STUDY TO DETERMINE OUTLINE PLANS FOR ELIMINATING ENERGY POVERTY IN NEPAL

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STUDY TEAM MEMBERS

List of Core Study Team Members

S.N.	***Name***	***Responsibility***
1.	Ms. Jun Hada	Team Leader, AIM-3, Practical Action
2.	Mr. Ranjan Parajuli	Research Coordinator, Consultant
3.	Mr. Vishwa Bhusan Amatya	Energy Planning Expert, Consultant
4.	Ms. Manjari Shrestha	Research Assistant, Consultant

List of Advisory Committee Members

S.N.	***Name***	***Organization/Institution***
1.	Mr. Achyut Luitel	Practical Action in Nepal
2.	Mr. Bibek Chapagain	Winrock-International, Nepal
3.	Mr. Bikash Sharma	International Center for Integrated Mountain Development
4.	Dr. Indira Shakya	Biogas Sector Partnership – Nepal
5.	Prof. Dr. Jagan Nath Shrestha	Centre for Energy Studies, Institute of Engineering, Tribhuvan University
6.	Prof. Dr. Ramesh Kumar Maskey	Centre for Excellence in Production and Transportation of Electrical Energy, School of Engineering, Kathmandu University
7.	Mr. Sanjay Dhungel	Water and Energy Commission Secretariat
8	Mr. Uttam Prasad Jha	Netherlands Development Organization
9.	Mr. Rajeev Munankami	Alternative Energy Promotion Centre
10.	Representative	National Planning Commission

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August, 2009 The Study Team

EXECUTIVE SUMMARY

Energy is a pre-requisite for technological, social, economic and environmental development and transformation of a society. The limited supply of reliable and efficient energy in Nepal have compelled majority of its population to burn loose biomass resulting into indoor air pollution and health hazards developed there from. Not only the households but also the economic sectors rely on the supply of biomass fuels in addition to fossil fuels. Lack of reliable and sustainable supply of these energy resources is resulting in loss of income and environmental degradation in the country.

Almost 89 per cent of the total energy consumption occurs in the residential sector. A sound qualitative and quantitative knowledge of access to energy in the residential sector is essential in pin-pointing lacking and to help develop plans and programme to address energy poverty of people in the country. Practical Action in Nepal has thus initiated to conduct a study to determine outline plans for reducing energy poverty in the residential sector of Nepal. The key objective of the study has been assessing a baseline of energy poverty situation and thereby setting an outline plan to reduce energy poverty and investment needs.

The study is based on the secondary information collected and reviews from different publications of Water and Energy Commission Secretariat (WECS), National Planning Commission (NPC), Nepal Electricity Authority (NEA), Alternative Energy Promotion Center (AEPC), Energy Sector Assistance Programme (ESAP), Biogas Support Programme (BSP) and Rural Energy Development Programme (REDP), as well as through advisory panel representing institutions and organization involved in energy development in the country constituted for the purpose of the study. The study is based on the information derived from Energy Resource and Consumption Profile of the five development region of Nepal, studied and published by WECS in the 90's. The information were verified and screened with various other information collected from different institutions.

An energy model to portray Nepal's residential energy consumption has been developed in Long Range Energy Alternative Planning Model (LEAP), an energy accounting tool devised for simulating energy scenarios by Stockholm Environment Institute (SEI), Boston.

The study has made a number of assumptions to define energy poverty in the context of Nepal and end-use device/technology selection in various scenarios in the energy model. Initially, all the residential energy end-uses like cooking, water boiling, lighting, space-conditioning, livestock feeding and others were analysed to take stock of the total primary energy consumption. The analysis is based on the model that disaggregates the residential energy sector in terms of shares and specific energy intensities of different end-use devices in different development regions and their respective ecological sub-regions and settlements (urban and rural). The study has adopted 2001 as the base year, which was further projected to 2005/06 as a verification year to adjust device shares and intensities according to the total energy consumption presented by WECS on these two years.

Even though space conditioning, livestock feedings and other rituals activities consume substantial amount of energy, only the basic needs like cooking, lighting and drinking water boiling have been considered in the study from the point of energy poverty. Energy poverty has been defined as lack of quantitative and qualitative access to minimum energy required to satisfy the basic needs. This has resulted into two parameters for defining energy poverty -- i) minimum energy requirement for cooking, lighting and drinking water boiling; estimated as the ratio of total primary energy consumption with current end-use device configuration and their specific energy intensity to the specified minimum energy requirement for the same end-use device configuration (Parameter-1); ii) end-use device efficiency; estimated total number of households residing below the line is depicted by end-use devices having efficiency lower than 25 per cent (Parameter-2). The study has made an exception in the Parameter-2 regarding the use of improved cooking stove (ICS) having efficiency of 20 per cent, which is considered above the energy poverty line due to its contribution towards reducing indoor air pollution and fuel wood consumption.

