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Solar Multi Utility Centres in Madhya Pradesh: Baseline and Technology Details

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1. Introduction and methodology

The Norwegian Framework Agreement (NFA) between the Norwegian Ministry of Foreign Affairs (MFA) and TERI aims at addressing national and global concerns of energy security and climate change through a cooperative effort between TERI, Norwegian and other third party institution. Addressing the knowledge gap between the three strategic areas of (i) clean energy, (ii) climate change and energy security and (iii) climate change are the major concerns of NFA. Five projects are implemented by TERI matching the above three strategic domains.[1] The project "***Clean Energy Interventions for Livelihood Enhancement in Rural India***" under the project ***"Innovating to bring clean energy for livelihood generation in India"*** intrudes in the rural areas of the states of Uttar Pradesh, Odisha, Assam and Madhya Pradesh.[2]

Promotion of clean energy based technologies for enhancing livelihoods in the rural communities across the four states is the foremost objective of the project ***"Clean Energy Interventions for Livelihood Enhancement in Rural India"***. The specific objectives[3] of the project include:

I. Mapping of livelihoods, their market linkages and energy needs
II. Identifying livelihood options for interventions
III. Identifying clean energy options in consultation with the technology team
IV. Developing business models for implementation and sustainability
V. Reporting of baseline and impact assessment of the interventions
VI. The approaches *4*in the project process are enlisted below:
VII. Identification of the site based on the state specific identification criteria
VIII. Energy needs assessment and baseline survey
IX. Identification of technologies and implementation model
X. Measuring change after a year of installation

The state of Madhya Pradesh (MP) is the second largest state in India by area lying in the central part of the country. The Census of 2011, reports the population of the state to be 7,25,97,565 comprising 3,76,12,920 males and 3,49,84,645 females. This contributes to 6 percent of India's total population. The state of MP is characterized by low literacy levels and high population growth. *5*

MP is one of the power deficit states in India and additional power generation initiative for fostering economic prosperity of the state is utmost. The present power scenario in terms of state peak power load and the energy requirement forecast is shown below:

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1 TERI. (n.d.). *The Framework Agreement between the Norwegian Ministry of Foreign Affairs(MFA) and The Energy and Resource Institute.*

2 TERI. (2012). Clean Energy Intervensions for Livelihood Enhancement in Rural Odisha: Baseline and Way Forward. New Delhi.

3 Ibid
*4*Ibid
5Ritika Sehjpal, A. R. (2012). Rural Energy Transitions: Insights from Madhya Pradesh. New Delhi: The Energy and Resources Institute

Table 1: Details regarding Peak Load and Energy Requirement

(Source: Environmental Impact Assessment for 600 MW Coal Based Thermal Power Plant at Village-Barela-Gorakhpur Dist. Seoni, M.P.)

Details	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2016-2017	2021-2022
Peak Load(MW)	7206	7501	7809	8129	8462	11772	16129
Energy Requirement (MkWh)	40666	42680	44793	47011	49338	70445	98987

Till the year 2011, 66.4% of the households in MP were dependent on firewood for cooking. The rural scenario was even worse with 78.6% of the household relying on firewood as primary cooking fuel. At the mean time the percentage share of electricity in rural MP as main source of lighting was 58.3% and dependence on kerosene was 40.9%.

Taking the energy shortfall into due consideration in the rural MP, the project sightsees the next clean energy access for uplifting the livelihood of the rural population. Primarily, the scooping study in different villages was carried out, and based on the Panchayat's willingness to implement the project, the two sites were finalized i.e. Chikali and Imaliya. The figure below represents the overall process adopted for implementation of the project in the state.

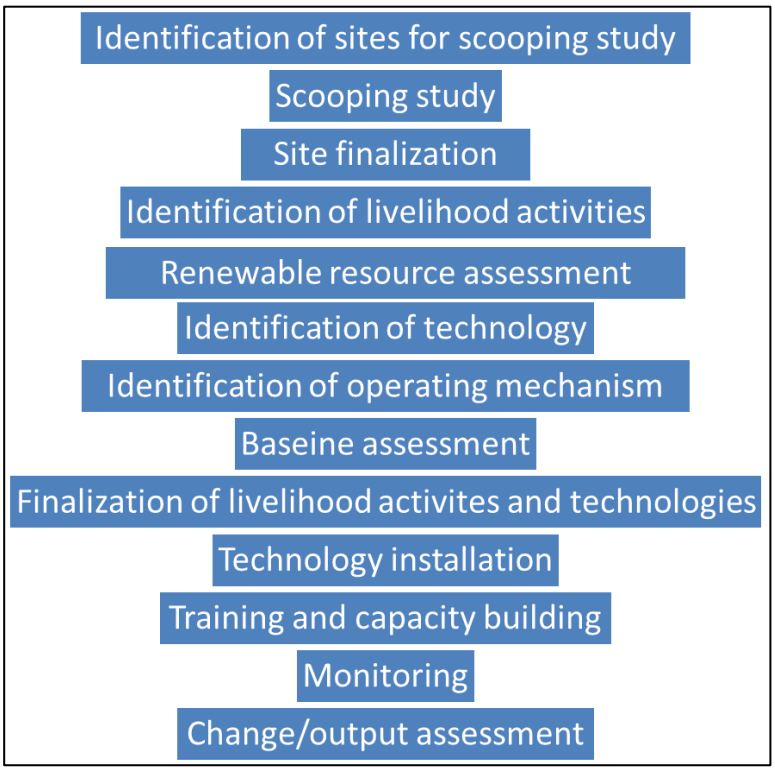


Figure 1: Approach toward project implementation

(Source: TERI. (2012). Clean Energy Intervensions for Livelihood Enhancement in Rural Odisha: Baseline and Way Forward. New Delhi)

1.1 Scope of the Report

The report presents the baseline scenario of the operating groups with activity details, marketing linkages; educational and skill status; the energy needs; livelihood activities; employment status; energy access for basic lighting, cooking and productive usage; income security; migration; children involvement in income generation activities; women's participation in household income generation and decision making; employability; health; education; and ownership of basic assets. Based on the baseline reporting, the report forwards the energy needs, according to the operating group. The resource assessment and technology feasibility analysis finds the technology to be installed. The report also discusses the detailed approach, indicators and assessment tools to be followed during the process of output assessment and also proposes the measures for implementing the project at the grassroots level. The responsibility of maintaining and operating the multi utility centres are entrusted to the operating groups. The operating groups shall process their produces in the multi-utility centres. The group shall also keep aside a decided share of profit for maintenance of the utility centre.

1.2 A Brief Note on Institutional Framework

The equipment for power generation shall be installed by TERI in partnership with TAAL. "Chikali Surakshya Samity" is the village level institution (operating group) that was formed in February 2012. It comprises of 14 members. This operating group is entrusted with the responsibility of maintaining and operating the multi utility centres.

1.3 Survey Design

All the operating group households from both the villages i.e. Chikali and Imaliya are considered for the study.

Village	Total Households
CHIKALI	27
IMALIYA	77
TOTAL	104

Baseline was conducted at four levels:

a. Village level information: Village level information is collated from the Panchayat members.

b. Information on operating groups and SHGs: Focused group discussions were conducted to collect information on present activities, structure and employability status of the operating groups.

c. Livelihood details at household level: The existing livelihood pattern prevailing among the operating groups' household was captured through household level schedule.

d. Quality of life at household level: Quality of life of the operating group household's was assessed through indicators related to employment and employability, education, health, access to energy for cooking and lighting, and income security. Closed ended schedules were used to collate the information.

1.4 Utility of the Report

The report provides a database and analysis framework for measuring changes in the output of energy and technology interventions in the different aspects of rural life such as

1. Income security
2. Livelihood activities
3. Employment pattern
4. Employability level

Migration

5. Energy usage for productive purpose
6. Energy usage at household level
7. Children's involvement in income generation
8. Role of women in income generation and decision making
9. General health

10. Education
11. Ownership of assets

Base data for finalization of methodology, sub indicators and tools for output assessment to be conducted after a year of installation of technologies.

2. Situational Analysis: Reporting of Village and Livelihood Profile

This chapter discourses a brief profile of the intervention villages.

2.1 Chikali

Chikali is a village in Madhya Pradesh situated in Gandhwani block in Dhar district. It is at the distance of 12 km from the block headquarters. The tribes in the village are Bhils and Bhilala. The village consists of 180 households with 1500 persons. The village is settled in two hamlets located at a distance of 1 km from each other and known as Patelpura and Vaskelpura.

2.1.1 Village Profile

The village is electrified since 1895. All the households in the village are electrified. Grid connection and diesel generator is the electrification source for the village. However, the villagers get to enjoy this facility only at alternate days. The duration of power cuts is 126 hours in a week. There is also a mobile charging centre in the village.

MGNREGA, Indra Awas Yojana, Old Age Pension, Mukhyamantri Kanyadan Yojana are some of the governmental schemes operational in the village. TAAL NGO and Mahatma Gandhi Pratisthan, implement some of the livelihood development activities in the village.

2.1.2 Livelihood Profile

Agricultural cultivation and sale of the products thus produced is the primary source of livelihood for the households in Chikali village. These products include wheat, maize, mung, tuar, groundnuts, cotton, soya-bean, gram etc. The agricultural products are sold to the small trader in the weekly market. Agriculture wage labor, labor work in industry/mines/ or public work are the secondary occupations from which people earn their livelihood. Rain fed agriculture and small size of land holdings are some constraints hindering better incomes from this sector.

2.2 Imaliya

Imaliya is situated in Gairatgunj block of Raisen district in Madhya Pradesh. There are 285 households in the village with the population of approximately 1362. There are 71 scheduled castes, 89 scheduled tribes, and other 112 backward categories in the village.

