HOUSEHOLD FUEL AND ENERGY USE FOR RURAL DEVELOPMENT IN NEPAL
(A case study in Ilam district)

RADHA DEVI BHATTARAI

NORWEGIAN UNIVERSITY OF LIFE SCIENCES
Department of international environment and development studies, noragric
Master Thesis 30 credits 2014

acradha@gmail.com

Noragric

Department of International Environment and Development Studies

P.O. Box 5003

N-1432 Ås

Norway

Tel.: +47 64 96 52 00

Fax: +47 64 96 52 01

Internet: http://www.numb.no/noragric

Declaration

I, (Radha Devi Bhattarai), declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature……………………
Date 14th March 2014

Acknowledgement

My grateful thanks go to my main supervisor **Prof. Jens B. Aune**, PhD, Norwegian University of Life Sciences (UMB) for his valuable suggestions, feedback, critical comments, correction and supportive guidance to bring this thesis at this form. My special thanks go to Department of International Environment and Development Studies (Noragric), UMB for supporting travel grant and other to carry out this study. My gratitude to Mr. Tirtha Limbu, Lekhnath Dahal and people of Barbote and Kanyam Village for their cooperation during the field work. I would also like to thank the officials from different government organizations and references from whom I have collected the information.

My special thanks go to my beloved husband **Mr. Madan Raj Acharya** for his unconditional support and contributed to the research invaluable moral support and comments. I would also like to thank my lovely son **Sashwat Acharya** for his patience during my study. Finally, my respect goes to my parents, relatives and friends for their continuous support and sacrifice. Especially my mother whom I lost during the thesis writing, her inspiration for further study always guides me to positive path of life.

Abstract

In the past, the energy ladder was the main model for understanding changes in energy use. This model shows that as households income increase they will change to more efficient fuels. However, recent studies including my study show that culture, individual preferences, availability, efficiency, price and cost effectiveness also play vital role in determining energy and fuel choice. The research was conducted in two village development committee in Ilam district namely Barbote and Kanyam. The field work was conducted for two weeks from Feb. 1-15, 2013. The data were collected through structured questionnaire and key informant interviews. A total of 100 households were included. The households were selected basically on the availability of people in their house and snowball sampling. The research identified the household energy consumption pattern and the effects of economic. The main energy sources of the households were biomass, charcoal, electricity, biogas, candle and batteries. Biomass is widely used as almost 100% of HHs used it regardless economic status of the households. The research found that better off HHs consume almost all type of fuels and used various types of cooking stoves. Electricity was mainly used for lighting, communication and entertainment. Prices per kWh produced from different energy sources were compared. It was found that biomass and biogas are the cheapest fuels among these sources. The price per kWh produced from the biomass was just Rs. 1.25/kWh. The price of LPG, electricity and kerosene was in comparison Rs.7.7, Rs.9.7 and Rs.9.37 per kWh respectively. Biomass is highly used due to cultural preferences (alcohol making, milk boiling) and used for energy demanding task such as animal food cooking. The rural energy policy has also to be taken into consideration when analyzing the consumption pattern of the HHs. The rural energy policy is targeted with rural poor, ethnic group, disadvantaged and marginalized people. However, the policy implication did not seem fair due to political instabilisation of the country and absence of political leader of local representatives in the VDCs. Finally, introduction of biogas and improved cooking stoves can play an important role in order to save fuel wood and money.

Table of Contents

List of Figures

List of Tables

Acronym and Abbreviations

AEPC	Alternative Energy Promotion Centre
BSP	Biogas Support Program
CBS	Central Bureau of Statistics
CRT/N	Centre for Rural Technology, Nepal
DCEP	District Climate and Energy Plan
DDC	District Development Committee
DEEU	District Energy and Environment Unit
DFO	District Forest Office
DPNet	Disaster Preparedness Network
ESMAP	Energy Sector Management Assistance Program
ESMAP	Energy Sector Management Assistance Program
Fig.	Figure
GDP	Gross Domestic Product
GJ	Giga Joule
GoN	Government of Nepal
GOs	Government Organization
HHs	Households
IAP	Indoor Air Pollution
ICS	Improve Cooking Stove
IEA	International Energy Agency
IFC	International Finance Corporation
ISPS	Institutional Solar Photovoltaic System
IWM	Improved Water mill
KG	Kilogram
KW	Kilowatt
kWh	Kilowatt Hour
LPG	Liquefied Petroleum Gas
Ltr.	Liter

M	Month
MDGs	Millennium Development Goals
NCDC	Namsaling Community Development Centre
NEA	Nepal Electricity Authority
NGOs	Non-Governmental Organization
NOx	Nitrogen Oxide
NPHC	Nepal Population and Housing Census
PV	Photovoltaic
RE	Renewable Energy
REDP	Rural Energy Development Program
REF	Rural Energy Fund
RERL	Renewable Energy for Rural Livelihood
Rs.	Rupees
SC	Solar Cookers
SD	Solar Dryers
SHS	Solar Home System
SNV/N	Netherland Development Organization, Nepal
SO_2	Sulphur Di-oxide
SPVPS	Solar Photovoltaic Pumping System
SSHS	Small Solar Home System
SWH	Solar Water Heaters
TPES	Total Primary Energy Supply
UNDP	United Nations Development Program
VDC	Village Development Committee
WHO	World Health Organization
WWF	World Wildlife Forest

Chapter One: Introduction

1. Introduction/ Background

Traditional biomass fuels such as firewood, charcoal including agricultural waste is used excessively in many developing countries. According to the International Energy Agency (IEA) over 2.7 billion people are without clean cooking facilities and are relying on the traditional use of biomass for cooking (IEA 2011). By 2030, the number of households using traditional biomass fuels is estimated to rise even further by 100 million (IEA 2010). Such dependency has negative effects on human health as well as in the environment. Over 10 million people fall sick of illness due to the biomass combustion and the associated Indoor Air Pollution (IAP). According to World Health Organization (WHO), IAP accounts for about 2.7% of the global burden of disease (WHO, 2006). It is estimated that about 1.5 billion people live without electricity and almost 3 billion do not have clean fuels for cooking. Access to modern energy is a development imperative and it has been well documented that without electricity, efficient cooking fuel and heating options, economic activity is curtailed and advancement toward the Millennium Development Goal is constrained—particularly in meeting health, education, and local environmental targets (World Bank/IFC, 2012).The increasing rate of deforestation leads to land erosion, loss of watershed and desertification and affects the biodiversity of the regions dangerously. Additionally, deforestation accelerates the climate change rate due to the changed land cover albedo as well as the reduction of the forest's carbon stock potential (Schlag & Zuzarte 2008,cited Trieber,2012).

Governmental policies and actions as well as development interventions by various organizations often involve vast amounts of resources and might lead to adverse outcomes in the case of bad design. Especially the poor are highly dependent on cheap energy sources and hence vulnerable to changing policy. The dominant approach on which most governmental and non-governmental activities and policies are based on is the energy ladder model which emphasizes household's income as the major driver and implies a complete transition from one fuel to another. This theory is widely acknowledged and utilized in explaining energy consumption behaviors (Barnes & Floor, 1996). However, various authors have criticized this model and presented contrary research results. Rather than a complete transition; households seem to diversify their fuel consumption and utilize multiple fuels simultaneously from all levels of the energy ladder. Okeefe and Munslow (1989) explains multiple fuel use as '…fuel security rather than fuel switching is the way that household energy is managed…; a risk minimizing but not necessarily benefit maximizing strategy' (cited in Grimsby, 2013). Furthermore, it is demonstrated that the impact of income on the fuel choice and transition to cleaner fuels is positive, but not the major factor rather one of many forces. Social, cultural and individual characteristics are put more into focus in recent research (Masera et al. 2000, Pachauri & Spreng 2003). In all literature, proposed concepts implemented within the framework of the energy ladder model without offering an alternative framework for interpreting and explaining energy transition. Furthermore, literature still does not give a reasonable answer why households choose or dismiss particular fuel types and technologies and use or possess more than one fuel or stove (Masera et al. 2000).

Previous research into the area of energy consumption has shown that socio-demographic variables can be highly related to household energy use (Gatersleben et al. 2002; Lenzen et al. 2006; Abrahamse 2007; Abrahamse & Steg 2009). Income, for example, influences purchase decisions, while age increases the need for heating or cooling increases, thereby raising energy consumption (Abrahamse & Steg 2009).

According to WHO (2006), 'Taking household energy solutions to scale will overcome a major barrier to achieving the Millennium Development Goals.' Liquefied petroleum gas, biogas and other cleaner fuels represent the healthiest alternative. Switching from a traditional stove to an improved stove substantially reduces indoor smoke. Improved household energy practices promote education, empower women, save the lives of children and their mothers and benefit our forests and our climate. There is no Millennium Development Goal on energy. Yet, energy poverty is one of the many manifestations of poverty and a prevailing feature of deprived rural and urban households in developing countries. Table 1 shows the contribution of improved household energy in rural household.

Table 1: Contribution of Household Energy in achieving MDGs

Millennium Development Goals and contribution of improved household energy practices
Goal 1: Eradicate extreme poverty and hunger -Saving time spent being ill or having to care for sick children will cut health care expenses and increase earning capacities. -Where fuels are purchased, increasing fuel efficiency and thus cutting down on the quantity of fuel needed will ease constraints on already tight household budgets. -Improved household energy technologies and practices will open up opportunities for income generation. - Access to electricity will provide a source of light for economic activities in the evening and a source of energy for operating, for example, a sewing-machine or refrigerator.
Goal 2: Achieve universal primary education -With less time lost in collecting fuel and due to better health, children will have more time available for school attendance and homework. - Better lighting will allow children to study outside of daylight hours and without putting their eyesight at risk.
Goal 3: Promote gender equality and empower women - Alleviating the drudgery of fuel collection and reducing cooking time will free women's time for productive endeavors, education and child care. - Reducing the time and distance that women and girls need to travel to collect fuel will reduce the risk of assault and injury, particularly in conflict situations. - Involving women in household energy decisions will promote gender equality and raise women's prestige.
Goal 4: Reduce child mortality - Reducing indoor air pollution will prevent child morbidity and mortality from pneumonia. - Protecting the developing embryo from indoor air pollution can help avert stillbirth, perinatal mortality and low birth weight. -Getting rid of open fires and kerosene wick lamps in the home can prevent infants and toddlers being burned and scalded.
Goal 5: Improve maternal health - Curbing indoor air pollution will alleviate chronic respiratory problems among women. - A less polluted home can improve the health of new mothers who spend time close to the fire after having given birth. - A more accessible source of fuel can reduce women's labour burdens and associated health risks, such as prolapse due to carrying heavy loads.
Goal 6: Combat HIV/AIDS, malaria and other diseases - Lowering levels of indoor air pollution levels can help prevent 1.6million deaths from tuberculosis annually.
Goal 7: Ensure environmental sustainability - Where biomass is scarce, easing the reliance on wood for fuel through more efficient cooking practices will lessen pressures on forests. - Moving up the energy ladder and using improved stoves can increase energy efficiency and decrease greenhouse gas emissions.
Goal 8: Develop a global partnership for development - Recognition in development agendas and by partnerships of the fundamental role that household energy plays in economic and social development will help achieve the Millennium Development Goals by2015.

Source: WHO, 2006

Chapter Two: Literature Review

2. Introduction to Energy Use in Nepal

Nepal is situated in the lap of the Himalayas and landlocked between India and China. It lies between the latitudes of 26° 22' N to 30° 27' N and longitudes of 80° 4' E to 88° 12' E. The elevation of the country ranges from 60m above the sea level to the highest global altitude, Mount Everest, of 8848 m, all within a distance of 150 km (DPNet Nepal, Homepage). This vast sudden variation in its altitude gives a country a climatic condition, which ranges from sub-tropical to that of the arctic.

Fig 1: Map of Nepal

Nepal has a population of 26,620,809 in 2011(CBS, 2011) and had over 6.6 million poor people (25.4% of its population) in 2010 (Nepal Economic Survey, 2010). Nepal is one of the poorest countries in the world. Agriculture is the main source of revenue for three-fourths of Nepalese and accounts for one-third of GDP. Industrial activity mainly involves the processing of agricultural products, including pulses, jute, sugarcane, tobacco, and grain. In recent year's progress has been made in exploiting Nepal's natural resources, tourism and hydroelectricity.

2.1 Status of Energy Consumption in Nepal

Energy resources used in Nepal are biomass (for cooking and household), petroleum (for transportation) and electricity. Fossil fuels are imported from outside the country. Prices of electricity and petroleum are controlled by the Government whereas prices of coal, charcoal and other petroleum products such as candles, raw petroleum, etc. are set in the market. The pricing strategy of the government is motivated by providing energy at low costs. Commercial energy resources particularly like electricity, petroleum and traded fuel wood are subsidized and distributed through different dealers or sales point. (WECS, 2010)

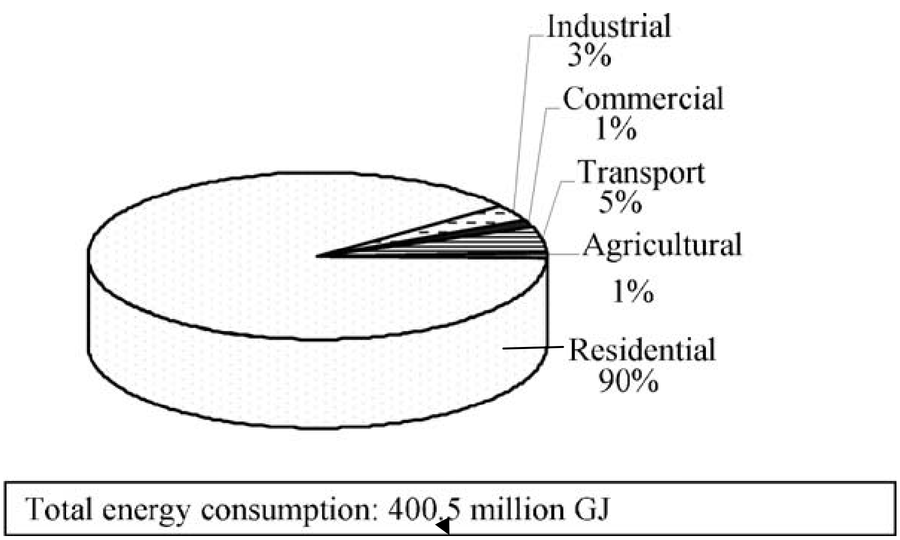


Fig. 2: Energy consumption by different sectors in the year 2008/09. (K.C. et al., 2011)

2.1.1 Residential Sector

Energy consumption in residential sector, 356.8 million GJ in the year 2008/09, significantly contributes to the 90% (fig. 2) of total energy consumption in national energy demand (WECS, 2010). The energy expenses are mainly for cooking, heating, lighting and animal feed preparation. The rural population represents about 80% of the country's population and demands 85% of the residential energy. Yet the rural population has limited or no access, and lacks affordability to commercial fuels such as kerosene, liquid petroleum gas (LPG) and electricity (WECS, 2006). Therefore, the energy dependence is primarily on biomass resources in these areas. Fuel wood alone supplies 86% of the total residential energy requirement followed by animal dung, agricultural residues and petroleum products. The overall growth rate of residential energy consumption is about 2.3% per annum (WECS, 2010).

2.1.2 Transportation Sector

The Transport sector is second to the residential sector in terms of total energy consumption. In 2008/09, the total energy demand of this sector was 20.9 million GJ which comprised 5.2% of the total energy consumed in that year. Road transport (86.5% of the total transportation sector associated energy consumption) dominates all other modes of transportation followed by the aviation sector (13.4%). Among fuels, high speed diesel (67%), petrol (20%), and air turbine fuel (12%) were the major fuel entities. For the last few years, the annual energy consumption growth rate in this sector has been about 8.9% (WECS, 2010).

