run, a payback period longer than typically 3 years is too long an investment horizon to replace the regular controller with the USPC for operating the agri equipment.

Economics against the diesel/electricity savings will be a deciding factor for a farmer to opt for USPC. Below illustrates calculations showing the business case of a farmer showing the extent of capital subsidy required to attain around 2-years of breakeven on the incremental cost.

Table 3: Key Parameters of a Business Case

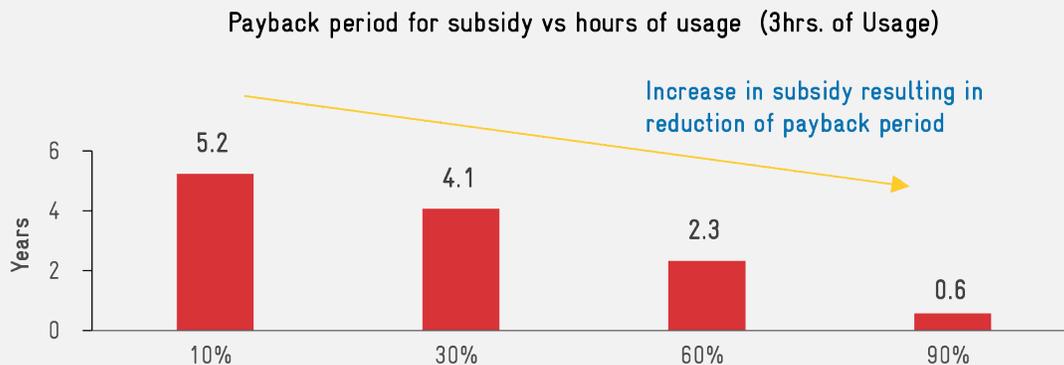
Parameters	Details
Business Case	Farmer purchasing grid powered agricultural Shredder machine and SWP with USPC
Financial Support/Grant	60%
Capital Expenditure (in INR) <i>(Including the cost of a 3 phase Agricultural Shredder machine along with '5 HP SWP with USPC)</i>	INR 52,410
Average annual savings <i>(due to avoided manure costs of the farmer)</i>	~INR 22,500
Payback Period	2.3 Years

1 HP= 0.745 kW; with daily 3 hours of operation for 150 days, for 3 HP Shredder machine, the cost incurred is INR 5,000 per tractor load (a ton of capacity) and assuming requirement of 3 tons of organic manure annually.; Average of annual savings for the period of 10 years have been considered.

Here, the farmer doesn't have any type of agri equipment and purchases a three phase Agricultural Shredder machine along with '5 HP SWP with USPC'. The Payback period computed basis savings incurred due to avoided manure cost of the farmer.

To analyze the impact of subsidies, below in [Figure 21](#), the break-even period for the above business case is illustrated with all other parameters remaining the same apart from a change in subsidy:

Figure 21: Payback period for subsidies vs hours of usage



It can be observed that change in subsidy is resulting in a decreasing payback period down to ~0.6 years from more than ~5 years. Thus, indicating that subsidies are highly critical for increasing the penetration of USPC and for making it financially viable from the farmer's perspective.

However, subsidies should only be provided to those farmers who were selected based on the predetermined criteria (as discussed in [Issue 6](#)) for allocating USPC. In case of other farmers who are not meeting the above criteria and are still willing to purchase the system, they can opt for contributing the full cost against the system without any subsidy. For small and marginal farmers and farmers belonging to economically weaker sections, additional subsidies may also be provided.

2. Enabling compatibility for single phase equipment

During the survey conducted with farmers across Himachal Pradesh, it was revealed that 24 out of 54 farmers were using single phase agri equipment for meeting their daily agri need. Also, while conducting one-on-one discussions with various stakeholders and even during the virtual workshop, it was outlined that a high demand for enabling compatibility for operating single phase agri equipment using USPC was witnessed on the field and in contrast, the demand of three phase equipment was quite low. Thus, it was emphasized that since the single phase supply is available at many places, universal solar pump controllers should have a provision to couple with single phase controllers. Enabling compatibility to operate single phase equipment using USPC will facilitate farmers to use a wide range of agri-equipment with USPC and shall also result in better savings/revenue for the farmers as farmers will be meeting their daily agri goal by tapping free solar energy and avoiding the electricity cost. Further, it was mentioned that adding compatibility for single phase agri equipment may also encourage farmers to adopt USPC, as farmers can potentially relate to the applications.

The utilization of solar energy shall be enhanced further due to various options available to farmers such as Atta Chakki, Chaff Cutter, Battery operated spraying machine, etc. Farmers can even utilize the solar energy for operating the single phase domestic residential load using USPC.

However, the inclusion of single-phase compatibility into USPC specifications needs to be done holistically taking into consideration all key factors such as the technical feasibility (e.g. – three phase equipment requires initial torque to be operated, which is not the case for single phase equipment), commercial attractiveness and the safety of the end user.

Next Steps

For the inclusion of single-phase compatibility with USPC, the MNRE may constitute a technical committee to recommend necessary steps to be taken for enabling single phase compatibility with USPC.

3. Facilitating cost reduction through target setting

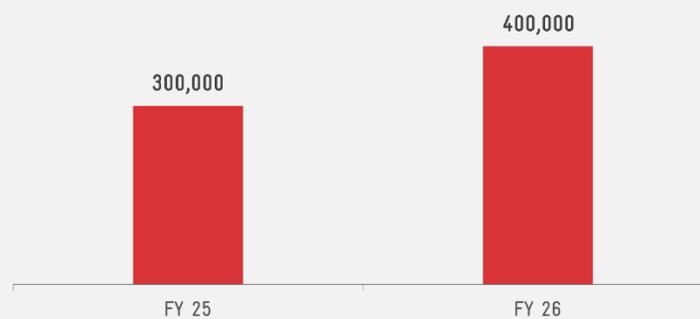
Gradually with time, as the market grows and scale economies kick in, the cost of SWP along with USPC optimized for solar power usage is expected to come down. Based on our interactions with various manufacturers and solution providers, it was revealed that with scale economies, and local manufacturing, the price of solar pump sets and USPC can be reduced over the next few years.

This shall translate into a significant subsidy reduction for the government. However, for this to happen, the USPC installation target has to be announced by the MNRE and implemented by empaneled vendors. Currently very few players are in the USPC manufacturing space in India. However, dedicated targets for USPC installations by the MNRE may give confidence to existing manufacturers and attract more players to the market.

Under component B of the PM KUSUM Scheme, MNRE has a set target of 1.4 million standalone solar pump installations to be installed by 31st March 2026. The yearly targets⁹ under component B of the scheme are shown in [Figure 22](#):

Figure 22: Yearly targets under Component B of the PM KUSUM scheme

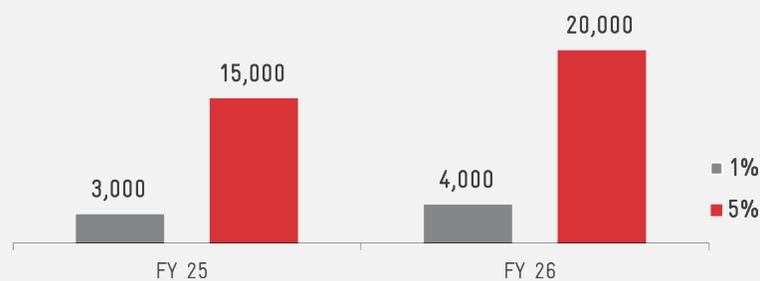
Yearly approx. targets under Component B of the PM KUSUM Scheme*



Assuming the USPC target of an increase from 1% to 5% of the total standalone SWP installations targets, the yearly USPC potential is illustrated in Figure 23:

Figure 23: Yearly USPC penetration assuming targets of 1% to 5% of total installations

Yearly USPC potential assuming targets of 1% to 5% of total installations



This shall translate into cumulative USPC potentials ranging from **7,000 to 35,000 USPC installations** under the PM KUSUM scheme, subjective to USPC penetration of 1% to 5%, respectively.

This will not only lead to cost reduction due to the increased scale, this will also incentivize the much needed Research and Development (R&D) to improve the technology.

⁹ Currently, approx. 8 lakhs off-grid SWPs have been sanctioned till November 2022 and it is assumed that another 2 lakhs will be sanctioned by FY 23 (? Is this the most current number?). Hence, the remaining quantum of pumps has been proportionally distributed over the remaining years.

Way Forward

In order to set the targets, a three-stage approach for target setting is required, as illustrated in [Figure 24](#).

Figure 24: Approach for target setting



To achieve this goal, MNRE may conduct consultations with concerned stakeholders to specify dedicated targets (annual or cumulative) for USPC installations in line with standalone SWP targets specified by MNRE.

5. Proposed Business Models for accelerating USPC adoption

5.1 Key criteria for business models

Currently, the use of USPC is limited to operating a few agri-equipments by the farmers. Hence, very few business models are available in the market.

There is a need for the preparation of robust business models to accelerate the use of USPC by the farmers.

Figure 25: Business Model Framework

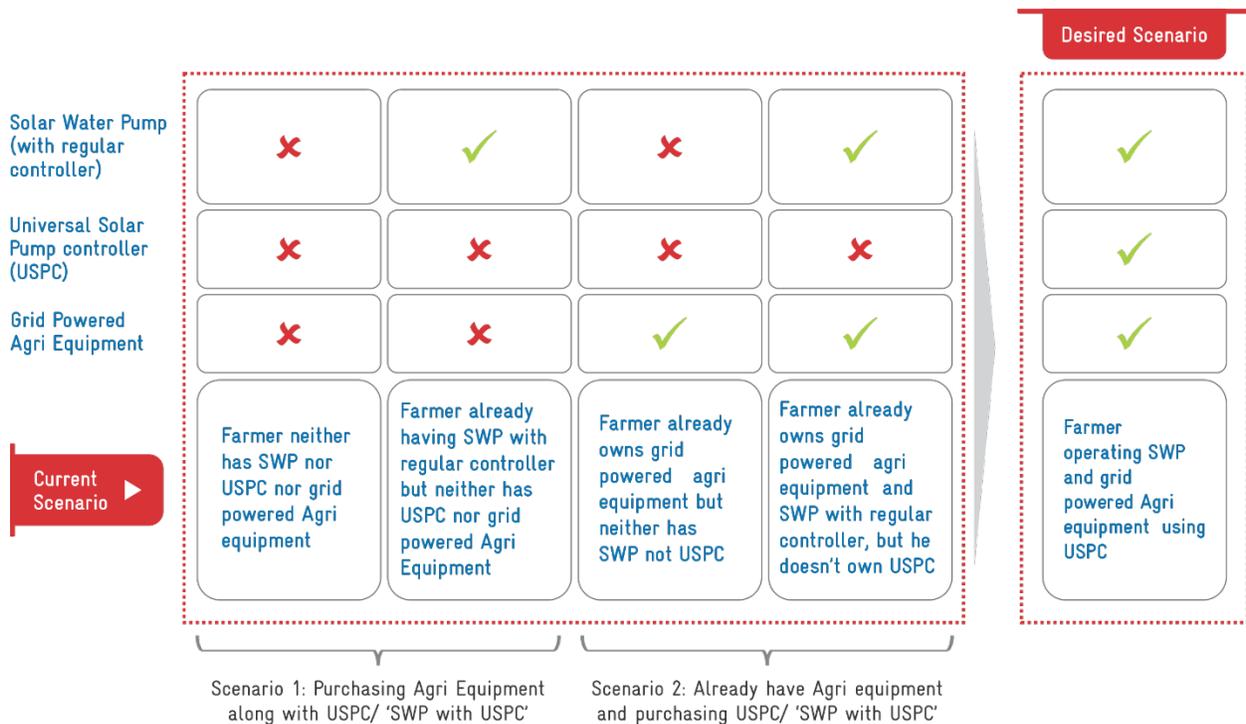


The parameters mentioned in [Figure 25](#) are key components of a successful business model, where reducing capital cost for SWP/USPC helps to minimize expenditures, while maximizing savings/revenue for the end user. A low payback period indicates that investments are generating returns quickly, making the business model more attractive and sustainable. Further, it will optimize the utilization of solar energy, while providing benefits to all stakeholders. By focusing on these elements, business models can achieve a competitive advantage by providing value propositions to all the stakeholders.

Diverse scenarios on basis of the farmers ownership of the equipment

The business models have broadly been categorized into two cases, one where the farmer already has grid powered equipment and one where the farmer doesn't have a grid powered agri equipment. Depending upon whether the farmer is already owing a SWP or not, there are multiple sub scenarios as illustrated below. As the business models are proposed for USPC penetration, it is assumed that the farmer currently doesn't own USPC.

Figure 26: Various Business Models

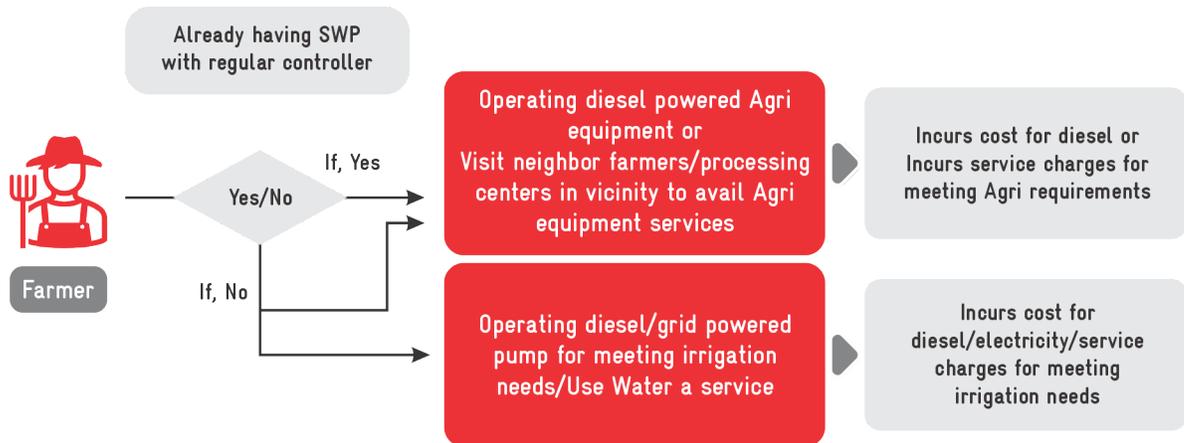


Model 1: Purchasing grid powered agri Equipment along with USPC/SWP with USPC

This model is applicable for farmers who currently do not possess grid powered agri equipment and may/may not own SWP for meeting the irrigation requirements. Accordingly, two scenarios can be mentioned as illustrated in Figure 27.

1. In the first scenario, the farmer already owns a SWP with a regular controller: In this situation, it has typically been witnessed that the farmer is either meeting his daily agri needs by operating diesel powered Agri equipment, thereby incurring high diesel costs. He may also be visiting neighboring farmers/processing centers in close vicinity to avail Agri equipment services and incurs service charges for meeting his agri requirements.
2. In the second scenario, the farmer does not own the SWP with regular controllers. Besides meeting his agri requirements as highlighted in the above scenario, the farmer is meeting his irrigation needs using a diesel/grid powered pump (incurring cost for diesel/electricity tariff) or using water as a service from his neighboring farmer and paying service charges against the same.

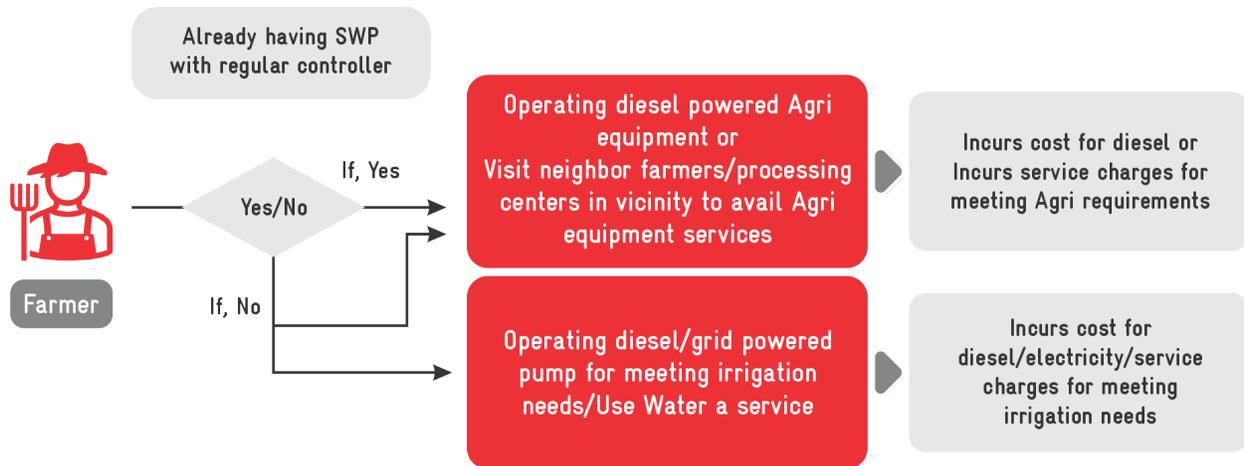
Figure 27: Current Scenario where the farmer is not owning grid powered agri equipment



Desired Business Model

As illustrated in [Figure 28](#), Farmers can approach the concerned SIA to apply for electric agri equipment and also the respective SIA for the USPC or the ‘SWP with USPC’. This would enable farmers to operate the SWP to meet their irrigation needs and aid in avoiding diesel costs spent or the service charges. In situations where SWP is not in use, farmers may use USPC for operating agri equipment such as Atta Chakki, Chaff Cutter, etc. This would result in farmers avoiding the cost of electricity or diesel or service charges that the farmers would have been spending for meeting their agri needs.

Figure 28: Suggested Business model for farmers not owning grid powered agri equipment



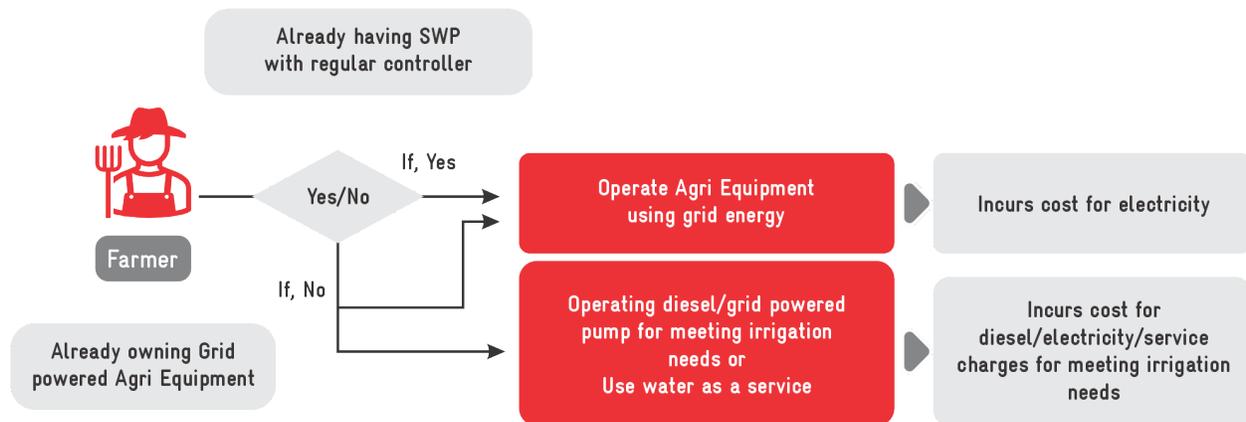
Model 2: Already owns grid powered agri equipment and purchasing USPC/’SWP with USPC

This business model pertains to farmers who own grid powered agri equipment and may/may not own SWP for meeting their irrigation requirements. Further scenarios are highlighted below as shown in [Figure 29](#).