3.2.1 Village Profile

The electrification status in the village has a long history back to 35 years. Grid is the electrification source and almost 90 percent of the households are electrified. The electricity is used for both the agricultural and household purposes. The electricity is available 12 hours out of 24 hours and the duration of power cuts is 12 hours a day and 84 hours in a week. The electricity bill per household normally ranges from INR 150-250. Sirsoda is the neighboring village which is at a distance of 500 meter from Imaliya. There are a total of 6 Self Help Groups (SHGs) in the village.

Janani Suraksha Yojana (JSY), Ladli Laxmi Yojana, Deendayal Antyodayal Upchaar Yojana are the governmental schemes operational in the village.

3.2.2 Livelihood Profile

Majority of the households in Imaliya depend on agriculture and agricultural labor for their primary income. Wheat, paddy, soya bean, gram are some of the major agricultural products. Some of the wholesalers and middlemen visit the village to procure these products. Dehgaon which is at the distance of 10 km from the village and Raisen which is at the distance of 27 km are the two markets largely used by the villagers for selling their agricultural produce.

The dairy products produced in the village are marketed by Bhopal Dairy Cooperative Federation. There are a total number of 14 shops in the village which include 4 tea shops and sweet shops and 2 vegetable shops. There are a total of 2 restaurants in the village.

2.3 Inference

Agricultural is the primary source of livelihood. Farm based employment is seasonal and much vulnerable to weather conditions. Wage labor in construction sites is another cash income dominant in the village. It also has limited elasticity in terms of capacity to provide employment and raise household income. Therefore, modernization and diversification of agricultural for increasing agricultural productivity, and energy need appear to be way forward for tackling with the present economic scenario in both the villages, Chikali and Imaliya.

2.4 Key Points

Both the villages though electrified have poor electrification status characterized by regular and long hours of power cuts thereby limiting the livelihood activities only during the daytime.

1. There is negligible usage of energy to support livelihood activity.
2. Rain-fed agriculture and small size of landholdings limits farming only to subsistence level or even below that.
3. Health infrastructure and service delivery require serious attention.

3. Situational Analysis: Reporting of Baseline

Beginning with the demographic profile of the two villages, this chapter continues with reporting the baseline scenario against the following indicators:

1. Livelihood status
2. Employment status
3. Functional literacy and training
4. Involvement of women in economic activities
5. Cooking Energy
6. Household lighting
7. Fuel usage in livelihood activities
8. Educational level
9. Health
10. Ownership of assets

3.1 Demography

As per the survey design, a total of 104 operating households were surveyed in the village, Chikali and Imaliya, which comprised 27 from Chikali and 77 from Imaliya. The demographic details of these operating households help in understanding the age groups and genders across the benefiting households.

Table 2 provides gender distribution across the operating group households. The overall gender distribution is 98 females benefiting per 100males. The outcome signposts a balanced impact on the quality of life can be expected if compared from gender perspective.

Table 2: Gender distribution across benefiting operating group households

	Male members	Female members
CHIKALI	67	75
IMALIYA	191	177
Grand Total	258	252

Table 3 provides the age distribution of population across the operating households in the two villages with a detailed demographic scenario. The male to female ratio is 1.02. A very small number of populations above the age group 60 indicate low life expectancy among both the operating groups of the 2 villages. The operating groups in both the villages have high population in between the age group 18-35, for both the genders.

Table 3: Distribution by age in absolute terms across the villages

Age group	CHIKALI	IMALIYA	Grand Total
Male (0-6)	11	34	45
Male (7-17)	19	56	75
Male (18-35)	24	56	80
Male (36-60)	11	42	53
Male (< 6O)	2	3	5
Female (0-6)	9	44	53
Female (7-17)	27	34	61
Female (18-35)	26	53	79
Female(36-60)	11	43	54
Female (<60)	2	3	5

An assessment of Below Poverty Line (BPL) households was done on the basis of whether the household had BPL card or not. Table4 indicates that a considerable number of BPL card holders in the village Imaliya. As the application for the issuing BPL ration card may take a considerable time, this indicator is not likely to show any variation within the timeframe of 1-2 years thus it neglecting the scope for incorporation of indicator during the impact assessment.

Table 4: BPL Card holders in absolute and percentage (with base as total households surveyed)

Row Labels	BPL CARDS
CHIKALI	10(31%)
IMALIYA	22(69%)
Grand Total	**32**

3.2 Livelihood Status

The primary and secondary source of income of the last one year is taken for assessing the livelihood status of the operating groups in the villages. The primary and secondary income sources are divided into 15 categories.

3.2.1 Primary Income Source

2% of the operating household reported the sale of milk and milk products from the rearing of cattle as the primary source of income. However, none of the operating group households in Chikali was involved in this income source. 2% of the operating household reported collection and sale of NTFP constituted their primary income source. The involvement in this income source from village Imaliya was nil. Majority of the operating household i.e. 57% indicated farming on own agricultural land or the leased in land constituting their primary source of income. The income from agricultural land is seasonal. In the meantime, it is subjected to fluctuation in the weather and climate. This irregular income source demands for development of comprehensive livelihood development plan. 19% of the benefiting operating household groups stated labour work in agriculture and 8% of them were involved as the labourers in industry or mines or public works for their primary income generation. 7% of the households leased out their agricultural land while 2% owned small business.

Table 5: Distribution of households based on primary income source

Count of PRIMARY SOURCE_INCOME			
	CHIKALI	IMALIYA	Grand Total
Cattle rearing/sale of milk and milk products		2(3%)	2(2%)
Collection and sale of NTFP (Non timber forest produce)	2(7%)		2(2%)
Farming on own agricultural land/ leased in land	16(59%)	43(56%)	59(57%)
Labour Work in Agriculture	2(7%)	18(24%)	20(19%)
Labour work in industry/mines/public works		9(12%)	9(8%)
Leases out agricultural land	6(23%)	1(1%)	7(7%)
No Other Source of Income	1(4%)	1(1%)	2(2%)
Owns small business-retail/teashop/restaurant/vehicle repair/black		2(3%)	2(2%)
Works in shop/restaurant/tea shops/sweet shops		1(1%)	1(1%)
Grand Total	27	77	104

3.2.2 Secondary Income Source

Labour work in agriculture forms the second largest share of income for 38% of the operating group households. 34% of the household reported no other secondary source of income. Income from rentals is secondary source of income for 7% of the households.

Table 6: Distribution of households based on secondary income

Count of SECONDARY SOURCE_INCOME			
	CHIKALI	IMALIYA	Grand Total
Farming on own agricultural land/leased in land	4(15%)		4(4%)
Labour work in agriculture	19(70%)	21(27%)	40(38%)
Labour work in Industry/mines/public works	1(4%)	10(13%)	11(11%)
Leases out agricultural land		1(1%)	1(1%)
No income source	2(7%)	34(45%)	36(34%)
Owns small business-retail/teashop/restaurant/vehicle repair/black		3(3%)	3(3%)
regular service in private sector/industry		1(1%)	1(1%)
Rentals	1(4%)	6(8%)	7(7%)
Works in shop/restaurant/tea shops/sweet shops		1(1%)	1(1%)
Grand Total	27	77	104

3.2.3 Livelihood Categories for Intervention

Table 5 and table 6 indicate that major proportions of the household depend on farming as primary and secondary source of income. 83% of the households depend on agriculture directly and indirectly for their primary income. And 43% of the households depend on agriculture as their secondary income source. Labor work in industry/mines/public works also forms a considerable income source for both the operating group households. Since the primary objective of the project is enhancing the existing livelihoods, the project interventions shall directly and indirectly support the following:

1. Farming in own agricultural land/ leased in land
2. Labour work in agriculture
3. Labour work in industry/mines/public work

3.2.4 Agriculture as Livelihood Source

Rain-fed agriculture is practiced in both the villages. In general, cotton, soya bean, mung are sold by the households to wholesalers in Chikali whereas paddy and wheat are sold by the households in Imaliya. The households from both the villages grow vegetables and fruits for self-consumption as well as for selling. In Chikali, the household reported their selling price of the end products to the wholesalers to be cotton INR3800/quintal, soya bean INR3000/quintal, mung INR3500/quintal, magan INR 1200/quintal. Wholesalers buy paddy at the cost of INR 2300 per quintal, gram INR 3000, wheat INR 1385 in Imaliya.

3.3 Employment Status

The two major livelihoods farming in own agricultural land/ leased in land and labour work in agriculture involves majority of the population of the operating households groups to participate in income generation activities. Here, members searching for income generation activities are not involved in any sort of income generation doings. In total, 25% of males and 55% of females reported searching for income generation. It illustrates the project intervention to support females for livelihood opportunities.

Table 7: Employment status

	CHIKALI	IMALIYA	Grand Total
Male members 18-60 involved in income generation	31(86%)	71(71%)	102(75%)
Male members 18-60 searching for income generation activities	5(14%)	29(29%)	34(25%)
Male members(18-60) years	36	100	136
Female members 18-60 involved in income generation	30(52%)	54(41%)	84(45%)
Female members 18-60 searching for income generation activities	27(48%)	77(59%)	104(55%)
Female members 18-60 years	57	131	188

Table 8: Members migrated to other villages/towns for employment

	CHIKALI	**IMALIYA**	**Grand Total**
Members migrated for employment	20	29	49

2% of the operating households' children participated full time in income generation activities which deprived them from education. This may lead to school dropout. 2% of the

households reported children contributed occasionally for their income. And 10% of them reported children involved on part time basis for supporting their family income. The solar multi utility centre if is able to reduce drudgery in present activities and anticipate the working population in better livelihood opportunities or support their existing livelihood to enhance income can reduce the children involvement in income generation and allow them to participate in education.

