MILLION SOLAR URJA LAMP (SoUL) PROGRAM

Right to Clean Light

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An Initiative of
Indian Institute of Technology Bombay

Sponsored by
Ministry of New and Renewable Energy, Government of India

Concurrent Evaluation Report of Million SoUL Program in Madhya Pradesh

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About Million SoUL Program

Million SoUL Program (MSP) is an initiative of Indian Institute of Technology - Bombay (IIT-B). MSP headquarter is located in Mumbai within the campus of IIT-B. Its principle funders include Ministry of New and Renewable Energy (MNRE), Madhya Pradesh Govt., Sir Dorabji Tata Trust (SDTT), Larsen and Turbo (L&T) and Tata Motors.
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List of Acronyms

BP	British Petroleum
CEA	Central Electricity Authority
CRISIL	Credit Rating Information Services of India Limited
MDG	Millennium Development Goals
MNRE	Ministry of New and Renewable Energy
MP	Madhya Pradesh
MSP	Million SoUL Program
NGO	Non Governmental Organization
IEA	International Energy Agency
IIT-B	Indian Institution of Technology, Bombay
PDS	Public Distribution System
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RVEP	Remote Village Electrification Program
SDG	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SELCO	Solar Electric Lighting Company
SKO	Superior Kerosene Oil
SoUL	Solar Urja Lamps
SRC	SoUL Repair Centre
SRCM	SoUL Repair Centre Manager
TERI	The Energy and Resource Institute

Executive Summary

The Million SoUL Program (MSP) an initiative by Indian Institute of Technology (IIT) Bombay aims to bring 'Right to Clean Light' to every child in India. With this vision, two year program is being implemented in 2014-15 across 4 states (Madhya Pradesh, Maharashtra, Rajasthan, and Odisha) with the help of NGO partners who act as implementers at the ground level. During two year program, one million solar study lamps called as Solar Urja Lamps (SoUL) are to be distributed in two phases (I & II). This report presents the results of the concurrent evaluation (Round I) of the MSP in the state of Madhya Pradesh (MP) in India. The objective of concurrent evaluation is to bring transparency in the MSP, make mid-course corrections and assess impact of the SoUL. The concurrent evaluation, which is made by conducting the household survey in sample blocks, is planned in two rounds: (a) after SoULs are distributed (so that mid-course corrections can be made) (b) 4-5 month prior to the end of Phase I in December 2015. In order to understand the impacts, a comparison between treatment sample (households of students who purchased SoUL) and control sample (households of students who didn't purchase SoUL) as well as electrified and non-electrified households in both the samples was made. The MSP team of IIT-B study conducted this study.

The main findings for MP are presented here. The cost or the beneficiary contribution of SoUL (Rs. 120) acted as a positive discrimination and was 'not the barrier' in purchasing or accessing the SoUL with 75% or more eligible beneficiaries purchasing the SoUL. The socio-economic profile of the treatment sample showed that SoUL has reached marginalised and poor households with 28.37% non-electrified, 68% scheduled tribes (STs), 23% other backward castes (OBCs), and 6% scheduled castes (SC) households, while 66% of the households were poor as they possessed either below poverty line (BPL) or Antyoday cards. The direct positive and significant impacts of SoUL such as elimination of one kerosene lamp specifically for study purpose, shift to SoUL's clean and better quality light resulting into complete cease of exposure of

children to kerosene fumes while studying, significant decline in kerosene expenditure for lighting due to saving from one kerosene lamp was observed. The usage of SoUL in other activities reaffirmed its utility merit and emphasises the requirement of home lighting system in order to fulfil domestic lighting needs. It was an aid in performing various domestic activities, in irrigating farms, and as a torch providing increased mobility during night. Other impacts though not significant but they showed positive direction such as reduction in total expenditure on lighting as well as expenditure on electricity bill, and more and increased night study hours for children using no other device than SoUL. However, it needs to be acknowledged that complete elimination of kerosene cannot be possible with SoUL or a small solar study lamp as it would have limited impact. According to Census 2011 data for rural Madhya Pradesh 97.15% of the households reside in a dwelling having more than 1 room and will apparently require the illumination solution that caters the need for all the rooms. This reflects in continued dependence on kerosene purchase from PDS and its consumption primarily for illumination purpose. Therefore, unless the need for lighting for entire house gets fulfilled through solar home lighting the significant impact in terms of elimination of kerosene consumption for lighting and its expenditure cannot be expected. The high percentage of non-functional SoULs (19.51%) in the sample called for stringent quality control and SRC awareness campaign on a priority basis to ensure that people avail the SRC facility and all SoULs are in working condition till the end of phase I. Other mid course corrections required were regular monitoring of SRC operations for timely identification and resolution of issues, better quality switches, goose neck. The need assessment of solar technology related needs demonstrated the needs at the domestic level. However, the expressed capacity to pay for these needs revealed it quite low and can be a hindrance in converting the need into the purchase and hence, requires some financial model to facilitate this.

Chapter 1: Introduction

Energy access is an important issue to be addressed at international, national and sub-national level to accelerate development of low income communities. As the development discussion has progressed from Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs), energy access became one of its central goals. UN General Assembly declared year 2012 as Sustainable Energy for All (SE4ALL) and 2014-2024 a decade for the same (UNDP 2011). In 2015, UN General Assembly adopted the agenda for Sustainable Development under which the goal 7 of SDGs aims to "*ensure access to affordable, reliable, sustainable and modern energy for all"*[1]. While the focus on improving the energy access has grown in last decade, there are still billion plus population across the developing and under-developed countries lack access to modern source of energy (IEA 2013). Lack of access to modern energy such as electricity undermines the key development indicators such education, health and livelihoods. It is clear through understanding of literature that without access to modern energy, achieving social and economic development of countries will remain distant dream. While the energy access is multidimensional which includes household (cooking and lighting needs) and productive (livelihood) needs, this report is specially focused upon the lighting needs presenting arguments and results from evaluation of solar lighting project 'Million SoUL Program' (MSP) introduced by Indian Institute of Technology – Bombay (IIT-B).

1.1. Energy Scenario in India

According to BP statistics review of world energy (2015), India is the fourth largest electricity producer in the world. However India is also home to the largest number of people without access to electricity (IEA 2013). On supply front, India faces multiple challenges in terms of making electricity available to its rural population. One of important challenge faced by the power utilities is form of under-recoveries from sale of

[1] Can be read further read about the goals Sustainable Development Knowledge Platform <https://sustainabledevelopment.un.org/topics>

electricity to the consumers. This results huge financial losses undermining the ability of the utilities to expand and improve services (CRISIL 2012)[2]. Apart from financial constraints that have burdened the state power utilities, the infrastructural challenges seem to more daunting towards making electricity available to the rural communities (IEA 2011). Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), the flagship Program for rural electrification had set objective to achieve complete rural electrification of rural area by 2012, which however the Program has missed and still large population live without electricity.

Most of the people without access to electricity depend upon kerosene as their primary source of lighting in the households. Census (2011) data show around 43.2 percent of the rural households in India depends upon subsidized kerosene as the main source for lighting. Use of kerosene which not only pose health risks at household level, but also pose a burden on substantial state and national financial budgets by means of subsidy (Nouni et al. 2009). For example, TERI study shows the accumulated under-recoveries on the sale of kerosene over last decade amounts to INR 188,502 crore[3] (TERI 2014).

1.2. Emergence of Renewable Energy

Renewable energy has shown potential for being alternative to energy access problem, specifically for access to electricity for lighting needs. Off-grid applications of renewable energy have been growing over past decade in context of failure of grid electrification to reach the sparsely populated rural population. Various actors – governments, NGOs and social enterprise have experimented with business models for provisioning of off-grid based services. From government standpoint while range of off-grid renewable options (like biomass based generation, wind power, solar power etc.) is available, the most preferred option under renewable energy Programs like Remote Village Electrification Program (RVEP)[4] is seen to solar (Bhushan and Kumar 2012). As of August 2015, cumulative off-grid solar PV systems already accounts for 279.74

[2] More on the under recoveries of the state power and distribution utilities can be read in CRISIL (2012).
[3] Crore is Indian number system and equals to 10 Million.
[4] Remote Village Electrification Program (RVEP) is government off-grid renewable technology electrification Program for remote villages and hamlets which could not electrified through grid electrification or covered under RGGVY.

Megawatt (MW)[5], of which 45.39 MW was added in the last one year (MNRE 2015). Off-grid systems are installed either through local mini/micro grids[6] or isolated solar home systems, solar lanterns. Similarly, a large range of social enterprises like SELCO, Mera Gaon Power, D.light are experimenting with solar technology as viable off-grid option through different service provisioning models. Off-grid interventions are fast becoming preferred option in rural areas over grid electrification due its reliability (Bhushan and Kumar 2012).

1.3. Need for the solar technology based solution for rural children

India has one of the youngest populations in the world, with 350 million children less than 14 years of age. School education is thus essential for the better future and development of the country. Many young children going to schools either do not have access to alternate clean light source or those having access to grid electricity suffer from erratic electricity supply, both of which affect their study during evening hours. Hence, alongside 'Right to Education' it is desirable to provide the 'Right to Clean Light' as well.

The light level required for study purposes is about 150 Lux[7] at the reading area. Thus, to provide light for 4 hours every evening for study purposes requires only 0.7 kWh (Note: 1 unit = 1 kWh) of electricity per year. Now, a 0.5 Watt LED provides up to 250 Lux of light. A solar power lamp with LED light can hence provide 150 Lux of light at the table in low intensity, and up to 250 Lux of light in high intensity mode using a 1 Watt solar panel, at a cost of Rs.400-Rs.600 per lamp. The Ni-MH batteries can be used for 700 cycles.

A clear mismatch between the requirements and the scope of past solar lamp Programs acted as hindrance for sustainable adoption of solar energy products in India. Solar PV technology that could be decentralised is typically required in remote, rural areas inclusive of some 'must' features like low-affordable cost, availability in local market with

[5] Megawatts are used to measure the output of a power plant
[6] Mini/micro grids are centralized generation at local village or Panchayat level
[7] Lux is unit of illuminance and luminous emittance, measuring luminous flux per unit area.

distribution mechanism, and access to timely and low cost after sales service. However, concentration of the solar technology production in urban areas at present results in high cost of lamp (due to higher overheads), minimal availability at local level (due to absence of distribution channels), and time consuming and expensive after sale service. Hence, to remove the bottlenecks, the solar lamp Program must involve and train local people in all aspects of assembly, distribution and after sales service at the local level. This will ensure sustainable adoption of the solar technology in rural areas. Given the magnitude of children being deprived of right to clean light there is an urgency to address this need. For this a countrywide large-scale solar lamp Program simultaneously addressing the issues of *Scale*, *Speed* and *Skill* is needed.

1.4. Literature Review

Literatures are available in context of impacts of off-grid solar interventions in India. This impact assessment report adds to the growing literature on impact of small scale technologies like solar lamps and lanterns on improvement in lives and livelihoods of the rural communities. A study on impact of solar lantern Program named LaBL[8] conducted by TISS (2013), have outlined positive impact across education, health and livelihoods through increased studying hours, lesser exposure to sooth from the kerosene lamps and aiding livelihood activities. This substantiates the potential of off-grid solar intervention to offer benefits at household level. A research by Agoramoorthy and Hsu (2009) on 100 households in tribal areas of rural India also confirms increased study duration of children by hour and half as a result of provisioning solar lantern. Similarly, their study also reports of decreased expenditure on kerosene and electricity bill expenditure of these households post purchasing the solar lanterns. Their result were important in context as the rural areas where study was conducted have not receiving power between 3 to 6 am in the morning and 6 to 9 pm in the evening, which are actually dark hours. Similar insights are provided by Garg (2014) on the solar lantern Programs introduced by Government of India for school going girls in rural areas. Study of solar PV electrification Program in India by Chakrabarti and Chakrabarti (2002) reveal higher willingness to pay by the sample households who currently use

[8] Lighting a Billion Lives (LaBL) is solar lantern Program launched by TERI in 2008. More details about the Program can be found at the Program website http://labl.teriin.org/

solar energy. The study also highlights the overall change in behavior as communities are willing to move towards adoption of cleaner technology. The authors state (pp. 41) ' … (communities) have expressed their willingness to continue the use of solar power, even if diesel power is available at low cost, to avoid the air and noise pollution caused by a diesel generator'. There are also literatures available on impact of off-grid solar Programs, however systems disseminated in such cases are of larger capacity (like in case of Solar Home Systems under RVEP in India or IDCOL Program in Bangladesh) which can fulfill higher needs of the households and the impacts literature cannot be contextualized within the scope of MSP.

1.5. The Million SoUL Program

IIT Bombay has developed the 'localisation of solar energy model' through its Million SoUL Program (MSP). In this model assembly, distribution and maintenance of the solar lamp are done by the local people. In order to achieve *scale*, the model is designed such that it can be replicated in parallel in multiple blocks, across districts and states. To achieve *Speed*, the assembly and distribution for any block is designed to be completed in 90 working days. In order to target *skill development*, rural people are trained in the assembling, distribution and repair of these lamps in their local areas.