1. The farmer is already owning a grid powered Agri Equipment & SWP with regular controllers and is meeting his agri needs by incurring electricity cost by operating agri equipment using grid energy.
2. The farmer already owns grid powered Agri Equipment & does not have a SWP with regular controllers and is meeting his agri needs by incurring electricity costs by operating agri equipment using grid energy. Further, he is meeting his irrigation needs through diesel (incurring diesel cost) or grid powered pumps

(incurring electricity cost) or availing water as a service facility from neighboring farmers (incurring service charges).

Figure 29: Current Scenario for farmers already owning grid power agri equipment

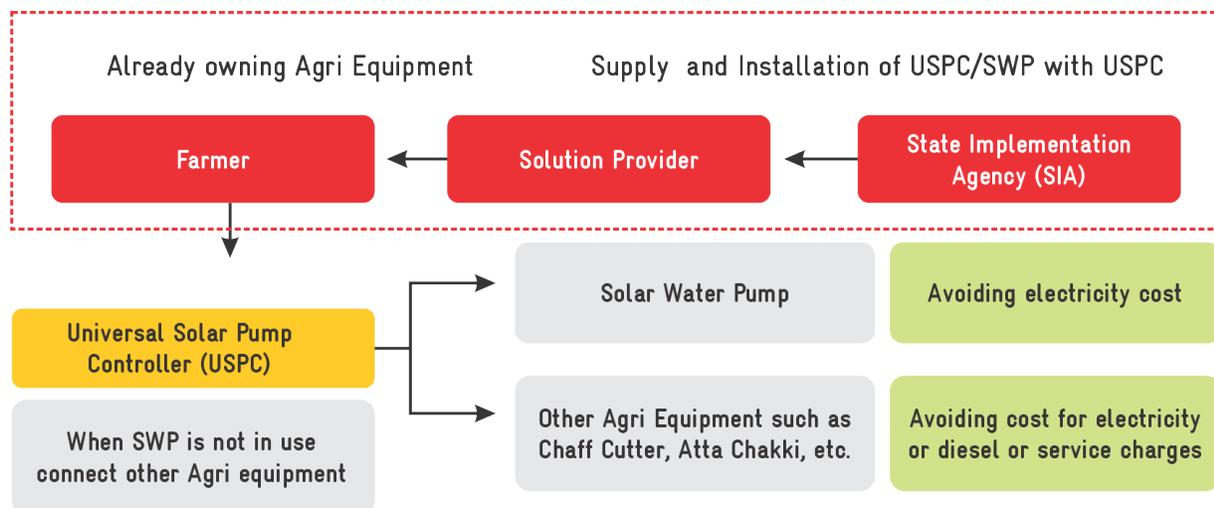


This model assumes that farmers who already own agricultural equipment will be motivated to invest in SWPs with USPCs if these systems help them reduce costs in their business processes. Additionally, farmers who currently use SWPs with regular controllers can be encouraged to upgrade to USPCs for further cost savings and efficiency improvements.

Under this model, farmers can approach the respective implementation agency of the state for the installation of USPC or ‘SWP with USPC’. With the help of USPC, farmers can operate SWP to meet their irrigation needs and in turn aiding in avoiding the cost (diesel/electricity/service charges) spent on meeting the irrigation needs. In addition, when SWP is not in use, farmers can use USPC to operate existing agri equipment, resulting in avoiding the electricity cost spent on operating the equipment using grid energy.

This model has been illustrated in [Figure 30](#):

Figure 30: Suggested Business model for farmers already owning grid power agri equipment

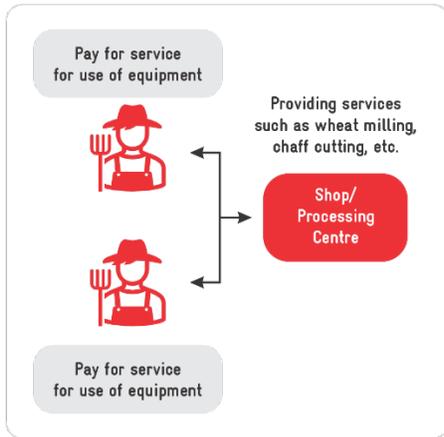


Model 3: USPC as a Service Model

These business models could act as a game changer going forward. In the ‘USPC as a service’ model, the farmer purchases USPC with agri equipment for captive consumption and provides services using Agri equipment by operating it with USPC to the other farmers/neighbors in exchange for the service charges. This would aid the

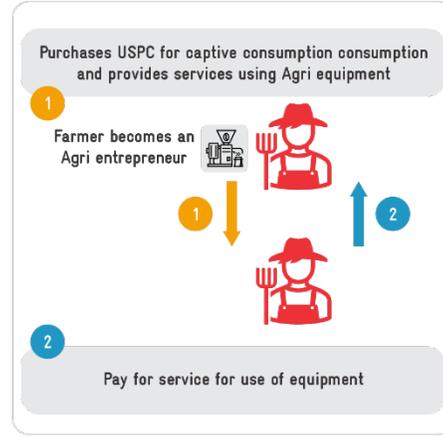
farmer in saving the costs that he would have spent on visiting nearby shop/processing centers for availing agri services such as wheat milling, chaff cutting, etc., also enabling income generation opportunities by selling services to the community, thus reducing the payback period.

Figure 31: Current Scenario for farmers availing services at processing center



Suggested Scenario

Figure 32: Suggested business model for farmers becoming agri-entrepreneurs



The model is also beneficial for farmers/agri entrepreneurs already providing agri services such as wheat milling, chaff cutting, etc. to the community using grid or diesel powered agri equipment in exchange for the service charges from the consumers. Under the 'USPC as a service' model, these farmers/agri entrepreneurs can further enhance his savings by operating their agri equipment using solar energy through USPC (by avoiding electricity/diesel cost), resulting in a better payback period.

Figure 34: Current Scenario for farmers providing services to neighboring farmers

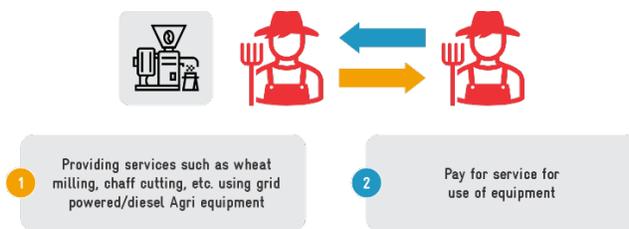
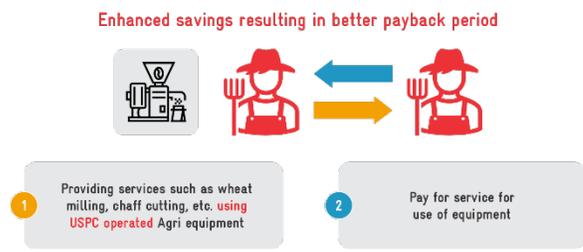


Figure 33: Suggested Business model for farmers providing services to neighboring farmers

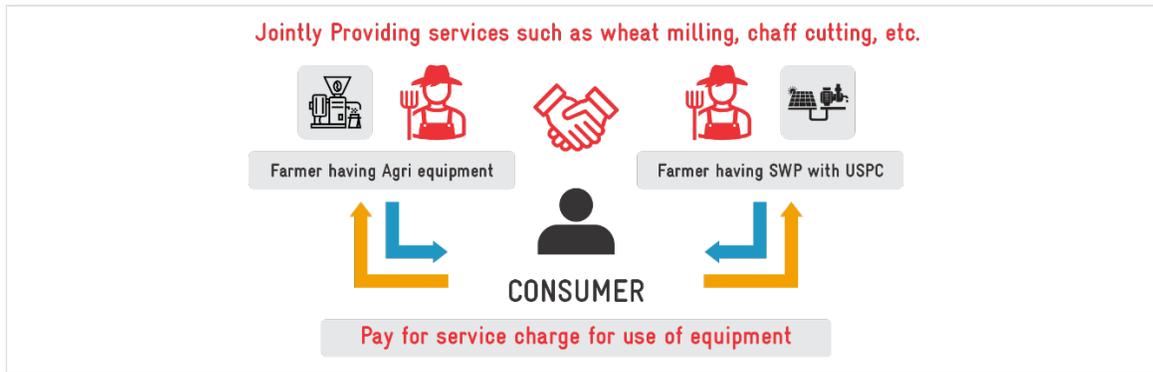


This model would enable farmers to generate additional income by selling services to the community, thus reducing the payback period and making the whole proposition become much more attractive for the farmers.

Additional variant of the 'USPC as a Service' Business Model

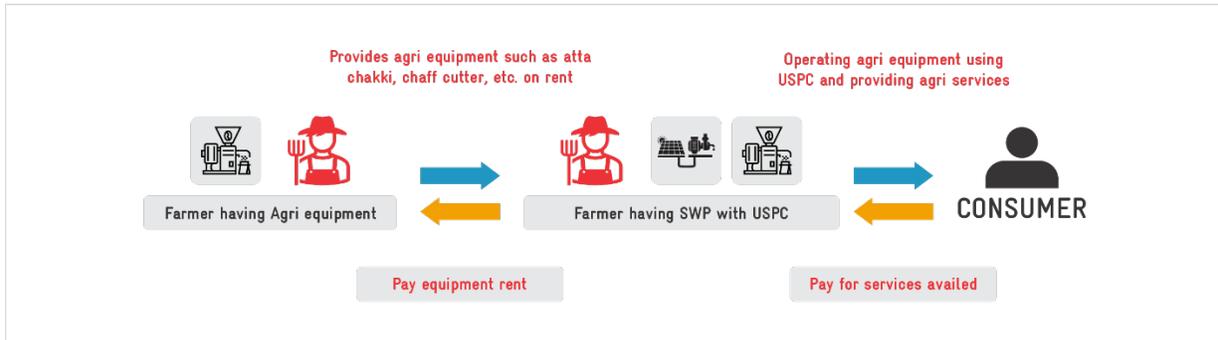
1. **Strategic Partnership offering service:** In this approach, two different farmers/individuals having agri equipment and 'SWP with USPC', respectively can come together to jointly provide agri services such as Wheat Milling, Chaff Cutting, etc. to the community and charge them a fixed service charge for the use of the equipment. Thus enabling farmers to formulate a value proposition of both the individuals/farmers in generating additional income by selling the services to the consumers and resulting in enhancing the utilization of solar energy for operating agri equipment and avoiding electricity/diesel costs. This model is feasible in cases where farmers own a portable agri equipment such as a Chaff Cutter machine, Shredder machine, etc.

Figure 35: Business model for farmers jointly providing services



- 2. Farmers renting agri equipment for offering ‘USPC as a service’:** In this approach, farmers already having SWP with USPC rent the agri equipment from other farmers/individuals, for providing agri services to the consumers in return for the service fee. The detailed model is shown in [Figure 36](#).

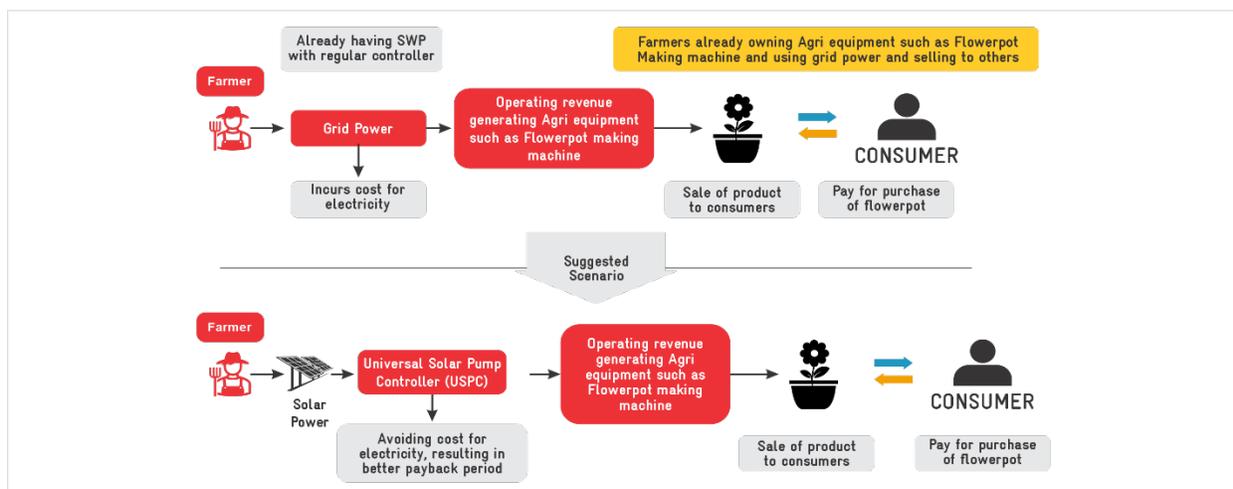
Figure 36: Business model for farmers renting agri equipment for offering ‘USPC as a service’



Model 4: USPC for enhancing payback period

This model highlights the use of USPC for operating equipment using solar power, instead of relying on costly grid energy. By using USPC, farmers who are otherwise using grid power for producing e.g. flowerpots, can enhance their savings and improve the payback period. This demonstrates an additional application of USPC, showcasing its versatility and potential for cost savings.

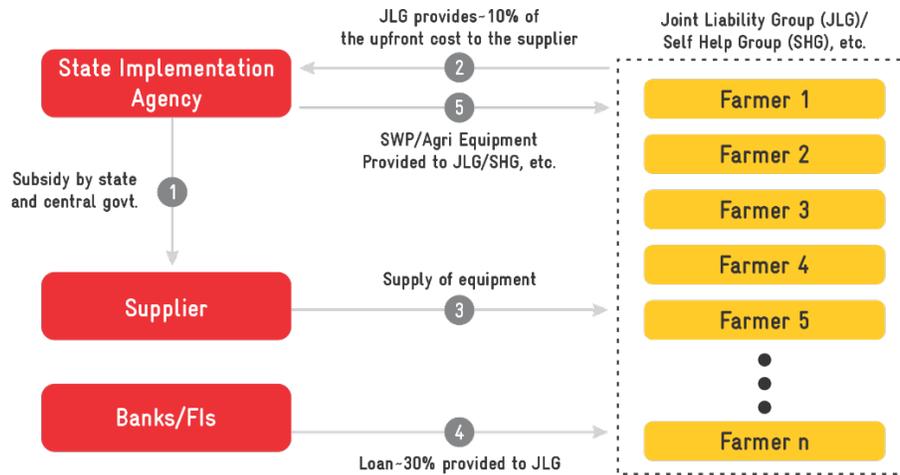
Figure 37: Business model for farmers using USPC for shorten the payback period



Model 5: Community based SWP with the USPC model

Small and marginal farmers often face challenges in purchasing SWP due to the high upfront cost and lower utilization of solar energy and agri equipment (considering that their land acreage is limited). To address this, this model states that eligible groups of farmers such as FPOs, Self Help Groups (SHGs), Primary Agricultural Cooperative Society (PACS), JLG, multipurpose co-operative societies, etc. can come together to avail a loan equivalent to ~30% of the SWP with USPC cost and can also collectively contribute 10% of the total cost due to a beneficiary contribution. The schematic representation of the model is illustrated in [Figure 38](#).

Figure 38: Community Business Model



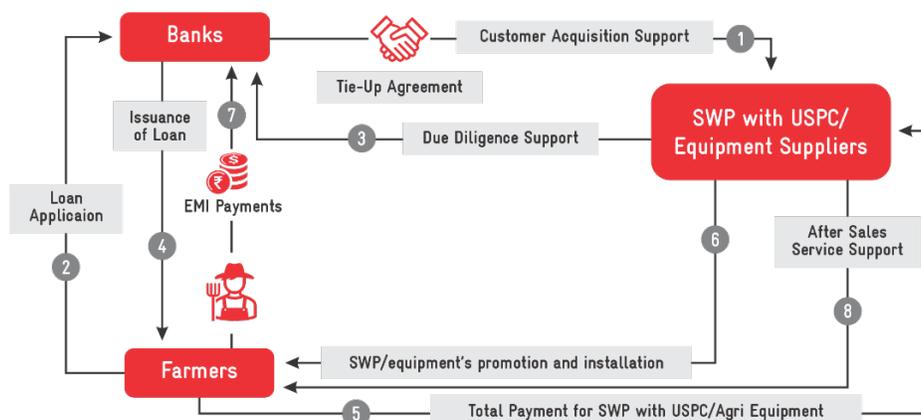
Potential benefits of this model:

- Enhanced utilization of solar energy and agri equipment
- **Reduced cost contribution of individual farmers:** By utilizing excess solar energy, farmers can reduce their dependence on traditional energy sources and reduce their costs.
- **Better Payback period:** Increase in savings/revenue leads to lower costs for individual farmers. With these changes, farmers may see a shorter payback period, meaning they will be able to recoup their investment in these technologies more quickly.

Model 6: Tie up with banks/Financial Institutions (FI) and SWP/USPC manufacturers

This model proposes the collaboration between banks and SWP/USPC/agri equipment manufacturers, which shall facilitate increasing awareness among farmers related to USPC/agri equipment as well as increased loan portfolios for bankers.

