Final Report
on
Energy Baseline Survey of Hatuwagadhi Rural Municipality, Province 1

Prepared By

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List Acronyms and Abbreviations

AEPC	Alternative Energy Promotion Center
BMZ	German Federal Ministry for Economic cooperation and Development
DAG	Disadvantaged Group
FGD	Focused Group Discussion
GESI	Gender Equity and Social Inclusion
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbei
GON	Government of Nepal
GPS	Global Positioning System
HDI	Human Development Index
HHs	Households
ICS	Improved Cooking Stoves
IWM	Improved Water Mills
KII	Key Informant Interviews
LPG	Liquefied Petroleum Gas
MH	Micro-Hydro
MIS	Management Information System
MES	Municipal Energy Situation
MTF	Multi-tier Framework
NEA	Nepal Electricity Authority
PEU	Productive End Use
PJ	Peta Joule
PPES	Probability Proportionate to Estimated Size
PSU	Primary Sampling Unit
RERA	Renewable Energy for Rural Areas
RE	Renewable Energy
RETs	Renewable Energy Technology
RM	Rural Municipality
SHS	Solar Home Systems
SMEs	Small and Medium Scale Enterprises
UN	United Nation

Abstract

This report presents the finding of energy baseline survey of Hatuwagadhi Rural Municipality (RM) from Bhojpur district. The survey data include a comprehensive energy demand and supply situation and energy use pattern of households, enterprises and institutions of Hatuwagadhi Rural Municipality. In addition, the study also presents a broad analysis of the status of renewable energy interventions, grid extension, possibilities of financing, potential renewable energy interventions and stakeholder analysis. The findings of this survey will assist in preparing Municipality Energy Situation (MES) report to support in the promotion of Renewable Energy Technologies (RETs).

The baseline study is based on the primary data collection along with the review of secondary sources to better understand the energy demand and supply situation in the RM. The survey focused on the household energy access along with the energy access situation for the institutions and enterprises the RM.

Findings – Household energy situation

Energy access
About 96% households in Hatuwagadhi rural municipality have access to electricity, Solar Home System (SHS) being the predominant source. Traditional cookstoves are still the most common type, with two-third (66%) households using it as the primary stove.

Energy access and education
Households with higher level of education tend to have better access to electricity. All households with graduate level education have access to electricity. Household's access to electricity is decreasing proportional to their level of education. However, irrespective of the level of education, traditional cookstoves (3-stone and biomass self-built) are the most common cooking device. Modern cooking means are relatively higher in households with higher level of education.

Energy access and GESI Perspective
Male led households appear to have a slight edge over female led households in terms of access to electricity with 98% of the former having access compared to 96% of the latter.

Access to electricity analysed among four ethnic sub-types namely; *Ethnic DAG*, *Non-DAG*, *Janjati* and *Others*, showed SHS as a predominant electricity source followed by solar lantern. *Ethnic DAG* households neither have access to grid nor mini grid.

Irrespective of the gender, use of traditional cookstoves is common in both male and female led households. However, the use of cleaner cookstoves is marginally higher (by 2%) in case of female led households compared to male led households.

For all four population subtypes, traditional cookstoves are the most common type of stoves. Use of traditional cookstoves is about 50% for all population sub-types. Regarding cleaner cooking technologies, use of ICS is more common in *Non-DAG* subtype and LPG use was observed only *Janajati* subtype.

Energy access and Income

Even though no apparent relationship could be observed between primary source of income and electricity source, SHS was the predominant source irrespective of the household income. Similarly, no visible relationship could be observed between primary source of income and cooking source as all income categories primarily used 3-stone stoves.

Productive end use of energy

Household's productive use of energy in Hatuwagadhi is considerably low. Only 14% HHs are engaged in electricity based productive end use activities and 23% in non-electric. Shop/kiosk is the most common electricity based productive end use activity whereas animal feed preparation and alcohol brewing are the two common non-electric productive end use activities.

Measurement of energy access using MTF

The *capacity* attribute is the least performing among all attributes. 80% households of Hatuwagadhi rural municipality fall in the tier 1 category, 8% in tier 2, 7% in tier 3 and 1% in tier 4 with respect to capacity attribute. There is no tier 5 households but about 4% households fall in tier 0 as they don't have access to electricity or they possess non-functional solar lantern.

With regards to *Duration* attribute, 75% households are between tier 1 – 3 and 6% households fall in tier 4 whereas 16% households falls in tier 5. About 4% households don't have access to electricity supply hence falls in tier 0.

Attributes related to *Reliability, Quality, Legality and Health & Safety* are applicable for households with grid and minigrid. About 8% households connected to grid or minigrid fall in tier 4 with regards to the *reliability* attribute. With regard to *Quality* attribute, about 3% households fall in tier 4 whereas about 4% households fall in tier 3. And with respect to the *Legality* attribute, 7% households fall in tier 5 whereas 1% households fall in tier 3. With respect to *Health & Safety attribute*, 7% households fall in tier 5 and about 1% households fall in tier 3.

Hence, in the final tier distribution, 80% households of Hatuwagadhi rural municipality fall in tier 1 mainly because its poor performance in *Capacity* attribute.

Indicative consumer preference of energy service bundles

Appliances that serves for basic lighting and entertainment & communication are the most commonly owned appliances and are considered as basic or mandatory appliance by most households. Mobile phone and LED room light are the two most commonly owned electrical appliances followed by radio, smart phone/tablet, task light/torch and TV.

LED light, rechargeable light, fridge, mobile phone and the smart phone are the top five appliances households aspired to have in case of sufficient electricity supply.

Indicative affordability analysis of energy access

Indicative consumer preference was measured using contingent valuation method. With regards to electricity service improvement, about 55% respondents expressed their ability to pay up to NRs. 200 per month. About 9% are willing to pay up to NRs. 900 per month whereas only 5% of the respondents are willing to pay up to NRs. 1700 per month.

With regards to cooking service improvement, only 37% of the respondents expressed their willingness to pay up to NRs. 500 per month. 17% of them were willing to pay NRs 900 per month whereas only 8% households expressed willingness to pay NRs 1300 per month.

Findings – Enterprise energy situation

Types and registration status
Small scale commercial enterprises are the most common type of enterprise in Hatuwagadhi with Shops/kiosks being the most common type. However, only 62% operating enterprises have been formally registered.

Sources of energy
Of the different type of enterprises in the rural municipality, about 95% enterprises use electrical energy, 48% enterprises use thermal energy and only 10% use mechanical energy. The electrical energy is mostly catered through solar system (80%) and national grid (45%) with few eneterprises using diesel generators. Fuelwood being the primary source for most of the industries, using it to generate thermal energy along with LPG and charcoal.

Capacity of Solar System
The peak power of the installed solar system ranged between 20Wp to 200Wp. Buiscuit factories, IT enterprieses, hotels/restaurants, shop/kiosk and poultry farms are the top five enterprises with highest installed capacity.

Fuel wood Consumption
Fuel wood consumption varied between 2.7 tons to 86 tons per annum. Biscuit factory is by far the largest consumer of fuel wood followed by hotels and restaurants.

Use of stoves
Various types of cookstoves are in use depending on the type of enterprises. Biscuit factory is using specially designed oven, whereas poultry and pig/goat farms are using traditional cookstoves. About 75% of the hotels/restaurants using ICS as their primary stoves whereas about 25% are using LPG.

Diesel Consumption
Diesel based generators are used mainly in agro processing and automobile workshops with average monthly consumptions of 42.5 liters and 20 liters respectively.

Current and desired electrical load
The current connected load varies between 36Wp to 7036Wp. Automobile workshop has the highest connected load whereas biscuit factory and traditional blacksmith has the lowest connected load. If the electricity supply is made adequately available, the desired load appears to increase significantly from 225Wp to 9036Wp.

Findings – Institution energy situation

Types, sources and consumption of energy
Electrical energy is the main form of energy in most institutions other than army barracks and police stations where thermal energy is primarily used. NEA grid and solar are the two main sources of electrical energy. Fuel wood and kerosene is used for thermal energy generation.

The electrical energy is mostly catered through solar system. 91% institutions have installed solar system for electrical energy. About 45% are also using national grid and just 9% of them are using micro hydro grid.

Army barracks consume upto 3,000 liters of kerosine each year whereas annaul average fuelwood consumption in police stations is about 11 tons.

Capacity of Solar System
The peak power of the installed solar system ranges between 40Wp to 3500Wp with larger system common in schools.

Current and desired electrical load
The connected load vaires between 172 Wp to 1072Wp. Currently, health facilities have the highest connected load whereas army and police stations have the lowest. Desired load varies between 1125Wp to 3072Wp. Health facilities have the highest desired load followed by army and police stations.

Recommendation
The results of the baseline study indicates an urgent need to improve the energy access in this rural municipality to ensure higher tier energy use. This can be achieved through mass awareness campaign to educate people regarding the economic, health and environmental benefits of different RETs so as to help them make informed decisions for appropriate technology selection. Also there is a need to develop long term plans and policies, focusing on developing decentralized energy projects due to the scattered human settlement in the region. Also emphasis should be given to technologies that have the capability to make use of the large biomass resource available in the rural municipality. In addition there is a need to develop financial provisions to aid the households to attain better energy access and engage in better productive uses.

Contents

List of Tables

List of Figures

1 Background and Introduction

1.1 Rationale of Study

The Renewable Energy for Rural Areas (RERA) is a joint technical support programme, for the Nepalese small-scale renewable energy sector, of the Government of Nepal (GoN) and the German Federal Ministry for Economic Cooperation and Development (BMZ). The programme is jointly implemented by the Alternative Energy Promotion Centre (AEPC) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). This is a 3 year project commissioned in 2016 for 3 years.

RERA envisions ***'to ensure efficient and effective service delivery of small-scale renewable energy through improved outreach and enhanced local cooperation in a federalised and decentralised Nepal'.*** This vision will be delivered through improving and developing a framework for participatory and demand-led promotion of small-scale renewable energy in central, provincial, and local government authorities, ensuring the effective cooperation with civil society and the private sector in the context of federalisation and constitutional reform. The programme will also support local level and potentially federal government, work together with civil society, the private and banking sector to improve service delivery of small-scale renewable energy.

The programme is divided into four components:

Supporting central government institutions to help them prepare for decentralised energy service delivery

Supporting AEPC in establishing a decentralised outreach structure so that they are enabled to implement support programmes in collaboration with local and central government structures

Promoting local energy service delivery through effective institutional engagement with local governments, civil society, the private and banking sector

Involving disadvantaged groups (DAGs)[1] and women to ensure their engagement in the energy service delivery as decision maker, implementers and beneficiaries

Purpose and rational of the assignment:

Nepal's Constitution of 2015 has incorporated a federal system as the cornerstone of Nepal's political governance system. According to article 55 of the new constitution, there will be 3 levels of governments i.e. i) Federal, ii) Provincial, and iii) Local Level. Furthermore, the Constitution states that central, provincial and local levels can enact laws, prepare annual budgets, take decisions, prepare and implement policies and plans within its areas of authority. However, the roles that will be carried out in the decentralised structure is still not clear.

In this backdrop, the RERA programme is supporting GoN to define these roles and responsibilities of the three levels with regard to renewable energy (RE) to support the transformation into the decentralized structure. The local governments are expected to be directly engaged in managing the implementation of RE promotion programmes. The local unit and

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[1] Disadvantaged Groups (DAG) is defined as those people who are discriminated based on gender, caste and ethnicity and are economically poor.

provincial government will be responsible for energy planning. GIZ/RERA will support AEPC in developing tools and standard processes for the provincial/local level to assess the energy baseline and undertake RE resource mapping. GIZ/RERA will support AEPC in its efforts towards creating a systematic methodology to map the existing use of energy (qualitatively and quantitatively) and RE potentials in the respective provinces.

In this context, the Energy Access (lighting, cooking and productive/consumptive us of energy) situation in the municipalities is the key document that will indicate how the current projects will address energy development at municipality level and which will help AEPC to promote various Renewable Energy Technologies (RETs) in the selected municipalities and thus achieve the targets of GoN. This energy baseline study provides a holistic and updated picture of the energy situation in selected rural municipality (RM) which will be the base document for the RETs promotion.

The main rationale of the study is to identify the current energy access situation in the municipalities and analyse the potential of RETs dissemination through technical assistance from the RERA programme. Ultimately this report will serve as a guiding document not only for the selected municipalities but for other municipalities as well, aiding them to identify potential interventions to provide improved energy access.

1.2 Objectives of Study

The major objectives of this assignment are to conduct a survey of energy baseline situation as well as energy resource mapping in Hatuwagadhi Rural Municipality (RM) from Bhojpur district in Province 1. The information surveyed shall include a comprehensive energy demand and supply situation, energy use pattern, status of RE interventions, grid extension, possibilities of financing, potential RE interventions, stakeholder analysis and to prepare the Municipality Energy Situation Report (MESR) to support in promotion of the RETs.

1.3 Limitation of Study

- In some of the clusters, number of households (HHs) were less than 20. In such cases, HHs outside the clusters have also been surveyed to reach the desired number of samples.
- The baseline study methodology of enterprises and infrastructures had to be revised due to insufficient data on energy consumption and demand. The survey was carried out only after the completion field survey based on key informant interview (KII). Due to limited time and budget, few respondents were randomly selected and interviewed. Hence, the survey of enterprises and infrastructures is not structurally well sampled.
- Due to lack of internet accessibility, many collected data were uploaded at the end of the survey, rather than during the survey period as previously planned. Hence, data control and correction could not be performed during the duration of the survey. Since many such data had to be cleaned up after the completion of survey, there might have been some discrepancies in the data quality. However, the team has tried their best to carefully scrutinize such data and carry out necessary cleaning to the possible extent.
- Due to the large variation on HHs income data, the analysis of energy assess with respect to energy access could not be performed. Instead, impact on energy access with respect to the source of income has been analysed and presented in the report.

2 Methodology

2.1 Strategy for Study

The baseline survey was carried out to assess potential of renewable energy technologies, the supply and demand gaps, people's knowledge and attitude towards renewable energy, gender and social inclusion (GESI) aspects of energy access, energy financing opportunities and mapping of existing stakeholders engaged on RE promotion to assist in preparing MES.

The baseline study was primarily based on primary data collection but some secondary data sources were also reviewed to get a better understanding of the municipality energy situation. The study primarily focused on household energy access but information on energy access situation in institutions, infrastructures and enterprises were also collected for the analysis.

A tablet based baseline survey was conducted using standardized energy baseline methodology to assess the renewable energy situation. About 400 households from 20 pre-defined clusters within the RM were randomly selected for the survey. Similarly, major infrastructure, institutions and enterprises were mapped and few samples from each category were randomly selected to assess the energy access situation. In addition, the Global Positioning System (GPS) coordinates of major energy infrastructure such as mini-grid, transmission line, transformers, substations etc. were also recorded for the detail mapping during the field study.

During field survey, a team of six, comprising of a survey supervisor (RE engineer) and five enumerators were deployed in each municipality. Before their deployment, the survey team was oriented and trained to carry out the energy baseline survey. The survey supervisor overviewed the survey and provided necessary backstopping to enumerators to ensure the consistency, completeness and correctness of the survey.

The detail survey methodology is outlined in the subsequent chapters below.

2.1.1 *Secondary data collection, review and gap analysis*

Though this study was predominantly based on primary data, a review of secondary data sources was carried out prior to field study in order to get a basic understanding of the municipality, to identify gaps and to better prepare the team for the field study.

Some of the literature reviewed included National Census 2011, Identification of Municipalities, Winrock, District Profile of Bhojpur and various reports prepared by Nepal government and development agencies.

The data on area, population, number of households, ward demarcation and socio-demographic, geo-physical statistics were gathered and compiled from the secondary sources.

2.1.2 *Consultation at municipality, ward level and community level*

Before commencement of the field survey, a consultation meeting was carried out in the rural municipality with the elected representatives including chairperson, vice-chairperson and ward chairpersons to familiarize them with the study, acquire their consent and ensure their support during the field study. Also, the meeting was taken as an opportunity to collect preliminary information on accessibility, energy access, infrastructures, enterprises, energy infrastructures and institutions. Similarly, the municipality's vision and plan to increase energy access were also documented during the meeting. In addition, the planning process and the technical capacity of the municipality for energy planning were also assessed.

2.1.3 *Sampling design for household (HH)*

2.1.3.1 Sampling methodology

The sampling methodology provided a spatially distributed representative sample at the municipal level. It was also crucial that the resulting sample obtained from the sampling methodology was logistically feasible, within the available budget and above all provides a decent representation of the rural municipality in question.

In order to achieve this, a multistage sampling strategy has been used.

1. Sample stratification, where the population is divided into administrative areas - in this case municipality. Here the sample is representative within each municipality.
2. Clustering selection, where every member of the stratum population is assigned to a cluster and a selection of clusters is chosen, within which a uniform number of population units are randomly selected.

2.1.3.2 Sample size

Following stratification by municipal boundaries, the sampling size was determined following UN guidelines for household survey sampling design, (UN, 2008, pp. 41) as described below.

$$n = \frac{(z^2)(r)(1-r)(f)(k)}{(p)(\eta)(e^2)} \qquad \text{Eqn. 1}$$

Where;

n is the parameter to be calculated and is the sample size in terms of number of households to be selected in each municipality;

z is the statistic that defines the level of confidence desired; set at 1.96 for a 95% confidence interval

r is an estimate of a key indicator to be measured by the survey; set at 0.5 to obtain the most conservative (largest) sample due to lack of prior knowledge on key indicator prevalence and the broad nature of the household survey.

f is the sample design effect, $deff$, set at 1.38, which is an adjustment to the empirical $deff$ calculated through the latest DHS report ($deff$ = 1.58), adjusted for the difference between the cluster size of 30 used in the DHS and that the cluster size of 20 used in this survey[2], (MOHP New ERA and ICF DHS Program, 2017, pp. 379).

[2] $deff = 1 + \delta\,(\mathrm{N} - 1)$ where δ is the intra-class (or intra-cluster) correlation, that is, to say the degree to which two units in a cluster compared with two units selected at random in the population, are likely to have the same value; and N is the number of units of the target population in the cluster. (UN, 2008, pp. 48)

k is a multiplier required to account for the anticipated rate of non-response; set at 1.05 which caters for 5% of households that refuse to answer specific questions necessary for energy baseline evaluation, in-line with the survey completion rates in the most recent DHS of 95.7% (MOHP New ERA and ICF DHS Program, 2017, pp. 381).

p is the proportion of the total population accounted for by the target population and upon which the parameter r is based; set at 1 which represents that the entire population is accounted for in the sample due to the nature of the baseline survey, which inherently encompasses all households.

η is the average household size (number of persons per household); which is set at 1 due to the sampling unit being the household, rather than a member or subset of the household.

e is the margin of error to be attained, set at 0.06 such that for any given sample statistic, such as the percentage of solar home system ownership across the sample, the aim of the sampling strategy is to deliver a sample such that the sample percentage should be within +- 6% of the true percentage of solar home system ownership across the entire municipality with a confidence level of 95%

Substituting these values into the Eqn. 1 yields the following;

$$n = \frac{(1.96^2)(0.5)(1-0.5)(1.38)(1.05)}{(1)(1)(0.06^2)}$$

$$n = 387$$

This sample size must now be rounded up to enable a uniform and simple sample size that is reproducible across each municipality. Upon discussion with the GIZ team and the local consultant, it was agreed that the final sample size to be split evenly across n clusters (of maximum size 20) to be;

$$Final\ Municipal\ Household\ Sample\ Size, n = 400$$

2.1.3.3 Primary sampling unit (PSU) selection

It is important here to consider the inclusion of sample weights such that each population unit, be it a household, enterprise or institution, has a non-zero and uniform chance of being selected. This improves the quality of a representative sample at the municipal level. In order to develop such weights, the probability proportionate to estimated size (PPES) method is recommended.

Due to the lack of up-to-date municipal records and the age of the census data (most recently conducted in 2011), it was decided to take advantage of recently developed remotely sensed population and built-up area data available through worldpop.org and developed by Gaughan et al. (2013).

The PSU selection was conducted within the R language and environment for statistical computing environment, (R Core Team, 2018). The Grid Sample R package developed by Thompson et al. (2017a, 2017b) provides the functionality to combine the PPES approach with remotely sensed population datasets. The following parameters were provided to the Grid Sample algorithm:

Sample Size:	400
Households per cluster:	20; representing a cluster size of 20 households
Minimum people per pixel (100mx100m):	2; to exclude uninhabited areas
Maximum PSU size:	1, representing $1km^2$
Population per PSU:	100, representing a cluster size of 20 households
Spatial Resampling Scale:	10; to ensure spatial distribution at $10km^2$

The municipal boundaries were provided by Pathways Technologies Nepal (http://ptas.com.np/). These boundaries were imported into QGIS for visual validation and then directly used within the Grid Sample algorithm as stratum boundaries.

The Grid Sample algorithm outputs a shape file with 20 defined PSUs per municipality. These were then loaded into QGIS in order to conduct visual validation of the cluster selection with satellite imagery provided by Google Maps (2018). Minor changes to the cluster locations were conducted in case of a mismatch between satellite imagery and population raster data from WorldPop.org. Both initial and adjusted cluster locations are maintained for transparency. The pre-identified primary sampling units are presented in Annex 7.1.

Finally the validated PSU shape files were exported as .KML files enabling the consultant to import these into the Google Earth (2018) application on each tablet in order to use these off-line in the field.

2.1.3.4 Secondary sampling unit (SSU) selection

As per the calculations performed for primary sampling unit selection, the consultant was tasked to survey 20 households from each of the pre-defined clusters. During the field survey, the clusters were divided amongst the enumerators such that the number of household surveys to be conducted by each enumerator were (almost) same. Amongst the 5 enumerators deployed to conduct the survey in the municipality, 4 worked in groups of two whereas the final enumerator worked alone. It was ensured that the single working enumerator and at least one from each of the two groups were locals, who were aware of the geographic and demographic features of the municipality.

On entering their respective assigned clusters, the two enumerators from each of the two groups split up and surveyed 10 households each. The household selection was done at random by the enumerator, ensuring uniform selection from the whole cluster. In cases where the number of households in a cluster were less than 20, households within a 100m from the cluster boundary were also surveyed. If no houses could be found within a 100m of the cluster boundary, only the available number of samples were collected. Amongst the two surveyors of a group, one was tasked with the conduction of the “contingent valuation game” whereas the other with the “discrete choice game.” 10 samples of each game were conducted in a single cluster. The enumerator assigned the discrete choice game was asked to conduct the two blocks of the game alternatively.