The goal of the MSP is to fulfil 'right to clean light to every child' in rural areas for the study purpose during dark hours in the fastest possible way, thus reducing dependency on kerosene lamp and contribute to build a better future. The specific objectives are:

- Provide one SoUL to every student to increase their study hours
- Involve local people and develop their capabilities to assemble, sale, provide repair and maintenance service for solar products
- Generate sustainable employment in rural areas

The model is based on the solar PV technology with its inherent feature of providing off-grid decentralised energy at an individual or household level. It integrates three critical elements of speed and reach at wider scale (access) through saturation, cost effectiveness (affordability), and sustainability. The model has three core concepts of

'partnership approach', 'capacity building' and 'financial viability'. These concepts in the model are interrelated and interdependent and they converge in to realisation of localisation of solar energy.

During two year MSP, one million solar study lamps called as Solar Urja Lamps (SoUL) were targeted to be distributed in two phases (I & II). During phase I, 7,50,000 SoUL are distributed, while in phase II rest 2,50,000 will be distributed. Phase I is implemented across 72 blocks in four Indian states of Madhya Pradesh, Maharashtra, Rajasthan, and Odisha states covering more than 7900 villages. Funding from central and state governments as well as philanthropic partners contributed towards keeping the beneficiary contribution low. The actual cost per solar urja lamp (SoUL) is Rs. 500, however at the subsidised cost the beneficiary contribution is Rs. 120 per lamp. Any child enrolled in the school and studying between Class V to Class XII is eligible to purchase one SoUL and they can avail free servicing facility provided in their vicinity till end of the phase I, i.e. December 2015. For localisation and ground level implementation partnership is formed with the NGOs. The capacity building of the local people has resulted into development of 260 solar entrepreneurs (called as SoUL repair centres managers – SRCM). This report presents the results of the concurrent evaluation (Round I) of the MSP during phase I in the state of Madhya Pradesh (MP) in India.

Chapter 2. Scope and Objectives of the Study

The phase I of the MSP has influenced the sizeable number stakeholders in rural areas of four Indian states in a short span which needs to be studied in depth to gain insights about the efficacy of the MSP. This can further contribute to up-scaling, replication, and the policy recommendations related to solar technology. Hence, the research component formed an integral part of the MSP and accordingly the concurrent evaluation of the MSP was conducted.

The objectives of the concurrent evaluation are to:

1. Assess performance of SoUL and SoUL Repair Centres (SRC)
2. Assess socio-economic impact of the Million SoUL Program
3. Assess market potential for solar PV products in rural areas
4. Bring transparency in the project and make mid-course corrections
5. Assess localisation model for scalability and replicability

The objectives of the research guided to take the mixed methods approach. The research objectives consist of both qualitative as well as quantitative dimensions, so it was appropriate to employ quantitative and qualitative research methods. In the quantitative data the survey method was applied by collecting the data at the household level, whereas for qualitative data collection the focus group discussion and interview methods were used. The main focus of qualitative method is to assess the objective of localisation model and its scalability, whereas the household survey primarily focuses on the objective of assessing the impact of the MSP.

The concurrent evaluation covered both stakeholders as well as non-stakeholders of the MSP. The qualitative method covered NGO partners and the staff involved in the MSP, solar entrepreneurs (i.e. SRCM), parents of SoUL recipients' children, school teachers, knowledgeable person in the village, and IIT B's field officer posted with the NGO Partner. The quantitative method studied the households of the SoUL recipients (treatment sample) and SoUL non-recipients (control sample) who despite being eligible

had not purchased SoUL. The household survey is planned to be conducted in two rounds in 20 representative sample blocks. The round one is after SoULs are distributed and round two is 4-5 months prior to the end of Phase I in December 2015. In survey the same household will be surveyed twice at two intervals.

This report presents the results of the household survey for the state of Madhya Pradesh and the mid-course corrections that are required for improvement of the Program.

2.1 Sample for the household survey

The sampling method employed for selecting the sample was "stratified random sampling". The sampling size and plan was as follows:

- Two samples were drawn, viz. Treatment Sample and Control Sample. Treatment sample was defined as the recipients of SoUL (who have purchased SoUL from the school) studying in class V-XII. While control sample defined as the children studying in classes V- XII who have not purchased SoUL from the school.
- 1.2% of the total population (i.e. one million students who have purchased the SoUL) was taken as the "treatment sample".
- The control sample was considered as 10% of the treatment sample, with the 2% of the control sample as the error while surveying, making a total of 12% of the Treatment Sample.
- Stratified Random Sampling was used for the evaluation. The sampling involved dividing the population into two strata, viz. electrification status of house and caste category of the household. The castes were divided into three categories, namely, Scheduled Castes (SC), Scheduled Tribes (ST) and others comprising general and Other Backward Castes (OBC). Thus, the sample (number of households to be surveyed) was arrived at by referring to Census 2011 block level data which determined the proportionate percentage of electrified and non electrified households and caste composition.
- The blocks where the MSP has been implemented were clustered and then a representative block was chosen for the survey. This clustering was based on

homogeneity of geographical and social characteristics of the population in each block. Thus, sample of 20 blocks was selected of a total of 72 blocks where one Million SoULs were distributed.

- Using database on recipients of SoUL, villages having sufficient number of SoUL recipients of the required strata were selected. During selection it was ensured that remote and relatively small villages were not left out.

2.2 The MSP in Madhya Pradesh

The MSP is implemented in 27 blocks and eight districts of MP. For presence of the MSP refer the Figure 2 given below.

Figure 1: Presence of the MSP in MP

There are six NGO partners and two vendors namely Thrive Solar Energy Private limited and Sirus Solar Energy Systems Private Limited for supplying the material (disassembled kits) in MP. In the phase I of the MSP, 383412 SoULs were distributed in the state of MP. An overview of covered blocks in the district, the NGO partners, the vendor, and the number of distributed SoULs in the respective block are given in table 1 below.

Table 1: Overview of NGO partners, Vendors and SoUL Distribution in MP

NGO Partner	District	Block	Vendor	Distributed SoULs	Start Date	Saturation Date
Ashagram	Barwani	Pati	Thrive	10781	20-Feb-2014	14-Mar-2015
Ashagram	Barwani	Niwali	Thrive	11672	20-Feb-2014	19-Mar-2015
Ashagram	Barwani	Barwani	Thrive	14070	6-Apr-2014	14-Mar-2015

Ashagram	Barwani	Rajpur	Thrive	312	20-Feb-2014	1-Aug-2014
AKRSP	Barwani	Sendhwa	Thrive	15900	11-Apr-2014	13-Mar-2015
AKRSP	Khargone	Jhirnia	Thrive	13789	28-Mar-2014	6-Apr-2015
AKRSP	Khandwa	Pandhana	Thrive	2060	22-Aug-2014	19-Nov-2014
AKRSP	Khandwa	Khalwa	Thrive	2920	21-Aug-2014	13-Nov-2014
CARD	Mandla	Bichiya	Sirus	16000	16-Aug-2014	15-Feb-2014
CARD	Mandla	Mandla	Sirus	18700	19-Jul-2014	9-Feb-2015
CARD	Mandla	Ghughri	Sirus	10800	3-Jun-2014	12-Jan-2015
CARD	Dhar	Tirla	Sirus	6600	19-May-2014	15-Nov-2014
CARD	Dhar	Nalcha	Sirus	15892	26-May-2014	10-Jan-2015
CARD	Dhar	Dhar	Sirus	11662	12-Sep-2014	10-Jan-2015
CARD	Dhar	Sardarpur	Sirus	21000	10-Sep-2014	14-Mar-2015
GVT	Dhar	Kukshi	Sirus	9500	10-Jul-2014	23-Feb-2015
GVT	Jhabua	Ranapur	Sirus	1492	7-Nov-2014	12-Feb-2015
GVT	Jhabua	Jhabua	Sirus	13595	24-May-2014	28-Feb-2015
GVT	Jhabua	Meghnagar	Sirus	9963	24-May-2014	16-Dec-2014
GVT	Jhabua	Thandla	Sirus	9865	24-May-2014	5-Feb-2015
GVT	Jhabua	Rama	Sirus	8585	7-Nov-2014	12-Feb-2015
Sahjeevan	Shahdol	Burhar	Thrive	20663	24-Mar-2014	10-Dec-2014
Sahjeevan	Shahdol	Kotma	Thrive	10145	24-Mar-2014	5-Mar-2015
Sahjeevan	Shahdol	Sohagpur	Thrive	20940	24-Mar-2014	17-Jan-2015
Sahjeevan	Shahdol	Gohparu	Thrive	11757	18-Sep-2014	13-Jan-2015
CARD	Dhar	Badnawar	Thrive	4035	1-Feb-2015	9-Feb-2015
CARD	Jhabua	Petlawad	Thrive	16565	4-Nov-2014	4-Feb-2015
BAIF	Betul	Chicholi	Thrive	8638	11-May-2014	31-Dec-2014
BAIF	Betul	Betul	Thrive	22153	11-May-2014	11-Feb-2015
BAIF	Betul	Athner	Thrive	11355	11-May-2014	10-Feb-2015
BAIF	Betul	Shahpur	Thrive	15449	1-Aug-2014	8-Dec-2014
BAIF	Betul	Ghodadongri	Thrive	16554	1-Aug-2014	21-Feb-2015

2.3 Profile of MP

Centrally located, Madhya Pradesh (MP) is also known as the heart of India. Spread across an area of 308,000 sq km, MP is the second largest state of the country and ninth largest economy in India. The state is endowed with vast natural resources like forests, minerals, rare and valuable herbs and medicinal plants and eight important rivers flowing across the state. The topography of the State is defined by the Narmada Sone valley extending through almost whole of the state from east to west (Planning Commission 2010). There are 10 districts in MP that come under Fifth Schedule Areas

All implementation districts namely Jhabua, Mandla, Dhar, Khargone, Barwani, Betul, Shahdol, and Khandwa in the MSP fall under the fifth scheduled areas. All these blocks in which the MSP is spread over has predominant tribal population.

The latest electrification data as on 30-02-2014 by Ministry of Power, Government of India for Madhya Pradesh stated that 97% of the villages in MP are electrified. However, this percentage looks commendable due to the definition of an electrified village which does not require 100% households in the village to be electrified. As per Ministry of Power, the village is defined electrified if:

- Basic infrastructure such as distribution transformer and distribution lines is provided in the inhabited locality as well as the Dalit Basti/hamlet where it exists.
- Electricity is provided to public places like Schools, Panchayat Office, Health Centres, Dispensaries, Community centres etc.
- The number of households electrified should be **at least 10% of the total number of households in the village.**

The household survey conducted under the MSP revealed that 28% of the treatment households in MP were non-electrified highlighting that this is a significant percentage.

2.4 Cluster approach and representative blocks for the household survey

As aforementioned the distribution of SoUL in MP has taken place in 27 blocks. All these blocks have predominant tribal population, which resides in remote rural areas, with some of the blocks having forest areas. Conducting household survey for the purpose of concurrent evaluation in all the implementation blocks was not feasible considering the geographic spread and resources required; hence ‘cluster’ approach was taken towards resolving this issue. The cluster of two or more blocks was formed on the basis of their geographic and demographic similarities, and one block is selected as a representative block from each cluster for conducting the concurrent evaluation. This allowed for generalization of impacts without compromising on the validity of the research sample. There were eight such clusters on basis of aforementioned criteria and eight blocks were selected as a representative blocks for the concurrent evaluation.

The following table 2 presents the clusters that were formed and the representative blocks in which the household survey was conducted.

Table 2: Representative Block and Block Cluster

Representative block for HH Survey	Names of Blocks in the Cluster	District	IP's Name
Shahpur	Shahpur	Betul	BAIF
	Chicholi	Betul	BAIF
	Ghodadongri	Betul	BAIF
Betul	Betul	Betul	BAIF
	Athner	Betul	BAIF
Burhar	Burhar	Shahdol	Sahjeevan Samiti
	Sohagpur	Shahdol	Sahjeevan Samiti
	Gohparu	Shahdol	Sahjeevan Samiti
	Kotma	Annupur	Sahjeevan Samiti
Nalcha	Nalcha	Dhar	CARD
	Tirla	Dhar	CARD
	Dhar	Dhar	CARD
	Sardarpur	Dhar	CARD
Jhirnia	Kukshi	Dhar	GVT
	Jhirnia	Khargone	AKRSP
Meghnagar	Petlawad	Jhabua	CARD
	Meghnagar	Jhabua	GVT
	Thandla	Jhabua	GVT
	Rama	Jhabua	GVT
	Jhabua	Jhabua	GVT
Pati	Barwani	Barwani	Ashagram
	Pati	Barwani	Ashagram
	Niwali	Barwani	Ashagram
	Sendhwa	Barwani	AKRSP
Ghughri	Ghughri	Mandla	CARD
	Bichiya	Mandla	CARD
	Mandla	Mandla	CARD

Chapter 3: Madhya Pradesh – Concurrent Evaluation Result (First Round)

For the concurrent evaluation the household survey was conducted in eight representative blocks of MP. The total sample household surveyed in MP were 5826, amongst which 5157 were treatment sample and 669 control sample. The sample households were distributed across 242 villages and 177 Gram Panchayats. Table 3 and 4 below give an overview of block wise sample households and villages covered.