Figure 39: Business model for a tie-up with banks/financial institutions and SWP/USPC manufacturers

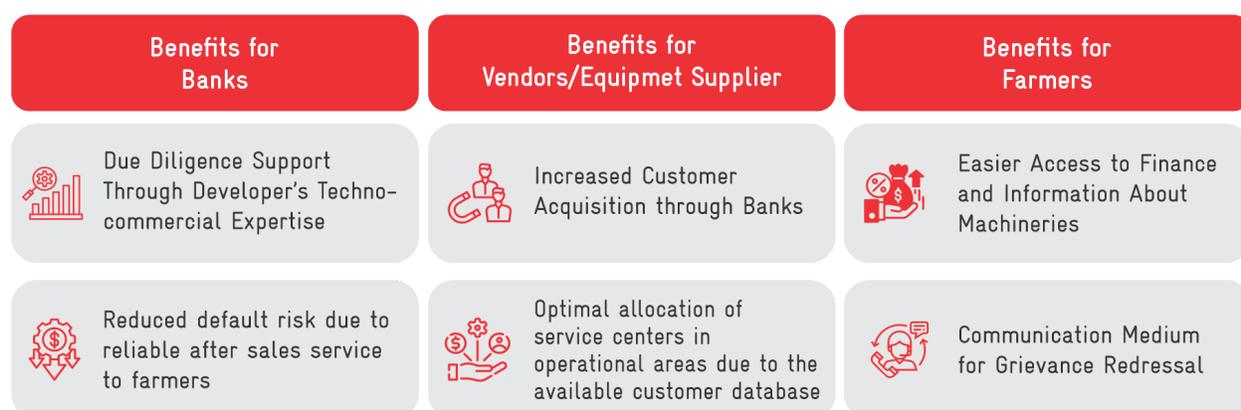


The brief of the tie-up process as illustrated in [Figure 39](#), is discussed below:

1. **Tie-Up Agreement:** A formal agreement is established between the bank/financial institution and equipment suppliers (SWP/ USPC manufacturers) to facilitate the process.
2. **Customer Acquisition Support:** The equipment suppliers identify potential farmer customers and introduce them to the bank. It helps the banks to enhance their customer base and portfolio.
3. **Loan Application:** Farmers apply for a loan from the bank to purchase SWP with USPC or other agricultural equipment.
4. **Due Diligence Support:** The equipment suppliers assist banks in conducting due diligence on the loan applications.
5. **Issuance of Loan:** The bank processes the loan application and issues the loan to the farmer.
6. **Total Payment for SWP with USPC/Agri Equipment:** The total payment for the equipment is made through the loan provided by the bank.
7. **SWP/equipment's promotion and Installation:** Suppliers promote their products to farmers and install the equipment once purchased.
8. **EMI Payments:** Farmers repay the loans to banks through regular EMI (Equated Monthly Installment) payments.
9. **After Sales Service:** Equipment suppliers offer after-sales service to ensure the equipment operates efficiently and to address any issues.

The proposed partnership between banks and vendors/equipment suppliers offers a win-win scenario by simplifying the loan process, reducing risks, and boosting market credibility for both parties. This collaboration guarantees quick equipment financing, effective customer acquisition, and dependable after-sales support, which in turn promotes the wider use of SWPs/SWPs with USPC among farmers. The potential tie-up will result in the following benefits to each stakeholder:

Figure 40: Benefits of the Tie-up arrangement for various stakeholders



In January 2022, Karnataka Vikas Grameena Bank (KVGB) and Mecwin Technologies India Private Limited (Vendor, Mecwin) entered into a tie-up agreement to finance solar pump sets in the state of Karnataka. This collaboration is expected to result in a favorable lending environment, leading to higher SWP loan offtake due to the synergic benefits for all the key stakeholders.

6. Roadmap for USPC penetration – Key Action Points

Based on the key solutions proposed in section 4.2, the roadmap for accelerating the adoption of USPC has been laid out, including steps that should be taken in the short term, medium term and long term as illustrated in the figure below.

Figure 41: Holistic Roadmap for increasing the adoption of USPC

Proposed Activities	Entity Responsible	Q1	Q2	Q3	Q4
Phase 1: Foundational Setting					
Constitute committee for reviewing the specifications	MNRE	█			
Selection of agency for collating data	Industry	█			
Initiate discussions with farmers on specific requirements	SIA	█			
Begin adding compatibility for single phase equipment	Research Labs	█			
Phase 2: Awareness and Process Enhancement (Months 4-6)					
Launch awareness campaigns and pilot installations across the country	SIA		█		
Develop and implement Virtual Reality (VR) solutions for mass outreach	Industry		█		
Start enhancing procurement process	Industry		█		
Begin making amendments in operating/communication manual	Industry		█		
Phase 3: Unified Approach and Information Enhancement (Months 7-9)					
Enhance info related to agri. equipment on state and central portals	Industry			█	
Strengthen single window to ensure 'One-Stop' information and support	Industry			█	
Ensure supply of USPC to deserving farmers	SIA			█	
Develop concessional financing opportunities	Banks/Fis			█	
Phase 4: Target Setting and Business Model Development (Months 10-12)					
Set targets for the sale of USPC	Industry				█
Enhance awareness about business model options	SIA				█

7. Conclusion and Way Forward

As solar energy (especially photovoltaic) is steadily becoming more cost-effective than its fossil-fuel counterparts, the number of energy intensive applications powered by solar is also consistently increasing. In addition to this, policymakers in India are promoting sustainable use of solar energy in all sectors due to global commitments pertaining to climate change and net-zero transition. Considering the vast potential of leveraging the low-cost dynamics of solar power in land irrigation, SWP are becoming popular. SWP have become a cost-effective and environmentally friendly alternative to diesel pump sets and therefore intend to reduce fuel dependency. Due to minimal operational costs post-installation, they have also become more cost effective than grid-connected electric pumps.

However, due to high initial costs, the adoption of SWP has been sluggish. Although the initial cost of SWP is higher than a diesel pump set of equivalent capacity, the life-time savings of SWP vis-à-vis diesel pump far outweigh its high upfront cost. The farmers may also find SWP to be a better alternative than grid-connected electric pumps in areas with frequent blackouts and load shedding. However, due to highly subsidized power sponsored by the respective state governments, the cost of grid-connected electricity provided to agricultural consumers is very low. This may lead to farmers opting for a grid-connected power supply over sustainable SWP leading to less offtake of SWP. In the long run, it may not be feasible for respective state governments to provide subsidized power continuously due to the high quantum of financial costs associated with subsidies. In this regard, the replacement of electric pumps with SWP will reduce the financial burden on state exchequer and channelize the savings towards other public welfare schemes.

Additionally, the SWPs are typically utilized 100-150 days a year and for the remaining days remain underutilized. This excess solar energy generated by solar panels can be tapped to run other agricultural equipment. This not only maximizes the efficiency of solar power usage but also provides farmers with more opportunities to leverage RE for various farming operations.

With this backdrop, the MNRE, Govt. of India introduced technical specifications for USPC, a controller with multiple outputs giving farmers' the opportunity to utilize the excess energy generation for other applications such as flour mills, grinding, and other applications. The USPC have also been integrated in the PM-KUSUM scheme, but there is only limited information on the uptake and use of USPCs on the ground. Despite the advantages offered by USPC, the uptake remains limited.

In this context, this project was commissioned to understand the potential of USPC and identify key issues hindering the penetration of USPC in the market and potential solutions to address those. The study suggests that the various barriers to which low USPC penetration can be attributed are majorly due to the high cost of USPC, non-provision of subsidy for USPC, limited knowledge of the benefits, improper targeting & screening of farmers and lack of supporting ecosystems constraining the demand and thus income generation potential for other end-use applications.

The success or the failure of the USPC will be primarily controlled by both demand and supply side factors as well as implementation mechanisms. This includes USPC potential, economic and commercial viability, additional income generation opportunities, availability of affordable financing, govt. subsidies and incentives, USPC costs, business models, on-ground acceptance and demand for end-use applications.

In this regard, as part of the study to promote the deployment of USPC, consultations with a diverse pool of manufacturers of USPC, SWP, Agri-equipment manufacturers, researchers and farmers were held.

The majority of stakeholders cited, that since USPC is a relatively new technology compared to SWPs, most farmers and a considerable number of SIA's lack proper understanding of the technology including its functionality. Thus, awareness among both set of stakeholders (farmers and SIA's) is a pre-condition for accelerating the adoption of USPC. Focused promotional campaigns by MNRE, state governments, and USPC/SWP developers are needed on a priority basis to act as a medium to build confidence and create a spike among prospective buyers regarding USPC

performance. Along with the promotional campaigns, it is equally crucial to set up live demonstrations for potential beneficiaries and arranging for exposure visits to view successful USPC systems installed across the districts. This could play a major role in changing the farmers mindsets.

Further, it was revealed that the cost differential between the price of a normal standalone controller and USPC is substantially high from the farmers' perspective. Thus, bridging the price between the two is the need of the hour. Target setting from the govt. will give manufacturers the confidence to invest more and achieve cost reduction through economies of scale and localized manufacturing. Thus, gradually with increase in demand of USPC, the production volume will be increased, resulting in lower costs of USPC in line with the cost of SWP controllers at present. Along with that, USPC technical specifications and testing procedure also needs to be evaluated which will aid in bringing down its cost.

Finally, a collaborative environment along with a strong communication channel between major stakeholders such as MNRE, USPC manufacturers, SWP manufacturers, Agri equipment manufacturers, state implementing agencies and SWP developers to create a viable ecosystem for facilitating USPC to farmers is essential. Through such a collaboration, appropriate interventions from the concerned stakeholders will be required to create a more robust ecosystem for USPC. However, in order to improve existing conditions, SIAs should need to improve the screening of farmers so that USPC can be given to the appropriate audience fulfilling the requirements to power the additional equipment's apart from SWP, in order to accelerate the off-take of USPC.

Annexures

Annexure-1: Cumulative Installations of SWP under Component B of the PM-Kusum Scheme

Figure 42: State-wise Cumulative Installations of SWP under the Component B of the PM-Kusum Scheme

State	Cumulative Capacity installed under the Off-grid SPV Programme ¹⁰	Capacity sanctioned under the PM-Kusum Scheme ¹¹	Total
2015 onwards	501,673	-	501,673
Chhattisgarh	119,282	25,000	144,282
Rajasthan	108,644	158,884	267,528
Maharashtra	49,036	200,000	249,036
Haryana	42,153	252,655	294,808
Uttar Pradesh	41,423	36,842	78,265
Andhra Pradesh	34,045	-	34,045
Madhya Pradesh	25,138	57,000	82,138
Punjab	16,710	63,000	79,710
Jharkhand	13,592	16,717	30,309
Gujarat	12,805	8,082	20,887
Odisha	10,689	5,741	16,430
Tamil Nadu	7,927	6,200	14,127
Karnataka	7,734	10,314	18,048
NABARD	4,012	-	4,012
Bihar	2,813	-	2,813
Tripura	1,325	6,021	7,346
Kerala	848	100	948
West Bengal	653	-	653
Others	609	-	609
Jammu & Kashmir	501	5,000	5,501
Himachal Pradesh	484	1,580	2,064
Telangana	424	400	824
Uttarakhand	333	1,838	2,171
Arunachal Pradesh	113	200	313
Delhi	90	-	90
Manipur	26	150	218
Meghalaya	19	535	589
Assam	15	5,000	5,045
Goa	30	200	245
Mizoram	90	2,700	2,737
Puducherry	22	-	21
Chandigarh	3	-	12
Andaman	37	-	5
Nagaland	21	165	168
Sikkim	12	-	-
Lakshadweep	5	-	-
Total	1,003,346	864,324	1,867,670

¹⁰ Source: MNRE Annual Report 2023

¹¹ Source: PM-KUSUM official portal (<https://pmkusum.mnre.gov.in/landing.html>)

Annexure-2: Framework for selection of states and districts

Background:

Solar Water Pumps (SWPs) are steadily gaining ground in response to the subsidy support being provided under various central and state government schemes. While Standalone SWPs are already being deployed across India, new grid connected SWP models are also being promoted to provide additional income to farmers through the sale of surplus solar power generated by these pumps. The deployment is expected to increase multifold with the roll-out of MNRE’s Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM KUSUM) which has three components targeting both on and off grid solar pumping.

This solarization of agriculture pumps under Component B of the PM-KUSUM scheme will lead to the creation of a solar PV capacity of over 9,600 MW¹². It is estimated that these pumps are typically utilized for only 100-150 days¹³ in a year, thereby not utilizing the solar energy generated during the remaining days of the year.

Universal Solar Pump Controller (USPC) has the potential to reduce/avoid this loss of solar energy and use the unutilized energy for alternate applications. USPC helps utilize the solar power to a maximum by using the excess generated power during non-irrigation time for different productive uses like operating chaff cutter, floor mill, cold storage, drier, battery chargers, etc. This not only increases the utilization of assets but also aids in increasing the income of the farmer.

The Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), a federal enterprise based in Germany is providing technical assistance to the MNRE as part of the Promotion of Solar Water Pumps (PSWP) component of the Indo-German Energy Programme (IGEN) with the objective to ensure that solar pumps for productive use are rolled out more rapidly through a multi-level and multi-actor approach. In this regard, GIZ has invited a tender and selected KPMG to ‘Develop business models and strategies for large scale uptake of universal solar pump controller’.

Given this background, the objectives of this assignment are as follows:

- To understand the different issues, benefits, and challenges in the adoption of USPC
- To identify probable solutions and directions for the large-scale uptake of USPC
- To identify business models to make USPC affordable to farmers

Methodology for shortlisting states

The IWMI-TATA policy paper “**Har Khet Ko Pani - Rethinking Pradhan Mantri Krishi Sinchai Yojana (PMKSY)**” has divided the 590 districts of India into 12 clusters based on varying geography, hydrogeology, and socio-economic conditions. The data from the 9th Agricultural Census (2010-11) and the Minor Irrigation Census (2006-07) was considered for this clustering of districts. Though the policy paper was intended to study and propose interventions to strengthen the PMKSY scheme, the parameters considered for clustering are comprehensive in nature, covering various aspects of irrigation including energy consumption and the presence of electric pump sets. The defining aspects of each of the clusters are highlighted below:

Table 4: Defining Aspects of Clusters outlined in IWMI-Tata Policy Paper

Cluster	Key characteristics	No. of Districts
1	Groundwater surplus districts with a high share of farm holdings without any source of Type I or Type II irrigation	112
2	Groundwater surplus districts where Type II irrigation is constrained by high energy costs	36
3	Groundwater surplus districts where Type II irrigation is constrained by an inadequate electricity supply	24
4	Groundwater-deficit alluvial districts where Type II irrigation will further deplete aquifers	103

¹² PM KUSUM scheme guidelines

¹³ <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1672580>

Cluster	Key characteristics	No. of Districts
5	Groundwater deficit hard-rock districts with excessive groundwater depletion (dark or over-exploited zones)	27
6	Districts with a dense network of MMM systems and large canal irrigation areas	114
7	Districts with high density of irrigation tanks, check-dams, and water harvesting structures	161
8	Districts having potential waste-water usage ¹⁴	-
9	Hill districts, mostly the Himalayas, where agro-climatic conditions are not conducive to conventional irrigation	100
10	Districts with high irrigation incidences and high agricultural productivity	54
11	Districts with high irrigation incidences and low agricultural productivity	41
12	Urban and UT districts with little agriculture and missing or patchy data	25

As can be seen above, the clustering has been done on the basis of the combination of technical parameters as well as geographical parameters, resulting in 12 clusters that have an overlap of districts. Accordingly, it was identified that the 540 districts of India are categorized under 43 unique cluster combinations, representing the varied geographic and hydrogeologic conditions prevalent across India as highlighted below:

Table 5: Unique Cluster Combinations outlined in the IWMI-Tata Policy Paper

S. No.	Cluster combination	No. of Districts	No. of Districts to be selected
1	1.	54	5
2	2.	9	1
3	3.	8	1
4	4.	44	4
5	5.	13	1
6	6.	35	4
7	7.	42	4
8	8.	-	-
9	9.	76	7
10	10.	10	1
11	11.	8	1
12	12.	25	2
13	1 and 2	13	1
14	1 and 3	4	0
15	1 and 7	25	3
16	1,2 and 7	9	1
17	1,2,6 and 7	1	0
18	1,3 and 7	6	1
19	2 and 7	3	0
20	2,6 and 7	1	0
21	3 and 6	1	0
22	3 and 7	5	0
23	4 and 6	11	1
24	4 and 7	8	1
25	4 and 10	17	2
26	4 and 11	9	1
27	4,6 and 10	12	1
28	4,6 and 11	2	0
29	5 and 6	2	0

¹⁴ As per the policy paper, it is difficult to quantify the potential for wastewater irrigation at the district level and hence Cluster 08 is not defined by selecting specific districts

S. No.	Cluster combination	No. of Districts	No. of Districts to be selected
30	5 and 7	7	1
31	5 and 10	1	0
32	5 and 11	1	0
33	5,6 and 7	1	0
34	5,6 and 11	1	0
35	5,7 and 11	1	0
36	6 and 7	18	2
37	6 and 10	8	1
38	6 and 11	15	1
39	6,7 and 10	3	0
40	6,7 and 11	3	0
41	7 and 9	24	2
42	7 and 10	3	0
43	7 and 11	1	0
	Total	540	50

To ensure uniform representation across India, it was decided that the 50 districts for the estimation of excess energy shall be chosen from each cluster combination in proportion to the districts in each cluster combination as highlighted in the table above. Accordingly, 50 districts are selected from 25 unique cluster combinations as highlighted in Table 2. The districts from each cluster combination are selected based on the relatively high level of farm mechanization¹⁵ (i.e., in each cluster combination, the districts with relatively high farm mechanization have been selected on basis of the requirements in Table 2). 50 districts have been shortlisted from 11 states as highlighted below ensuring maximum diversity and representing varying geographical conditions across the country.

Table 6: States and districts shortlisted based on the IWMI-Tata Policy Paper

S. No.	States	Shortlisted Districts
1	Arunachal Pradesh	Dibang Valley, East Kameng, Lohit, East Siang
2	Assam	Hailakandi, Cachar, Dhubri
3	Gujarat	Patan, Surat, Rajkot
4	Haryana	Yamuna Nagar
5	Himachal Pradesh	Bilaspur, Una, Kullu, Kangra
6	Madhya Pradesh	East Nmar, Mandsaur, Gwalior, Katni, Ujjain
7	Odisha	Dhenkanal
8	Tamil Nadu	Madurai, Karur, Tiruchirappalli, Thiruvallur, The Nilgiris, Chennai, Vellore
9	Telangana	Khammam, Hyderabad, Adilabad, Mahbubnagar, Nizamabad
10	Uttar Pradesh	Sonbhadra, Chitrakoot, Balrampur, Sant Ravi Das Nagar (bhadohi), Allahabad, Kushinagar, Meerut, Deoria, Farrukhabad, Ghaziabad, Varanasi, Pratapgarh, Lucknow, Gorakhpur
11	Rajasthan	Jaipur, Rajsamand, Sawai Madhopur

The purpose of shortlisting selected districts and states is to ensure that the selected districts represent the varied geographical, geological, and climatic conditions across India. Accordingly, 50 districts across 11 states have been shortlisted based on the analysis highlighted above.

¹⁵ The district-wise level of farm mechanization value has been taken from the Council on Energy, Environment and Water's (CEEW) report, – 'The Solar Pump tool' (<https://portal.ceew.in/solar-pumps/explore/>) and represents the numbers of tractors, threshers, and harvesters per hectare of land.