The single working enumerator had to cover the entire 20 HH from within a cluster, conducting contingent valuation game in 10 of the HHs and discrete choice game in the remaining.

2.1.4 *Surveying of public service providers*

The presence and the location of public service providers such as ward offices, schools, campuses, health-posts, police station and army camps within each ward of the municipality were mapped in consultation with the ward chairperson of the respective ward.

For each type, at least one service provider was interviewed to assess the energy access situation following the standard survey questionnaires. Also, GPS coordinates of service providers that are located within the pre-defined clusters were also recorded for the analysis.

2.1.5 *Medium, small and micro enterprise (MSME) Survey*

Many MSMEs operate as informal industry without registration. Hence, mapping and acquiring data of MSME was challenging. So the presence of MSMEs in each ward was identified based on the consultation with ward chairpersons.

For each type of MSME, at least one sample was randomly selected and interviewed following the pre-defined questionnaire to assess the energy access situation. For MSME with more than one in number, maximum three samples were selected for the interview.

2.1.6 *Energy supply infrastructure*

The presence of major energy infrastructure such as mini-grids, transmission lines, transformers and sub-stations were identified based on consultation with the municipality. The GPS coordinates of energy infrastructure that were within the survey clusters were recorded during the field study. In addition, the GPS coordinate of micro-hydro, which was the major energy infrastructure, within the municipality was identified from google earth. The capacity and operational status of these infrastructures were gathered from municipality or from the micro-hydro chairperson or operator.

2.1.7 *Focus group discussions (FGD)*

Three focus group discussions were carried out using pre-defined questionnaire to collect qualitative data and information on household energy assess situation. The FGDs were carried out by the supervisor in an interactive group setting. The three FGD groups included – general HHs, women and disadvantage groups (DAG). The questionnaire generally focused on understanding the knowledge, attitude and practices of households in energy uses and gain a general overview of their willingness to invest in the energy sector. The questionnaire used for the interview is attached in the annex 7.2.

2.1.8 *Key informants' interview (KII)*

Local key informants were identified and interviewed to gain further insight on the energy scenario and document the perceived limitations and challenges. Some of the key informant included school teacher, district energy and environment officer and social mobilizers.

These interviews helped in identifying various government and non-government service providers in the energy sector and the future prospects of various energy source in these areas. The key informant interview was carried out by the supervisor.

2.1.9 *GESI analysis*

The GESI analysis has been carried out in two stages. During HH survey, the questionnaires were designed in such a way that factors such as women and DAG led HHs, impact on energy access in women and DAG led HHs, influence of women in buying energy appliances and fuel were accounted for. In addition, two FGDs were carried out; one with a group of women and another where participants were form the DAGs. In these FGDs the participant’s knowledge, attitude and practices on household’s energy use were further assessed.

2.1.10 *Verfication of data/information and quality control*

The survey was conducted for a period of three weeks. To minimize the errors in the survey data, the survey supervisors were stationed at the municipality for the entire survey period. However due to the location and topography of the municipality and project time constraints, it was impossible for the survey supervisor to meet the enumerators in person on a daily basis. Thus the supervisors kept in contact with each of the enumerators via phone guiding them through any difficulties faced during the survey.

The data verification and triangulation was conducted in two different phases. Initially the data collected and uploaded by the enumerators was checked on a daily basis by the survey supervisors over the period of the survey. Any irregularity observed in the data during this primary data checking was immediately consulted with the enumerator via phone or in person depending on the location of the enumerator. If the justification, for the irregularity, provided by the enumerator was valid and genuine, the data was kept unchanged. Otherwise the data was corrected based on consultation with enumerators.

The second phase of data scrutinizing was done by the senior energy expert from Kathmandu itself, to locate any errors in data which could have been missed by the survey supervisor. The supervisors were made aware of these errors, who then would contact the enumerators for validation of the anomaly. The final cleaned data after the completion of the triangulation were submitted to GIZ/RERA. The alterations made to the raw data were marked along with the reasoning for carrying out each of these changes.

3 Municipality Background

3.1 Background on Hatuwagadhi Rural Municipality

3.1.1 *Location*

Hatuwagadhi RM is one out of seven RMs in Bhojupur district. The municipality lies in south-west of Bhojpur district. Hatuwagadhi was known as Majh Kirant before the unification of Nepal by Shah Kings. It was capital of Kirat Kingdom. The ruins of the ancient capital and forts still exist at Hatuwagadhi (Wikipedia, 2018).

This rural municipality is formed comprising of following then village development committees/municipality - Ranibas, Sindrang, Khirang, Homtang, Patlepani, Hasanpur (District Coordination Committee Office, 2017). There is road connection from Bhojpur Bazar as well as from Machuwatar.

3.1.2 *Demography*

The total population in this municipality is 22,804. The male and female population is almost equal with 11,470 male and 11,334 female. There are a total of 4,231 HHs in the RM with an average family size of 5.39. About 31% of the population is below 15 years of age, 60% of the population is between 16 to 60 years of age whereas about 9% of the population is above 60 years of age (District Coordination Committee Office, 2017).

Rai and Chettri are the two major ethnic groups comprising 67% and 17% of the population. Rai is the mother tongue for the 60% of the population whereas for 37% Nepali is their mother tongue. In terms of religion, 54% are Kirat, 42% are Hindu, 3% are Buddhist and the rest are others (District Coordination Committee Office, 2017).

3.1.3 *Topography*

Hatuwagadhi RM is spread across 142.2 sqkm with most part of the RM lying on mid-hills. As per the topography map, the altitude varies between 120m to 1856 m above sea level. About 58% of the RM is covered with forest land area. The RM lies between 26°54′55″to 27°4′28″N and 87°3′28″ to 87°11′27″E.

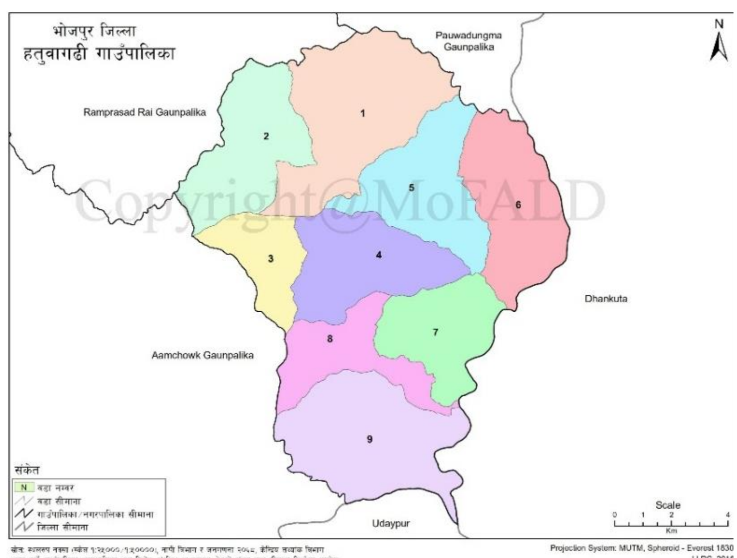

Figure 1: Map of Hatuwagadhi RM

3.1.4 *Governance and administration*

Hatuwagadhi RM comprise of nine wards. The municipality is led by the chairperson who is assisted by a female vice-chairperson. In addition, each ward has one elected ward chairperson and four ward members. Two out of four members are women and one of the ward member is from dalit[3] community.

The day-to-day administrative duties within the municipality is carried forward by the executive officer under the supervision and directives of the chairperson. The municipality has six thematic committees for education, finance, local development, social, monitoring and budget preparation & planning.

All elected members including chairperson, vice-chairperson and ward members elected within the municipality make up municipal assembly. The municipal assembly approves the yearly plan of action and budget. The municipal assembly is also responsible for local affairs including tax collection, local legislation, policy-making, development planning, administration, and disbursement of benefits and local development funds. The municipal assembly takes place twice a year.

The municipality chairperson is responsible for calling meetings of the assembly and executive body, tabling agenda in the meeting, assigning responsibilities to the deputy chief or members, overseeing fixed and moveable assets of the local level, concluding performance contract with concerned authorities, coordinating with other local levels, provinces and federal government, preparing monthly progress report, monitoring activities of national and international non-governmental organizations, preparing budget and determining price of construction materials, among other things (The Himalayan Times, 2017).

Similarly, deputy chief of rural municipality or municipality acts as a coordinator of judicial committee besides working in the capacity of acting chief in the absence of chief. The ward chairperson is responsible to prepare budget and plan of the concerned ward, collect and maintain data of households, maintain records of public property, conduct child and environment-friendly programmes, carry out market monitoring and ensure smooth supply of essential goods and services, initiate action against anyone who builds house without obtaining permission of the local level, and prepare monthly progress report. In addition, s/he is also responsible for issuing letter of recommendation and certify various documents related to personal incidents, land, house, citizenship, reconciliation and relationship both in Nepali and English. "Ward members shall carry out functions, duties and responsibilities as assigned by ward chief," read the Order (The Himalayan Times, 2018).

[3] Dalit refers to a group of people who are religiously, culturally, socially, economically and historically oppressed, excluded and treated as untouchables and they belong to different geographical region, language, culture and castes (Dalit Wlfare Organization, 2018).

3.1.5 *Women and DAG in municipality*

The municipality is comprised of 49.7% of women population, almost equal to that of men. However, the society is very much patriarchal in nature. About 81% of HH ownership is with male compared to 19% with female (District Coordination Committee Office, 2017).

The majority of the population (83%) is from indigenous community, Rai being the most predominant ethnic group. About 8% of the total population is from Dalit community (District Coordination Committee Office, 2017).

3.1.6 *Local economy*

The economy is primarily based on Agriculture. Rice, maize, wheat and millet are the major cash crops. Agriculture and animal husbandry contributes 57% of the total HH income of the municipality followed by oversees employment and service sector which contributes 22% and 10% of the total HH income respectively. Despite an agriculturally based economy, only 19% of HHs produces food sufficient for more than nine months a year whereas for about 14% HHs, the produce is sufficient for less than three months a year. The average monthly HHs income is about NPR 17,000. Out of total HHs, about 16% HHs are categorized as extreme poor and about 36% are categorized as poor. Ghoretar and Hasanpur Bazar are the two major market centers in the municipality but the industry and business sector is very limited contributing only about 3% of the HH income (District Coordination Committee Office, 2017).

3.1.7 *Stakeholder analysis*

The major stakeholders of the energy sector in the municipality are, the municipality and ward offices, micro-hydro users committee, community forest users groups, Nepal Electricity Authority (NEA), AEPC, local stove promoters and various NGOs and development partners.

4 Findings

4.1 Current Energy Scenario

4.1.1 *Access to energy*

Access to energy plays a crucial role in the socio-economic development of any society. For the study, energy access of the households of Hatuwagadhi were determined by analyzing their access to electricity and cooking sources. Also, the household's level of satisfaction regarding their current energy sources were assessed.

4.1.1.1 Access to electricity

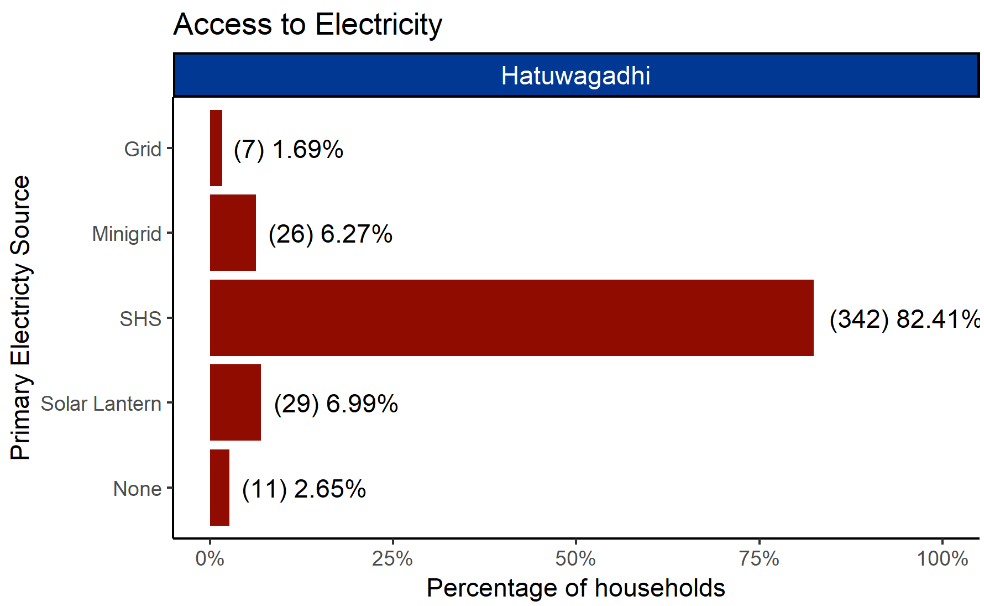

Figure 2: Access to electricity

About 96% HHs of Hatuwagadhi RM have access to electricity from off-grid sources whereas a mere 1.6% of the households have access to the national grid. SHS is the predominant source, providing electricity access to almost 82% HHs followed by solar lantern (7%), minigrid (6.3%) and national grid (1.7%).

The private sector has played an instrumental role in promoting SHS in Hatuwagadhi. They have been engaged in identifying potential customers, installing SHS and providing after sales maintenance and support. About two-third of SHS are below 20Wp capacity which is enough for basic lighting and mobile charging. Interestingly, majority of the HHs (85%) have installed SHS on their cost though they were entitled for subsidy from the government. Lack of awareness and the cumbersome process to access subsidy were mentioned as the primary reasons for not accessing subsidy during the FGD.

Micro-hydro is the only type of minigrid in the municipality. Currently, three micro hydro projects are in operation at Ranibas (55kW), Syndrang (11kW) and Machuwatar (12kW). Municipality has been recently connected to national grid but the connection is limited to few

HHs of ward number one, where the municipality office is situated. Power cuts are common even with grid connection so most of those HHs also have SHS.

Despite having good electricity coverage, and the quality and adequacy of electricity are the major issues observed in the municipality. The study shows that 38% of HHs have expressed dissatisfaction with their current electricity service. The two major reasons being the small capacity of the source and unreliable service. The HHs have also complained about voltage fluctuation, repair and maintenance issues and cost as other factors for dissatisfaction. The graphs depicting the electricity service satisfaction and reasons for dissatisfaction are presented below.

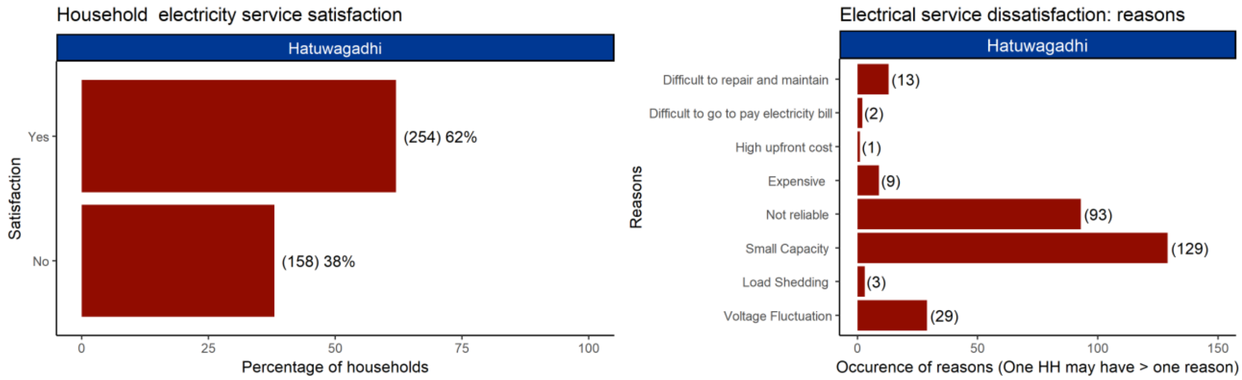

Figure 3: Household electricity service satisfaction and reasons

According to the municipality, access to national grid is one of the most common demand of local people. The municipality aims to provide access to the national grid electricity for every HH within five years. For this, the municipality has already started allocating budget for the pole erection to expedite the setting up of distribution line.

4.1.1.2 Access to primary cookstoves

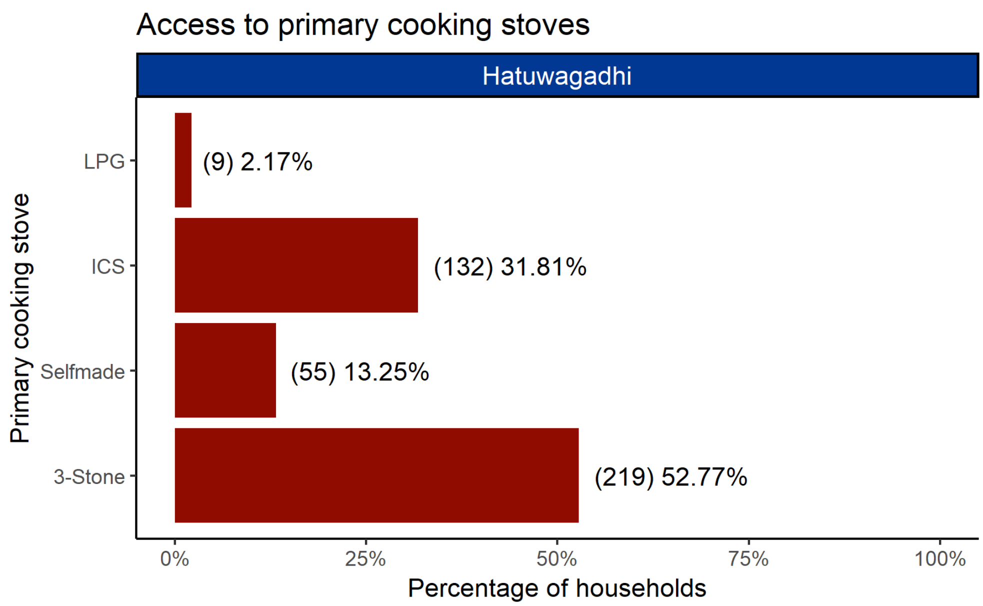

Figure 4: Access to primary cooking stoves

Traditional cookstoves are still the most common type of cooking means in use. About two-third HHs still rely on traditional cookstoves. Three-stone/open fire stove is the most common type of traditional cookstove. About 53% HHs are using it as the primary stove whereas about 13% HHs are using self-built biomass stoves. About one-third (32%) households are using mud based ICS, which is a significant proportion of the total stove users, thanks to different NGOs for their past efforts to make villages free of indoor air pollution. Despite higher subsidy, none of the households reported using portable or metallic cookstoves which generally are more efficient and environmentally friendly compared to mud based ICS. This highlights the need to place in more efforts for the promotion of these type of efficient stoves in the municipality. Only 2% HHs are using LPG as the primary stoves which is much lesser than the national average of 21%. However, with an increase in household income and improved road connection, its use can be expected to rise sharply, as it has in the other parts of the country.

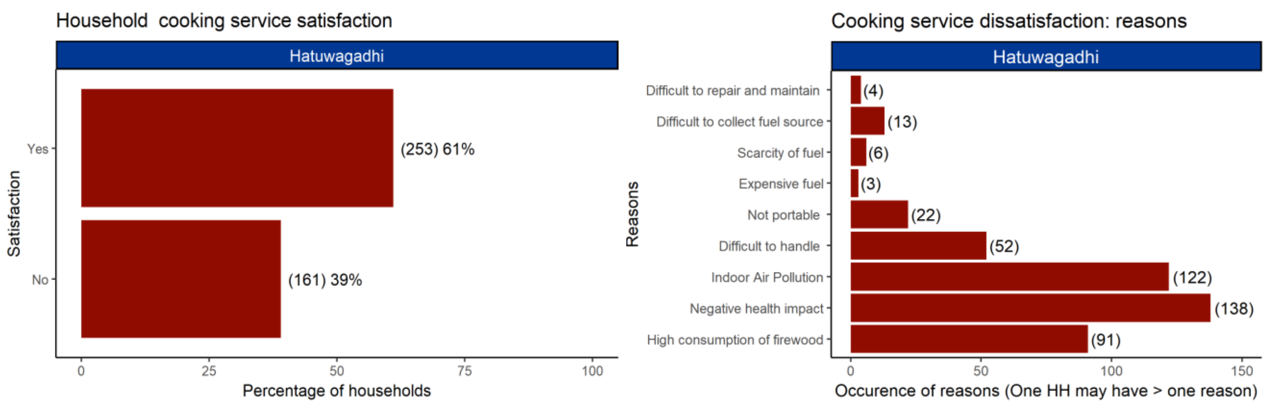

Figure 5: Household cooking service satisfaction and reasons

39% HHs have expressed their dissatisfaction with their current cooking service. The major reasons for dissatisfaction being the negative health impact, presence of indoor air pollution and higher consumption of firewood. People have also sighted higher fuel consumption and fixed design as other reasons for their dissatisfaction. Relatively, few HHs have complained about fuel wood scarcity and difficulty in fuel wood collection for cooking.

4.1.2 *Energy access and education*

Education is a major factor driving the increase in an individual's energy needs. Studies indicate a linear relationship between education and energy consumption in developing nations. (Inglesi_Lotz. & Morales., 2017). Hence the analysis was conducted assess the impact of education levels on energy access in Hatuwagadhi RM.