Table 9: Level of involvement of members (aged 7-14) in income generation activities

Children assisting in income generation			
	CHIKALI	IMALIYA	Grand Total
Full time	1(4%)	1(1%)	2(2%)
Occasional	1(4%)	1(1%)	2(2%)
Part time		10(13%)	10(10%)
Grand Total	2(8%)	12(16%)	14(13%)
Total Household Surveyed	27	77	104

3.4 Functional Literacy and Training

The baseline study aimed at capturing employment status in terms of basic literacy and vocational training. Table 10 indicates 68% of the adult males, and 49% of the adult females including both the villages, of the operating group households are literate reflecting ease for using user friendly literatures during training. On the other hand, only 7% of adult males and 8% of the adult females had received vocational training. The number of adults receiving any training related to operations and maintenance of SMU shall provide as assessment of change in skill level.

2 Status of functional literacy and formal training among the adult members

Literacy and training status	CHIKALI	IMALIYA	Grand Total
Functionally literate adult males (18-60 years)	19(53%)	73(73%)	92(68%)
Adult males (18-60 years) who received vocational training	3(8%)	6(6%)	9(7%)
Total male (18-60 years)	36	100	136
Functionally literate adult females (18-60 years)	25(44%)	68(52%)	93(49%)
Adult females (18-60) who received vocational training	1(2%)	14(11%)	15(8%)

Literacy and training status	CHIKALI	IMALIYA	Grand Total
Total females (18-60 years)	57	131	188

3.5 Involvement of Women in Economic Activities

The baseline survey also tried to capture the women's involvement in economic activities based on their involvement in household expenditure, buying and selling equipment, buying necessary raw materials, buying and selling equipment, expenditure on children's education, expenditure on food, and clothes and selling produce. Table 11 provides information in absolute terms. This information will be used by the gender expert while accessing the level of women participation in the SMU related activities and change in their level of involvement in economic activities.

Table 11: Distribution of households by women's involvement in Income generation

Nature of women involvement in household income and expenditure management			
	CHIKALI	IMALIYA	Grand Total
All household expenditure	12(44%)	29(38%)	41(39%)
Buying and selling equipment		1(1%)	1(1%)
Buying necessary raw materials		11(14%)	11(11%)
Expenditure on children education		3(4%)	3(3%)
Expenditure on food and clothes	15(56%)	26(34%)	41(39%)
Selling produce		7(9%)	7(7%)
Grand Total	27	77	104

3.6 Income Security

The cash income of the household can portray the income levels. 20% of the operating group households reported to be in miserable poverty with cash income less than INR 6000. 8% of the house hold had income more than INR 22000. However major of the households had cash income in between INR 6000 to 12000. The indicator would serve to be a major tool for assessing the change in income level because of the intervention of the project.

Table 12: Distribution of households by total cash income in the last one year

Total cash income of the household in the past one year			
	CHIKALI	IMALIYA	Grand Total
Less than Rs 6000	1(4%)	20(26%)	21(20%)
Rs 6000 to Rs 12000	13(48%)	23(29%)	36(35%)
Rs 12000 to Rs 18000	7(26%)	23(29%)	30(29%)
Rs 18000 to Rs 22000	3(11%)	6(9%)	9(9%)
More than Rs 22000	3(11%)	5(7%)	8(8%)
Grand Total	27	77	104

40% of the households reported no savings as on February 2012. Proportion of household reporting no cash saving is higher than any other category. Only 1% of the operating group households reported cash saving to be in between INR 3000-6000. Table 13 provides the detailed cash saving distribution. The indicator shall be used to assess income security in the output assessment study.

3 Distribution of households by total cash saving as on February 2012

Households under any form of debt			
	CHIKALI	IMALIYA	Grand Total
	22(81%)	69(90%)	91(88%)
Total households surveyed	27	77	104

A total of 91 operating group households i.e. 88% of the operating group households reported to be under debt as on February 2012.

3.7 Cooking Energy

The villagers mostly used the traditional biomass mud stoves for cooking. Table 15 illustrates 98% of the operating households including both the villages Chikali and Imaliya use firewood as the primary cooking fuel. 2 households belonging to Chikali and Imaliya reported the usage of kerosene as primary cooking fuel. Affordability and accessibility both are limiting factors towards the usage of cleaner cooking fuels.

Table 14: Distribution of households by primary cooking fuel

Primary Cooking fuel			
	CHIKALI	IMALIYA	Grand Total
Coal	1(4%)	1(1%)	2(1%)
Firewood	26(96%)	74(96%)	100(98%)
Kerosene		2(3%)	2(1%)
Grand Total	27	77	104

Dependency on firewood for cooking is very high as 100 among 104 households use it as primary cooking fuel with no other cooking fuel alternative. Only 2 operating group households reported LPG as secondary cooking fuel. Looking at the high dependency on traditional biomass stove, there is scope of introducing improved cook stoves through business models involving local level entrepreneurs.

Table 15: Count of households by secondary cooking fuel

Primary cooking fuel	Secondary cooking fuel			
		CHIKALI	IMALIYA	Grand Total
Firewood		26	74	100
	Gobar gas		1	1
	LPG		2	2
	None	1	71	97
	Others		3	4
	Grand Total	27	77	104

Table 17 illustrates that 81% of the households collect firewood form the forest areas. The change in forest cover in the region over a period of time is beyond the scope of baseline study. The introduction of efficient cook stoves may help to address the long term climate change and reduced use of biomass at a very micro level.

Table 16: Distribution of households by primary source of firewood collection

Primary source of firewood collection			
	CHIKALI	IMALIYA	Grand Total
Agricultural land	8(30%)	1(1%)	9(9%)
Both forest and agricultural land	3(11%)	3(4%)	6(5%)
Forest	15(56%)	69(90%)	84(81%)
Market		1(1%)	1(1%)
None		1(1%)	1(1%)
Other		2(3%)	2(2%)
Roadside	1(3%)		1(1%)
Grand Total	27	77	104

The responsibility of firewood collection is borne by the adult women in 90% of the households. And in 10% households, both adult men and women involve in this process.

Table 17: Distribution of households by members responsible for firewood collection

Count of MEMBERS_FIREWOOD COLLECTING			
	CHIKALI	IMALIYA	Grand Total
Adult men and adult women	10(37%)		10(10%)
Adult women	17(63%)	77(100%)	94(90%)
Grand Total	27	77	104

Table 18: Distribution of households by hours spend on fuel collection

Count of hours spent for fuel collection			
	CHIKALI	IMALIYA	Grand Total
Between 2 hours and 4 hours	13(48%)	77(100%)	90(87%)
Between 4 and 6 hours	6(22%)		6(5%)
More than 6 hours	1(4%)		1(1%)
Up to 2 hours	7(26%)		7(7%)
Grand Total	27	77	104

48% of the households in Chikali reported collection time between 2 to 4 hours, whereas all the operating group households from Imaliya reported 2 to 4 hours to be their average collection time. The figures in the table 19 indicate considerable amount of time spend on fuel collection. This indicator might not capture the change in case if interventions limit to multi utility centre, however if improved cook stoves are introduced in the area, then significant changes are bound to occur.

3.8 Household lighting

All the operating household groups are electrified. The electrification status in village provides scope for decentralized generation for lighting. Solar operated grids and household systems may lead to provision of basic clean and reliable energy for lighting to the households.

Table 19: Distribution of households by electrification status

	CHIKALI	IMALIYA	Grand Total
Count of households electrified	27(100%)	77(100%)	104(100%)
Grand Total	27	77	104

79% of the operating household groups used incandescent bulb as a primary device used for lighting during evening hours while 2% of them use CFL. Though all the houses are electrified, still 19% of the households use kerosene lamp as the primary device for lighting during the evening hours. This indicator can be used to measure change in quality of light available during the evening hours.

Table 20: Distribution of households by primary device used for lighting during evening hours

Count of primary device used for lighting during evening hours			
	CHIKALI	IMALIYA	Grand Total
CFL		2(3%)	2(2%)
Incandescent bulb	12(44%)	70(91%)	82(79%)
Kerosene lamp	15(56%)	5(6%)	20(19%)
Grand Total	27	77	104

The duration of usage of electricity operated devises for lighting such as incandescent bulb, tube-light, CFL in a day was scanned. 58% of the household reported the duration of usage of electricity operated lighting device in a day to be 2-4 hours. And only 10% of the households reported above 6 hours. The reason was assumed irregular power supply and lifestyle.

Table 21: Distribution of households by the duration of usage of bulb/tube light/CFL in a day

Count of duration of usage of bulb/tube light/CFL in a day			
	CHIKALI	IMALIYA	Grand Total
2-4 hours	17(63%)	43(56%)	60(58%)
4-6 hours	2(7%)	20(26%)	22(21%)
Above 6 hours	2(7%)	8(10%)	10(10%)
Less than 2 hours	6(23%)	6(8%)	12(11%)
Grand Total	27	77	104

All the operating group households use kerosene for lighting purpose. On an average, monthly consumption of kerosene for lighting purpose for 42% of the households falls in the range of 2-4 litres. And 38% of the households use less than 2 litres of kerosene in a month for the lighting purpose. Table 23 gives a detailed distribution of usage quantity of kerosene for the purpose of lighting.

Table 22: Distribution of households by usage quantity of kerosene for lighting

Kerosene consumption per month for lighting			
	CHIKALI	IMALIYA	Grand Total
Less than 2 litres	5(19%)	35(45%)	40(38%)
2-4 litres	14(52%)	29(38%)	43(42%)
4-6 litres	8(29%)	11(14%)	19(18%)
6-8 litres		2(3%)	2(2%)
Grand Total	27	77	104

3.9 Fuel usage for livelihood purpose

6% of the operating groups from both the villages use electricity, and 1% of them use kerosene for earning their livelihood. However, 97% of the households reported they didn't use fuel for earning their livelihood. The solar home light system can be used for lighting purpose so that the family members can involve in some sort of income generation during their spare time in the night to enhance their livelihood. Mini/ micro grids may be suitable option for this.