The estimation of minimum useful energy required for cooking is based on the heat required to cook meal that can provide at least 2250 food calorie of energy; useful energy required to boil drinking water has been estimated on the basis of per-capita drinking water requirement (5 litres per capita per day). The resulting minimum useful energy required for cooking and water boiling, adopted by the study has been 5.5 and 3.09 GJ per household per year, respectively, in the Hills. The minimum useful energy required for cooking and water boiling in Terai and Mountains were estimated by adjusting energy useful requirement in Hills based on difference in mean annual temperature. Although, demand for energy to purify water can be reduced through use of other forms of pasteurization technology such as SODIS (solar disinfection), they have not been considered in the model. Similarly, estimated minimum energy required for lighting, operating radio and charging phone in Hills is based on the use of 4 number of 7 W CFL for 3.5 hours daily, radio and phone (about 15 W), comes to be 35.77 kWh per household annually. Minimum lighting energy required in Mountains and Terai is estimated as 30.66, and 40.88 kWh per household per year, respectively, assuming 3 and 4 hours of use every day.

Energy Poverty Baseline

The estimated percentage of household residing below energy poverty based on different end-uses combining two parameters are at least 71 and 68 per cent in the year 2001 and 2006, respectively. The overall energy poverty in cooking was at least 61 and 51 per cent in 2001 and 2006, respectively. Similarly, the overall energy poverty in lighting was at least 62 and 60 per cent in 2001 and 2006, respectively. Likewise, the energy poverty in drinking water boiling was at least 91 and 88 per cent in 2001 and 2006, respectively. The study has also found good correlation between the Human Development Indices (HDI) of the country and the energy poverty.

Projection of Energy Poverty Situation

Energy poverty situation has been projected under two scenarios (i) Base-case Scenario, representing usual trend of energy, technology intervention and utilization; and (ii) Energy Poverty Reduction (EPR) Scenario, where energy poverty situation estimated from Base-case Scenario has been re-devised to meet the objective of the study; halving the energy poverty situation in 2016 and eliminating by 2026.

Base-case Scenario

The overall percentage of household below energy poverty in Cooking in 2016 and 2026 has been estimated to be about 49 and 40 per cent, respectively. Nearly 52 and 46 per cent of the households has been projected to be below energy poverty in Lighting in 2016 and 2026 respectively. Similarly, about 82 and 76 per cent of the households are expected to be below energy poverty line for water boiling in 2016 and 2026, respectively. Combining all these parameters, the study has derived that the overall composite energy poverty index to be about 61 and 54 per cent in 2016 and 2026, respectively.

Setting Energy Target for EPR

Energy target required to halve the energy poverty in 2016 and eliminate by 2026 is based on the estimated energy and technology mix required to meet the objective.

Energy poverty reduction target is based the population dynamics, i.e. intervention of energy technologies should be able to mitigate the issues of energy poverty of the increased population. Hence, halving population residing below energy poverty by 2016 has been defined as; at least the projected gradual technology intervention should be able to reduce the energy poverty situation of 2016 derived from Base-case scenario. Likewise, eliminating energy poverty in 2026 means, there is need of gradual technology intervention, by which the household residing below energy poverty as derived from Base-case Scenario becomes zero. The propositions in the EPR scenario incorporate the continuity of programmes currently implemented under AEPC. The current targets set by AEPC in promoting ICS, biogas, Solar Home System (SHS) and Small Solar Home System (SSHS) for the period until 2011 has been continued along with the expansion commercial energy technologies in a required number that can meet the objective of the study.

It has been estimated that to reduce the energy poverty in cooking and water boiling by half in 2016, at least 35 per cent of the total households in 2016 should have access to improved biomass technologies and 36 per cent should have access to commercial energy technology like Liquefied Petroleum Gas (LPG) stoves, bio-fuel/kerosene pressure stoves, electric clay heater and electric cooker/kettle. Furthermore, to eliminate the energy poverty totally by 2026, share of improved biomass technology should be increased to about 46 per cent of the total households in 2026; households with need to increase access to commercial energy to be increased to about 54 per cent of the total households.

In order to half energy poverty in lighting by 2016, electrification coverage should be increased to more than 61 per cent from the national grid and about 8 per cent through micro-hydro plants, while remaining shares should be from SHS and SSHS which stands at about 11 and 10 per cent, respectively. For eliminating energy poverty in 2026, extension of the national grid and mini-grid to cover almost 78 per cent of households is needed, whereas rest of the population has to be served through SHS and SSHS.