4.1.2.1 Electricity access and education

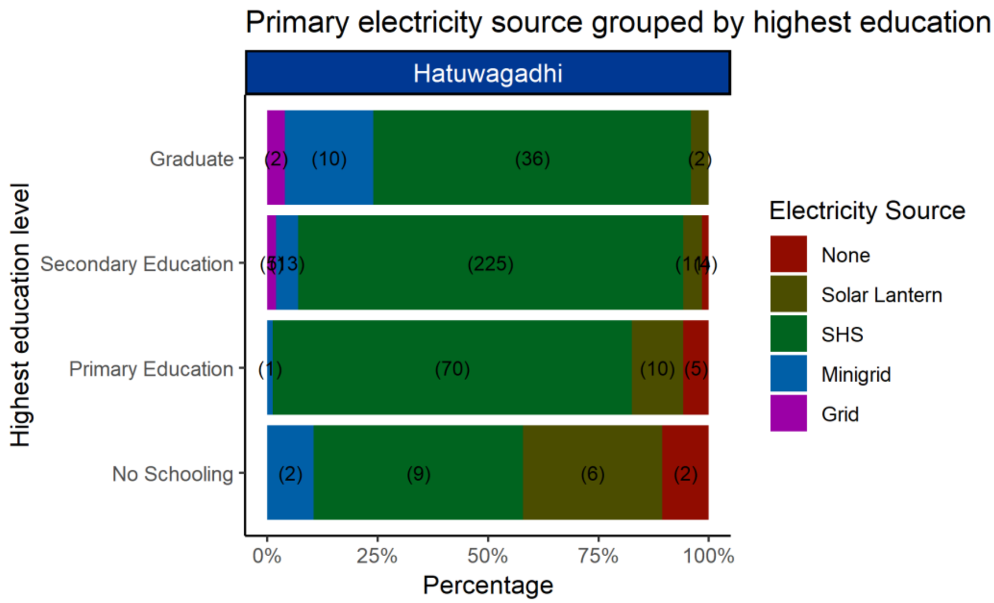

Figure 6: Electricity access and education

Education level appears to have positive impact on access to electricity sources. HHs with higher level of education tend to have better access to electricity. 100% HHs with graduate level education have access to certain form of electricity. Just 2% of HHs with secondary level of education does not have access to electricity. Whereas, 6% HHs with primary level of education does not have access to electricity. And for HHs without schooling, this is even higher, where 11% does not have access to electricity at all.

HHs with higher level of education (secondary and graduate) appears to be using more reliable and higher tier of electricity. Access to national grid is limited to HHs with secondary (2%) and graduate level (4%) of education. Use of SHS and minigrid is about 92% in HHs with secondary and graduate level of education. Whereas, its use is about 81% with HHs with primary level of education and just about 58% with HHs with no schooling. In contradictory, use of solar lantern, with peak power generally below 5w, is in decreasing trend with increasing level of education. Only 4% HHs with secondary and graduate level of education are using solar lantern whereas in case of primary level, its use is about 12% and in case of HHs without schooling, its use is about 32%, the highest among all category.

4.1.2.2 Primary cookstoves and education

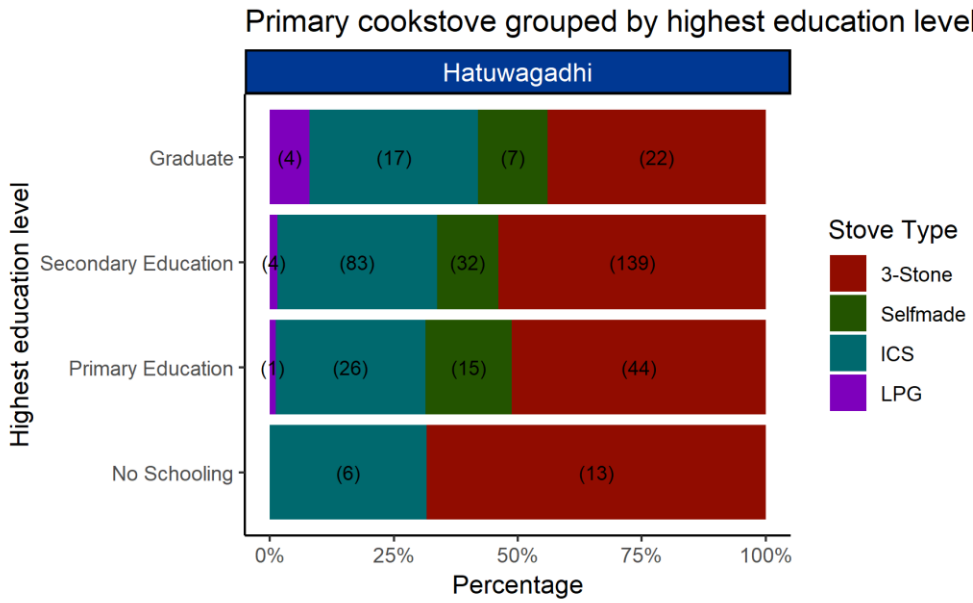

Figure 7: Primary cook stoves and education

Irrespective of the level of education, traditional cookstoves (3-stone and biomass self-built) are the most popular stoves in all HHs. Use of traditional cookstoves is same (68%) at all level of education. 3-stone stove, which is considered to be the most primitive design, is the most common stove in all HHs irrespective of their level of education. However, use of 3-stone stove is relatively low in educated HHs compared to HHs without education. In contrary, use of biomass self-built is prevalent in educated HHs than HHs without education. None of the HHs without schooling are using biomass self-built stoves.

The ICS mud stoves had been promoted in several VDCs of the region, by different NGOs in the past which now lies in Hatuwagadhi RM. As a result, the use of ICS mud stoves appears relatively well established in this rural municipality. The use of ICS mud stoves is also almost the same, between 32% - 34%, irrespective of the level of education. Whereas use of LPG, the cleanest among of all stoves, is prevalent in educated HHs. 8% HHs with graduate level education are using LPG. The percentage is 2% and 1% with HHs with secondary and primary education respectively but incase with HH without education, none of the HHs were using LPG. Interestingly, use of portable and metallic improved cookstoves, which are considered to have better thermal efficiency and is considered cleaner than mud based ICS, was not found in any HHs. Though no strong relationship is observed between education and use of cookstoves, but there is an indication that as the level of education increases, there is higher likelihood for the HHs to use cleaner stoves. This might be because educated households have better income, permitting them to invest in better/cleaner stoves or they might have better access to information on improved technologies.

A brief introduction of different stoves discussed above is provided in the annex 7.3.

4.1.3 *Energy access and GESI perspective*

The development of a concrete energy plan in Hatuwagadhi rural municipality requires equal participation from the population, irrespective of their gender and social background. Hence, the assessment of current energy access was carried out with regard to the gender of the household head and social background of the household. The data obtained helped to understand the current disparity in energy access between the elites and backward population of the municipality.

4.1.3.1 Electricity access and gender perspective

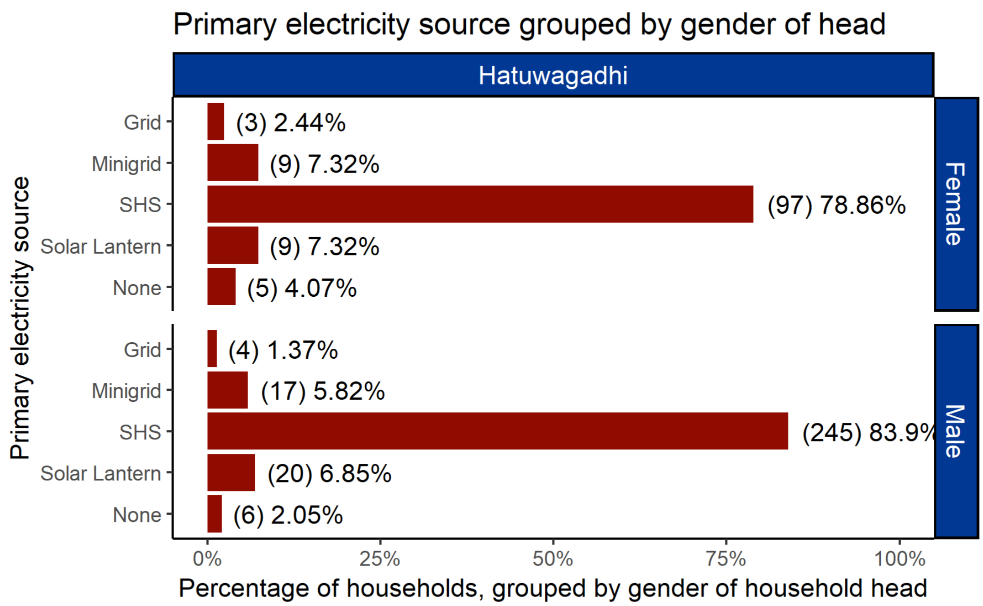

Figure 8: Primary electricity source grouped by gender of head

Gender does not appear to have significant impact on electricity access in Hatuwagadhi however, male led HHs seem to have a slight edge over female led HHs in terms of access to electricity. HHs lead by male (98%) have marginally better access to electricity than those led by female (96%). In terms of use of electricity sources, it is almost the same for all sources analysed except for the use of SHS which is slightly higher in case of male led (~84%) compared to female led (~79%) HHs. SHS are bought commercially from the local market and in general males have better mobility and access to market, and this could the reason why HHs led by male have higher percentage of SHS.

4.1.3.2 Electricity access and social inclusion

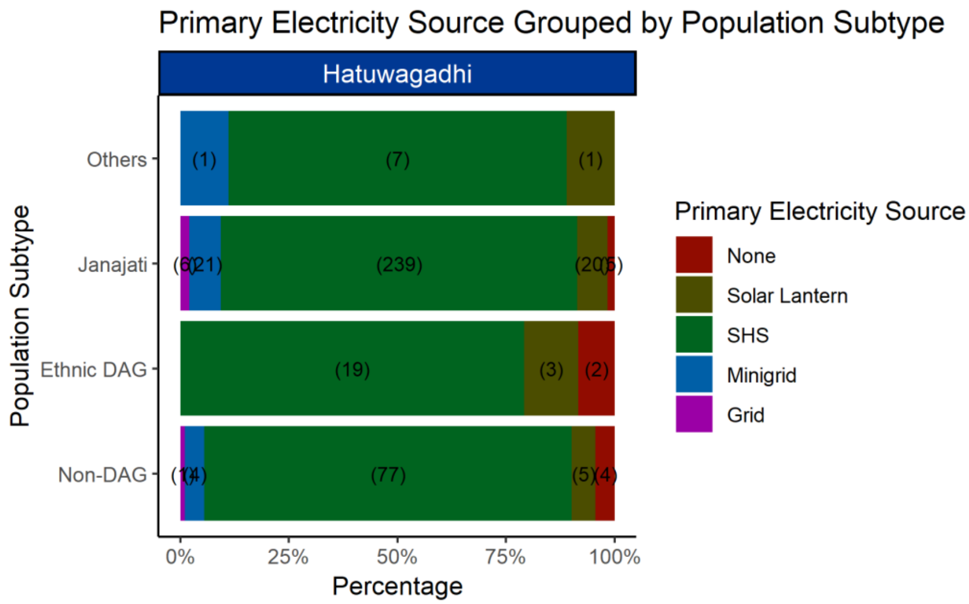

Figure 9: Primary electricity source grouped by population subtype

Ethnic DAG[4] appears to be relatively laid back in terms of access to electricity sources. HHs with ethnic DAG group neither have access to grid electricity nor to minigrid. Access to the national grid is seen to be limted only to Non-DAG and Janjati[5] subtypes. About 1% Non-DAG HHs and about 2% of Janajati HHs have access to grid electricity. Similarly, about 4% Non-DAG HHs, 7% of Janajati and 11% of *other*[6] subtypes have access to minigrid. Use of solar lantern exist in all the four groups analysed but its use is relatively high in ethnic-DAG and other population subtypes. About 13% of ethnic-DAG and 11% of other population sub-type are using solar lantern whereas only 7% of Janajati and 6% of Non-DAG are using solar lanters as primary electricity source. For all four groups, SHS is the predominant source electryfying about 78% - 85% of HHs. About 85% of Non-DAG HHs have SHS as primary electricity source followed by Janajati, ethnic-DAG and Others subtypes pecpecctively.

[4] Ethnic DAG are those people who are discriminated based on caste.
[5] Janjati is the umbrella term used to identify the ethnic indigenous people of Nepal. (Karma99, n.d.)
[6] *Other* population subtype has been categorized as those respondents who were unwilling to disclose their caste/surname to the surveyor. No respondents were forced to reveal their identity as such practice is deemed unethical.

4.1.3.3 Primary cookstoves and gender perspective

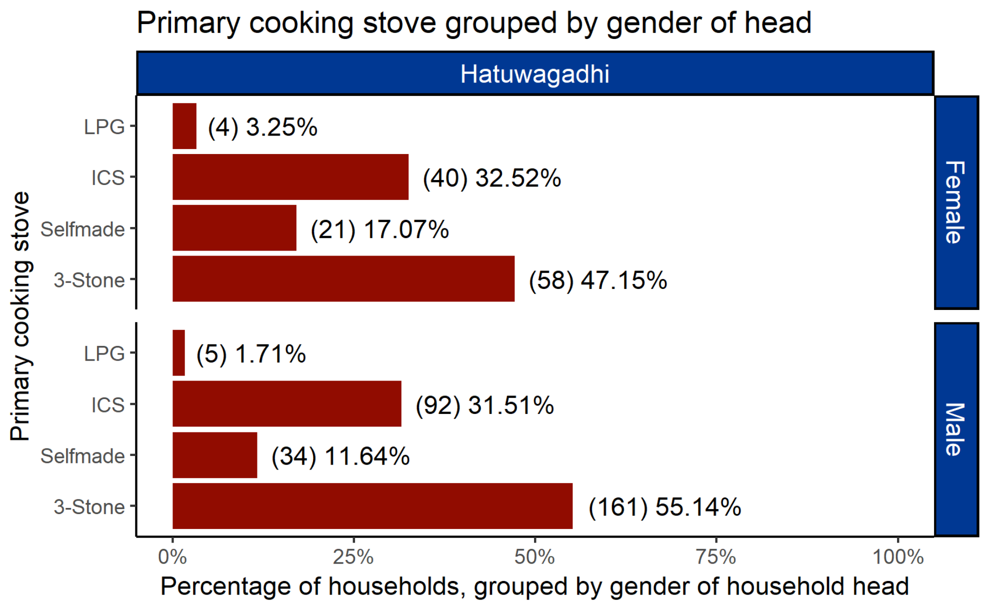

Figure 10: Primary cooking stove grouped by gender of head

Irrespective of the gender, use of traditional cookstoves is common in both male and female led HHs. Use of traditional cookstoves, 3-stones and biomass self-built, is marginally (3%) low in case of female led HHs than male. Female led HHs appear to be using less of 3-stone stoves and more of self-built biomass stoves compared to male led HHs. The monitoring result shows that traditional biomass stoves is relatively energy efficient and environment friendly compared to a 3-stone stove. A study conducted in rural Kenya indicates the reduction fuel consumption by about 15% using traditional mud stoves compared to those using three stone stoves (Ochieng & Tonne,C., 2013). Similarly, CO emission reduction of over 5% and PM reduction of over 10% were observed in traditional mud stoves compared to the three-stone stoves (MacCarty & D., 2008).

Similarly, the use of cleaner cookstoves, ICS-mud and LPG, is marginally higher (2%) in case of female led HHs than compared to male led HHs. So female led HHs appear to be using marginally higher percentage of clean cookstoves compared to male led. Even though the difference is marginal, the female led HHs appears to be more interested to improve kitchen environment compared to male.

4.1.3.4 Cookstoves and social inclusion

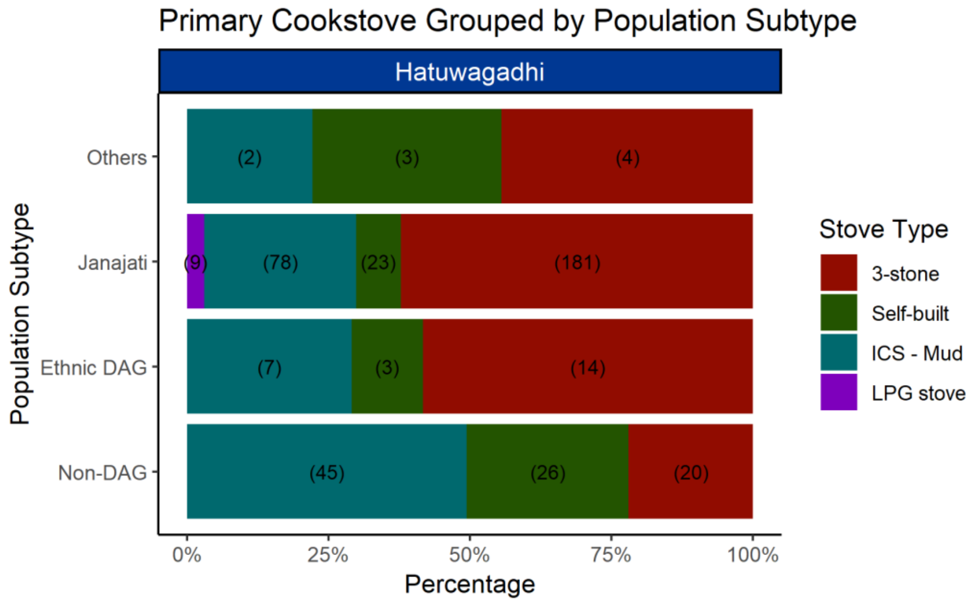

Figure 11: Primary cookstove grouped by population subtype

For all four population subtypes, traditional cookstoves (3-stone and self-built biomass) are the most common type of stoves. Use of traditional cookstoves is highest with the "Other" subtype among four subtypes analysed. About 78% of Other population subtypes are using traditional cookstoves followed by Ethnic-DAG (71%), Janajati (70%) and Non-DAG (51%). 3-stone cookstove, the most primitive type among all stoves, is the most commonly used traditional cookstoves, except for Non-DAG subtype. Only 22% HHs from Non-DAG subtypes are using 3-stone cookstove, compared to over 45% for the remaining three subtypes.

Similarly, about half (49%) of the Non-DAG subtype HHs are using ICS as the primary cookstove which is the highest among all four subtypes. The use of ICS is about 29% among Ethnic-DAG, 27% among Janajati and 22% among Others subtypes. Use of LPG was found only in Janajati subtype where 3% are using it as the primary stove. Because of highest use of ICS and least use of 3-stone stoves, Non-DAG subtype appears to be relatively better off in terms of access to clean cookstoves.

4.1.4 *Energy access and income*

In most rural households, the desire for better electricity source and cooking means are restricted by their income. As the financial capability of the household is crucial for accessing better energy means, the study carried out the analysis of current energy use of the households with regard to their profession/source of income.

4.1.4.1 Electricity access and income

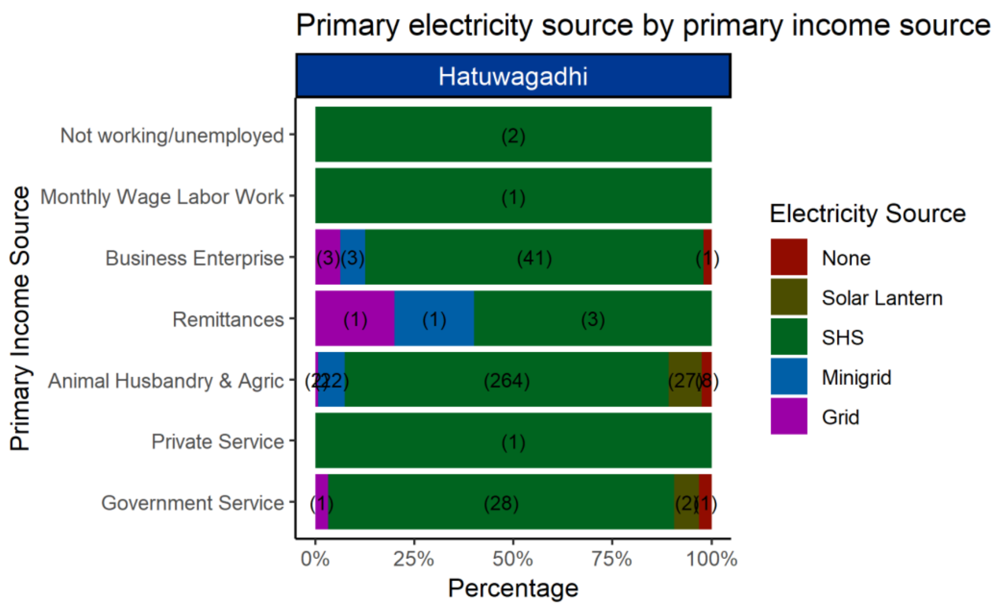

Figure 12: Primary electricity source by primary income source

Irrespective of their source of income, SHS is the predominant source of electricity for all. For unemployed HHs, HHs with monthly wage labor work and private service, SHS is the only source of electricity. However, the sampled HHs for each of these categories are 2 or less than 2. Few non-electrified HHs were found to exist in HHs having business enterprises, animal husbandry & agriculture and government service as primary source of income but its percentage is less than 3%. Access to grid or minigrid is available only in HHs having business enterprise, remittances, animal husbandry & agriculture and government service as primary source of income. Hence, no apparent relationship could be observed between primary source of income and electricity source. In general, it could be concluded that irrespective of the source of income, most of the HHs have financial capacity to install SHS. Access to grid and minigrid might be subjected to the availability and the extension of minigrid or grid electricity rather than HHs income source.

4.1.4.2 Access to cookstove and income

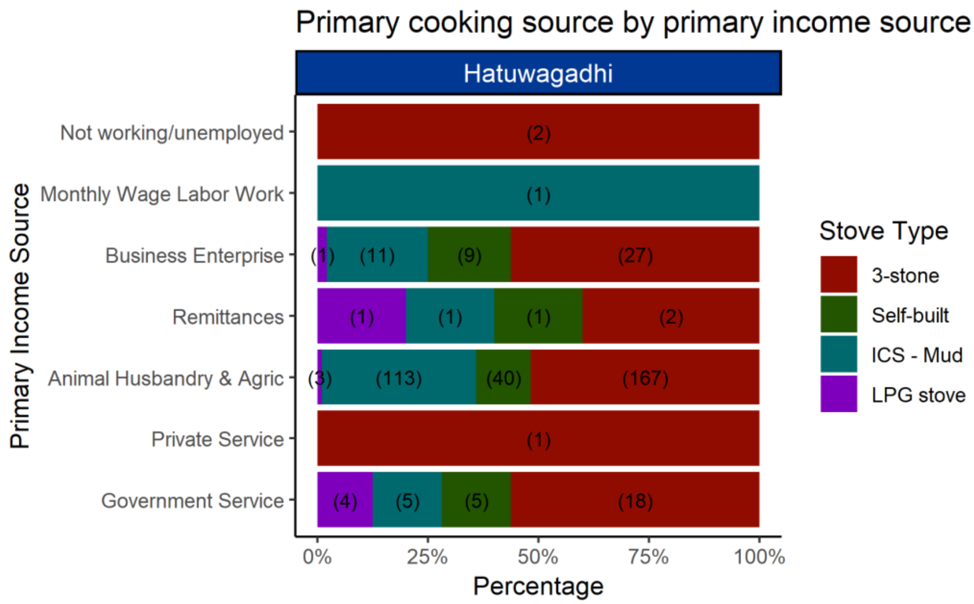

Figure 13: Primary cooking source by primary income source.