Table 23: Fuel usage for livelihood purpose

Fuel used for livelihood purpose			
	CHIKALI	IMALIYA	Grand Total
Electricity	6(22%)		6(6%)
Kerosene		1(1%)	1(1%)
Not applicable	21(78%)	76(99%)	97(93%)
Grand Total	27	77	104

3.10 Educational Level

An attempt was made to find out the educational status of children among the operating group households in both the villages i.e. Chikali and Imaliya. Introduction of technology is expected to facilitate livelihood activities and uplift the people from BPL. A good household income will encourage young population to divert to education. Table 24 provides boys and girls attending primary and secondary school. The table indicates that only 30% of the girls and 75% of the boys attending primary school go further for the secondary school.

Table 24: Count of children attending primary and secondary school

	CHIKALI	IMALIYA	Grand Total
Boys attending primary school	12	28	40
Girls attending primary school	17	27	44
Boys attending secondary school	9	21	30
Girls attending secondary school	3	10	13
Proportion (girls/boys) attending primary school	1.42	0.96	1.1
Proportion(girls/boys) attending secondary school	0.33	0.48	0.43
Percentage of boys attending secondary school with base count of boys attending primary schools	75%	75%	75%
Percentage of girls attending secondary school with base as count of girls attending primary schools	18%	37%	30%

Reason for dropping out from school was analysed separately for boys and girls. Table 25 shows the various reasons for the drop out. Contributing to household income was the major reason for dropout among both boys and girls. It constituted 32% of the total reasons. Surprisingly the dropout rates for both boys and girls were the same. 14% of the dropout rate was for contributing to the daily household work.

Table 25: Reasons for dropping out from school

	CHIKALI	IMALIYA	Grand Total
Count of reasons of school dropout boys			
Others		2(11%)	2(10%)
Health reasons	1(50%)		1(5%)
Lack of funds to support education		2(11%)	2(10%)
Lack of sufficient number of teachers		1(5%)	1(5%)
Contributing to daily household work		3(15%)	3(14%)
Contributing to household income		7(36%)	7(32%)
Lack of fund to support education		2(11%)	2(10%)
Not interested in studies	1(50%)	2(11%)	3(14%)
Total	2	19	21
Count of reasons of school dropout girls			
Others		2(11%)	2(10%)
Health reasons	1(50%)		1(5%)
Lack of funds to support education		2(11%)	2(10%)
Lack of sufficient number of teachers		1(5%)	1(5%)
Contributing to daily household work		3(15%)	3(14%)
Contributing to household income		7(36%)	7(32%)
Lack of fund to support education		2(11%)	2(10%)
Not interested in studies	1(50%)	2(11%)	3(14%)
Total	2	19	21

Table 26 reveals that 48% of the children study up to 2 hours at home and only 7% of the students at the operating household group study more than 2 hours at home. It is important to note that 45% of the students don't study at home. 36% of the students study during the morning and evenings. SMU can be better means for increasing children studying hours and their better performance in the study directly and indirectly.

Table 26: Distribution of households by the average number of hours for which children study

Count of AVERAGE_HOURS_CHILDREN STUDY_HOME			
	CHIKALI	IMALIYA	Grand Total
More than 2 hours		8(10%)	8(7%)
None	12(44%)	34(44%)	46(45%)
Up to 2 hours	15(56%)	35(46%)	50(48%)
Grand Total	27	77	104

Table 27: Distribution of households by the average number of hours for which children study at Home

Count of TIME OF DAY_CHILDREN STUDY_HOME			
	CHIKALI	IMALIYA	Grand Total
In early morning and evening	3(12%)	34(44%)	37(36%)
In the evening	12(44%)	9(12%)	21(20%)
None of above	12(44%)	34(44%)	46(44%)
Grand Total	27	77	104

A gauge on the accessibility level of computer for the children in between 6 to 17 was included in the survey. At present time 98% of the children in between the age group 6 to 17 have no access to computers.

4 Distribution of households by accessibility level to computers for children in between 6-17

Count of COMPUTER ACCESSIBILITY_CHILDREN_AGE GROUP_6-17			
	CHIKALI	IMALIYA	Grand Total
At internet café OR at any other place apart from school or home		1(1%)	1(1%)
At school OR at school and home OR at home	1(4%)		1(1%)
None	26(96%)	76(99%)	102(98%)
Grand Total	27	77	104

3.11 Health

32% of the operating household groups reported that they went to the private dispensaries in case of health problems and 28% of them visited both private dispensaries and PHCs. And 5% of them go to traditional healers for health problems, who use herbs and forest products to prepare medicines based on their traditional knowledge systems. Table 29 reveals that 67% of the operating household groups suffer from the health problems other than cholera, diarrhoea, malaria /dengue, tuberculosis and typhoid. 15% of them suffer from malaria/dengue. One of the project interventions relates to provision of refrigerators for storage of medicines for malaria and dengue.

Table 29: Distribution of households by health institutions assessed by them

Count of HEALTH INSTITUTION_ASSESSED_TREATMENT			
	CHIKALI	IMALIYA	Grand Total
Both private dispensaries and PHC/sub centres	10(37%)	19(25%)	29(28%)
Health Centre in nearby town	1(4%)	8(10%)	9(8%)
Local village doctors		13(17%)	13(13%)
None		1(1%)	1(1%)
PHC/sub centre	3(11%)	10(13%)	13(13%)
Private dispensaries	13(48%)	20(26%)	33(32%)
Traditional healers/Vaidya		6(8%)	6(5%)

Count of HEALTH INSTITUTION_ASSESSED_TREATMENT			
Grand Total	**27**	**77**	**104**

Table 30: Distribution of households by health problems reported by the members in the last 1 year

Count of HEALTH PROBLEMS_MEMBERS_LAST 1 YEAR			
	CHIKALI	IMALIYA	Grand Total
Cholera	1(4%)	1(1%)	2(2%)
Diarrhea		1(1%)	1(1%)
Malaria/dengue	9(33%)	7(9%)	16(15%)
Malaria/dengue and Diarrhea	1(4%)		1(1%)
Other	10(37%)	60(79%)	70(67%)
Tuberculosis	1(4%)	1(1%)	2(2%)
Typhoid	5(18%)	7(9%)	12(12%)
Grand Total	27	77	104

Hand pumps are the primary drinking water source for 95% of the operating household groups in Chikali and Imaliya and the distance of the hand pump ranges between 100 M to 1 KM. Open well is the drinking water source for 2% of the households in Imaliya and the distance ranges from 100M to 500M. Only 2% of the households from both the villages depend on tap water, which lies at the distance of 500M to 1km from their house. And tube well is the drinking water source for 1% of the operating household groups.

Table 31: Distribution of households by primary source of drinking water and distance from the water source

	CHIKALI	IMALIYA	Grand Total
Hand pump	25(92%)	74(96%)	99(95%)
Between 100M to 500M	1	41	42
Between 500M to 1KM		7	7
More than 1KM		1	1

	CHIKALI	IMALIYA	Grand Total
Up to 100 M	24	25	49
Open well		2(3%)	2(2%)
Between 100M to 500M		1	1
Up to 100 M		1	1
Tap water	1(3%)	1(1%)	2(2%)
Between 500M to 1KM	1	1	2
Tube well 1(3%)			1(1%)
Between 100M to 500M	1		
Total Count of PRIMARY SOURCE_DRINKING WATER	27	77	104

Only 6% of the operating household groups reported the quality of their drinking water to be brackish while remaining 94% of the operating household groups reported water quality to be clear.

Table 32: Distribution of households by quality of drinking water

Count of QUALITY_DRINKING WATER			
	CHIKALI	IMALIYA	Grand Total
Brackish	1(4%)	5(6%)	6(6%)
Clear	26(96%)	72(94%)	98(94%)
Grand Total	27	77	104

3.12 Ownership of Assets

94% of the operating household groups live in Kutcha house while 9% of them live in semi pucca and only 1% of them including both the villages reported to be living in pucca house.

Table 33: Distribution of households by the type of dwelling

Count of HOUSE TYPE_RESIDING			
	CHIKALI	IMALIYA	Grand Total
Kutcha house	19(70%)	75(98%)	94(90%)
Pucca	1()		1(1%)
Semi pucca	7()	2(3%)	9(9%)
Grand Total	27	77	104

79% of the households reported to have mobile phone. Still 16% of the households do not have any telephone facility available to them.

Table 34: Distribution of households by telephone facility available

Count of KIND_TELEPHONE FACILITY			
	CHIKALI	IMALIYA	Grand Total
Accessing phone through neighbor's house	4(15%)		4(4%)
Fixed line telephone		1(1%)	1(1%)
Mobile phone	14(52%)	68(88%)	82(79%)
None of the above	9(33%)	8(11%)	17(16%)
Grand Total	27	77	104

Only 2% of the operating household group own radio. 26% of them own television. The utility centre will provide refrigerator, which would benefit the villagers in storing perishable items such as milk and vegetables.

Table 35: Distribution of households by selected assets

	CHIKALI	IMALIYA	Grand Total
Owns radio	1(4%)	1(1%)	2(2%)
Owns Television	1(4%)	26(34%)	27(26%)
Owns refrigerator		1(1%)	1(1%)
Grand Total	27	77	104

3.13 About Operating groups

Focused group discussions were conducted with the operating groups. This chapter reports the baseline scenario of the operating groups of both the villages of Chikali and Imaliya.

Chikali

Durga Aajivika SHG of Chikali has a total of 7 members, out of which 4 of them are able to read and write, 1 is primary passed but all the 7 members have received vocational training. The training was conducted by NGO TAAL on flour mill, and spice grinder. Their present activities deal with savings and lending credit. The members reported that their average income in the last year ranged between INR 6000 to INR 12000. And they have a total saving of INR 19000 till date. The members expressed the notion of community development and income enhancement from the operation of solar multi utility centres.