During the discussion with MNRE and GIZ, MNRE suggested that weightage may be given to states with necessary policy interventions for SWPS and also states with a higher number of SWP installations and demand submitted for the PM-KUSUM Scheme. The current project involves developing a roadmap to promote the deployment of USPCs across India wherein the various state-level policy interventions for the promotion of SWPs/USPC shall be studied in detail. Accordingly, the current framework considered the cumulative installations of standalone Solar pump sets and sanctioned capacity of standalone solar-powered agricultural pumps under the Component B of the PM-KUSUM scheme for shortlisting the states as highlighted in Annexure-1: .

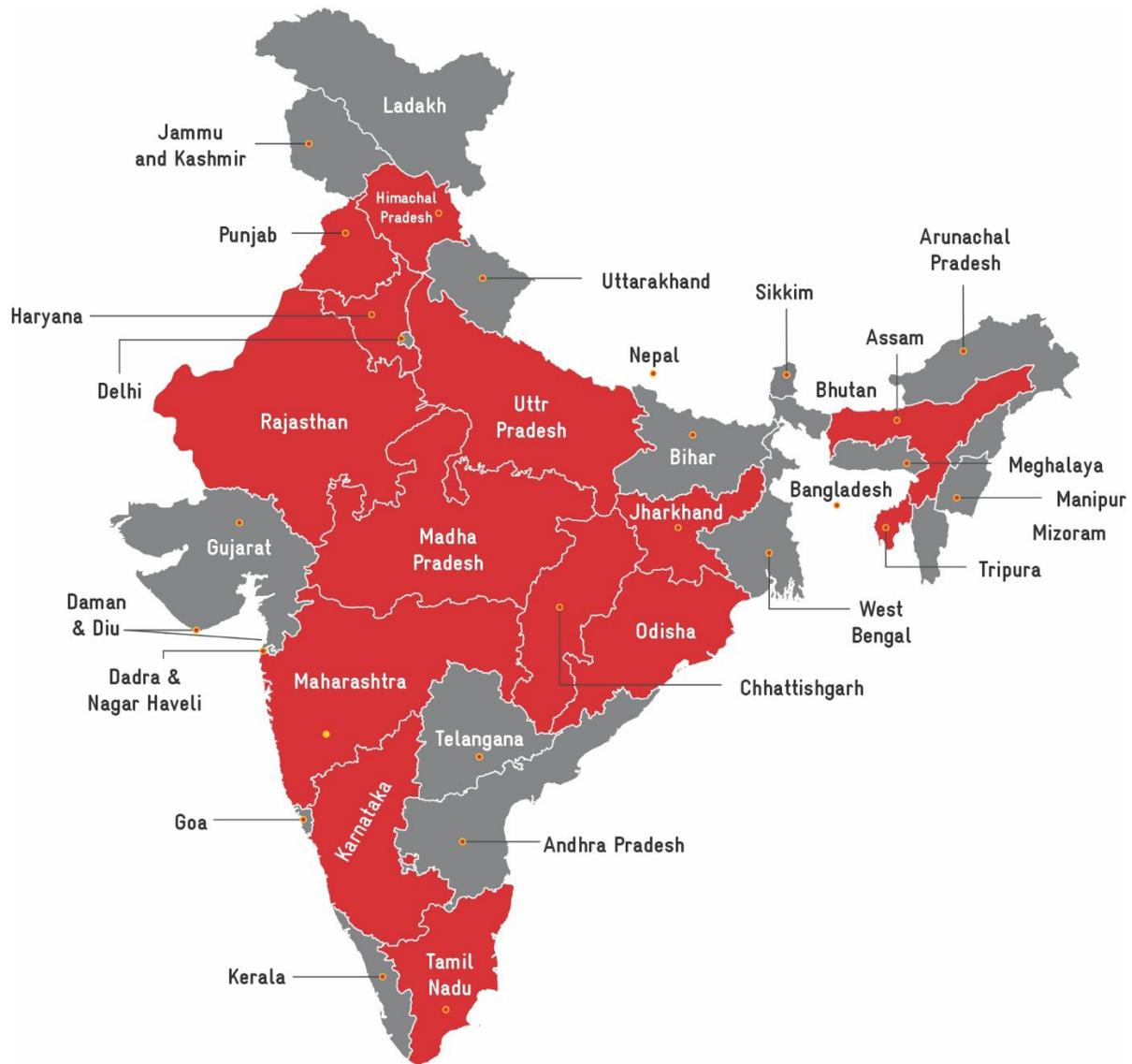
The states are arranged in descending order of the summation of current installations and future demand of standalone solar water pumps (Component B of PM-KUSUM scheme) to outline leading states with high potential for standalone SWP and accordingly having a higher potential for the uptake of USPC. Andhra Pradesh, despite being amongst the top 10 states for standalone SWP potential, is not considered for the study because of the fact that no new capacity of standalone SWPs has been sanctioned under the component B of the PM-Kusum scheme.

The states that are common between the states selected as per analysis conducted in² the IWMI-Tata policy paper as shown in [Table 6](#) and top states exhibiting high demand are shortlisted for the study as highlighted in [Table 7](#):

Table 7: List of states shortlisted for the study ensuring diversity and future demand potential

S. No.	States	Rationale
1	Rajasthan	The states have been selected as they are common between the states selected on basis of the IWMI-Tata policy paper analysis and top states exhibiting high demand potential.
2	Madhya Pradesh	
3	Uttar Pradesh	
4	Haryana	
5	Odisha	
6	Assam	
7	Tamil Nadu	
8	Himachal Pradesh	
9	Gujarat	
10	Maharashtra	The states have been selected as they are amongst the top states with a high number of cumulative installations of off-grid SWPs and future demand of standalone SWPs under the PM-KUSUM schemes, thereby indicating high potential for USPC.
11	Chhattisgarh	
12	Karnataka	
13	Jharkhand	
14	Punjab	
15	Tripura	The state has witnessed a huge surge in the demand sanctioned under the PM-KUSUM scheme in comparison to the current installations of standalone SWPs and accordingly has a higher potential for the uptake of USPC in the future.

Figure 43: List of states selected for the study



The 50 districts have been selected from the above 15 states on basis of the following:

- The number of districts selected from each cluster combination is in proportion to the total districts in each cluster combination as listed in [Table 5](#)
- In each cluster combination, districts with relatively high farm mechanization are selected
- Districts with close proximity are not considered to ensure diversity and varied geographical conditions among selected districts

Accordingly, the following states and districts were selected for the study:

Table 8: List of districts selected across 15 states for the estimation of excess energy

Sl. No.	State	No. of districts selected	Name of the district	Cluster combination	Farm mechanization value
1	Rajasthan	3	Jaipur	4	0.57
			Rajsamand	4	0.76
			Sawai Madhopur	4	0.62
2	Madhya Pradesh	4	East Nimar	3	0.15
			Mandsaur	7	0.31
			Gwalior	6	0.38
			Ujjain	4 and 7	0.32
3	Uttar Pradesh	6	Varanasi	4 and 11	1.26
			Kushinagar	6	1.18
			Sonbhadra	1	0.69
			Ghazipur	11	0.7
			Pratapgarh	4 and 6	0.86
			Meerut	10	0.48
4	Haryana	2	Yamuna Nagar	4,6 and 10	0.52
			Kaithal	4 and 10	0.14
5	Odisha	3	Dhenkanal	1,2 and 7	0.51
			Jagatsinghapur	6	1.06
			Rayagada	7	0.08
6	Assam	2	Hailakandi	1	0.03
			Karbi Anglong	7 and 9	0.02
7	Tamil Nadu	4	Madurai	6 and 7	1.34
			Thiruvarur	6 and 11	0.57
			The Nilgiris	9	0.07
			Chennai	12	NA
8	Himachal Pradesh	4	Una	9	0.15
			Kullu	9	0.06
			Kangra	9	0.06
			Solan	9	0.06
9	Maharashtra	5	Ratnagiri	1	0.43
			Washim	1 and 7	0.18
			Bhandara	7	0.09
			Pune	1, 3 and 7	0.14
			Mumbai (Suburban)	12	NA
10	Chhattisgarh	2	Mahasamund	1 and 7	0.79
			Bilaspur	6 and 7	0.26
11	Karnataka	5	Bidar	1	0.10
			Kodagu	9	0.14
			Uttara Kannada	7	0.03
			Tumkur	5 and 7	0.29
			Bagalkote	5	0.24
12	Jharkhand	3	Purbhi Singhbhum	1	0.68
			Lohadarga	2	0.68
			Dhanbad	1 and 2	2.95

Sl. No.	State	No. of districts selected	Name of the district	Cluster combination	Farm mechanization value
13	Punjab	2	Fatehgarh Sahib	4 and 10	0.20
			Muktsar	6 and 10	0.07
14	Tripura	2	Dhalai	9	0.00
			South Tripura	9	0.00
15	Gujarat	3	Panch Mahals	1	0.19
			Surat	6	0.33
			Rajkot	7	0.31

The framework for shortlisting states and districts will be validated and finalized based on the comments/inputs received from the MNRE and GIZ team.

Annexure-3: Framework for the estimation of unutilized excess energy

Background

Solar Water Pumps (SWPs) are steadily gaining ground in response to the subsidy support being provided under various central and state government schemes. While Standalone SWPs are already being deployed across India, new grid connected SWP models are also being promoted to enable additional income to farmers through the sale of surplus solar power generated by these pumps. The deployment is expected to increase multifold with the roll-out of MNRE’s Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM KUSUM) which has three components targeting both on and off grid solar pumping.

This solarization of agriculture pumps under Component B of the PM-KUSUM scheme will lead to the creation of a solar PV capacity of over 9,600 MW¹⁶. It is estimated that these pumps are typically utilized for only 100-150 days¹⁷ in a year, thereby not utilizing the solar energy generated during the remaining days of the year.

Universal Solar Pump Controllers (USPC) have the potential to reduce/avoid this loss of solar energy and use the unutilized energy for alternate applications. USPC helps to utilize the solar power to a maximum by using the excess generated power during non-irrigation time for different productive uses like operating chaff cutters, floor mills, cold storages, driers, battery chargers, etc. This not only increases the utilization of the asset, but also aids in increasing the income of the farmer.

The Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), a federal enterprise based in Germany is providing technical assistance to the MNRE as part of the Promotion of Solar Water Pumps (PSWP) component of the IGEN project with the objective to ensure that solar pumps for productive use are rolled out more rapidly through a multi-level and multi-actor approach. In this regard, GIZ has invited a tender and selected KPMG to ‘Develop business models and strategies for large scale uptake of universal solar pump controller’.

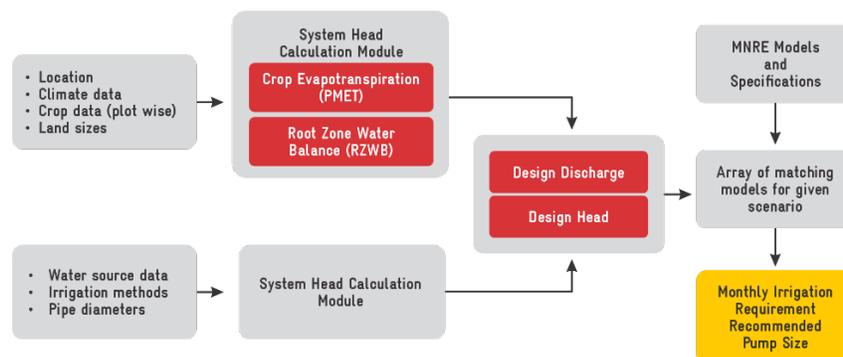
Given this background, the objectives of this assignment are as follows:

- To understand the different issues, benefits and challenges in the adoption of USPC
- To identify probable solutions and directions for large scale uptake of USPC
- To identify business models to make USPC affordable to farmers

Methodology for estimation of surplus energy

ICAR, GIZ, CCAFS and IWMI have developed a tool, viz. **Solar Irrigation Pump Sizing (SIPS) Tool**, for estimating the optimal solar pump capacity at a given location in India. The tool intends to increase the understanding of factors that drive farmers’ irrigation demand, pumping behavior, and ultimately recommends ‘pump size’ and monthly irrigation requirement based on the various factors highlighted in the **Figure 44**. The tool considers specifications laid down by the MNRE for standalone Solar water pumping systems (SWPs).

Figure 44: General architecture of the Microsoft (MS) Excel based SIPS tool¹⁸



¹⁶ PM KUSUM scheme guidelines

¹⁷ <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1672580>

¹⁸ Solar Irrigation Pump Sizing (SIPS) Tool User Manual V1.0- December 2021

- The tool divides the country into gridded spatial data on soil (Soil texture, wilting point, etc.) and climatic conditions (maximum temperature, minimum temperature, rainfall) at the resolution of 0.5^o latitude X 0.5^o longitude
- The user is required to select a location of his/her choice to install the SWP by selecting the preferred colored grid
- Further, users need to provide the ‘Cropping system details’ viz. select the type of crop to be sown (user can select eight crops at maximum), sowing area, plantation date and month, and type of irrigation systems (drip, sprinkler etc.) intended to be used for each plot
- For estimating the system head requirement, the user is required to enter the depth of pumping water level/tube well, the distance from the water source to the field, the elevation of the highest point in the field, the diameter of the pipe, the SWP type, etc.
- Below table shows the various data requirements i.e., input parameters to be entered by the user and also embedded parameters considered by the SIPS tool

Table 9: Inputs considered for estimating the optimal SWP capacity using SIPS tool

User inputs to the tool	
Location	Selected directly on the map of India
Crop data	Type of crop, cropped area, planting date, planting month
Irrigation system	Type of water source (well, pond, stream, river etc.), depth of water table (in case of groundwater sources), depth of the water level, type of irrigation system, number of days for irrigation in a month
Data Embedded in the tool	
Soil	Soil texture, field capacity, wilting point, saturation percentage and infiltration rate, percolation rate
Spatial reference	Longitude, elevation, latitude
Climate	Maximum temperature, minimum temperature, rainfall
Irrigation system	Operating heads for different irrigation methods

- Based on the input values, the SIPS tool provides outputs as the optimal capacity and type of solar pumps in the form of the MNRE’s model number, motor capacity (HP), operational head (M), shutoff head (M), discharge (LPD) and required panel capacity of the model and the finally selected model.
- The tool also provides the monthly water requirements based on the crop selected for the given location.

Based on the output of the tool (SWP capacity and monthly irrigation requirement), the excess energy unutilized by the SWP shall be estimated as highlighted below.

Estimation of Excess Energy unutilized by SWP

- The excess energy is calculated by subtracting the energy consumed by the solar water pump for irrigation purpose from the energy generation by solar panels during a year
- The excess energy unutilized by the SWP is calculated on a monthly basis

Figure 45: Computation of Excess Energy Generation



➤ **Solar Energy Generation:**

- Solar energy generation mainly depends on two factors, namely solar panel capacity and solar irradiation.
- The optimal capacity of pump sets estimated by the SWP tool aids in determining the Solar Panel capacity in accordance with the specifications issued by the MNRE.
- Solar irradiation is the total amount of solar energy received at a particular location during a specified time period, often in units of kWh/m²/day. Solar Irradiance varies from month to month. Hence the average monthly solar irradiation is considered for the computation of monthly solar energy generation.
- The solar energy generation is computed separately for each month.

➤ **Energy consumption for irrigation purposes:**

- Similar to solar energy generation, the energy consumption by pump is computed separately for each month of the year.
- The number of hours of solar operation is determined based on the average monthly water irrigation requirement derived from the SIPS tool (based on water output as per MNRE specifications).
- It is assumed that during the non-cropping months (where monthly water requirement is nil) the farmer utilizes ~10% of solar energy generated for allied activities.

The energy consumed by pump usage when deducted from solar energy generated during the year, will give the excess energy generation.

The Methodology for the estimation of surplus energy will be validated and finalized based on the comments/inputs received from the MNRE and the GIZ team.

Working with an Excel based tool to estimate surplus energy

The step by-step procedure to estimate the excess energy generated and to work with the excel version of the SIPS tool and 'Excess energy Computation' tool is explained in the following section.

- Step 1: Open the excel file SIPS Tool and it will display the 'Start screen'. Click on 'Start'. This will open the 'Location' sheet.

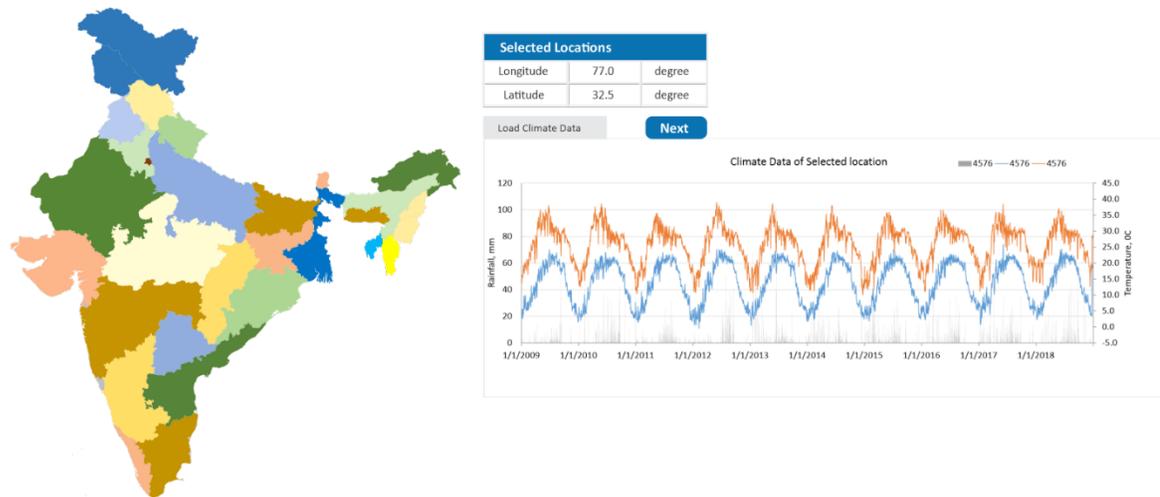
Figure 46: 'Start' Screen



➤ **Step 2: “Location” sheet**

- Select the location where the surplus energy is to be estimated, by clicking within the colored grid. Here the boundaries of the states are marked in different colors. The latitude and longitude of the ‘selected location’ will be updated automatically (*Here, we have selected the “Kullu” District of Himachal Pradesh*).
- Click on ‘Load Climate Data’. The graph will be updated with climate data of selected grid point.
- Click on ‘Next’. This will open the ‘Input’ sheet

Figure 47: ‘Location’ Sheet



➤ **Step 3: “Input” sheet**

- Select the crops from the dropdown menus (a maximum of eight crops can be selected).
- Enter the area of each plot in the ‘Area’ column (based on the average landholding size of the selected district). The area is in the units of ‘acre’.
- Enter the planting date of each crop in ‘Planting date’.
 - Against each planting date, select the month of planting from the dropdown menu.
 - Select the irrigation systems for each plot from the dropdown menu in the column ‘Irrigation system’.
 - The operational head of the selected system will be updated automatically in the last column ‘Operating head’.
 - Click ‘NEXT’. This will open the irrigation water requirement ‘IWR’ page.