Number of samples with unemployed HHs, HHs with monthly wage labor work and private service are two or less, so these samples have not been considered for the analysis.

For the remaining four categories of income source, 3-stone traditional stove is the predominant type of stove irrespective of the income source. ICS mud stove appears to be the second most popular stove followed by self-built biomass stove. Use of ICS mud is higher than self-built biomass stove in case of HHs with business enterprise and animal husbandry & agriculture as the primary source of income. For HHs with remittances and government service, use of ICS mud and self-built biomass stove are equal. Use of LPG is limited with HHs having government service, remittances, animal husbandry & agriculture and business enterprises as primary income source. About 20% HHs having remittances and 12% HHs having government service as primary source of income are using LPG as their primary stove. Hence, no visible relationship could be observed between primary source of income and cooking source. For all income categories, penetration of ICS is appreciable, between 16% - 35%, which shows inclination for cleaner cooking solutions.

4.1.5 *HH level productive end use of energy*

Productive end use of energy has direct impacts on livelihood and revenue generation. Productive use of energy provides opportunity to generate additional income for many HHs. Also, productive use of energy is important for the sustainability of grid and mini-grid plants, as HHs with productive end use of energy will have better capacity to pay their monthly bills. Hence both electric and non-electric productive end use of energy in Hatuwagadhi RM have been assessed.

4.1.5.1 Household electricity productive use

Any activities that use electricity for HHs income generation are termed as productive use. The productive use of energy is an important consideration as it maximizes the economic and social development there by leading to rural economic development (Kapadia, 2004). Also, productive use of electricity is closely linked with the financial sustainability of micro hydro projects in Nepal because HHs with more productive use of electricity are more likely able to pay their electricity bills.

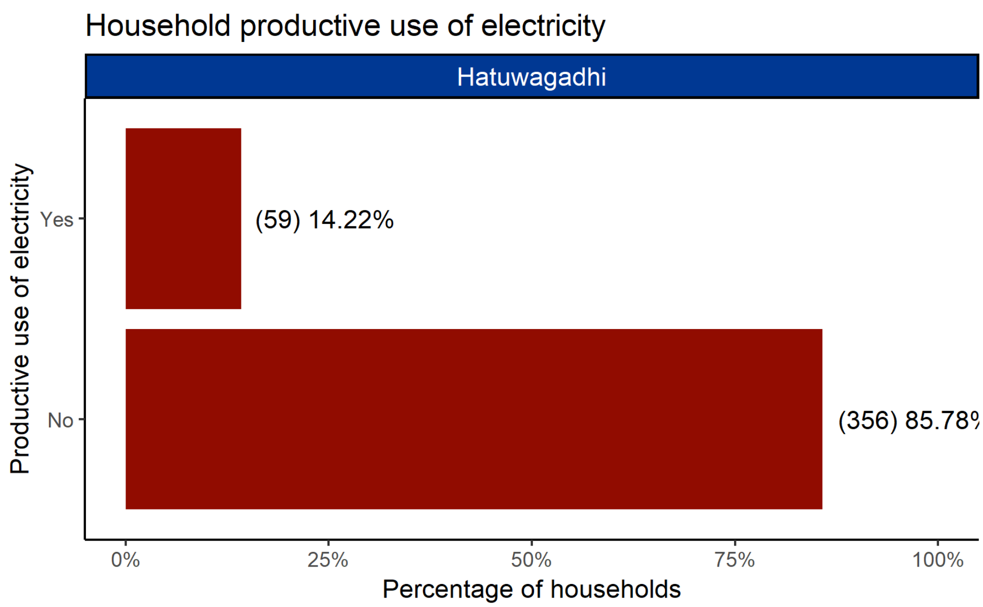

Figure 14: Household productive use of electricity

Unfortunately, the HHs productive use of electricity in Hatuwagadhi is considerably low. Only 14% HHs are using electricity for productive activities. This might be because many HHs are using SHS primarily to cover basic lighting requirements. There is need to develop electrification projects prioritizing the strategies for productive use of electricity service.

Shop/kiosk is the most common productive activity followed by cottage industry/handicrafts and iron works/carpentry. Of the total HHs, 11% of HHs are using a single productive use activity. 3% are using two productive use activities and just 2 HHs are using it for three or more productive activities.

Major productive use of electricity in Hatuwagadhi RM is shown in the bar chart below.

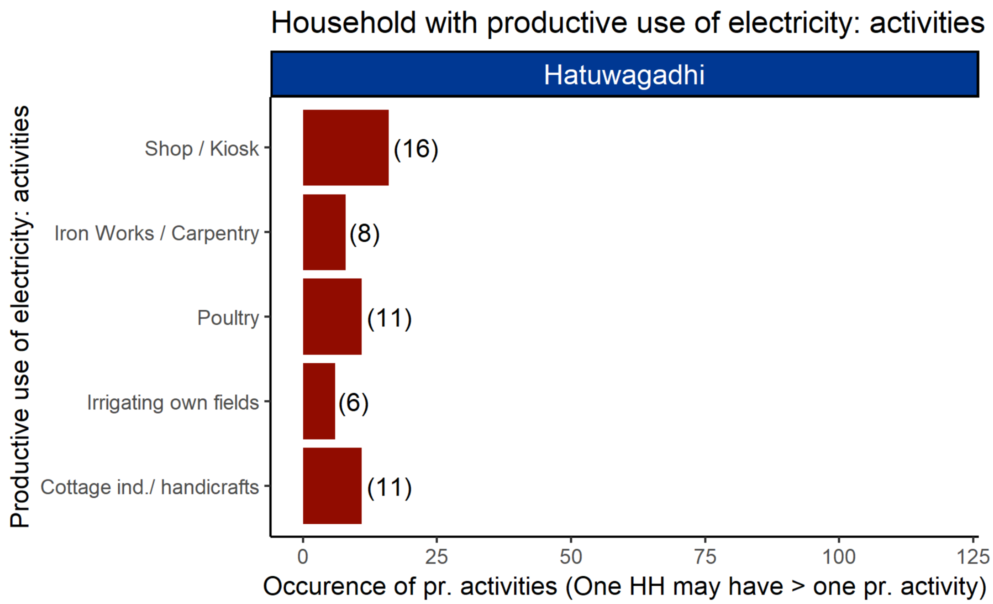

Figure 15: Household with productive use of electricity activities

4.1.5.2 Household non-electricity productive use

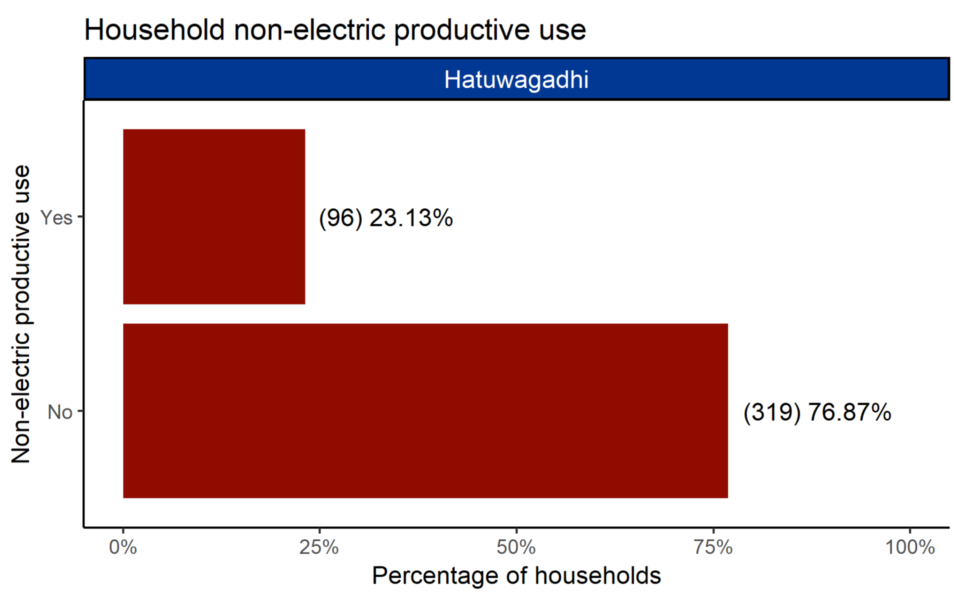

Figure 16: Household non-electric productive use

The income generating activities using energy other than from grid, mini-grid and SHS are categorized as non-electric productive use activities. It covers activities such as biomass, biogas and solar thermal technologies for heating, cooking, baking, drying etc.

Like electric productive use, HH non-electric productive use is also significantly low in Hatuwagadhi. Only 23% HHs are using non-electric productive activities. 21% HHs are using one non-electric productive activities, 2% HHs are using two non-electric productive activities and only one HH is using more than two non-electric productive activities. Non-electric energy is used for twelve different HH productive activities. Animal feed preparation and alcohol brewing are the two most popular non-electric productive use activities. Tailoring, Shops/kiosk and Iron works/rural carpentry are other commonly use activities. Major non-electric productive use activities in Hatuwagadhi RM is shown in the bar chart below.

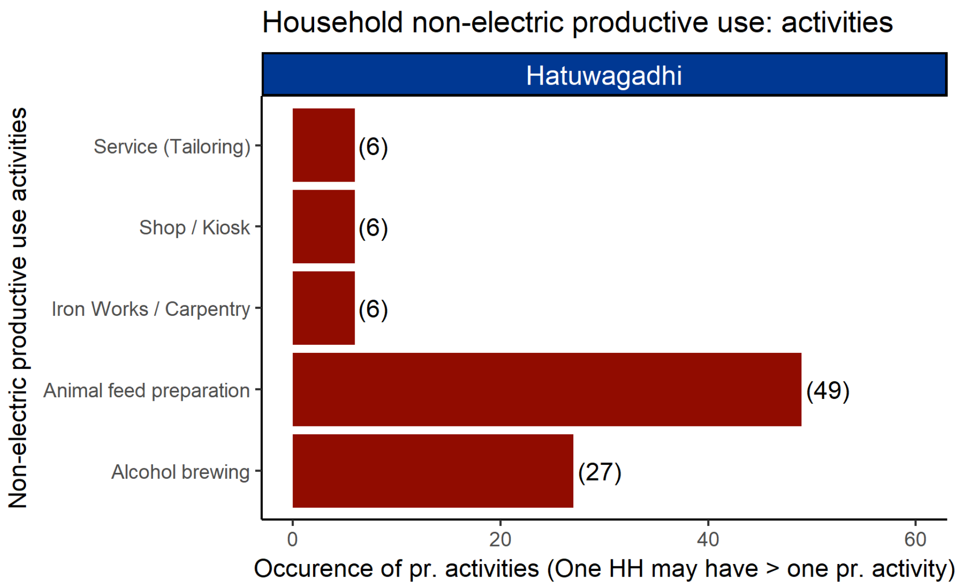

Figure 17: Household non-electric productive use activities

4.1.6 *Measurement of energy access using MTF*

Measuring energy access using binary indicators can be often misleading as it does not say anything about the quality and adequacy of the service. 97% HHs in Hatuwagadhi has electricity access, hence from the binary perspective, we can say the access is good. However, more than 1/3rd HHs have expressed their dissatisfaction on electricity service they are getting. Hence, it is important to look beyond 'connection' to measure energy access, which is the primary reason for developing the multitier framework.

The MTF was developed by World Bank acting in the role of the SE4ALL Knowledge Hub, with the support of the Energy Sector Management Assistance Program (ESMAP) (The World Bank Group, 2015). MTF not only measures energy accessibility, but also looks into attributes such as adequacy, quality, reliability, affordability, safety and availability (Rysankova, Portale, & Carletto, 2016). The MTF developed by the World Bank for HH electricity supply is presented in the annex 7.5.

However, assessment of these attributes as per the World Bank definition is practically challenging. Various studies from the past has also highlighted that capturing aspects such as reliability, legality, quality and health & safety through respondent surveys is extremely challenging because the acceptance level of these attributes widely vary depending on the context of a specific country. Also, the responses are at times subjective and respondent's recall of prior incidences may not accurately reflect what actually had happened in the past (Pelz, Pachauri, & Groh, 2018). Hence, the decision heuristic for defining these attributes have been modified to fit to the surveyed municipality's context. The revised indicators for measuring these attributes are presented in the table below.

Table 1: Revised indicators for measuring MTF attributes

Attributes	Applicability		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity	All	Grid/minigrid: Fuse size (amps) DG: Nominal Peak Power (W) SHS: Nominal PV Output (W)		Min 3W & Functional Pico	Min 50W	Min 200W	Min 800W or 5 - 15 amp	Min 2kW or ≥ 15 amp
Duration	All	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs

Reliability	Grid Minigrid						Otherwise	Grid load shedding months = 0
Quality	Grid Minigrid					Otherwis e	No Damages to appliances but light flickering	No damage to appliance s and no light flickering
Legality	Grid Minigrid					Otherwis e		Pay to legal entity
Health & Safety	Grid/min igrid					Otherwis e		No exposed wires

The attribute tier distribution of Hatuwagadhi RM is depicted below:

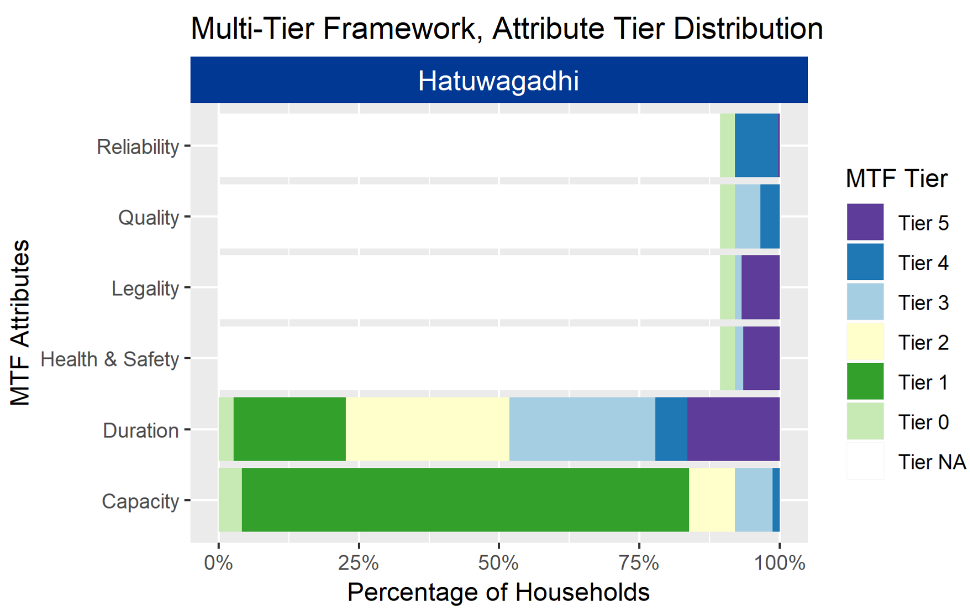

Figure 18: Multi-tier framework: attribute tier distribution

80% HHs of Hatuwagadhi RM are connected with solar lantern or SHS with peak power between 3 to 49W, hence they fall in the tier 1 category in terms of the *Capacity* attribute. These HHs have enough electricity to access basic service such as lighting and mobile phone charging. 8% HHs have 50-199W capacities and falls in tier 2 whereas 7% HHs are in tier 3, with access to 200-799W electricity capacity. About 8% of HHs in this municipality are connected to the national grid or minigrid. And just 1% of those HHs are connected with 5 – 15 amp fuse size, hence falling into tier 4. None of the HHs have fuse size greater than 15 amp or are connected with more than 2kW solar system, so there is not a single HH that falls in tier 5 in Hatuwagadhi. About 4% HHs either don't have access to electricity or they possess non-functional solar lantern, hence falls in tier 0.

With regards to *Duration* attribute, 75% HHs are between tier 1 – 3 which means they have supply between 4 to 15 hours a day. 6% HHs have more than 16 hours of electricity supply and falls in tier 4 whereas 16% HHs have at least 23 hours of power supply and falls in tier 5. About 4% HHs don't have access to electricity supply hence falls in tier 0.

As shown in the table above, attributes related to *Reliability, Quality, Legality and Health & Safety* are applicable for grid and minigrid only. There is not even a single grid connected HH without a single load shedding in a month. So all 8% HHs connected to grid or minigrid falls in tier 4 with regards to the *Reliability* attribute. This shows that despite of grid connection, HHs are facing frequent unscheduled power outages, thus the reliability is poor. Poor reliability not only affects individuals and family life but it also impacts the development and economic condition of a country (Reinders & Kunaifi, 2018). "According to Murphy et al. (2014), a reduction in the number of outages from 100 days per year to 10 days per year corresponds to more than a two-fold increase in GDP per person" (Reinders & Kunaifi, 2018). Reliability of the system can be improved with frequency stabilization resulting from better matching of supply with demand and with fewer plant breakdowns (The World Bank Group, 2015).

All 8% HHs connected with grid or minigrid appears to have voltage problem. Because of the voltage fluctuation, they have problem with flickering lights or even damage to their appliances. About 3% of the HHs reported to having flickering lights hence falls in tier 4 with regards to *Quality* attribute, whereas about 4% of the HHs reported damages to their appliances and falls in tier 3 with respect to Quality attribute.

7% of the 8%HHs connected with grid are paying bills to the legal entity hence they fall in tier 5 with respect to *Legality* attribute. For grid connected HHs, Nepal Electricity Authority is the legal entity and for minigid connected HHs local micro hydro management committees are the legal entity. About 1% HHs are defaulters and falls in tier 3.

With respect to *Health & Safety attribute*, 7% HHs reported to have proper wiring so they do not perceive high risk using electricity services and fall in tier 5. About 1% HHs reported having exposed wires and falls in tier 3.

The final tier distribution of the MTF is derived based on the lowest performing attribute (Pelz, Pachauri, & Groh, 2018). In case of Hatuwagadhi RM, the Capacity attribute is the least performing attribute hence the final tier distribution is the reflection of this attribute. The final tier distribution is shown in the figure below, which shows 80% HHs fall in tier 1 with respect to electricity access.

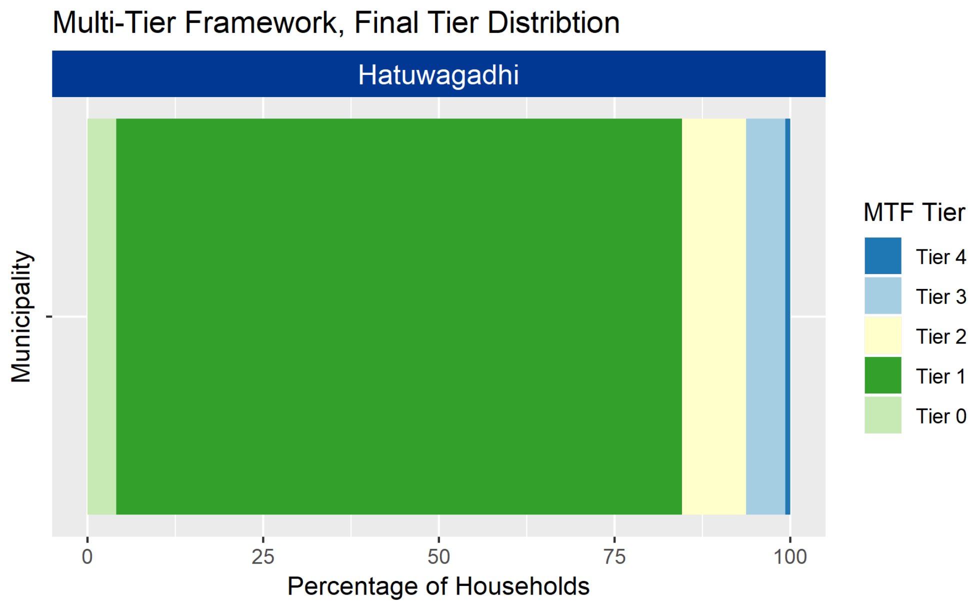

Figure 19: Multi-tier framework, final tier distribution

4.1.7 *Indicative consumer preference of energy service bundles*

Consumer's preference of electrical appliances was assessed at three levels. The respondents were asked about the appliances they currently own, appliances they think are basic or mandatory for day to day operations and electrical appliances they would aspire to have, if the electricity supply improves in the future. These information are important to assess current demand as well as forecast future electricity demand for that particular municipality.

The result shows that most of the appliances they own fall into tier one and two category. Most of those appliances serves for basic lighting and entertainment & communication. Mobile phone and LED room light are the two most commonly owned electrical appliances as more than 80% HHs own these two appliances. Respondents think these are also the basic appliances they should own. This finding is in line with the World Bank's assessment which claims that lighting and mobile services are the first critical application for those HHs just about to climb the energy ladder as access to lighting and mobile charging enhances economic activity, improves public health and safety and boosts social connectivity (The International Bank for Reconstruction And Development / THE WORLD BANK GROUP, 2015). However particularly in case of LED lights, even though they are categorized as Tier 2 appliances and almost 80% of the households own it, the final multi-tier framework in figure 19 shows only 10-15% of households in falling under the tier 2 category. This is because, most of the households' total load connection in Hautwagadhi does not exceed 50 W. Thus under the *capacity* attribute of the MTF, these households fall under Tier 1 even if they own and use multiple LED bulbs for lighting.

The other popular appliances owned by HHs are radio, smart phone/tablet, task light/torch and TV which again are appliances for lighting and entertainment & communication. Fan and fridge are the only two appliances which they own and used for other services than lighting and entertainment & communication. However, the current ownership of fan and fridge is less than 2%. Fridge is the only tier 3 appliance they currently own.