Institutional and Policy Arrangement

EPR Scenario foresees a need to increase current sectoral activities by multi-fold involving a mix of different energy sources and technologies. It will require a substantial institutional strengthening and expansion of all the energy stakeholders of the country. The existing lack of harmonization and coordination among energy development institutions and organizations will have to be addressed with earnest. The existence of coordination gap among stakeholders, who are involved in handling commercial energy sources and alternative energy technologies, will need to be streamlined to increase service delivery efficiency of these institutions.

In the part of the proposed intervention of alternative energy technologies in the study, it has been found that it is about 3 times larger than current size of AEPC's programme of the period 2001-2006. This reveals that there is need of more involvement of private sectors, I/NGOs, where they can support the Government of Nepal (GoN) in implementing the renewable energy technologies in rural as well as urban areas as per their specific demand.

Similarly, extension of grid based electricity and scaling up of infrastructures of Nepal Oil Corporation are other key essentialities that have been found in the study, which are required in multi fold depending on the scale of demand in different projected periods.

Even though at the current period, alternative energy technologies are popular in rural areas, access to very remote hills is still very poor, due to low affordability and availability. The current subsidy model is already experiencing many issues in terms of fund shortage and administration. Therefore, interventions need to be based more on credit in future than subsidy with stronger participation of micro-financing institutions, cooperative financing and banks. Need to increase access to credit in rural areas warrants special attention to increase access to credit to people in general and poor in specific. For the increased in magnitude of energy interventions, capacity of private sector, NGOs and other service provider needs to be increased by multi folds in terms of quality as well as quantity of service delivery. Capacity buildings of service providers has to be increased with formal and informal trainings/workshops and vocational trainings. Similarly, consumer based knowledge sharing programmes should also be given attention to increase awareness to technologies.

Investment Required

It has been found that the GoN needs to allocate or mobilize investments in energy development, which can ensure reduction in energy poverty. For reducing energy poverty by half in 2016 and eliminating by 2026, intensive intervention of alternative energy technologies is required. The investment necessary to cover up those intervention in different time series has been estimated as around 234.4 million EUR (2006-2011), 233.5 million EUR (2011-2016), 136.0 million EUR (2016-2021) and 136.0 million EUR (2021-2026), considering the overall alternative energy program cost. In addition, additional investment in grid expansion will also be necessary which is estimated at about 1.35 billion EUR.

Recommendation for Further Studies

The study has been an important first-step towards understanding energy poverty situation in Nepal. We, therefore, would recommend future researches and studies to strengthen the information and understanding required to address energy poverty issues. Some of the field where the future research and surveys can focus are:

a) Diversity in minimum energy requirement to live a decent life in Nepal in various regions.

b) Exploring energy resources and their utilisation technologies from the energy poverty perspective.

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ACRONYMS AND ABBREVIATIONS

AEPC	Alternative Energy Promotion Center
BSP	Biogas Support Programme
BSP-Nepal	Biogas Sector Partnership-Nepal
cap	Capita
CBS	Central Bureau of Statistics
CES	Center for Energy Studies
CDR	Central Development Region
CFL	Compact Fluorescent Lamp
CO	Carbon Monoxide
DANIDA	Danish International Development Agency
DDC	District Development Committee
DKK	Danish Krone
DMG	Department of Mines and Geology
EDB	Environmental Data Base
EDR	Eastern Development Region
ENPHO	Environment and Public Health Organization
EPR	Energy Poverty Reduction
ESAP	Energy Sector Assistance Programme
EUR	Euro
FAO	Food and Agriculture Organization
FWDR	Far-Western Development Region
FY	Fiscal Year
g	Gram
GDP	Gross Domestic Product
GJ	Giga joule
GoN	Government of Nepal
HDI	Human Development Index
HH (hh)	Household
hr	Hour
IAP	Indoor-Air Pollution
ICIMOD	International Centre for Integrated Mountain Development
ICS	Improved Cook Stove
INGO	International Non-Governmental Organization
IWM	Improved Water Mill
J	Joule
K	Kelvin

