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Improving Sustainable Energy Access among SC/ST households in Chamarajanagar District of Karnataka – A pilot study

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Abbreviation

ACF		Assistant Conservator of Forest
CEO	:	Chief Executive Officer
CFCs	:	Common Facility Centres
CO	:	Carbon Monoxide
CO_2	:	Carbon Dioxide
DST	:	Department of Science and Technology
GP	:	Grama Panchayath
EO	:	Executive Officer
IDES	:	Integrated Demotic Energy System
LPG	:	Liquefied Petroleum Gas
PDO	:	Panchayath Development Officer
PDS	:	Public Distribution System
SC	:	Scheduled Caste
ST	:	Scheduled Tribe
TERI	:	The Energy and Resources Institute
TP	:	Taluk Panchayat
TPM	:	Total Particulate Matter
ZP	:	Zilla Panchayath

1. Title of the project

Improving Sustainable Energy Access among SC/ST households in Chamarajanagar District of Karnataka – A pilot study

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4. Date of Commencement

15th July 2016

5. Planned date of completion:

31st October 2018

6. Actual date of completion

31st October 2018

7. Objectives as stated in the project proposal

To improve the indoor air quality among SC&ST households in Chamarajangara District, Karnataka by providing clean energy solutions for cooking and lighting.

The sub objectives of the project are;

- Improve awareness among energy entrepreneurs and villagers about the know-how of these technologies.
- To train the local participants/entrepreneurs /masons in maintenance and operation of the improved cook stoves.
- To reduce the fuel consumption and indoor air emissions by implementing improved cook stoves for cooking at household level.
- To ensure clean lighting for households by using off-grid solutions.
- Establishment of Uttam Urja shops.
- Dissemination of information among concerned authority through workshops.
- To develop strategies for replication and up-scaling.

8. Deviation made from original objectives if any, while implementing the project and reasons thereof

No deviation has been made. The project has been implemented as per the objectives mentioned in the proposal.

9. Experimental work giving full details of experimental setup, method adopted, data collected supported by necessary tables, charts, diagram and photographs

9.1 Background of the project

Modern energy access for basic lighting and cooking needs is fundamental to human development. In India there is a large gap between demand and supply of appropriate energy services. More than 40% of India's rural households and more than 5% urban households do not have electricity and are primarily dependent on kerosene or wick lamps to meet basic lighting needs. A typical kerosene lamp provides between 1and 6 lumens per square meter (lux) of useful light, compared to the recommended lighting level of 50-300 lux for regular domestic use like reading, dining and cooking. This low lighting from kerosene lamps can adversely impact human health (especially eyes) and increase likelihood of fire accidents.

Four out of every five rural and one out of every five urban households primarily use solid biomass fuel like firewood, crop residues and cattle dung as fuel in traditional mud stove/ three stone fire for cooking. Such traditional cooking practice is characterized by low thermal efficiency (10 to 12%) and emits toxic smoke. Women (and accompanying children) cooking with a mud stove, particularly in poorly ventilated kitchens, are at increased risk

from pneumonia, respiratory diseases, etc. Smoke from incomplete combustion of biomass during cooking also emits climate change agents like black carbon.

These issues create a huge opportunity for dissemination of off-grid lighting technologies that can provide reliable lighting during evenings and clean cooking technologies that can save fuel, reduce smoke in the kitchen and decrease cooking time substantially and minimise drudgery of collecting firewood.

The main activities of this project included demonstration and dissemination of improved biomass cook stoves and off-grid solar home lighting solutions combined with mobile phone charging, improving indoor air quality, fuel saving, ease of cooking, enhancing communication and thus reducing the drudgery among SC/ST people. Since this is a one off effort by DST and TERI for intervention of pilot level on enhancing energy access, awareness and training programmes were organized and technical know-how provided on the new technologies to village level energy entrepreneurs and end users of cook stoves and offgrid solutions among the SC/ST community.

TERI selected Chamarajanagara district for the pilot level intervention as more than 77.10% of the population use biomass as fuel for cooking, and over 20% of households are yet to be electrified (census 2011). Often power cuts can go on for more than 8- 10 hours a day, and sometimes power supply is available only in single phase. The district also has a large SC/ST population.

9.1.1 Overview of Chamarajanagara district

The district is situated between North latitude 11° 40'58'' and 12° 06'32'' and East longitude 76° 24'14''and 77° 46'55''. The average rainfall recorded in the past five years is 624 mm per annum, which is less than the State average of 1248 mm. The land holding pattern in the district indicates that small and marginal farmers account for 79% of the total land holdings. The average size of land holdings is 1.46 hectares as against the State average of 2.13 hectares. (http://chamrajnagar.nic.in/zp/About%20District.html and http://chamrajnagar.nic.in/diststat/dist_stat1.html).

The population of the district is 1020962 (2011 census). About 86 % of the district's population live in rural areas as against the State average of 69 %. SC/ST population (379664) accounts for 37.19 % of the total population in the district, which is more than the State average of 24.1 % (http://des.kar.nic.in/sites/KAG201516). Nearly 65 % of the total working population is dependent on agriculture, either as cultivators or as agriculture labourers. The literacy level in the district is 61.43%, which is lower than the State average (75.36%). The per capita income in the district is Rs 85832 (as per 2016) against the state average which is Rs.116238. (http://des.kar.nic.in/sites/KAG201516). The main crops grown in the district are ragi, paddy, groundnut, cereals etc.

Picture 1: Karnataka map indicating the project site.

The district is one of the most industrially backward among the 31 districts in Karnataka. Chamarajanagar is a **reserved parliamentary constituency.** Chamarajanagar is lowest in terms of Human Development Index when compared to other districts in the state.

Fuel for cooking: There are 244198 families in Chamarajanagar district. Out of them 77.10 % (Census 2011) of the population use biomass as fuel for cooking and heating. About 16.80% of the population use LPG. The use of biomass as fuel in open fires and/or the use of traditional stoves results in higher levels of indoor air pollution, Women and girls are primarily responsible for collecting biomass and using these stoves. To address these problems, TERI proposed to implement the improved cook stove, which is suitable to their local conditions. TERI has developed the cook stove for domestic as well as tiny and agro-based industries, and is approved by the Ministry of New and Renewable Energy and certified by Indian Institute of Technology, Delhi. This stove was implemented in select Grama Panchayaths.

Lighting: In this district only about 80% (Census 2011) of the households are electrified and the rest are not electrified because many of the tribal hamlets are situated deep inside forest areas. Although some villages are electrified, many households are not connected to the grid due to various reasons. Even the households that are electrified regularly use kerosene lamps for lighting due to power fluctuations and erratic power supply. The use of kerosene lamps leads to several health problems such as eye irritation, headache, etc. This hardship directly affects productivity and education of students. In order to address this problem, TERI proposed to implement off-grid power such as solar home lights in SC&ST households.

9.1.2 Profile of Bhogapura Grama Panchayath:

Bhogapura Grama Panchayath (GP) was selected in Chamarajanagara district because it has the highest SC/ST population compared to other GPs. It is also economically backward and more number of people depend on labour work for their income as compared to other GPs.

The Bhogapura GP is situated 10 kms away from the district headquarters. There are 10 villages in this GP and out of them the SC and ST population dominantly reside in five villages namely, Bhogapura, Kallahalli, Kellamballi, K. Mookahalli and Sappainapura.

There are 1150 households in the GP, out of them 513 (44.60%) households are SC and ST. The total population of the GP is 5121, out of which 2486 (48.54%) belong to SC and ST community.

Table 1: Village names, population and number of households in Bhogapura GP

Name of the village	Number of households				Population			
	SC	ST	Others	Total	SC	ST	Others	Total
K Basavanapura	0	0	158	158	0	0	596	596
K Mookahalli	24	0	24	48	135	0	89	224
Kellamballi	125	21	33	179	678	87	138	903
Kallahalli	104	0	0	104	489	0	0	489
Kasturu	5	0	115	120	22	0	477	499
Puttegowdana Doddi	0	0	46	46	0	0	198	198
Bhogapura	119	60	158	337	511	274	724	1509
Sappainapura	50	0	34	84	265	0	136	401
Hanahalli	3	0	19	22	15	0	80	95
Honnegowadana hunddi	2	0	50	52	10	0	197	207
Total	**432**	**81**	**637**	**1150**	**2125**	**361**	**2635**	**5121**

Source: Grama Panchayath office, Bhogapura

The total area of Bhogapura GP is 2996 hectares, out of which only 2419.39 hectares is cultivable. Out of the 2419.39 hectares, only 42 (1.73%) hectares is irrigated and rest is rainfed.

9.2 Methodology

This project involves identifying beneficiaries, demonstration cum implementation of interventions, training of local people for promotion of cook stoves, off grid solution, testing of cook stoves, user training etc,. The following methods were adopted to assess the socio economic condition of the target community, determine energy usage pattern and testing of traditional cook stoves. Awareness programmes, capacity building and other activities have been conducted as per project plan to meet the objectives.