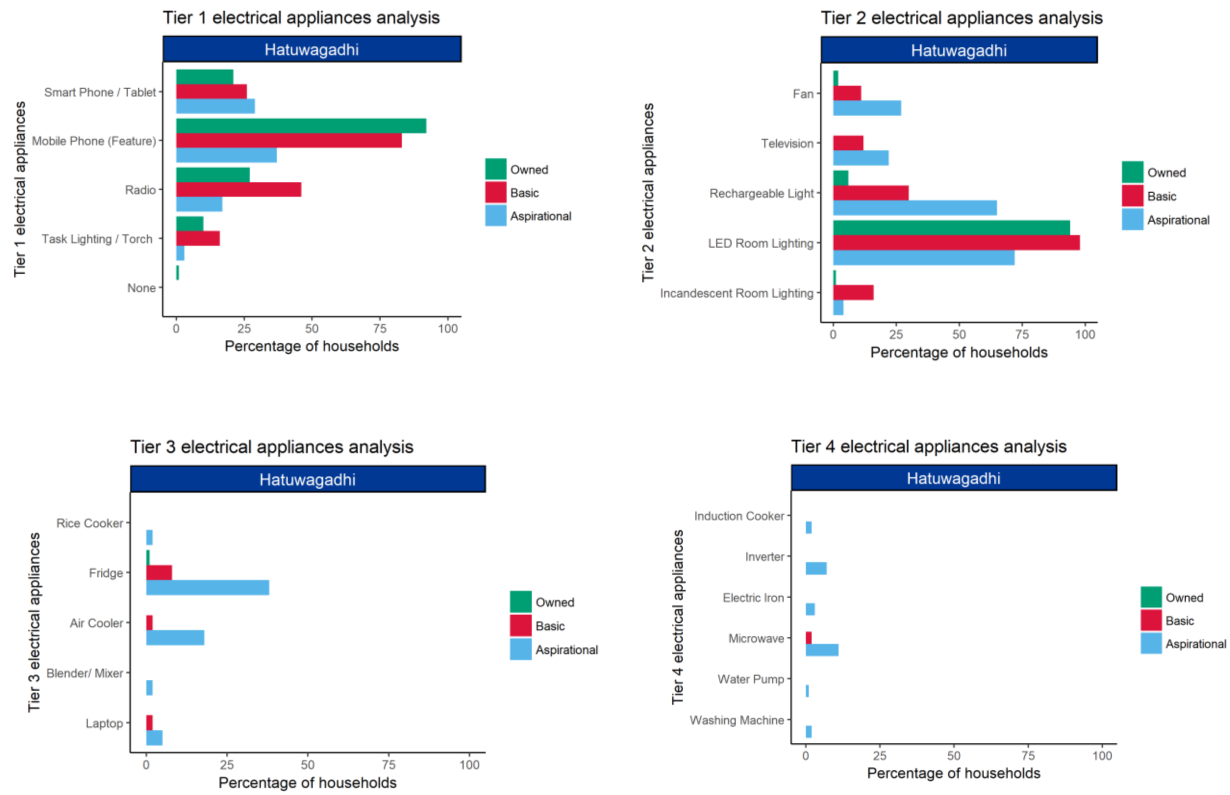

Figure 20: Electrical appliances analysis

Radio, smart phone/tablet, task light/torch, TV, fan and fridge, still remains the basic or the mandatory appliances for most HHs. Percentage HHs claiming these appliances as mandatory is higher compared to the current ownership. In addition, few respondents also think air cooler, laptop and microwave are basic appliances.

With regards to aspiration, the choices are more scattered between tier 1 and tier 4 appliances. LED light, rechargeable light, fridge, mobile phone and the smart phone are the top five appliances HHs aspired to have. But the HHs also aspire to high power appliances such as microwave, air cooler, inverter, electrical iron, washing machine, rice cooker, blender, induction cooker and water pump, which falls into tier 3 and 4, and were not in their preference list before. And, interestingly, none of the tier 5 appliances are owned or considered as basic or even considered as aspiration for them. Thus, for energy planning, it is important to consider these HHs aspiration and prepare municipal energy plan to fulfill these aspirations.

4.1.8 *Indicative affordability analysis of energy access*

Indicative affordability analysis of energy access is crucial to determine the willingness of the households to pay for certain energy facilities. The analysis could be pivotal for the future demand assessment of the municipality.

4.1.8.1 Indicative ability to afford electricity service improvement

The HHs ability to afford for electricity service improvement was assessed using the Contingent Valuation method. The respondents were asked to choose between three packages, each package consisting of combination of different electrical appliances, timing and duration of electricity supply and price tag.

The details in each package is enlisted in the table below:

Table 2: Package details for contingent valuation (Electricity)

Package	Package 1	Package 2	Package 3
Availability of electricity	Morning: 2hrs Evening: 2 hrs Total: 4 hrs	Morning: 3hrs Evening: 3 hrs Total: 8 hrs	Morning: 5hrs Evening: 5 hrs Total: 23 hrs
Appliances	LED light, Mobile, LED TV and Fan	Fridge, Mixer/blender Rice Cooker and Water Pump	Iron, Microwave, water heating Rod and electric cooker
Monthly cost	NRs 200	NRs 900	NRs 1700

Package one consist of up to tier 2 appliances with 4 hours of total electricity supply and minimum of 2 hours supply in morning and evenings. Package two comprise of up to tier 3 appliances with 8 hours of total electricity supply and minimum of 3 hours supply in the morning and evenings. Package three consist of up to tier 4 appliances with 23 hours of total electricity supply and minimum of 5 hours supply in morning and evenings.

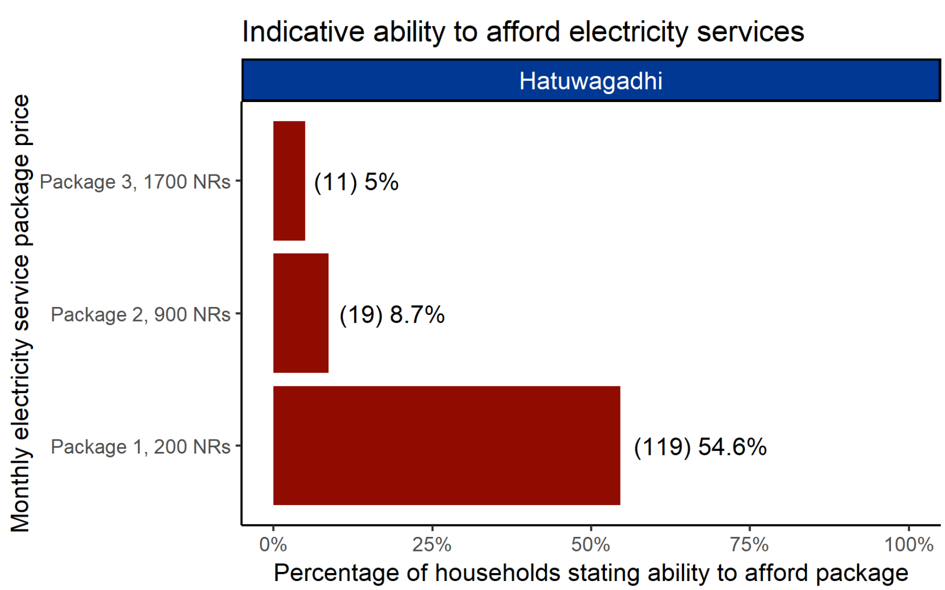

Figure 21: Indicative ability to afford electricity services

Among 218 respondents, majority (55%) of them expressed their ability to pay upto Nrs. 200 per month for electricity service. About 9% were willing to pay up to Nrs. 900 per month whereas only 5% of the respondents were willing to pay up to NRs. 1700 per month. Most HHs appears to be satisfied with lower tier electrical appliances that could fulfill basic lighting and communication & information needs. Several socio-economic and demographic factors such as income, education level, family size, ethnicity, age affects willingness to pay for these kind of services (Abdullah & Mariel, 2009), hence it is difficult to draw the exact reason for their unwillingness to pay for higher tier appliances and for better service. However, NRs 200 is comparatively higher than most HHs are currently paying for grid electricity supply. Most HHs in Hatuwagadhi RM are currently paying NRs 80 per month for micro-hydro grid. For national grid the minimum tariff rate is NRs 90 per month ((Nepal Electricity Authority, 2017).

4.1.8.2 Indicative ability to afford cooking service improvement

The HHs ability to afford for cooking service improvement was also assessed using Contingent Valuation method. The respondents were asked to choose between three packages, each package consisting of combination of different stoves, fuel collection time (in hours/ week), stove preparation time (in minutes), fuel availability and monthly fuel consumption and monthly cost of fuel supply.

The three different cooking service packages are shown in table below:

Table 3: Package details for contingent valuation (Cooking Services)

Package	Package 1	Package 2	Package 3
Type of stove	100% ICS	50% ICS, 50% LPG	100% LPG
Fuel collection time	< 7 hours per week	<3 hours per week	<0.5 hours per week
Stove preparation time	<15 minutes	<10 minutes	<2 minutes
Availability of fuel	< 10 months in a year	>10 months in a year	Throughout year
Monthly fuel consumption	100 kg wood	50 kg wood, ½ LPG cylinder	1 LPG cylinder
Monthly cost	NRs 500	NRs 900	NRs 1300

The respondents were asked if they could afford the lowest package. In case of acceptance, they were asked to bid for the second package and similarly for the third one.

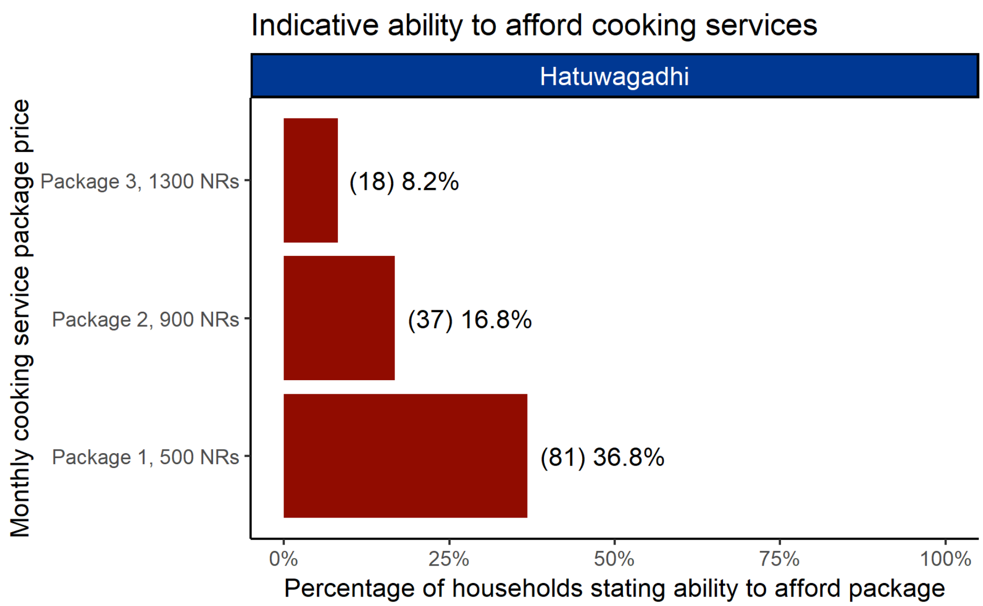

Figure 22: Indicative ability to afford electricity services

Among 218 respondents, 63% respondent couldn't even afford the lowest bid amount. This could be because most HHs are using firewood for cooking which they are getting for almost free of cost. As per our survey, 93% respondents are not paying for firewood. Most of the HHs are the member of community forest users groups (CFUGs) for which they are paying between NRs 25 - 100 per annum. As a member of CFUGs, they are allowed collect fuelwood free of cost, once or twice a year, from the respective community forest in which they are the member. So only cost implication for them is for cutting and transporting the fuel wood from the community forest to their HHs.

37% of the respondents expressed their ability to pay up to NRs. 500 per month for the cooking service improvement whereas 17% of them could afford package two costing NRs 900 per month. Though the use of LPG is on the rise, only 8% HHs expressed their ability to afford NRs 1300 per month which comprise of sole LPG use. Currently, only about 6% HHs are using LPG stove and they are paying between NRs 1500 – 2200. And for most of those HHs the annual consumption is between one to six cylinders as they are also simultaneously using firewood stove for cooking.

4.2 Challenges to Improve Energy Access

4.2.1 General users

Energy service satisfaction

SHS and solar lantern are the major sources electricity in the general users HHs of Hatuwagadhi, with most HHs using a 20W capacity system and a few with 10W capacity system.

As per the data from the survey and FGD, most participants showed their dissatisfaction with regard to their current electricity service access, as these sources are sufficient only for basic lighting and mobile charging services. Most of them consider LED bulb and mobile as the basic electrical appliances.

Furthermore, the supply is limited during winter and monsoon season. Morning and evening are the most important periods for electricity availability in the HHs. Minor maintenance of the solar electricity system can be done locally though there are no sales agent of solar companies in this municipality. In general, the users appear to have sound knowledge on different types of electrical appliances even though such appliances are not in use in most households.

Firewood appears to be adequately available in Hatuwagadhi RM, mostly obtained from community forests at minimum costs. The general users HHs are allowed to harvest firewood from the community forest, once or twice a year at a nominal price of NRs 50 per year. About 66% of firewood is used for preparing animal fodders whereas about 33% is used for HH cooking. Few HHs, those who can afford, are using rice cookers and LPG for cooking. LPG at the moment is expensive mainly due to high transportation costs.

Energy service desire

Television and computer are the two most preferred electrical appliances they would prefer to buy on accessing sufficient electricity. Most of them think that biomass will continue to remain the main cooking fuel source for a long term mainly due to the easy accessibility and low cost of fuel wood. However, people are willing to use LPG given that it is affordable, reliable and readily available.

Most of the participants think that firewood will remain the primary fuel for preparing animal fodder and alcohol brewing even in the future. But they would prefer to have certain improvement in existing design such as stoves with 3 to 4 potholes and of modular design. None of the respondents reported using energy for space heating.

The participants also believe that access to more reliable and modern sources of energy can contribute towards improvement of their livelihood. They think that with reliable source of electricity, more people will be involved in business and enterprises like carpentry, agro processing and tailoring. Also, they believe that the productivity would increase as better agricultural irrigation can be done.

Sources and access to information

Most HHs amongst the general users lack information and knowledge of various RETs subsidy policies, with most having had installed the SHS system without subsidy. They are not aware about institutions from where they can acquire information on subsidies. The participants suggested the opening of an information center either at RM or ward office.

Energy governance/ Participatory planning

At present, there are no dedicated group or committee to discuss on energy related issues in the RM. Access to national grid is the main priority for the HHs and the main focus of all energy related discussions despite several other option to access electricity. The off grid solution does not appear to be in their priority list. However, there are instances where villagers have put in their own efforts to develop micro-hydro, but unfortunately could not be materialized due to lack of budget.

The user's committees/groups appears to be the most functional forum to discuss on various development issues. Participation of women and DAG is mandatory, hence there is fair representation of women and DAG members in such committees/groups. In some of the committees and groups, women and DAG are in key decision making positions as well. They believe the practices on inclusion have brought some positive changes as the women and DAG are now more aware about different technologies, opportunities and policies compared to the past.

A few trainings and workshops on energy related issues are organized in the RM, however participation is high only for those provisioned with allowance. Also, there are no formal grievances handling office with people generally expresses their complaints in ward offices.

The group feels that the energy governance could be improved by building awareness and capacities of local people on energy technologies and policies.

Political barriers

One of the major barriers foreseen by general public is lack of policies and plans to guide the people for the promotion of RETs. Transparency in ongoing RE projects is another issue raised by general public. People demanded for good governance in on going energy projects to build back their confidence.

Technical barriers

People are limited to small scale technology solutions for energy access which can't fulfill their basic energy needs. After sales service is also an issue with regards to solar home system. Though the production of high value crops is high, efficient processing technologies are not available as much. Also, potential market for product sales is scarce.

Socio-cultural barriers

Scattered settlement pattern is one of the major challenges to provide basic facilities such as drinking water and energy services in HHs. Also, migration is another serious concern for the municipality. People with relatively good source of income are migrating to the terai for a better life.

Financial barriers

Most of the population in the RM are economically weak so many cannot afford bigger energy systems required to fulfill their energy needs. Due to the low income status, people are less willing to contribute in community work.

4.2.2 Disadvantaged groups

Energy service satisfaction

Solar lantern is the main source of electricity in most DAG HHs with only a few having access to SHS. The electricity available is only sufficient to charge mobile phones and provide basic lighting facility. However, these low capacity systems are unable to provide even such basic facilities during winter and foggy days. Despite these facts, DAG households seem to be relatively happy with their current electricity source. For them, electricity supply is important during early morning and late evenings. They consider LED lights and mobiles as basic electrical appliances. TV and rice cookers are considered as luxurious electrical appliances.

Though there are few local promoters and shops to buy electrical appliances, the after sales service is relatively poor. They complained of the lack of solar technicians.

Firewood is the major fuel for cooking which appears to be adequately available in their village, from the nearby community forests, at relatively low price. 30kg firewood is obtained just at NRs 7.5. In addition, twigs, dead tree and fallen trees can be collected for free. However, in some cases, they need to pay additional NRs 100 for the transportation of firewood to their HHs. The annual consumption of firewood is between 3 to 3.5 tons.

Energy service desire

If the electricity is sufficiently available, they are willing to use appliances such as television and rice cooker in their HHs. In such case, they are also willing to establish enterprises such as poultry and hotels. Also, they see such a scenario as an opportunity to enhance their skills as electrician and in the field of agriculture and generate additional income for their HHs.

In terms of cooking, LPG is the most preferred cooking appliance. However, due to the high initial as well as operation cost of such stoves, all households would not be able to afford it at the moment. Hence many believe high quality ICS would be good enough for them. The participants believe that replacing current cooking sources completely by LPG and electricity would take considerable time. They feel firewood will remain the main fuel for preparing animal fodder and alcohol brewing even in the future hence stressed the need to improve the quality of cook stoves for preparing animal fodder and alcohol brewing. Also, they suggested to enhance skills of the ICS promoter for the same.

Sources and access to information

In general, most of the participants appear to have sound information on various RETs and RE projects in their villages. At present, there are no authorized information center to aware or provide information on energy technologies, energy service providers, subsidy and energy policies. Most participants seemed aware of the subsidy policy however affordability was an issue even after subsidy.

Energy governance/ Participatory planning

The DAGs are generally invited, often to fulfill the quota, and have been participating in various planning meetings and training programs. They are allowed to express their views openly and they feel that their voices are also often heard.

Now-a-days there is fair representation of DAG in different committees and user's group. A major reason for this is the mandatory provision to have representation from DAG in such committees and groups.

Political barriers

Participants expressed their dissatisfaction over the pace of project implementation by government bodies. However, they see local government institutions (ward offices and rural municipality) as a forum where that can openly express their dissatisfaction or grievances.

Technical barriers

National grid has been recently connected to one of the wards of Hatuwagadhi RM, hence most of them are hopeful that they will be connected to the national grid in next two years. However, the topography and the geographical extremities of the area along with the scattered settlements hinder the smooth connection to the grid.

With respect to access to clean cooking solutions, most of them think that affordability would be the major challenge for them. They feel they will not be able to afford modern cooking and heating solutions due to poverty.

Socio-cultural barriers

Compared to a few years back, the DAG group feel the level discrimination to have lessened. They seem to be happy with the opportunities they are getting to participate in training and workshops. They consider capacity building as the crucial factor to empower DAG and encourage them to access energy services and engage in income generating productive activities.

Financial barriers

Access to financial institution does not appear to be an issue for DAG community. Some of the financial institutions even provide subsidized loan, with 1% less interest, than for other communities. In the past, solar lantern were also distributed by VDCs for some of the poor DAG households. Also, there is a provision to access loan without collateral for buying RETs or for PEU activities but only against group guarantee.

4.2.3 Women group

Energy service satisfaction

SHS and solar lantern are the major sources of electricity in most HHs. However, they not satisfied with the electricity service they are getting from these sources mainly because of inadequate supply. The available electricity is not sufficient to operate all mandatory electric appliances such as mobile, lights and water heater. The supply is limited during winter and monsoon season. Three hours in the Morning (4-7AM) and six in the evening (5-11PM) are important period for women to have electricity in their HHs. Minor maintenance of the solar electricity system can be done locally. There are couple of service providers in Ghoretar Bazar, which is the main market center in this RM.

Firewood appears to be adequately available in Hatuwagadhi RM. Most of them get firewood from community forest at almost no cost. They are allowed to harvest firewood once or twice a year from the community forest for which they have to contribute about 15 working days for wood cutting. And interestingly, about 75% of the firewood is used for preparing animal fodders whereas about 25% is used for HH cooking.

Energy service desire

In case of sufficient access to electricity, they are willing to add in higher power appliances such as television, water heater and fridge and have shown willingness to pay up to NRs 250-300 per month for it. In future, they are hopeful either LPG or electricity would replace traditional cook stoves. But given the choice, they would prefer to use LPG for cooking rather than electricity as they perceive electricity will not be a reliable source for cooking. However, they would prefer to stick with firewood for preparing animal fodder and alcohol brewing even in the future. However, they would appreciate improvements in cook stoves for preparing animal fodder and alcohol brewing.

Currently energy is primarily used for cooking and lighting. None of the respondents reported using energy for space heating. Limited access to reliable and quality energy supply appears to have severely affected productivity and economic activity. In case of improved supply, may of the respondents expressed their willingness to open up hotels and poultry business which could boost their income opportunities.

Sources and access to information

Women appear to have limited access to information on energy access, service and policies. There are no authorized information centers provide awareness and information on energy technologies, energy service providers, subsidy and energy policies. Very few of the participants were aware of subsidy policy on RETs though few of them had acquired subsidy for the installation of SHS in their homes.

Energy governance/ Participatory planning

Women's participation in development planning meeting appears appreciable. Most of them have expressed benefits of participating in such meetings as it is a source of information. The participants also mentioned of their suggestion and demands being addressed in these meetings.

Many of them gave an example of the extension of national grid which was one of their major demands. They have even stressed that there should be participation of both and male and female members of each HH in such meetings so that they are well informed and can take collective decision for the benefitting of the HH. Some of them have even expressed that women participation on such meetings is even more vital as women are more affected by the type and availability of energy service compared to men.