Figure 48: ‘Input’ Sheet

Cropping System Details						
Enter data in these cells only						
Sl.No.	Crop	Area, acre	Planting date	Planting month	Irrigation system	Operating Head,m
Crop 1	Soybean	1.28	20	Apr	Micro-sprinklers	12
Crop 2	Lentil	1.28	10	Oct	Surface/flood	3
Crop 3	Bean/green	1.28	15	Jun	Surface/flood	3
Crop 4	none	0	10	Feb	Surface/flood	3
Crop 5	none	0	10	Mar	Surface/flood	3
Crop 6	none	0	10	Apr	Surface/flood	3
Crop 7	none	0	10	May	Surface/flood	3
Crop 8	none	0	10	Jun	Surface/flood	3

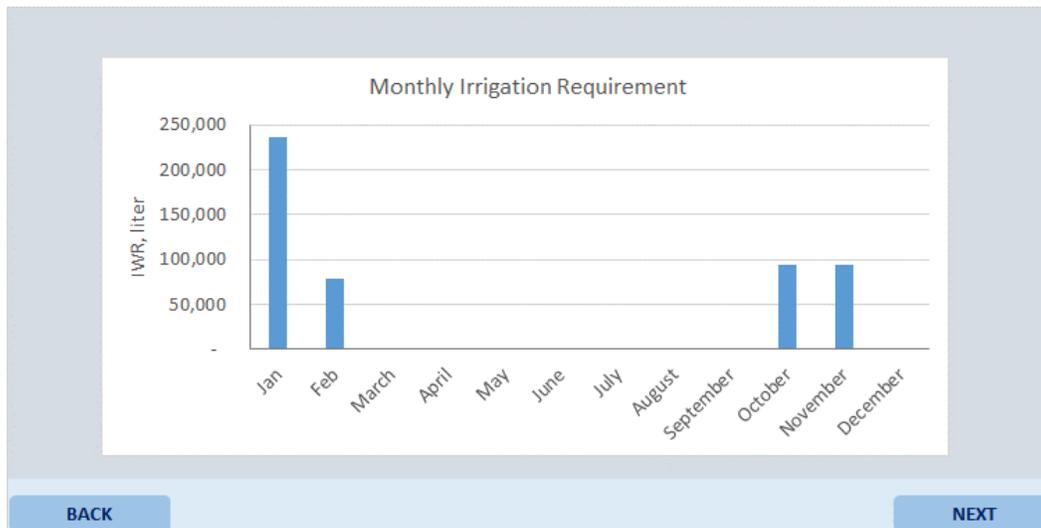
BACK

NEXT

➤ **Step 4: 'IWR' sheet**

- This sheet provides the visual presentation of the monthly irrigation water requirement of all the crops in a cropping sequence (*Utilized in assessment of excess energy*).
- Click 'NEXT'. This will open the system head calculation module 'SYSTEM-HEAD'.

Figure 49: 'IWR' Sheet

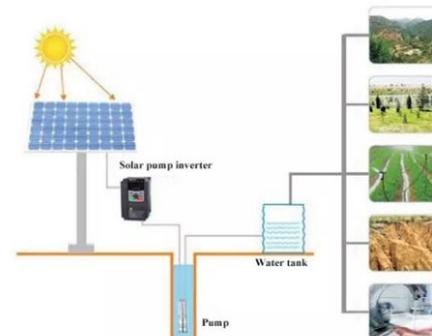


➤ **Step 5: 'SYSTEM-HEAD' sheet**

- Enter all the required data in the 'INPUTS' section of the sheet.
- Pipe diameter from source to field is the diameter of the pipe used to convey water from the water source to the field.
- Select the water source from the dropdown menu.
- Enter 'Number of days allocated for irrigation in a month'. This field denotes the actual number of days on which irrigation is to be done. This is the same for all months.
- The last row of the 'OUTPUT' section is the total system head. It includes all the elevation head, friction head and geodetic head.
- Click 'NEXT'. It will open the sheet 'RESULTS'.

Figure 50: 'SYSTEM-HEAD' sheet

System head requirement		
INPUTS		
Parameter	Enter data here	Unit
Depth to pumping water level (Total depth of tube well if source is tube well)	15	m
Distance from source to field	50	m
Pipe diameter from source to field	75	mm
Water Source	Tubewell	
Number of days allocated for irrigation in a month	22	days
OUTPUT		
Estimated total head requirement		
Head component	Head, m	
Depth To Water level, m	14.3	
Head required for irrigation system, m	12.0	
Frictional Head Loss, m	0.0	
Total System head, m	26.3	



➤ **Step 6: The 'Results' sheet**

- Enter the choice of pump type as 'AC' or 'DC'.
- Based upon the inputs, the 'SIPS tool Results' will be updated automatically.

- The section ‘SIPS tool Results’ provides the type of solar water pump along with the capacity (in HP). *(Utilized in assessment of excess energy)*

Figure 51: ‘Results’ sheet

Input for Futuristic Senarios		Enter data here
I	Farmers choice of Pump type	AC
III	Increased irrigation requirement scenario, %	20%
V	Increased Depth to Water Level, %	15%
VI	Target Discharge Scenario, lpd	150,000

Pump Sizing Results										
	Scenario	Design Discharge litre per day	Design Head Meter	Category	Model	Pvarray_Wp	Motor HP	Head, m	Shutoff head, m	Discharge, LPD
Scenario - I	Base Scenario	10,739	26.3	Submersible	Model-I	1200	1	30	45	42,000
Scenario - III	Scenario A Increased irrigation requirement	12,886	26.3	Submersible	Model-I	1200	1	30	45	42,000
Scenario - V	Scenario B Increased Depth to Water Level	10,739	28.4	Submersible	Model-I	1200	1	30	45	42,000
Scenario - VI	Scenario C Target Discharge Scenario	150,000	27.7	Submersible	Model-XII	9000	10	50	70	189,000

BACK

- **Step 7: Open the excel file EXCESS ENERGY COMPUTATION and it will display the ‘Key Inputs’ Sheet.**
 - As entered in the SIPS Tool, Select the state and corresponding district from the dropdown menu.
 - The water table depth for the selected district will be updated automatically.
 - Select the type of SWP and corresponding capacity from the dropdown menu *(based on the result shown in the SIPS Tool)*.
 - The average land holding (in hectare) of the selected district will be updated automatically in the ‘Area Under Irrigation’ row.

Figure 52: ‘Key Inputs’ Sheet

Key Inputs (Please select desired inputs from dropdown)	
Particular	Value
State	HimachalPradesh
District	Kullu
Water Table Depth (mts.)	8.47
Type of Pump	Submersible Pumps
Pump capacity (HP)	1
Area Under Irrigation (acres)	1.28

To be input by user

To be input by user

To be input by user from IWMI Tool

To be input by user from IWMI Tool

- **Step 8: Enter ‘Cropping System Details’**
 - Now, similar to the SIPS Tool, select the desired crops from the dropdown menus.
 - Enter the plantation date of each crop in ‘Sowing date’.
 - Select the proposed irrigation systems for each plot from the dropdown menu.

Figure 53: ‘Cropping System Details’

Cropping System Details (Please select desired inputs from dropdown)			
Particular	Crop	Sowing Date	Irrigation System
Crop 1	Maize, grain	20-Jul-21	Micro-sprinklers
Crop 2	Wheat	10-Nov-21	Surface/flood
Crop 3	none	15-Oct-21	Surface/flood
Crop 4	none	10-Feb-21	Surface/flood
Crop 5	none	10-Mar-21	Surface/flood
Crop 6	none	10-Apr-21	Surface/flood
Crop 7	none	10-May-21	Surface/flood
Crop 8	none	10-Jun-21	Surface/flood

To be input by user

➤ **Step 9: Enter ‘Monthly Irrigation Requirement’**

- Enter the monthly water requirements as provided in the ‘IWR’ sheet of the IWMI Tool.
- Open the ‘Calculation’ sheet.

Figure 54: ‘Monthly Irrigation Requirement’

Monthly Irrigation Requirement	
Particular	Water Requirement (Liters)
Jan	236,251
Feb	78,927
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	94,607
Nov	94,606
Dec	-

To be input by user from IWMI Tool
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➤ **Step 9: ‘Calculation’ Sheet**

- Here, based on the SWP capacity selected, ‘Solar AC Capacity’ will be updated automatically.
- Enter all the required data in the ‘Capacity Utilization Factor (CUF) Calculation’ section of the sheet.
- Based upon the inputs, the ‘Energy Generation’, ‘Energy Consumption’ and ‘Excess Energy Generation’ will be updated automatically.

Figure 55: ‘Calculation’ Sheet

State selected	HimachalPradesh												
District	Kullu												
Energy Generation													
CUF calculation													
Description	Units	Value											
Solar AC Capacity	KW	1.2											
DC to AC Ratio		1											
To be input by user													
Module Capacity	Wp/m ²	200											
Module Efficiency	%	18%											
Ambient Temperature	oC	35.00											
Temperature Coefficient	%	0.35%											
Controller Efficiency	%	96%											
Other Technical losses (soil losses)	%	3%											
To be input by user													
To be input by user													
To be input by user													
To be input by user													
To be input by user													
To be input by user													
Description	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of Days	No.s	31	28	31	30	31	30	31	31	30	31	30	31
Avg. Monthly Irradiation	kWh/m ² /day	4.67	4.65	5.98	6.3	6.67	6.4	5.36	5.49	6.02	6.5	5.63	4.96
CUF	%	16%	16%	20%	21%	22%	22%	18%	19%	20%	22%	19%	17%
Total Energy Generation	KWh/Month	140.50	126.36	179.91	183.42	200.67	186.34	161.26	165.17	175.27	195.56	163.92	149.22
Energy Consumption													
Description	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of hours	Hours	45.00	15.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.02	18.02	0.00
Energy consumed by the pump	KWh/Month	33.53	11.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.43	13.43	0.00
Energy utilized for allied Activities (During non-cropping season)	KWh/Month	0.00	0.00	17.99	18.34	20.07	18.63	16.13	16.52	17.53	0.00	0.00	14.92
Total Energy Consumption	KWh/Month	33.53	11.20	17.99	18.34	20.07	18.63	16.13	16.52	17.53	13.43	13.43	14.92
Excess Energy Generation													
Excess energy utilized	KWh/Month	106.97	115.16	161.92	165.08	180.60	167.70	145.13	148.65	157.74	182.13	150.49	134.30

Annexure-4: Estimation of excess energy that remains unutilized across each district.

S. No.	State	District	SWP capacity	Excess generation													Total Solar generation (kWh)	% of excess energy
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
1	Uttar Pradesh	Sonbhadra	5.0	201	214	422	416	-	-	371	438	423	257	-	-	2,742	5,073	54%
2	Assam	Hailakandi	10.0	865	528	179	-	-	325	798	707	794	481	434	616	5,728	10,043	57%
3	Maharashtra	Ratnagiri	10.0	391	233	-	-	-	932	1,068	894	978	1,002	1,088	698	7,284	13,347	55%
4	Karnataka	Bidar	7.5	-	531	987	1,030	1,023	815	720	648	392	359	-	-	6,505	10,042	65%
5	Jharkhand	Purbhi Singhbhum	10.0	-	-	-	819	199	265	764	866	35	861	838	251	5,697	10,018	57%
6	Gujarat	Panch Mahals	10.0	494	461	407	-	-	658	988	1,001	958	981	943	670	7,561	11,453	66%
7	Jharkhand	Lohadarga	10.0	192	-	260	836	-	227	830	879	849	876	853	202	6,003	10,195	59%
8	Madhya Pradesh	West Nimar	10.0	255	633	208	-	-	568	989	1,003	879	494	-	415	5,444	11,496	47%
9	Rajasthan	Rajsamand	10.0	425	210	211	-	-	-	857	953	914	700	-	504	4,774	11,030	43%
10	Rajasthan	Sawai Madhopur	10.0	271	137	-	-	-	-	610	831	799	500	149	347	3,644	9,639	38%
11	Madhya Pradesh	Indore	10.0	319	766	533	-	-	465	954	927	888	511	-	237	5,601	11,093	50%
12	Madhya Pradesh	Rajgarh	10.0	401	671	533	-	-	392	914	893	822	364	-	261	5,252	10,700	49%

S. No.	State	District	SWP capacity	Excess generation													Total Solar generation (kWh)	% of excess energy
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
13	Karnataka	Bagalkote	10.0	-	670	1,359	1,391	1,380	1,076	957	980	593	-	-	-	8,407	13,554	62%
14	Gujarat	Surat	10.0	329	341	359	-	-	730	1,025	1,032	985	1,006	965	604	7,376	11,766	63%
15	Odisha	Jagatsinghapur	5.0	228	175	382	191	-	290	470	486	469	370	225	145	3,430	5,633	61%
16	Uttar Pradesh	Kushinagar	1.0	29	33	79	78	-	-	67	74	65	-	-	-	425	949	45%
17	Karnataka	Koppal	10.0	-	544	1,093	1,094	1,098	1,086	1,135	939	631	-	-	-	7,621	13,177	58%
18	Karnataka	Uttara Kannada	2.0	66	119	240	240	242	237	248	248	136	123	136	122	2,158	2,868	75%
19	Maharashtra	Bhandara	10.0	391	587	557	735	341	649	811	823	984	1,131	994	594	8,597	12,773	67%
20	Odisha	Rayagada	5.0	163	78	296	199	182	399	499	531	497	485	277	-	3,606	6,126	59%
21	Rajasthan	Sabarkantha	10.0	545	241	365	-	-	255	905	986	950	718	347	573	5,885	11,562	51%
22	Himachal Pradesh	Kangra	5.0	248	363	549	560	211	598	600	579	588	578	260	276	5,411	6,446	84%
23	Tripura	South Tripura	1.0	60	21	58	117	-	29	112	119	115	105	56	48	839	1,400	60%
24	Himachal Pradesh	Kullu	1.0	55	104	153	150	-	148	143	138	112	104	61	67	1,236	1,691	73%
25	Tamil Nadu	The Nilgiris	5.0	323	180	485	668	618	514	480	505	550	540	485	487	5,836	6,890	85%

S. No.	State	District	SWP capacity	Excess generation													Total Solar generation (kWh)	% of excess energy
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
26	Himachal Pradesh	Una	10.0	494	732	1,125	1,157	457	393	933	1,032	1,079	1,100	849	687	10,037	12,661	79%
27	Tripura	Dhalai	1.0	28	37	72	157	-	54	130	135	128	125	70	32	969	1,602	60%
28	Karnataka	Kodagu	10.0	-	446	1,163	1,168	1,185	1,176	1,106	1,225	1,175	1,206	1,164	-	11,013	14,112	78%
29	Himachal Pradesh	Solan	10.0	441	545	710	176	-	429	633	458	264	285	344	332	4,617	8,405	55%
30	Uttar Pradesh	Meerut	5.0	196	304	328	322	-	-	231	334	323	139	-	99	2,277	3,910	58%
31	Uttar Pradesh	Ghazipur	2.0	37	80	127	125	-	-	91	131	108	-	-	-	699	1,525	46%
32	Tamil Nadu	Chennai	2.0	171	50	159	273	247	149	141	122	153	155	140	182	1,943	2,626	74%
33	Maharashtra	Mumbai (Suburban)	7.5	230	183	162	-	-	564	814	816	746	664	768	496	5,443	9,315	58%
34	Jharkhand	Dhanbad	5.0	-	-	381	694	666	548	495	512	499	525	463	174	4,957	6,390	78%
35	Maharashtra	Washim	10.0	425	128	-	-	-	635	991	1,002	816	617	956	613	6,184	11,520	54%
36	Chhattisgarh	Mahasamund	10.0	522	683	761	459	-	-	954	963	929	925	666	516	7,378	11,107	66%
37	Maharashtra	Pune	10.0	564	394	308	348	-	808	1,093	1,097	1,050	1,078	1,040	762	8,543	12,573	68%

S. No.	State	District	SWP capacity	Excess generation													Total Solar generation (kWh)	% of excess energy
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
38	Odisha	Dhenkanal	5.0	197	232	534	383	187	334	450	480	492	411	218	-	3,918	6,417	61%
39	Haryana	Ambala	10.0	417	444	704	689	678	654	685	692	671	650	-	-	6,284	8,252	76%
40	Uttar Pradesh	Farrukhabad	1.0	60	52	90	89	-	-	75	87	84	67	-	-	604	1,037	58%
41	Uttar Pradesh	Varanasi	1.0	39	55	86	85	-	-	82	84	86	58	-	-	574	1,029	56%
42	Uttar Pradesh	Pratapgarh	2.0	68	101	135	133	-	-	121	131	135	35	-	-	859	1,621	53%
43	Madhya Pradesh	Shajapur	10.0	299	741	513	-	-	367	918	894	740	370	-	223	5,065	10,719	47%
44	Haryana	Yamuna Nagar	7.5	307	486	525	515	510	494	522	535	518	441	-	-	4,853	6,247	78%
45	Karnataka	Tumkur	5.0	162	343	612	613	619	611	637	637	397	538	516	226	5,911	7,386	80%
46	Odisha	Puri	5.0	181	110	402	140	-	265	487	506	488	359	180	-	3,119	5,887	53%
47	Tamil Nadu	Thiruvarur	5.0	369	248	457	698	663	502	329	171	389	444	449	478	5,197	7,193	72%
48	Chhattisgarh	Bilaspur	10.0	556	818	1,229	841	308	445	852	858	947	1,081	704	371	9,008	12,511	72%
49	Tamil Nadu	Madurai	1.0	52	-	60	145	146	125	62	-	39	113	145	132	1,020	1,740	59%
50	Assam	Karbi Anglong	2.0	163	-	-	101	159	154	160	-	155	146	-	46	1,082	1,890	57%

Annexure-5: Stakeholder Questionnaire

SWP Manufacturers Questionnaire

1. Respondent Details

1.1 Name	
1.2 Designation	
1.3 Name of Unit and Address, Website	
1.4 States with active presence	
1.5 Phone Number	
1.6 E-mail	
1.7 Date of Interview	
1.8 Experience of providing USPC with SWP	Yes / No
1.9 If yes, years of experience	

2. General Information About SWP Components Manufactured

2.1 From when is your company manufacturing the components of Solar Water Pumping systems (SWPS)?
(This is supposed to seek total no. of years the respondent's firm has been manufacturing the components of the SWP for. E.g., 3 years)

2.2 Please provide the details of the components manufactured by your firm?

2.3 What are the various types (surface mounted/submersible)/ (AC/DC)/ capacities of SWP's for which the components are manufactured by you?
(This is supposed to seek the details such as SWP capacity (in HP), corresponding type of equipment i.e., surface mounted or submersible, AC/DC, etc. for which the compatible component is manufactured by the respondent's firm, e.g. – 3,5 and 10 HP capacity SWP, etc.)