Santoshi Aajivika is another SHG in the village Chikali comprising of 7 members and all of them are able to read and write. All 7 of them have attended the vocational training conducted by TAAL as Durga Aajivika SHG. The SHG's average income in the last year also ranged in between INR 6000 and INR 12000. Their saving till now amounts to INR 23000.

Both of these SHGs were formed in 2010 and they conduct inner loaning amongst the members and save INR 100 per member per month.

Imaliya

Village Imaliya comprises a total of 6 SHGs. Poonam SHG consists of 12 members out of which 7 are able to read and write, 4 members are primary passed and 1 is secondary passed. According to this SHG, Solar Multi Utility Centre can help in enhancement of the social esteem and self-esteem and boost income and social awareness. The average income of the group in the past one year was less than INR 6000. Till date they don't have any savings. Jai Durga SHG has 10 members out of which, 5 are able to read and write, 3 are primary passed, 1 is secondary passed and 1 is a graduate. Krishna SHG has a total of 11members, 10 of them are able to read and write and 1 is a graduate. Laxmi SHG has 11 members in total, 8 of them are able to read and write, 2 of them are primary passed and 1 is secondary passed. Prem SHG consists of 9 members, 5 can read and write and 4 are primary passed. Shri Ganesh SHG has a total of 9 members, 4 primary passed and 5 secondary passed. None of the SHG has savings till date; however all the groups reported their income in the last year to be less than INR 6000. All of the groups are optimistic about their income enhancement by the Solar Multi Utility Centre.

3.14 Inference

Above details give an insight on the baseline scenario of the operating household groups in Chikali and Imaliya. At the current time, the household scenario reflects poor access to clean energy for lighting and cooking. In spite of all the households being electrified, they are not able to take benefits of electricity for enhancing their livelihood due to power shortage. Low income level and minimal savings with subsistence agriculture is the state of both the villages. So, these all indicate a need for a planned livelihood intervention. Since majority of the households have agricultural farming as their major occupation, energy intervention for agricultural activities along with marketing of output thus produced from agriculture would be able to make some positive impacts for enhancement of livelihood and increasing income.

4. Renewable Resource Assessment and Technology Details

The technology proposed for the project is a clean energy based integrated multi-utility platform that utilizes the locally available renewable energy resources to generate electricity. The clean energy based Multi-Utility platform will act as the energy hub for meeting energy requirements of the community for running a variety of high market valued applications. The platforms would be located near the energy utilization points in villages to provide electricity services as per the need of the community. The generated electricity would then be used for variety of applications such as charging lanterns, powering other appliances such as computer, mobile phones, water purifier, grinder, driers, etc. Benefits of energy supply will be three-fold, as outlines below, which will lead to not only revenue generation but also save time.

- Increased throughput of already mechanized processes, due to more reliable and regular power supply; e.g. increased production of honey because of more hours of production.
- Mechanization of those processed which were otherwise manual; e.g. saal leaf plate stitching etc
- Initiation of new value-added activities, which fetch high revenue but were otherwise ignored, for want of power; e.g. tamarind processing and brick making. With no energy supply raw tamarind was sold is being sold in the market at a very low price without any processing.

The idea is to bridge the gap in energy demand and supply, which hamper economic development of these remote rural areas which otherwise have a high potential for revenue generation, with the use of renewable energy sources. The aim is to make Solar Multi-Utility (SMU) Platform a focal point for economic and social growth that would promote sustainable development in rural areas it serves.

The Multi-Utility platform is based on an entrepreneurial model of electricity service delivery that integrates a range of applications to provide for various end uses of electricity by a rural consumer. The model is designed so as to benefit both the service provider as well the consumer. Each facility will be operated by a local solar entrepreneur chosen from the selected villages. These local solar entrepreneurs will be trained to manage and operate the platform. The operational cost (which is primarily the salary of the operator) required for operating and managing the Multi-Utility platform would come from the revenue that would be generated through the electricity services provided by the Multi-Utility utility.

While the facility will create income generation for the local solar entrepreneurs at one end, the end user gets the benefit of electricity services within his/her region on the other end. This model, besides bringing electricity services to many lives in rural area, will also become a source of income generation for local entrepreneurs, thereby contributing to not just the social and economic development of the rural communities, but will help accelerate the regional economic development as well.

4.1 Introduction to Solar Multi Utility (SMU)

The project envisages setting up of clean energy based, primarily Solar Multi-Utility platforms for meeting a variety of energy needs of the community which has a high market value. A Multi-Utility Platform is a platform that utilizes the locally available energy resources to generate electricity. The generated electricity would then be used for variety of applications such as grinders, pulverisers, flour mills etc. It could also be used for charging lanterns, powering other appliances such as computer, mobile phones, water purifier etc. Such platform is located near the energy utilization points in a village to provide electricity services as per the need of the community. In the case of this project, since the renewable energy used is mainly solar (along with wind at one site) the platform may also be called a Solar Multi-Utility Platform (SMU).

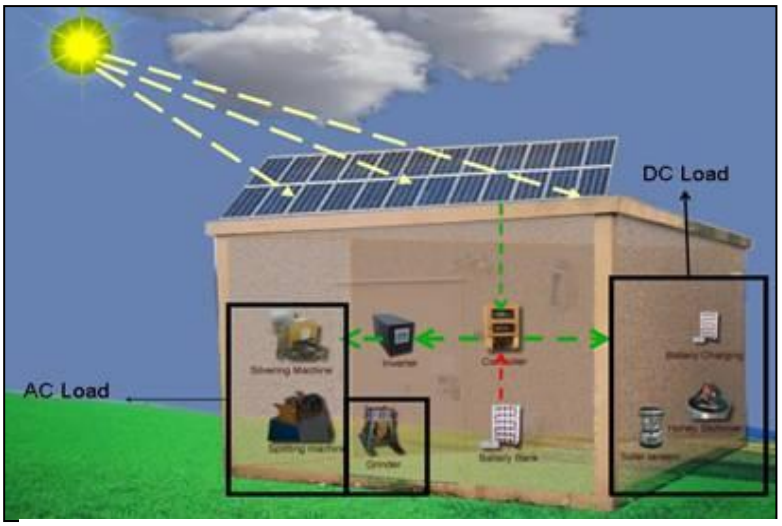


Figure 2: Schematic representation of an SMU

4.2 Design & Development of an Appropriate SMU

A complete scoping study was carried out to assess the energy requirement of the local communities in villages namely Imliya Babliya, Dist.Raisen & Chikli, Dist.Dhar in Madhya Pradesh. The very objective of carrying out this activity was to identify those livelihood generation activities which are required by the community and which can enhance the income generation of the beneficiaries by increasing the market value through improvement in quality and production output. The energy intervention required to strengthen such activities and the added appliances that could enhance productivity and give a boost to the revenue generated were also identified for each of these livelihood options.

4.2.1 Technology Details of the Identified Technology Applications in the Villages

- Location: Imliya Babliya Village, Raisen District, Madhya Pradesh.
  Spatial Info: Latitude: 23.33°N, Longitude: 77.8°E [in Decimal Degrees]

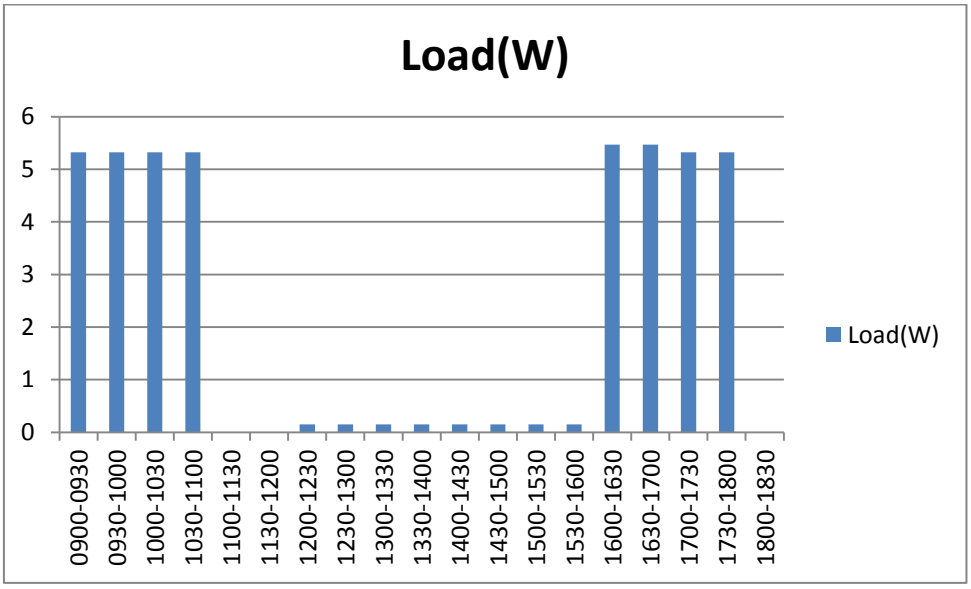
Table 36: Details of livelihood applications based on SPV technology

Appliances for the Technology Application	Power	Nos.	Hrs. of Operation	Time Duration	Output	Phase Info
Atta Chakki + Motor	5 HP	1	4	9am to 11AM and 4PM to 6PM	120 Kg/Hr	three
Masala Pulvarisor	3HP	1	4	9am to 11AM and 4PM to 6PM	10 to 20 Kg/Hr	single
Rice Hullar	5 HP	1	4	9am to 11AM and 4PM to 6PM	200 Kg/Hr	single