Traditionally women are considered to be responsible for many HH chores such as cooking, cleaning, baby-sitting and preparing animal fodders. But it appears that women in Hatuwagadhi are not restricted to HH activities only and participate in different meetings and capacity building activities. In fact, representation of women is mandatory in different user's committees and community groups. But because of the immense work load, most women are reluctant to take responsibilities in these kinds of committees and groups.

Political barriers

Most of the participants have expressed a positive opinion on the local government agencies (ward offices and RM office). They see these institutions as a forum where they can openly express their dissatisfaction or grievances however they have stressed the need to formulate long term energy policy to improve energy access in the RM.

Technical barriers

Most of them expect the HHs within Hatuwagadhi RM to be connected to national grid in next two years. The national grid has been connected to one of the wards recently but connection to the remaining HHs is expected to take some time due to the scattered settlement pattern.

With respect to access to clean cooking solutions, most of them think that accessibility would be a major challenge. Nevertheless, they are hopeful that they will have access to clean cooking solution in the near future. They feel fuel availability and affordability will be the major influencing factors for the selection of particular type of stove.

Socio-cultural barriers

Though there is lesser restriction for women to participate in trainings and out of HH activities, they feel the need to further raise awareness among women on GESI and build their capacities on different occupations so as to ensure further empowerment. However, many participants demanded for these awareness and capacity building programs to organize closer to their dwellings/villages.

Financial barriers

Major financial decisions are generally made jointly by male and female member of the HH. Financial schemes are available to buy SHS and in addition there are some women friendly schemes such as women saving groups, especial financial provision for single women, pregnant women which could be utilized to purchase RETs as well as to establish energy enterprises. Also, there is provision to access loan without collateral for buying RETs or for PEU activities but only against group guarantee.

4.3 Access to Infrastructure

There are two major roads to reach Hatuwagadhi Rural municipality, one connecting it to Bhojpur Bazar and the other to Machuwatar. The distance from Hatuwagadhi to Bhojpur Bazar is 46 km and takes about 5 hours by Jeep. The RM is 17 kms form Machuwatar which takes about two hours to reach by Jeep. The roads are earthen and hence are not accessible throughout the year. Similarly, there is a road connection to each wards but the condition is poor hence most are seasonal. There is limited public transport facility. There are facilities for hiring jeeps however the costs are very high.

High quality health services are scarce in the rural municipality of Hatuwagadhi. Only one Primary Health Care facility is available in the entire RM located in ward 1. There are 6 health posts in the municipality which are hardly sufficient to facilitate the entire population of the municipality. In addition, 2 birthing centers have been established in wards 1 and 8.

There are a total of 39 schools in the municipality, of which 31 are primary (classes 1-8), 5 secondary (classes 8-10) and 1 higher secondary (10+2). In addition, there are two private boarding schools as well. But surprisingly there is not even a single college for higher education in this RM.

Municipality has been recently (bhadra 2074) connected to national grid but the grid connection to limited few households of ward no 1, where the municipality office is located. The quality of grid is poor. Frequent power cuts are common. There is no NEA office yet but they are planning to setup their office soon. In addition, there are three micro hydro projects are in operation at Ranibas, Syndrang and Machuwatar. The combined power output from all three micro hydro plants is less than 100kW. The Municipality aims to provide access to national grid to all households within five years. So the municipality is erecting electric poles on its own budget to expedite the distribution lines.

Currently, there are 39 water supply schemes in this RM but it is far from sufficient to quench the thirst of many inhabitants of the municipality. Water supply schemes are one of the most demanded project types from local communities.

Ghoretar ward-1 and Hasanpur ward-9 Bazar are the two major market place in the municipality. Ghoretar is the only location with a permanent market. Weekly markets (Haat Bazar) are organized every Wednesday in Ghoretar and every Friday in Hasanpur.

4.4 Present Uses of Energy in the Enterprise and Institutional Sector

4.4.1 Present uses of the energy in enterprise

4.4.1.1 Types, number and ownership

Fifteen different types of enterprises have been identified in Hatuwagadhi RM. Among these, small shops/kiosks are the most common and predominant type of enterprises constituting about 52% of the total enterprises in the RM. The second most dominant type are hotel and restaurants which is about 20% of the total number of enterprises in the municipality. Diesel based agro processing mills (8%), Tailoring (5%), Traditional Blacksmith (4%), IT Service (3%) and Goat Farm (3%) are the other types of enterprises.

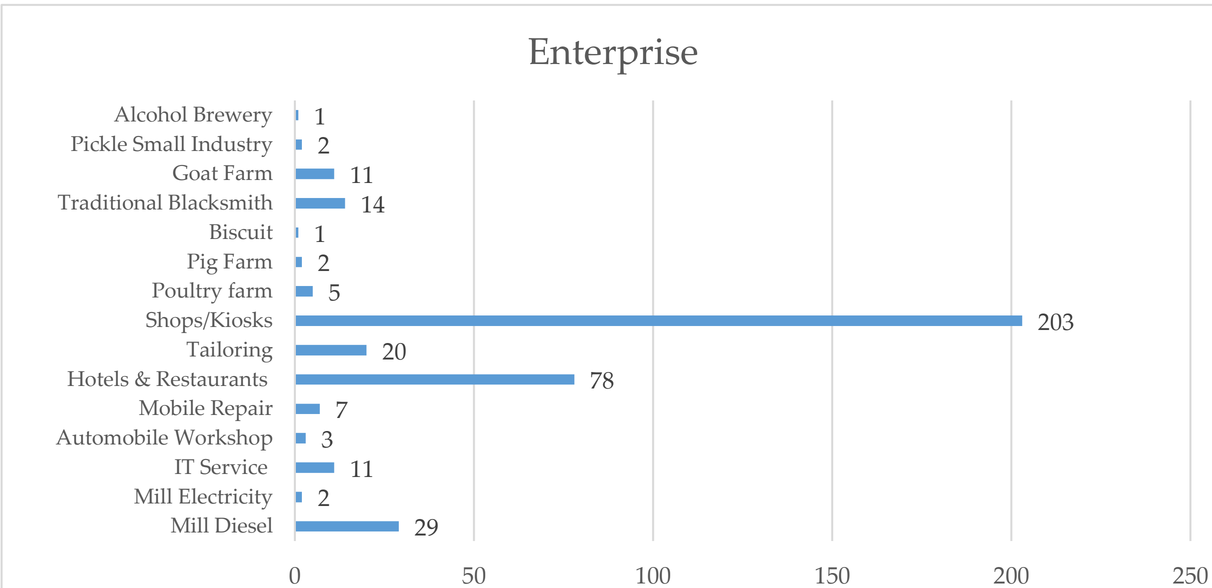

Figure 23: Enterprise type and number

A significant number of the enterprises have been operating in the RM without any formal registration. Only 62% operating enterprises have been registered whereas 38% are operating without formal registration.

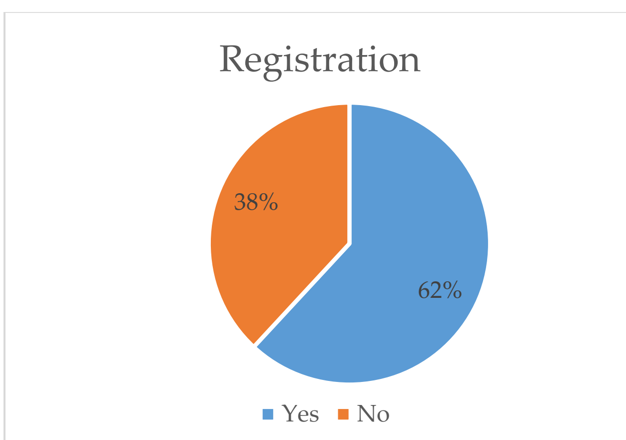

Figure 24: Registration status of enterprises in Hatuwagadhi

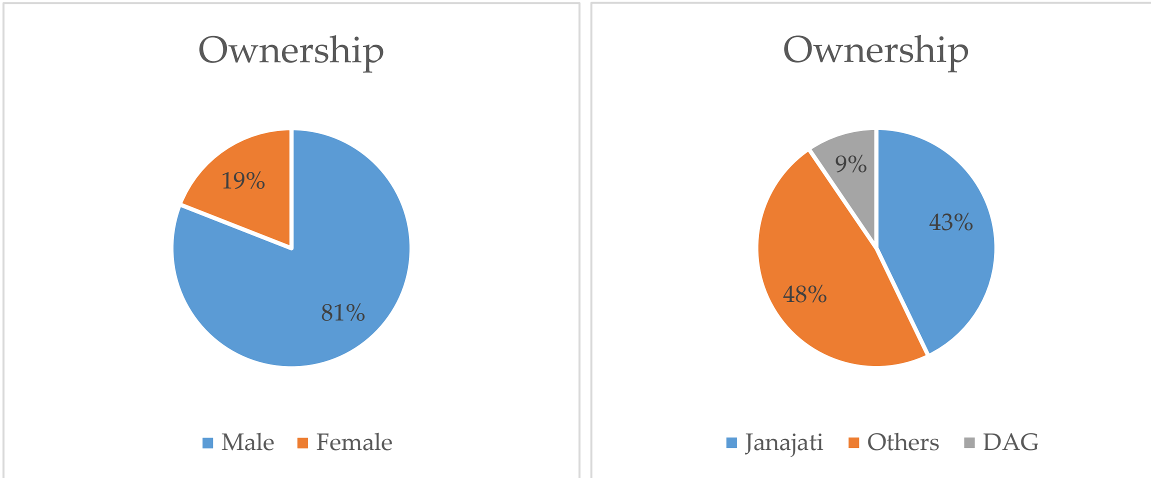

Figure 25: Enterprise ownership on the basis of gender and population subtype

From gender perspective, enterprises are predominantly owned by male. About 81% of the enterprises are owned by male whereas only 19% by female. With regards to social inclusion, about 43% of the enterprises are owned by *Janajati*, 9% by ethnic *DAG* and 48% of enterprises are owned by *Other* sub-castes.

4.4.1.2 Types and sources of energy

Twenty enterprises of ten different types were surveyed to assess energy profiles of each. Except agro processing, the remaining enterprises required mechanical and/or thermal energy. The primary requirement of the Agro processing is mechanical energy.

Table 4: Energy source for enterprises

S No	Enterprise	Electrical			Mechanical	Thermal		
		NEA	Solar	Diesel	Diesel	LPG	Fuelwood	Charcoal
1	Agro Processing				✓			
2	IT Service	✓	✓					
3	Workshop	✓		✓				
4	Hotel/Restaurants	✓	✓			✓	✓	
5	Tailoring	✓	✓					✓
6	Shop/Kiosks	✓	✓					
7	Poultry Farm		✓				✓	
8	Pig/Goat Farm		✓				✓	
9	Traditional Blacksmith						✓	
10	Biscuit Factory		✓				✓	

Agro processing enterprise was solely dependent on diesel based mechanical energy whereas the remaining were using electrical and/or thermal energy. Except agro processing, all other enterprises were relying on more than one source of energy.

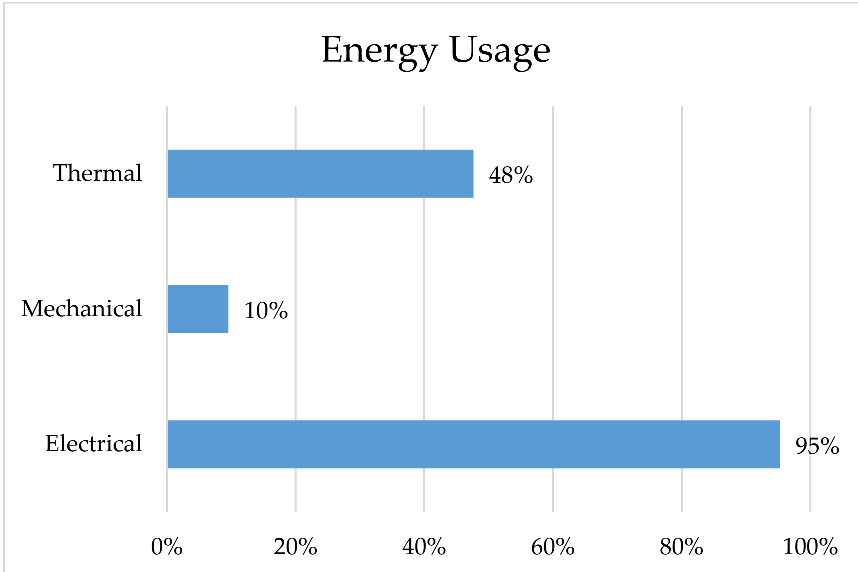

Figure 26: Enterprise energy usage

Amongst the 20 enterprises surveyed, 95% were relying on electrical energy. About 48% enterprises were using thermal energy and only 10% were using mechanical energy.

The electrical energy is mostly catered through solar systems (80%) and NEA grid (45%). Few interprises were generating electrical energy through diesel generator (15%). None of the enterprises were using micro-hydro grid for electricity supply.

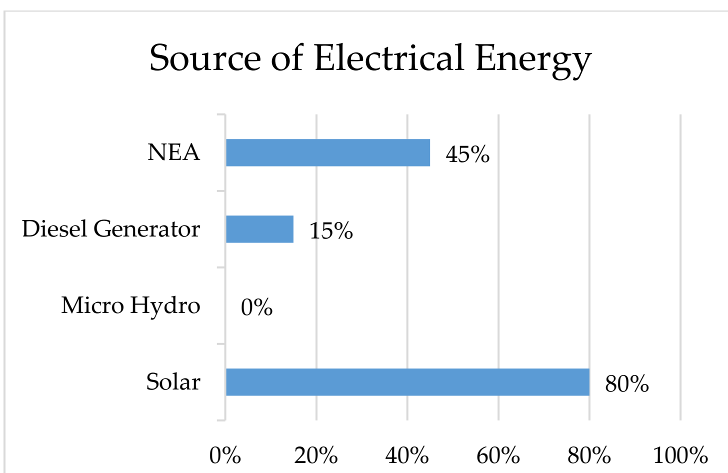

Figure 27: Electricity sources in enterprises

Thermal energy is generated from fuelwood, LPG and charcoal. However, fuelwood is the primary source for most of the industries. Some hotel/restuarants were using LPG as a source of cooking whereas charcoal use was exclusively observed in tailoring for ironing.

Average monthly electricity bill

The enterprises using national grid were found to pay between NRs 300 to NRs 3300 per month. Taking into acccont the new electriciity tarif rates, the electricity consumption is estimated to range between 30 to 250 units (kWh) per month. The automobile workshops are the highest consumer, paying upto NRs 3300 per month. These workshops use high power applinaces such as lathe machines, drilling, welding and cutting machines, thus resulting in higher power consumption.

IT service based enterprises are the second highest payers, with monthly bill at round NRs. 750. These enterprises use excessive energy for printing and photcopying hence the high monthly cost in comaprison to other industries. Tailoring industries make use of iron, fan and TV and have been paying around NRs 500 per month for electricity supply. The average payment of hotels and restaurants is NRs 400 per month. The electricity is primarily used for lighting and TV. Few have also been using appliances such as fridge for cooling foods. Shops/kiosks are paying upto NRs 300 per month with their primary electricity for lighting, communication and entertainment services. The average monthly electricity bill of different enterprises is presented in the figure below

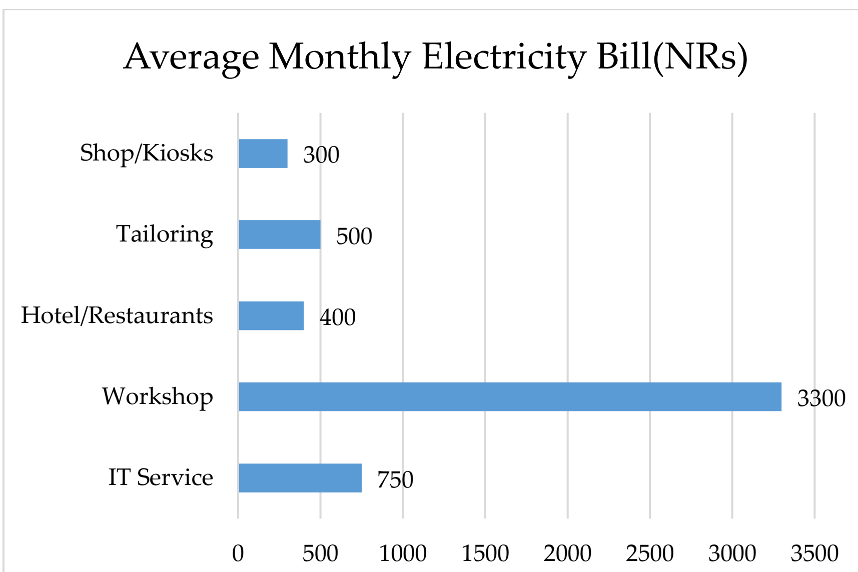

Figure 28: Average monthly electricity bill of enterprises

Capacity of Solar System

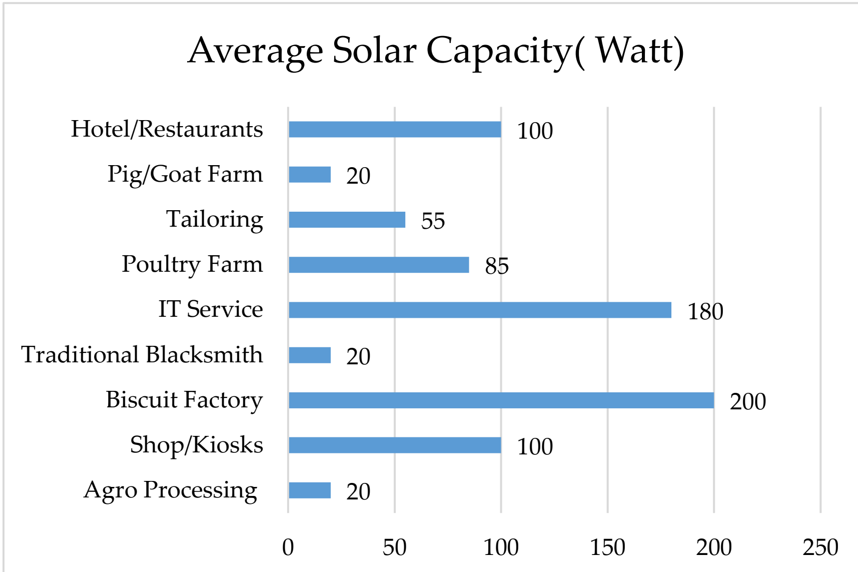

Figure 29: Average capacity of SHS installed in enterprises

The peak power of the installed solar system ranged between 20Wp to 200Wp. Buiscuit factory, IT enterprieses, hotels/restaurants, shop/kiosk and poultry farms are the top five enterprises have the highest installed capacity. In most of the enterprises, solar system is primarily used for lighting, mobile charging and entertainment. In enterprises such as IT service the electricity from solar system is also used for operating computers and for printing and photocopying.

Fuelwood consumption

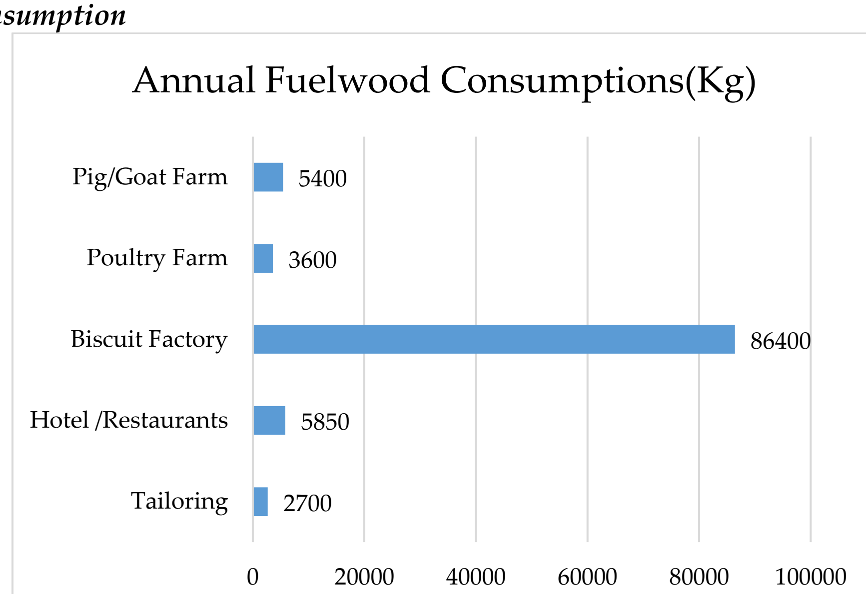

Figure 30: Annual fuelwood consumption in enterprises

Among five different fuel wood consuming enterprises, biscuit factory is by far the largest consumer of fuel wood with an annual consumption of about 86 tons. The fuel wood is used for baking biscuits in especially designed ovens. Hotel and restaurants consume about 6 tons of fuel wood each year and is the second largest fuel wood consumer. The fuel wood consumption in hotel and restaurants varied widely between 2 tons to 11 tons per annum. In addition to fuel wood, these enterprises also uses LPG. The average annual consumption of LPG was 2 cylinders per year. Pig/goat farm and poultry farm consumes about 5.4 tons and 3.6 tons of fuel wood. Fuel wood is primarily used for preparing fodders for animals and birds. Interestingly, tailoring enterprises consume 2.7 tons of fuel wood per annum. Fuel wood is primarily used for making charcoal for ironing.

Some of the tailor shops also buy charcoal directly from the market. Such tailor shops consume up to 500 kg of charcoal per year. In addition, traditional blacksmith also depend heavily on charcoal fuel. Charcoal is used for sintering of metals to give it the desired shape. The annual consumption of charcoal in traditional blacksmith was found to be 5.4 tons per annum.