2.1.3 Industrial Sector

The energy consumption by the industrial sector was 13.4 million GJ, which constitute about 3.3% of total energy consumption in the year 008/09. The main energy usages in the industrial sector are process heating, motive power, boilers, and lighting. Coal supplied 57.7% of total industrial energy demand, and electricity and biomass sources supplied 23.3% and 15.5% of the total demand, respectively. The industrial energy demand is increasing at 0.4% annually (WECS, 2010).

2.1.4 Commercial Sector

Energy consumption in the commercial sector was 5.1 million GJ, which accounting about 1.3% of the total energy demand in the year 2008/09. Cooking is the largest end use in this sector consuming about 68.4% of the total energy consumption followed by lighting (19.3%), and space heating and cooling (5.3%). Petroleum, especially liquid petroleum gas (LPG) and kerosene, supplied about 53% of the total demand. Fuel wood and electricity fulfilled about 36% and 11% of commercial sector associated demand, respectively. The energy consumption in this sector has been increasing at an annual rate of 3% since 2001 (WECS, 2010)

2.1.5 Agricultural Sector

The total energy consumption in the agricultural sector was 3.6 million GJ, which accounted for 0.9% of total national energy used in the year 2008/09. This energy demand did not include human and animal draft power which is very difficult to assess. The major energy source is petroleum, contributing about 95% especially from diesel fuel, followed by electricity which takes 5% of the total demand. The consumption of electricity is, however, increasing at a higher rate than the petroleum in recent years (WECS, 2010). Chemical fertilizers are not produced domestically in Nepal (http://www.irinnews.org/)

2.2 Current Status of Various Renewable Energy Technologies in Nepal

Energy is indispensable in modern societies. We need energy for home appliances, lighting, transportation, cooking, heating/ cooling, communication, and industrial processes to produce and supply commodities of our daily needs. Thus, energy is one of the most important indicators of socio-economic development, and per capita energy consumption is often viewed as a key index of the development. Developed countries have significantly higher per capita energy consumption. For example, the United States has a per capita energy consumption of 314.1 GJ/year, Japan has 162.5 GJ/year, and United Kingdom has 142.4 GJ/year. For Nepal, the per capita total primary energy supply (TPES) is just 14.2 GJ/year, which is far less than world's average per capita TPES of 76.6 GJ/year (IEA, 2010).

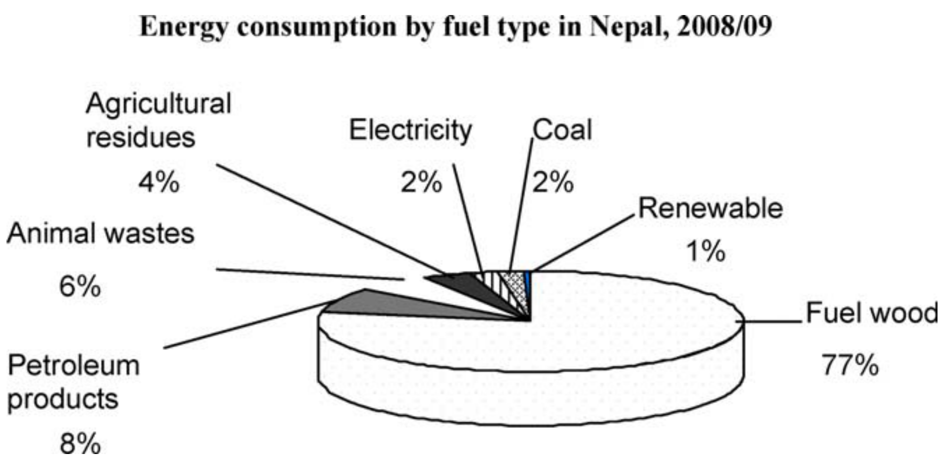


Fig.3: Energy consumption by fuel type in 2008/09 (KC et al, 2011).

2.2.1 Biofuel/bioenergy

About 18 million tons of fuel wood is consumed annually in Nepal, out of which less than 1% is commercialized. Rest is collected by the users free of cost from forests or their own cultivated land (WECS, 2010).

a. Biogas

Biogas plant, which is locally called 'Gobar Gas', has been established in individual household in all 75 districts of Nepal. 2800 out of 3913 village development committees (VDCs) have biogas plants (BSP, 2009). The figure 4 shows the details about biogas installation in different years. It is clear from this figure that biogas installation is increasing every year which is due to the Biogas Support Program (BSP) of Netherlands Development Organization-Nepal (SNV/N).

BSP is the first, with two projects in Clean Development Mechanism (CDM) program, which started to work from 2005. Biogas program has been successful in southern part of Nepal where average temperature is about 25°C as the optimum temperature required for biogas production through anaerobic technology is 35–37 ◦C. The cold mountainous region is unfavorable for biogas production as temperature drop below 5◦C during winter. People in these areas need more energy for heating purpose rather than cooking. Many household have not sufficient animal dung to run plant. So, they use both biomass and wood fuel for cooking. Another problem is that there is a shortage of water in hilly region to run biogas plant (K.C. et al. 2011). These factors lead us to think about other energy sources

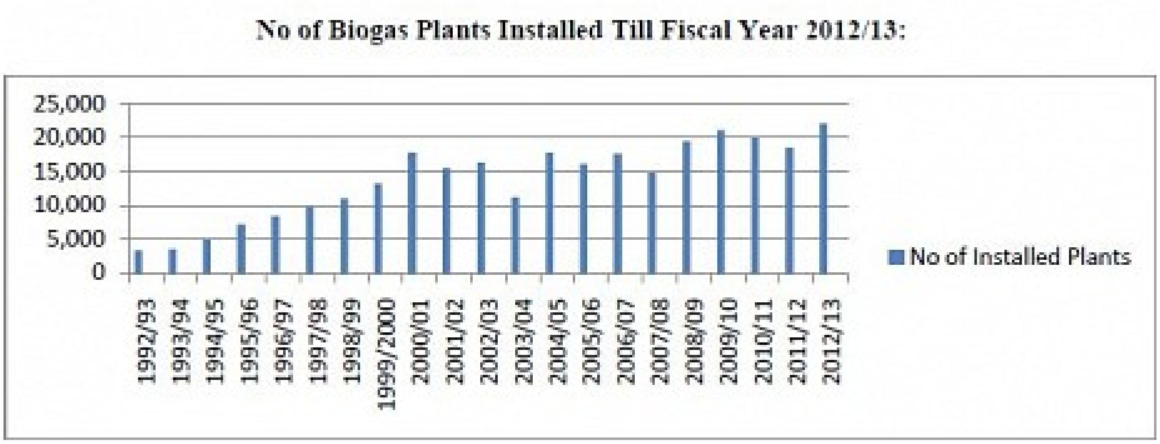


Fig. 4: No. of Biogas Plants Installed till fiscal year 2012/13 in Nepal

Source: AEPC web homepage, aepc.gov.np

In Nepal, the Biogas Support Programme has installed more than 120 000 biogas plants over the last 13 years (Fig. 4) and 3% of Nepalese homes now benefit from much lower levels of indoor air pollution. Moreover, 72% of the biogas plants are connected to latrines, leading to improved cleanliness and reduced health risks in the vicinity of the home (WHO, 2006)

b. **Biomass**

According to estimation of WHO, nearly 7500 deaths are due to pollution due to use burning wood , which counts 2.7% of the total death due to different casus (WHO, 2007). Improved cooking stoves (ICS) has been introduced in order to lower the indoor air pollution and related disease. Alternate Energy Program Promotion Center (AEPC) has been successful in installing ICS in many parts of the country. This program was organized by government organization (GOs) and local non-government organization (NGOs), without direct subsidy to households. Table below (2.) shows the target number of this biomass program.

Table2: Target of biomass program (Bajracharya, A. 2010)

S.N.	Biomass program Progress till March 2010	Target
1.	Improved cook stoves (mud)	434, 000
2.	Institutional improved cook stoves	5, 000
3.	Iron cook stoves	50, 000
4.	Household gasifier	10, 000
5.	Institutional gasifier	1, 000

It is estimated that 50% of the 11 million tons of dry fuel wood which is annually consumed, can be saved by replacing traditional cooking stoves (3.0-15% efficient) by ICS, although fuel saving depends upon several factors such as effective cooking practice, the condition of fuel wood, the type and amount to food prepared and cooking utensils (Bajracharya and Gongal, 1998). Stoves provided by ICS program need some modification as people are not able to use it for all kinds of cooking. Narrow opening of ICS restrict the use of all sorts of biomass such as crop residue and large pieces of fire wood including industrial residue. Large utensils cannot be used. Improvements according to the need of small and big household will surely save huge amount of biomass. If ICS develop new technology for both cooking and space heating stoves, it would be advantageous to the people in hills and mountainous region.

c. **Bio-briquetting**

Bio-briquette is a dense material made from the crop and forest residues mixed or without mixing with the animal dung. The production process includes the application of temperature, pressure and moisture and a energy material. They have better physical–chemical and combustion properties such as a higher heating value, and lower emission of undesirable gaseous pollutants such as SO2 and NOx (Singh, 2009). Now a day, many private organizations and communities are producing briquettes from rice husk, weeds, household and agricultural wastes and residues.

No detail research has been done about this biofuel but it has been used in many parts of the country especially in the southern part as people in these areas have enough husk and crop residue in comparison to hilly region (K.C. et al., 2011). So, it has the potential to replace wood fuel and others fossil fuels like kerosene, coal and LPG which are expensive as they are imported from foreign country.

Bio-briquetting is a low-cost simple technology that is free from geographical and climatic limitations. Moreover, bio-briquette is ideal for both cooking and space heating, and has potential in reducing IAP by up to 90% (Practical Action Nepal, home page). The production of bio-briquette during monsoon season is, however, affected by proper storage and drying requirements. Other limitations of bio briquette are its low volatility and long ignition time compared to fire wood. Moreover, bio-briquette is unsuitable to use in the traditional stoves (ibid).

d. Biofuel

The Biofuel concept was initiated in the year of 2008/2009 by the Government of Nepal, announcing Biofuel program through AEPC. Biodiesel production from Jatropha carcass L. has been given focus in this program. Many private organizations have been involved in the promotion of the Jatropha plant (Dhakal and Dhakal, 2009). Biofuel program has established 20 modern nurseries through 12 different organizations, and they have distributed 1.25 million jatropha plants to interested farmers and organizations. Two private organizations have established two processing plant for the Jatropha seeds with the capacity of 1000 liter biodiesel per day (ibid). Now, commercial cultivation of Jatropha has been started and Jatropha research center is working on it. As mention in Bhattarai (2010), biodiesel can replace up to 5% of imported diesel within 2-3 years.

Still, there are limited economical and technical feasibility studies about it in all over Nepal as geographical landscapes are quite different even in such a small country. The yield of Jatropha could be different if the quality of land differs. Jatropha can grow in rather marginal land. It needs minimal input of water and survives through periods of drought, but surely the oil yield varies. It is calculated that it require 20,000 l water for each liter of biodiesel although only

14,000 l is required for the same amount for soybean and rapeseed oil (Gerbens-Leenesa et al. 2009). But the problem in case of Nepal is that of growing food insecurity. It is much debated whether or not the cultivation of Jatropha in cultivable land will lead to food deficit (SNV/WWF, 2009). So, it unlikely to follow the mono-cultures of energy crops of neighboring countries. There are opportunities for growing of several species of plants which are oil-bearing and indigenous in nature. A study of this has been conducted since 1980s and found 286 oil-bearing species (edible and non-edible). Non-edible can be used for the biodiesel production. According to the research conducted by K.C. Surendra and coworker in 2011, up to 12% (18,000 km^2) of the barren and under-utilized land could support cultivation of potential feed stock for biofuel production. There is also a possibility to incorporate Jatropha in community forest which already has become successful in many region of Nepal. This would lead to extra income for the local communities and also helps to stop money used for purchasing diesel from foreign country.

2.2.2 Micro and Pico-hydro Technology

A total of 13.9 MW from 1977 micro-hydro (including pico-hydro) electrification program has been generated in various parts of the country as per 2008/09 (WECS, 2010). Due to the subsidy program implemented by AEPC/Energy sector Assistance Program (ESAP) after 2000, installation of micro-hydro has been steeping up. Nepal has many rivers and streams and there is a high potential for the fast growth of the hydro and micro- hydro power. It is estimated that micro-hydro can generate 50KW electricity. But the investment cost of it is $2860 per KW which is higher than the cost of electricity generated by large hydropower plants (Center for Rural Technology CRT/N, 2009). The problem with micro and pico-hydro is that of continuous water supply and remoteness from residential areas. Small rivers and streams are seasonal and the flow is low in winter season causing fluctuation in electricity production.

2.2.3 Improved Water Mill (IWM)

Nepal government started IWM program in order to improve the living condition of traditional water mill owner and its user. It is estimated that there are 25,000 water mills throughout the country. This program is supported by the Government of Nepal and SNV/Nepal under AEPC from 2003. The program helped to install 5400 IWMs which are providing services to about 1,680,000 rural people of 280,000 household (CRT,2009). The installation cost per KW electricity for IWM is $2143 which is lower than that for micro-hydro. This help to reduce the time taken to process their food and can do income generating work in their spare time.

2.2.4 Solar

a. Solar Photovoltaic (PV) Technology

Solar PV technology has been used in some parts of Nepal. Specially, those area where electricity is not available through national or micro hydropower, and other technology such as diesel generator and biogas plant are not available, PV technology is the only mean. It is also gaining popularity in other accessible region also due to more than 12 hours of power cut off in winter season. Various public and private company are using it and it is estimated that it supplies about 8278.8KW electricity. Table 3 shows the number of installation of PV solar system. Due to high installation cost ($14,286 per kW) of production of electricity by solar PV system, it is very difficult for the poor people to use this system (CRT/N, 2009). Although the cost is high, Nepal electricity authority has carried out centralized solar PV based rural electrification in different locations. The main disadvantage of solar PV system is that electricity production is weather dependent and it fails in case of bad weather.

Table 3: Total number of solar systems and total installed capacity (Draft report on status of photovoltaic in Nepal; 2010 cited in K.C. et al., 2011)

S.N.	Photovoltaic (PV) system	Install capacity (watt)	Number of system
1.	Solar home system (SHS)	5, 624, 475	206,152
2.	Small solar home system (SSHS)	737,258	155, 574
3.	Solar photovoltaic in communication sector	1, 243, 894	943
4.	Institutional solar photovoltaic system (ISPS)	537, 216	415
5.	Solar photovoltaic pumping system (PVPS)	135, 969	76
	Total	8, 278, 812	363,16

b. Solar Thermal Technology

In Nepal, the average sunlight hours are 6.8 h/day and solar insulation intensity is 4.7kWh/m2 per day. So, there is a huge potential for solar thermal devices such as solar water heaters (SWH), solar dryers (SD), and solar cookers (SC). SWH has gain tremendous success with 100,000 panels in 80,000 households but SD and SC are still behind in commercialization (Shrestha, 2009). Due to high cost and those regions with long and harsh winter where the temperatures in below freezing point, solar thermal devices are not gaining more interested among many households. As an ordinary solar heater cost $215, average people cannot afford it easily. Another hindrance is the lack of energy storage system and all-purpose energy, such as frying and fast cooking is not possible and SD and SC are lying behind the SWH systems (ibid).

2.2.5. Wind Energy

Very little has been done in this sector. Lack of research and data implies that only small efforts are made in this sector. Danish Government helped to build 20 KW wind mill in Kagbeni but unfortunately, it could not continue and no electricity has been produced. Lack of sufficient research and complicated geographical landscape made it not succeed, but the wind-solar hybrid system of 400 W with 150 W solar power projects have been established in six rural communities. More than 48 households with two secondary schools are taking advantage from these micro-projects (AEPC, 2010). The government plan of generating 20MW electricity by wind energy within three year 2007/08- 2009/10 has been unsuccessful. This is because installation of wind mill requires specific geographical condition, skilled manpower and other infrastructures.