kcal	Kilo Calorie
kg	Kilogram
kl	Kilolitre
km	Kilometre
KoE	Kilogram of Oil Equivalent
kW	Kilowatt
kWh	Kilowatt Hour
l	Litre
LEAP	Long Range Energy Alternative Planning
Lm	Lumen
LPG	Liquefied Petroleum Gas
m	metre
m^2	Square metre
m^3	Cubic metre
mg	milligram
MDG	Millennium Development Goal
MFI	Micro Finance Institution
MGSP	Mini Grid Support Programme
MH	Micro-hydro
MHP	Micro-hydro Plant
MoCS	Ministry of Commerce and Supplies
MoEST	Ministry of Environment, Science and Technology
MoFSC	Ministry of Forest and Soil Conservation
MoWR	Ministry of Water Resources
MS	Microsoft
MT	Metric Tonnes
MW	Megawatt
MW_e	Megawatt-electrical
MW_p	Megawatt-peak
MW_t	Megawatt-thermal
MWh	Megawatt Hour
MWDR	Mid-Western Development Region
NA	Not Available
NEA	Nepal Electricity Authority
NGO	Non-Governmental Organization
NOC	Nepal Oil Corporation
NoK	Norwegian Kroner
NORAD	Norwegian Agency for Development Cooperation
NPC	National Planning Commission
NRs	Nepalese Rupees

PM	Particulate Matter
ppm	Parts per million
REDP	Rural Energy Development Programme
RESSP	Rural Energy Sector Support Programme
RETs	Renewable Energy Technologies
SEI	Stockholm Environment Institute
SHS	Solar Home System
SNV	Netherlands Development Organization
SPV	Solar Photo Voltaic
sq.	Square
SSHS	Small Solar Home System
TCE	Tonne of Coal Equivalent
TCN	Timber Corporation of Nepal
TJ	Terajoule
TOE	Tonne of Oil Equivalent
ToR	Terms of Reference
UNDP	United Nations Development Programme
USD	United States Dollar
VDC	Village Development Committee
WDR	Western Development Region
WECS	Water and Energy Commission Secretariat
WHO	World Health Organization
WLED	White Light Emitting Diode
wrt	with respect to

Basic Energy Conversion:

S.N.	***Units***	***kcal (‘000)***	***GJ***	***TCE***	***TOE***
1.	Kilo Calorie	1	0.0042	0.0001	0.0001
2.	GJ	238.846	1	0.0341	0.0235
3.	TCE	7000	29.308	1	0.0688
4.	TOE	10290	42.622	1.454	1

(Source: WECS, 2006)

Energy Contents of Various Fuel Type:

S.N	***Fuel Types***	***Unit***	***kcal (‘000)***	***GJ***	***TCE***	***TOE***	***Others***	
1	**Traditional Fuels**							
1.1	Fuel Wood	tonne	4000	15.5	0.57	0.364	1.43	m^3
1.2	Charcoal	tonne	7100	29.31	1.01	0.688	2.86	m^3
1.3	Agricultural Waste	tonne	3000	12.5	0.43	0.293		
1.4	Animal Dung*	tonne	2600	10.9	0.37	0.256		
1.5	Biogas	('000) m^3	5800	22.5	0.83	0.528		
2	**Commercial Fuels**							
2.1	LPG	tonne	11760	47.31	1.68	1.14	1.637	kl
2.2	Kerosene	kl	8660	35	1.24	0.84	0.78	tonne
2.3	Electricity	MWh	860	3.6	0.12	0.08		

*on dry basis, 1 tonne of dung yield 190 m^3 of biogas at 15^o C.

(Source: WECS, 2006, www.iea.org & www.hedon.info)

Cross Country Exchange Rate; dated 27.04.09

S.N	***Currency***	***Conversion for EUR***
1	EUR	7.4469 DKK
2	EUR	8.7443 NoK
3	EUR	1.3261 USD
4	EUR	104.76 NRs

INTRODUCTION

1.1 Background

Energy is a pre-requisite for transformation of society in terms of technological, social, economic and environmental development. Demand for energy in Nepal is largely met with biomass fuels to facilitate economic growth and social development. In spite of having substantial hydropower potential (83,000 MW), only 558 MW has been harnessed so far.

Energy consumption pattern of the country is dominated by traditional energy resource, contributing more than 86 per cent of the total energy consumption (379.52 million GJ) (Water and Energy Commission Secretariat (WECS), 2006). Commercial and renewable energy sources contribute about 13 and 0.6 per cent to the total energy consumption of the nation, respectively.

Residential sector is the largest sector in the total energy consumption, where more than 89 per cent of the total primary energy consumption is consumed. Whereas, industrial, commercial, transportation, agricultural and others sectors consumes about 4.5, 1.5, 3.7, 0.8 and 0.2 per cent, respectively (WECS, 2006).

Almost 96 per cent of the total residential energy consumption is met by traditional energy resources followed by commercial (3.6 per cent) and renewable energy (0.6 per cent). Of the total traditional energy consumption (324.5 million GJ), the stake of fuel wood is about 89 per cent, followed by agricultural residues with 3.9 per cent and animal waste with 6.7 per cent. Similarly, in the share of commercial energy (120.5 million GJ), electricity contributes 0.9 per cent, coal puts in 0.01 per cent, kerosene makes up 2 per cent and LPG contributes 0.7 per cent (WECS, 2006).