9.2.1 Assessing socio economic condition and energy usage of SC/ST households

9.2.1.1 Secondary data collection

Secondary data was collected from sources such as Grama Panchayath, Zilla Panchayath offices, Agriculture department and statistical department. The data collected included demography, crops grown, energy usage, availability of fuel , cost of fuel , type of devices used for cooking and lighting, sources of fuel, rainfall data, organizations who are working in the selected villages of GP, etc.

9.2.1.2 Preparation of questionnaires for survey

A questionnaire for the survey was prepared to elicit information and obtain data on socio - economic details such as, land holding, occupation, agriculture, type of energy devices used, power usage, electrical bill, availability etc.,. The questionnaire was pilot tested and based on feedback from the field it was revised.

9.2.1.3 Survey

A survey was carried out in 440 households out of the 513 SC/ST households from seven villages. The number of households covered in each village is given in Table 2.

Table 2: Number of households covered during the survey

Name of village	No. of Sample
Bhogapura	161
Kellamballi	103
Kallahalli	110
K. Mookahalli	23
Honnahalli	2
Kasturu	6
Sappaianapura	35
Total	***440***

9.2.1.4 Data compilation and analysis

Before entering the data, a master sheet was prepared using excel software and hands-on training was provided to data entry operators to enter the primary and secondary data as per the format. The data entered was checked for errors, cleaned and then converted into meaningful tables.

9.2.2. Study of cook stoves

Four parameters were tested on four traditional cook stoves and one portable clay cook stove which are commonly used in the project area as well as four improved low cost forced draft cook stove and one top load forced draft cook stoves. The parameters such as Kitchen Performance Test (KPT), Burning rate, thermal efficiency and emissions were monitored in four villages. The BIS procedures (Bureau of Indian Standards-IS 13152 part-1:2013) was adopted to study the cook stoves. The tests on the stoves were carried out in four villages namely Sappainapura, K Mookahalli, Bhogapura and Kellamballi. The same households were selected for testing following the installation of the improved ovens testing using the same setup.

9.2.2.1 Kitchen performance Tests

The objective of the KPT is to simulate usage by one person by measuring fuel wood consumption per day as used in a typical household environment.

Procedure: Typical households were selected to conduct experiments. Information on the number of members, sex and age of the people of the household was collected. Details on cooking style, type of meal cooked was recorded and the required quantity of wood was weighed and supplied in the evening. At the same time next day the remaining wood was weighed and the required quantity of fuel for next day was added. The same method was repeated for five days.

Instruments used for the study: Weighing balance and Wood moisture meter

9.2.2.2. Burning Tests

The burning rate was calculated to know how much each cook stove was burning biomass in one hour. This was conducted before starting the thermal efficacy testing of the cook stoves.

9.2.2.3. Thermal efficiency

The main objective was to understand the efficiency of the existing chulha as well as improved ovens at field conditions for cooking and water heating purposes. Three trial tests were carried out on each stove in five different households. Thermal efficiency was determined using the Water Boiling Test (WBT). The required instrument/measuring devices/ aluminium pots were used during testing

9.2.2.4. Emission Testing

The main objective of emission testing was to measure and compare the emissions and determine quantity of emissions emitted by traditional cook stoves as well as improved ovens. The tests were conducted by using appropriate instruments for measuring CO/CO_2 and Total Particulate Matter (TPM). The instruments were kept near the stove during cooking for measuring the emissions. Three trials were done and in each trial the data was collected for the complete cooking cycle.

Instruments: The Instruments used for monitoring were Personal Dust Sampler, PO monitor with impactor (2) CO/CO_2 Monitor (Combo IAQ meter, Combo CO_2, CO, Temperature and RH) and other instruments.

9.3 Progress of the project

The main activities of this project included demonstration and dissemination of improved biomass cook stoves and off-grid solar home lighting solutions. Energy access, awareness and training programmes were organized and technical know-how was provided about new technologies to village level energy entrepreneurs and end users of cook stoves and offgrid solutions among the SC/ST community.

9.3.1. To improve awareness among energy entrepreneurs and villagers about the know-how of these technologies

To improve the awareness, various activities were carried out including discussions during the survey of socio economic and energy usage by community, conducting awareness campaign, etc.,

9.3.1.1 Discussions with stakeholders for development of rapport with the community

The project team held several meetings with officials like the Chief Executive Officer (CEO), Project Director, project Engineers from Zilla Panchayath (ZP), Executive Officer (EO)and President of Taluk Panchayath (TP), PDO, Secretary, President, Vice President, members of Grama Panchayath (GP), officers from revenue, agriculture, statistical department and other concerned officers and the community to discuss the objectives of the project. Subsequently, the CEO issued a letter directing the EO, PDO and GP President to give necessary support for successful implementation of the project.

With the permission of the GP, TERI made a presentation on the project in the GP general body meeting. This helped in spreading information about the project among the GP officials and people. The GP members (24 members), PDO, Secretary of GP and other officers evinced a lot of interest and appreciated the project objectives. Subsequently, they assured full support for the successful implementation of the project in their GP.

Picture 2: Conducting awareness programme at the General Body meeting in GP, Bhogapura

9.3.1.2 Awareness programme

Six awareness programmes were conducted in five villages in the Grama Panchayath on the project purpose, objectives, and activities of the project. During the programme, information about the improved biomass cook stove, IDES and their advantages were explained. More than 500 people (women were more in number) participated in the awareness programme and pamphlets in local language were distributed to all of them.

Picture 3: TERI staff conducting awareness programme at Kallahalli and Bhogapura villages

9.3.1.3 Socio economic conditions

Caste breakup of the respondents:

Out of the 440 households surveyed, 13.41% were ST households and the remaining were SC households.

Education level:

About 55.91% of the respondents are illiterate, due to poverty and lack of awareness on importance of education. Of the educated group, only 2.95% of the respondents had higher education such as degree and other courses. About 14.55% of respondents had studied up to primary /middle school level. 12.05% of the respondents had studied up to 10th standard. The education levels of the respondents are given in Table 3.

Table 3: Education status of the respondents

Name of village	Illiterate	Signature only	Primary/ Middle	SSLC	PUC	Graduate and others	Grand Total
Bhogapura	95	6	16	25	9	10	161
Honnahalli	1			1			2
K. Mookahalli	15	3	2	3			23
Kallahalli	42	23	24	15	5	1	110
Kesturu	4		2				6
Kellamballi	62	12	19	5	3	2	103
Sappainapura	27	2	1	4	1		35
Grand Total	246	46	64	53	18	13	440
Percentage	**55.91**	**10.45**	**14.55**	**12.05**	**4.09**	**2.95**	**100**

Family Size:

About 67.05 % households have family size between 3 to 5 members which is a typical family size in India. About 14.32% households had less than two members and this was because most of them were old and separated from their children. About 18.64% of the households have family size of 6 to10 people and these were mostly joint families. The details of the family sizes in the surveyed villages are given in Table 4.

Table 4: Family size of respondents in surveyed villages

Name of village	<2	3-5	6-10	Grand Total
Bhogapura	27	97	37	161
Honnahalli		1	1	2
K. Mookahalli	3	17	3	23
Kallahalli	15	80	15	110
Kasturu		5	1	6
Kellamballi	13	69	21	103
Sappainapura	5	26	4	35
Grand Total	63	295	82	440
Percentage	**14.32**	**67.05**	**18.64**	**100**

Land holding pattern of respondents:

About 44.55 of respondents were landless, about 50% have less than two acres of land, and about 5.45 of respondents owned between two to five acres of land. The land holding details of the villagers are given in Table 5.

Table 5: Land holding pattern of the respondents

Name of village	Landless	Marginal (less than 2 acre)	Small (2.1-5 acre)	Grand Total
Bhogapura	76	76	9	161
Honnahalli	2			2
K. Mookahalli	9	14		23
Kallahalli	55	51	4	110
Kasturu	2	4		6
Kellamballi	41	51	11	103
Sappainapura	11	24		35
Grand Total	196	220	24	440
Percentage	**44.55**	**50.00**	**5.45**	**100**

Average annual income of respondents:

Average annual income details of the respondents were collected during the study to ascertain their financial status. About 11.82% of the respondents had an average annual income less than Rs. 10000, 36.36% of respondents earned from Rs. 10001 to Rs. 25000, whereas 38.86% of the respondents had an income of Rs. 25000 to Rs. 50000 and 12.96% of the respondents had an annual income of about Rs. 50000. The income details of the respondents is given in Table 6.

Table 6: Average income of respondents in selected villages

Name of village	<10000	10001-25000	25001-50000	50001-100000	100000-200000	Grand Total
Bhogapura	2	27	106	24	2	161
Honnahalli		2				2
K. Mookahalli	6	11	5	1		23
Kallahalli	34	48	23	4	1	110
Kasturu		4	2			6
Kellamballi	10	45	23	19	6	103
Sappainapura		23	12			35
Grand Total	52	160	171	48	9	440
Percentage	**11.82**	**36.36**	**38.86**	**10.91**	**2.05**	**100**

Sources of income:

The main source of income is labour work. About 74.09% of the people work as masons, construction workers, brick industries and general work since the district headquarters is close to the villages. Only 14.54% of the people generate their income through agriculture. About 6.81 % of the people work as drivers, security guards, employees in factories, etc. and the rest 3.61% earned through other work. The income details are given in Table 7.