Table 3: Distribution of Sample Households across the Sample Villages in MP

Block	No. of Treatment Household	Percentage	No. of Control Household	Percentage
Betul	552	10.70	64	9.57
Burhar	1042	20.21	152	22.72
Ghughri	598	11.60	80	11.96
Jhirnia	362	7.02	46	6.88
Meghnagar	417	8.09	48	7.17
Nalcha	515	9.99	69	10.31
Pati	905	17.55	114	17.04
Shahpur	766	14.85	96	14.35
Total HH's covered in MP	**5157**	100	**669**	100

Table 4: Distribution of Villages and Gram Panchayats covered in MP

Block	Treatment		Control		Treatment		Control	
	No. of Villages	%	No. of Villages	%	No. of Panchayats	%	No. of Panchayats	%
Betul	31	12.81	15	11.54	24	13.56	14	12.61
Burhar	43	17.77	25	19.23	36	20.34	22	19.82
Ghughri	20	8.26	14	10.77	17	9.60	12	10.81
Jhirnia	33	13.64	17	13.08	24	13.56	15	13.51
Meghnagar	21	8.68	13	10.00	20	11.30	13	11.71
Nalcha	15	6.20	11	8.46	14	7.91	10	9.01
Pati	36	14.88	18	13.85	26	14.69	15	13.51
Shahpur	43	17.77	17	13.08	16	9.04	10	9.01
Total	242	100.00	130	100.00	177	100.00	111	100.00

3.1. Socio-economic Background of the Sample Households in Madhya Pradesh

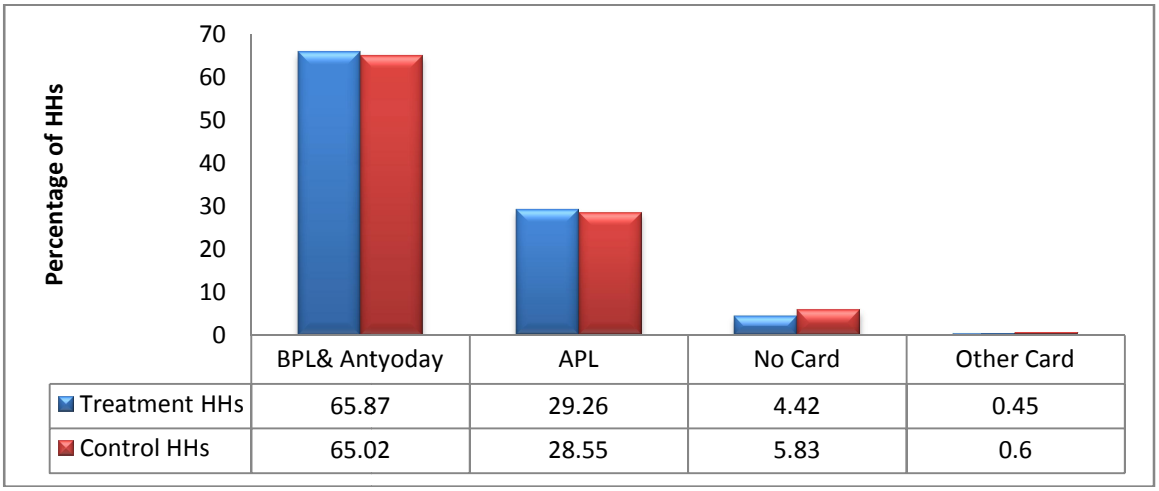
As per Census 2011, in rural Madhya Pradesh 15.76% of the population was Scheduled Caste (SC), 27.16% was Scheduled Tribe (ST), and 57.10% Others. The table 5 given below presents the classification of sample as per social categories as well as the Census 2011 data for the same. In the sample the percentage of Scheduled Tribes (STs) was highest in both treatment as well as control samples (68% each), followed by 23.52% other backward castes (OBCs) in the treatment and 21.82% in the control sample.

Table 5: Social category of Sample Households in MP

Social Category	No. of Treatment HHs	Percentage	No. of Control HHs	Percentage	Percentage of rural population as per Census 2011
ST	3,511	68.08	460	68.76	27.16
SC	298	5.78	52	7.77	15.73
OBC	1,213	23.52	146	21.82	57.10
General	135	2.62	11	1.64	
Total	5,157	100	669	100	

Maximum percentage of treatment households (37.48%) had agriculture followed by 32.23% households with labour as their primary occupation, while amongst control households 39.61% had labour and 29.9% had agriculture as their primary occupation. In both the samples approximately 20% relied on both agriculture and labour as their primary occupation. The households possessing either below poverty line (BPL) or Antyoday cards were defined as poor households and figure 2 below presents the percentage of households and the type of cards possessed by them.

Figure 2: Type of Cards possessed by Sample Households



	BPL& Antyoday	APL	No Card	Other Card
Treatment HHs	65.87	29.26	4.42	0.45
Control HHs	65.02	28.55	5.83	0.6

About the access to the grid electricity either through legal or non-legal (by putting hook) connection, it was seen that 28.37% of the treatment sample and 24.51% of control sample had no access, i.e. they were non-electrified. However, 65.46% treatment and 67.56% control households had legal connection, which means 6.17% treatment and 7.92% control households had illegal connection.

3.2. Children Details

In the sample households only the information of children that were either in the school going age group of 5-17 years or were studying between classes 1 to 12 was collected as they come under the age group that attends the school. Moreover, children studying from class 1 onwards are expected to complete the home-work at home when given or are expected to study at home. Therefore, availability of light at home during dark hours enables them to study. In 5157 treatment households 10,598 children were either in the school-going age (5 to 17 years) and or studied in classes from 1st to 12th. However, amongst these 10,408 children (98.21%) were enrolled in the school. In 669 control households 1,271 children (97.39%) were enrolled in the school. The classification of children as per the age group showed that maximum percentage (54.86% in treatment and 50.8% in control) of households have children in the age group of 10-15 years, followed by 5-10 years age group (31.09% in treatment and 34.64% in control) then the age group of 15-20 years (approximately 14% each in treatment and control sample)

There were very few (less than 1%) households that had children in the age group of 20-25 years. In the treatment sample 37.04% of the school going children studied in upper primary (6^{th} to 8^{th}), while approximately 20% each studied in primary (between class I-IV) and secondary (9^{th} & 10^{th}) respectively. There were 14.8% children studied Class V, while 7.19% in higher secondary (11^{th} & 12^{th}). In the control sample 32.57% studied in upper primary followed by 23.76% in primary, 18.41% in secondary, and 7.55% in senior secondary. The gender distribution did not show much difference**.**

Of the total of 10,408 school-going children in the treatment sample 60.08% have purchased the solar urja lamp (henceforth SoUL). As there was higher percentage of male children in the school-going age group in the sample the gender differentiation was not comparable, while the data within the gender category revealed 60.5% boys have purchased SoUL against 59.61% girls. Thus, no significant differences in gender were observed with regard to purchase of SoUL. 84.6% of the households had one SoUL, with 13.81% households with two SoULs, and 1.4% with three SoULs. There were only 0.19% households that had 4 SoULs. The reason for not purchasing SoUL in treatment sample revealed that 47.01% children in treatment were not eligible for purchasing SoUL as they studied in classes below class V, followed by 16.01% children that reported to study from SoUL recipient sibling's lamp and then by 11.69% reporting the purchased number of SoULs are enough. In the control sample 30.84% children did not purchase SoUL as they had no enough money followed by 18.88% children who were not eligible, and then by children stating SoUL was not available for sell. There were only 6 children (0.47%) in control stating SoUL is expensive indicating that cost is not the barrier for accessing the SoUL (see table 6).

Table 6: Reasons for Not Purchasing SoUL by school-going children in MP*

Reason	No. of Children in treatment	%	No. of Children in control	%
Child not present when SoUL was given	33	0.83	57	4.48
Not Eligible	1,870	**47.01**	240	**18.88**
Not Enough Money	285	7.16	392	**30.84**
Not Given in School	195	4.9	85	6.69
Not Required	333	8.37	73	5.74
Purchased number of SoUL are enough	465	11.69	0	0.00

SoUL lamp not available	134	3.37	201	**15.81**
Studies from recipient sibling's lamp	637	**16.01**	0	0.00
Not Aware	8	0.2	121	9.52
Other	9	0.23	18	1.42
Lamp given to somebody else	7	0.18	0	0.00
Not Interested in studies	1	0.03	0	0.00
One more Solar device available	1	0.03	0	0.00
Don't know the reason	0	0.00	33	2.6
Electricity present 24 hours	0	0.00	35	2.75
Not interested in purchasing SoUL	0	0.00	10	0.79
SoUL is expensive	0	0.00	6	0.47
Total	3,978	100	1,271	100

* Since asking for reasons for not buying Soul Lamp begun from Shahpur, so the reasons are not available for 177 cases

3.3. Lighting: sources, devices and expenditure

3.3.1. Electricity bill: Interval of receiving it and amount paid by sample households

The majority of households in both the samples received their electricity bills in every month [81.53% treatment and 84.28% control households]. There were 17.14% treatment and 14.18% control households reported receiving annual bill. Maximum percentage of households in both the samples 69.11% in treatment and 72.68% in control received the bill in the range of Rs. 0 - 300, followed by 23.01% in treatment and 17.27% in control receiving the bill in the range of Rs. 300 to Rs. 600.

3.3.2. Kerosene: purchase, expenditure and usage

The data related to kerosene purchase, expenditure and usage was calculated for only those households that purchased and consumed kerosene. The distribution of monthly kerosene purchase, usage, and expenditure was examined according to electrification status of the households to know if any differences exist.

There were only 8.16% treatment and 6.88% control households that reported not purchasing kerosene at all, so most of the households in both the samples purchased kerosene. 'Public distribution system (PDS) was the 'only source of kerosene purchase' for 87.55% treatment and 85.65% control households making it the predominant source of kerosene purchase. There were only 3.03% of treatment and 5.23% control

households for whom open market was the 'only source of kerosene purchase'. There were very few households (less than 2.5% each) in both the samples that purchased kerosene from both the sources.

The data on kerosene usage showed that lighting was taking precedence over cooking. There were very few households that reported 'not using kerosene for lighting purpose' [only 1.35% in treatment households and 0.96% in control households] whereas 75.17% in treatment and 78.33% in control reported not using kerosene for cooking. There were 55.91% treatment households and 49.6% control households that consumed kerosene 'only for lighting' purpose, while remaining households (44.09% in treatment and 50.4% in control) consumed it for other uses including lighting.

For maximum percentage of households in both treatment (52.99%) and control sample (53.4%) per month kerosene purchase was in the range between 4-5 litres from PDS outlet. This was followed by 22.16% treatment and 21.26% control households purchasing 2-3 litres of kerosene. As aforementioned open market purchase of kerosene was not much. The maximum percentage of households (38.91% in treatment and 30%in control) purchased 1-2 litres of kerosene (refer table 7).

Table 7: Monthly Kerosene Purchase from Different Sources in MP

	PDS Shops				Market			
Kerosene Purchased (in Ltrs)	**No. of Treatment Households**	**%**	**No. of Control Households**	**%**	**No. of Treatment Households**	**%**	**No. of Control Households**	**%**
0-1	45	0.98	4	0.68	37	16.74	4	8.00
1-2	396	8.65	62	10.54	86	38.91	15	30.00
2-3	1015	22.16	125	21.26	41	18.55	10	20.00
3-4	656	14.32	78	13.27	18	8.14	7	14.00
4-5	2427	52.99	314	53.40	34	15.38	11	22.00
5-6	7	0.15	1	0.17	0	0.00	0	0.00
Above 6 Litres	34	0.74	4	0.68	5	2.26	3	6.00
Total	4580	100	588	100	221	100	50	100

Data about the monthly purchase revealed a slight difference in monthly average kerosene purchase only in electrified control household purchasing more than other categories. However, t-test results showed significant differences. The table 8 below presents t-test results for difference in total monthly kerosene purchased between treatment and control. It demonstrated that the difference between monthly purchase of kerosene by control households and treatment households is significant at 90% confidence level (p-value 0.0833).

Table 8: T-test Results for Total Monthly Kerosene Purchased

Total Monthly Kerosene Purchased	Treatment	Control	Diff	t-test	p-value
Mean	3.9207	3.7923	0.12845	1.7321	0.0833

Kerosene consumption for the lighting purpose as observed in table 9 below showed that maximum percentage of non-electrified households in both the groups as well as electrified households in control group were consuming 4-5 litres of kerosene per month which is more compared to maximum percentage of electrified treatment consuming 2-3 litres per month.

Table 9: Monthly Kerosene Consumption for Lighting in MP

Kerosene usage for lighting (in litres)	Treatment HHs				Total	%	Control HHs				Total	%
	Electrified		Non-Electrified				Electrified		Non-Electrified			
	No.	%	No	%			No.	%	No.	%		
0-1	183	5.53	26	1.82	209	4.41	16	3.48	2	1.23	18	4.71
1-2	613	18.54	191	13.37	804	16.98	72	15.65	21	12.88	93	16.88
2-3	1,076	**32.54**	376	26.31	1452	30.66	121	26.3	44	26.99	165	39.18
3-4	624	18.87	290	20.29	914	19.30	110	23.91	28	17.18	138	50.9
4-5	738	22.32	526	**36.81**	1264	26.69	132	**28.7**	66	**40.49**	198	45.88
5-6	4	0.12	5	0.35	9	0.19	0	0.00	0	0.00	0	40.49
Above 6 Litres	7	0.21	13	0.91	20	0.42	3	0.65	2	1.23	5	0.65
Kerosene not used for lighting	62	1.87	2	0.14	64	1.35	6	1.3	0	0	6	2.53
Total	3,307	100	1,429	100	4736	100	460	100	163	100	623	100

As far as consumption of kerosene for cooking is concerned, majority of sample households' majority of households reported not using kerosene for cooking at all.