2.4 What is the typical cost of a SWP unit (for various solar pump capacities)?
(This is supposed to seek information on typical capacity wise cost of the total SWP unit from the respondent)

SWP Capacity (HP)	Price (Rs.)
1	
2	
3	
5	
7.5	
10	

2.5 Have you done any installations of SWP with USPC? If yes, kindly share the details of the same?
(This is supposed to seek from the respondent whether they have installed SWP with USPC. If yes, seek the corresponding information on the same)

2.6 If the answer to Q2.5 is yes, please provide the information on whether the USPC is in-house manufactured or procured from outside?
(This is supposed to seek from the respondent information on where the USPC is sourced viz. either it is manufactured by the respondent's firm or it is sourced from other manufacturer's)

2.7 If the answer to Q2.6 is 'USPC is procured from outside', what are the reasons for not manufacturing the USPC in-house?
(This is supposed to seek from the respondent the reason for not manufacturing the USPC in-house)

2.8 If the answer to Q2.5 is 'USPC is procured from outside', please provide the contact details of the USPC manufacturers?
(This is supposed to seek from the respondent the contact details of the USPC manufacturer from which the USPC is procured by the respondent)

2.9 If the answer to Q2.5 is yes, please provide the technical details of the USPC?
(This is supposed to seek from the respondent the reason for not manufacturing the USPC in-house)

S.No.	Input Parameter	Details	Output Parameter	Details
	Input Voltage Range (V_{OC} (Open Circuit) and V_{MIN})		Output Voltage Range	
	Input Frequency Range		Output Frequency Range	
	Input Current Range		Output Current Range	
	Efficiency	At V_{min}	At $V_{nominal}$	At 90% V_{oc}
	(i) 10% of max load			
	(ii) 25% of max load			
	(iii) 50% of max load			
	(iv) 75% of max load			
	(v) 100% of max load			
	Waveform (@min 300W/M2)			

2.10 What are the steps to be taken (cost/policy/awareness/connectivity of more equipment etc.) to accelerate USPC adoption?
(This is supposed to seek from the respondent what the steps are to be taken, based on their experience, by central and state govts. to accelerate USPC adoption (such as higher subsidies, awareness creation, modifying technical specifications to suit certain requirements etc.))

-
-
- 2.11 What are the key bottlenecks in accelerating the adoption of USPC?
(This is supposed to seek the major bottlenecks/issues perceived by the respondent which lead to a slower uptake of USPC (e.g. – low awareness among the farmers, etc.).
-
-
- 2.12 What are the alternative ways to optimally utilize the excess energy generated by the SWP?
(This is supposed to seek alternative ways apart from using the USPC, in which the excess energy generated during non-irrigation hours by the SWP can be utilized).
-
-
- 2.13 Please explain the difference in the performance of solar water pumps with USPC vis-a-vis a normal controller?
(This is supposed to seek information on the question if the performance of Solar water pump is impacted by the use of USPC against the normal SWP controller)
-
-
- 2.14 Please highlight the key components of USPC that are increasing the cost of USPC vis-à-vis a normal SWP controller.
(This is supposed to seek the key components/factors/parameters which led to an increase in the price of the USPC controller as compared to a normal SWP controller as perceived by the respondent)
-
-
- 2.15 Please provide the details on any future plan to start the in-house production of USPC?
(This is supposed to seek whether the respondent's firm has any plans to start the manufacturing of USPC. If yes, seek the corresponding information on the same)
-
-

USPC Manufacturers Questionnaire

1. Respondent Details

1.1 Name	
1.2 Designation	
1.3 Name of Unit and Address, Website	
1.4 Type of Manufacturer (Original Equipment Manufacturer (OEM)/ trader/ integrator)	
1.5 States with active presence	
1.6 Phone Number	
1.7 E-mail	
1.8 Date of Interview	
1.9 Experience of providing USPC with SWP	Yes / No
1.10 If yes, years of experience	

2. General information about equipment/machineries manufactured

2.1 From when is your company manufacturing/marketing USPC for Solar Water Pumping systems (SWPS)?
(This is supposed to seek total no. of years the respondent's firm has been manufacturing/marketing USPC to be used with SWP for. E.g., 3 years)

2.2 What are the various types/models of USPCs manufactured/ marketed by you?
(This is supposed to seek the details such as USPC capacity (in HP), corresponding efficiency, etc. of the USPC manufactured/ marketed by the respondent's firm, e.g. – 3,5 and 10 HP capacity USPC, etc.)

2.3 What is the typical cost of USPC (for various solar pump capacities)?
(This is supposed to seek information on typical cost of the USPC from the respondent for e.g. – 3 HP – Rs. 42000/-, 5 HP – Rs. 80000/-, etc.)

Capacity (in HP)	For Three Phase
1	
2	
3	
5	
7.5	
10	
Maximum	

- 2.4 Please provide the details of any additions/variations included in the USPC technical specifications released by MNRE or whether the equipment is manufactured following only the MNRE specifications?
(This is supposed to seek from the respondent whether the USPC manufactured is strictly based on the technical specifications issued by MNRE or if some additional modifications have been made to enhance the compatibility of USPC with other Agri equipment's and SWP. If yes, seek the corresponding information on the same)

S.No.	Input Parameter	Details	Output Parameter	Details
	Input Voltage Range (V_{OC} (Open Circuit) and V_{MIN})		Output Voltage Range	
	Input Frequency Range		Output Frequency Range	
	Input Current Range		Output Current Range	
	Efficiency	At V_{min}	At $V_{nominal}$	At 90% V_{oc}
	(i) 10% of max load			
	(ii) 25% of max load			
	(iii) 50% of max load			
	(iv) 75% of max load			
	(v) 100% of max load			
	Waveform (@min 300W/M2)			

- 2.5 Would you like to suggest any other set of technical specifications for USPC? If yes, kindly share details and reasons of those modifications.
(This is supposed to seek from the respondent whether they would suggest any modification/changes in the technical specification issued by MNRE to make USPC more compatible with the existing equipment/machinery. If yes, seek the changes/modification suggested by the respondent in the USPC technical specifications and the reason behind that)

- 2.6 What are the major applications of USPC that can be used/witnessed by USPC manufacturers being used in tandem with solar pumps including those mentioned in the MNRE specifications?
(This is supposed to seek from the respondent the name and corresponding details of the major equipment/ machineries which can be powered with solar electricity using USPC in conjunction with the SWP (for e.g. – Chaff Cutter, Cold Storage, etc.))

- 2.7 For farmers, is there any requirement of additional equipment/cost to be incurred for connecting the equipment/machineries as cited by the respondent in Q2.6, with USPC?
(This is supposed to seek from the respondent whether any additional equipment is required, or any additional cost needs to be incurred by farmers/ villagers for powering the existing Agri equipment/ machineries with solar electricity using USPC. If yes, seek the corresponding information on the equipment/ modification suggested by the respondent)

- 2.8 What are the limitations or typical issues (technical issues, durability etc.) of USPC?
(This is supposed to seek the major limitations/issues of USPC as perceived by the respondent based on the experience of manufacturing and feedback from the existing users of USPC)

- 2.9 Based on your prior experience, is there any central or state subsidy being provided to farmers for USPC?
(This is supposed to seek information whether any subsidy is being provided by the government either state, central, or both, for purchasing the USPC from the respondent. If yes, seek information from the respondent on the quantum of the subsidy being provided by the government, either state, central, or both, for purchasing the USPC)

S.No.	Equipment Type	USPC Cost Contribution		
		Subsidy provided by Central Govt. (in %)	Subsidy provided by State Govt. (in %)	Cost borne by Farmer/user (in %)
1	USPC			

- 2.10 How many SWPs have been installed with your company's USPC so far?
(This is supposed to seek information on the number of SWP with USPC that have been installed by the respondent's firm till date)

No	SWP Capacity (HP/kW)	Price (Rs)	Quantity range			Region covered
			Year 1	Year 2	Year 3	
1						
2						
3						

- 2.11 What is the farmer's feedback on the incremental usage/cost-benefit analysis of solar PV with USPC?
(This is supposed to seek from the respondent information on the farmers' view of the incremental benefit by Powering Agri equipment's with the excess solar electricity using USPC)

Very Good Good Average Satisfactory Poor

- 2.12 What are the key bottlenecks in accelerating the adoption of USPC?
(This is supposed to seek the major bottlenecks/issues perceived by the respondent which lead to a slower uptake of USPC (e.g. – low awareness among the farmers, etc.).

- 2.13 What are the steps to be taken (cost/policy/awareness/connectivity of more equipment etc.) to accelerate USPC adoption?
(This is supposed to seek from the respondent information on what are the steps to be taken by central, state govts, based on their experience, to accelerate USPC adoption (such as higher subsidies, awareness creation, modifying technical specifications to suit certain requirements etc.))

- 2.14 Please explain in detail the key technical differences between normal SWP controllers and USPC?
(This is supposed to seek information on the major difference between the normal SWP controller and the USPC controller to have a better understanding thereof)
-
-
- 2.15 Please explain in detail if a normal SWP controller can be used to operate other Agri equipment apart from SWP?
(This is supposed to seek information on whether the normal SWP controller can be used to power other Agri equipment with solar electricity and if yes, seek the details on the same)
-
-
- 2.16 The distance between the Solar panels and the load center (non-pump load) can be substantial. What kind of distortions can it create in technical parameters like waveform?
(This is supposed to seek from the respondent in detail the impact on various technical parameters such as voltage, freq., current, etc. if the distance between the solar panels and non-pump load such as Agri equipment is substantially high)
-
-
- 2.17 What kind of enhancement in the circuit can offset the distortion as cited by the respondent in Q2.16?
(This is supposed to seek from the respondent information on the additions/modifications which can be done in the circuit to offset the impact/issues as cited by respondent in Q2.16)
-
-
- 2.18 Would you like to suggest the standardization of such features as mentioned in Q2.17?
(This is supposed to seek if the respondent suggests the standardization of additions/modifications to offset the impact/issues as cited by respondent in Q2.17)
-
-
- 2.19 In case a farmer wants to change an equipment currently connected with USPC (say the milk chiller is to be replaced with a chauff cutter), what would be the process? Can the farmer do it himself?
(This is supposed to seek information on the process that a farmer would need to follow, if he wanted to replace the Agri equipment currently being powered by USPC with some other Agri equipment (say the milk chiller is to be replaced with a chauff cutter))
-
-
- 2.20 Please highlight whether a single-phase equipment can be operated using the USPC? If yes, please provide the details of the installations, i.e., Motor capacity, location, etc. of the same?
(This is supposed to seek the information from the respondent on whether a single-phase motor can be operated using USPC. If yes, seek the details of the installations i.e., Motor capacity, location, etc.)
-
-
- 2.21 Please highlight the technical modifications undertaken for operating single-phase motors with USPC?
(This is supposed to seek information from the respondent on the modifications/improvements being done to make the single-phase motors compatible with USPC)
-
-

-
- 2.22 Please highlight the key components of USPC that are increasing the cost of USPC vis-à-vis normal SWP controllers.
(This is supposed to seek information on the key components/factors/parameters which led to the increase in the price of the USPC controller as compared to a normal SWP controller as perceived by the respondent)
-
- 2.23 Please highlight the potential actions to decrease the cost of USPC in terms of:
- a. Cost of production
 - b. Cost of service during warranty period
- (This is supposed to seek information on the suggested measures/ actions which can aid in reducing the cost of USPC production and the cost of service being provided during the warranty period)*
-
- 2.24 What is the typical production rate of USPC at your manufacturing facility?
(This is supposed to seek the production rate i.e., the quantity of USPC which can be/ is being produced in the manufacturing facility of the respondent's firm)
-
- 2.25 With a potential increase in demand/orders from various tenders, what are the future plans to expand the production of USPC?
(This is supposed to seek information from the respondent on the measures/ action being planned to increase the production of USPC and cope with the increase in demand/ orders)
-
- 2.26 As part of R&D, what are the future modifications being done to USPC to improve the efficiency/robustness/applications being operated by USPC.
(This is supposed to seek information from the respondent on the modifications/improvements being planned in the technical specification/design of the USPC to increase the efficiency/robustness/ and Agri equipment compatibility with USPC)
-
- 2.27 Please provide the details of the raw material supply chain related challenges witnessed that are hindering the manufacturing of USPC?
(This is supposed to seek details from the respondent on the key challenges/issues being faced with the raw materials supply chain (e.g. – shortage of silicon chips, etc.) which impacts the USPC production)
-
- 2.28 What measures do you suggest to mitigate the challenges as cited in Q2.27?
(This is supposed to seek details on the measures being suggested by the respondent to offset/mitigate the issue/difficulty with the raw materials supply chain as cited in Q2.27)
-

2.29 Please highlight various standards being adopted in the manufacturing of USPC.
(This is supposed to seek the details of the various standards being adopted by the respondents' firm in the manufacturing of the USPC)

2.30 What are the improvements being done to address the concerns as cited by the respondent in Q2.27?
(This is supposed to seek information from the respondent on the modifications/improvements being done to address/offset the prevalent issues as cited by the respondent in Q2.27)

2.31 Please highlight the safety requirements of the equipment (e.g. – earthing, vibration, other electronic equipment, etc.).
(This is supposed to ask the respondent to outline the typical safety requirements for the various equipment)

2.32 Please highlight the details on the Energy Monitoring feature available for your USPC device?
(This is supposed to seek from the respondent whether any energy monitoring feature is available in the manufactured USPC. If yes, seek the corresponding details on the same)

2.33 For the installation of USPC in the field, what kind of support/arrangements are required?
(This is supposed to seek from the respondent information on the support/arrangement required to install the USPC outside on the field)

Agri Equipment Manufacturers/Suppliers Questionnaire

1. Respondent Details

1.1 Name	
1.2 Designation	
1.3 Name of Unit and Address, Website	
1.4 Type of Manufacturer (Original Equipment Manufacturer (OEM)/ trader/ integrator)	
1.5 States with active presence	
1.6 Phone Number	
1.7 E-mail	
1.8 Date of Interview	
1.9 Experience of providing equipment compatible with USPC Segment	Yes / No
1.10 If yes, years of experience	

2. General Information About Equipment/Machineries Manufactured

- 2.1 Which major equipment is manufactured/marketed by your firm that can be used in tandem with Solar Water Pump (SWP) with USPC?
(The KPMG team is supposed to seek the name of major Agri equipment manufactured/ marketed by the respondent's firm which is compatible with USPC and corresponding information on the technical specification. ((The units have been mentioned in the table below and the KPMG team to obtain information accordingly)). Price, channel of distribution, supply region, brochure details and any additional remarks on the same).

a. Name of Equipment			
b. Purpose			
c. Key Specification(s) and technical input needed			
Voltage (Min)			
Voltage (max)			
Frequency (Hz)			
Power Factor			
No. of Phases			
Current (Min)			
Current (Max)			
Operating Temperature (Deg Cel)			

Maximum Temperature (Deg. Cel)			
Any other key parameters			
d. Capacity (HP/ kW)			
e. Price (Rs.)			
1 HP			
2 HP			
3 HP			
5 HP			
7.5 HP			
10 HP			
f. Whether Portable/ Can be moved with little effort/ Fixed			
g. How manufacturers supply to the customer – Through dealers / direct (one to one)			
h. Which Regions’ products are supplied			
i. Remarks, if any			
j. Brochure of product details if available			

2.2 How much of the USPC compatible equipment mentioned in Q2.1, has been sold/ marketed by your firm so far for the last three years?

(KPMG team is supposed to seek information on the quantity of the USPC compatible equipment as mentioned in Q2.1 that has been sold/ marketed by the respondent’s firm in the last three years and corresponding details on the product type, capacity, the price at which the product is sold and region(s) in which the product is supplied)

No	Type of Product	Capacity (HP/kW)	Price (Rs)	Quantity range			Region covered
				Year 1	Year 2	Year 3	
1							
2							
3							

2.3 What additional cost do farmers incur for the equipment to be compatible with USPC?

(The KPMG team is supposed to seek information from the respondent on whether any additional cost needs to incur by the farmer to make the device compatible and power the equipment with electricity generated from Solar panels)

2.4 Please provide the details of the activities the farmers typically use the equipment for, for any revenue generating purposes.

(KPMG team is supposed to seek information from the respondent about the details of the activities for which the farmer uses the Agri equipment for additional revenue generation)

2.5 What is the typical payback period for farmers if the above-mentioned equipment/ machineries with USPC as cited by the respondent in Q2.4? (In comparison to different sources of energy such as grid power, diesel, etc.).

(The KPMG team is supposed to seek information from the respondent on the typical payback period i.e., the duration in which a farmer is able to recover the amount spent on the purchase of equipment/ machineries compatible with USPC as cited by respondent in Q2.4)

3. Questions Related to Equipment Compatible with USPC

3.1 Based on your experience, what are the key issues faced while connecting the equipment with USPC and solar panels?

(The KPMG team is supposed to seek information on the major issues perceived by the respondent while connecting/powering the Agri equipment/machinery with solar electricity using USPC)

3.2 Please suggest the mitigating measures adopted for addressing these issues as mentioned in Q3.1.

(The KPMG team is supposed to seek information from the respondent on the typical measures adopted to mitigate/address the issues/difficulties faced while powering the Agri equipment using USPC (as cited by the respondent in Q3.1))

3.3 What kind of technical parameters can harm the equipment?

(The KPMG team is supposed to seek information from the respondent on whether the technical parameters such as voltage, freq., current, etc. can harm the equipment. If yes, the KPMG team shall seek information from the respondent on the possible impact (e.g. – High Voltage/Low Voltage) and corresponding information on the same)

S. No.	Parameters	Impact	Details (if Yes, Elaborate)
1	Voltage (Above and below)	High	
		Low	
2	Frequency (Above and below)	High	
		Low	
3	Waveforms		
	Other noises like spikes, harmonics etc.		

3.4 Please suggest any modifications in the USPC technical specifications released by MNRE that will enhance the product range compatible with USPC? (The MNRE specifications are to be explained / shared with the equipment manufacturer if he / she is not aware of them.)

(The KPMG team will explain to the respondent the USPC technical specifications as issued by MNRE and shall seek suggestions on any changes/modifications in the technical specifications of the USPC (released by MNRE) which will aid in increasing in the product range compatible with USPC)

3.5 What are the key technical specifications that need to be modified to make existing equipment feasible/compatible with USPC?

(The KPMG team is supposed to seek information from the respondent on the details of changes made in the technical specifications of the existing Agri equipment to make them compatible/feasible and power them with solar energy using USPC)

3.6 Do you provide any after sales service to the farmers/villagers using equipment with USPC? If yes, please highlight how the after sales service is provided? (E.g., Customer care number, service center in district/mandal etc.).

(The KPMG team is supposed to seek information on whether any after sales service support is provided to the customers i.e., farmers/villagers, who have purchased Agri equipment and are powering it using USPC. If yes, the KPMG team shall seek information from the respondent on the details on how customers can avail the support (e.g., Customer care number, service center available in district/mandal etc.) and ensure maintenance of their equipment)

3.7 Is there any insurance clause violation if the product is purchased through a loan and is to be operated with SWP and USPC? If yes, please mention the details of the violated insurance clause.