Table 7: Sources of income

Name of village	Agriculture	Other	Business	Labour work	Services/ employment	Grand Total
Bhogapura	27		2	113	19	161
Honnahalli				2		2
K. Mookahalli	1	4		18		23
Kallahalli	13	5	1	86	5	110
Kasturu	3			3		6
Kellamballi	20	6	1	73	3	103
Sappainapura		1		31	3	35
Grand Total	64	16	4	326	30	440
Percentage	**14.54**	**3.64**	**0.90**	**74.09**	**6.81**	**100**

Women members in SHGs:

Women from 55.45% of the respondents' houses were members of Self Help Groups (SHG) set up by the Department of Women and Child Development and private organisations. Out of them 53.28% of the women are actively involved in micro finance activities, about 40.17% were involved in income generating activities and the rest involved in both activities. The details are given in Table 8.

Table 8: Women involvement in SHG activities

Name of village	Not involved in SHGs	Involved in SHGs	Grand Total
Bhogapura	70	91	161
Honnahalli	1	1	2
K. Mookahalli	8	15	23
Kallahalli	39	71	110
Kasturu	1	5	6
Kellamballi	67	36	103
Sappainapura	10	25	35
Grand Total	196	244	440
Percentage	**44.55**	**55.45**	**100**

Types of Dwellings:

About 85.23% of respondents had houses with tiled roofs, 7.95% of respondents had houses with asbestos sheets, 3.41 % had thatched roof and 4.41 % of the respondents had houses with RCC roof. Details regarding type of houses and ownership are given in Table 9.

Table 9: Type of house and ownership status

Name of village	Type of houses					Ownership of house		
	Asbestos sheet	RCC	Thatched roof	Tiled	Grand Total	Own	Rent	Total
Bhogapura	12	9	5	135	161	160	1	161
Honnahalli				2	2	2		2
K. Mookahalli	6	1	1	15	23	23		23
Kallahalli	12	2	5	91	110	103	7	110
Kasturu				6	6	6		6
Kellamballi	4	3	4	92	103	101	2	103
Sappainapura	1			34	35	35		35
Grand Total	35	15	15	375	440	430	10	440
Percentage	**7.95**	**3.41**	**3.41**	**85.23**	**100**	**97.73**	**2.27**	**100**

Toilet facilities:

As part of the study, TERI collected information about the availability of toilets in the respondent houses. 50.45% of the respondents had toilet facilities, which were constructed under the Swachh Bharath Mission and the rest (49.55%) did not have toilets in their houses. The percentage of respondents having toilet facilities is less in the GP when compared to the State average (65.65%). The toilet status is given in Table 10.

Table 10: Availability of toilets in houses

Row Labels	No	Yes	Grand Total
Bhogapura	81	80	161
Honnahalli		2	2
K. Mookahalli	17	6	23
Kallahalli	59	51	110
Kasturu	3	3	6
Kellamballi	45	58	103
Sappainapura	13	22	35
Grand Total	218	222	440
Percentage	**49.55**	**50.45**	**100**

9.3.1.4: Energy used for cooking

Out of the 440 houses, 95 households have two cooking devices. About 48.60% of respondents have conventional ovens, 11.78% of respondents have kerosene stoves, 32.34% of respondents have LPG connection and 7.29 % of respondents have portable mud cook stove. The cooking device used by respondents is given in Table 11.


Picture 4: Traditional cook stoves and portable clay cook stove used in Bhogapura GP

Table 11: Types of cooking devices used

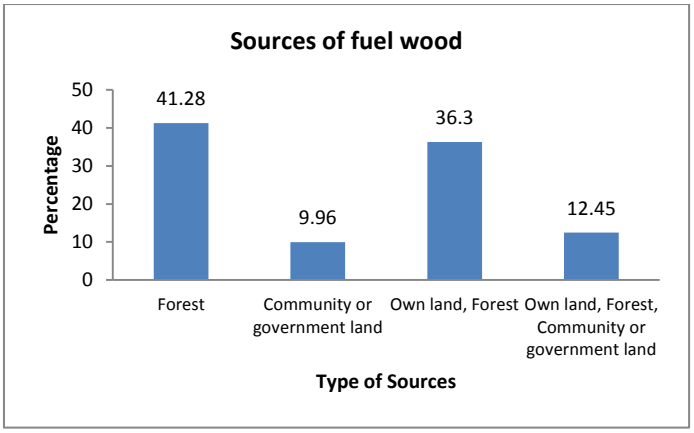
Type of cooking devices	Traditional oven	Kerosene stove	LPG	Portable mud cook stove	Total
Bhogapura	96	22	70	5	193
Honnahalli				2	2
K. Mookahalli	18		1	5	24
Kallahalli	76	21	37	7	141
Kasturu	5		1		6
Kellamballi	45	17	59	10	131
Sappainapura	20	3	5	10	38
Total	260	63	173	39	535
Percentage	**48.60**	**11.78**	**32.34**	**7.29**	**100**

Purchasing of fuel wood:

Out of the 282 respondents, only 18.43% of the respondents were buying firewood while the rest 81.56% were collecting it from farmland, common lands and forest. The wood was purchased from other villages at a cost of Rs. 3 to 5/ kg.

Sources of fuel wood:

Fuel wood is collected from various sources by family members as depicted in the graph below. About 41.28% respondents were collecting it from forests, 9.96% from community and government lands, 36.36% from their own farms and forest land and rest 12.45% of respondents were collecting from their land, forests, community and government lands. About 54.17% of the respondents mentioned that fuel wood was collected by men, 20.14 % of the respondents mentioned that women were involved in collecting fuel wood and the rest 25.69% of respondents mentioned that both sexes were involved in collecting fuel wood.



Problems of conventional oven:

Villagers using conventional ovens highlighted several problems caused by using fuel wood. Most respondents spoke about excess smoke, carbon deposition, eye irritation, non - availability of fuel wood and the requirement to travel long distances. The problems faced by the villagers are given in Table 12.

Table 12: Problems identified by respondents due to usage of fuel wood

SL.No	Parameters	No. of respondents
1	Difficulties in collecting fuel wood	199
2	Respiratory problems	68
3	Carbon deposition	323
4	Fuel wood non-availability	292
5	Travelling long distance for collection	189
6	Persistent cough	44
7	Smoke	347
8	Eye irritation	313

Use of Kerosene stoves:

Kerosene stoves have been using as subsidiary devices by villagers. About 14.31% of the respondents use kerosene stoves for cooking coffee/tea, snacks items, etc., Kerosene is purchased from the Public Distribution System (PDS). The average cost of kerosene is Rs. 18.5 per litre at the PDS and Rs. 31.6/ litre when bought from private sources. The PDS provides three litres per month for each BPL family and one litre to LPG holders. Kerosene is mainly used for lighting purpose. The usage details are shown in Table 13.

Table 13: Kerosene usage details

SL.No	Parameters	No. of respondents
1	Number of people who use kerosene	63
2	Kerosene purchased from PDS	63
3	Kerosene purchased from PDS and Private sources	5
4	Average cost of kerosene from PDS	18.5
5	Average cost of kerosene from private sources	31.6

According to the respondents, using kerosene stoves for cooking is leading to several problems which are listed in Table.14.

Table 14: **Problems associated with kerosene use**

SL. No	Parameters	No. of respondents
1	Bad smell	51
2	Travel long distance to purchase	3
3	Availability difficulties	16
4	More Sound	46
5	Eye irritation	45
6	High cost	12
7	Smoke	24
8	Respiratory problems	6

LPG connection and consumption:

39.31% of the respondents were using LPG for cooking. Out of them 4.54% had two cylinders and the rest had one. Most of them had availed the connection only in the last one year. A LPG cylinder lasts 72 days for two people, 54 days for 3 to 5 people in a household and 41 days for 6 to 10 people in a household. The cost of the cylinder depends upon the distance between the distributer and end users and government policy. During the survey, the cost of refilling gas cylinders at subsidized prices was between Rs. 560 to 570 per cylinder. The LPG use and cost details are given in Table 15.

Table 15: **LPG consumption usage and cost**

SL. No	Family size	Number of days	No. of respondents	Cost of refilling of gas per cylinder
1	Less than two	71	11	567.27
2	3 -5	54	121	566.6
3	6-10	41	41	570
Avg		55.33	57.66	567.5

Problems due to use of LPG:

173 people were using LPG for cooking and out of them 71.10% expressed that the food taste had changed when compared to cooking using biomass based cook stoves. About 16.18% of the respondents mentioned that the risk factors were more when LPG was used. About 8.09% of the respondents mentioned that LPG cylinders were not available on time and 6.36% of the respondents mentioned that it was costly. The problems associated with use of LPG is given in Table 16.

Table 16: **Problems associated with using LPG**

SL. No	Parameters	No. of respondents	Percentage
1	Changes in food taste	123	71.10
2	Not available on time	14	8.09
3	High risk	28	16.18
4	Need to procure from long distance	1	0.58
5	High cost	11	6.36

9.3.1.5: Types of devices used for heating water for bathing

In southern Karnataka hot water is used for bathing purpose. For heating water a conventional oven or three stone ovens or improved oven with chimney is constructed in the bathroom separately. Generally people take bath in a separate room or *thotti* inside the house and some people take bath in open places outside the houses. Usually agriculture residues and fuel wood are used as fuel for generating hot water. The survey indicated that most people were taking baths two to three times per week. TERI team found that there is scope to improve the conventional oven in terms of fuel efficiency.