Majority of household in both the samples [15.43% in treatment and 14.93% in control] consumed less than 1 litre of kerosene per month, whereas few percentage households consumed more than 1 litre of kerosene.

The use of number of kerosene based lighting devices in treatment and control households was looked into to understand if there is a difference in pattern due to presence of SoUL. 87.63% of treatment and 90.43% control households have simple wick lamps (C*himnis*), while approximately 12% households each in both treatment and control sample used hurricane lamp. Not much difference was observed between treatment and control households about the number of wick lamps used. In treatment sample 50.28% and 60.42% in control sample used only one wick lamp followed by usage of two wick lamps by 33.26% treatment and 43.14% control households. There were few households that used 3 or more wick lamps.

Per day usage of kerosene devices in hours is presented in table 10 below. It showed that maximum percentage of treatment households used it for less than 2 hours, whereas in control maximum percentage of households' used it for 2-4 hours. Thus, in terms of hours more usage was observed in control group than in treatment group. The data as per electrification status revealed that higher percentage of control non-electrified households is using kerosene based devices for more number of hours than other groups.

Table 10: Usage of Kerosene Devices (in hours) for Lighting in MP

No. of hrs	Treatment						Control					
	Electrified		Un-electrified		Total	%	Electrified		Un-electrified		Total	%
	Nos.	%	Nos.	%			Nos.	%	Nos.	%		
0-2	1,901	**58.58**	367	25.72	2,268	**48.54**	211	**46.48**	35	21.47	246	39.87
2-4	1,000	30.82	583	**40.85**	1,583	33.88	175	**38.55**	73	**44.79**	248	**40.19**
4-6	198	6.1	266	18.64	464	9.93	39	8.59	34	20.86	73	11.83
6-8	52	1.6	88	6.17	140	3.00	10	2.2	12	7.36	22	3.57
8-10	20	0.62	37	2.59	57	1.22	3	0.66	0	0.00	3	0.49
10-12	74	2.28	86	6.03	160	3.42	16	3.52	9	5.52	25	4.05
Total	3,245	100	1,427	100	4,672	100.00	454	100	163	100	617	100.00

The average cost of one litre of kerosene for was Rs. 17 and Rs. 28 from PDS and market respectively. The monthly kerosene purchase was approximately 4.15 litres for both electrified and non-electrified treatment households and higher at 4.24 litres for control treatment and slightly lesser at 4.12 litres for control non-electrified. The monthly kerosene expenditure showed that treatment households were spending lesser than the control households. The non-electrified control households were spending more (Rs. 75.36) than non-electrified treatment (Rs. 72.65) group and control electrified spent Rs. 77.8 as compared to Rs. 72.55 (refer table 11).

Table 11: Source-wise per litre Kerosene Cost and Monthly Expenditure as per electrification status in MP

Average price and Monthly expenditure	Treatment				Control			
	Electrified		Non - Electrified		Electrified		Non - Electrified	
	Rs.	No. of HH's	Rs.	No. of HH's	Rs.	No. of HH's	Rs.	No. of HH's
Average Price from PDS Shops	17.14	3196	17.11	1384	17.61	437	17.4	151
Average Expenditure on PDS	70.41	3196	71.3	1384	73.62	437	70.07	151
Average Price from Market	29.69	147	27.37	74	27.77	31	26.36	19
Average Expenditure on Market	82.57	147	84.68	74	127.74	31	88.63	19
Total Kerosene Purchased*	4.15L	3307	4.15L	1429	4.24L	460	4.12L	163
Total Average Expenditure*	72.55	3307	72.657	1429	77.8	460	75.36	163

* The values have been calculated from the number of households that actually purchase kerosene

3.4. Electricity based devices used for lighting

The data on electricity based lighting devices in 3694 electrified treatment households showed that 76.98% had incandescent bulb, 39.36% had compact fluorescent lamp (CFL), 1.84% had tube light, and 0.2% light-emitting diode (LED), and 10.44% rechargeable torch. Similarly in 505 electrified control households, 80.39% used incandescent bulbs, 32.07% CFL, 0.39% tube light, and 10.44% rechargeable torch. Regarding the number of incandescent bulb in the households in treatment sample 56.91% households had one bulb, followed by 31.96% with two bulbs. In the control sample 55.42% households had one incandescent bulb followed by 33.74% with two. In both the samples there were few households that had more than 2 bulbs. Similarly

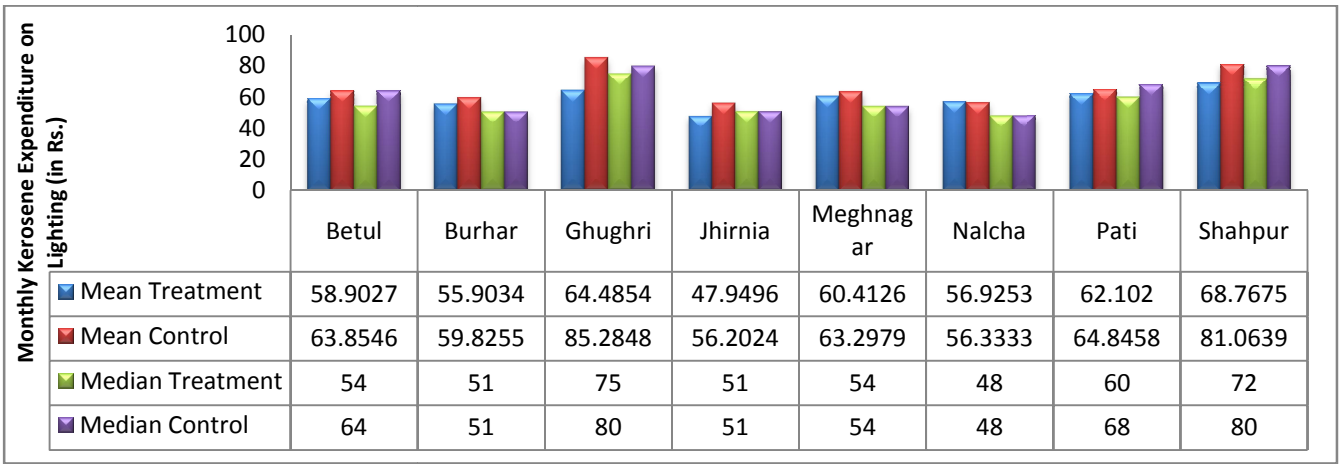
about CFL in treatment 35.49% households had one CFL followed by 32.05% with two CFL and 16.16% with three CFLs, while in control 37.65% had one and 28.4% had two, and 16.67% had three. Mean of per unit cost reported by respondent households was Rs. 11 for incandescent bulb and Rs. 139 for CFL. The average bulb life was stated to be approximately 1 and half months and for CFL it was 11 months. Amongst the households possessing tube light majority in both the samples had one tube light (67.65% and 100%). The average life of tube light reported by the respondents was one year one month with average cost of Rs. 149. There was not a single control household that had LED, while negligible treatment sample had it with majority of 60% households having 1 LED. Amongst those households possessing rechargeable torch, majority of households in both the samples (94.3% in treatment and 98.11% in control) had one.

3.5. Expenditure on lighting

In order to see the impact of SoUL on 'lighting expenditure' of the households the comparison was made between treatment and control households. However for this analysis, data was calculated for those households which had SoUL in working condition, while the households with non working SoULs were not considered. In order to arrive at monthly lighting expenditure monthly mean and median expenditure on various heads such as electrical lighting devices like CFL, incandescent bulb, electricity bill, and kerosene purchased for lighting purpose was calculated separately and then the total mean and median lighting expenditure was calculated.

3.5.1. Monthly expenditure on kerosene used for lighting: The figure 3 below presents the monthly mean expenditure on kerosene in treatment and control sample across the blocks in MP. It showed that except for Nalcha in all remaining 7 blocks the expenditure was more in control households. The difference in mean expenditure on lighting between control and treatment showed that it was highest in Ghughri block with control households spending almost 20.79 rupees more, while it was lowest in Pati block with control households spending 2.74 rupees more than the control households.

Figure 3: Mean & Median of Monthly Kerosene Expenditure on Lighting in Treatment & Control Groups in MP



	Betul	Burhar	Ghughri	Jhirnia	Meghnagar	Nalcha	Pati	Shahpur
Mean Treatment	58.9027	55.9034	64.4854	47.9496	60.4126	56.9253	62.102	68.7675
Mean Control	63.8546	59.8255	85.2848	56.2024	63.2979	56.3333	64.8458	81.0639
Median Treatment	54	51	75	51	54	48	60	72
Median Control	64	51	80	51	54	48	68	80

The table 12 given below makes two comparisons about kerosene expenditure on lighting: (a) electrified treatment and electrified control group (b) non-electrified treatment and non-electrified control group. It was found that non-electrified control households tend to spend more on kerosene than the treatment households in Betul, Burhar, Ghughri, Jhirnia, and Shahpur. Even in control electrified households the mean kerosene expenditure was more in all blocks.

Table 12: Monthly Expenditure on Kerosene as per electrification status Blocks in MP

Blocks in MP	Treatment				Control				Difference			
	Electrified		Non - Electrified		Electrified		Non - Electrified		Electrified		Non - Electrified	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Betul	57.14	54	73.86	80	63.37	62	90	90	6.22	8	16.13	10
Burhar	53.44	51	58.09	51	58.63	51	61.31	51	5.19	0	3.22	0
Ghughri	56.82	50	70.33	80	87.57	75	81.10	80	30.75	25	10.77	0
Jhirnia	44.85	51	60.19	54	53.32	51	70.57	72	8.47	0	10.37	18
Meghnagar	58.8	51	68.23	68	62.42	54	65.83	61.5	3.56	3	-2.39	-6.5
Nalcha	54.48	48	89.32	72	55.65	48	62.2	51	1.17	0	-27.12	-21
Pati	60.47	54	69.22	68	64.43	68	67.57	68	3.95	14	-1.65	0
Shahpur	66.75	72	74.26	80	78.60	80	85.97	85	11.85	8	11.70	5

3.5.2. Monthly expenditure on electric devices: The data on mean expenditure on electrical devices showed that in four blocks (Betul, Burhar, Meghnagar, Nalcha) control households were spending slightly more than treatment, whereas in Ghughri, Jhirnia, Pati, and Shahpur treatment households were found to be spending more than the control. On the whole it was found that there was not much difference in the expenditure on electric devices between treatment and control households.

3.5.3. Monthly expenditure on electricity bill: The data on mean expenditure on electricity bill showed that in Meghnagar, Nalcha, Pati, and Shahpur control households were found to be spending more than the treatment, whereas in Betul, Burhar, Ghughri, and Jhirnia treatment households were spending more than control.

3.5.4. Monthly expenditure on lighting: Except for Jhirnia, Meghnagar, Pati, and Shahpur blocks in all remaining four blocks mean expenditure on lighting was slightly more in control than the treatment sample. Although the treatment and control group level broad findings showed mixed results, however data as per electrification status revealed expected results whereby monthly lighting expenditure of non-electrified control group was higher than the treatment. As observed in the table 13 below monthly mean lighting expenditure of non-electrified households was more in Betul, Burhar, Ghughri, Jhirnia, and Shahpur blocks and this higher expenditure was in the range of Rs. 4 to Rs. 18. Amongst the remaining three blocks non-electrified treatment sample was spending approximately Rs. 4 more than the control.

Table 13: Monthly Expenditure on Lighting in Electrified & Non-Electrified Households across MP

Blocks in MP	Impact				Control				Difference			
	Electrified		Non - Electrified		Electrified		Non - Electrified		Electrified		Non - Electrified	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Betul	422.69	383	72.2979	80	403.247	338	90	90	-19.443	-45	17.7021	10
Burhar	337.927	297.5	56.6607	51	310.313	263	60.403	51	-27.615	-34.5	3.74227	0
Ghughri	445.948	337.065	70.098	80	322.898	286.042	81.1071	80	-123.05	-51.023	11.0091	0
Jhirnia	282.82	227.667	57.7398	52.5	270.834	256	70.5714	72	-11.986	28.3333	12.8316	19.5
Meghnagar	194.322	163	68.2315	68	171.819	139.583	65.8333	61.5	-22.503	-23.417	-2.3981	-6.5
Nalcha	466.986	325	66.1667	64	545.681	310.958	62.2	51	78.6944	-14.042	-3.9667	-13

Pati	271.451	152.667	68.0217	68	257.017	107.167	67.5714	68	-14.434	-45.5	-0.4503	0
Shahpur	422.992	355.167	71.5988	76	429.937	325.5	85.975	85	6.945	-29.667	14.3762	9

T-test for statistical significance

T-test was conducted for checking the statistical significance of the difference in the monthly expenditure on lighting between two samples i.e. treatment group and control group and the related heads. Furthermore t-test was also conducted in order to see any differences between electrified and non-electrified households across both groups. In the t-test, mean treatment was subtracted from mean control to observe whether the differences are statistically significant or not. The expected outcome shall be that the expenditure on lighting in treatment should be less than those in control group.

Table 14 given below presents t-test results, which were run for two samples, i.e. treatment and control, by calculating 'the mean' for total expenditure on lighting and for related heads separately.