Use of stoves

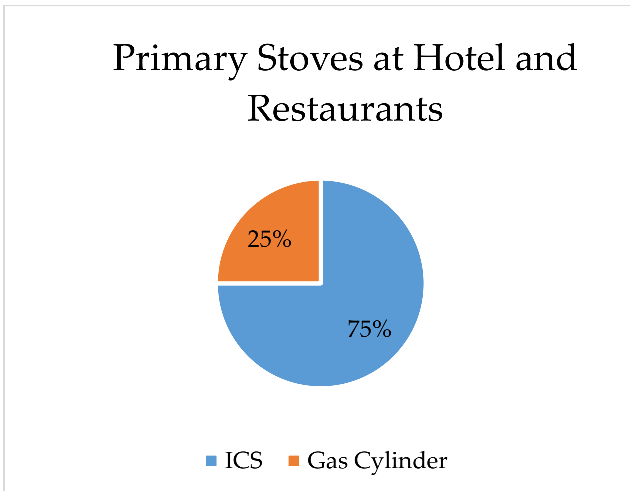

Figure 31: Stove use in enterprises

Various types of cook stoves are in use depending on the type of enterprises. As mentioned before, biscuit factories make use of specially designed oven to bake its products. Poultry and pig/goat farms utilize traditional cook stoves to prepare fodders for birds and animals. Traditional blacksmiths use open fire to prepare charcoal required for metal forming, whereas, hotels and restaurants use ICS and LPG for preparing food for guests. About 75% of the hotels/restaurants use ICS as their primary stoves whereas about 25% make use of LPG.

The penetration of ICS is limited to hotels and restaurants as most other enterprises use traditional cook stove for combustion. Hence, enterprises could be another potential area for the promotion of ICS and other energy efficient biomass combustion technologies.

Diesel consumption
Diesel based generators are used mainly in agro processing and automobile workshops. The average size of diesel generators was 7.5kW with the average monthly consumption of diesel at 42.5 liters for agro processing industry and 20 liters for automobile workshop.

4.4.1.3 Current and desired electrical load

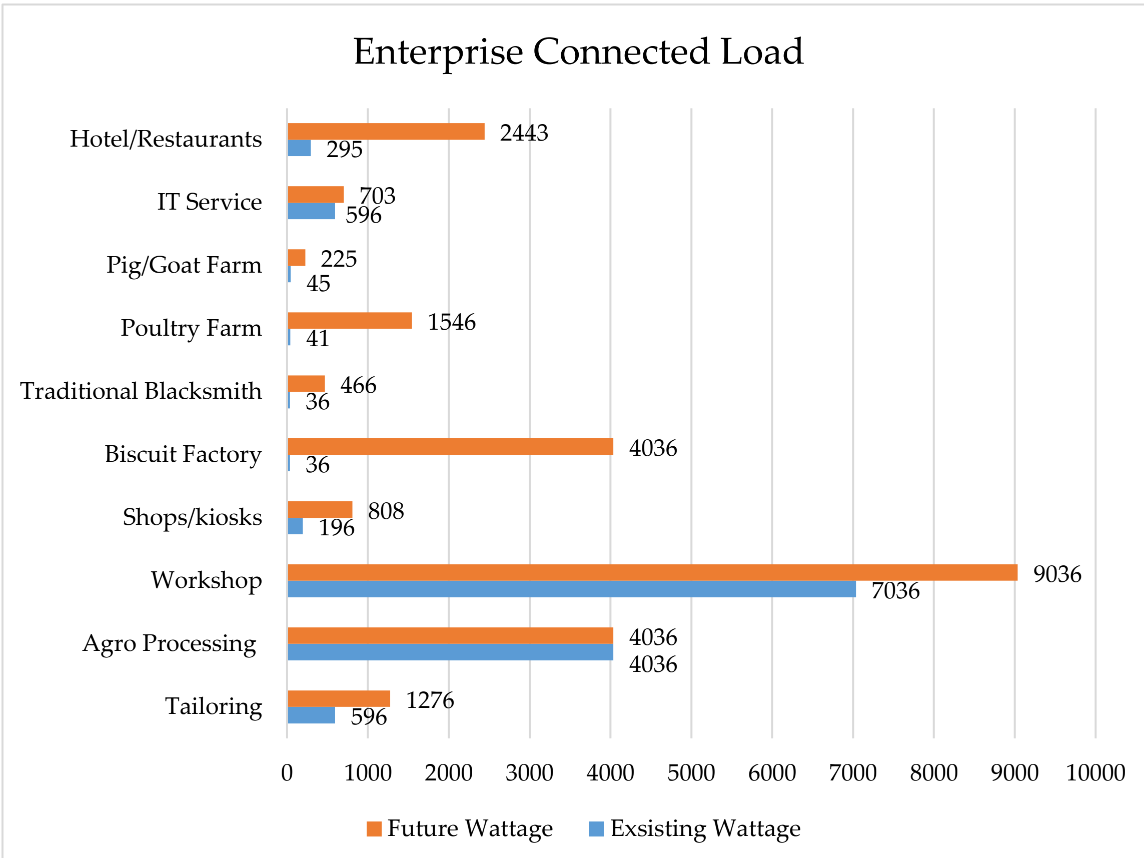

Figure 32: Connected load and future demand of enterprises

The electrical load consumption and projection is calculated taking into account the existing and desired appliances and the average wattage power of each appliance. The list of appliances that are in use and that are desired for future use for each type of enterprise was generated from field survey. For each type of appliances, the rated power was generated from literature review.

Based on the current use of appliances, automobile workshop has the highest connected load whereas biscuit factory and traditional blacksmith have the lowest connected load. Workshops make use of various types of high power appliances such as lathe, drilling and welding machines. However, in biscuit factories and traditional blacksmith, LED bulbs are the only types of appliances in use. Agro processing enterprises are the second largest load consuming sector followed by tailoring, IT service and hotels/restaurants.

If the electricity supply is adequately improved in the future, a significant increase in the desired load for each of these enterprises was observed. In such a scenario, the desired load in biscuit factory appears to increase by more than 110 times that of the existing load. This is mainly due to the enterprise's desire to shift to electrical oven from the existing fuel wood based oven. Other significant increment was observed in poultry farms (38 times), traditional blacksmith (13 times), hotels/restaurants (8 times), pig/goat farm (5 times) and shops/kiosks (4 times). In poultry and goat/pig farms, the major load consuming appliances will be freezer and heater. Traditional blacksmith desires to use fridge and fan in case of availability of electricity. Most of the hotels and restaurant would like to have geyser, fan and heater if the electricity supply is in adequate. Similarly, shops/kiosks would like to add on appliances such as fridge, TV and computers. However, only in the case of agro processing enterprise, the load is expected to remain the same.

4.4.2 Present uses of the energy in institutions

4.4.2.1 Types, sources and consumption of energy

Electrical energy is the main energy source in use in most institutions. Thermal energy is primarily used in army barracks and police stations. All institutions are depending on more than one source energy for electricity supply. NEA grid and solar are the two main sources of electrical energy. Fuelwood and kerosene are used for thermal energy generation and is limited to army barrack and police stations.

Table 5: Energy source for institutions

S.No	Institution	Electrical				Thermal		
		NEA	Micro Hydro	Solar	Diesel	LPG	Fuelwood	Kerosene
1	School							
2	Offices							
3	Police and Army Barrack							
4	Hospital							

Amongst 11 different institutions surveyed, 100% having been using electrical energy whereas only 18% are relying on thermal energy. The electrical energy is mostly catered through solar systems. 91% institutions have installed solar system for electrical energy. About 45% are also using NEA grid and just 9% of them are using micro hydro grid.

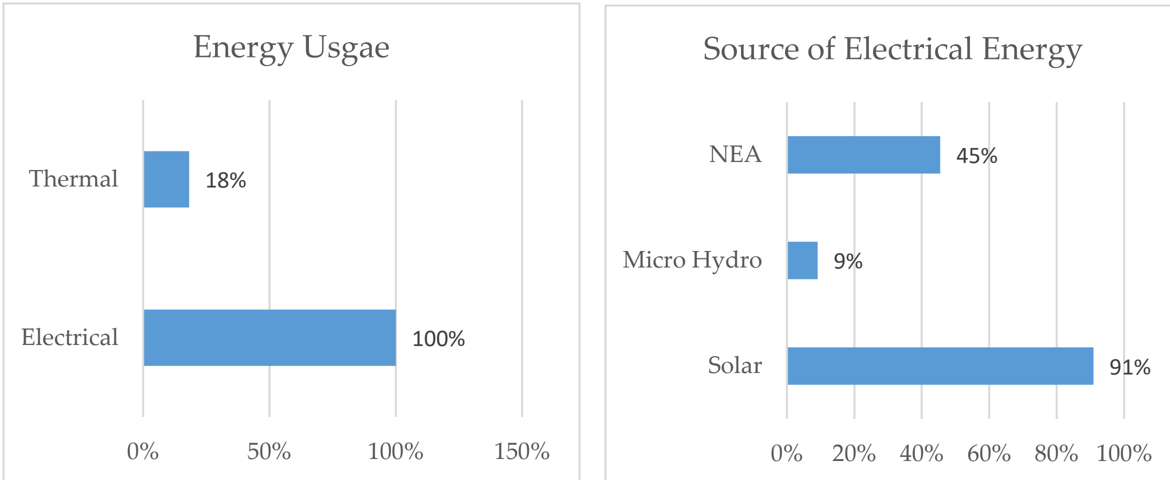

Figure 33: Institutional energy usage and sources

The average monthly electricity bill of the institutions is NRs 1470. Institutions are paying between NRs 250 to NRs 3500 per month for the electricity bills. Schools are paying the least amount whereas primary healtch care facitliy is the highest payer.

With regards to thermal energy, army barracks primarily rely on kerosene where as police stations are using fuelwood as a source of energy. Army barracks consume upto 3,000 liters of kerosene each year whereas annaul average fuelwood consumption in police stations is about 11 tons.

Capacity of solar system

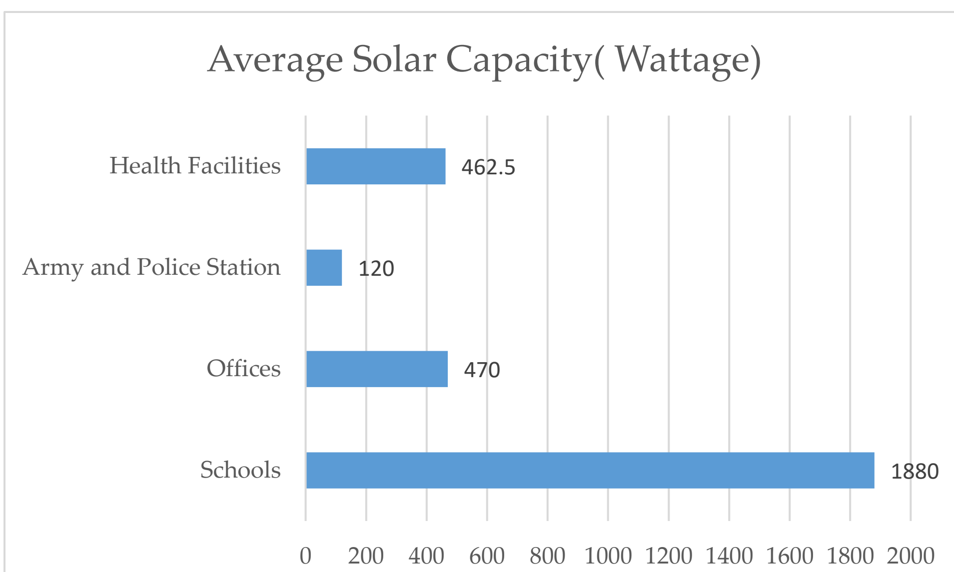

Figure 34: Average capacity of SHS installed in institutions

The peak power of the installed solar system ranges between 40Wp to 3500Wp. Army barrack has the smallest capacity solar system whereas the school has the largest system. The average capacity of solar system in police station and army barrack is 120Wp, in health care facilities it is about 460Wp, in offices it is 470Wp and in school it is 1880Wp.

4.4.2.2 Current and desired electrical load

The current and desired electrical load is calculated taking into account the existing and desired appliances and the average wattage power of each appliance. The list of appliances that are in use and that are desired for future use for each type of institution was generated from field survey. For each type of appliances, the rated power was generated from literature review.

Based on the current use of appliances, health facilities have the highest connected load whereas army and police stations have the lowest connected load. In hospitals, electricity is used for services such as mobile charging, lighting, and computers and for X-ray machines. In army and police stations, the electricity is primarily used for lighting, mobile charging and for televisions. Schools and offices use electricity for lighting, mobile charging, computers, photocopy machines, projectors, printers and fax.

If the electricity supply were adequately available, the desired load appears to increase significantly. In such scenario, the desired load in army barrack and police station appears to increase by more than 7 times that the existing load, mainly due to their desire to use appliances such as fridge and heater. In health facilities, the load can be expected to increase by almost three times as they would like to add appliances such as x-ray machines, fridges and heaters. In schools and offices, the connected load will double in case of sufficient electricity availability.

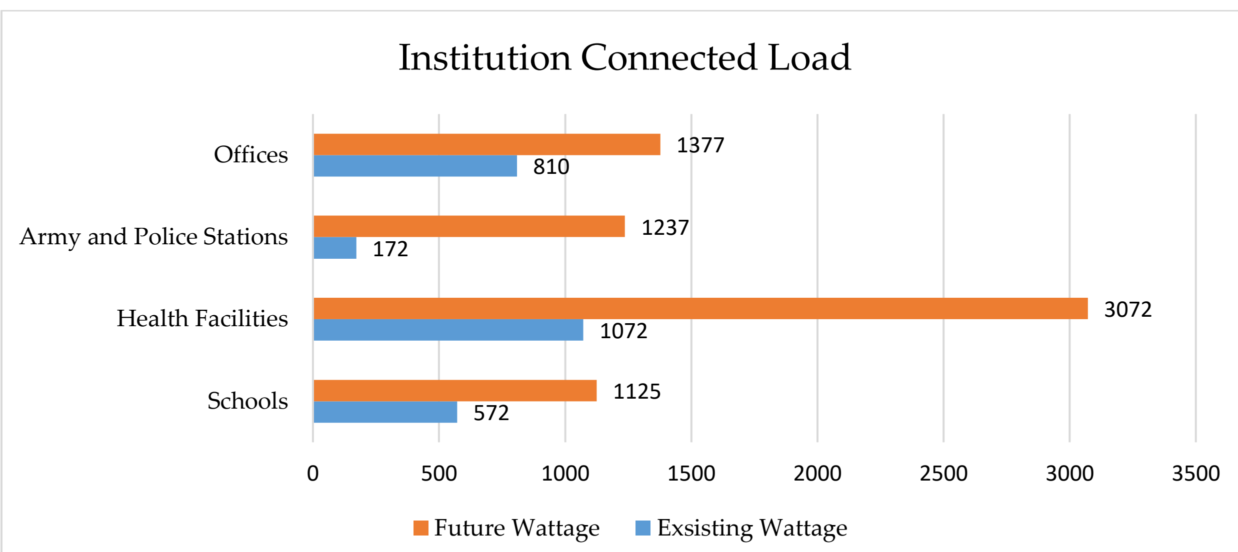

Figure 35: Connected load and future demand of institutions

4.4.3 Distribution of enterprises, institutions and energy infrastructures

The distribution of various enterprises, institutions and energy infrastructures across different wards of Hatuwagadhi RM is depicted below. The figure done not include the GPS location of all enterprises and institutions. Only those enterprises and institutions which were surveyed during the field work is included in the figure.

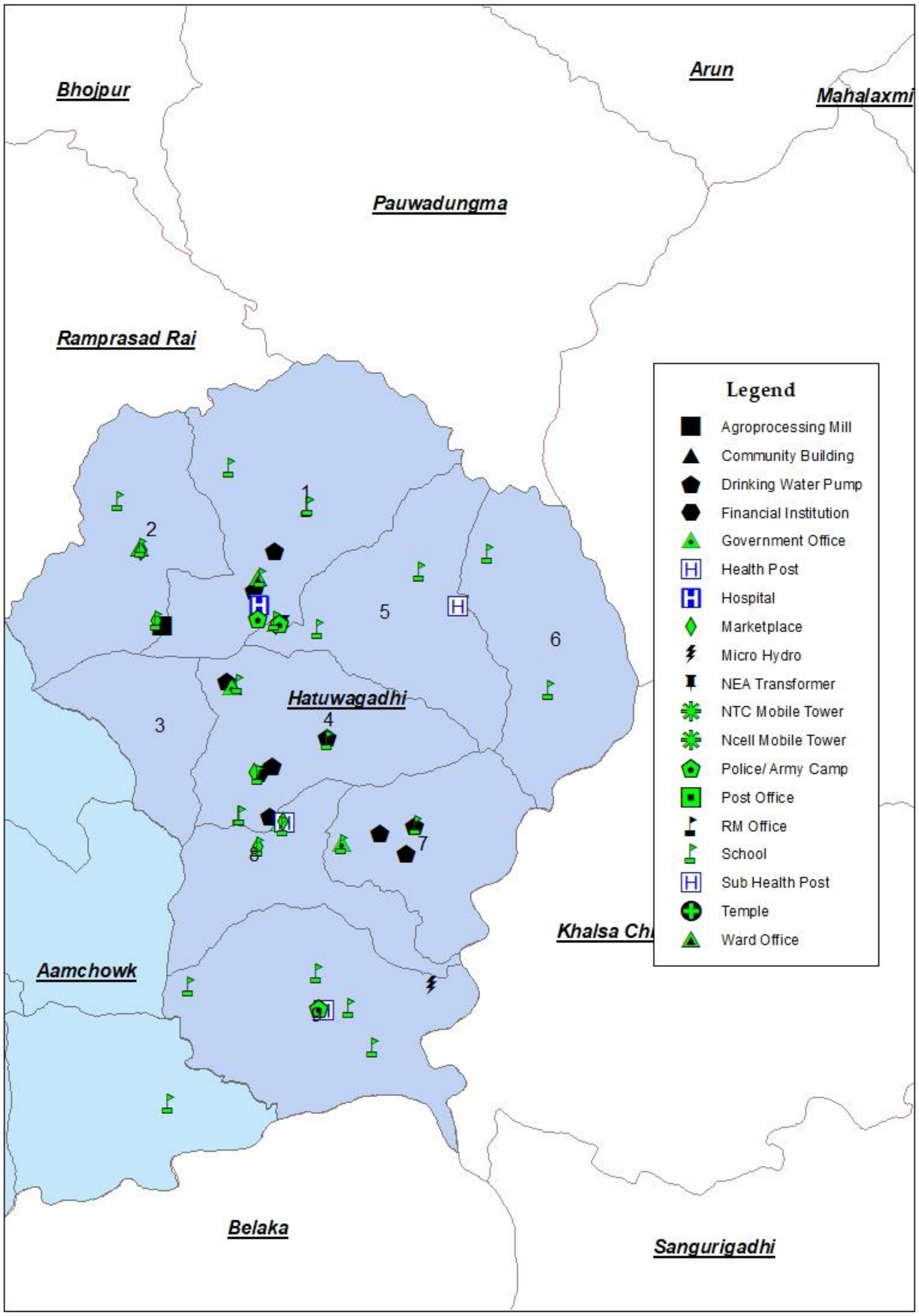

Figure 36: Institution, enterprise and energy infrastructure distribution

4.5 Government and Non-government Energy Service Providers

The energy sector had been primarily driven by non-government sector in Hatuwagadhi RM. However, with the formation local governments the intervention of governmental sector is on the rise.

Access to national grid electricity is one of the major demands of local denizens. Even though, the municipality has been recently connected to national grid, the connection is limited to a few households in ward-1. Though the responsibility for the connection and expansion of national grid mainly lies with NEA, the municipality aims to expand national grid connection to all HHs within the next five years. For this, the municipality has been working in close liaison with NEA. Furthermore, the municipality has also allocated some budget for electric pole erection to expedite the distribution of grid electricity. And NEA is also planning to establish it office in this RM.

In addition, the municipality has plans to install solar street lights in all wards with the allocation of about NRs. 17 lakhs for it. But due the lack of adequate budget, the plan has not yet materialized. Currently, the municipality is coordinating with AEPC to acquire additional fund for it.

The off-grid electrification is mainly driven by the private sector and local community initiatives. All of the three operating micro hydro projects are managed by user's committee. The user's committee is responsible to operate, maintain and manage the micro hydro plants including tariff setting and collection. The installation of SHS is mainly driven by the private sector. There are private service providers engaged in identifying potential users, installing SHS and providing after sales service. However, the presence of these private service providers is limited to major market places within the municipality. For institutional solar system, the service providers are generally hired from other districts or from Kathmandu.

Dissemination of ICS has been mainly driven by local NGOs. It appears that lot of efforts have been place to promote ICS in the past. However, during the time of this survey, no active initiatives for the promotion of ICS in this RM was reported but the presence of local stove promoters was mentioned during the FGD with locals.

4.6 Technical Capacity at Municipality Level for Energy Uses and Operations

Irrespective of the sector, the planning process starts from the ward level. In consultation and taking in to account the demand from the locals, the ward office develops and proposes the Town Development Plan. Based on the development plan received from different wards, a draft plan including budget for the whole RM is prepared by Planning Committee within the RM. The draft proposal prepared by Planning Committee is discussed and approved by Steering Committee and is forwarded to City Council a) which has full rights to approve, dis-approve and change the draft plan. All the elected members of the municipality are the members in the city council.

At present there is no focal person for energy sector within the municipality. One Assistant Sub-Engineer has been positioned to assess the technical parts of the development plan. However, municipality can hire an engineer on temporary basis. The RM has recently hired a civil engineer to assist on municipality planning, supervision and technical monitoring. However, the work load for the engineer is huge and supervising the technical aspects of all development activities can be challenging.

4.7 Banks and Financial Institutions in the Energy Sector

Hatuwagadhi has good presence of financial institutions. Parbhu Bank, a national level commercial back, has recently started its branch office in Hatuwagadhi. Also, micro finance institutions such as Mahuli, Solve Nepal and Swodeshi are also operating in the municipality. In addition, Everest, Rastriya Banijya and Laxmi Bank is also operating branchless banking in the Hatuwagadhi RM. On the basis of KII it has been reported that Mahuli, Solve Nepal and Swodeshi have been providing loans up to NRs. 300,000 for RE installation without any collateral.

4.8 Future Prospects of Various Energy

Connected with national grid and expected rapid expansion to all wards, many HHs in this rural municipality could be expected to have grid connection in the next few years. This will reduce the HHs dependency on SHS which at the moment is the main source of HH electrification. But due to the difficult terrain and scattered settlement pattern, national grid connection to all HHs may take some time. Hence, it might be a wise to simultaneously develop off-grid electrification projects for those settlements.