Nearly 40 per cent of the population has access to the electricity, around 33 per cent of which is supplied by the national grid and about 7 per cent by alternative energy sources (National Planning Commission (NPC), 2002). The inequality in the access to electricity between urban and rural areas is also very high.

Decentralized energy supplies in the country are made up of renewable energies and meet about 0.6 per cent of the total residential energy consumption. Of the total renewable energy consumption in residential sector, biogas technology contributes about 97 per cent, micro-hydro shares of 2.5 per cent and solar makes up 0.14 per cent (WECS, 2006).

The total residential primary energy consumption in Fiscal Year (FY) 2002/03, 2003/04, and 2004/05 has been found to be 320.3, 326.3, and 331.6 million GJ, respectively (WECS, 2006). Similarly, the human development indices (HDI) in the same years were 0.526, 0.527, and 0.534, respectively (United Nations Development Programme (UNDP)). The Millennium Development Goals (MDGs), adopted from United Nations Millennium Summit in September 2000, provide concrete, time-bound objectives for dramatically reducing extreme poverty in its many dimensions such as income poverty, hunger, disease, exclusion, and lack of infrastructure and shelter by 2015 (Modi et. al., 2005). The MDG objectives are supposed to be met by promoting gender equality, education, health, and environmental sustainability. Even though MDG objectives do not refer to energy explicitly, improved energy services (including modern cooking fuels, improved cook stoves, increased sustainable biomass production, and expanded access to electricity and mechanical power) are necessary for meeting all the Goals (Modi et. al., 2005).

The major energy issues in the country are constraints in accessibility, availability and affordability which are more serious in the rural areas. The recent declaration of “electricity crisis” by the Government of Nepal (GoN) also signifies the need of energy management and development in urban areas too.

Realizing the need, to overview access of energy services in residential sector of the country to satisfy basic needs, Practical Action in Nepal has initiated to conduct a study to determine outline plans for eliminating energy poverty in residential sector of Nepal.

1.2 Geographic Information

Nepal is stretched 885 km long along east-west and 145 to 241 km along north-south and makes up the total area of 147,181 sq. km, bordering China in the North and India in the South. Country's topography constitutes of flat and fertile terrain in the Southern region, rapidly flowing Mountain Rivers in the Central hills; and the high Himalayas in the North.

Geographically, the country is divided into three distinct regions ranging from north to south; the Mountains, Hills and Terai plains. Administratively, the country is divided into five developmental regions, and seventy five districts. Districts are divided into Municipalities and Village Development Committees (VDCs). There are 58 municipalities and 3,992 VDCs (United States Department of States, 2008) in the country. In the same manner, each VDCs and municipalities are divided into numbers of wards according to its areas.

The country witnesses climates that range from subtropical in the south to temperate in the Hills to arctic in high altitudes in the north. The monsoon (rainy) season is from June to September, when rain is a daily phenomenon, bringing 75 to 150 centimeters of rain in average.

According to the population census of 2001, Nepal's population was 23.15 million and the growth rate is 2.13 per cent. Population distribution shows that 49, 44 and 7 per cent of the total population resides in southern Terai, Hills and Mountainous region, respectively.

1.3 Energy Policies and Acts

Hydro power production, renewable energy promotion, supply of fuel wood and other commercial fuels are the key supply sub-sectors for the meeting the energy demand and are guided through number of Acts and Regulations. Some of the existing Acts and Policies of the government involves; Forest Act (1993), Electricity Act (1992), Water Resources Act (1993), Hydro Power Development Policy (1992), Soil and Watershed Conservation Act (1982), Nepal Petroleum Act (1983), Nepal Electricity Authority Act (1984), Mines and Minerals Act (1985), Industrial Enterprises Act (1992) and Environment Protection Act (1996). Similarly the underlying statute rules involves;

Petroleum Rules (1993), Solid Waste (Management and Resource Mobilization) Rules (1989), Water Resources Rules (1993), Electricity Rules (1993), Forest Rules (1994), Buffer Zone Management Rules (1995), Conservation Area Management Rules (1996) and Environmental Protection Rules (1997). Nonetheless, number of inter governmental ministries and departments' involvement in policy formulation, planning at the sectoral and sub-sectoral level for execution of different projects has demonstrated a serious lacking in terms proper coordination among them.