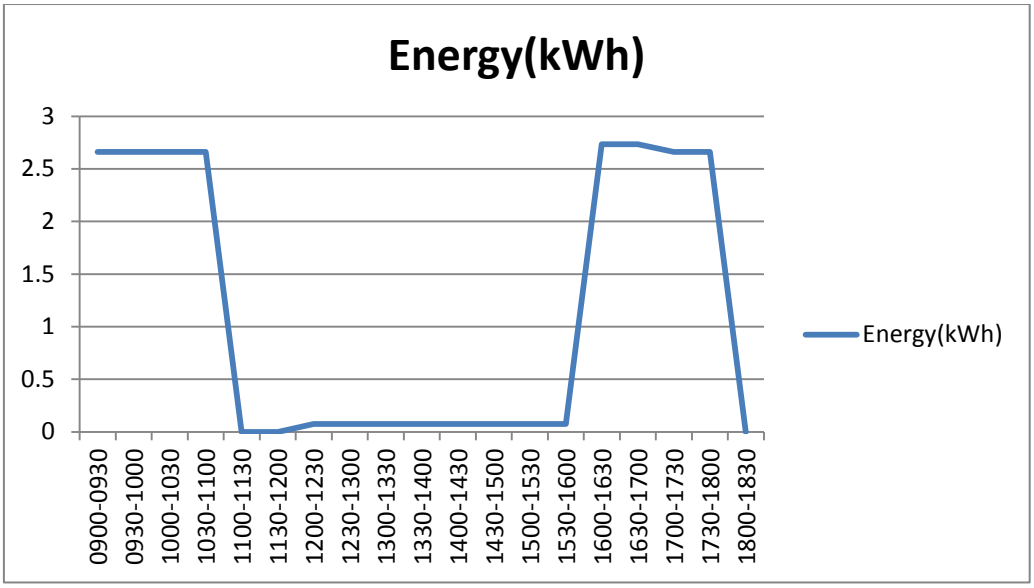
Load Usage pattern for Imliya Babliya Village, Raisen, M.P.:

Time Interval	Load(W)	Time	Energy(kWh)
0900-0930	5.3212	0.5	2.6606
0930-1000	5.3212	0.5	2.6606
1000-1030	5.3212	0.5	2.6606
1030-1100	5.3212	0.5	2.6606
1100-1130	0	0.5	0
1130-1200	0	0.5	0
1200-1230	0.15	0.5	0.075
1230-1300	0.15	0.5	0.075
1300-1330	0.15	0.5	0.075
1330-1400	0.15	0.5	0.075
1400-1430	0.15	0.5	0.075
1430-1500	0.15	0.5	0.075
1500-1530	0.15	0.5	0.075
1530-1600	0.15	0.5	0.075
1600-1630	5.4712	0.5	2.7356
1630-1700	5.4712	0.5	2.7356
1700-1730	5.3212	0.5	2.6606
1730-1800	5.3212	0.5	2.6606
1800-1830	0	0.5	0

Load Profile for Imliya Babliya Village, Raisen, M.P:



Energy Profile for Imliya Babliya Village, Raisen, M.P:



- Location: Chikli Village, Dhar District, Madhya Pradesh.
  Spatial Info: Latitude: 22.60°N, Longitude: 75.30°E [in Decimal Degrees]

Table 37: Details of livelihood applications based on SPV technology

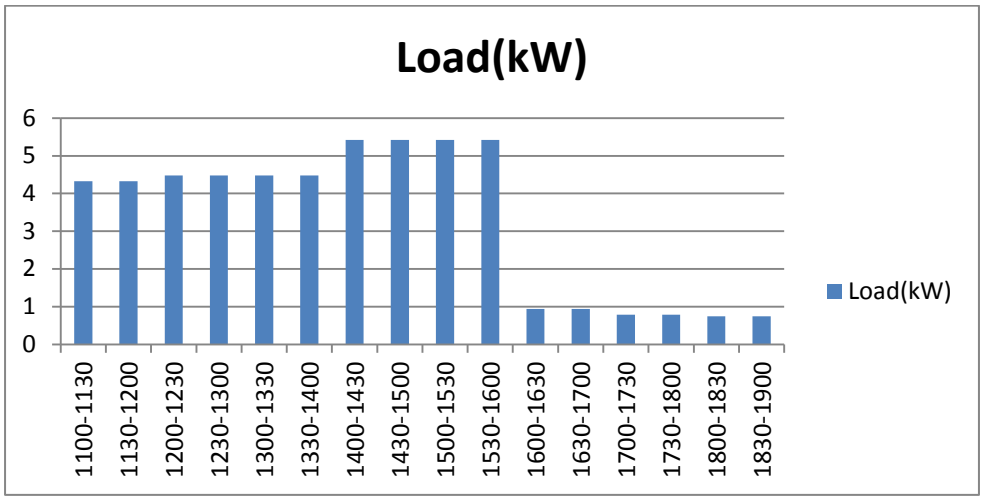
Appliances for the Technology Application	Power	Nos.	Hrs. of Operation	Time Duration	Output	Phase Info
Mini Dal Mill	2 HP	1	4	9am to 11AM and 4PM to 6PM	100 kg/hr	three
Cleaner and Grader	0.5 HP	1	4	9am to 11AM and 4PM to 6PM	330 to 800 kg/hr	single
Grinder (wheat)	1 HP	1	4	9am to 11AM and 4PM to 6PM	Up to 15 kgs/hr	single
Chilly Grinder	3 HP	1	4	9am to 11AM and 4PM to 6PM	18 to 28 kgs/hr	three
Packing Machine	250 watts	1	4	9am to 11AM and 4PM to 6PM		single

Load Usage pattern for Chikli Village, Dhar, M.P.:

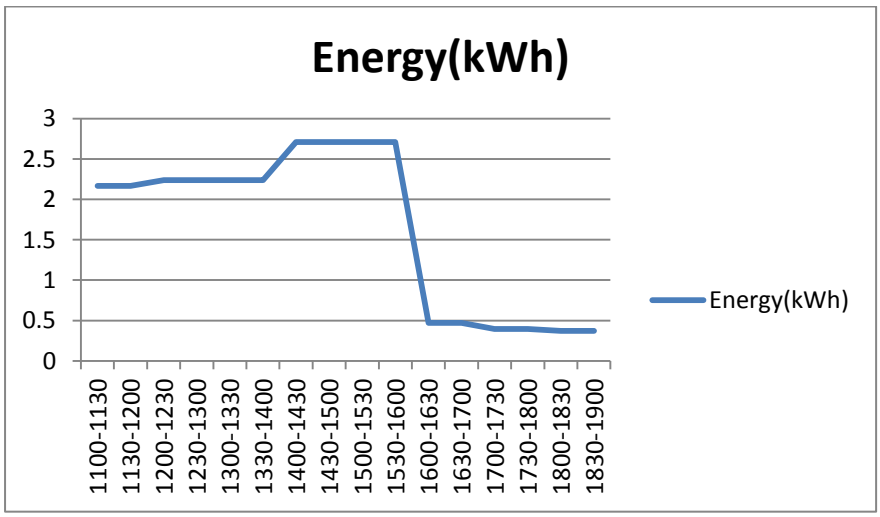
Time Interval	Load(kW)	Time	Energy(kWh)
1100-1130	4.3292	0.5	2.1646
1130-1200	4.3292	0.5	2.1646
1200-1230	4.4792	0.5	2.2396
1230-1300	4.4792	0.5	2.2396
1300-1330	4.4792	0.5	2.2396
1330-1400	4.4792	0.5	2.2396
1400-1430	5.4168	0.5	2.7084

Time Interval	Load(kW)	Time	Energy(kWh)
1430-1500	5.4168	0.5	2.7084
1500-1530	5.4168	0.5	2.7084
1530-1600	5.4168	0.5	2.7084
1600-1630	0.9376	0.5	0.4688
1630-1700	0.9376	0.5	0.4688
1700-1730	0.7876	0.5	0.3938
1730-1800	0.7876	0.5	0.3938
1800-1830	0.7456	0.5	0.3728
1830-1900	0.7456	0.5	0.3728

Load profile for Chikli Village, Dhar, M.P.:



Energy profile for Chikli Village, Dhar, M.P.:



4.3 Clean Energy resource Assessment

Planning and operation of renewable energy conversion systems need a detailed knowledge of the availability of energy resources. For a precise characterization of renewable energy based electricity generation systems, the system response under the influence of the varying resources has to be analysed. Availability of different RE resources such as solar, woody biomass, hydro, and wind was assessed. The details of the RE resource availability are described in the following sections.

4.3.1 Solar Energy Resources Assessment

The average annual solar radiation in Madhya Pradesh ranges between 4.5 to 6 kWh/m2/day (source:- solar resource map, SEC, MNRE).

Madhya Pradesh, because of its sub-tropical geographical location between latitude 21°04'N-26.87°N and longitude 74°02'-82°49' E, **receives an abundance of solar radiation throughout the year** except for some interruption during the monsoon and winter seasons. Occurrence of number of sunny days in a year and average daily solar radiation at the horizontal surface at the nearest locations from the proposed project site were considered. The secondary information (from NASA for the nearest locations) for the month of July was validated with primary data collection on the average daily solar radiation on horizontal surface at the project sites. Subsequently the secondary data is used for estimating the size and configuration of the clean energy based Multi-Utility Platform. Month wise averaged solar radiation data at Babliya and Chikli is given below in Table and Figures.