2.3 Nepal Energy Policy and Subsidy

Hydroelectric power has a big potential in Nepal. The Nepalese hydropower electricity potential is 83,000 MW of hydropower of which about 3, 000 MW of power production seems to be economically and technically feasible. Till now, only about 563 MW has been harnessed which is mainly consumed in urban areas (Rural Energy Policy, 2006). The rural and remote areas of the nation have no access to reliable and clean energy. In spite of high possibility of producing energy in rural areas (biogas, solar energy, wind energy, improved water mill, micro and mini hydropower), no attention has been given due to political and economic causes.

The energy Policy 2006 has been designed, in particular, with the following strategies:

- Development of a policy which addresses the energy needs of the rural population;
- Creation of a rural energy subsidy with clear objectives and criteria for target groups;
- Development and enforcement of efficient and effective credit systems;
- Incorporation of rural energy policies of ministries and institutions related to rural development;
- Effective cross-sectoral and donor coordination of rural energy programs;
- Adequate information campaigns and education programs; and
- A broad stakeholder involvement to ensure success.

Alternative Energy Promotion Center (AEPC) is a Government institution established in 1996. It is now under the Ministry of Science, Technology and Environment with the objective of developing and promoting renewable/alternative energy technologies in Nepal. It functions independently, and has an eleven member board with representatives from government sector, industry sector and non-governmental organizations. There are six major externally co-funded programs/projects within AEPC. These programs are making an important contribution not only in promoting the use of renewable energy in the country but also to mitigate greenhouse gas emissions, expand the off-grid rural electrification, improving the education and health. There is a potential of developing AEPC projects into carbon projects. Clean Development Mechanism (CDM) opportunities are being pursued in biogas, micro hydro, improved cooking stoves, improved water mills and solar home. According to annual progress report of AEPC2010/11, the Governments of Denmark, Norway, Germany and Nepal continued their support in providing subsidy fund through Rural Energy Fund (REF) which is responsible for providing the subsidy and facilitating the credit to the rural energy systems/projects. In March 2011, DFID/UK joined the ESAP II for providing financial support to around 34,000 Solar Home Systems (SHSs). Through REF, 60,501 rural households in 72 districts have received subsidy for SHSs. Further, 6,020 rural households have received subsidy for Small Solar Home Systems (SSHSs) in 47 districts (AEPC report 2010/11). The difference between , SHSs and SSHSs is that in the latter the purpose is just for lightening rather than running other electric devices such as television, tape recorder and water heater etc.

Subsidy Arrangement

The rural energy policy 2006 has introduced the different energy subsidy policies focusing on remoteness, poor, ethnic, marginalized, backward castes and tribes. The subsidy rate and disbursement criteria as per the existing renewable (rural) energy subsidy arrangement have been revised. The rural energy subsidy policy (2013) has categorized the village development committee (VDC) according to remoteness. The village have been categorized into A, B, and C. A is the more accessible C is the least accessible in terms of basic facilities (road, electricity, drinking water etc.).While designing the subsidy rate, the basis of around 40% of the total cost will be covered by subsidy, around 40% by the soft loan from the financial institutions, and rest minimum of 20% by the community or households in kind and cash.

Renewable energy options such as biomass energy, solar energy and micro-hydropower are locally appropriate and practical solutions for supplying modern energy. In Nepal, the Rural Energy Policy 2006 and associated policies, e.g. subsidy policy, have been adopted to promote the renewable rural energy technologies. These policies are gradually evolving and have addressed gender concerns to some extent. Practical experiences have shown that women-friendly technologies and dissemination approach can yield significant benefits to the society.

2.4 Opportunities and Constraints Regarding Energy Use

Nepal has a vast number of natural energy resources, but renewable resources contributed least 1.0% and fuel wood use was the highest 77% of total energy consumption in 2008/2009(K.C. et al. 2011). This is related to geophysical, technical, economic and political reasons. The majority of the population in rural areas relies on traditional biomass resources for energy; whereas in cities, they are forced to use expensive imported fossil fuels for fulfilling their energy needs. Supply shortage is quite common in Nepal especially for commercial energy particularly electricity, which arises mainly due to inappropriate policies and investment decisions. If current infrastructures and policies are not modified, Nepalese people will continue to rely on traditional biomass and imported fossil fuel in coming years. Thus, for developing countries like Nepal, the use of RETs has a huge potential. RET can provide clean and reliable energy, to restrict the costly import of fossil fuels, create employment opportunities, preserve the local environment, and improve the quality of life. I am going to discuss about the opportunities and constraints of RETs in Nepal.

a. Biomass

Biomass is the traditional energy sources for cooking food and animal feed, water heating and also popular for space heating in winter season in Ilam. The fig. 2.4 shows the rapid growth of improved cooking stove (ICS) installation in eastern part of Nepal after 2007.The improved cooking stove and biogas programs initially had the goal to reduce firewood consumption. No direct subsidy has been provided for the promotion of household mud improved cook stoves. But local bodies are encouraged to provide some financial support to install mud ICS to household with single woman, backward, disaster victim, poor and endangered ethnic group as identified by the Government of Nepal (RE subsidy policy, 2013). Local people are trained by AEPC center to make the ICS stove and the technicians install the stove based on demand. Some HHs displace the ICS stove when they start to cook food on LPG gas or biogas stove but they are still using the open fire stove and charcoal stove because ICS stove is not preferred to cook animal food as it does not support the use any type of firewood, such as log, twigs and crop residue. The dwindling forest due to land clearing for tea-plantation has serious implications on the availability of wood fuel in Ilam. Besides, reduced wood fuel availability has led to the adoption of mixed wood fuel use. Mainly husk and homemade charcoal based stoves are used in the lower income groups such as the Lepchas, Rais and Tamangs. Others have resorted to LPG as well as electricity. According to DCEP (2011), wood fuel is still the only cooking energy source in most HHs in Ilam. By large, the high cost of systems has still forced the households with biogas and LPG to still stick with wood fuel. Thus indicating that wood fuel will still remain as a prime energy source for many of the families irrespective of economy or caste/ethnicity

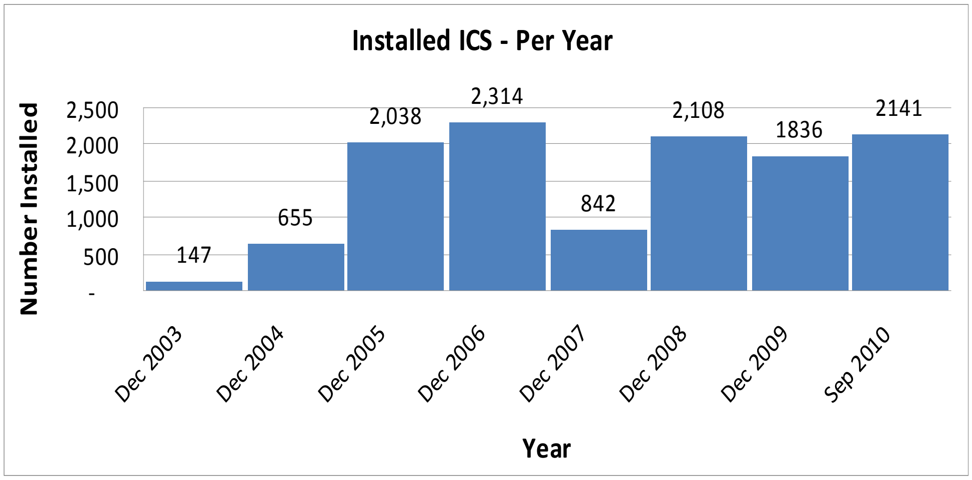


Fig. 5: Improved Cooking Stove (ICS) Installations trend in Ilam

Source: NCDC cited in DCEP (2011)

According to DCEP (2011) 2141 ICS have been installed by the end of September in 2010 where only 147 ICS were installed in 2003 and 2314 ICS were installed in 2006.Many households benefitted from the technology. This means that numbers of HHs are increasing to use ICS in Ilam district.

b. Micro Hydro Power

Ilam has good hydro power resources and number of organizations including DEEU, AEPC, DDC and private sectors are also involved in providing various services in the hydro power sector. NCDC has been working as a regional service centre for micro hydro development, promotion and end use promotion activities. AEPC provide support through subsidy and RET (rural energy technology) promotion whereas NCDC is involved in dissemination of technology, training, maintenance support and some research and development. There are also other organizations like Gurkha Welfare Society/KADOORIE, Sanima Hydro power and Dolakha hydro power company for Small hydro promotion.

RE subsidy policy (2013) categorized micro hydro from 10 KW to 100 KW, mini hydro from 10 KW to 1000 KW (1MW) and pico hydro is below 10KW for subsidy arrangements. The subsidy for community/cooperative owned mini hydro off-grid from 100kw to 1000kw project is as follows.

Table 4: The subsidy for community/cooperative micro hydro power

Subsidy Category	Subsidy Amount in Rs.		
	Category "A" VDCs	Category "B" VDCs	Category "C" VDCs
Subsidy per household	20, 000	18, 000	16, 000
Subsidy per kW	120, 000	100, 000	70, 000

Source: RE Subsidy Policy, 2013

For mini hydro project connected to grid, the household subsidy has been provided based on number of households connected to the plant. The subsidy amount per household to be connected to grid is Rs. 15,000.

Figure 61: Hydro plant installed in Nepal in different years.

Source: AEPC web page, www.aepc.gov.np

From the Fig. 6, we can see the growth trend of mini/micro/hydropower installations every year in Nepal. Micro hydro power projects in Ilam have a capacity of 125 KW and 1251 HHs are benefitted from this source (AEPC progress report, 2010/11). Micro hydro is seen as a technology to reduce drudgery, provide light other activities such as watching TV, listening radio.

c. Solar Power

Solar energy has traditionally been used for drying things like crops, fuel wood, clothes, and crop residues. But by the help of solar technology, solar energy has also been used for cooking food, powering computers, TV, radio, irrigation and drinking water systems as well but these uses are very limited.

Nowadays different solar energy technologies have been introduced including solar thermal systems and solar photovoltaic (PV) systems. Solar heaters are popular in Kathmandu and they are also suitable to other parts of the country except the Himalayan region where the temperature falls below freezing point. However, this technology is too expensive for most people. The solar PV (photovoltaic) systems convert solar energy directly into electricity. The NEA has carried out centralized solar based rural electrification in different location but the problem was the high cost of centralized solar PV-based system compared to electricity generation by smaller micro hydropower units.

Table 5: Subsidy for solar PV home systems through Government of Nepal

Solar PV system		Subsidy Amount in Rs.	
	Category"A" VDCs	Category "B" VDCs	Category "C" VDCs
Small Solar Home System with 10 Watt Peak(per HH per system)	5, 000	4, 800	4, 500
20 Watt Peak-50 Watt peak Solar PV System (per HH per system)	7,000	6,200	6,000
> 50 Watt Peak Solar PV System (per HH per system)	10, 000	9, 000	8, 000

Source: RE Subsidy Policy, 2013

The maximum subsidy amount to75% of the total systems cost but not exceeding Rs. 1000,000 has been provided for solar photovoltaic system to be installed in public institutions like school, health post. Beyond this, subsidy for the PV pumping system for drinking water to be managed by community has been provided up to 75% of the total system cost but not exceeding Rs. 1500,000 per system. The additional subsidy of Rs. 2500 per household has been provided to household with single woman, backward, disaster victim, poor, and endangered ethnic group as identified by the Government of Nepal (RE Subsidy Policy, 2013).

d. Biogas Technology

Biogas is considered to be the most sustainable sources of renewable energy in Nepal. Biogas has been mainly used for cooking and the bio slurry has been used as a high quality fertilizer for increasing agricultural productivity. Only few HH have used the biogas for lighting. Biogas plants are popular in Terai region but they are increasingly used in the hilly region. The biogas plant reduces the GHG emission, save the fuel wood and kerosene use. The drawback of biogas in Ilam is that it does not produce enough gas in the winter season.

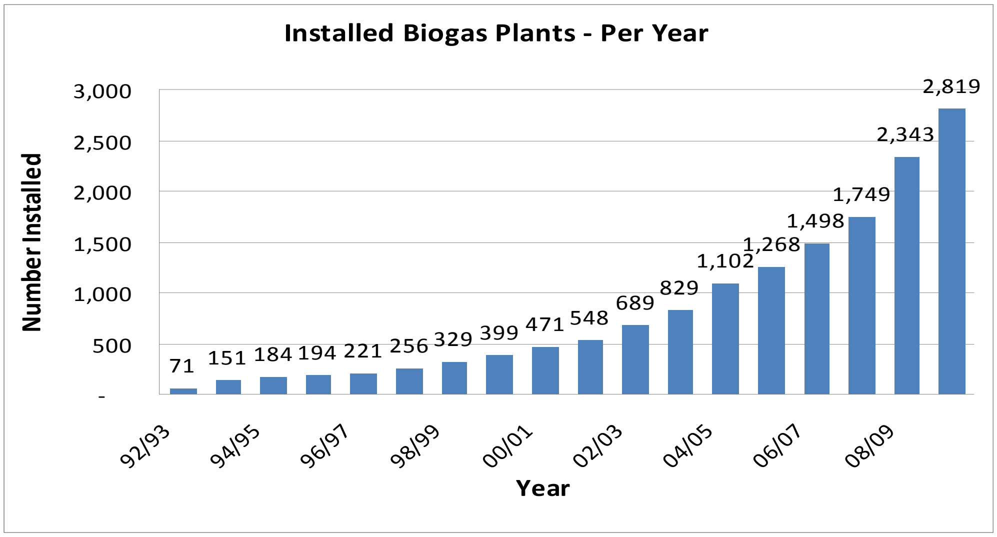


Figure 7: Number of Biogas plant installed in Ilam in different years

Source: Biomass support program cited in DCEP (2010)

The figure 7 illustrates the installation trend of biogas plant every year where the significant growth can be observed starting from 1992 with 72 to 2819 by 2008/09. Nepal has recently started to promote energy project under CDM for the exchange of carbon credit as per the Kyoto Protocol linking energy with the environment and climate change. The Government of Nepal has given the responsibility to Ministry of Environment to act as the Designated National authority (DNA) for any CDM activities in Nepal. The role of the DNA is basically to ensure the CDM projects objective of contributing in sustainable development of the country.

Table 6: Subsidy for Domestic Biogas Plant from Government of Nepal (GoN)

Region		**Subsidy Amount in Rs**		
	2 Cum	**4 Cum**	**6 Cum**	**8 Cum**
Mountain Districts as specified by GoN	25, 000	30, 000	35, 000	40, 000
Hill Districts as specified by GoN	20, 000	25, 000	30, 000	35, 000
Terai Districts as specified by GoN	16, 000	20, 000	24, 000	25, 000

Source: RE Subsidy Policy, 2013

The additional subsidy up to 4000 rupees will be provided to household with single woman, backward, disaster victim, conflict affected, poor and endangered ethnic group as identified by the Government of Nepal. The Table 6 indicates that the subsidy has remained an important component of financing biogas in Nepal. Subsidy has been made pro poor recently to expand the coverage among relatively poorer people. Subsidy has taken into consideration of remoteness and connectivity too in terms of differentials in rates.

Lack of adequate water for operating the biogas plants in hills and mountainous areas is another hindrance (WECS, 1996). The availability of sufficient feedstock for biogas digesters is also a critical problem for Nepal. Nearly all existing biogas plants, except institutional biogas plants, are operated on cattle dung. Thus, households need to have sufficient numbers of livestock in order to feed the digester with required manure for biogas production. Though installation of biogas plants are subsidized, depending on the plant size and remoteness but the cost share by individual household is still expensive for the rural populations (REDP, cited in K.C. et al. 2011). Furthermore, the poorest of the poor who have no livestock, are unlikely to benefit from the subsidy policy of BSP. Lack of technical knowledge coupled with cold climates, are hindrances in increasing service coverage in poor rural areas. The main problem with a family-sized plant is low biogas yield during the winter and rainy seasons.