(The KPMG team is supposed to seek information from the respondent on whether it violates any insurance clause, if the Agri equipment purchased on loan by the farmer/villager is powered with solar electricity using USPC. If yes, the KPMG team shall seek information from the respondent on the mitigation measures to address this issue.

4. Questions Related to Challenges Faced in Accelerating the Adoption of USPC

4.1 For which applications does the manufacturer foresee a significant demand for usage with USPC?

(The KPMG team is supposed to seek the name of the USPC compatible Agri equipment/ machinery for which the respondent anticipates a high demand in the future by the farmers)

4.2 What are the key issues faced by users in adopting equipment compatible with USPC?

(The KPMG team is supposed to seek information from the respondent on the concerns/ issues faced by the farmers/ villagers while adopting USPC compatible equipment (e.g. – Issue with installation, etc.).

4.3 Do these issues as cited by the respondent in Q4.2, vary for different equipment in different geographical regions. If yes, please provide details on the typical issues faced with the adoption of USPC compatible equipment in different regions?

(The KPMG team is supposed to seek whether the issues as cited by the respondent in Q4.2, also depend upon geography and if these issues vary for different equipment in different geographic regions. If yes, the KPMG team shall seek the corresponding details from the respondent)

4.4 What are the steps that can be taken to accelerate the adoption of Agri-equipment compatible with USPC? *(The KPMG team is supposed to seek information from the respondent, based on their experience, what steps central, state govts. need to take in order to accelerate USPC adoption (such as higher subsidies, awareness creation, modifying technical specifications to suit certain requirements etc.))*

4.5 Please highlight the difference between USPC driven equipment vs. diesel driven equipment. In case the diesel driven equipment's efficiency is better, what can be done to make USPC driven equipment equally efficient (e.g. – Initial startup current, power factor, etc.?). *(The KPMG team is supposed to seek information from the respondent about the difference between the equipment driven by USPC in comparison to the equipment driven by diesel. In case the efficiency of diesel driven equipment is better, the KPMG team shall document suggested measures to improve the efficiency of USPC driven equipment)*

4.6 Please highlight the safety requirements of the equipment (e.g. – earthing, vibration, other electronic equipment, etc.). *(The KPMG team is supposed to ask the respondent to outline the typical safety requirements for the various equipment)*

USPC Beneficiaries Questionnaire

1. Respondent Details

1.1 Name	
1.2 SWP Owner's Name	
1.3 Relation of Respondent to SWP Owner	
1.4 Gender	
1.5 Age	
1.6 Educational Qualification	
1.7 Phone Number	
1.8 Village	
1.9 Post Office	
1.10 District	
1.11 Installed Location	Latitude: Longitude:
1.12 State:	Himachal Pradesh

2. GENERAL INFORMATION OF FARMER

2.1 For how long have you been farming? (Input - No's)
(The enumerator is supposed to seek total no. of years the respondent has been conducting farming. e.g., 5.5 years)

2.2 How much farmland do you currently own (in acres) on which you use / intend to use the solar water pump with USPC? (1 acre=3.025 bigha=60.5 katha) (Input - No's)
(The enumerator is supposed to seek the size of the farmland in which the respondent is currently farming. The unit of measurement may be in as per the local convention. E.g., 5.5 Acres)

2.3 What are the main crops grown by you in a year in the farmland on which you are using / intend to use the solar water pump?
(The enumerator is supposed to seek the number of crops cultivated by the respondent along with the name of the crop and the corresponding area of land on which the crop was cultivated last year, e.g., Paddy in 2.5 acres of land)

S. No.	Name of the crop	Area of land cultivated (Acre)	Month of Sowing	Month of Harvesting

- 2.4 What source of water (canal water, rainwater, ground water etc.) and irrigation method (sprinkler irrigation, drip irrigation, micro irrigation etc.) is used at the farm? How much additional infra cost is required for this? *(The enumerator is supposed to seek the name of the crops cultivated by the respondent and information on the corresponding land type (owned/ leased), the water source, irrigation method and its installation cost)*

S. No	Type of crop grown (e.g., Paddy, wheat etc.)	Land type		Source of Water (canal water, rainwater, ground water etc.)	Irrigation method used (sprinkler irrigation, drip irrigation, micro irrigation etc.)	Cost of irrigation method (In Rupees per installation)
		Owned	Leased in			

- 2.5 Are you aware of PM-KUSUM or any other government sponsored solar water pump scheme? *(The enumerator is supposed to check if the respondent is aware of any government sponsored solar water pump scheme and its details)*
(Input – Yes/ No, if Yes, name of the scheme e.g., PM-KUSUM scheme etc.)

- 2.6 Where and when did you first hear about USPC? *(The enumerator is supposed to seek information on the 'Location', 'Month' along with the 'Year' or how long back (in years) the respondent first came to know about Universal Solar Pump Controllers (USPC))*

- 2.7 How did you hear about USPC? *(The enumerator is supposed to seek information on the primary source through which the respondent first came to know about Universal Solar Pump Controllers (USPC))*

S. No.	Particularities	Select the option
1	Newspaper	
2	Word of Mouth	
3	Local Agricultural Institution	
4.	Any other, please specify	

- 2.8 Why did you opt for USPC? *(The enumerator is supposed to seek the reason due to which the respondent opted for SWP with USPC. The reasons could be uninterrupted power supply to agri equipment, ease of operation of agri equipment, avoided cost of diesel/ fuel, efficient operation of agri equipment etc.)*

2.9 Have you witnessed any pilot demonstration installation before the purchase of USPC?
(The enumerator is supposed to seek information on whether the respondent has witnessed any prior operation of USPC before opting to purchase the USPC)

3. Questions related to Applications of Solar Water Pump and USPC

3.1 When was the solar powered irrigation pump installed in your field?
(The enumerator is supposed to seek information on how long the respondent has been using the solar powered water pump on his farm for irrigation purposes (month and year or duration in years))

3.2 When was the USPC installed? (In case the USPC and SWP were not installed at the same time)
(The enumerator is supposed to find out for how long the respondent has been using the USPC along with the existing SWP system on his farm (month and year or duration in years))

3.3 What is the capacity of the Solar Water Pump (in HP) installed?
(The enumerator is supposed to seek information on the capacity (1,2,3,5,7.5, 10 and 12.5 HP etc.) of the solar powered water pump installed by the respondent on his farm)

3.4 What is the capacity of the USPC (in HP) installed?
(The enumerator is supposed to seek information on the capacity (1,2,3,5,7.5, 10 and 12.5 HP etc.) of the Universal Solar Pump Controller (USPC) installed by the respondent on his farm)

3.5 What is the type and technology of the solar pump installed?
(The enumerator is supposed to find out if the pump is surface mounted or submersible and if the pump is an AC or DC pump. The enumerator is to tick the appropriate boxes below)

Type	Select the option	Technology	Select the option
Surface mounted		AC	
Submersible		DC	

3.6 How many solar PV panels are installed at the farm and what is the total wattage of the solar panels installed?
(The enumerator is supposed to seek information on the no. of solar PV panels and total capacity (in watts) of the solar panels installed at the farm of the respondent to power the SWP)

- 3.7 What is the distance between the solar PV panels and the load (water pump)?
(The enumerator is supposed to seek information on the distance i.e., length (in cm. or meters) between the solar PV panels and the USPC and the distance between the USPC and the pump)

S. No.	Description	Distance (in cm. or meters)
1	Distance between solar PV Panels and USPC	
2	Distance between USPC and load (Water Pump)	

- 3.8 How much is the diameter of the delivery pipe through which the water is ejected (2.5 inches/4 inches/etc.)?
(The enumerator is supposed to seek information on the size of the diameter of the delivery pipe in inches (2.5 inches/4 inches/etc.) through which water is ejected from the respondent)

- 3.9 What are the key technical specifications of USPC installed?
(The enumerator is supposed to take a photograph of the USPC specifications and also seek information on the technical specifications of the USPC from the respondent. The units have been mentioned in the table below and the enumerator is to obtain information accordingly)

S. No.	Description	Value (Give range or description where applicable)
1	Output voltage (V)	
2	Output frequency (Hz)	
3	Current (Amperes)	
4	Output Power (Wattage)	
5	Any other important parameter	

- 3.10 What is the average usage of SWP for irrigation in a month? Please provide the number of days in a month and the monthly water consumption (in liters) respectively?
(The enumerator is supposed to seek information on the monthly water consumption (in liters) for the crops cultivated by the respondent and on the no. of days of SWP usage to calculate the average monthly irrigation requirement)

S.No.	Month	Crop name	Number of days of SWP usage (No.)	Monthly water consumption from SWP (liters)	Average duration of pump usage (Hr./day)
1	January				
2	February				
3	March				
4	April				
5	May				
6	June				
7	July				
8	August				
9	September				
10	October				

11	November				
12	December				

- 3.11 Did you make any changes to the cropping pattern when you started using SWP? If yes, why so and what is its impact in terms of productivity, profits etc.?
(The enumerator is supposed to seek information on whether any changes have been made in the type of crops cultivated on the farm after the installation of the SWP by the respondent. The enumerator shall also seek responses on the impact of SWP on parameters such as the increase in revenue, the decrease in time of usage, the increase in Agri productivity etc.)

S.No.	Cropping pattern before the installation of SWP	Change in cropping pattern (Please mention in detail the changes in cropping pattern)	Reason for the change in the cropping pattern
1			
2			

S.No.	Impact	Details (Quantum or percentage of increase/decrease)
1	Productivity/Yield	
2	Time	
3	Revenue	

Any other parameter, pls specify:

- 3.12 Based on your assumption/estimation, have you witnessed any change in the water table depth due to the use of SWP? If yes, please mention the difference perceived.
(The enumerator is supposed to seek information on whether the respondent perceived any change in the water table depth as compared to the levels before the usage of SWP. If yes, the enumerator shall seek information on the difference in the ground water table (in meters or in feet) perceived by the respondent after the installation of SWP)

- 3.13 Do you sell the pumped water to the neighboring farmers to generate extra income? If yes, on average how many liters of water is sold in a month and at what price?
(The enumerator is supposed to find out if water pumped out using SWP is being sold to the neighboring farmers. If yes, the enumerator is to seek information on what the average quantum of water is that is being sold to neighboring farmers (in liters or kilo liters) every month and what the average price is (INR/ kiloliter or INR/ liter) that the water is sold at)

- 3.14 Is your SWP system connected to the grid (Yes/No)?
(The enumerator is supposed to seek information on whether the SWP system installed at the farm of the respondent is connected to the grid powered electricity)

- 3.15 If the answer to Q 3.14 is Yes, please highlight the year of the connection to the grid.

(The enumerator is supposed to capture the year of the connection to the grid. The question is not applicable if the answer to Q 3.14 is No)

3.16 If the answer to Q 3.14 is yes, please confirm if the pump can be operated with energy from the grid. *(Yes/No)*
(The enumerator is supposed to seek whether the respondent can operate the SWP with grid power)

3.17 If the answer to Q 3.14 is yes, please confirm if the pump can inject energy into the grid. *(Input – Yes/No)*
(The enumerator is supposed to seek information on whether the respondent can inject energy into the grid)

3.18 If the answer to Q 3.14 is yes, please mention the tariff paid by the discom (INR/kWh) for excess energy injected into grid.
(The enumerator is supposed to seek the tariff paid by distribution utilities for the purchase of power from the respondent)

3.19 What typical equipment/machineries do you use in tandem with SWP with USPC? Please share the name of the supplier and contact details. What is the average usage of this equipment?
(The enumerator is supposed to seek details on the equipment/ machineries which the respondent powers with solar power using USPC, along with the associated details such as on the load of the equipment, output capacity, name and contact details of the supplier from which the equipment is purchased and the average monthly usage of the equipment in hours)

S.No.	Equipment used with USPC	Load (HP/ kW)	Output capacity of the equipment (Kg/Hr.)	Average usage of the equipment in a month (Hrs.)	Typical Usage of the equipment in months	Name and contact details of the supplier

3.20 After realizing the benefits of USPC, have you purchased any additional equipment to be operated with USPC? *(Yes/No)*
(The enumerator is supposed to seek information on whether the respondent has purchased any other Agri equipment to power it with electricity generated through solar PV panels using USPC)

3.21 If the answer to Q 3.20 is yes, please mention the name of the agri equipment purchased to be operated with USPC.

(The enumerator is supposed to seek details on the agri. equipment purchased and any other Agri equipment that is powered with electricity generated through solar PV panels using USPC)

S.No.	Agri. equipment name	Date of purchase	Load (HP/ kW)	Average usage of equipment in a month (Hrs.)

3.22 How were the energy needs of Agri equipment currently powered with USPC met before the installation of USPC?

(The enumerator is supposed to seek information on the way the respondent used to power the Agri equipment (e.g. Diesel generator/ Grid electricity, etc.) before the installation of USPC in the field)

3.23 Does any govt scheme (state/central) provides subsidies for purchasing the agri. equipment? *(Yes/No)*

(The enumerator is supposed to seek information from the respondent on any government subsidy being provided by the government i.e., either state, central or both, for purchasing the agri. equipment to be operated with USPC)

3.24 If the answer to Q 3.23 is yes, please mention the details of the subsidy provided by the state and central govt. for the purchase of agri. Equipment.

(The enumerator is supposed to seek information from the respondent on the quantum of the government subsidy being provided by the government i.e., either state, central or both, for purchasing the agri. equipment to be operated with USPC from the respondent)

S.No.	Agri equipment name	Total cost of equipment (INR)	Central Subsidy (INR)	Name of the central subsidy scheme	State subsidy (INR)	Name of the state subsidy scheme

3.25 What problems have you faced while using USPC? Please elaborate.

(The enumerator is supposed to seek information on the problems/difficulty faced by the respondent (e.g., the power output is not sufficient to operate the agri. equipment, a drop in rpm of the equipment due to variation in solar irradiation etc.) while using USPC with SWP in the farm).

3.26 Based on your experience, what has been USPC's most significant benefit? Please elaborate.

(The enumerator is supposed to seek information on the most important benefit of using SWP with USPC from the respondent based on his experience. E.g., better quality products, cost reduction, increase in productivity etc.)

3.27 What are the monthly additional savings or the additional revenue earned by using equipment/ machineries with USPC?

(The enumerator is supposed to seek information on the monthly revenue earned or saved (INR/month) by powering the equipment/ machineries with solar electricity using USPC)

S.No.	Equipment name	Monthly savings due to USPC	Additional monthly revenue due to USPC

3.28 Is there any revenue generated by leasing the equipment/ machineries (run by USPC) to neighboring farmers (Yes/No)?

(The enumerator is supposed to seek information from the respondent on whether the equipment/ machineries which are compatible with USPC are currently being leased out to other neighboring farmers leading to some additional revenue generation, along with the name of the equipment and corresponding lease rentals for the same)

3.29 If the answer to Q3.28 is yes, please mention the name of the equipment and lease rentals charged for each of the equipment,

(The enumerator is supposed to seek information from the respondent on the equipment/ machineries which are compatible with USPC and are currently being leased out to other neighboring farmers, and the monthly rentals charged for this equipment)

S.No.	Equipment name (leased)	Monthly rental income (INR/month)

3.30 Would you recommend USPC adoption to other farmers in your village (Yes/No)? Please give reasons.

(The enumerator is supposed to seek information on whether the respondent would recommend USPC to other farmers and the reasons for which the respondent finds USPC useful for other farmers)

3.31 Please share your experience on the following:

(The enumerator is supposed to seek information on any difficulty/ concerns the farmers faced with USPC installation, training provided by the vendor, issues faced and its frequency and time taken to resolve the issue from the respondent)

S.No.	Topics (matters concerning USPC)	Description
	Quality of installation	
	Training and service provided by the vendor	
	Frequency of the issues faced by respondent	
	Time taken to resolve the Issue	

3.32 For what kind of farmers do you think USPC is best suited for?
(The enumerator is supposed to seek information from the respondent, based on their experience, what type of farmers would be ideal users of the USPC, e.g., small, and marginal farmers with less than 2 hectares of land, medium and large farmers with more than 2 hectares of land, farmers with horticulture crops, farmers with cash crops, farmers with water intensive crops, etc.)

3.33 We request you to please demonstrate the applications being used with USPC.
(The enumerator is supposed to seek a visual demonstration of the devices being operated with USPC)

3.34 What typical equipment/machineries do you (or others) want to use with USPC but it cannot be used as of now? Please elaborate the reasons why you cannot use them.
(The enumerator is supposed to seek the name of equipment/machineries which the respondent is unable to operate with the USPC and also seek the reason for the same)

3.35 What, according to you, should be done to accelerate the USPC adoption.
(The enumerator is supposed to seek information on what, based on the respondents experience, would be the next steps to would have to be taken by central, state govts. to accelerate the USPC adoption (such as higher subsidies, awareness creation, modifying technical specifications to suit certain requirements etc.))

4. Questions related to the Financing of Solar Water Pumps and USPC

4.1 What is the all-inclusive, total cost of the Solar Water Pumps (inclusive of SWP)?
(The enumerator is supposed to seek information from the respondent on the total cost of setting up a SWP system)

4.2 How much did USPC cost – over and above the cost of solar water pumps?
(The enumerator is supposed to seek information from the respondent on the cost of USPC including the installation costs etc. (excluding of cost of SWP))

4.3 Did you avail a loan for the SWP system and/or USPC (Yes/No)?
(The enumerator is supposed to seek information on whether the respondent has availed any loan from the bank for setting up of SWP and/or the UPSC system)

4.4 What is the total amount of loans that you have applied for?
(The enumerator is supposed to seek information on the amount of the loan availed by the respondent and other related information related to the loan such as loan tenure, moratorium, interest rate, installment amount and its frequency)

- i) Loan amount _____ INR
 - ii) Loan Term _____ years
 - iii) Moratorium (if any) _____ years
 - iv) Interest rate _____ % p.a.
 - v) Installment frequency _____
 - vi) Amount Payable per installment _____ INR
-
-

4.5 Is there any govt. subsidy provided for setting up SWP and UPSC (Yes/No)?
(The enumerator is supposed to seek information on whether the respondent has availed any subsidies from the government (either state, central or both) for setting up SWP and UPSC systems.)