Table 38: Monthly average solar insolation at the village sites (Source: -NASA)

Month	Daily solar radiation - at Babliya	Daily solar radiation - at Chikli
	kWh/m2/d	kWh/m2/d
January	4.57	4.61
February	5.24	5.35
March	6.02	6.2
April	6.59	6.65
May	6.36	6.75
June	5.33	5.54
July	4.1	4.27
August	3.64	3.83
September	4.53	4.72
October	5.1	5.17
November	4.63	4.69
December	4.24	4.32

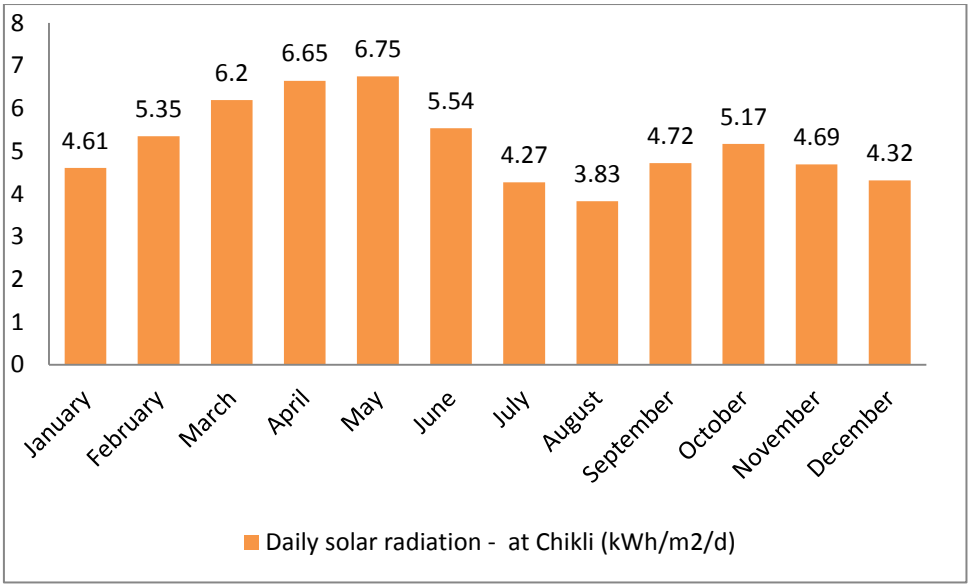


Figure 3: Solar resource (DNI) at Chikli Village

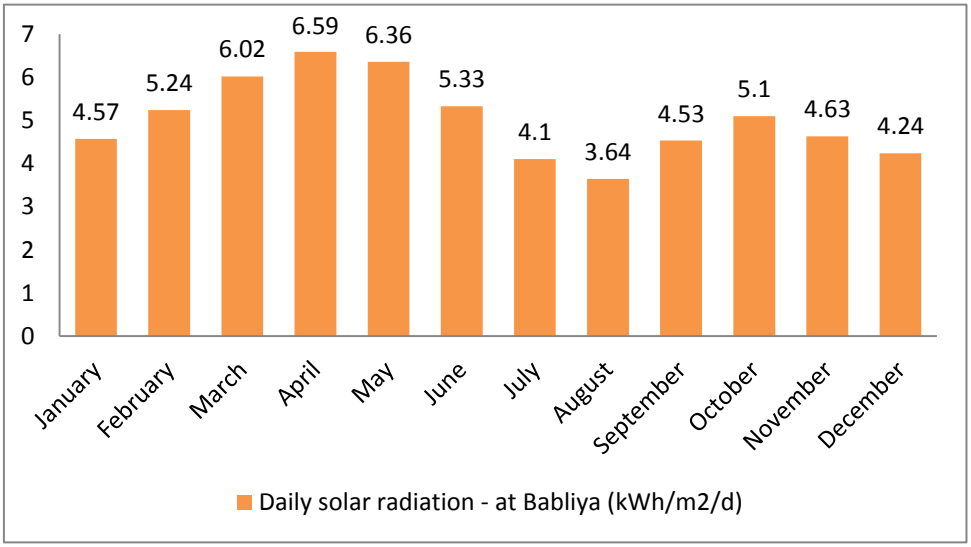


Figure 4: Solar resource (DNI) at Imliya Babliya

4.3.2 Wind Energy resources assessment

The power from wind flow is proportional to the cube of the instantaneous wind velocity and for this reason wind measurement is very crucial. For accurate estimation of wind resources, site - specific wind monitoring is essential.

TERI assigned the task of preparation of Wind Resource Maps for the regions of Chikli & Babliya to M/s Consolidated Energy Consultants Limited (CECL), Bhopal,Madhya Pradesh. Tables below show the monthly distribution of wind speeds at the village sites at a height of 10 meters and 20 meters respectively.

Table 39: Wind resource at the selected village sites for 10 m height

Wind Speed at 10m (m/s)	Months											
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Chikli VIllage	2.04	2.293	2.272	2.696	3.282	3.434	3.08	2.606	2.232	1.727	1.767	1.878
Imliya Babliya	2.293	2.414	2.492	2.682	2.916	2.916	2.63	2.284	2.102	1.765	1.843	2.042

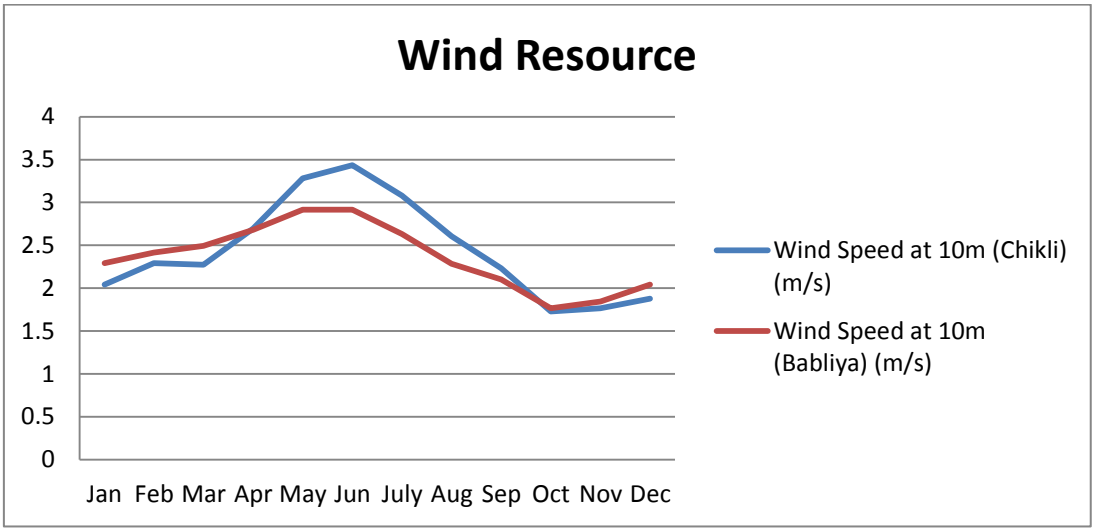


Figure 5: Graphical plot of the wind resource at the selected village sites for 10 m height

Table 40: Wind resource at the selected village sites for 20 m height

Wind Speed at 20m (m/s)	Months											
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Chikli VIllage	2.669	2.999	2.972	3.527	4.293	4.492	4.029	3.408	2.92	2.259	2.312	2.457
Imliya Babliya	2.985	3.143	3.244	3.492	3.796	3.796	3.424	2.974	2.737	2.298	2.399	2.658

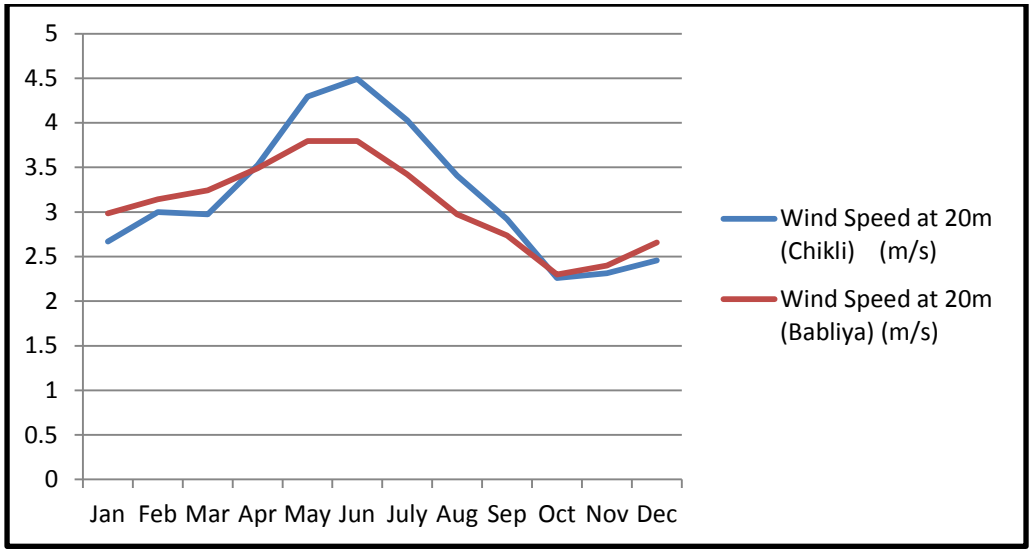


Figure 6: Graphical plot of the wind resource at the selected village sites for 20 m height

4.3.3 Woody Biomass Resource

Availability of woody biomass for power production and land availability for energy plantation were the two options that were checked. Sustainable production of biomass from forests was estimated using the data on area of forest land and the expected yield per hectare. The right to access to forest was also checked. The availability of biomass for power generation on a sustainable basic was estimated by deducting the existing biomass consumption for domestic purposes.

The current domestic requirements of biomass for the villagers were obtained from the household level questionnaire. It is observed that the fuel wood consumption was mainly for cooking and found to be 5-6 kg per household / day (with 4-5 members in a household). It is found that the availability of woody biomass was not sufficient and sustainable to be ensured for supply for both the locations.

4.3.4 Hydro Resource Assessment

There was no hydro source or perennial stream found nearby the village to be techno-economically feasible for the project, therefore, hydro was not considered in the final power plant configuration.

4.4 Renewable Energy Technology (RET) Assessments

The daily peak loads were optimized to 8KW and the different Renewable Energy technologies were assessed to meet the energy demand.

Table, as per the resource assessment, currently non-availability of hydro source, wind and woody biomass, defers our objective of using the solar PV/wind/biomass/hydro hybrid system. Hence for the village sites, Solar PV is used to supply power to the SMU.