Picture 5: Three stone oven used for heating water for bathing at Kellamballi village

Fuel consumption for heating water for bathing:

About 62.72% of the respondents were using fuel wood and rest of the 37.37% respondents were using agriculture residues. Out of the 37.37% respondents 11.13% and 11.81% of them were purchasing fuel wood and loose biomass such as coconut husk, coconut mid robin etc., The average fuel consumption was 4.55 kg and 4. 57 kg of fuel wood and biomass residues respectively.

9.3.1.5: Status of electrification in households

About 91.13 % of the households have been electrified. Out of the electrified households, 50.13% respondents had electricity connection under the Bhagya Jyothi programme and the rest were connected under general schemes.

About 32.17% of respondents had not paid electricity bill till date of their houses. The rest 67.83% were paying electricity bills. The village level details are given in Table 17.

Table 17: **Status of electrified households, type of scheme and status of electricity bill payment**

Name of village	Status of electrified			Name of scheme for electricity connection			Electricity bill paid status		
	No	Yes	Total	Bhagya Jyothi	General connection	Total	No	Yes	Total
Bhogapura	15	146	161	47	99	146	38	108	146
Honnahalli		2	2	2		2	2		2
K. Mookahalli	2	21	23	20	1	21	18	3	21
Kallahalli	14	96	110	47	49	96	22	74	96
Kasturu		6	6	4	2	6	1	5	6
Kellamballi	7	96	103	52	44	96	20	76	96

Name of village	Status of electrified			Name of scheme for electricity connection			Electricity bill paid status		
	No	Yes	Total	Bhagya Jyothi	General connection	Total	No	Yes	Total
Sappainapura	1	34	35	29	5	34	28	6	34
Grand Total	**39**	**401**	**440**	**201**	**200**	**401**	**129**	**272**	**401**
Percentage	8.86	91.1364	100	50.13	49.87	100	32.17	67.83	100

Electricity bill payment:

The electric bill amount varied from house to house based on power consumed. About 13.16% of the respondents were paying less than Rs.50 per month towards electrical bill, about 42.28% were paying in the range between Rs.51 to 100 per month, 23.53 respondents were paying in the range from Rs. 101 to 150 per month, 13.97 % of respondents were paying in the range of Rs. 151 to 200 per month and the rest 6.62% were paying Rs. 200 per month.

Alternative lighting devices:

Since the State Electricity Board does not supply continuous power and there are frequent power cuts in the evening the respondents use various devices for lighting purpose such as kerosene lamps, charging lamps, solar lanterns , candle etc., . About 87.50% of respondents were using kerosene lamps, 5.48% were using charging lamps, 4.09 % were using solar lamps and 2.95% of the respondents used candles.

9.3.1.6 Agriculture practices:

About 55.45% of the respondents owned land and the rest 44.54% were landless in the studied villages. Out of the landowners, 95.49% of the respondents practiced rainfed agriculture and the rest had irrigation facilities in their land. The major crops grown are Ragi, Jowar, Horsegram, redgram and coriander under rainfed conditions, and banana, vegetable and floriculture crops in irrigated land. The irrigation details are given in Table 18.

Table 18**: Irrigated lands in selected villages**

Village name	Rainfed	Irrigated	Total
Bhogapura	80	4	84
Honnahalli	0	0	0
K. Mookahalli	14	0	14
Kallahalli	53	2	55
Kasturu	4	0	4
Kellamballi	58	5	63
Sappainapura	24	0	24
Grand Total	233	11	244
Percentage	95.49	4..51	100

9.3.2. Training local participants/entrepreneurs /masons on maintenance and operation of improved cook stoves

9.3.2.1 Training for local masons / entrepreneurs

Two training programmes were carried out by TERI- one on construction and maintenance of cook stoves and other on repair and maintenance of solar lighting devices. The training programme was conducted at Bhogapura Grama Panchayath. 32 people participated in the construction and maintenance of cook stove training programme including entrepreneurs, who had background in ITI, Diploma, PUC and SSLC and 15 masons including five women, who have background in masonry work in their family. The training included theory and practicals. Cook stove construction manuals which are in local language were distributed to the participants. The participants prepared the combustion chamber and constructed three ovens, one at an Anganavadi and two in the beneficiaries' houses.

The second training programme was on lighting devices and conducted at the TERI field office in Bhoganapura. About 30 people participated in the training including entrepreneurs who have studied ITI, Diploma, PUC, 10th standard etc. The training programme included theory and practicals. A brief profile of the participants who attended the training programme was collected for future reference. Some of the selected participants were taken on a field visit.

Picture 6: Training programme on construction of cook stoves conducted by TERI staff

Picture 7: Training programme on solar lighting devices repair and maintenance

9.3.2.2: User Training programme

After commissioning the IDES low cost forced draft cook stoves and distribution of top loading forced draft cook stoves, TERI team along with EEs conducted 20 user training programmes. Three to four programmes were conducted in each village. During the user training, live demonstration of cook stoves and IDES were done so that the participants could understand how to feed the fuel, cleaning of ash, operational and maintenance problems, etc. In case of IDES the participants were trained in replacing fuse, wire connection, switching on and off of lights in the charges controller, etc. In addition, during the commission of IDES and Stoves, individual households were briefed on how to operate, repair and maintain the devices.

Picture 8: User training programme on top loading cook stoves at Kallahalli & solar lighting devices at Sappaianapura

9.3.3 Reducing fuel consumption and indoor air emissions by implementing improved cook stoves for cooking at household level.

This section explained testing of conventional oven and improved oven, construction of improved ovens, distribution of top loading cook stoves, monitoring, impact study etc.,

9.3.3.1 Testing of cook stoves

This section presents results from the Kitchen Performance Tests (KPT), burning rate, thermal efficiency and emission tests conducted on four traditional biomass cook stoves and one portable clay cook stove, in four villages namely Sappainapura, K Mookahalli, Bhogapura and Kellamballi.

Results of Kitchen performance study:

The KPT of the stoves showed that the average fuel consumption from five households was 5.39 kg per day in conventional oven, the average family size from five houses was 4.74 members and average fuel consumption per person per day was 1.28 kg in the conventional oven. In case of improved oven the average family size was 4.8, average fuel consumption was 3.112 kg per day per family and average fuel consumption was 0.77 kg per day per person, which is less than 39.84%. The results are in Table 19.

Table 19: **Results of KPT cook stoves**

Village	K Mookhalli		Sappainapura		Bhogapura		Bhogapura		Kellamballi		Average	
house owner	Prakesh		Gowramma		Sakamma		Chandramma		Mahadevamma			
Type of stove	Conventional oven	Improved oven	Conventional oven	Improved oven	Conventional oven	Improved oven	Portable clay stove	Top loading improved oven	Conventional oven	Improved oven	Conventional oven	Improved ovens
Fuel Consumption (kg)	6.1	3.8	6.56	3.05	5	3.4	4.3	2.67	3.1	2.64	5.39	3.112
Family size	3	3	7.6	7	5.9	6	4.1	4	5	4	4.74	4.8
Fuel consumption per person/day (kg)	2.03	1.26	0.86	0.43	0.85	0.56	1.05	0.66	1.61	0.66	1.28	0.77

Burning rate:

The average fuel burning rate of the traditional cook stove was 2.17 kg/hour. In case of improved oven the average fuel consumption was 1.3 kgs per hour. This was conducted before starting the thermal efficacy testing of the cook stoves.

Thermal efficiency:

The overall performance of traditional cook stove was 15.16% which is lower than the recommended BIS standards for natural draft cook stoves. In case of improved ovens the efficiency was 28.06 % under field conditions. The results of the performance evaluation (efficiency testing) of five cook stoves are given Table 20.

Table 20: **Performance evaluation results of biomass stoves in the field**

S. No	Name of the village	Name of the owner	Thermal efficiency of Conventional oven (%)	Thermal efficiency of improved oven (%)
1	Sappainapura	Gowramma	15.3	25.3
2	K Mookhalli	Prakash	14.4	26.0
3	Bhoagapura	Sakamma	15.7	31.9
4	Bhogapura	Chandramma	16.1	28.4
5	Kellamballi	Mahadevamma	14.3	28.4
Average			15.16	28.06

Picture 9: Thermal efficiency test conducted by TERI staff

Emission Testing:

The average CO_2 emission of the five traditional stoves was 461.62 ppm, which when compared to the improved oven (397.8 ppm) is more. The average CO emitting from traditional cook stove was 5.43 ppm, which is more compared to the improved oven which was 1.15 PPM. The particulate matter emitting from conventional ovens was 2737.8 µg/m3 which is high when compared to the improved oven, which was 1836 µg/m3. The particulate matter emissions from one respondent Gowramma 's house was higher as the fuel wood usage was slightly on higher side and there was no adequate ventilation for air circulation in the conventional oven. Similarly, there was higher PM emission at Mahadevamma's house due to lack of ventilation in the conventional oven. The emission test results are given in Table 21.