Barriers

Several barriers that have prevented penetration of RETs, that include cost-effectiveness, technical barriers, and market barriers such as inconsistent pricing structures, institutional, political and regulatory barriers, and social and environmental barriers. UNDP Renewable Energy for Rural Livelihood (RERL) report, 2012 has mentioned the seven main constraints/barrier regarding energy use.

a. policy and regulatory barrier

   Due to the instability political situation of Nepal, the absence of rural energy (RE) guidelines, RE policy, subsidy policy, RE policy particular at district and village level are the major challenges regarding energy use in Nepal

b. Institutional(capacity) barrier

   Inadequate capacity within district and local governments to regulate, develop and monitor the RE projects, weak networking between energy companies and finance institutes, stakeholders and the projects, inadequate cooperation between different RE programmers' in Nepal are the main institutional barriers.

c. Technical Barriers

Limited experience with the technical, economical, and environmental aspects in RE, inadequate knowledge on the installation, management, operation and maintenance of rural energy systems as well as insufficient human resources for operating the systems are the main technical barriers.

d. Financial barriers

High cost of RE system, high dependency on donor funds ,risk aversion of finance institutes, the high cost of the plants and low load factors(below 50%) of the plant make the projects economically unviable.

e. Information and awareness barrier

Local level people are still unaware about the renewable energy systems specially information on the costs and benefits of various RE systems.

f. Systemic, decentralization and governance

Decision making process in Nepal is normally central driven. Renewable energy development program are appraised at the central level and their operation modalities are discussed among central level stakeholders. This top to down approach sometimes led to conflict at the time of implementation.

g. Social, cultural and gender barriers

Many rural and remote areas people have their own cultural and social values different from the other regions. The RE programmes have to address these issues to ensure active participation of the local people and incorporate their values. The concerns of women and disadvantaged groups must be addressed while implementing energy programmes to make it more inclusive and sustainable

Chapter Three: Theory

3. Theories on Energy Use

Energy poverty can be described as 'the inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read, or for other households and productive activities after sunset.' (Modi et al. 2006). Modern energy systems are often characterized by adaptation of higher energy density, higher combustion and heat-transfer efficiency, and controllability (Takama, Lambe et al. 2011). Modern energy is considered a key step in enhancing the living conditions of billions of people in developing countries. Access to modern energy systems (e.g. electricity, LPG) has been found to positively impact in human wellbeing by reducing the health and safety risks associated with traditional energy use (IEA 2002, IEA 2006); decreasing the time constraints on household members particularly women and children; increasing labor productivity and income (IEA 2002); and positively impacting social issues such as gender inequality and literacy (Cecelski 2002, Rukato 2002, ESMAP 2004(cited from Koswari, 2013). In most rural and semi-urban communities, wood fuel is still the dominant energy source which is used for various tasks such as cooking, lighting, or space heating (Masera & Navia 1997). The researcher has attempted to illustrate two main models which have been formulated to structure the discourse on energy transition theory: the energy ladder and multiple fuel approach.

3.1 Energy Ladder Approach

From the perspective of energy fuel use, development has for a long time been modeled as the ascent of a 'rural energy ladder' (Barnes and Floor, 1996). This model proposes that, as families gain socioeconomic status, they abandon technologies that are inefficient, less costly, and more polluting, i.e. 'lower' on the energy ladder, such as dung, fuel wood, and charcoal (Barnes & Floor, 1996). In general, such an ascent follows a movement away from the utilization of human, animal and biofuel power to a mix of traditional and modern fuels. This model casts the picture of an imaginary ladder, each rung of which corresponds to a specific energy carrier. At a particular point in time each household is assumed to stand on a single rung, thereby, choosing one out of numbers of fuels arranged before in an increasing order of technological sophistication.

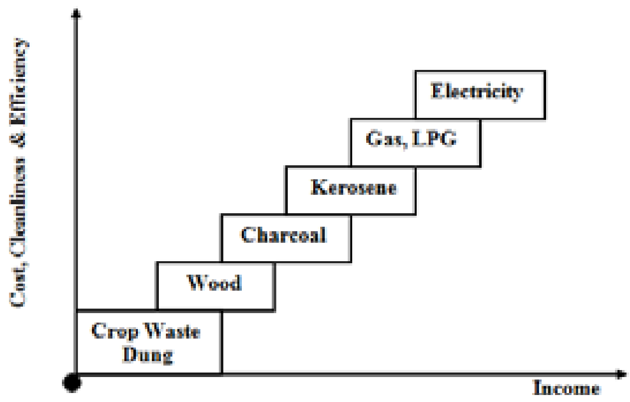


Fig.8: Energy Ladder Approach (source: Masera et al. 2000)

The energy ladder model describes the positive relationship between socio-economic level and modern fuel uptake. The linear model suggests that an increased income is positive correlated with the adoption of and transition to more efficient, cleaner, and more costly energy sources (Fig.8). This model can be characterized by three stages. At lowest rung biomass is used in the form of agricultural residues, dung and wood; the second phase is defined by a shift to so-called transitional fuels such as charcoal or kerosene; the final step constitute the adoption of 'clean' energy forms like LPG, natural gas, or electricity on the energy ladder model. The lowest step of the ladder relates to animal dung and crop waste while the top-most rung corresponds to electricity (as indicated in Fig. 8).

According to Masera et al. (2000), the different fuels and stoves carry a social status as well. Hence, the greater costs of advanced technologies are on one hand compensated by the greater fuel efficiency and cleanliness of the stove but also by the strived increase in societal status. Agricultural waste and firewood are perceived as the 'energy of the poor' which is used out of necessity rather than choice and it is assumed that consumers will strive to the most sophisticated energy form they can afford (Hiemstra-van der Horst & Hovorka 2008, Soussan et al. 1990).

3.2 Multiple Fuel Use Model

The multiple fuel model has been proposed as alternative to the energy ladder which more often than not, has failed to correctly predict developments (Masera et al., 2000). This model suggests that people use different energy fuels where most appropriate like cooking practices for different food for reducing cost or increasing efficiency. Masera and Navia (1997) explain that most households in developing countries do not apply the single-fuel substitution and linear transition suggested by the energy ladder but rather employ a variety of fuels simultaneously potentially including all levels indicated on the energy ladder. Multiple fuel use allows for the maximization of energy security and the allocation of different fuels to purposes where they are most appropriate (Grimsby,2013).The underlying rationale of multiple fuel model lies in the need for securing sufficient energy where supply is erratic (Masera et al., 2000).

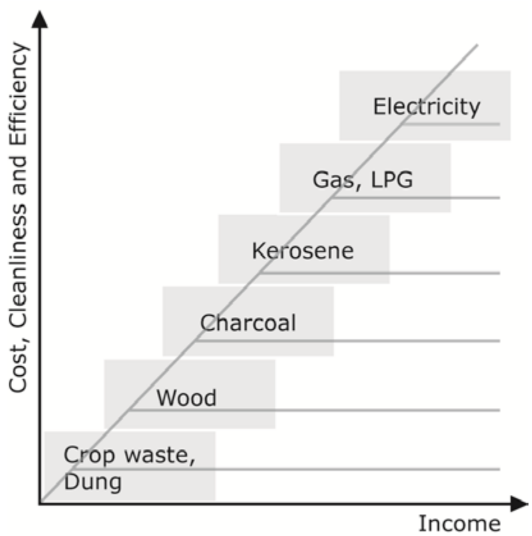


Fig.9: Multiple fuel use approach (modified from Duflo et al., 2000 cited in Trieber, 2012)

The traditional energy ladder, like any such general model, is likely to provide only a limited view of the reality in households. Due to the failures of the linear energy ladder to describe adequately the fuel use dynamics in Jar_acuaro and other Mexican villages, Masera et al. 2000 further elaborated a ‘multiple fuel’ model. He further cited that multiple cooking fuel use patterns have been reported frequently in the literature on household energy use since the eighties (Evans, 1987; Leach & Mearns, 1988; Fitzgerald et al., 1990). In the case of rural energy, households rely on multiple cooking fuels to better cope with the variety of methods needed for food preparation (Tinker, 1980) or as a form of ‘back-up’ against policies that can modify the relative prices of fuels for example in Africa, the escalation of kerosene prices led to extensive switch-back to biofuel (Leach & Mearns, 1988). Thus, the extent and permanence of multiple fuel use patterns in households are the result of complex interactions between economic factors (such as highly variable fuel prices and unreliability of fuel supply), social factors (such as evolution and security of monetary household incomes) and cultural factors (such as specific cooking practices, habits, and religious beliefs). Therefore, three important questions are related to the understanding of fuel switching process: a. to what extent is multiple-fuel cooking a transient or a long-term situation (i.e., what is the 'strength' of traditions relative to that of modernization)? b. what is the influence of these patterns in terms of fuel wood demand? and c. what are the implications of multiple-fuel cooking for indoor air pollution in rural households? To address these questions Masera et al. (2000) argue that fuel switching should be considered as a process resulting from the simultaneous interaction of factors pushing households away from biofuels and others pulling them back toward biofuel use, a bi-directional process. 'Push' factors include more convenience.

There is evidence that populations that have already adopted modern energy systems sometimes switch back to traditional energy systems, often due to increases in modern energy prices due to the removal of subsidies (Masera, et al. 2000, Pachauri, et al. 2012) switching back has been reported in Brazil (IEA 2006), Ethiopia (Kassa 2009, (cited in Takama, et al.2012)),Morocco (Elgarah 2011), Senegal (Lallement 2008), and recently in restaurants in India's major urban centers (Koswari, 2013). Both adopting modern energy systems and switching back are, however, rarely binary processes; often users adopt multiple energy systems, which are called energy stacking (Masera, et al. 2000). One of the main findings is that fuel wood is never replaced entirely, even in households that have been using LPG for many years. Fuel wood is still considered essential for tortilla making, for both cultural and technical reasons, and for traditional parties. Households that purchase fuel wood and LPG are even willing to pay a 'premium' for continuing to use fuel wood. Therefore, fuel wood is also seen as a fuel with advantages that go beyond price and include cultural considerations (Masera, O., and Navia, J., 1997.).

Early studies (Leach, 1992) hypothesized that households switch completely away from using traditional fuels when they gain access to modern fuels (that is, they move linearly up the 'energy ladder'). This hypothesis has not been supported by empirical evidence (Masera and Straatkamp (2000), Masera and Navia (1997), and Ruiz-Mercado et. al (2011), Hiemstra-van der Horst and Hovorka (2008)); instead households tend to add fuels into their mix, a process called 'fuel stacking' (Mekonnen and Kohlin, 2008). Current research does not adequately address how fuel decisions occur as part of the complex of economic activities in which rural households engage. Therefore, there remains a gap between theory and empirics in explaining fuel-use decisions.

Fuel-use studies focusing only on the rural energy sector (Hosier and Kipondya, 1993, cited in Guta, 2012)) may miss significant impacts of changes in other economic activities.

Chapter Four: Materials and Methods

This chapter covers the methodology that was adopted while conducting the research. Bryman, 2008 Social Research Methods was taken as guide book for research design and methodology. The appropriate methods have been used to get the reliable data. The wealth ranking of the HHs was based on the ownership of the land, House location and type of house, education , labour immigration country, livestock they owned, vehicle like motorbike, cycle owner ship as well as the electrical devices in their home as indicators.

4.1 Site Selection

Ilam has the highest number of the ethnic group Rai (24%). Altogether there are 13 different ethnic groups living in the district including Brahmin, Limbu, Chhetri, Newar and marginalized groups such as Sherpa, Sunwar, etc. The residential sector is the largest consumer of energy in the district with a demand of 2,497,000 GJ (Giga Joule) in 2010. Residential electrification in the district is approximately 35% and 95% in rural and urban areas respectively (DCEP Ilam, 2011).

Fuel wood remains the major energy resource for residential and commercial use in the district. In total the district has 80,926 hectares of forest of various categories. Agricultural residue and animal dung are the next important biomass energy sources that supplies246.63 GJ and 553 GJ, respectively (ibid: iv).

4.2 Study Site

The total population of Ilam is 290254 with 64502 HHs (CBS, 2011).Ilam district lies in Mechi Zone of the Eastern Development Region of Nepal. Ilam is a hilly district and lies in the eastern part of Nepal with altitude from 140 meter to 3636 meter covering an area of 1,714 sq km(DFO Ilam,2010Cited in: DCEP 2011). The district is bordered with Panchthar in the North West, Morang in the South West, Jhapa in the South East and India's Darjeeling District in the East. There are three electoral constituencies in Ilam, comprising 48 VDCs and 1 municipality. Ilam bazaar at the centermost is the district headquarters.

I chose two Village Development Committees (VDCs) of Ilam district. The research was conducted Barbote VDC of ward no. 3, Barbote village and Kanyam VDC of ward no 5, Kanyam villages. Both VDCs were selected purposefully with different diversity in terms of social, cultural, and socio-economic means. The other reasons for selecting them encompasses the number of rural energy users and NCDC monitored areas covering household energy. Both the villages were attached to Mechi highway. In total, 100 households were interviewed. Among them, 50 respondents are from Barbote village and 50 are from Kanyam village.

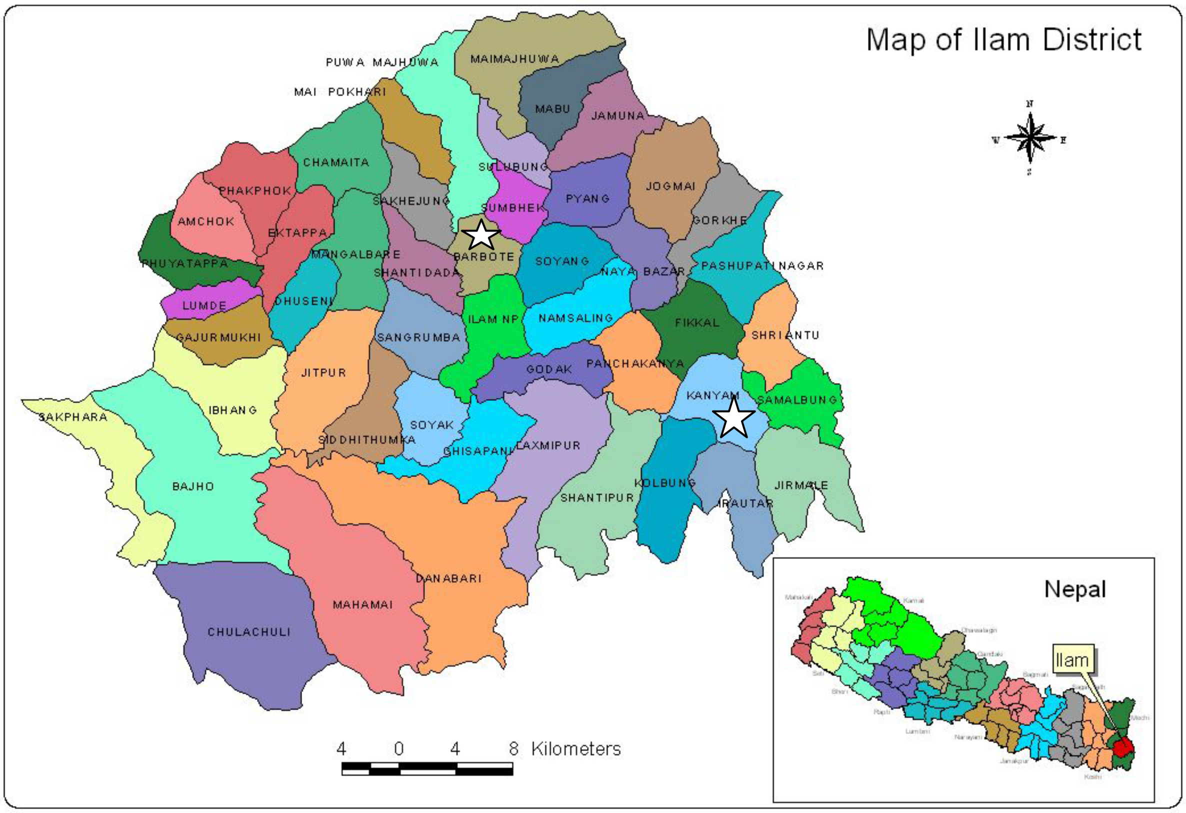


Fig.10: Map of Ilam District, Source: DCEP Ilam, 2011. *Star of the map indicates the study site.*

Barbote

Barbote VDC has the population of 6424 where 3227 are male and 3197 are female (NPHC, 2011. There are 1414 households. The altitude is from 690 to 1752 meter high with subtropical weather. The VDC has 4 community forests from where local residents get access to firewood and timber (Barbote VDC profile, 2010). Almost all HHs are farmers. They mainly keep cow, pig, goat and chicken. Since the majority of people are small-scale and subsistence farmers, most foods are produced for own consumption and only the surplus is sold. This village is 7 km distant from Ilam municipality. People in this area make cheese, milk chocolate, and ghee from milk and are also involved in cultivation of ginger, cardamom, tea and red round chilli. They sell their products in the nearby market (Ilam bazaar). Due to the high demand, people of this area have recently started cash crop farming and other income generating activities.