Table 14: Two sample (treatment & control) T-test Results

	Exp on Electricity Bill		**Exp on Electric Devices**		**Exp on Kerosene used for lighting**		**Total Exp**	
	t- test	**P-Value**	**t- test**	**P-Value**	**t- test**	**P-Value**	**t- test**	**P-Value**
Consolidated MP	-0.2613	0.7939	-0.7902	0.4295	**6.1967**	**0.0000**	-0.0361	0.9712
Block Wise	**t- test**	**P-Value**	**t- test**	**P-Value**	**t- test**	**P-Value**	**t- test**	**P-Value**
Betul	-0.9661	0.3344	0.2704	0.7869	1.7889	0.0777	0.2113	0.8328
Burhar	-1.2718	0.2041	0.5818	0.5609	1.7746	0.0775	0.2197	0.8262
Ghughri	-2.6411	0.0087	-1.4621	0.1448	2.7267	0.0078	0.0412	0.9671
Jhirnia	-0.4543	0.6502	-1.372	0.1713	1.596	0.1172	-0.0274	0.9781
Meghnagar	0.1232	0.902	0.1827	0.8551	0.9876	0.3272	-1.2571	0.2095
Nalcha	0.5862	0.5581	0.4388	0.661	-0.149	0.882	0.8704	0.3845
Pati	1.1771	0.24	-0.6808	0.4963	1.504	0.1344	-0.0563	0.9551
Shahpur	0.3217	0.7478	-0.5508	0.582	4.8556	0.0000	-0.247	0.805

T-test results for 'lighting expenditure' showed that the difference was significant for 'expenditure on kerosene used for lighting' and was not significant for 'electricity bill' and 'expenditure on electric devices'. T-test for the difference in kerosene expenditure on lighting was significant at 99% confidence level for entire MP state as well as for

Shahpur and Ghughri and 90% confidence level for Betul and Burhar, blocks, whereas for remaining blocks it was insignificant.

T-test results for difference in total expenditure on lighting was insignificant, although the direction emerged was as expected with total expenditure on lighting was slightly higher in control than in treatment households. The results are not significant because contribution of SoUL was limited to substituting only one kerosene lamp as well as saving consumption of lighting through grid electricity in one room. Unless the need for lighting for entire house gets fulfilled through solar home lighting the significant impact in terms of reduced kerosene usage and expenditure and overall reduced expenditure on lighting cannot be expected.

Two sample (treatment & control) T-test Results with electrification Status as a Constraint

As mentioned earlier electrification status was put as a constraint to explore whether there were any differences between the expenditure pattern of electrified and non electrified households in control and treatment groups. As observed in table 15, t-test results for 'expenditure on kerosene used for lighting' for Madhya Pradesh was significant for both electrified and non-electrified households. For electrified sample, the difference was significant at 99% confidence and for non-electrified households significance was at 95% ($p < 0.033$) confidence level, both indicating higher expenditure by control electrified as well as control non-electrified households than the treatment sample.

For total expenditure on lighting although the results were they were in opposite direction against the expectation as well as insignificant. However, for non-electrified households the significance was at 95% confidence level, indicating higher expenditure by control non-electrified households than the treatment non-electrified sample.

Table 15: Two sample (Treatment & Control) T-test Results – Electrification Status as a Constraint

	Exp on Kerosene used for lighting		Total Exp	
	Electrified	Non- Electrified	Electrified	Non- Electrified

	t- test	P-Value	t- test	P-Value	t- test	P-Value	t- test	P-Value
Consolidated MP	6.3333	0.0000	2.1288	0.0335	-0.8245	0.4097	2.5672	0.0104

3.6. Studying during dark hours: lighting devices, electrification status, gender differentiation (studying during dark hours henceforth referred as studying in night)[9]

Regarding usage of lighting devices for study at night it was reported that 92.56% children in treatment and 90.56% in control study at night. The reason for not studying were asked to the children, which revealed that in treatment 54.91% and in control 86.66% were not interested in studying followed by 32.56% in treatment and 10.83% in control who were in lower classes, i.e. class I to IV and did not study at night. There were 10.34% in treatment and 6.67% in control who reported not studying during night.

The 'lighting devices used for study at night' is a single and or multiple response question. The respondents from the treatment sample informed that **80.58%** were beneficiary children[10] who used **SoUL to study at night as one of the study device** (either as the only lighting device or along with other devices), while 19.42% children did not use SoUL as one of the studying devices. The gender wise comparison did not show any difference. Amongst the children not using SoUL, for the maximum percentage of students (94.95%) non-functioning of SoUL was the reason.

The data on usage of **solely kerosene** based **lighting devices** like C*himni* (simple wick lamp) and hurricane revealed that in treatment sample only 5.4%, whereas in control sample **24.07%** children used it. There were **6.47%** in treatment sample and **23.46%** in control sample used **electricity as a single source** to study at night. In the control sample maximum percentage of children (47.09%) used electricity and kerosene based lighting device to study at night. It was observed in the treatment sample that **18.68%**

[9] Dark hours are defined as the time when there is no daylight and there is darkness and lighting devices are required for the illumination. The dark hours pertain to hours from dusk (darker stage of twilight) to dawn (the first appearance of light in the sky before sunrise). These hours will vary from season to season for example in winters it becomes dark early in the evening and the nights are longer as sun rises late and vice-versa during summer.

[10] Beneficiary children are defined as children who are using SoUL for studying during dark hours and they could be both recipients as well as non-recipients of SoUL.

children used **'merely SoUL'** as a lighting device and maximum percentage (41.92%) of treatment households used SoUL and electricity (refer table 16).

The comparison across the blocks revealed that Burhar had most percentage (34%) of 'only SoUL' users followed by 14.83% in Pati, and 13.33% in Jhirnia. Within the block data about percentage of only SoUL users showed Burhar and Jhirnia has 32% each 'only SoUL' users followed by 19.55% in Nalcha, 16.55% in Meghnagar, and 15.33% in Pati. The remaining three blocks, Betul, Ghughri, and Shahpur had 'only SoUL' users in the range of 3-7%. The data on children studying in 'only kerosene based devices' across the blocks showed that except for Betul in which there are no 'only kerosene source' users at all in both the samples, in other blocks less percentage of children in treatment households are using it. The 'only kerosene source' for studying at night was highest in Ghughri at 33.6% followed by 30.12 in Meghnagar, 29.75% in Shahpur, 20.66% in Burhar, 15.66% in Jhirnia, 12.23% in Pati, and 12.6% in Nalcha. Thus, in all blocks the control sample has 'only kerosene' source users in the range of 12% to 33%, whereas this range for the treatment was in the range of 3% to 7%.

Table 16: Lighting Devices used for Study at Night in MP

Lighting Devices Used for Night study	No. of treatment HHs	Percent	No. of control HHs	Percent
Electricity, Kerosene Source	701	7.28	542	47.09
Kerosene Source, Other Solar Device	0	0.00	1	0.09
Only Electricity	623	6.47	270	23.46
Only Kerosene Source	520	5.4	277	24.07
Only SoUL	1,800	18.68	0	0
Other Device	8	0.08	4	0.35
Other Solar Device	6	0.06	5	0.43
SoUL, Electricity	4,039	41.92	0	0.00
SoUL, Electricity, Other Device	17	0.18	0	0.00
SoUL, Kerosene Source	849	8.81	0	0.00
SoUL, Other Device	8	0.08	0	0.00
SoUL, Electricity, Kerosene Source	1,046	10.86	0	0.00
SoUL, Kerosene Source, Other Device	4	0.04	0	0.00
Electricity, Kerosene Source, Other Solar Device	1	0.01	0	0.00
Electricity, Other Device	6	0.06	27	2.35
Kerosene Source, Other Device	3	0.03	13	1.13

Electricity, Kerosene Source, Other Dev	0	0.00	11	0.96
Electricity, Other Solar Device	0	0.00	1	0.09
Total	**9,634**	**100.00**	1,151	100

The following table 17 presents t-test results presented for two samples, i.e. treatment and control, by calculating 'the mean' for children studying using 'only kerosene based devices' and mean for children studying 'only in grid electricity'.

Table 17: T-test Results for Users of 'Only Kerosene based Devices' and 'Only Electricity' for Study purpose

	Only kerosene based devices		**Only Electricity Users**	
	t- value	**p-value**	**t- value**	**p-value**
Consolidated MP	23.4562	0.0000	20.1364	0.0000

T-test results in both the cases were highly significant at 99% confidence level with children in control sample studying in 'only kerosene based devices' and in 'only grid electricity based devices' as compared to treatment sample. This confirmed the reduced usage of kerosene based devices as well as usage of grid electricity based devices for studying by children in the treatment sample and shift towards usage of SoUL, a clean energy, as a study device during dark hours.

Thus, the data on lighting devices used for night study and t-test results indicated primarily two important points (a) children from treatment sample study in better lighting conditions as compared to control sample; (b) children from treatment sample are less exposed to harmful effects of kerosene fumes as compared to control sample as there is less usage of kerosene based devices in treatment households.

3.6.1. Study hours during night

The data on studying hours showed that maximum percentage of children (44.44% in treatment, 45.26% in control) in both the samples studied for one to two hours a night followed by 41% each studying for less than an hour in both the samples and followed by 10.45% in treatment and 9.73% in control studying between 2-3 hours. There was little percentage of children who studied for more than 3 hours in both the samples. Thus, no difference could be observed between treatment and control sample with

regard to study hours and similarly no gender differentiation was observed in this regard.

The following table presents t-test results for hours of study during night with 'constraint' for 'only SoUL users' in treatment against all children studying in night using various lighting devices in control sample. In this t-test 'the mean of study hours' was calculated. T-test results with constraint of children that use 'only SoUL' for night study in treatment were although not significant, however they showed expected direction with 'only SoUL users' studying for more hours than the children in control households.

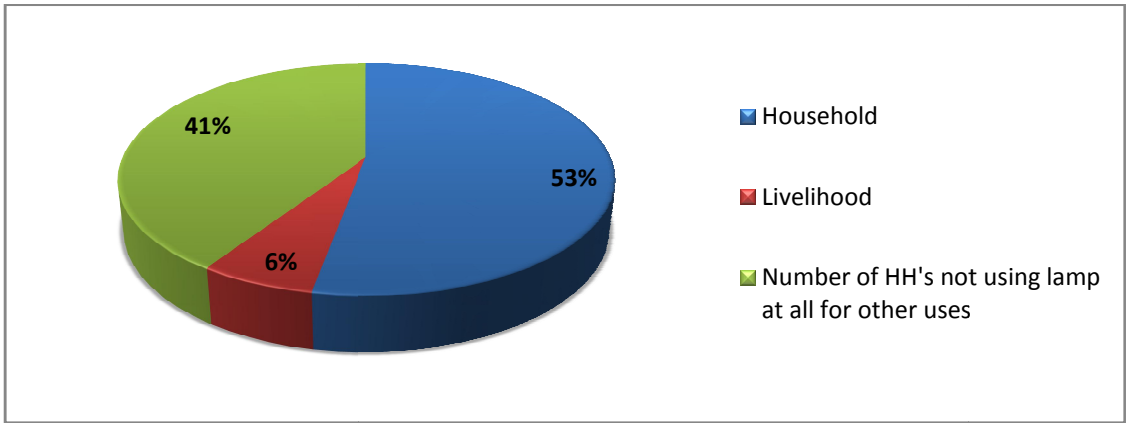
Table 18: T- test Results for Average Hours of Study

Hours of Study	Mean Treatment	Mean Control	Diff	t-value	p value
Only SoUL users in treatment & all studying children in control (with 'constraint')	1.8002	1.7179	-0.082357	-2.5596	0.0105

3.7. Uses of SoUL other than the study purpose

"Other uses of SoUL" is a multiple answer question. The data showed that the beneficiary households besides using SoUL for studying during night also used it for multiple and diverse purposes. As presented in figure 4 below there were 40.69% household that reported using it only while studying during night, whereas 59.31% households reported using SoUL for other purposes.

Figure 4: Percentage of Households using SoUL in various activities

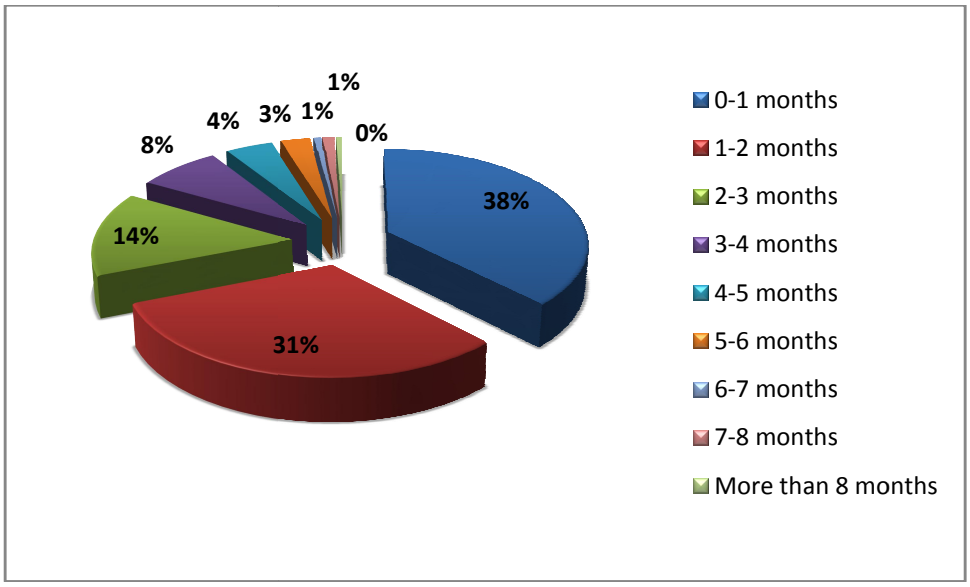


Amongst the households that used SoUL for other purposes besides study, 52.93% households used it as an aid in domestic activities, while 6.38% used it in livelihood activities. The main domestic activities included aid during **cooking (42.20 %), having dinner (11.91 %),** whereas activities in which SoUL aids as a torch were going out of the house during dark hours and going outside for toilet.