Table 21: Results of emission testing

SN	Name of the owner	Village	Conventional ovens			Improved ovens		
			CO (PPM)	CO_2 (PPM)	PM (µg/m3)	CO (PPM)	CO_2 (PPM)	PM (µg/m3)
1	Gowramma	Sappainapura	10.32	501.08	2142	1.20	401	2326
2	Prakash	K Mokhalli	1.14	418.00	2170	0.75	400	1665
3	Sakamma	Bhogapura	2.27	424.95	2091	1.47	387	1664
4	Chandramma	Bhogapura	3.61	448.93	2525	1.03	388	1745
5	Mahadevamma	Kellamballi	9.82	515.16	4761	1.3	398	1680
	Average		**5.432**	**461.62**	**2737.8**	**1.15**	**394.8**	**1816**

Picture 10: Mounted instruments of Dust Sampler, PO monitor with impactor

Picture 11: Monitoring of emissions by TERI staff

9.3.3.2 Cook stove demonstration and installation

Manufacturers supply cook stoves

TERI had developed a manufacturer and supply network of cook stoves in an earlier project. Under the DST project, TERI utilized the same energy entrepreneurs for supplying cook stove spare parts for low cost forced draft cook stoves (STPL 0143) from M/s Chaithanya Enterprises, combustion chamber from M/s Lakshmi Ceramic and top load forced draft cook stoves (STPL 0610) from M/s ODP, Mysore. The low cost forced draft cook stoves were constructed by local masons, who had been trained during the training programme.

TERI procured in two batches spare parts of the low cost forced draft cook stoves (310 nos) and 115 top loading forced draft cook stoves from energy entrepreneurs and manufacturers to be kept as stock at TERI field units in Bhogapura.

Demonstration: The main objectives for demonstration of the cook stoves were to make the people aware of the technology and create demand from people in the villages so that they can adopt them in their houses. Five households were identified from five villages for demonstration of cook stoves (out of five four are low cost forced draft cook stoves and one was top loading cook stove). These households were willing to cooperate in installation and monitoring of cook stoves. TERI constructed cook stoves by using local masons, in association with energy entrepreneurs in selected households and also trained the people in cook stoves use. The same device was also shown to other people in the villages.

Dissemination of cook stoves: TERI checked (Pre Dispatching Inspection) 5% of the low cost forced draft cook stoves spare parts and top loading cook stoves randomly before dispatching to the field by the manufacturers. TERI has opened a small office cum storeroom at Bhogapura to help the beneficiaries as and when they need services and also to build confidence among the community.

TERI procured parts of the low cost forced draft cook stoves (315 nos) such as combustion chambers, air jacket, fan, stand etc., and 110 top loading cook stoves from energy entrepreneurs and manufacturers and stored them at the Bhogapura TERI field office.

After the demonstration, 200 low cost forced draft cook stoves were installed in six villages. 100 top loading forced draft cook stoves were distributed in five villages. All the low cost forced draft cook stoves were commissioned by TERI technical team and the beneficiaries were briefed about the procedure of using cook stoves.

200 low cost forced draft cook stoves were installed and 100 forced draft top loading cook stoves were distributed alone and in addition 125 cook stoves were installed along with solar home lights as part of IDES. The details of installation of cook stoves alone and with solar home lights as IDES are given in Table 22.

Table 22: **Number of IDES and improved cook stove installed in villages**

SL No	Name of Village	Number of IDES (cook stoves and solar home lights)	Number of low cost forced draft cook stoves	Number of top loading forced draft cook stove	Total families benefited
1	Bhogapura	28	70	37	135
2	K Mukhalli	21	0	1	22
3	Sappainapura	23	30	0	53
4	Kallahalli	25	7	41	73
5	Kellmaballi	25	58	20	103
6	Kasturu	3	20	1	24
7	Kirgasur		15		15
Total		***125***	***200***	***100***	***425***

Picture 12:Construction of low cost forced draft cook stove by local masons

Picture 13: Low cost forced draft cook stove used by a beneficiary at K Mukhalli

After installation and commissioning of cook stoves, TERI continuously monitored the cook stoves usage by beneficiaries. TERI gave the contact numbers of EEs and technicians to all the beneficiaries and GP members so that they can be contacted easily in case of any problems. The technicians address any problems received from beneficiaries.

Impact Study:

TERI conducted an impact study of 106 households through a questionnaire which included 55 IDES and 51 only cook stoves users. Out of 106 households, 93.40% of the respondents were still using the improved cook stove and the rest had dismantled the cook stove due to various reasons such as renovation of their homes (laying granite and floor tiles, re-design of the kitchen).

Out of the ICs holders19.81% of respondents were using it as and when required, 14.15% of respondents used it partially, 35.65%were using it regularly and 23.80% of respondents used it as a backup support during non-availability of LPG..

9.3.4 Clean light for households by using off-grid solutions.

TERI installed an integrated system of solar home light along with cook stove as IDES. This section deals with the procurement of solar home lights, installation, monitoring, and impact.

Manufacture and supply of solar home lights: TERI had developed a network of manufacturers and suppliers of solar home lights in an earlier project. The solar home lights were supplied by M/s Digiflick, which are certified and approved by MNRE with two years warranty**.**

Demonstration: Five households were identified for demonstration of IDES, (forced draft cook stove, 4.8 W/12V -2 solar lights, 20W/12v solar panel, 20 Ah battery, 5A solar charge controller, mobile charging port and one extra port for power supply for stove) TERI installed the devices in selected households through the manufacturer and energy entrepreneurs and also trained the households in usage of IDES. The same device was also demonstrated to other villagers.

Picture 14: Installation of solar panel by beneficiary at Kellamballi

Large scale dissemination:

TERI checked (Pre Dispatching Inspection) 5% of the products (IDES) which were selected randomly before dispatching to the field by the manufacturers. During dispatching TERI noted the specification of the products, testing certificates, warranty certificates, make, and efficiency of solar PV etc., in a form which has been developed by TERI for testing purpose. TERI in association with energy entrepreneurs procured solar home lights (125 nos) from manufacturers in two batches and stored them at the Bhogapura TERI field office.

After demonstration of the IDES, TERI identified 125 beneficiaries for installation of (solar home lights with cook stoves) IDES based on the socio economic survey and preference was given to un-electrified households. The beneficiaries list was shared with representatives of the SC/ST community (Grama Panchayath members and president) and their concurrence was taken. The solar home lights were installed by suppliers under supervision of TERI staff and the low cost cook stoves were constructed by local masons. Out of the 125 IDES, 15 are top load forced draft cook stoves with solar home lights (STPL 0610) and the rest 110 are low cost forced draft cook stove with solar home lights. Maximum beneficiaries showed interest in the low cost forced draft cook stove due to front loading of fuel and easy operation as it is similar to conventional ovens when compared to top load cook stoves.

Picture 15: Beneficiaries with IDES

Totally 125 IDES were installed in six villages and the details of installation of IDES are given in Table 22.

Monitoring and services:

After installation TERI has monitored continuously and collected feedback from beneficiaries on IDES and cook stoves usage. TERI also has attended to problems that appeared in the devices.

Picture 16: Servicing by technicians at a beneficiary's house

Impact study: TERI conducted an impact study of 106 households through a questionnaire. Out of them 55 are IDES. The information was collected on number of hours light usage, electricity bill saving, problems, benefits etc., Out of the households that are electrified, 25 respondents are connected under general scheme and rest under Bhagya Jyothi.

9.3.5. Establishment of Uttam Urja Shop

TERI had discussions with various energy entrepreneurs who participated in the training programme from six villages in Bhogapura Grama Panchayath to explore the possibility of establishing shops in Bhogapura GP and surrounding villages. One entrepreneur agreed to establish a shop in Bhogapura village. TERI took him to Bangalore and introduced suppliers and manufacturer of solar devices for procurement and built a rapport. TERI provided him with initial stock which included sets of cook stoves and spare parts and solar home lights, solar lanterns, and its spare parts such as battery, fuse, mother board, cook stove spare parts, fans, adopter etc., and also tool boxes for repair and services. Now the spare parts are available with energy entrepreneurs for repair and maintenance purpose at Urja shop.

Picture 17: EE shop at Bhogapura

9.3.6 Dissemination of information among authorities through workshops.

TERI organized a stakeholders workshop on 13th August 2018 at hotel Nijaguna residency in Chamarajanagar under DST project for sharing the project experiences. The main objective of the workshop was to share and disseminate information to stakeholders. In the

workshop, more than 65 people participated including officers from DST, Zilla Panchayath, Karnataka State Council for Science and Technology (KSCST), Forest Department, Karnataka Renewable Energy Development Ltd., (KREDL) , Department of Backward community, department of Agriculture, Department of Tribal Development, Department of Social Welfare, NGO's/Organization, Taluk Panchayath officers, Grama Panchayath President, Vice president and their members, Panchayath Development Officers (PDO), GP secretary, Beneficiaries, masons, solar devices manufacturers etc.