For the promotion of renewable energy technologies, Alternative Energy Promotion Center (AEPC) under the umbrella of Ministry of Environment, Science and Technology (MoEST) in 2000, endorsed the first Renewable Energy Policy and subsidy guidelines. The energy development is also directed towards reducing drudgery of the rural women in Nepal due to collection of fuel, basically firewood. Because of ever depleting forests and biomass resources, rural Nepalese women need several hours of walk to collect fuel-wood and thus are vulnerable due to increased physical drudgery. In addition to this, spending hours for cooking in inefficient stoves have been found in the respiratory and other health problems. In this recently, the GoN has initiated to formulate Indoor Air Pollution Standard and Guidelines, with the technical support of Practical Action in Nepal.

1.4 Energy Resources Base of Nepal

1.4.1 Traditional Energy Resource

Traditional energy resources like fuel wood, agricultural residues, animal waste have a major stake in the energy supply scenario of Nepal. Fuel woods are mainly derived from the forest and on farm land, where agricultural residues are derived from different crops like paddy, wheat, maize, jute, oil seeds and legumes. Livestock waste (Cattle and Buffaloes) is the major source of animal waste in the country. Due to limited access of efficient energy resources and technology, large stake of traditional energy is still expected in the coming years.

Fuel Wood

Fuel wood comes from various sources and the role of forest is substantial in this regard. The sources of fuel wood are generally categorized on the basis of the major land use types of the country. The major land use types of the country are Forest, Shrub land, Grassland, Non-cultivated inclusions, cultivated land and other land. Other land includes the snow covered, water bodies, cliff and wasteland. All four categories of land use types have been considered for fuel wood production except other land types. Total sustainable supply of fuel wood from gross and accessible/reachable areas of each land category for FY 2003/04 has been found about 6.478 million tonnes (WECS, 2006).

There is wide scope in the sustainable use of fuel wood with the promotion of Improved Cook Stoves (ICS) in the country. Till date more than 0.25 million ICS have been disseminated by Energy Sector Assistance Programme (ESAP) of AEPC.

Charcoal

Charcoal is a derived form of energy from pyrolysis[1] of wood components. Even though, charcoal production for commercial purpose is illegal; there exists a substantial trade between traditional producers and commercial and industrial entrepreneurs at small scale. Charcoal uses are generally found in commercial activities like hotels/restaurants, metal crafters, goldsmith and blacksmiths. Commercial production of charcoal on an experimental basis was initiated by the Sagarnath Forestry Development Project and Fuel Wood Corporation in FY 1985/86. Traditional method of carbonization was adopted to produce charcoal on the attempt, which produced about 1000 tonnes of charcoal over three months. However, the initiation was ceased due to poor marketing (WECS, 2006).

Agricultural Residues

Major residue generating crops are Paddy, Maize stalks, wheat, Sugarcane, Barley, Millet, Oilseeds, and Legumes etc. The potential production of agricultural residues for FY 2003/04 has been found about 15.26 million tonnes (WECS, 2006). More efficient utilization of these resources can be achieved through biomass briquette[2] production in the country.

Animal Waste

Animal wastes are used in the form of energy after mixing animal dung with straw, agri-residues etc. The dried mixture of dung and biomass (dung cake) is used as a source of energy in many rural areas of Nepal. Estimated total potential availability of dung as a fuel in Nepal has been estimated to be 5.10 million tonnes in FY 2004/05 (WECS, 2006). This source has high potential to be used through biogas technology in the country.

1.4.2 Commercial Energy Sources

Hydro-Power

The annual average run-off within the Nepalese land is estimated at 174 billion m^3, with the changes in elevation from high Himalayas to the flat plains. This geographical and enormous water resource generates substantial hydraulic head for the development of hydro power in Nepal. Mechanical and electrical power generated from the hydraulic energy is used to operate indigenous water mills, improved water mills and mini/small hydro power and large hydro power schemes. Current hydro power utilization is expected at about 1.5 per cent of the proven potential (WECS, 2006). Despite having estimated theoretical hydro power potential of 83,000 MW and technical potential of 43,000 MW, only 558 MW is currently generated from the large hydro power schemes (WECS, 2006).

[1] Pyrolysis is the process of chemical decomposition of organic materials by heating in the absence of oxygen or any other reagents, except possibly steam.

[2] Biomass briquettes are made from compressed charcoal dust, with or without a binding agent such as asphalt, clay or lime solution, which can be burned as fuel.

Petroleum Products

Petroleum products are the imported source of energy in Nepal. Various efforts of exploring petroleum reserves in Nepal have concluded that there are no any proven petroleum reserves, which can be economically exploited for commercial purpose. Nepal Oil Corporation (NOC) is responsible for its import and distribution.