4.6 If the answer to Q 4.5 is yes, please provide the name of the scheme and details of the subsidy provided for setting up SWP and USPC.
(The enumerator is supposed to seek the quantum of the subsidy from the government (either state, central or both) for setting up SWP and UPSC systems)

S.No.	Equipment	Total cost of equipment (INR)	Central Subsidy (INR)	Name of the central subsidy scheme	State subsidy (INR)	Name of the state subsidy scheme
	SWP					
	USPC					

4.7 Do you know any farmers among your neighbors/relatives who have installed SWP with USPC or would be interested to install SWP with USPC? If yes, please mention their contact details.
(The enumerator is supposed to seek information from the respondent on the contact details (name, phone number, address of the farmer) of the any known existing/potential user of SWP with USPC)

Annexure-6: List of Stakeholders

List of the USPC Manufacturers

S. No.	Name of the key official	Designation	Organization
1	Umesh Balani	MD	Rotomag
2	Piyush Patidar	MD	Shakti Pumps
3	Nimesh Seth	MD	Kisan Solar
4	Mr. Mayank Rajvanshi	Sr. Manager Business Development A2E	Schneider Electric Infrastructure Limited
5	Amar Bendale	Manager (R&D)	Jain Irrigation Systems Ltd
6	Arpit Srivastava	MD	Tata Power

List of the SWP Manufacturers/Integrators

S. No.	Name of the key official	Designation	Organization
1	Santosh Lalwani	Director	Ren-En-Gen Solutions
2	Mr. J Shekar Reddy	Owner	Junna Solar Systems
3	Amit Magnani	VP Sales	Premier Energies Limited
4	Balaraju	Sr. Manager Business Development A2E	SunEdison
5	Mr. Bibek Saha	Head-Govt. Relations	Grundfos India
6	Abhinav Rajput	Deputy Business Head	Mahindra
7	Shiva		Mecwin India

List of Agri equipment manufacturers/suppliers

S. No.	Name of the key official	Designation	Organization
1	Mr. Sandip Shan	CEO and founder of Mechair	Mechair
2	Nisar Ahmed	Proprietor	Able Manufacturers
3	Prateek Singhal	Proprietor	Ecozen Solution
4	Ajay	Proprietor	Our Food

List of USPC beneficiaries

S. No.	Beneficiary Name	Pump Capacity (in HP)	District	Village
1	Rajesh Kumar	5	Mandi	Khalardu

S. No.	Beneficiary Name	Pump Capacity (in HP)	District	Village
2	Rajender Paul	7.5	Mandi	Chatar
3	Santosh Kumar	5	Mandi	Chamyanu
4	Desh Raj	10	Mandi	Khyalag
5	Kamldev	5	Mandi	Kummi
6	Khem Raj	5	Mandi	Kunsot
7	Kush	7.5	Kullu	Jachhavi
8	Devi Singh	10	Kullu	Hawai
9	Rahul Sood	10	Kullu	Akhara bzar
10	Maheshwar Singh	10	Kullu	Kandheri
11	Aatma Ram	5	Kullu	Korla
12	Dev Raj	5	Shimla	Bijrolipul
13	Ranjeet Singh	5	Shimla	Balawog
14	Kulbir Singh	7.5	Hamirpur	Jalari
15	Rajen Katoch	3	Hamirpur	Ujhan
16	Anil Rana 2	5	UNA	Panjawar
17	Bamdev	12.5	UNA	Jarla khori
18	Arjun singh	10	Kangra	Amroh
19	Kulwinder Singh	10	Kangra	Darab
20	Rajeev S/O Sansar Chand	5	Kangra	Koei
21	Kulwinder Singh	10	Kangra	Amroh
22	Balwant Singh	5	Kangra	Ghati
23	Rajender Singh	5	Kangra	Kundail
24	Ram Krishan Sain	5	Kangra	Balla
25	Sunil s/o vikram singh	5	Kangra	Balla
26	Manohar Lal	5	Mandi	Barchhwad
27	Man Chand	5	Mandi	Dophi
28	Sunny	10	Mandi	Bhaderwar
29	Pradeep Kumar	3	Mandi	Sajaori
30	Vijender Singh Guleria	5	Mandi	Galma
31	Harish Chandra	5	Mandi	Oli
32	Bhup Singh	10	Kullu	Kot
33	Roop Chand	3	Kullu	Shiah
34	Prem Singh Verma	7.5	Kullu	Shishamatti
35	Kuldeep Singh	7.5	Kullu	Oredhar
36	Prem Singh	5	Shimla	Majhgaun
37	Naresh Kumar	5	Shimla	Kyartu
38	Kuldeep Chand	3	Hamirpur	Bari
39	Rajesh Kumar 2	5	Hamirpur	Balh
40	Anil Rana	5	UNA	Panjawar
41	Surjeet Kumar	5	Hamirpur	Gulelea
42	Kushal Singh	5	Hamirpur	Bharmoti
43	Rohit Das	5	Hamirpur	Khaggal
44	Narottam Singh	5	Hamirpur	Balh
45	Rajender Kumar	5	Hamirpur	Swahal
46	Hoshiar Singh	3	Hamirpur	Burnar
47	Baldev Raj	5	Hamirpur	Gharthon

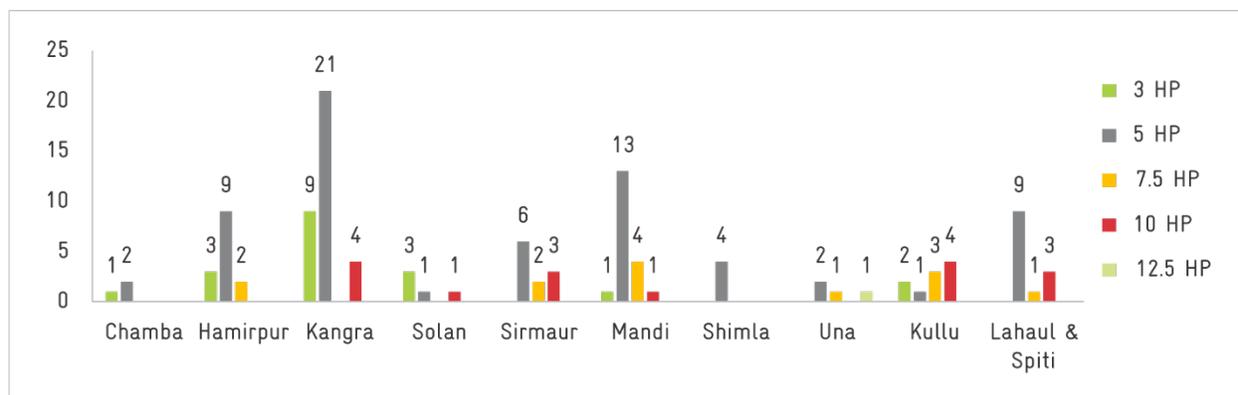
S. No.	Beneficiary Name	Pump Capacity (in HP)	District	Village
48	Sonika Ratan W/O Late. Sunil Kumar	5	Hamirpur	Sasan
49	Hoshiyar Singh	5	Hamirpur	Telkar
50	Man Singh	5	Chamba	Jattan da bagh
51	Ishwar Prasad	5	Chamba	Janna
52	Bimla Devi	5	Mandi	Galma
53	Dharm Singh	5	Mandi	Ratti
54	Roshan Lal	5	Mandi	Vanoun

Annexure-7: Methodology for the selection of farmers for the primary survey

The Himachal Pradesh Agri department has provided a list of 124 farmers including details on the pump capacity and installation locations. Out of the listed farmers, contact details of only 117 farmers are available, who have SWP, as highlighted below. The 117 farmers are from 10 districts of Himachal Pradesh and the solar pump set varies from 3 HP to 12.5 HP with majority of the population having 3 HP and 5 HP capacities of SWP.

S.No.	District	Places of Installation	3 HP	5 HP	7.5 HP	10 HP	12.5 HP	Total
1	Chamba	Chamba	1	2	-	-	-	3
2	Hamirpur	Hamirpur, Badsar	3	9	2	-	-	14
3	Kangra	Nadaun, Dehra, Dharamshala, Nurpur, Palampur, Jai singh Pur, Baijnath, Baldwara, Kangra, Gangath, Indora	9	21	-	4	-	34
4	Solan	Dharampur Kanda Ghat, Arki	3	1	-	1	-	5
5	Sirmaur	Paonta, Kamrau, Shillai		6	2	3	-	11
6	Mandi	Mandi, Galma, Sarkaghat	1	13	4	1	-	19
7	Shimla	Theog	-	4	-	-	-	4
8	Una	Una	-	2	1	-	1	4
9	Kullu	Kullu and Banzar	2	1	3	4	-	10
10	Lahaul & Spiti	Keylong and Udaipur	-	9	1	3	-	13
Total			19	68	13	16	1	117

Figure 56: District wise SWP Installations



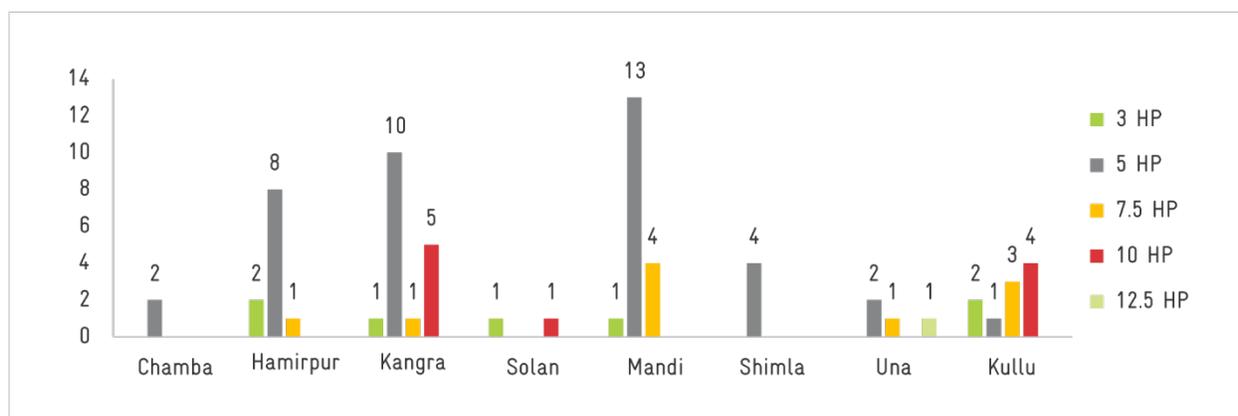
With the intend to validate the data and check whether the farmers in their respective regions are using USPC controllers or the normal controllers, consultations with various concerned District officials (DO's) of the HP Agri department were held. Following is the summary of the information provided by the DO's:

S. No.	Details	No's
1	No. of farmers using USPC controllers	68
2	No. of farmers using normal SWP controllers	49
Total		117

Out of the 117 SWP users (for whom the contact details are available), it was found that only 68 were USPC users. The district wise availability of the details of 68 farmers who have installed USPC along with SWP are as follows:

S. No.	District	Places of Installation	3 HP	5 HP	7.5 HP	10 HP	12.5 HP	Total
1	Chamba	Chamba		2				2
2	Hamirpur	Hamirpur, Badsar	2	8	1	-	-	11
3	Kangra	Nadaun, Dehra, Dharamshala, Nurpur, Palampur, Jai singh Pur, Baijnath, Baldwara, Kangra, Gangath, Indora, Baijnath, Palampur	1	10	1	5		17
4	Solan	Dharampur Kanda Ghat, Arki	1			1		2
5	Mandi	Mandi, Galma, Sarkaghat	1	13	4		-	18
6	Shimla	Theog		4				4
7	Una	Una		2	1		1	4
8	Kullu	Kullu and Banzar	2	1	3	4		10
Total			7	40	10	10	1	68

Figure 57: District Wise USPC Installation (installed by farmers for whom contact details are available)

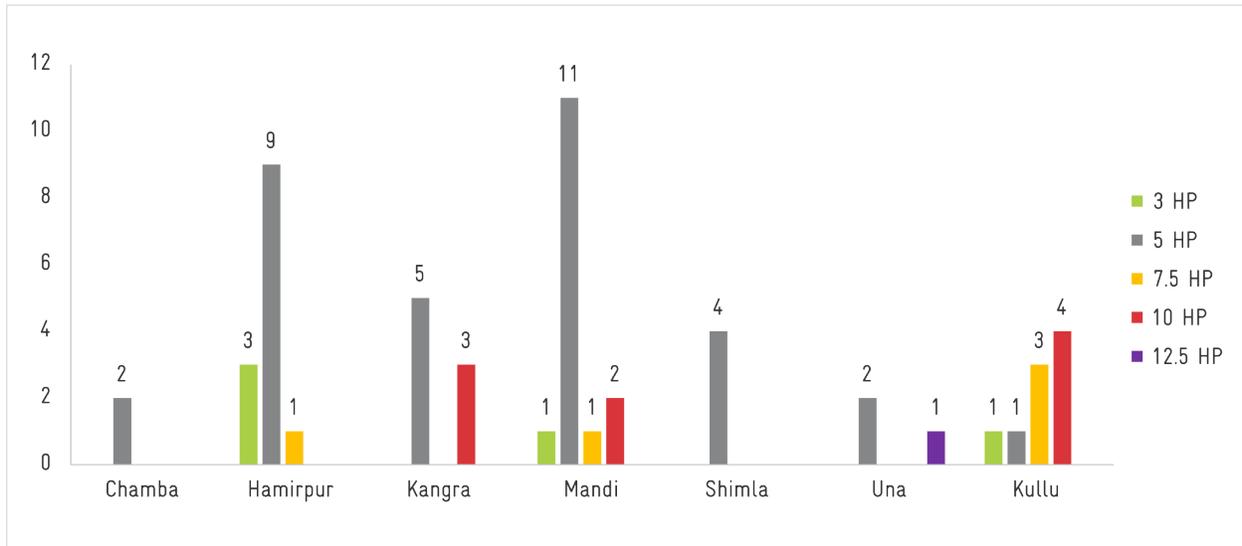


Further, based on the information provided by GIZ, IWMI has conducted a survey within total 18 SWP users. Out of the above-mentioned farmers, consultations with 15 farmers using USPC have already been held and hence, they will not be considered for the consultations again. Accordingly, the district wise availability of the details of farmers who have installed USPC along with SWP and have not yet been surveyed are as follows:

S.No.	District	Places of Installation	3 HP	5 HP	7.5 HP	10 HP	12.5 HP	Total
1	Chamba	Chamba	-	2	-	-	-	2
2	Hamirpur	Hamirpur, Badsar	3	9	1	-	-	13
3	Kangra	Nadaun, Dehra, Dharamshala, Nurpur, Palampur, Jai singh Pur, Baijnath, Baldwara, Kangra, Gangath, Indora, Baijnath	-	5	-	3	-	8
4	Mandi	Mandi, Galma, Sarkaghat	1	11	1	2	-	15
6	Shimla	Theog	-	4	-	-	-	4

S.No.	District	Places of Installation	3 HP	5 HP	7.5 HP	10 HP	12.5 HP	Total
7	Una	Una	-	2	1	-	1	4
8	Kullu	Kullu and Bazar	1	1	3	4	-	10
Total			5	34	5	9	1	54

Figure 58: District Wise USPC Installation



The 15 USPC users with whom IWMI has conducted surveys, will be considered as stand-by or back up for consultations in case we are not able to reach out to the targeted 50 farmers. Further, out of the 7 farmers whose contact details are not available to us, 3 farmers have the USPC installations. We are in process of getting the contact details of them from the HP Agri department & the concerned DO's. The details will be updated in the stand by list as soon as we receive the update from the HP Agri dept.

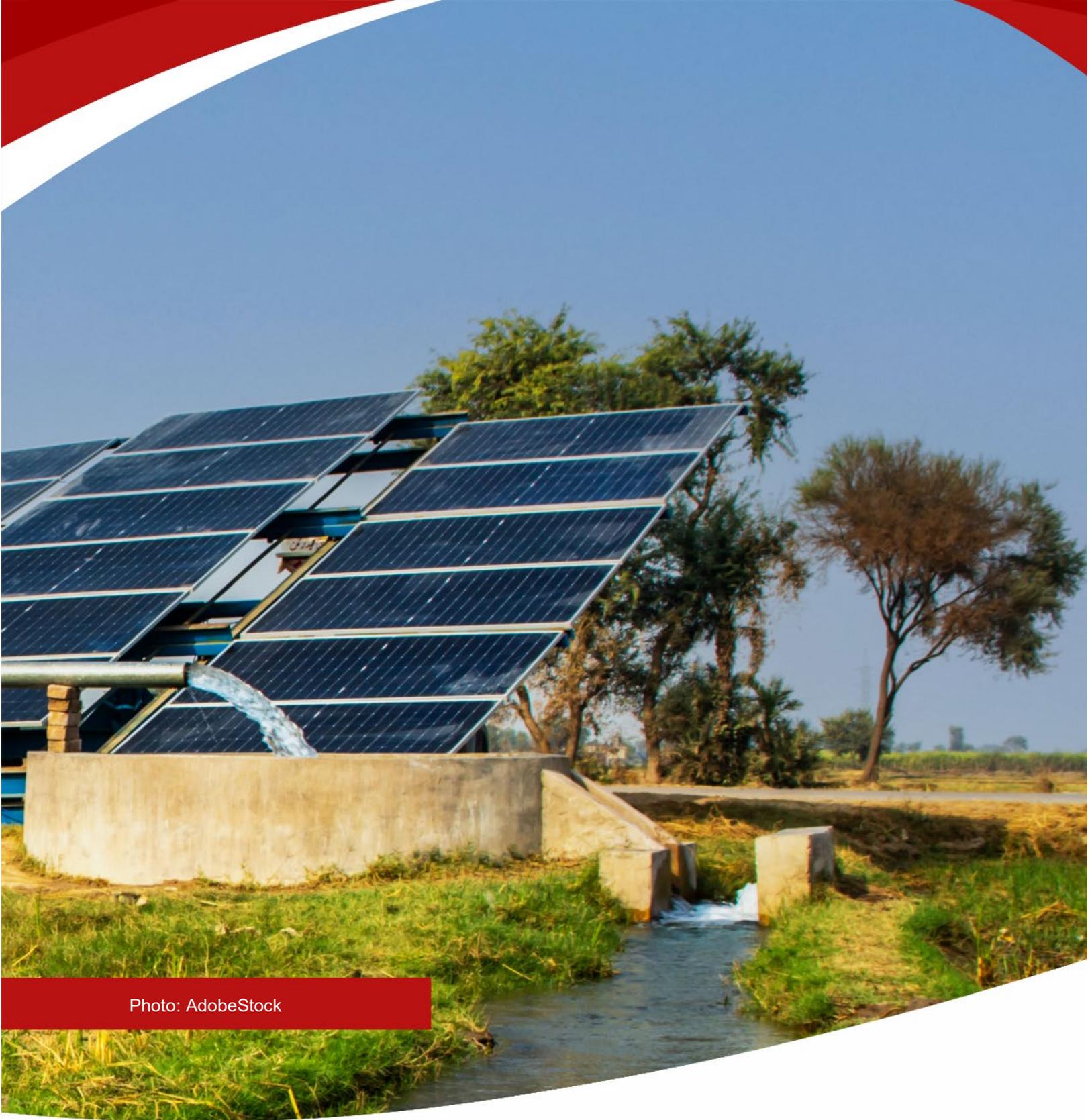


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