3.8. Performance of SoUL

Out of 6044 SoULs received by 5157 treatment households, **19.51%** were found **non-functional.** The data on period for which non-working SoULs worked for before they stopped functioning is given in the pie chart below (refer figure 5). As evident from the figure 6, maximum percentage of lamps functioned up to 1 month (38%) and between 1-2 month (31%).

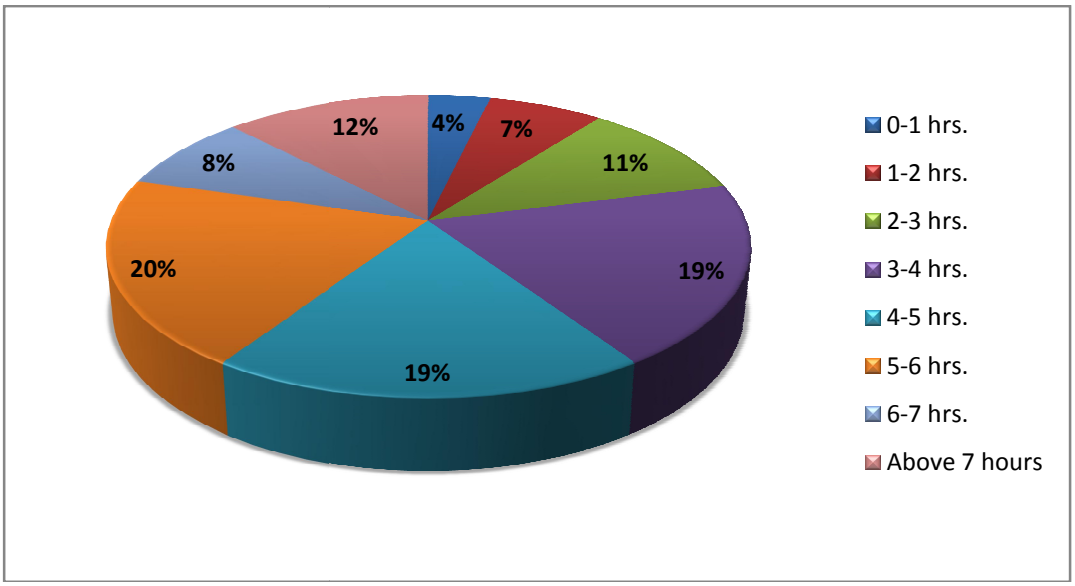
Figure 5: Percentage of SoUL and Number of Months they worked before stop functioning



The working SoULs were checked for functioning of its various parts. Amongst 4865 functioning SoULs, 80.72% were without any problem or no part defectives, whereas 19.28% lamps had some problem relating to one or the other part of the lamp. The main problem identified in 9.85% lamps was loose connection followed by switch related problem in 6.19%. LED, panel and red light indicator related problems were not much.

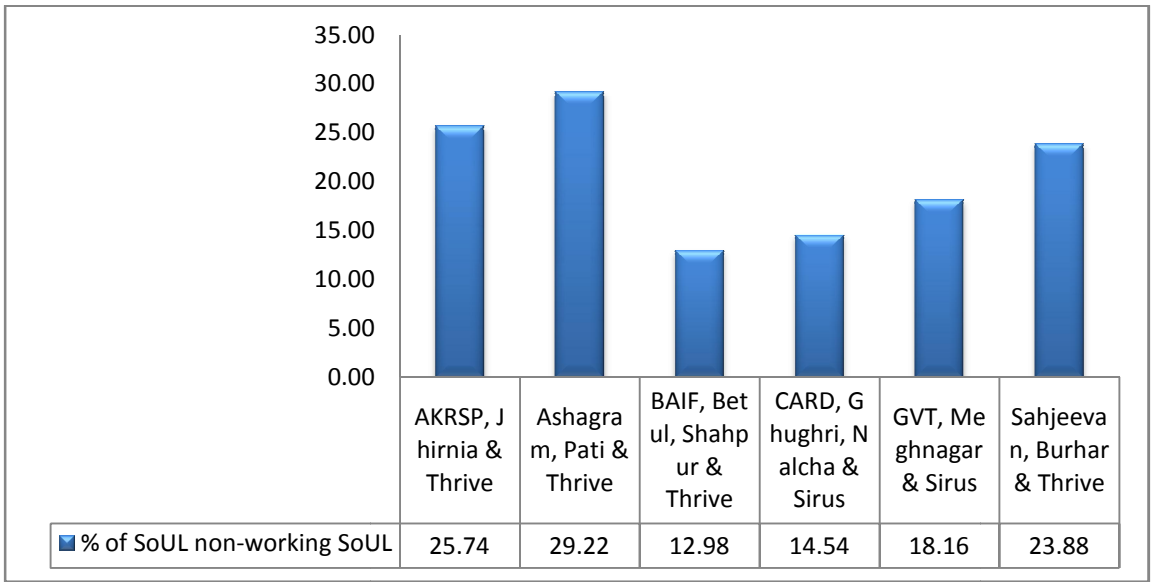
The respondents were asked about the lighting back-up in hours that SoUL provides after one day of charging. There was a broad range of response ranging from less than an hour to more than 7 hours. As it can be seen from figure 7 below there are 22% households reporting back-up of less than 3 hours, while 78% households reported the back-up of more than 3 hours and for 59% households the back-up received was more than 4 hours (Figure 6).

Figure 6: Back-up provided by SoUL



The vendor-wise comparison of working SoULs pointed that percentage of functioning of Sirus lamps (84.51%) was better than Thrive (78.82%) by 5.56%. The working of SoUL was also looked at as per the NGO partner and the block in which NGO distributed the lamps. BAIF (87.02%), CARD (85.46%), and GVT (81.84) had more than 80% SoULs in working condition, whereas Ashagram had 70.78%, i.e. lowest percentage of working lamps, followed by 74.26% in AKRSP, and 76.12% in Sahjeevan. Figure 7 below gives an overview of percentage of non-working SoULs as per NGO partners, block in which they have implemented the MSP, and vendors who have supplied lamp material in the block.

Figure 7: Overview of Non-working SoULs

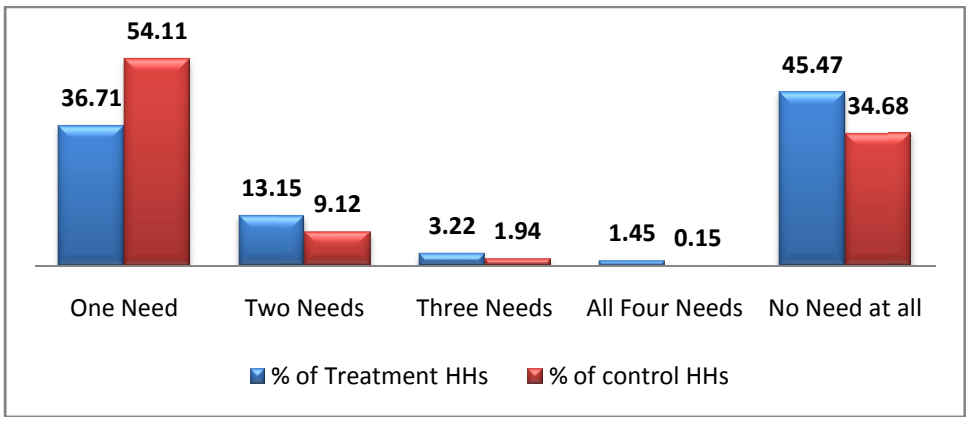


3.9. Need for solar energy based products and willingness to pay

The household survey tried to explore the household level solar energy related needs and in case of existence of such needs then willingness to invest or pay assuming there is no subsidy available and they are to purchase it from the market. The exploration of these two needs was linked to assessing the market potential for the solar products in rural areas. However, households in the SoUL Program implementation areas being rural and tribal tend to have less exposure to solar technology and solar products. So the barrier about knowing or visualising the product and state some cost that they think they can afford to pay was anticipated. In order to overcome this barrier a placard illustrating pictures of solar products like solar light, solar torch, solar home lighting system, solar fan, solar pump for irrigation, solar drier for drying crops (food grains, vegetables) and their approximate costs in the market at present was prepared. While administering the questionnaire it was shown to them and care was taken to inform and assure them that any kind of marketing of solar products was not intended and there is no commitment when they state they can afford certain amount. Need for solar energy based products mainly covered three needs: lighting, cooking, irrigation and additionally if they expressed any other specific need it was recorded. About stating the cost it was noticed that the respondent households were hesitant to state any amount as most of them belonged to poor households. The figure 8 below shows the percentage of

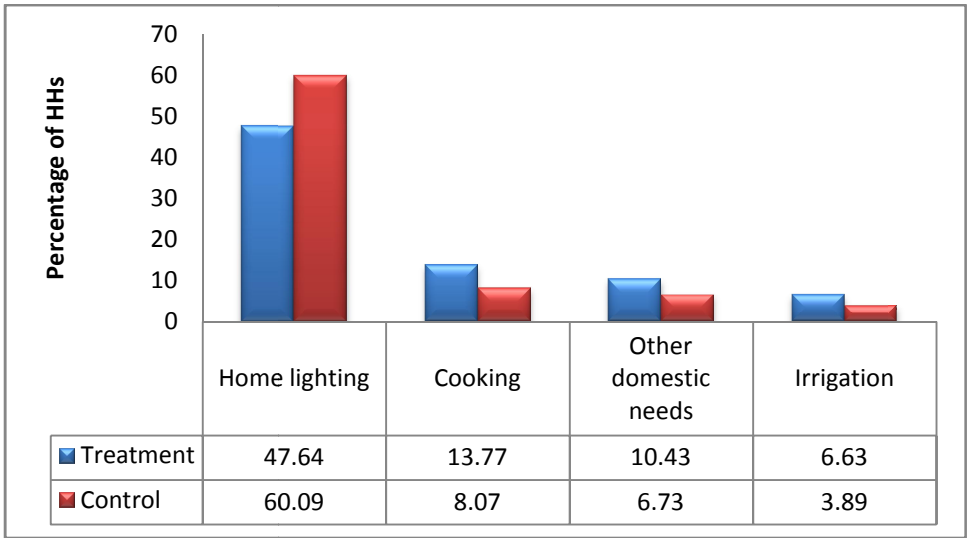
households and the number of solar product needs that they have expressed. Maximum percentage of households, 36.71% in treatment and 54.11% in control had one need.

Figure 8: Percentage of Households expressing Need for Solar Products



From the following figure 9, it could be observed that maximum percentage of households in both the groups 60.09% control households and 47.64% in treatment have expressed the need for solar home lighting.

Figure 9: Percentage of Households expressing Needs that are to be addressed by Solar Technology in MP



	Home lighting	Cooking	Other domestic needs	Irrigation
Treatment	47.64	13.77	10.43	6.63
Control	60.09	8.07	6.73	3.89

For solar lighting in both the samples maximum percentage of household showed willing to pay less than Rs. 500 [84.74% households in treatment and 91.04% in control]. There were 10.62% treatment and 6.97% in control willing to pay in the range of Rs.

500 - 1000. The need for solar cooking was stated by 13.77% treatment and 8.07% control households. The maximum percentage of households amongst these, i.e. 32.96% in treatment and 31.48% showed capacity to spend in the range of Rs. 500-1000 followed by 23.52% treatment household ready to spend less than Rs. 500. The need for solar based pump for irrigation was reported by fewer households. In treatment sample 45.03% and 57.69% in control were willing to spend in below Rs. 5,000 for solar irrigation pump. For the need for other solar based domestic product, there were 73.79% treatment and 71.77% control households showed willingness to spend below Rs. 1000. The maximum percentage of households in both the samples, 74% in treatment and 71% in control, showed willingness to pay up to Rs. 1000 for other domestic products like solar fan.

Chapter 4. Conclusion

1. Low cost of SoUL as a positive discrimination: The findings indicated that the cost or the beneficiary contribution of Rs. 120 acted as a positive discrimination and was 'not the barrier' in purchasing or accessing the SoUL. This has contributed in reaching the school-going children from needy communities by providing the clean light irrespective of their socio-economic status in rural areas. In the entire sample in Madhya Pradesh there were only 6 children (0.47%) from control sample who stated that they did not purchase SoUL as they thought it to be expensive. The field investigators reported that it was difficult to identify control households in the sample villages. This confirmed that the principle of saturation[11] and localisation approach was successful in the sample blocks and most of the eligible beneficiaries have purchased the SoUL.

2. SoUL reaching the marginalised and poor households: The access to the grid electricity either through legal or non-legal (by putting hook) connection revealed that 28.37% of the treatment sample was non-electrified. The socio-economic profile of the treatment sample in Madhya Pradesh showed that 68% were scheduled tribes (STs), followed by 23% other backward castes (OBCs), and 6% scheduled castes (SC) households, while 66% of them were poor as they possessed either below poverty line (BPL) or Antyoday cards.