Kanyam

Kanyam has 1715HHs and a total population 7290 in which male and female are 3596 and 3694 respectively (NPHC, 2011). Most of the HHs are farmer, labors and also kept animals. Farmers in Kanyam have built up gardens of tea. It is a beautiful spot in hill side. The landscape of those gardens is very attractive for all and recognized as local tourism place. 12 tea factories produce green tea, orthodox tea, herbal tea and black tea in Ilam. Most of the poor people around tea garden go to pick up the tea leaves. Many respondents were labour workers of the tea garden. One respondent of kanyam Sabita Bhujel said '*we are five members in my family: I, husband, son and daughter go to pick up the tea leaves in the morning from 9 am till 4 pm. My mother- in- law take care of the cow and house in the time we are out. We get 40 rupees per kg. , mostly I pick 8 kg leaves in one day. Tea leaves plucking is possible for 6 months. The rest of the time we live on that income.*

4.3 Sources of Data

Data were collected in February 2013 (1-15) for 15 days by researcher herself. This research covers both the qualitative and quantitative research design. Qualitative method is the research method specially adopted by the social science researchers. It focuses on in-depth study of the human behaviour and the reasons why humans act in a certain way. It tries to answer the questions such as why, how, when etc and focus on the small samples. The quantitative method has been used in order to find only the demographic characteristics of the respondents and household energy use.

4.3.1 Primary Sources of Data

Two villages (Barbote and Kanyam) from two different Village Development Committee (VDC) were the main part of primary data collection. Here, VDC and the village name are same. Hundred HHs were selected for the questionnaire survey. The household survey was conducted through quantitative method. The samples were selected on the availability of the people in the house and also snowball sampling was applied. Snowball sampling is a sampling design where a particular subject refers to another person whom they know. As it was broom grass (scientific name: *Thysanolaena maxima,* its flower is used to clean home and called 'Amliso' in Nepali language), ginger harvesting, and firewood collecting season in the Barbote village. Most of the members of the house were on the field, so it was hard to meet people at their home. But we collected the data early morning and evening time in Kanyam because many HHs went to pick tea leaves in day time. The respondent representing the household was selected by using convenience sampling design. Convenience sampling is a sampling technique where the subjects are taken into study because of their availability and also because the sample is convenient.

Primary data collection is the main part of the study which was conducted through structured questionnaire (survey method) and semi-structured interview was applied for the key informant interviews. Four key informants were selected by purposive sampling design where one VDC secretary and one local leader from each village were taken for interview. Purposive sampling is a sampling technique where the subjects are selected based on these persons knowledge. The researcher wanted to know about the household energy consumption pattern, energy policy, subsidy and its implication on the local people. Observation analysis was also undertaken on different fuel types, cooking stoves they used, the involvement of women and children in their daily work and house location, household chores, observation around the respondent's home etc. so as to have an idea of their economic well-being. Attention was given so as to avoid any sort of biasness while interpreting the data.

4.3.2 Secondary data collection

Different books, e-books, thesis, journals, online publications and papers were the secondary data for this research.

4.4 Data Analysis

The survey questionnaire was entered into Microsoft excel sheet. The data were segregated into different categories and produced the different desired graph, tables and charts. The quantitative research was supplemented with qualitative research to get information about the social. Semi-structured interview with open-ended questions were also used. The voice was recorded in a voice recorder for further analysis. The recorded observation was used to contextualize and support the reasoning. They were also supported by notes taken during the interviews describing the setting or participants' behavior and interaction. All the data were captured on paper and encoded using a predefined set of codes (also the qualitative part). These, however, had to be extended by additional answers that had not been considered before. A result, the general household data was extended by a stove, fuel, and HHs status database. Qualitative form of data and information were also coded and analyzed similarly. All identified groups are then coded in an appropriate manner. The HHs economic status was mainly calculated according to ownership and quality of land, household type, house location, employment, no. and type of livestock asset, ownership of vehicle etc. In some cases, secondary data like neighbors' view and social status was taken consideration.

4.5 Limitation of the Study

The study is not free from the constraints and limitations. Yet it has been conducted with best efforts. Some limitations while conducting the research are as follows

a. The study has been confined only to 100 HHs owing to time constraints.
b. The study has been based on field work which was conducted only for 2 weeks.
c. The study has been done in Barbote ward no. 3 and Kanyam ward no 5 of Ilam district. Hence the findings of the study cannot be generalized for the whole district.
d. No clear village boundaries but rather a continuous flow of compounds and households appeared to be a problem for identifying the exact study areas. The typical village borders are rivers, roads, paths or even small trails.
e. Household economic status was the subjective judgment of the researcher.

Chapter Five: Result and Discussion

5. Result and discussion

This research is based on mix method where the researcher herself visited the study area and collected the data. A total of 100 households were studied. 50 households were selected from each of the villages Barbote and Kanyam respectively. Each household was represented by one respondent.

5.1 Characteristics of Households

Table 7: Characteristics of Households

Stratum	**Sub -Stratum**	**Barbote**		**Kanyam**	
		N	%	N	%
Interviewee type	Male	32	64	30	60
	Female	18	36	20	40
Household's head	Husband	41	82	37	74
	Wife	8	16	12	24
	Others	1	2	1	2
	From 20 to 40	19	38	26	52
Age	From 41 to 60	22	44	19	38
	Above 60	9	18	5	10
Education	Literate	7	14	11	22
	Primary	9	18	20	40
	Secondary	20	40	11	22
	HigherEducation	8	16	4	8
	None	6	12	4	8
Occupation	Farmer	37	74	33	66
	Self-employee	3	6	1	2
	Employer	10	20	12	24
	Other	_		3	6
	No job at all	_		1	2

Out of the 100 survey households from both villages, 62% were male and 38% were female respondents. In rural areas most of the household structures are male dominated though most women are engaged in household work like cooking, taking care of children, cleaning etc. 78% of the households were male headed in both villages. From the data, I can say that the household structure is male dominated. The age division of the respondents has been shown in table 7. The respondents were of varying age. The youngest respondent was found to be 20 years and the oldest respondent was of 83 years. The highest number of the respondents was from the age of 41 to 60. Respondents in Barbote were highly educated (56% with secondary and higher secondary education) while in Kanyam there was 30% with secondary and higher secondary education. This might be related with the difference in poverty level in there two region. Residents in Kanyam are poorer (74%) than in Barbote (24%) although farming is the same main occupation in both villages.

5.2 The Fuels

The increasing use of local fuel resources in rural areas has affected the natural resources, threatening the beauty of environment and contributing to global warming, flooding, desertification and the drying up of water resources source. Since the rural people are obliged to use the biomass fuels (firewood, agricultural residue and animal dung) as a main sources of energy, energy use has both environmental and development implications. In the area where large population depends on agriculture, improved use of biomass resources will be essential to preserve the natural resources (Thapa, 1994). At the same time, saving human energy in managing energy resources and improving the health conditions by reducing domestic air pollution are prerequisites for increasing the productive and reproductive capacities of women (Kartha and Larson, 2000). Larger quantities and better quality of energy is necessary to raise the living standards of the people.

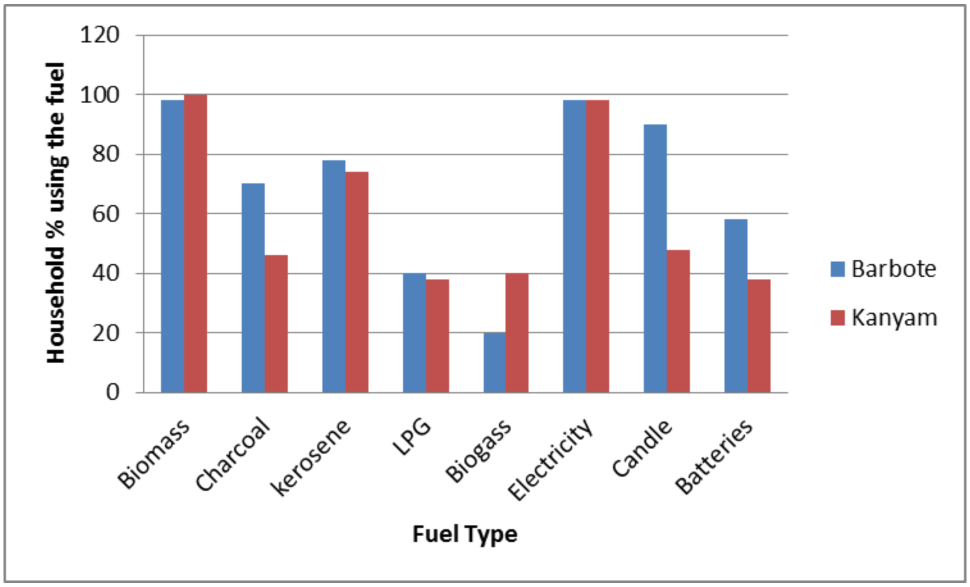


Fig. 11: Comparison of energy use patterns in both villages

Figure 11 illustrates the fuels used by households for the total sample. The household use a wide variety of fuels including crop residues, twigs and firewood. Biomass and electricity are the most used fuels by the respondents in both villages. Around 100% used them. Charcoal is free of cost as they make it themselves from the firewood while cooking meal and animal food. Charcoal creates less pollution inside the home. They use the charcoal is mainly for room heating, warming up food. The reason behind high number of biogas users in Kanyam is that poor HHs are given priority to get subsidy in installing biogas plant from government of Nepal through the biogas support program. The VDC secretary of Kanyam, Netra pokhrel said that *'…though the no. of Kanyam village people are poor, at the same time they prefer sophisticated life style and use equally LPG and biogas. Whenever they have money in their hand, they buy luxurious things like Sound system, Cassettes, CD, DVD, TV, LPG gas etc. and drink alcohol and invest money in other unproductive things. They don't prefer to spend money to send their children in schools. They are not conscious about saving the money for their future...'*

Kerosene was mainly used for lighting and to light the firewood or biomass. Candle users were high in Barbote (90%) which may reflect that the high status of people and more educated people lived there.

5.3 The Different Stoves in Used

Within the total sample, stoves types they were using asked. The number of stoves found to be used within the HHs as illustrate in fig. 12.

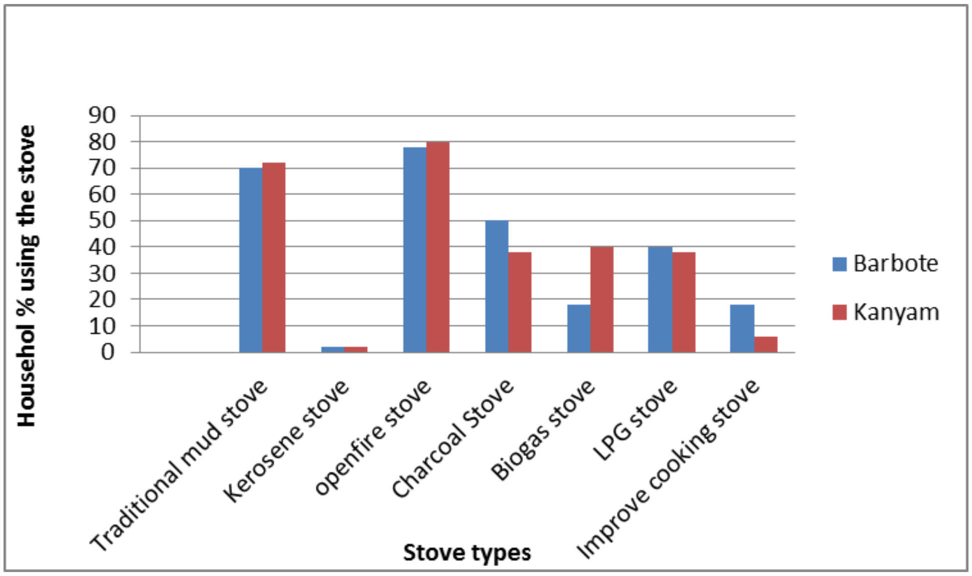


Fig. 12: Diversification of stoves used in both villages

The most common stoves used (>70%) in both villages were traditional and open fire stoves. Mainly open fire stove was used for animal food preparation because any type of biomass fuel like crop residue, animal dung, twigs, fire wood etc can be used in this stove. People usually cook animal food outside the home. Charcoal stove and ICS stove users were 50% vs. 38% and 18% vs. 6% in Barbote and Kanyam village respectively.

5.4 Energy for Different (cooking and lighting) Purposes

The research findings clearly indicate that within the representative sample, all households follow the multiple fuel approach using a minimum of two and a maximum of eight fuels. While in the case of stoves the results are not that uniform, the majority of households possesses and utilizes more than one stove in their daily routine. For the intended task, the household will always choose the best fuel and stove. Following that assumption, a richer household having the financial means will specialize its fuel use and use specific fuels for a particular task only.

Furthermore, such household can afford a variety of fuels. In times of fuel shortage due to lack of supply at the distribution centers or due to seasonal events such as rain, a richer household can afford not only the free or cheap alternatives but also those which are more expensive. Such fuel stocking behavior for energy security reasons is quite an important fragment in the multiple fuel use idea.

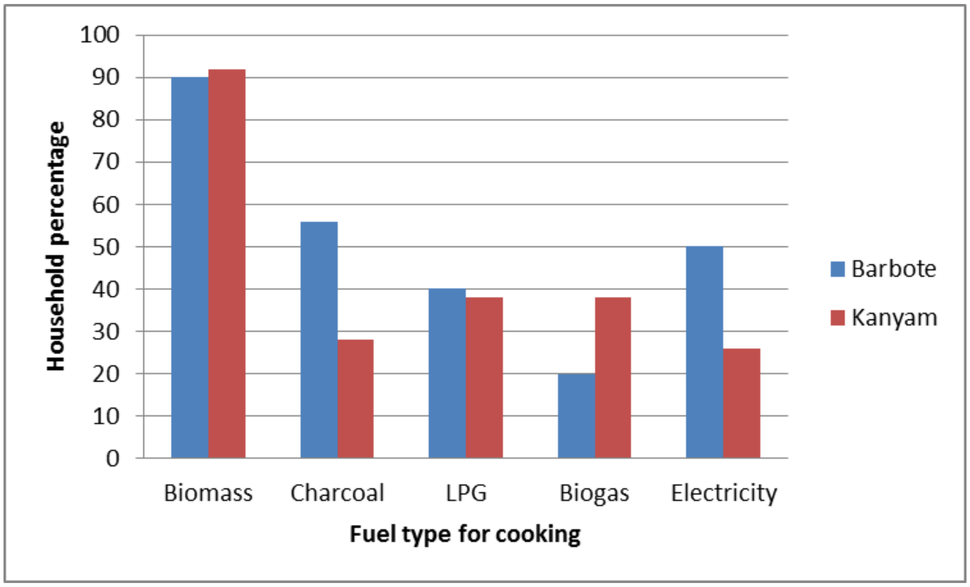


Fig. 13: Comparison of energy use patterns for cooking purpose in both villages.

People use various fuels for cooking. Figure13 indicates that the magnitude or the percentage of HHs using the multiple fuels for cooking task. More than 90 % HHs in both villages use the biomass for cooking purpose. The graph illustrates cooking food including animal feed cooking. Biomass was also used for alcohol fermentation. Some ethnic groups like Limbu, Rai, Gurung prepare homemade alcohol using biomass fuel. During the field visit observation, I also noticed that when they finished cooking their meal, on the same fire they also cook the animal food. Charcoal, LPG and electricity were particularly used for cooking meal. The use of electricity to cook rice in rice cooker is also popular especially in Barbote village. Barbote is nearby Ilam district capital city and people are more motivated in using modern energy.