Table 41: Shows the suitability of different RET's for the village sites

Villages	Daily Peak Load(KW)	Solar	Wind	Hydro	Biomass
Chikli	8	Solar PV	Not Sufficient Resource	Not Available	Not Available
Imliya Babliya	8	Solar PV	Not Sufficient Resource	Not Available	Not Available

4.5 Technical Specifications

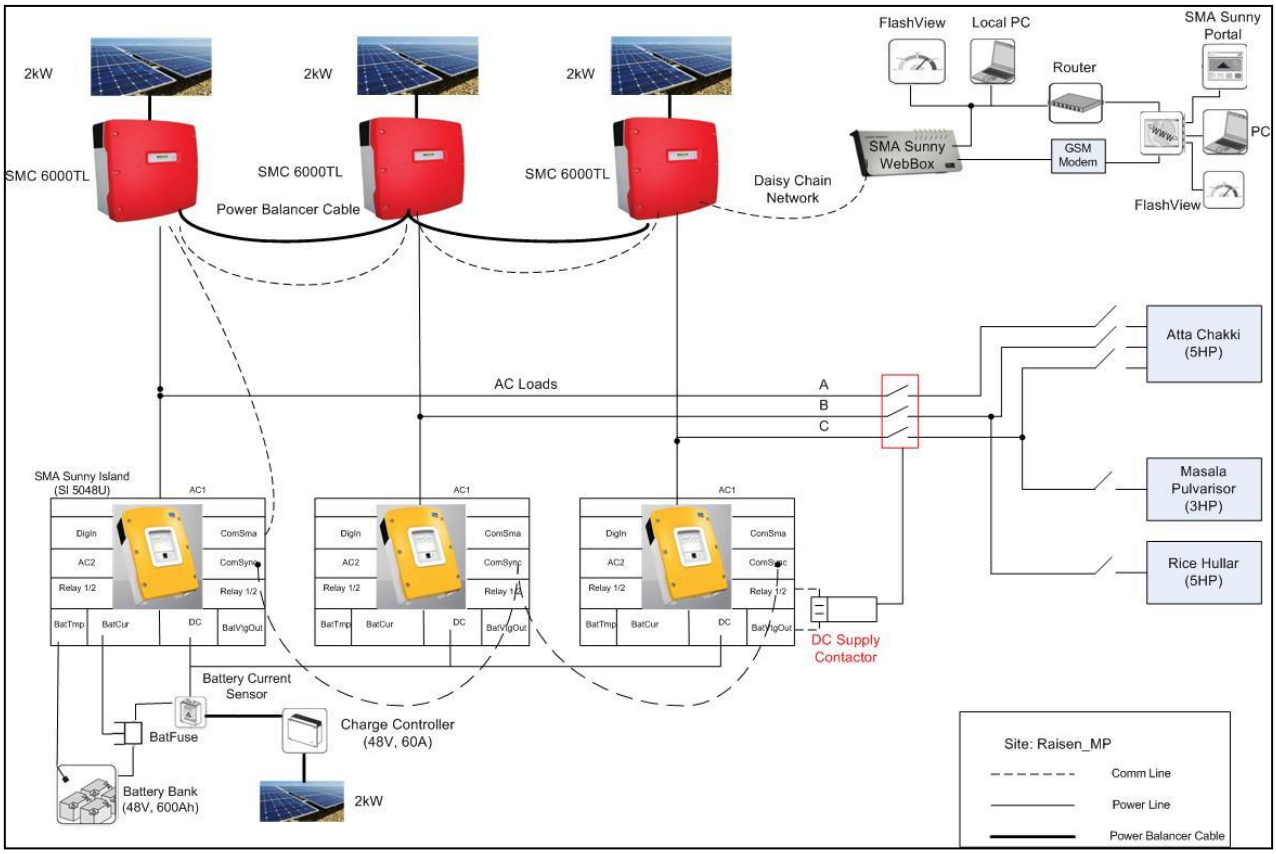
Table 42: Technical specifications of the SPV power plant at both the village sites

Components	Specifications
Technology and Size of the clean energy based Multi-Utility	Solar PV
Total SPV array capacity	8kW
Power Conditioning Unit (estimated)	
Inverter type	Bidirectional inverter & Grid Tied
Solar charge controller type	PWM, 48V 60 A
Battery voltage (nominal)	48 V
Inverter AC Output (nominal)	230V AC, Single phase, 50Hz.
PCU Inverter rating	5 kVA
Mounting	Roof Mounting Type

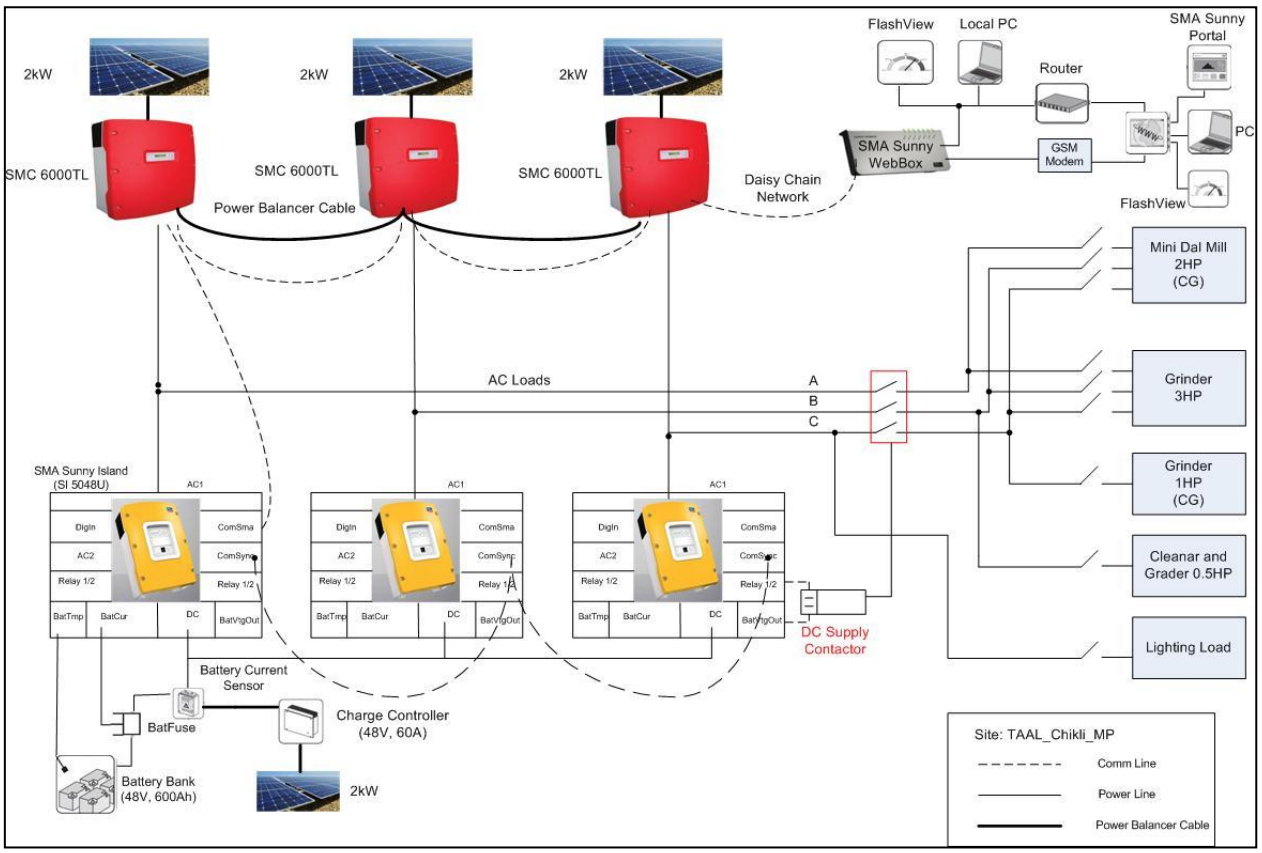
Battery Bank	
Type	Lead Acid Flooded Electrolyte Tubular Plate Batteries
Total battery bank capacity - nominal	48V,600 Ah @ C10
Remote monitoring system(Optional)	

Figure below shows the systematic line diagram of the proposed 8KWp SPV systems.

Line diagram of SPV system for Imliya Babliya Village;



Line diagram of SPV system for Chikli Village



4.6 System Technical Details

Technical details of solar module

The rated output power of the module as provided by the supplier should not vary more than 2% from the specified power rating of the modules. The module should have a power output warranty for 10 years. The performance of the module should not be degraded more than 10%. The efficiency of the module should be more than 14% with good transitivity of the top glass. Plastic weather-proof terminal box should be provided at the back of the module. Bypass diode should be mounted on each module terminal. Table shows the technical specification of solar module

Array support structure

Module should be mounted on a support structure suitable for site condition. After installation, the array structure should be capable of withstanding a substantial wind load.

Power Conditioning Unit (PCU)

The PCU converts DC power produced by SPV array into AC power. The capacity of the PCU depends on the load requirement of the village. The PCU should be so chosen that

hybridization of power plant based on other technologies would be easily done. While choosing the PCU, its reliability and durability in the field condition has to be checked. The inverters are grid interactive and capable of taking multiple electricity generation resources.

Battery Bank

The battery bank capacity will be different depending upon the load requirement and capacity of the system. Acid proof storage racks has to be provided to accommodate the cell.

Table 43: shows the technical specification of tubular lead acid battery

Type	Lead Acid Tubular
Cell Voltage	12 V
Cell Capacity	100 Ah
Battery Bank Capacity	48V 600 Ah

Junction Boxes

It is used for termination of connections from various arrays.

DC and AC Distribution Boxes

DC Distribution Boxes (DCDB) receives the DC power from SPV array through junction boxes, which shall be terminated on copper bus bars of suitable capacity. Meter shall be provided for measurement of voltage, current. Suitable arrangement should be made for controlling the DC power output from PV array. AC Distribution Board (ACDB) shall control the AC power from PCU to distribution feeders. Ampere meter should be provided.