Natural Gas

The exploration carried out since 1980 has proved a reserve of 47 million m^3 of natural gas up to a 300 m depth in an area of 4 sq. km of Kathmandu Valley. On an experimental basis, a model gas plant with a capacity of 500 m^3 per day was supplying gas to some government organizations since 1983. A total of 500 million m^3 of natural gas was also estimated through continued active exploration over the total prospective area of 26 sq. km and up to a depth of 600 m (Ministry of Industries, 1996). Till date economic exploitation of natural gas is still awaited in Nepal.

Coal

There are four major types of coal occurrences in Nepal; Quaternary Lignite of the Kathmandu valley, Miocene to Pliocene Siwalik Coal of the Sub-Himalayas, Cretaceous-Eocene coal of the Lesser Himalayas and Gondawana coal of the Lesser Himalayas. It has reported that a probable coal reserve of 12 million tonnes exists in Nepal. Similarly, two peat seams of 1.2 to 1.5 m thickness with calorific value of 4200 kcal/kg were reported to exist in Lukondol area in 1932 (Department of Mines and Geology (DMG), 2003). The DMG, till 2003, has investigated about 500 sq. km of Dang, Salyan, Rolpa, Pyuthan and Palpa districts under its coal resource assessment study.

1.4.3 Renewable Energy Resources

Mini/Micro-Hydro and Peltric Sets

The history of waterpower in Nepal begins with the traditional water mills or ghatta[3] used for grinding flour. However, there are varieties of technologies already available or being developed, which come under the mini and micro hydropower category. Nepal has over 6,000 rivers of length over 2 km. Mini and micro-hydro technology has enormous potential to promote environmentally sound sustainable development in Hilly region of Nepal (WECS, 2006).

It has been found that till date more than 1,885 mini-grid electrification schemes have been established in the country with total power production of about 26.85 MW. Similarly, around 824 Turbine Mills[4] have been installed generating about 7.25 MW of mechanical power (AEPC, 2008a). AEPC/ESAP has also been undertaking map-based identification of mini/micro hydro power in Nepal.

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[3] Ghatta is a traditional technology usually found in remote hills and mountains for grinding purpose. It is made up of wooden shaft, runner and open chute for the flow of water.

[4] Turbine mill is a technology for generating mechanical power utilizing the hydraulic power.

About 30,000 traditional water mills existing in rural Hilly and Mountain region of Nepal shows potential range of improving them and scaling up rural energy technologies. It has been reported that around 5000 improved water mills (IWMs[5]) have been installed in Nepal with the technical support of Centre for Rural Technology (CRT/N).

Biogas Technology

Potentiality of biogas in Nepal has been estimated with the registered cattle population. Based on the registered cattle population as per the Agriculture Sector Census (2001/02) and technical and geographic feasibility, it was estimated that 1.9 million biogas systems can be installed in Nepal, comprising 57 per cent in Terai, 37 per cent in Hills and 6 per cent in Mountainous regions (Biogas Sector Partnership Nepal (BSP-Nepal), 2004). When taking economic factors, the potential of the smaller fixed dome design (4 and 6 m^3) is estimated at about half a million units. With innovative financing (subsidy structures, co-operatives) and delivery structures (self help building), the potential is expected to be doubled to one million units. Besides the above small domestic biogas systems, huge potential of cold climate, industrial as well as municipality systems is also expected.

BSP-Nepal has been successful in promoting biogas technology, with the support of Rural Energy Sector Support Program (RESSP), financed by the Government of Netherlands and implemented by the Netherlands Development Organization (SNV). More than 0.182 millions of biogas plants have been installed in the country. The achievements of BSP-Nepal are acknowledged worldwide and are replicated in many other countries by SNV.

Solar Energy

The assessment of Solar and Wind Energy Resource in Nepal based on geo-spatial database shows that there is wide potential of solar energy in Nepal. It has been found that about 37,501 sq. km area, which is about 25 per cent of the total area of Nepal, has potential for Concentrated Solar Power. Similarly, for grid connected integrated photo-voltaic potential, estimated on the basis of the urban areas, shows that if power generation per sq. km is considered to be 50 MW and 2 per cent of the land area is considered as suitable land, then an area of 2,100 sq. km could yield 2,100 MW of power. In addition to this, about 28,789 sq. km area of Nepal has been found not connected to the grid and population, over which the potentiality of remote Solar Photo Voltaic (SPV) is about to provide access to population of about 2.4 million in 2006 (AEPC, 2008b).

It has been reported that that the installed capacity of Solar Home System (SHS) in Nepal is about 3.09 MW_p (AEPC, 2008c).

[5] IWM is a modified version of traditional water mill which consists of metallic shaft and runner along with closed penstock. This technology is popular mostly for grinding purpose.