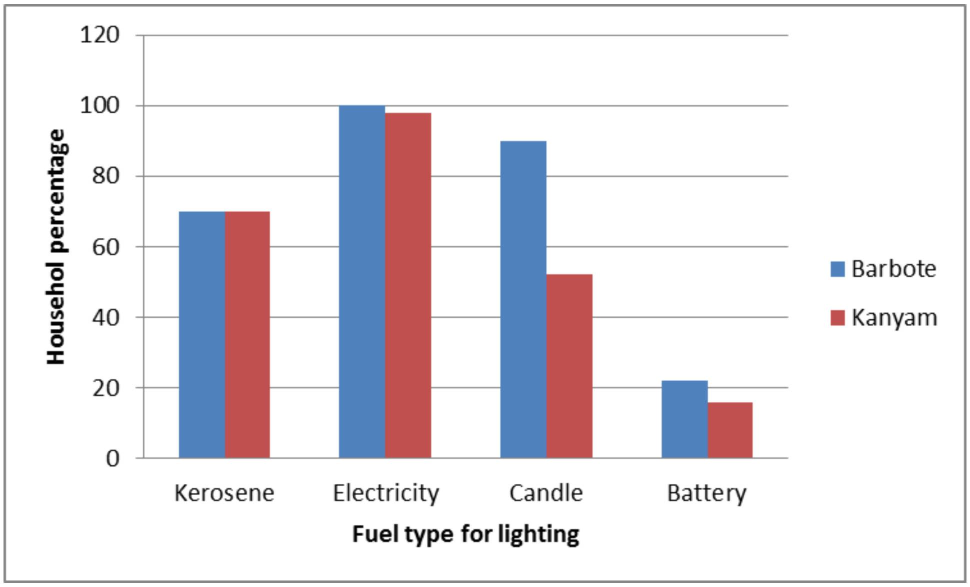


Fig. 14: Comparison of energy use patterns for lighting purpose in both villages.

Fig. 14 illustrates that electricity is the main fuel for lighting in both villages except only one household don't use electricity for lighting in Kanyam village. In Barbote 90% of HHs used candles but only 52% of HHs used in Kanyam. Only a few HHs used battery (22% Barbote vs. 16% Kanyam) for lighting in both villages. In both villages HHs used kerosene (70%) and electricity (100%) almost equally. Though electricity is accessible for almost all the HHs in both villages, kerosene, candle and battery are used as back up fuel for lighting. People use multiple fuel sources for lighting purpose because of everyday load shading. At the time of data collection, people said that there was power cut for two hours at the evening time (from 7-9 pm) every day. This is the time that people need the light the most. They were worried about the supply of electricity through the Nepal Electricity Authority (NEA). Batteries are used in torches. Some HH also use the emergency light (light which are more powerful torch and used in case of load shading) that is charged from electricity. Economically well off HH also use the inverter that is charged from electricity and people can light, watch TV, charge computer and mobile when there is power cut off. Only three HH used it.

5.5Cost of Energy Sources Use versus Economic Status

At the time of data collection (Feb. 2013), the purchase price was for firewood 5 Rs. /kg in average, LPG Rs.1500/cylinder, kerosene 97rs/Ltr. and for electricity 9.6 Rs/unit. All the units were transferred into monitory value rupees/currency.

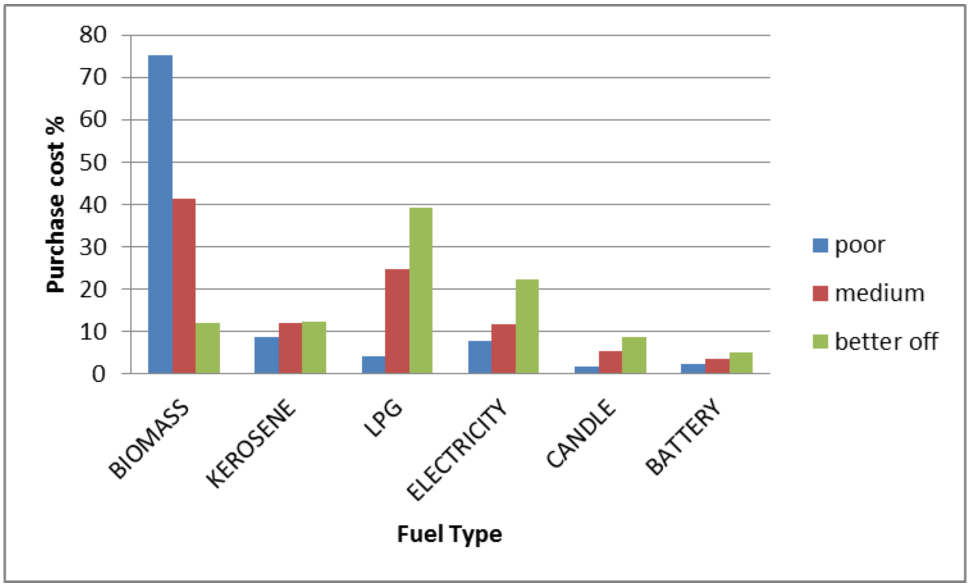


Fig. 15: Comparison of average fuel purchase patterns according to wealth rank in Barbote village. *(% of individual fuel purchase cost from totaling the different fuel purchase cost when they buy from the market)*

Figure 15 illustrates that poor people spend more money relatively in buying biomass and wealthy people spend more on LPG and electricity than other energy fuels. More than 75% of money in total of fuel purchase cost of poor HH's spent in biomass buying, 8.8% for kerosene, 4.1 % for LPG, 7% for electricity and only 3.3 % for battery purchase. Better off HHs spent around 40% money in buying LP gas and 22.4% in electricity. Out of this, HH spend on biomass purchase (12%), kerosene (12.34%), candle (8.6%) and battery (5%). This is comparable to poor and medium HHs purchase. Most of the better off people had their private land with trees and just collect biomass. They sell biomass to poor and medium HHs, but poor people have to buy biomass from rich people or from the local market. Reliance on firewood and other traditional energies used for cooking, which constitute the major source of energy demand by the poor. It shows that poor people are still behind in using of modern energy.

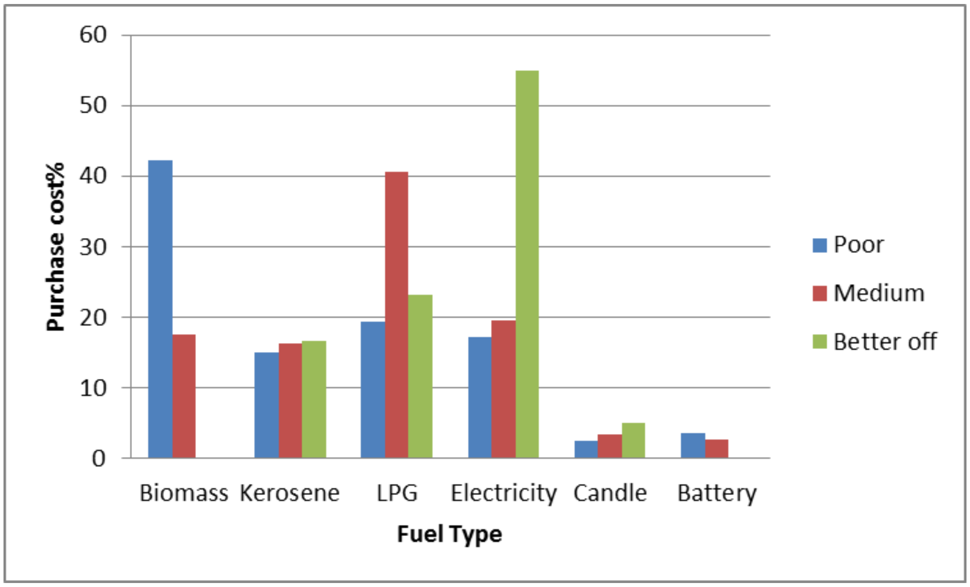


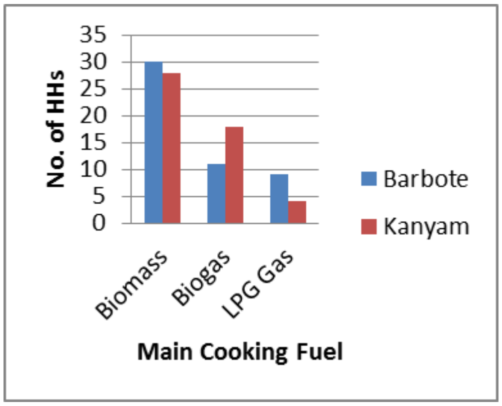
Fig.16: Comparison of energy purchase costs patterns according to wealth rank in Kanyam village.

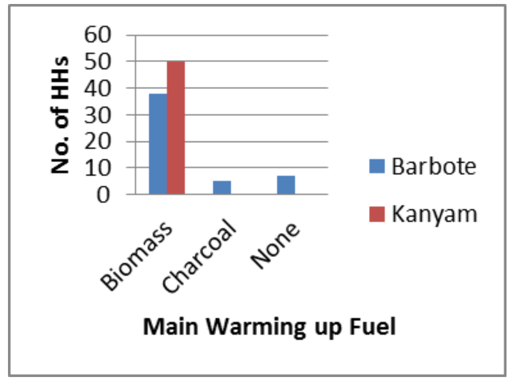
In Kanyam also poor HH buy more biomass for energy while wealthy people buy more electricity, LPG and candle. For the poor HH, 42% of the expenses went to buying biomass from the total buying cost for energy. Medium people spend 40% on LPG gas. Better off HH don't buy biomass and battery, but used more electricity (more than half of their total fuel purchase cost). Only 20% HHs have biogas plant and poor HHs had not it, so as the biomass purchase if high (75%) by the poor in Barbote. 40% (Fig. 11) Kanyam HHs have biogas plant mostly in poor HHs, hence their expenditure on biomass is less (42%). Better off people in Kanyam do not buy biomass; rather they sell to the poor HH. Due to the possession of modern electric device (like rice cooker, electric iron, electric light, sound system), rich people's cost for electricity is very high in comparison to poor and medium HHs, who mostly use electricity for lighting purpose.

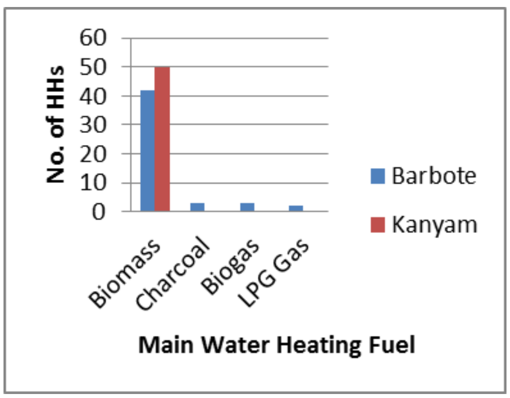
5.6 Types of Fuels Used

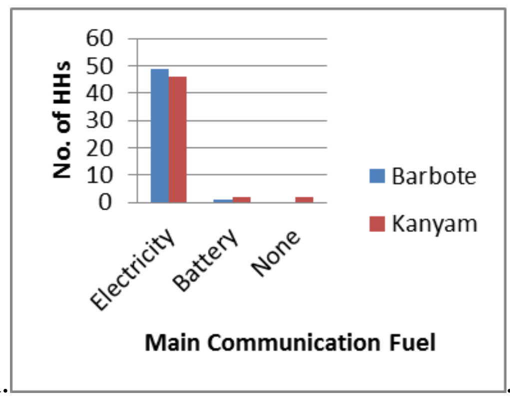
Figure 17 summarizes the main task fuels stated by households with more than one option. While biomass is stated to be mostly used for cooking, boiling water, and warming up food, Electricity is the main lighting source in most households. Communication and entertainment devices were

TV, radio and mobile used by most HHs. Here, the households were asked to identify the technology mostly used.

a. 

b. 

c. 

d. 

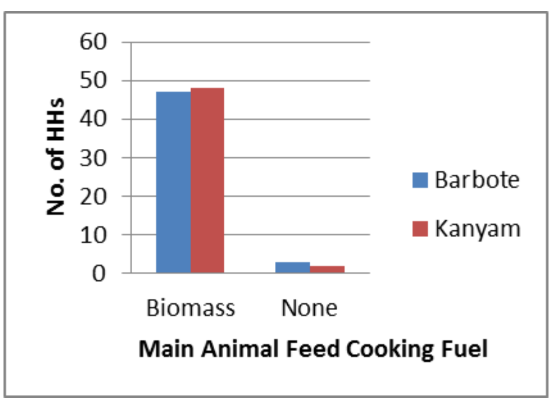
e. 

Fig. 17: Main fuels for household energy consumption in both villages

a. Main cooking fuel, b. Main warming up Fuel c. Main water heating fuel d. Main communication Fuel e. Main animal feed cooking fuel

Figure 17 gives an overview of the main fuels used for different purposes. Biomass was taken as a main fuel for cooking (30 HHs), warm up the room (38 HHs), water heating (42 HHs) and animal feed cooking (47 HHs) households in Barbote village. Almost all the HHs use electricity for lighting (50 HHs) and communication (49 HHs) as a main fuel. Only 7 HHs didn't use any fuel for warm up room/space and 3 HHs didn't cook animal food. Biomass (30 HHs), biogas (11 HHs) and LPG gas (9 HHs) fuels were main fuel for cooking meal in Barbote village. On the same way biomass used was for cooking (28HHs), warming up (50 HHs), water heating (50 HHs) and animal food cooking (49 HHs) as a main fuel in Kanyam village. People of old age prefer to cook food with firewood assuming that cooking food in firewood is tastier than other options. This also heats the room in the winter season. Some old people also said that they don't know how to use other energy devices like biogas, LP gas. People normally used firewood that is nicely chopped and burns well for cooking meal. They also used crop residues, log, and twigs for cooking animal feed. One of the respondents of Barbote village Mina Ghimire explained that *'I have 3 cows, 2 calves, and 5 goats in my house. I keep them in the farm house all the day. I cook animal food in the morning and in the evening every day for the two cows' .They are giving milk now. In winter time, water is too cold and I also boil the water for all livestock. At that time biomass is used more for cooking animal feed than cooking meal for us.'* Normally animal food is prepared by the ingredients of coarse maize flour, rice husk, green fodder and/or vegetable leaves of like raddish, cabbage, couliflower,mustard etc. mixing in water in open fire stove that takes around 45 minutes to cook well.

Electricity is the main source for lighting (49) and communication (46) in Kanyam as the National grid electricity has reached to almost all the houses. Most of those HHs who keep animals, cooked animal food using biomass in the traditional three stone stove and open fire stove. Biogas and LPG gas were the main cooking fuel for 18 and 4 HHs respectively.

5.7 Expenditures on Fuel

Table: 8 Purchase costs and collecting time of energy fuels according to wealth rank from both villages

HHs	Fuel use (No.)	Stove use (No.)	Total BM used Kg/Month		Collection time Hours/Months		BM purchase cost(Rupees/Months)		Total purchase cost of fuel (Rupees/Months)	
	Barbote	Kanyam	Barbote	Kanyam	Barbote	Kanyam	Barbote	Kanyam	Barbote	Kanyam
Poor	3	3	535	637	19,58	23	756,94	251	1008	595
Medium	5	4	662,72	881	20,34	20	367,42	128	887,5	728,5
better off	8	6	517	375	16,68	19,5	88,54	0	1255	728

The table 8 shows the total purchasing cost of fuel per month according to wealth rank of people. The table shows that poor people in Barbote buy fuels for 1008 rupees per month and out of this they spend 756.94 rupees on firewood purchase. For Kanyam, poor HHs spend 595 rupees per month in total fuel purchase cost. Out of this almost 42% of money i.e. 251rupees went to biomass buying. Poor people consumed more firewood (535 kg/M Barbote and 637 kg/M Kanyam) and also spend more time in collecting firewood in both Barbote and Kanyam village(19.5 and 23 hours/M). It might be assumed that declining of forest due to land clearing for tea plantation, Kanyam HHs take longer time in collecting firewood. Most of the medium and better off people have their own private land forest for collecting the firewood. Every year in the winter season, they cut trees and make firewood by the help of labor manpower. At the time of data collection in February, people were busy in storing the firewood to be used for the next cold season. Those people who have not their own forest, they buy it from the market or from local people. Poor people spend money on buying biomass. Biomass is a cheap fuel source and is used more in comparison to other sources (e.g. electricity, candle, kerosene). According to WHO (2006), poor people purchased large quantities of inefficient fuel which is the large amount in their household budget. Those households tend to spend a larger percentage of their income on energy than well-off households.