The workshop was inaugurated by Dr. Ravinder Gaur, Scientist and Member Secretary from DST, Mr. Sridhar, Project Director, ZP, Mr. P Ruthren, IFS, ACF Chamrajanagara and other Dignitaries. Presentations were made by the PI on overall progress and achievement of the project. Interaction was held with beneficiaries to understand the utility of the project activities. In addition, representatives of various departments shared information on schemes /benefits available to people from their department.

Picture 18: Stakeholders' workshop in Chamarajanagara

9.3.7: Strategies for replication and up-scaling

TERI has made several efforts for replication and up-scaling of the technologies such as IDES, cook stove and solar lights, including solar streetlights.

TERI has developed brochure and documents which consists of specification of devices, make, details of spare parts availability, cost of devices, method of implementation of project by TERI at Bhogapura Grama Panchayath, advantages, impact etc., This was shared with various state government departments and NGOs.

Further, TERI has developed entrepreneurs, promoted the products and created market linkages. The entrepreneurs can approach different departments to promote these technologies.

The Karnataka forest department has implemented energy devices such as LPG, solar home lights, solar lanterns, solar water heater etc., under their programme in the forest fringes, especially in backward and tribal community areas. As per the forest department, they can also implement IDES in their future programmes. LPG is being distributed to the SC and ST community free of cost, however this cannot be sustained because the community has not been able to purchase the refill gas cylinders due affordability issues. Since fuel wood is easily available and at free of cost especially the tribal people can opt for biomass based oven. Therefore the forest department has preference to distribute IDES among the community and promote solar lighting devices. TERI has provided the required information to the forest department for further promotional activities.

The tribal development officer has recommended that that the department implement IDES in tribal communities in Chamarajanagara district, by replicating the procedure adopted by TERI in Bhogapura Grama Panchayath.

The Zilla Panchayath is responsible for implementing Integrated Rural Energy programme, such as improved cook stoves, biogas, solar lighting devices, solar street lights etc., The ZP has provided support during implementation of the project in all the stages. Based on the impact and user feedback from Bhogapura GP, they are also planning to implement IDES in interior places of the GP, where power supply is erratic and there is poor transportation facilities for LPG supply. In this regards, ZP have been in touch with TERI.

KREDL is the nodal agency for implementing renewable energy in Karnataka like solar, biomass, wind etc., After participation in the workshop, they have plans to implement IDES in interior regions in Karnataka. They have collected the required information from TERI.

10. Detailed Analysis of results indicating contributions made towards increasing the state knowledge in the subject

The main activities of this project included demonstration and dissemination of improved biomass cook stoves and off-grid solar home lighting solutions. Energy access, awareness and training programmes were organized and technical know-how provided about new technologies to village level energy entrepreneurs and end users of cook stoves and offgrid solution among the SC/ST community. Chamarajanagara district in Karnataka was selected for intervention as it is one of the backward districts in the State and more SC/ST population.

The project resulted in a collection of detailed information about Chamarajanagara District and the project provided several learnings on how to roll-out an intervention programme in backward districts in other parts of the country. Despite government intervention programmes, communities were still using kerosene lamps and low energy efficient cookstoves for reasons such as lack of affordability, erratic power supply, etc. This is leading to huge health and economic costs.

Among the learnings included the types of energy used for cooking, how access to clean energy and lighting interventions for rural communities (including landed and landless) can supplement free LPG and electricity programmes. The project also provided insights into why free LPG programmes can be less successful as it does not consider the paying capacity of the beneficiaries for replacing their cylinders. Use of biomass based energy devices can help supplement energy for cooking and prolong cylinder usage.

10.1 Improve awareness among energy entrepreneurs and villagers about the know-how of these technologies

A letter containing the objectives of the project was sent from TERI to various organizations like, ZP, RDPR, TP, GP, KREDL, etc. The intention of the letter was to build a rapport. The TERI project team also had detailed discussions with various officers and CEO of ZP, EO of TP, project Development officer of ZP, Project engineers, etc., TERI also made a presentation of the project in the GP general body meeting which helped spread information in the villages taken up for implementation. All these interactions helped in improving awareness and also led to the successful implementation of the project.

Six awareness programmes were conducted one each in five villages and one in Grama Panchayath and more than 200 people participated directly and indirectly.

During the socio economic and energy usage survey conducted by TERI team explanation about the project and type of devices installation etc., were made to the villagers

TERI team along with EEs also conducted about 20 user training programmes. Three to four programmes were conducted in each village. During the user training, live demonstration of cook stoves and IDES were conducted so that the participants could understand how to feed the fuel, cleaning of ash, operational and maintenance problems of cook stove as well as solar home lights. This awareness has spread across the beneficiaries and members of their households. .

10.2 To train local participants/entrepreneurs /masons in maintenance and operation of improved cook stoves.

Two training programmes were carried out by TERI, one for construction and maintenance of cook stoves and other one for repair and maintenance of solar lighting devices. After training, the trained local masons constructed 310 cook stoves under the project; in addition, they constructed some cook stoves in other communities as well. Some of the trained people are repairing cook stove fans, electrical repair and soldering work etc.,

After the second training, many participants have carried out minor repairs on the devices such as fuse replacing , observing charging indicator and wire disconnected etc., Out of them, some were regularly servicing and repairing lights based on demand.

10.3 To reduce fuel consumption and indoor air emissions by implementing improved cook stoves for cooking at household level

Testing of cook stoves: TERI has carried out testing of conventional ovens as well as improved oven likes kitchen performances test (KPT) , burning rate, efficiency of cook stoves and emission monitoring.

The result of KPT showed that the average fuel consumption per person per day was 1.28 kg in the conventional oven which is slightly higher compared to the standard fuel consumption in India which is 0.98 kg per person per day (sources: NSSO 2010). In case of improved oven the, average fuel consumption was 0.77 kg per day per person, (less 39.84%). of fuel consumption by per person, per day.

The result of average fuel burning rate of the traditional cook stove was 2.17 kg/hour which is higher compared to the improved oven which was 1.3 kgs per hour and overall reduced 40.1% of fuel burning.

The result of thermal efficiency of traditional cook stoves was 15.16% which is lower when compared to improved oven efficiency of 28.06.

The results of the average CO_2 emitting from five traditional stoves was 461.62 ppm, which compared to the improved oven was 397.8 ppm, average CO emitting from traditional cook stove was 5.43 ppm, which is more compared to improved oven at 1.15 PPM and particulate matter emitting from conventional ovens was 2737.8 µg/m3 which is high compared to improved oven at 1836 µg/m3.

The improved ovens fared better in fuel efficiency, had low emissions, increased comfort level of the women in the kitchen and reduced indoor air pollution. This was also backed by a survey to understand the impact.

Dissemination of cook stoves: Two types of cook stoves were disseminated, namely low cost forced draft cook stoves, which were constructed by local masons by using local resources materials and other one, top load forced draft cook stoves, which are ready made and fabricated by using stainless steel.

After training the local masons and others, the same people were used for construction of cook stoves in project areas. Initially four cook stoves were installed in four villages for demonstration purpose. These demonstrations helped create awareness among the community, especially women like usage pattern, type of fuel feeding, benefits of cook stoves etc.,

After demonstration, 310 low cost forced draft cook stoves were installed in six villages and 115 top load forced draft cook stoves were distributed in five villages. Totally 425 cook stoves were disseminated in six villages, out of 425, 300 cook stoves are alone and rest of 125 were disseminated with solar home light as IDES.

Initially there was more demand for cook stoves, after some time, the demand reduced, because the government of Karnataka and Government India has distributed LPG sets at free cost, and special preference has been given to SC /ST community under Anila Bhagiya and Ujjwala Yojana programme respectively.

TERI conducted an impact study of 106 households through desired questionnaire; out of them 55 are IDES users and 51 cook stoves users. Out of the 106 people 93.40% of respondents were still using and maintaining the improved cook stove and rest 6.60% had dismantled the cook stove due to various reasons such as modifications of houses, laying granite and tiles in the floor etc.

Out of ICs holders, 19.81% of respondents used as and when required, 14.15% of respondents used partially, 35.65% of respondents used regularly and 23.80% of respondents used it as back up support during non-availability of LPG.

After implementation of the Anila Bhagiya and Ujjwala Yojana, the usage of improved cook stove has drastically reduced because they got LPG free of cost and it is easy to use and there is no deposition of soot on the walls and cooking pots compared to biomass based cook stoves.

The opinion of respondents showed that 43.90% (2.36 kgs) of fuel wood was saved as compared to conventional oven. Totally 366.01 tonnes of fuel wood were saved per annum and 669.1 tonnes of CO_2 reduction. Out of them about 75.47% of respondents have mentioned less smoke, 94.34% of respondents mentioned suitability for cooking, 96.23% of respondents found it comfortable for fuel processing, 95.28% of respondents mentioned comfortable for fuel feeding and 78.30% of respondents mentioned less cooking time compared to conventional oven. About 4.04% of respondents have mentioned no changes in cooking time, 75.76% of respondents have mentioned that, it saves time by less than 30 minutes per house and 20.20% of respondents have mentioned time saving between 30 minutes to 60 minutes per day.