3. Continued dependence on kerosene for illumination: Though control households are purchasing slightly more than the treatment, 50% sample are observed to be consuming 4-5 litres per month primarily for illumination purpose indicating continued dependence on kerosene. Almost all households (99%) used kerosene wick lamp/s, with 50% sample using it for less than two hours daily. People depend exclusively on PDS outlet, with few households purchasing kerosene from the market. The continued

[11] In the MSP principle of 'saturation' is defined as reaching out to a minimum of 75% of enrolled class V – XII children in the given block. On an average, a block in India has 17,600 school children studying in 5th to 12th standard. This makes it possible to reach the maximum number of school going children enrolled in V – XII and thus strive towards providing 'right to clean light to every child'.

dependence on kerosene for lighting could be explained with the fact that it is unreasonable to expect cease of kerosene lamp usage with presence of one solar study lamp as their requirement remains unfulfilled given that the household has multiple rooms resulting into multiple lighting needs.

4. Decline in kerosene purchase of treatment households: T-test results for total monthly kerosene purchased between treatment and control showed that monthly purchase of kerosene by control households was significant at 90% confidence level (p 0.0833) indicating higher purchase by control sample and declined purchase in treatment sample.

5. Significant decline in expenditure on Kerosene for Illumination in treatment sample: T-test results for difference in expenditure on kerosene for illumination between treatment and control sample were significant at 99% confidence level for entire MP state as well as for Shahpur and 90% confidence level for Betul, Burhar, and Ghughri blocks, whereas for remaining blocks it was insignificant. T-test results for electrification status as 'constraint' for MP was significant for both electrified and non-electrified households. For electrified sample the difference was significant at 99% confidence and for non-electrified households significance was at 95% (p 0.033) confidence level. Thus, T-test results confirmed the significance of higher expenditure by control electrified as well as control non-electrified households than the treatment sample.

6. Decline in total expenditure on lighting for electrified treatment: In t-test results for 'total expenditure on illumination' the direction emerged was as expected with control households spending slightly more than the treatment, however results with electrification constraint were significant at 99% confidence level for electrified households and insignificant for non-electrified households. As one solar study lamp is a small intervention, insignificant t-test results for 'electricity bill', 'expenditure on electric devices', and 'total expenditure on illumination' could be explained. The 'mean' expenditure on 'illumination', 'electrical devices' and 'electricity bill' showed a mixed

pattern with control households spending more in four blocks and vice versa in remaining four blocks.

7. Slightly higher study hours for children using only SoUL as a study device: T-test results with constraint of children that use 'only SoUL' for night study in treatment were although insignificant, however they showed expected direction with 'only SoUL users' studying for more hours than the children in control households.

8. Significant decline in kerosene use for night study: Shift in illumination pattern for study at night from kerosene based devices to SoUL was observed. T-test results for both children using 'only kerosene devices for study' and 'only grid electricity' were significant at 99% confidence level with higher percentage of children in control than treatment sample. T-test results confirmed reduced usage of kerosene based devices as well as usage of grid electricity based devices for studying in the treatment sample and there is a visible shift towards usage of SoUL, a clean and better quality light, as a study device during dark hours. In treatment sample only 5.4% children studied in solely kerosene based lighting devices against 24.07% in control sample. This pattern was observed in all blocks except Betul (there were no only kerosene devices users). In all blocks the control sample has 'only kerosene' source users for night study in the range of 12% to 33%, whereas this range for the treatment was in the range of 3% to 7%. There were 6.47% in treatment sample and 23.46% in control sample used electricity as a single source to study at night. 80.58% of beneficiary children used SoUL to study at night as one of the study device (either as the only lighting device or along with other devices). Across the block data revealed that Burhar had most percentage (34%) of 'only SoUL' users followed by 14.83% in Pati, and 13.33% in Jhirnia. For 19.42% children who did not use SoUL as one of the studying devices the main reason was non-functioning of SoUL.

Thus, the data on lighting devices used for night study and t-test results indicated most significant impacts (a) Children from treatment sample have almost stopped studying in kerosene based devices demonstrating replacement of one kerosene wick lamp and

thus decline in kerosene consumption. (b) Children from treatment sample study in clean and better light as compared to control sample as a result they are not exposed to harmful effects of kerosene fumes while studying.

9. Aid in other activities besides study: The clean and better quality of light provided by SoUL induced its uses in other activities besides the study purpose. 59.31% households reported using SoUL for other purposes. Amongst these 52.93% households used SoUL as an aid in domestic activities, while 6.39% used it in livelihood activities like irrigating the farms and grocery shop. The main domestic activities included aid during cooking (42.20%), having dinner (11.91%), while activities in which SoUL aids as a torch were going out of the house during dark hours and going outside for toilet. The usage of SoUL in other activities reaffirmed its utility merit and emphasises the requirement of home lighting system in order to fulfil domestic lighting needs.

10. Performance of SoUL: Mid-course Correction: The MSP is accountable to the commitment of providing high quality solar study lamps that remain in functional state till the end of the phase I i.e. December 2015 (approximately for 1 year after distribution of lamp). Another aspect linked to functioning of SoUL till the end of phase I was faith and confidence of the rural community in solar technology. Hence, to address these two concerns following mid-course corrections are recommended, which are based on the results of user perspective about performance of SoUL.

10a. Stringent quality control at vendors & at NGO assembly centres: The high percentage of non-functional SoULs (19.51%) in the sample is a cause of concern and it called for stringent quality control at vendor's end as well as at the assembling level that comes under the purview of NGO partners. It was noticed that before SoULs stopped functioning 37.66% functioned for up to 1 month and 31.38% between 1-2 month. So, the non-functionality rate of SoUL within first 2 months of distribution is alarming. The vendor-wise comparison of working SoULs pointed that percentage of functioning of Sirus lamps (84.51%) was better than Thrive (78.82%) by 5.56%. The NGO wise

percentage of working SoULs showed three NGOs, BAIF (87.02%), CARD (85.46%), and GVT (81.84) had more than 80% SoULs in working condition, whereas Ashagram had 70.78%, i.e. lowest percentage of working lamps, followed by 74.26% in AKRSP, and 76.12% in Sahjeevan. In order to deliver high quality SoULs IIT-B should set up the benchmark for non-functionality rate for vendors as well as for NGO partners. IIT-B at its end should have a separate quality control team who can regularly supervise vendors and NGO partners.

10b. Requirement of SRC awareness campaign to ensure availing of service: In almost all the cases in which SoUL was reported to be non-functional respondents had not taken it for repairing at SoUL repair centres (SRC) set up in the vicinity to provide free after sale service. The reason for not availing SRC service was unawareness SRCs existence. This is another area that needs immediate action. An aggressive awareness campaign need to be taken up on a priority basis to ensure that people avail the SRC facility so that all SoULs are in working condition till the end of phase I.

10c. Monitoring mechanism for SRC operations: Absence of awareness about SRCs and non-conversion of non-functional SoULs into functional point towards lack of effective campaigning strategy of SRCs, though this happened in the initial stage of SRC set-up. Despite monitoring mechanism for SRC operation being in place the reason for not identifying the SoUL performance related problems should be identified and accordingly modification in it could be made.

10d. Improvements in the SoUL design: Amongst the working SoULs, 19.28% had problems related to one or the other part of the lamp. The main problem identified was loose connection and switch related problems. LED, panel and red light indicator related problems were not much. The switch related problems pertain to accumulation dust, switch not working, and operating it with wet hands. Many respondents suggested for better design as well quality switch that would address the problem faced. Another suggestion was making the bottom of lamp sturdier and better quality goose-neck as it

falls down after a while since the tension in is lost. The loose connection was assembling related issue calling for stringent quality control.

11. Positive feedback on back-up provided and quality of light: The feedback on the lighting back-up (in hours) provided by SoUL after one day of charging was positive. For 78.95% households the backup they got was for more than 3 hours, while for 59.44% households the back-up received was more than 4 hours. There was unanimity of opinion regarding the quality of light that SoUL provides. All respondents were satisfied with the brightness of SoUL and they also noted absence of negative effects such as safety concerns, fumes and pollution adversely impacting eyes and health.

12. Demonstration of market potential for solar technology: Through medium of SoUL the people residing in remote and rural blocks of MP have got exposure to solar technology. The first hand usage has increased the confidence of people in the solar PV which was reflected in the needs assessment of solar as 54% treatment and 66% control expressed at least one type of solar need. The highest percentage of sample expressed the need for solar lighting followed by need for solar cooking, and then for other solar based domestic product like fan demonstrating market potential for solar technology. However, there were very few households expressing the need for solar irrigation pump.

13. Requirement of financial mechanism for converting need into purchase: The capacity to pay for these expressed needs revealed the paying capacity of the people is quite less, with up to Rs. 500 for lighting, Rs. 1000 for cooking, and Rs. 5000 for irrigation pump respectively. This less paying capacity puts the question mark on conversion of need into purchase. This also highlights the requirement for development of a mechanism or a model with the help of NGO partners, vendors, or financial institutions like NABARD that will facilitate purchase of solar products.

Thus, the results clearly indicate direct positive impacts of SoUL such as elimination of one kerosene lamp specifically for study purpose, complete cease of exposure of

children to kerosene fumes while studying, significant decline in kerosene expenditure for lighting due to saving from one kerosene lamp. Other impacts though not significant but they showed positive direction such as reduction in total expenditure on lighting as well as expenditure on electricity bill, and increased night study hours. However, it needs to be acknowledged that complete elimination of kerosene cannot be possible with SoUL or a small solar study lamp as it would have limited impact. Therefore, unless the need for lighting for entire house gets fulfilled through solar home lighting the significant impact in terms of elimination of kerosene consumption for lighting and its expenditure cannot be expected.

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Annexure

A1. Household Impact Survey

State	[Pre-printed]	District	[Pre-printed]	Block	[Pre-printed]

Form Number												Interviewer's Name	Date	Gram Panchayat	Village	Hamlet
			/					/								
Block code [Pre-printed]			/	Village code				/	Serial number							

A. Household Details						
A1	Full Name of respondent		A3	Full Name of head of household		
			A4	Sex of head of household	◯ Male	◯ Female
A2	Relation of the respondent to the beneficiary		A5	Mobile Number		
			A6	Number of Members in the Family		
			A7	No of rooms in the house(including kitchen)		

B. Children's Details (Irrespective of receipt of SoUL lamp, applicable to all children from 5 to 17 years or up to 12th Class)										
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
S. No.	Full Name	Age	Sex (M/F)	Does he/she go to school? (Yes/ No)	Class	Has he/she received SoUL lamp? (Yes/ No)	If **"Yes" for B6**, specify the **lamp code** here. If only one child has bought and others are applicable why other children have not brought SoUL?*	Which devices** do you use for studying (Specify all the devices, else specify the reason for not studying in the dark hours)	If, **for B8**, one of the devices is SoUL lamp, specify **time** of **study using SoUL lamp**. If, **for B8**, none of the devices is SoUL lamp, specify the **reason for not using SoUL lamp** for studying	If the SoUL is working, and the child is using Chimni/Electricity with SoUL, mention the reason for using the same?
1										
2										
3										
4										
5										
6										

*If unable to obtain the lamp code, state the reason in B7

** If studying in street light or community light (in temple) etc. then specify in B8

C. Performance of SoUL lamp (Interviewers can themselves check SoUL lamp for following details)											
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
S. No.	Lamp Code	Is the SoUL lamp working? (Yes/ No) **If "Yes" go to C4**	If No, for how much time did it work? (days/weeks/ months) **Specify and go to E1**	Is the Switch working? (Yes / No)	Is LED working? (Yes / No)	Is red light in indicator working properly? (Yes/ No)	Is green light in indicator working properly? (Yes/ No)	After one day of charging, for how much time SoUL lamp works?	Is there any loose connection? (Yes/ No)	Is the panel broken? (Yes/ No)	State other problem, if any. If SoUL is not working; then state the problem with it?
1											
2											
3											
4											

D. Usage of SoUL lamp									
D1 Lamp code	D2 Do you charge SoUL lamp with mobile charger? (Yes/ No)	D3 What is the usage of SoUL in hours per day for purposes **other than Studies**?	D4 For what other purposes **other than Studies** SoUL lamp is used & used by whom **(Relation to the beneficiary)**						
			Other purpose 1	Used by whom	Other purpose 2	Used by whom	Other purpose 3	Used by whom
E. Repair and Maintenance of SoUL									

S. No.	E1 Lamp code**(Repeat the lamp code again if R&M availed more than once)**	E2 Have you availed R&M service?[#] (Yes/ No) **If Yes, Go to E4**	E3 If **E2 is "No"**, & SoUL lamp is not working then why service is not availed? **Specify and go to E11**	E4 If **E2 is "Yes"**, what was the problem in the SoUL lamp before repair?	E5 Was it repaired at SoUL R&M centre? (Yes / No)	E6 Where was it repaired? (Shop name, Village name, Gram Panchayat name)	E7 When did you avail R&M? (Month & year)	E8 In how many days was SoUL lamp repaired?	E9 How much did you pay for it? (Rs.)	E10 Are you satisfied with R&M service? (Yes/ No)
A										
B										
C										
D										
E										
F										

E11 If any of the SoUL lamps have been repaired at home (yourself), was it successful? (Yes/ No):

E12 Specify which component was not working before repair at home (yourself):

F1 Kerosene Purchased					
S. No.		Litre/s per month	Avg. Price per litre	Frequency (Number of trips for purchase per month)	Generally collected by whom? (specify whether Adult woman/Adult man/ Girl child/boy child)
1	Purchased from Govt. Ration shop - PDS				
2	Purchased from Market				

F2 Kerosene Used				
	Lighting	Cooking	Heating water	Other (Please specify)*
Consumption (litre/s per month)				

*Other use may also include resale, in vehicles, etc.