The average no. of fuel used by poor, medium and better off HHs was 3, 5 and 8 respectively. For the average stove was 3, 4 and 6 by poor, medium and better off HHs respectively. It shows that the richer people the more no. of fuels and stoves were used.

5.8 Energy and Price Parameters

The energy prices for different fuel were recorded according to purchase price of the respondents in February, 2013

Table: 9 Energy and Price parameters of different fuels used

Fuel (unit)	Amount	kWh	Cost in rupees	
			Cost(unit)	Cost/kWh
Biomass/wood (KG)	1	4	5	1.25
Electricity (unit)	1	1	9.6	9.6
LPG (cylinder)	1(= 14.2 kg)	194.1	1500	7.7
Kerosene (Ltr.)	1	10.35	97	9.37

Energy unit source for kerosene: Silvey oil fuel specialists webpage https://www.silvey.co.uk/index.php?option=com_content&view=article&id=78&Itemid=78

And for fuel wood: wood Fuel Handbook (2008) http://www.aebiom.org/IMG/pdf/WOOD_FUELS_HANDBOOK_BTC_EN.pdf

The table 9 shows fuels and their market price in per kWh. It illustrates that significant different in purchase costs per kWh of those fuels. The cost for 1kwh produced from biomass is Rs.1.25, electricity for Rs. 9.6, LPG for 7.7 and kerosene for 9.37. The first 20 kWh electricity cost Rs. 80 then after counts Rs. 9.6 /kWh. The comparison reveals that wood fuel is the cheapest among them. However, it more difficult to use wood efficiently and a lot of the heat in the wood is lost in smoke.

It is estimated that 5.56 kWh of thermal energy can be produced from 1 m3 of biogas (Singh et al. 2008). Therefore with 3.0 m3 of biogas the amount of energy generation is 16.68 kWh (5.6kWh x 3.0 m3). Singh and co-authors (2008) further assume that 50 Kg of poultry waste produced 3.0m3 biogas per day per plant. From above the thermal energy content of 14.2 kg LPG is 194.1 kWh. Therefore 194.1kWh energy is contained in one cylinder of 14.2 kg LPG which costs Rs. 1500. Therefore 1 kWh of thermal energy of LPG cost Rs. 7.7. So, comparing with LPG the generation of 3.0 m3 or 16.68 kWh the biogas could save Rs. 128 per day (LPG cost per kWh is 7.7 x 16.68 kWh produced energy from biogas per day) excluding the time used to maintain the biogas generator. From this point of view, biogas plant is more efficient and cost effective cooking fuel for rural people. Here, It is assumed that all gas produced is fully consumed. Solar 1 kilowatt installation cost equal to 14246 US dollar (K.C. et al. 2011) which is 1280140 in 2011(1 dollar = 90 rupees) .The Nepal Government provides subsidy for installation though it is not enough for the rural people specially for poor.

5.9 Preferences of Fuels

As in the case of energy preferences, firewood which they used for cooking and heating rooms, were found widely in use in both VDCs. Unlike to animal and agricultural waste as energy resources use in other plain region, two VDCs in Ilam where we surveyed, were not found to use them. Asked to rank available cooking fuels in order of preference, irrespective of price, LPG was the most popular, followed by biogas and then electric cookers; lowest on the list were charcoal, followed by Wood fuel as the least preferable option. It is clear that the community prefer fuels that are clean and simple to use. However, it was also noted that choice of fuel is dependent on price. For example, if free or comparatively much cheaper wood fuel can be accessed, it would be chosen over LPG. In certain situations, such as making tea, where starting a fire takes considerable effort, LPG is often used regardless of the price difference.

5.10 Theoretical Implication of Findings

Household fuel choice has often been conceptualized using the ‘energy ladder’ model. This model places heavy emphasis on income in explaining fuel choice and fuel switching. The energy ladder model envisions a three-stage fuel switching process. The first stage is marked by universal reliance on biomass. In the second stage households move to ‘transition’ fuels such as kerosene, coal and charcoal in response to higher incomes and factors such as deforestation and urbanization. In the third phase households switch to LPG, natural gas, or electricity. The main driver affecting the movement up the energy ladder is hypothesized to be income and relative fuel prices (Barnes and Floor, 1999).The major advantage of the energy ladder model is its simplicity and its ability to show the relationship between income and fuel choice. Many energy surveys, conducted mostly in urban areas, have found a strong familiar in modern fuel consumption. Treiber (2012) criticize the ladder theory and argue that adoption and acceptance of energy sources is not solely dependent on the household’s financial means but its cultural, social and individual preferences. He further explain that the western world, as relatively rich and hence at the top end of the energy ladder, they substitute electricity by wood or charcoal in some instances such as camping or barbecue which are inferior fuels according to the ladder. Similarly, electricity is the dominant energy source in the case of lighting, but is often replaced by candles due to the situation and individual preferences. For these reasons, the energy ladder theory is insufficient to explain fuel use as it does not acknowledge these factors.

Evidence from a growing number of countries shows that households use multiple fuels.; The fact that households consume a portfolio of energy sources does not easily fit with the energy ladder model (Davis, 1998). This phenomenon has been termed fuel *stacking* (Masera et al., 2000).To the extent multiple fuel usage for cooking is the norm, promotion of petroleum fuels may not induce the abandonment of traditional fuels and may therefore generate fewer benefits than sometimes hypothesized. The research findings show that all households follow the multiple fuel approach using a minimum of two to up to eight fuels within the representative sample. The households also use many types of stoves. Figure 11 and 12 indicate that the number of fuels and stoves are used in both villages.

Hiemstra-van der Horst &Hovorka (2008) mentioned that the use of firewood is not dependent on income and hence the hypothesis of the energy ladder model is not always followed: Their study in Maun, Botswana shows that firewood is burnt in almost every household regardless its socio-economic level. Despite the implicit ranking of fuels on the energy ladder model with agricultural waste and firewood being at the lowest stage, that 'no fuel is an inferior good' (Kebede et al. 2002:1040). According to Kebede et al. (2002), an increased income could cause even a growth in demand for traditional fuels. Although Barnes et al. (2005:103) do support the upwards trend on the energy ladder related to an income increase in urban settings, they state that 'where wood is inexpensive and readily available, people continue to use it extensively, even in more well-off households'. The results of Fig. 15 and 16 however, indicate that rich households did not stop exhausting these resources but even increase their consumption. Such behavior demonstrates that income does not influence the quality of the energy consumed but rather its quantity. Those figures also showed that different wealth rank HHs used almost all type of energy sources but the consumed amounts of those fuels were different.

The table 8 indicates that richer people spend more money to purchase the fuels other than biomass. It shows that availability and access as well as income influence on the household energy consumption patterns. The table also shows that large amount of firewood were consumed by the households. Specially for ethnic community like Rai, Limbu, Newar etc. spend a lot of biomass in cooking jad and rakshi(Homemade Alcohol)which is an important part of their life and culture. The food grains, root crops, fruits and spices are used for the preparation. Most of those HH were found having alcohols in their home. It was a common culture to welcome a guest with a drink. They were served at any hour of the day or night. It was seen that the alcohol culture consumed a huge amount of firewood. In the same way many HHs have milk cows, every morning and evening they boil the milk on biomass in order to get the particular taste and texture in the condensed milk they drink at lunch time and after dinner.

Fuel wood was also found to be used for cooking livestock feed especially for the cow and pigs. They had not adopted any alternatives to fuel wood. Though biogas, LP gas has been somewhat popular among the rural households in Nepal in recent times, yet the people still prefer to use the fuel wood because of its cost and its availability. According to one of the respondent, '*It is good that the community forest is here. Through this, the forests have been preserve, but we cannot collect the fire wood and fodder as we wished. We have to meet our demands and we need to survive. That was why we created our own private forests*.' And those of who have private forest are almostly rich HH as they don't buy the firewood from the market.

LPG is primarily used as substitute for firewood especially to cook tea, coffee and other instant food like cooking noodles, frying beaten rice etc. when guest have come or to make a quick snacks. One respondent from Barbote village explain *that 'I have bought a new cylinder of LP gas over a year ago that is not finished yet. Especially my daughter uses it when she comes home as she is studying in Birtamod city. Occasionally use it for making tea or coffee to guests so that I'll get the time to talk with them*. This implies that stove and fuel choice depend on social status as Masera et al. (2000) explained. Household tend to like modern fuel and stoves that comprises the certain social status. The LPG use indicates a richer household comparing with those using firewood. DCEP (2011) mentioned that Ilam also use fossil use which is imported from foreign countries. The VDCs which are neighboring to India also import fossil fuel like LPG, Kerosene illegally.

The fig. 15 and 16 show that better off people spend more money on modern energy like kerosene, LPG, electricity and candle because they can afford it. Availability and the economic status of the HHs are also the factor for different energy sources and amount in use. Kanyam village resident lack wood fuel and many organization such as NGO and governments poverty elimination program have been providing support to them to make their life better and also to save community forest being deforested. As cost of wood fuel in Kanyam is (5-6 Rs/KG) higher than in Barbote (4-5 Rs/KG), they prefer using more LPG in cooking. Medium and rich in both VDCs have preference toward LPG as cooking fuel as it produce less smoke, fast cooking, easy to use and more reliable. It was also found that poor people in both villages have LPG gas, but they use it only in the case of emergency. It last more than one year in comparison to average 3 months if they use LPG regularly as a main cooking fuel. One could argue that access and availability as well as income play a greater role than culture. As the research demonstrated that income and fuel cost constrain the choice of fuel and associated devices that are certainly a crucial factor for energy use adoptation.
As we surveyed almost only residential areas, our data represent only the energy consumption in households. In comparison with the national consumption of petroleum products (mostly LPG and kerosene), Barbote and Kanyam Village has found to use higher amount of it being rural area. This may be due to good infrastrure (easy road transport) and illegal import from India border. According to the respondent in both villages, LP gas is more reliable than biogas particularly in the winter season.

The table 8 has indicated that richer HHs use a greater number of fuels and stoves in comparison to poor HHs. For the particular task, richer HHs chose the best fuel and stove. Such HHs can afford a variety of stoves and fuels. They store backup fuels in the case of supply shortage or seasonal events such as rain. Such fuel stocking behavior indicate that they follow a multiple fuel energy security strategy.
Within the sample, stove and fuel choice was also affected by the food type and quantity intended to be cooked. For example, cooking animal food takes a lot of fuel energy that is only possible through biomass as it is the cheapest energy sources in terms of produced energy price per kWh (Table 9). This food is cooked mostly outside the home in open fire stove that supports unchopped log, crop residue and twigs as well. One interviewee from Barbote village declared

that *'…I don't prefer to cook animal food in ICS stove…I have a big pot to cook animal food but the stove has small hole… this stove only supports the small size nice chopped fire wood.'*
Electricity is provided through the National Grid which is used for lighting, watch TV, play woofer for entertainment and battery charging for mobile phone. The electrical devices were mainly TV, mobile phone, rice cooker, and radio. The average expenditure on electricity was Rs. 117-214 per month. Government has fixed the low rate Rs. 80 up to 20 kWh per months for the basic monthly electricity consumption. Those small electricity users usually poorer get benefit from the subsidy.

The use of electricity to operate rice cookers is also popular particularly in Barbote village. In the past solar energy was used for lighting and charging of phones and batteries; however this has become less popular with the arrival of the national grid. Many households have sold their solar systems once they are connected to the grid.

The main sources of energy for lighting are electricity, kerosene and candle. Electricity comes from the national grid. Light in the house was used 3.5 hours in a day. Kerosene is imported from India at an equivalent cost of Rs. 97 per month. The consumption rate is about 1 liter per month. However, with the increase in HH electrification and high purchase cost of kerosene; the use of kerosene for lighting is reduced. They rather prefer to use candles. This can be seen in Fig. 14

Space heating/ warming up fuel is almost exclusively through biomass (fig 17). The second most important source was charcoal. In most instances cooking and space heating is achieved together. Energy use for transport in Kanyam HHs is almost zero as they do not have private car and motorbike due to geographical difficulties, poor economic status of HHs in comparison to Barbote where five medium and higher class people owned motorbike

Recently there has been an overall trend away from biomass towards other sources. This is because of the difficulty and time necessary to collect wood as well as dwindling wood fuel reserves as forests are being cleared for tea plantations. The use of LPG in particular is on the rise; currently around 40% of households in Barbote and Kanyam are using LPG for cooking. The cost of LPG is around Rs. 1500 per cylinder in Nepal. Biogas was seen as a promising technology for cooking as most households own livestock. However the implementation of this technology has not been as successful as anticipated. According to member of the VDC , it was due to a lack of promotion and information. As mentioned above, the use of electricity is also used in both villages for powering rice cookers.

5.11 Policy Implication of Findings

The overall goal of the rural energy policy 2006 is to contribute to rural poverty reduction and environmental conservation by ensuring access to clean, reliable and appropriate energy in the rural areas. Biogas to targeted households to remote areas, low income groups, and marginalized ethnic group. Biogas generated from animal dung is an alternative clean fuel source suitable for those agricultural households who use dung-briquette. Dung-briquette produce more air pollution, not good to use in sense of health implications. Gasification process in biogas produces slurry that can serve as a good source of fertiliser (Pant, 2011). Thus, small-scale biogas plants are technically feasible, financially viable and environmentally clean. Biogas production has several benefits to poor households and disadvantaged communities. The government promotes biogas to reduce deforestation and minimize greenhouse gas emission. Households get a subsidy of Rs.8000-12,500 per cubic meter for installation according to different categories defined by RE subsidy Policy (2013). This supported under CDM projects. Many commercial banks and credit cooperative have developed credit schemes to finance biogas installation.

Government policy is vital to promote renewable at the initial stage. The subsidy policy for micro hydro and solar power is quite attractive when compared against direct subsidies in other countries such as Indonesia or Sri Lanka (The Kathmandu Post, 2013). There is also tax exemption for renewable energy production equipment to reduce the fixed cost for technology. Commodity import duties and Value Added Tax are waived for green energy products such as solar panels and hydro turbines. However, the policies maker should consider both the ‘economic efficiency’ and ‘social equity’ for the equal access on energy use. While social equity can be the immediate priority, economic efficiency in the long-run would ensure the sustainability of the sector and reduce dependency.

The banking sectors are increasing the involvement in the renewable energy sector. The financial products that are designed for renewable, such as micro hydro, solar and biogas, are steps towards capital market creation in the area of renewable energy. Policy to reduce interest rates by central bank on these products could go a far way in expanding the renewable portfolio of Nepal. Rural companies and cooperatives working in the areas of renewable energy should provide appropriate advisory and business support service along with the technical support to help them and understand end use of electricity. However, the promotion of renewable energy is dependent on existing policy and implementing agencies at the macro-level, supply companies, dealers and financing institutions at the middle level and local community and household economy at the micro- level.

Ilam has a number of mini/micro hydro projects, some are connected with the national grid. For mini hydro project connected to grid, the household subsidy has been provided based on number of households connected to the plant. The subsidy amount per household connected to the grid will be Rs. 15,000 (RE subsidy policy, 2013). They also have provision to consume more electricity being hydro projects in their home district. So, the Ilameli people don't have to face load shading for longer time. Other places of Nepal where almost 13 hours of load shading occurs in winter season.