10.4 Clean light for households by using off-grid solutions.

Demonstration of Integrated Domestic Energy System (IDES):

Solar home light (Off grid solution) is part of IDES. The demonstration of five IDES was carried out in five villages, out of four low cost forced daft cook stove and one top loading cook stove. After demonstration of devices, TERI monitored continuously and collected feedback from beneficiaries on IDES.

Large scale dissemination: After demonstration of the IDES, TERI identified 125 beneficiaries and installed IDES. Preference was given to economically weaker sections, and out of them homes which were not-electrified. Out of the 125 IDES, 15 are top load forced draft cook stoves with solar home lights (STPL 0610) and the rest 110 were low cost forced draft cook stove with solar home lights. There is more demand for IDES, especially solar home lights in other communities and other GPs in the same taluk and same district, because there is erratic power supply from the state grid and increase in power tariff. Households in the forest fringe areas are not getting four to six hours of regular power supply leading to increased demand for IDES.

The study was carried out in 55 IDES households in the project villages. The average electrical bill paid under general connection was Rs. 148 per month before installation of IDES and post installation it reduced to Rs 88 per month, which is about Rs. 60 (40%) savings in the electrical bill per month. Before installation of IDES, all the respondents were using three litres of kerosene as fuel for lighting because of irregular power supply and the cost of kerosene spending was Rs.81 per month. Out of them 375 litres kerosene was saved per month and annually 4500 litres was saved and 13.5 tonnes of CO_2 reduced by the use of solar home lights. In addition to the cost, usage of kerosene was causing eye irritation, headache and less light than desired. The entire amount, which was spent for kerosene is now saved.

81.81% respondents used the IDES regularly and 18.18% of respondents were using it partially. About 96.33% of respondents were using more than three hours and the rest 3.66 respondents were using less than three hours. Most of the respondents expressed that they had longer duration of light, saved kerosene cost, there was no smoke and eye irritation, and children got more time to study, and more time for work. The unelectrified household respondents expressed that they were able to charge their cell phones in their houses unlike before when they had to charge it in their neighbours' homes and their children had more time to study.

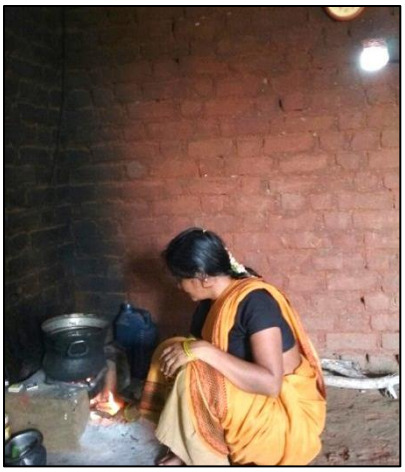
After installation, TERI monitored continuously and collected feedback from beneficiaries on IDES and cook stoves usage. TERI has attended to problems that appeared in the devices. This is very important after dissemination of technologies

1. ***Case study of Ms. Beby at Kallahalli Village***

Ms. Beby, is a 33 years old widow of late Paramesh and stays in a house which not electrified as it is away from any power infrastructure. She has her three children and lives in Kallahalli village, Bhogapura Grama Panchayath, Chamarajanagara district. Out of the three children, two are girls of 17 years and 16 years age respectively and one boy who is 14 years. Ms. Beby works in a garment factory in Chamarajanagara from last four months. Before joining this factory, she was working as a farm labourer in the same village and surrounding areas. She has less than 20 gunta of farm land under rainfed conditions, but due to the drought she has not been able to cultivate anything since last three years. She gets a salary of Rs 4000 per months and this is the only income used to maintain her family. The salary is used for running her family including her children education expenditure and she is the sole breadwinner for her family because her husband expired last five years back.

Her family uses kerosene lamps for lighting and conventional oven for cooking. An average of five liters of kerosene is used for lighting. Out of five liters, three liters is procured from PDS at cost of Rs 28.50 per liter and the rest from the open market at cost Rs 50 per liter. An average of Rs. 185 is spent on kerosene for lighting per month. The kids study under kerosene lamps. Several problems such as eye irritation, headache, low lighting conditions have been experienced by the family due to the use of kerosene lamps. Since the house is situated on a farm land, infestation by snakes and other creatures such as scorpions around their house is high.

The conventional oven was used for cooking and average fuel consumption by the oven was 5 kgs per day. Firewood was collected from farms and community lands by the family members. According to them usage of conventional ovens has several problems such as smoke emissions, excessive fuel consumption, and slow cooking.



TERI has given preference to providing IDES for un-electrified households and therefore Ms. Beby was selected as beneficiary. TERI has installed the IDES, which consists of solar home lights and improved cook stove. After installation, the family is continuously using the improved cook stove two times a day. As per them using improved cook stove had reduced the firewood consumption from 5 kgs to 3 kgs (40% saving), led to faster cooking and less smoke emissions compared to conventional oven. Totally 60 kgs of fuel wood save per month.

Picture 19: Ms. Beby cooking using improved cook stove at Kallahalli village

The solar home light module consists of two lights, mobile charging port and one port for power supply to the cook stove. Both the lights are being used from 6.00 pm to 11 pm. One of the lights is used up to 12.00 midnight for studying purpose by the children. The mobile phone is being charged using the solar module. Prior to the supply of the IDES they were charging their mobile in relatives' houses or work place during day time. Following the intervention, the children are able to study for long duration with much brighter and clean lights compared to kerosene lamps. There is no smoke and eye irritation when they are studying. They have been saving kerosene cost of Rs 185/ months and selling their quota of kerosene to others at higher prices. In 2017-18, the children scored more marks compared to previous years as they were able to study better and longer duration due to the solar lights. Due to the lights they have been able to avoid the snakes and worms entering their houses because of better visibility. The family are a happy lot after adopting IDES in their house.

2. Case study of Mr. Kumar's family at Bhogapura Village

Mr. Kumar. S has a family of four including two kids staying in an unelectrified house in Bhogapura village at Chamarajanagara Districts. This village is 8 km away from Chamarajanagara City. Kumar works as a labour in the village and surrounding areas and has less than 20 gunta of rainfed land. Due to drought in the last three years cultivation has not be done and is dependent on labour work. His daily earnings is about Rs 200 to 300 and he gets only about 15 to 20 days per month and his total monthly earning is in the range of Rs 3000 to 4000.

Prior to intervention by TERI, Kerosene lamps were used in the house for lighting and conventional oven for cooking. An average three liters of kerosene was used for lighting which is procured from PDS at cost of Rs 28.50 per liter. Totally Rs. 85 is spent for kerosene for lighting per month. Kids were studying using the light from kerosene lamps which caused several problems such as eye irritation, headache, less light, etc.

Picture 20: Mr. Kumar's wife cooking using an improved cook stove at Bhogapura village

The average fuel wood consumption for cooking using the conventional oven was six kgs per day, which was collected from farm and community lands by Kumar or his wife Kusma. They would spend about one to one half hour collecting fuelwood every day. As per them using conventional ovens was leading to several problems such as more smoke, more fuel consumption, taking more time for cooking etc.,

Mr. Kumar was selected as beneficiary for Integrated Domestic Energy System (IDES) among others beneficiaries, because un electrified households. TERI installed the IDES, which consisted of solar home lights and improved cook stove. After installation they used the cook stove for cooking for three times a day. As per Kumar and his wife using the improved cook stove led to drastic decrease in firewood consumption from six kgs to 3.2 kgs (46.66% saving), faster cooking and less smoke compared to conventional oven.

Picture 21: Mr. Kumar's children studying using solar home lights at Bhogapura village

The solar home light module consisted of two lights, mobile charging and one port for power supply to the cook stove. The two lights were used from 6.00 to 9.30 pm, and one light was extended up to 11.00 PM and also as and when required during the night. The mobile was charged using the solar power. Before the intervention, the family would charge their mobiles in neighbouring houses. The kids are now studying for longer hours with bright and clean lights compared to kerosene lamps. There is no smoke and no eye irritation during the study. The family is also saving cost of kerosene of about Rs 85/ month. The family is pleased with the advantages due to the intervention. The secondary benefits include better relationships with neighbours and friends as they tend to visit the family more often in the night because of better lighting conditions in the house. Even the kids are playing and studying for long hours in the evenings. They are very happy after adopting the IDES.

3. Case study of Shivamallaiah, K Mukahalli Village

Mr. Shivamallaiah s/o Late Doddaiah is 46 years old and lives with his wife. He has three children who reside at K Mukahalli, Bhogapura Grama Panchayath, which is nine km away from Chamarajanagara City. Out of the three children one is studying in higher school and the rest work as labourers. He works as a labourer in the village and surrounding areas. He has less than 20 gunta land under rainfed conditions and cultivates Ragi, Jowar, and Black gram in their land. His main source of income is labour work and he gets work for about 15 to 20 days per month earning wages of Rs. 300 per day. He earns about Rs 4000 to 5000 per month from labour work and this is supplemented by earnings from agriculture which is a subsidiary occupation. His house is newly constructed and has electricity connection under the Bhagiya Jyothi scheme. However, there is erratic power supply from the state electricity grid sometimes power cuts extending to more than 20 hours. In this village there are 25 SC families and all the households are benefitting from IDES.