Hatuwagadhi RM is rich in water resource with a total of 21 rivers in the RM (District Coordination Committee Office, 2017). Most of these rivers are said to have good prospects for the development of mini and micro hydro projects. During KII, respondents informed about the completion of feasibility study of few micro hydro projects, however due to lack of funds and strong leadership, these projects have not yet materialized.

At the moment, the productive use of energy is negligible. It is reported that there is good produce of cash crops such as ginger, potatoes, orange and cardamom in the municipality. Storage and processing of these agro products will needs substantial energy. Also, may HHs have initiated poultry farms and animal husbandry of goats and pigs that requires heating and cooling energy for a good economic return. Many others SMEs such as pickle industry, agro processing mills, biscuit factory and automobile workshops are dependent on diesel generators or have been operating at under capacity due to lack of energy. Hence, if available many of these industries will use significant amount of energy. Access to national grid can address many issues associated with energy access for these types of industries. Nevertheless, there is also opportunity to promote standalone renewable energy technologies for these industries and productive use to ensure the reliability, quality and availability of energy.

During discussion with the municipality and also from KII, scarcity of water for drinking and irrigation has been reported in many areas. In these water drought areas, there exists high prospect for the promotion of solar water lifting technologies.

The municipality appears to have good reserve of community forests. Hence, availability of firewood may not be the issue. Hence, the HHs reliability on traditional cook stoves can be expected to continue due to availability of such fuel source in abundance. Hence, there is opportunity to promote improved cook stoves in HHs to reduce the consumption of the firewood and drudgery to many women.

Also, currently many enterprises are relying on biomass based thermal processing for the production of goods. Very minimal intervention has been made to improve the efficiency of such biomass based processing technologies. Hence there is opportunity to introduce efficient RE technologies such as institutional improved cook stoves and gasifiers to reduce energy consumption and improve the environmental performance of such enterprises.

According to the data published by district coordination committee, there are more than 13,500 cattles (cows and buffalos) and above 33,000 chickens across different HHs in this RM (District Coordination Committee Office, 2017). The cattle and poultry manure could be utilized to generate biogas in many HHs at altitudes below 1500m. Using LPG for cooking appears to be the aspiration for many, so biogas could be a lucrative alternative for them as it will be significantly cost effective compared to LPG.

4.9 Limitations and Challenges in Energy Sector

Lack of affordability

Many respondents during the KII and FGD had stated that large proportion of the population in the municipality are economically weak. The average per capita income data also substantiates this claim. The average annual per capita income of Hatuwagadhi is estimated at around NRs. 37,900 (District Coordination Committee Office, 2017) compared to the national average of around NRs. 90,000 (Ministry of Finance, 2017). Because of the poor financial condition, most people will have limited capacity to afford modern energy services. Unaffordability can limit productive use of energy, can increase illegal use of energy and may compel HHs to stick with traditional and polluting sources of energy appliances. Lack of affordability also makes even highly rated electricity services meaningless as people would not be able to consume electricity and, therefore, benefit from the electricity services (The World Bank Group, 2015).

Lack of financial and technical capacity of the municipality

Annual budget of Hatuwagadhi RM in the last fiscal year was 26.75 crores. About 50% of this allocated budget is used to cover administrative expenses and the remaining 50% is only available for development activities. Of the available budget, the major chunk is used for road construction and water supply schemes, hence the municipality has limited budget available for other development activities including energy projects. In addition, the municipality has limited capacity to plan, implement and monitor energy projects. There is no focal person to look into energy aspects. At present there is just one assistant sub-engineer assigned to technically overlook all the development projects. Hence, lack of finance and technical capacity can seriously constraint municipality to plan and implement energy projects.

Dispersed settlement pattern

Like most parts of the country, the dispersed settlement pattern makes expanding energy services extremely challenging and costly. Distributing national grid electricity to each and every households will be costly and it can also take longer period than planned. Dispersed settlement pattern coupled with difficult road access will also hinder quality of energy service. Long transmission and distribution lines are required to provide energy services for all dispersed settlement, which increases under-voltage problems. Similarly, customer service outages are generally caused by distribution system failures than grid failures. Difficult access can result in longer period to restore system failures thus degrading quality of electricity services.

Low productive use of energy

Productive use of energy can dramatically increase economic and social development by increasing income and employment, reducing manual workload and freeing up time for other activities (The World Bank Group, 2015). However, the productive use of energy is extremely low in Hatuwagadhi RM. The low productive use of energy not only hinders paying capacity of end-users but can also make the energy projects financially unsustainable. Hence, enhancing productive use of energy will be one of the most challenging task for the municipality or energy service providers.

Increasing dependency on fossil fuel

Though the use of LPG at the moment is limited, there is high probability that its demand can increase significantly with better road access. Dependency on LPG will have serious economic impacts for HHs as well as for the whole municipality. On the other hand, availability of huge biomass resources may remain under-utilized. Hence, it is important to introduce efficient and user-friendly biomass based technologies for households as well as industrial application to encourage people to use locally available resources.

Awareness on RETs, policies and energy efficient appliances

The general population of the RM appear to be less aware and concerned about efficient RETs for cooking. About 66% HHs are using traditional cookstoves as their primary stove. It is important to raise awareness on different RETs that could serve their needs and also improve their living conditions. Also, very less peoples are aware about different subsidy schemes available for the adoption of RETs. It is important to raise awareness on subsidy schemes and mechanism for them to make informed decision and take benefits of the subsidy.

5 Conclusion and Recommendation

5.1 Improving Energy Access in Rural Municipalities

Energy access situation in Hatuwagadhi rural municipality is characterized by access to low tier of electricity supply, use of electrical appliances to serve basic lighting & communication services, high dependency on traditional fuels & cookstoves and low productive use of energy.

Electricity is mainly supplied through off-grid electrification, SHS system being the predominant source. Despite of good electricity coverage, quality and adequacy of electricity are major issues. Though traditional cookstoves are the most common type of cooking device, the penetration of mud based improved cookstoves is also considerable. LPG is not yet the significant source of cooking but with improved road connection, its use can be expected to increase.

Level of education appears to have positive impact on access to electricity as well as clean cooking solutions. Households with higher level of education have better access to electricity. Similarly, households with higher level of education tend to use cleaner cookstoves. Gender appears to have mixed impacts on energy access. Male led households have marginally better access to electricity and female led households have more inclination to use clean cooking stoves. With regards to social inclusion and energy access, ethnic DAG appears relatively left behind than other population sub-types. However, during FGD with DAG participants, it was reported that they feel less discriminated these days.

No apparent relationship could be observed between source of income and energy access. But in general paying capacity appears to be relatively less as most respondents showed unwillingness to pay higher tariffs for improved services.

Hatuwagadhi rural municipality has good forest reserve as well as rich water resources. There is a need to identify optimal plans to utilize these resources for benefiting its people. However, at present, the major focus of the municipality has been to expedite the expansion of distribution lines to provide access to electricity. The municipality should also focus on harnessing its locally available resources such as solar and micro-hydro for which its financial and technical capacity has to be enhanced. Good presence of financial institutions provides window of opportunity to access finance to harness and develop energy projects locally.

The energy supply and consumption in enterprise and institutional sector is extremely low. There are handful of manufacturing enterprises even though there is high potential for goods produced in agriculture and forestry sectors. Most of the enterprises are dependent on electricity which they primarily use for lighting and communication. Few service based and manufacturing industries are primarily dependent on fuelwood for the combustion. For institutions, electricity is the most common form of energy. Almost all of them rely on solar systems but many of them are also connected to the national grid. Though the energy consumption is low for both enterprise and institutional sectors, its consumption can significantly increase in both sectors, if the supply is adequate.

The specific recommendations to improve energy access in Hatuwagadhi RM is specified below:

- Carry out mass awareness campaign at ward level to educate people on potential economic, health and environmental benefits of different RETs. Also, mass awareness is required on energy policies and energy efficient appliances so that people are able to take the informed and the right decision.
- Develop long term energy goals and prepare policies and plan to achieve those goals. Establish a focal committee within RM to keep an overview on the energy sector. The focal committee can also act as an information center to aware people on energy plan, policies and technologies.
- Considering the scattered human settlements and difficulties to access, grid extension in all settlements will be challenging and uneconomical. So municipality should also focus on developing decentralized energy projects such as mini-grid and stand-alone system in those areas which could be more cost effective and could provide faster access to energy for the locals.
- Decentralized energy projects (grid/mini-grid/stand-alone) could be developed on public private partnership (PPP) model. This can reduce dependency on national grid, minimize cost on grid expansion and enhance overall quality of energy access. In addition, this can also be a sustainable source of income for the municipality.
- Encourage end-users for productive use of energy by offering economic incentives on productive use activities. Economic incentives could be of different types, such as free registration of industries, exemption of industry renewal tax for certain number of years or free land lease for the establishment of industry. These types of incentives will not have immediate financial burden to the municipality. Rather in long term such initiatives can bring in positive economic impacts in the form of local job creation, utilization of locally available resources, enhance production and exports of products etc.
- The municipality appears to have rich biomass reserves. Fuelwood will remain the major fuel for cooking in HHs. Most HHs have cattle farm so there is good prospect to develop biogas plants in many areas. However, most of the current biomass based technologies are rudimentary and outdated. These outdated technologies should be replaced with clean and efficient technologies such as ICS, IICS, gasifier and biogas at both HH and industrial sectors. This is important to curtail the increasing use on LPG for cooking.
- Findings show that almost two-third of household's fuelwood is consumed for animal fodder preparation. However, till date no intervention has been made to improve the efficiency of stoves that are used for fodder preparation. Priority should be given to improve the efficiency of stoves used for fodder preparation so that fuel wood consumption can be substantially reduced.
- In order to improve and expedite energy access in the municipality, provision of financing should be made available for local public. As most of the people have low income status, financing in terms of subsidy or soft loan could stimulate the adoption of RETs in both HHs and enterprise sectors. Hatuwagadhi has good presence of financial institutions. Hence there are opportunities to mobilize funds through these financial institutions for improving energy access.

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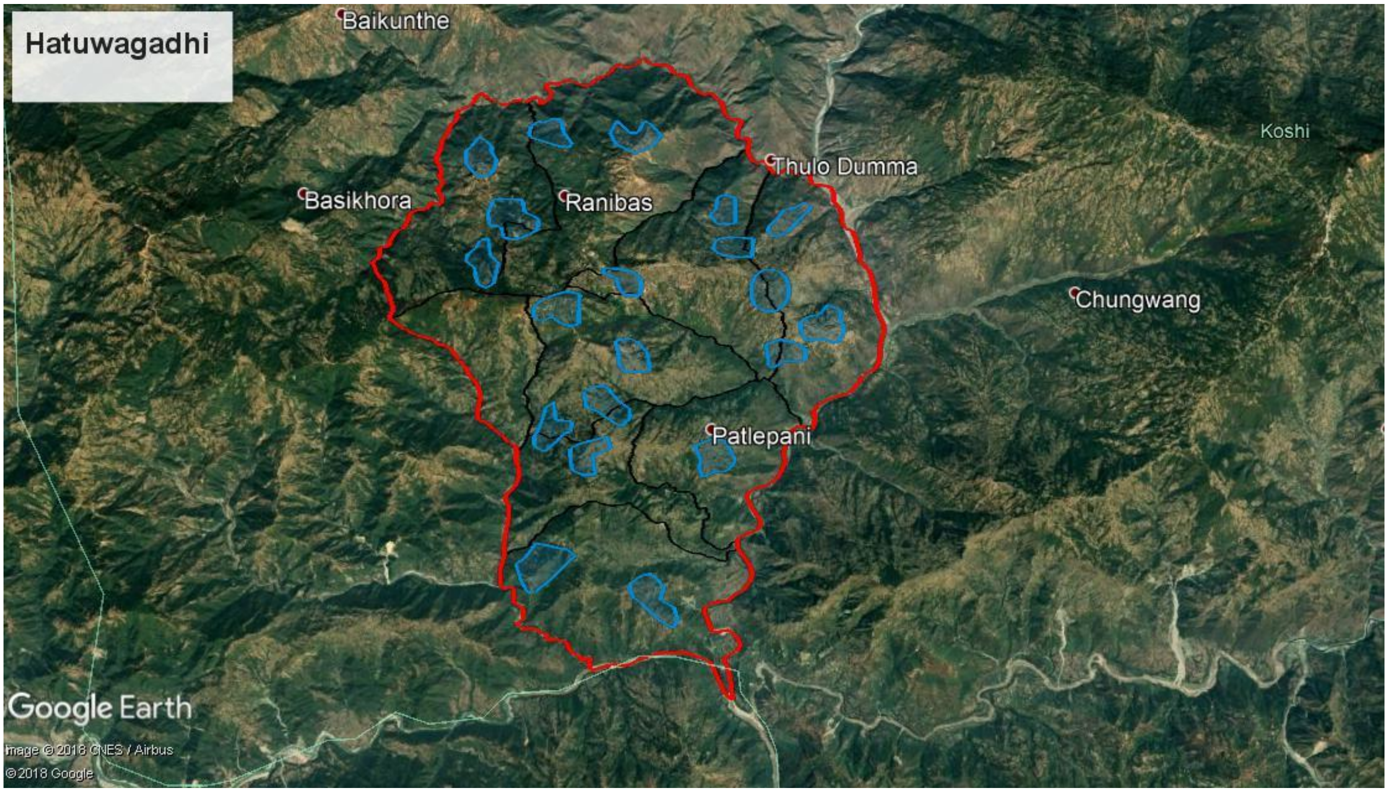
7 Annex

7.1 Hatuwagadhi Primary Sampling Unit



7.2 FGD Questionnaire

ENERGT SERVICE SATISFACTION

1. What is the source of lighting/electricity and cooking fuels in your village?
2. Are you satisfied with what you are using for electricity and cooking? If yes/no, why?
3. In general, do you get electricity at the time of day that is important to you?
4. Which hours of the day is important for you to have electricity to smoothly conduct all your HH activities?
5. What are the mandatory energy services (electrical appliances) necessary for your HH?
6. Is the current electricity supply enough to fulfil demand of mandatory energy services of your HH? If not, why?
7. Can you distinguish which electrical appliances are basic and important HH electrical appliances and which appliances are luxury appliances (those electrical appliances that you feel is good to have but can live without them)
8. How is the availability of firewood in your village (easily available or not)? Do you have to pay for the firewood, if yes how much per kg or bhari?
9. In general, how much firewood is consumed for animals and for humans in your HH? (in percent)
10. Are energy service providers (electric appliances, stove manufacturers, etc) locally available?
11. How is the after sales service of RETs if you have already using one?

ENERGY SERVICE DESIRE

1. If electricity access is improved and you are able to use as much electricity as you can, would you like to add more electricity services (or electrical appliances)? If yes, will you able to pay for increased electricity consumption?
2. Which cooking service do you prefer to use for your HH? If you have to select one stove for your household which one would that be and why?
3. Given a choice, LPG or electrical cooking which one do you prefer and why?
4. What do you think, in your village will LPG or electrical cooking be able to replace traditional cooking stoves in future with modern cooking facilities like ICS/LPG/Biogas/Electric Cooker? If yes/no, why
5. If they say no, then ask- Is there any particular improvement that you want to see in mud based cooking stoves (ICS) such that it is compatible with your culture and cooking behavior?
6. Do you use any stove or other technology for space heating? If yes, what is that and are you satisfied with it? If yes/no, why?
7. If energy (electricity/cooking fuel) access is improved, would you like to establish or initiate any business enterprise? If yes, what would be such enterprises in your RM? If no/why?
8. What are the opportunities associated with improved access to modern energy service in terms of establishing business?

9. Is there any restriction from society for DAG to establish or operate any business using electricity or cooking fuel? (FOR DAG)
10. What is your opinion "Access to modern energy (electricity/cooking) helps to improve livelihood in the community"?

SOURCE AND ACCESS TO INFORMATION

1. Are you aware about different modern technologies available which can be used for cooking and lighting/electrification? If yes what are they, please list them
2. Do you know that RETs have provision of subsidy?
3. Are you made aware or do you know about upcoming energy (for cooking and lighting) projects in your villages?
4. Is there provision of information Centre from where you can get information on energy conversion technologies, energy service providers, subsidy and energy access improvement policies?

ENERGY GOVERNANCE/PARTICIPATORY PLANNING

1. Do women participate in the meetings called upon by energy sector stakeholders? Are all the invited women present in the meeting? If women are not participating what are the reason for that? (FOR WOMEN)
2. Are members from DAG invited to participate in the meetings called upon by energy sector stakeholders? Are participants present in the meeting? If not (participating) what are the reason for that? (FRO DAG)
3. What can be done to improve the information system in the village? (FOR GENERAL POPULATION)
4. Are there any committee or group assigned to discuss energy related issues in the village? (FOR GENERAL POPULATION)
5. How is the energy related agenda identified in your locality/village? (FOR GENERAL POPULATION)
6. Compared to other development sector, are you satisfied with the share of budget allocated for energy sector? Is energy sector regarded as priority sector in your Rural Municipality? (FOR GENERAL POPULATION)
7. Is there provision of community level meeting to identify energy related agenda/issues? (FOR GENERAL POPULATION)
8. How can you ensure that all members of community (women, DAGs, etc.) are represented in the consultative meeting and development planning meeting? (FOR GENERAL POPULATION)
9. Have any one of you participated in any of such meetings? If not, why? If yes, was it fruitful or what can be done more to make the meeting for fruitful? (FOR WOMEN AND DAG)
10. Have you participated in development planning meetings? Do you get information about development planning meetings? (FOR WOMEN AND DAG)
11. Are there DAGs and women in key decision making position in the committee, organization working for energy sector? (FOR GENERAL POPULATION)

12. What do you think, are your suggestion taken seriously in the meetings that women have participated? (FOR WOMEN AND DAG)
13. Have you made any demands for energy initiatives/projects in the village? If yes/no, explain what was the outcome? (FOR GENERAL POPULATION)
14. Have you made any demands for energy initiatives/projects in the village? If yes/no, explain what the outcome was. (FOR WOMEN AND DAG)
15. If there are capacity building trainings for repair and maintenance of energy conversion technologies or other capacity building training related to energy sector, are you allowed to participate? Who from your HH has first priority to participate in such events? (FOR WOMEN AND DAG)
16. Have you communicated any energy related issues with concerned organization? If yes, what was the outcome? (FOR WOMEN AND DAG)
17. Are there any women/any DAG representative in positions where they can influence the decision making process or planning process in your village? (FOR WOMEN AND DAG)
18. Are there any quota schemes for community members to be selected for capacity building trainings for repair and maintenance of energy conversion technologies or other capacity building training related to energy sector PEU? If yes, how is does quota scheme work? (FOR GENERAL POPULATION)
19. Are there any sorts of forum where they could express their dissatisfaction/grievances they have on energy issues? (FOR WOMEN AND DAG)
20. What can be done to ensure maximum women/DAG participation in energy related meeting, workshop, decision making process in your village? What kind of role women/DAG can play to improve energy governance/participatory planning in RM? (FOR ALL)
21. How can we improve energy sector governance and planning process? (FOR GENERAL POPULATION)

POLITICAL BARRIERS

1. Are their challenges posed by political situation to develop energy sector in the village?

TECHNICAL BARRIERS

1. If the locality is not powered by national grid, when do you think your locality will be connected with the national grid? What is the reason for delay in connection? If it is not going to be connected what is the reason for no connection?
2. Have you ever thought of getting new/ modern type of stove/space heating technologies? What are the challenges you faced in getting modern stove? In your opinion what would be the benefit of using modern cooking energy service?
3. What factors do you look for in deciding to select that particular type of cooking service? Affordability, Availability of fuel in market, Quality of fuel used, Indoor air pollution, Size, Easy to handle, Low maintenance cost

SOCIO-CULTURAL BARRIERS

1. What do you think, what changes has to be made to motivate women/DAG to use energy and establish cottage industries or enterprises or to empower women in your locality?
2. If capacity building training and other meetings are held away from the dwelling, do you think women from the dwelling/village will be able to participate in such meetings and workshops?
3. Are members from Women/DAG community invited or prioritized in Repair and Maintenance (R&M) capacity building trainings and workshops? If yes/no, why? (FOR WOMEN AND DAG)
4. Have you felt any kind of discrimination in energy sector from the society? (FOR DAG)

FINANCIAL BARRIERS

1. Who takes financial decision at home? Who has the final say on the expenditure of the household? (FOR WOMEN)
2. Do you have access to financial institutes? Do you have any restriction on opening account or using certain facilities being offered by financial institutes? (FOR DAG)
3. Are there financial schemes provided by financial institutes to purchase RETs/enterprise based on energy?
4. Do you think women/DAG friendly financial schemes (loans/credit) helps to increase access to modern forms of energy technologies and initiate enterprises based on energy usage?

7.3 Description of Stoves

3-stone stove

3-stone stoves are fires surrounded by 3 stones such that the cooking vessel placed very close to the fire itself, limiting excessive heat wastage.

Self-Built Biomass Stove

These are cook stoves built by end users on their own without following any particular engineering design and principal and lack chimney.

ICS-MUD

Mud-brick ICS with and without chimney is one of the most simple, inexpensive and widely used technologies designed to improve combustion efficiency of biomass and reduce exposure to indoor air pollution. The benefits of ICS includes: increased thermal efficiency, conservation of forests by reducing fuel wood consumption, reduction in women's' drudgery, reduction in indoor air pollution.

LPG Stove

These are one of the most advanced and efficient cooking technologies that utilizes LPG as fuel with the ability to regulate the flame as per the users need.

7.4 Worlds Bank's MTF to Measure Household Energy Supply

Multi-tier Matrix for Measuring Access to Household Electricity Supply

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
1. Peak Capacity	Power capacity ratings[28] (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
			Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
	OR Services		Lighting of 1,000 lmhr/day	Electrical lighting, air circulation, television, and phone charging are possible			
2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
	Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hrs
4. Quality						Voltage problems do not affect the use of desired appliances	
5. Afford-ability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
6. Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
7. Health & Safety						Absence of past accidents and perception of high risk in the future	

7.5 Pictures

Enumerators carrying out field survey

FGD with women group

Goretar Bazar

Meeting with rural municipality chairperson

PEU activities using national grid