Nepal is still in a political transition. There are some barriers in the current management limiting the DDCs/VDCs. Lack of political leadership of local representatives is an important hindrance. The cost of construction materials are rapidly increasing. Most stakeholders agree that if the supportive policies for the biogas sector stopped now, the sector would suffer of a big 'shock'. The demand (especially in Hills and remote hills where subsidies rates are superior to 30%) would drastically be reduced, leading to the end of most of the biogas companies, who will not be able to sustain their activities (BSP, 2010). Thus, the extension of mid and long term subsidies a mechanism seems to be the key for the further development of the biogas sector in Nepal. The inadequacy of the available information makes it difficult for household to make the right decision on fuel choice. I found some poor people though they have land but they don't have the land owner's certificate. So, they can't get loan from Bank keeping it as deposit. Ramesh Bhujel from Kanyam village, explains that '…*I have been living here since I born. I used to live with my grandparents, parents, uncle, auntie with all in a house. Ten years before my parents separated from my grandparents. I got married last year and started to live separately from my parents. My grandparents have not transferred the landownership to my parents though they have given us some land for farming and to reside. This made it difficult for me to get a loan for biogas plant installation as I am not the property owner.*

Some respondents worked in richer HHs making a cottage on the owners land. They can live there as long as they will work in land owner’s house. They can’t be sure that how long they will be there as they are household workers in landowners home. In the same way, those people who are landless as squatters (sukumbasi in Nepali) are also deprived from the RE subsidy policy. I found two poor HHs who were landless and have illegal status. They aren’t secured about their dwelling as they don’t know when they should leave the current living place.

In Ilam, LPG and kerosene are imported from India illegally (tax evasion) as the purchase price is cheaper in India that leads to price fluctuation in the local market and influence on consuming pattern. There is no fix market price for firewood. For installing ICS, no direct subsidies have been provided but local people are encouraged to take technical and maintenance training of ICS.

Chapter Six: Conclusion

6. Conclusion

Energy is a basic good. In the past, household energy consumption was believed to follow the theories in the energy ladder. However, recent studies studies including my study show that culture, individual preferences, availability, efficiency, price and cost effectiveness also play vital role in determining energy and fuel choice. Future research should not rely excessively on the energy ladder model but also consider using household economics framework along with opportunity cost and cultural and individual preferences.

Self-collected or home grown wood is more common in rural Nepal. So, there is almost no fuel switching in the both villages. The main energy sources of the households were biomass, charcoal, electricity, biogas, candle and batteries. Biomass was widely used. Almost 100% HHs used it regardless economic status of the households. The research found that better off HHs consume almost all type of fuels and used various types of cooking stoves. Electricity was mainly used for lighting, communication and entertainment. Prices per kWh produced from different energy sources were compared. It was found that biomass and biogas are the cheapest fuels among them. The price per kWh produced from the biomass was just Rs.1.25/kWh. The price of LPG and electricity and kerosene was in comparison Rs.7.7, Rs.9.7 and Rs.9.37 per kWh. respectively. Electricity was used to only a limited degree Rs. 117-214 per month range which is equivalent to 84-94 kWh/M. Biomass was highly used due to cultural preferences (alcohol making, milk boiling) and used for energy demanding task such as animal food cooking

The rural energy policy has also to be taken into consideration when analyzing the consumption pattern of the HHs. The rural energy policy is targeted with rural poor, ethnic group, disadvantaged and marginalized people. However, the policy implication did not seem fair due to political instabilisation of the country and absence of political leader of local representatives in the VDCs.

One can conclude that where adoption of commercial cooking is not reliable, other energy improvements such as ICS, biogas or better ventilation of the cooking area would be required. Furthermore, modern use of bioenergy can improve the household energy consumption

7. References

Abrahamse W. &Steg L. (2009). How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? *Journal of Economic Psychology* 30: 711-720

Abrahamse W. (2007). *Energy conservation through behavioral change: examining the effectiveness of a tailor-made approach*. PhD thesis, University of Groningen, The Netherlands.

AEPC (Alternative Energy Promotion Centre) Report Nepal. (2007). Ministry of Environment, Science and Technology. Kathmandu, Nepal

AEPC (Alternative energy Promotion Centre). (2010/11). Annual Progress Report of Ministry of Environment, Science and Technology .Nepal

Bajracharya A. (2010).Jaibik Urja Sahayog Karyakram: *Yek Janakari. Sabaiko Lagi Urja Aviyan Urja Nepal*, 2:13–6.

Bajracharya K, Gongal RN. (1998). A case study of the improved cooking stove programme. In: Rijal K, (editor). *Renewable energy technologies: a brighter future. Kathmandu, Nepal: International Centre for Integrated Mountain Development*. p. 171–80.

Barnes, D.F., Floor, W. (1996) Rural energy in developing countries: a challenge for economic development, *Annual Review of Energy and the Environment 21*, pp. 497-530

Barnes, D.F., Krutilla, K., Hyde, W.F. (2005) *The Urban Household Energy Transition – Social and Environmental Impacts in the Developing World*, Resources of the Future, USA

Bhattarai K. (2010). Nepalma Biodiesel ko Sambhabana ra Aabasyakata. Sabaiko *Lagi Urja Aviyan Urja Nepal* 2:9–12.

Biogas support programme (BSP) Nepal. (2009). *BSP year book*. Kathmandu, Nepal

Bryman, Alan. (2008). *Social Research Methods*. Third Edition. Oxford University Press.UK

Cecelski, Elizabeth (2002). *Enabling Equitable Access to Rural Electrification: CurrentThinking on Energy, Poverty, and Gender*. Briefing Paper, Asia AlternativeEnergy Policy and Project Development Support. Washington, DC, World Bank.

CBS (Central Beauro Statistics). (2011). Kathmandu, Nepal

Centre for Rural Technology, Nepal (CRT/N). (2009). Internal Database;

Dhakal, N.R. & Dhakal, N. (2009). An overview of biofuel programme, Proceedings of

international conference on renewable energy technology for sustainable development, Kathmandu, Nepal, 12–14 November. P.112-118
Disaster Preparedness Network(DPNet) Nepal URL: http://www.dpnet.org.np/index.php?pageName=aboutnepal

DCEP (District Climate and Energy Plan) Report, Ilam District. (2011). Government of Nepal: Ministry of Environment.

Draft report on status of photovoltaic in Nepal. (2010).

Duflo, E., Greenstone, M., Hanna, R. (2000*). Indoor air pollution, health and economic well-being*, SAPIENS 1 (1)

Elgarah, Wafa. (2011). *Microfinance for Liquefied Petroleum Gas in Morocco*. Growing Inclusive Markets, UNDP. Energy Services for Millennium Development Goals. (2005). UNDP, USA.

ESMAP (UNDP/World Bank Energy Sector Management Assistance Programme). (2002a). *Development of a regional power market in the greater mekong sub-Region* (GMS). World Bank: Washington DC, USA

ESMAP. (2004). *Annual report*. World Bank: Washington DC, USA

Evans, M. (1987). *Stoves programmes in the framework of improved cooking practices: a changes in focus with special reference to Latin America*. ILO Working Paper, ILO, Geneva

Fitzgerald, B., Barnes, D., & Mc Granahan. G. (1990). *Inter fuel substitution and changes in the way households use energy: the case of cooking and lighting behavior in urban Java.* The World Bank Industry and Energy Department, Working paper #29. The World Bank, Washington, DC.

Gatersleben B., Steg L. & Vlek C. (2002). Measurement and determinants of environmentally significant consumer behaviour. *Environment and Behaviour* 34: 335-362

Gerbens-Leenesa W, Hoekstraa AY, Van der Meerb TH. (2009).The water footprint of bioenergy, 106(25):10219–23.

Grimsby, Lars Kåre. (2013). *Bioenergy Back to Basics: Exploring Multiple Technologies across The divide Between Traditional and Modern Energy*. Ph. D. Thesis. Norwegian University of Life Sciences, Ås Norway

Guta, Dawit Diriba. (2012). Application of an almost ideal demand system (AIDS) to Ethiopian rural residential energy use: Panel data evidence. *Energy Policy*, 50: 528-539

Hiemstra-van der Horst, G. and A. J. Hovorka (2008). Reassessing the "energy ladder": Household energy use in Maun, Botswana. *Energy Policy*. 36(9): 3333-3344

Hosier, R.H., Kipondya, W. (1993). Urban household energy use in Tanzania. *Energy Policy,* 21 (5):

454–473

IEA (International Energy Agency). (2010). *World Energy Outlook 2010*, IEA, Paris, France

IEA (International Energy Agency). (2011). *Energy for All - Financing access for the poor,* IEA: Paris, France

IEA (International Energy Agency). (2002). *World Energy Outlook 2002*, IEA, Paris, France

IEA (International Energy Agency). (2006). *World Energy Outlook 2006*, IEA, Paris, France

International Finance Corporation. (2012). From Gap to Opportunity: Business Models for Scaling Up Energy Access, International Finance Corporation (IFC), Washington.

K.C., S. Khanal, S. K., Shrestha, P. & Lamsal, B. (2011). Current status of renewable energy in Nepal: opportunities and challenges. *Renewable and Sustainable Energy Reviews*. 15:4107-4117

Kartha, S., & Larson, E.D. (2000). *Bio Energy Primer: Modernized Biomass Energy for Sustainable Development*. UNDP, New York.

Kassa, M. (2009). Ethanol cooking fuel and stove market development project highlights. Summary document prepared for Federal Environment Protection Authority, Addis Ababa

Kebede, B., Bekele, A., Kedir, E. (2002). Can the urban poor afford modern energy? The case for Ethiopia .*Energy Policy,* 30 (11/12):1029-1045

Koswari, Reza. (2013). Twisted energy ladder: complexities and unintended consequences in the transition to modern energy services. Ph.D. Thesis: The University of Columbia, Vancouver

Lallement, Dominique. (2008). *Energy Options for Livelihood Needs of the Poor and Women in an Era of High Fossil Fuel Prices.* Discussion paper for the High Level Regional Policy Meeting on Networking Towards Gender and Poverty Sensitive Energy Policies, November 3-4, United Nations Conference Centre, Bangkok

Leach, G. (1992). The energy transition. *Energy policy* 20 (2): 116-123

Leach, G., &Mearns, R. (1988). *Beyond the wood fuel crisis*. London: Earthscan URL: http://www.google.no/books?hl=no&lr=&id=bbL9AQAAQBAJ&oi=fnd&pg=PP1&dq=44.%09Leach,+G.,+%26+Mearns,+R.+(1988).+Beyond+the+wood+fuel+crisis.+London:+Earthscan&ots=bNj0-lMrR7&sig=-VvaPmrq9CyQ56UMbun82381M1E&redir_esc=y#v=onepage&q&f=false (Access: 5th January, 2014)

Lenzen M., Wier M., Cohen C., Hayami H., Pachauri S. & Schaeffer R. (2006). A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan. *Energy 31*: 181-207.

Masera, O., & Navia, J., 1997. Fuel switching or multiple cooking fuels? Understanding inter-fuel substitution patterns in rural Mexican households. *Biomass and Bioenergy*, 12(5): 347-361.

Masera, O., Saatkamp, Barbara & Kammen, Daniel (2000). From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model. *World Development*. 28(12): 2083-2103

Mekonnen, Alemu & Gunnar Köhlin. (2009). Determinants of household fuel choice in major cities in Ethiopia. rapport nr.: Working Papers in Economics 399

Modi, V., S. McDade, D. Lallement, & J. Saghir. (2006). *Energy and the Millennium Development Goals.* New York: Energy Sector Management Assistance Programme, United Nations Development Programme, UN Millennium Project and World Bank.

NPHC (National Population and Housing Census). (2011).Village Development Committee/Municipality. Government of Nepal. National Planning Commission Secretariat Central Bureau of Statistics Kathmandu, Nepal.

Nepal Economic Survey. (2010).Ministry of Finance. Fiscal year 2009/2010.Kathmandu: Nepal
Nepal Economic Survey. (2012). Ministry of Finance, Government of Nepal. Fiscal year 2011/2012. Kathmandu: Nepal.

Nepal: Got any Fertilizer? *online: http://www.irinnews.org/report/95700/nepal-got-any-fertilizer*(Access: 10th March 2014)

Objective lists and Sustainable Development Planning 2011/12-2014/15. (2011). Barbote Village Development Committee (VDC profile), Ilam

Pant, K.P. (2011). Cheaper fuel and higher health cost among the poor in rural Nepal. *Royal Swedish Academy of Sciences*. 41(3): 271-283

Practical Action Nepal URL: http://practicalaction.org/nepal

Renewable Energy for Rural Livelihood (RERL) report. (2012). UNDP Nepal

Ruiz-Mercado, Ilse, Omar Masera, Hilda Zamora & Kirk R. Smith (2011). Adoption and sustained use of improved cook stoves. *Energy Policy*. 39(12): 7557-7566.

Rukato, Hesphina (2002). *Gender and Energy in the South: A Perspective from Southern Africa*. Gender Perspectives for Earth Summit 2002: Energy, Transport,Information for Decision-Making, Berlin, Germany.

Rural Energy Policy. (2006).Government of Nepal, Ministry of Environment
Schlag, N., Zuzarte, F. (2008) *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature*, SEI Working paper, Stockholm Environment Institute

Shrestha JN. (2009). *Energy for development in the perspective of Nepal*. In: Proceeding of two days national conference in decentralized rural energy development in Nepal: challenges, opportunities and strategic option. Kathmandu: January 22-23, p. 21-26

Silvey oil fuel specialists webpage https://www.silvey.co.uk/index.php?option=com_content&view=article&id=78&Itemid=78 (Accessed: 5th March, 2014)

Singh Rajendra,Amrit B. Karki & JaganNath Shrestha (2008). Production of Boigas from Poultry waste. *International Journal of Renewable Energy*.3(1) :12-20

Singh RM & Heejoon K. (2009*). Biobriquettes—an alternative to fuel wood and coal*. Proceedings of international conference on renewable energy technology for rural development. Kathmandu, January 12-14, p. 150–152.

SNV/WWF. (2009). *Developing sustainable pro-poor biofuels in the Mekong Region and Nepal*. Netherland Development Organization Nepal and World Wildlife Fund

Soussan, J., O'Keefe, P. & Munslow, B. (1990). Urban fuel wood challenges and dilemmas. *Energy Policy*. 18 (6): 572- 582

Subsidy Policy for Renewable Energy. (2013). Ministry of Science and Technology, Government of Nepal.

Takama, Takeshi, StanzinTsephel and Francis X. Johnson (2012). Evaluating the relative strength of product-specific factors in fuel switching and stove choice decisions in Ethiopia. A Discrete Choice Model of Household Preferences for Clean Cooking Alternatives. *Energy Economics*. 34(6): 1763-1773.

Thapa, G.B. (1994). Issues in natural resource management in developing countries. *Natural Resources Forum*. 8 (2): 115-123

The Kathmandu Post, National Daily Newspaper. (Access: 6th March2014), http://www.ekantipur.com/the-kathmandu-post/2013/01/21/related_articles/renewable-nepal/244368.html

Tinker, I. (1980). *Women and energy: program implications. Internal Report*. Equity Policy Center, Washington, DC.

Trieber, M. (2012). Fuel and stove diversification in the light of Energy Transition and Technology Adoption Theory. Master Thesis: Norwegian University of Life Sciences (UMB). Ås, Norway

WECS (Water and Energy Commission Secretariat). (2006). Energy sector synopsis report. Kathmandu, Nepal.

WECS (Water and Energy Commission Secretariat). (2010). Energy sector synopsis report. Kathmandu, Nepal.

WHO (World Health Organisation) .(2006) .*Fuel for Life: Households Energy and Health.* WHO Press, Geneva, Switzerland

WHO, World Health Organization. (2007*). Indoor air pollution: National burden of disease estimates*. Geneva, Switzerland: WHO Press;

wood Fuel Handbook (2008) http://www.aebiom.org/IMG/pdf/WOOD_FUELS_HANDBOOK_BTC_EN.pdf (Access: 5th March, 2014)