F3 Usage of other oil for lighting (For example, if used for lighting purpose, any of the cooking oils like groundnut, mustard, sunflower, etc.)			
Name of oil	Consumption (litre/s per month)	Avg. Price per litre	Device/s used

F4 Devices using kerosene/ other oil					
S. No.	Device	Do you use the device? (Yes/ No)	Quantity used*	Number of hours per day	Number of days per month
1	Chimni (Simple wick lamp)				
2	Hurricane lamp				
3	Wick stove				
4	Other (Please specify)				

*By "Quantity used" we mean number of devices they are actually using for lighting purpose and NOT the number of devices they possess.

F5 Do you have electricity at home? If "No" go to F10	◯ Yes	◯ No
F6 Do you have electric meter/ one point connection/ shared connection?	◯ Yes	◯ No

F7 Interval of electricity bill receipt		
◯ Not applicable	◯ Every month	◯ Every 3 months
◯ Every 6 months	◯ Every year	◯ Other (Please specify)

F8	**Electricity bill amount paid as per the above mentioned interval (Rs)**	

F9 Features of electric lighting devices (bulbs/ tubes) used at home				
S. No.	Type of device	Number of devices	How much period (days/weeks/ months/ years) does this device last for?	Avg. price of device (Rs per unit)
1	Incandescent bulb			

2	CFL			
3	Tubes			
4	LED			
5	Chargeable torch			
6	Other (Please Specify)*			

* If using torch in mobile phone specify that also as other electric lighting device.

F10 Features of candle		
Number consumed/ month (Specify candle or pack)	Usage in hours per day	Avg. price of candle or pack (Rs per unit)

F11 Features of battery torch at home (non-rechargeable)				
	Number of cells	Number of times cells replaced per month	Avg. price of torch (Rs per unit)	Maintenance Cost (Rs per unit)**
Torch 1				
Torch 2				
Torch 3				

** If use-and-throw (Chinese) torch, then in 'Maintenance Cost' write **not applicable**

F12 Features of renewable energy devices other than SoUL used at home								
S. No.	Name of device	Purchase inspired by SoUL lamp (Yes/ No)	Number	Capacity	Initial investment (Rs)*	Working (Yes/ No)	Maintenance Cost (Rs per unit)	Year of purchase
1								
2								
3								

* If no investment has been made (grant/ donation), then in 'Initial investment' write **not applicable**

G. Willingness to pay for other Solar Products (Please tick in the appropriate circle)			
G3	**What are the solar energy related needs of the household?**	**Energy Needs**	**As you are aware, actual cost of SoUL lamp is Rs 500 but due to subsidy it is available for students at Rs 120. Keeping this in mind, how much you are willing to invest for the following uses?**
		◯ Lighting	
		◯ Cooking	

		◯ Irrigation	
		◯ Others (Please specify)	
		◯ None	

G.3.1 Preference of Lighting in the household			
G3.1	**What is the preferred source of lighting for the Household- Electricity; Kerosene Source; Solar Product? (Eg. Rank1 given to first preferred source etc.)**	**Energy Needs**	**Preferred Source of Lighting**
		Rank 1	
		Rank 2	
		Rank 3	
		Remarks (if any)	

G.3.2 Solar Needs		
G3.2	**Does SoUL lamp satisfy your child's study lighting needs? If No, then why?**	

H. Community Details (Please tick in the appropriate circle)		
H1	**Type of Card Holder (Please tick in the appropriate circle)**	
◯ Below Poverty Line (BPL)	◯ Antyoday	◯ Other (Please specify)
◯ Above Poverty Line (APL)	◯ No card	

H2	**Primary Source of Income (Please tick only one)**	
◯ Agriculture	◯ Labor	◯ Agriculture + Labor
◯ Service	◯ Dairy	◯ Skill-based occupation (carpentry, pottery, etc.)
◯ MGNREGS	◯ Remittance	◯ Other (Please specify)

H3	**Religion (Please tick only one)**		
	◯ Hindu	◯ Muslim	◯ Christian
	◯ Sikh	◯ Buddhist	◯ Jain
	◯ Other (Please specify)		

H4	**Social Group (Please tick only one)**	
	◯ Scheduled Tribe (ST)	◯ Scheduled Caste (SC)
	◯ Other Backward Caste (OBC)	◯ Nomadic/ Denotified Nomadic Tribe/ Vimukta Jati Nomadic Tribe (NT/ DNT/ VJNT)
	◯ Open (General)	◯ Other (Please specify)

H5	Name of caste/ tribe you belong to	

H6	Wealth Indicator					
Name of the asset	**#**	**Name of the asset**	**#**	**Name of the asset**	**#**
Radio		table		other asset 1	
Bicycle		chair		other asset 2	
motorcycle/scooter		mattress		other asset 3	
washing machine		bullock cart			
Fans		thresher			
Heaters		tractor			
colour television		buffalo			
b/w television		Cow			
telephone set/ mobile phone		bullock			
sewing machine		goats			
pressure cooker		cock/hen/duck			
Watches		Pigs			

H7 Household type: Tick the correct option		
Kacchha	**Semi- Pakka**	**Pakka**

H8: Preferred Activity for the children in the family					
How do all *MALE* children spend their non-schooling hours? Enlist three activities in which he spends most of his time and the number of hours spent on the same	**Activities**	**No. of Hours**	**How do all *FEMALE* children spend their non-schooling hours? Enlist three activities in which he spends most of his time and the number of hours spent on the same**	**Activities**	**No. of Hours**
Remarks (if any)			**Remarks (if any)**		

Signature of the respondent		Signature of the interviewer	

Please note the suggestions and complaints by the respondent below.

Interviewer's Notes:

A2. Household Control Survey Form

State	[Pre-printed]	District	[Pre-printed]	Block	[Pre-printed]

Form Number												Interviewer's Name	Date	Gram Panchayat	Village	Hamlet
			/					/								
Block code [Pre-printed]			/	Village code				/	Serial number							

A. Household Details						
A1	Full Name of respondent		A4	Full Name of head of household		
A2	Mobile Number		A5	Sex of head of household	◯ Male	◯ Female
A3	Number of Members in the family		A6	No of Rooms in the House(including Kitchen)		

B. Children's Details (Irrespective of receipt of SoUL lamp, applicable to all children from 5 to 17 years or up to 12th Class)								
	B1	B2	B3	B4	B5	B6	B7	B8
S. No.	Full Name	Age	Sex (M/F)	Does he/she go to school? (Yes/ No)	Class	Why has he/she not received SoUL lamp? (Specify the reason)	Which devices* do you use for studying (Specify all the devices, else specify the reason for not studying in the dark hours)	If, **for B7**, devices are used for studying, specify **time** of **study (mins/hours)**. If, **for B7**, no devices are used for studying, **go to C1**
1								
2								
3								
4								
5								
6								

*If studying in street light or community light (in temple) etc. then specify in B7

C1 Kerosene/ Other oil Purchased					
S. No.		Litre/s per month	Avg. Price per litre	Frequency (Number of trips for purchase per month)	Generally collected by whom? (specify whether Adult woman/Adult man/ Girl child/boy child)
1	Purchased from Govt. Ration shop - PDS				
2	Purchased from Market				

C2 Kerosene Used				
	Lighting	Cooking	Heating water	Other (Please specify)*
Consumption (litre/s per month)				

*Other use may also include resale, in vehicles, etc.

C3 Usage of other oil for lighting (For example, if used for lighting purpose, any of the cooking oils like groundnut, mustard, sunflower, etc.)			
Name of oil	Consumption (litre/s per month)	Avg. Price per litre	Device/s used

C4 Devices using kerosene/ other oil					
S. No.	Device	Do you use the device? (Yes/ No)	Quantity used*	Number of hours per day	Number of days per month
1	Chimni (Simple wick lamp)				
2	Hurricane lamp				
3	Wick stove				
4	Other (Please specify)				

*By "Quantity used" we mean number of devices they are actually using for lighting purpose and NOT the number of devices they possess.

C5 Do you have electricity at home? If "No" go to C12	◯ Yes	◯ No
C6 Do you have electric meter/ one point connection/ shared connection?	◯ Yes	◯ No
C7 Do you have inverter at home?	◯ Yes	◯ No
C8 Do you have generator at home?	◯ Yes	◯ No

C9 Interval of electricity bill receipt

◯ Not applicable	◯ Every month	◯ Every 3 months
◯ Every 6 months	◯ Every year	◯ Other (Please specify)

C10	**Electricity bill amount paid as per the above mentioned interval (Rs)**	

C11 Features of electric lighting devices (bulbs/ tubes) used at home

S. No.	Type of device	Number of devices	How much period (days/weeks/ months/ years) does this device last for?	Avg. price of device (Rs per unit)
1	Incandescent bulb			
2	CFL			
3	Tubes			
4	LED			
5	Chargeable torch			
6	Other (Please Specify)*			

* If using torch in mobile phone specify that also as other electric lighting device.

C12 Features of candle

Number consumed/ month (Specify candle or pack)	Usage in hours per day	Avg. price of candle or pack (Rs per unit)

C13 Features of battery torch at home (non-rechargeable)

	Number of cells	Number of times cells replaced per month	Avg. price of torch (Rs per unit)	Maintenance Cost (Rs per unit)**
Torch 1				
Torch 2				
Torch 3				

** If use-and-throw (Chinese) torch, then in 'Maintenance Cost' write **not applicable**

C14 Features of renewable energy devices used at home

S. No.	Name of device	Number	Capacity	Initial investment (Rs)*	Working (Yes/ No)	Maintenance Cost (Rs per unit)	Year of purchase

1							
2							
3							

* If no investment has been made (grant/ donation), then in 'Initial investment' write **not applicable**

D. Willingness to pay for other Solar Products (Please tick in the appropriate circle)			
D1	**What are the solar energy related needs of the household?**	**Energy Needs**	**As you are aware, actual cost of SoUL lamp is Rs 500 but due to subsidy it is available for students at Rs 120. Keeping this in mind, how much you are willing to invest for the following uses?**
		◯ Lighting	
		◯ Cooking	
		◯ Irrigation	
		◯ Others (Please specify)	
		◯ None	

D.2 Preference of Lighting in the household			
D.2	**What is the preferred source of lighting for the Household- Electricity; Kerosene Source; Solar Product? (Eg. Rank1 given to first preferred source etc.)**	**Energy Needs**	**Preferred Source of Lighting**
		Rank 1	
		Rank 2	
		Rank 3	
		Remarks (if any)	

E. Community Details (Please tick in the appropriate circle)		
E1	**Type of Card Holder (Please tick in the appropriate circle)**	
◯ Below Poverty Line (BPL)	◯ Antyoday	◯ Other (Please specify)

◯ Above Poverty Line (APL)	◯ No card	

E2	Primary Source of Income (Please tick only one)		
◯ Agriculture	◯ Labor	◯ Agriculture + Labor	
◯ Service	◯ Dairy	◯ Skill-based occupation (carpentry, pottery, etc.)	
◯ MGNREGS	◯ Remittance	◯ Other (Please specify)	

E3	Religion (Please tick only one)		
	◯ Hindu	◯ Muslim	◯ Christian
	◯ Sikh	◯ Buddhist	◯ Jain
	◯ Other (Please specify)		

E4	Social Group (Please tick only one)	
	◯ Scheduled Tribe (ST)	◯ Scheduled Caste (SC)
	◯ Other Backward Caste (OBC)	◯ Nomadic/ Denotified Nomadic Tribe/ Vimukta Jati Nomadic Tribe (NT/ DNT/ VJNT)
	◯ Open (General)	◯ Other (Please specify)

E5	Name of caste/ tribe you belong to	

E6	Wealth Indicator					
Name of the asset	**#**	**Name of the asset**	**#**	**Name of the asset**	**#**
Radio		table		other asset 1	
Bicycle		chair		other asset 2	
motorcycle/scooter		mattress		other asset 3	
washing machine		bullock cart			
Fans		thresher			
Heaters		tractor			
colour television		buffalo			
b/w television		cow			
telephone set/ mobile phone		bullock			
sewing machine		goats			
pressure cooker		cock/hen/duck			
Watches		pigs			

E7 Household type: Tick the correct option		
Kacchha	**Semi- Pakka**	**Pakka**

E8: Preferred Activity for the children in the family					
How do all *MALE* children spend their non-schooling hours? Enlist three activities in which he spends most of his time and the number of hours spent on the same	**Activities**	**No. of Hours**	**How do all *FEMALE* children spend their non-schooling hours? Enlist three activities in which he spends most of his time and the number of hours spent on the same**	**Activities**	**No. of Hours**
Remarks (if any)			**Remarks (if any)**		

Signature of the respondent		Signature of the interviewer	

Please note the suggestions and complaints by the respondent below.

Interviewer's Notes:

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