Previously the family used kerosene lamps for lighting during power cuts and conventional oven for cooking. An average of three liters of kerosene was used for lighting and was procured from the public distribution system at a cost of Rs 28.50 per liter. Monthly about Rs. 85 was spent for kerosene for lighting. The kid is forced to study under kerosene lamps during power cuts and their regular day to day activities are carried out under kerosene lamps. This caused several problems such as eye irritation, headache, less light etc., to the family.

Picture 22: Mr. Shivamalaiah's wife cooking by using improved oven under solar home lights

Conventional oven was used for cooking and the average fuel consumption of the oven was 6.5 kgs per day. The firewood was collected in farm and community lands by the family. They would spend around one to one half hours every day for collecting fuel wood. According to them the conventional ovens were causing several problems such as excess smoke, increased fuel consumption, longer time for cooking etc., In December 2017 they received LPG under the Anila Bhagiya Yojane which is a state government scheme. The LPG

was used very occasionally and for emergency purposes during shortage of fuelwood or when cooking had to be done quickly.

Mr. Shivamallaiah was selected as a beneficiary for Integrated Domestic Energy System (IDES) among others. TERI installed the IDES, which consisted of solar home lights and improved cook stove. The family is using the cook stove for cooking all the three times of the day and as per them using the improved cook stove has drastically reduced the fuel consumption from six kgs to 3.5 kgs (46.15% saving), led to faster cooking and reduced smoke emissions compared to conventional oven.

The solar home light module consisted of two lights, mobile charging and one port for power supply to the cook stove. The two lights were used from 6.00 to 9.30 pm, and one light was extended up to 11.00 PM and also as and when required during the night. The mobile was charged using the solar power. The kid is now studying for longer hours with bright and clean lights compared to kerosene lamps. There is no smoke and no eye irritation to the child. The family is also saving cost of kerosene of about Rs 85/ month and they are inturn selling their kerosene at higher price to others. The family is pleased with the advantages due to the intervention. They are very happy after adopting the IDES.

10.5 Establishment of Uttam Urja shops

The main objective was to support establishment of Uttam Urja Shop and develop local entrepreneurs to repair, maintenance and available of spare parts at local places after distribution or installation of devices at grassroots level.

TERI has supported one entrepreneur to establish Uttam Urja shop at Bhogapura village. This was build confidence to end users/beneficiaries to get services or spare parts at in their native and locally get repair. His business is doing marginally and he has received orders for devices, stoves and also getting additional income through repairs and servicing of devices in the villages

10.6 To develop strategies for replication and up-scaling

As discussed in earlier sections, throughout the project TERI has made several efforts for replication and up-scaling of the technologies such as IDES, cook stove and solar lights. This was done through information sharing, capacity building of government departments, workshops for entrepreneurs and communities. This has led to the Zilla Panchayat, Forest department and KREDL showing keen interest in replicating this project in their jurisdictions.

TERI has developed brochures and documents which consists of specification of devices, make, spare parts available details, cost of devices, methodology of implementation carried out by TERI at Bhogapura Grama Panchayath and shared with various departments, government of Karnataka and NGO's, especially who have promotion of energy technologies such as Zilla Panchayath, Forest department, Karnataka Renewable Energy Development Limited (KREDL), tribal development, backward development board, social welfare development, Agriculture etc., this documents may be useful in their future projects. Further, TERI has developed entrepreneurs for marketing and promotion of IDES and cook stoves at local places, they can approach various departments and helping for them by entrepreneurs for promotion of technologies.

11. Conclusions summarising the achievements and indication of scope for future work

The main objective of the project was to improve the indoor air quality among SC&ST households in Chamarajanagara district through provision of clean energy solutions for cooking and lighting. TERI completed all the objectives successfully as mentioned in the proposal.

The methodology for this project involved the entire project cycle including selecting beneficiaries based on primary and secondary research, demonstration cum implementation of technologies, capacity building of beneficiaries and training of local people for promotion of cook stoves, developing entrepreneurship and market linkages, providing after sales care, off grid solution, and testing of cook stoves to assess performance and assessing impact of the project on the beneficiaries. The key learning is that this project provides for a model template for rolling out such programmes in other backward regions/villages in other parts of the country. The brief summary of deliverable and achievements shown below

Approved Objective/activities	**Deliverables**	**Achievements/Outcome(specific to utilization of funds for a period reported upon)**
Improve awareness among energy entrepreneurs and villagers about the know-how of the technologies	Conducted six awareness programmes in five villages. Out of them one was in the GP office. Further developed rapport through letter communications, interaction with concerned authorities, sharing information during the survey etc.	30 GP representatives including staff and more than 200 people came to know about the project directly and about 1000 people indirectly through the discussions during the survey. It helped in successful completion of the project.
To train local people/entrepreneurs /masons for maintenance and operation of the improved cook stoves	Two Training programmes were conducted out of them one for cook stove construction and maintenance and other one for maintenance and repair of solar devices. 62 people participated which includes, entrepreneurs, electrician, masons, unemployed youth with education background in ITI, diploma, PUC, and others. More than 20 user training programme were conducted	Capacity and skilled of 62 people, skilled workers and entrepreneurs were built in cook stoves construction, operation, maintenance and repair and also maintenance of solar devices.
To reduce fuel consumption and indoor air emissions by implementing improved cook stoves for cooking at household level	The Following were disseminated in six villages. Totally 300 standalone forced draft cook stoves, out of them 200 are low cost forced draft and 100 are top loading forced draft cook stoves 125 IDES: Out of them 110 IDES with low cost forced draft cook stove and 15 IDES with top loading forced draft cook stove made up of stainless steel	There are 300 low cost forced draft cook stove standalone and 125 top loading forced drafts, out of them, 125 are part of IDES. The efficiency of improved oven was 28.06% which is compared with conventional oven was 15.16%, in case of improved oven CO_2 66.82 PPM less, CO 4.28 PPM less and particulate matter 921 $\mu g/m^3$ less compared to conventional oven. 43.90% fuel wood save, means 2.36

Approved Objective/activities	Deliverables	Achievements/Outcome(specific to utilization of funds for a period reported upon)
		kgs per day per oven, totally 366.01 tonnes fuel wood save and 669.79 tonnes of CO_2 reduction from among the beneficiaries. In addition reduction of drudgery for women, reduces health risk for women etc.,
To ensure clean light for households by using off-grid solutions.	125 IDES disseminated in six villages which includes forced draft cook stove and solar home lights as per specification mentioned in the proposal	Provided clean lights to 125 families in six villages. Benefits from IDES are 40% savings of electrical bill, limiting usage of kerosene, longer duration of light, no smoke, relief from eye irritation, children get more time to study, and more time for work. Further, the un-electrified households can charge their cell phone batteries. Beneficiaries are saving kerosene cost the Rs. 85 per months lighting in addition to electrical bill. An average 4500 litres of kerosene saved per annum and reduction of 13.5 tonnes of CO_2.
Establishment of Uttam Urja Shop	Uttam Urja shop was established and supported by TERI at Bhogapura villages.	Established Uttam urja shop, which has helped beneficiaries get repair services and spare parts locally.
Dissemination of information among concerned authorities through workshops	Stakeholder workshop conducted at Chamarajanagara	65 people participated from various departments like, DST, KSCST, ZP, TP, RDPR, Forest department, Agriculture department, KREDL, department of social welfare, masons, President and vice president of GP, masons, beneficiaries, solar devices manufacturers etc., The information were disseminated among the concerned stakeholders,
To develop strategies for replication and up-scaling of the initiative	Developed report which contains strategies.	Developed strategies and shared with concerned department. This will be useful for dissemination of their projects.

Other key points that emerged from this project:

- Implementation of Anila Bhagya and Ujjawala yojana (LPG programmes) of state and central government is catching up in a big way. However it does not address the issue of how under privileged communities will purchase refill cyliñders as these are less affordable for many families. Supplementing these programmes with biomass based improved cook stoves and IDES interventions will help these communities by alleviating

financial burden to some extent and also providing clean energy sources for cooking and lighting as backup measure.

- IDES is well accepted by people, because of the erratic power supply from the grid. There is huge scope for promotion of IDES across Chamarajanagara districts because of the following reasons - 20% of households are un-electrified even among electrified households as they are not getting continuous power from the state grid, most of the tribal settled in forest fringe areas or inside forest, no proper electricity connection, electricity bill has been increased day to day.
- Since this project is being implemented for the SC/ST community in Bhogapura GP, there has been tremendous demand from people of other communities for replicating it in their villages as well.
- Even after awareness and user training programmes some of the beneficiaries were not properly handling/operating the devices. Regular training can help improve their skills.

Scope for promotion of improved cook stoves and IDES:

- There is scope for promotion of cook stoves along with solar lighting in interior villages, where improper connectivity and there is lack of facilities for transportation of LPG, especially in tribal hamlets and forest fringe villages.
- Improved cook stove can be promoted in remote and tribal areas, because tribal people are not keen on using LPG due to scarcity and lack of affordability to buy refill cylinders amount. Moreover there is lot biomass /fuel wood available in their surrounding areas for using improved cook stoves.

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