Wind Energy

Various studies have indicated that there exist potential for wind energy development in Nepal, especially in river corridors and mountain valleys. Mustang and Sagarmatha region are also regarded as highly potential area for harnessing wind energy.

Moreover, Wind Resource Assessment made by AEPC shows that about 97 sq. km of area has been found to have power density of 300 Watt/m^2 and with 5 MW of installed capacity per sq. km, the total potential yields of wind energy is about 489 MW (AEPC, 2008b).

Even though, there is high potential of wind resource in the country, there is still a need of efforts to be done in the wind energy sector in Nepal. It is also necessary to make economic analysis of harnessing wind power in Nepal.

Practical Action and various private and public sectors have made attempts to harness small scale wind energy for household electrification in the country. Due to comparatively higher focus on hydro and solar power development and lack of adequate information on wind power development has not obtained priority in Nepal.

Geothermal Energy

Exploration of geothermal spring was initiated in Nepal after the experience of global oil crisis of 1973. Initial exploration works were confined to assess the potential of existing geothermal springs in terms of discharge, heat energy constitutions. Geothermal manifestations occur in more than twenty-eight localities in Nepal, scattered and confined to three distinct tectonic and structural features that characterize the Himalayas in general. The observed geothermal springs are of small discharge and low temperature type. Hence their utilization is currently limited in hot water shower/bathing and therapeutic application. However, a complete profile of all the geothermal localities of Nepal has still to be prepared, estimated total capacity of geothermal energy resources is 1.06 MW_t with an annual energy use of 22.2 TJ (Lund et. al., 2000).

1.5 Rationale of the Study

Energy sector development found its place in development plans of Nepal from 7th Development Plan (1985-90) and since then national development plans have increasingly focused on development of energy sector, but links between energy, environment and sustainable development present a difficult paradox to the GoN. Residential energy have largest stake in the total energy consumption supplied mainly by traditional energy sources through inefficient technologies for cooking. This is resulting in loss of income and environmental degradation as well as indoor air pollution in households causing degrading health.

Combustion of traditional energy sources in open hearth wood stoves (mud stoves, iron tripod stoves, three stone fires) are generally practiced in the nation. Similarly, large population is still dependent on the kerosene wick lamps, lantern, and other traditional energy sources for lighting. Thus, there is a need to assess minimum energy requirement for an average household (residential sector) primarily for cooking, water boiling and lighting, where by intervention of clean and safe energy technologies can be carried out to meet the energy demand in a way that will ensure reduction of energy poverty.

Energy poverty reduction planning with the intervention of clean, safe, adequate and affordable energy carriers and technologies is necessary to work towards setting a concrete national target and realize energy as a basic necessity of people. It is also imperative to come up with a national document that the concerned ministries/government agencies could own for them to be able to rationally allocate resources annually/periodically and in addition, could be used to seek commitments from bilateral and multi-lateral donors to reducing/eliminating energy poverty in the country. This is equally relevant at the changing political context as well where the agenda of developing renewable energy particularly, hydro-power sector has given a topmost priority.

1.6 Objectives

The main objective of the study is to establish an outline plan of how energy poverty could be halved in the country by 2015/16 and eliminated entirely by 2025/26. The specific objectives are:

i. To assess a baseline of energy poverty situation;
ii. To analyze the energy resource assessments and energy demand assessments;
iii. To assess national policy and institutional arrangements;
iv. To set a target/outline plan to reduce energy poverty;
v. To recommend the necessary changes in terms of investments needs, policy instruments, institutional arrangements, capacity needs, choice of technology mix etc.

1.7 Scope of Work

The scope of work has been limited to the Energy Poverty Reduction Planning; however, development of Updated Energy Synopsis Report was also included at the beginning, which has been revised according to Advisory Committee meetings. The scope of work for the study and other details as outlined in the Terms of Reference are given in the **Annex-1.**

1.8 Limitation of the Study

The study is based on the secondary data collected from different institutions involved in the energy sector. The collected data has been found with number of inconsistencies and anomalies, which were adjusted for further analysis. Energy consumption data, end-use device shares and energy intensity of end-use devices for the Base-Year has been based on various publications of WECS. Where information required in different development regions and their respective ecological settlements are not available, the study has made assumptions that they would be similar to adjacent development regions.

METHODOLOGY

Methodology adopted for the study allows to overview the energy consumption situation in the present energy and technology mix. The study team has adopted Long-Range Energy Alternative Planning Model (LEAP) developed by Stockholm Environment Institute (SEI), Boston, extensively for the purpose of the study which allows future scenario analysis. Even though amount of energy consumed in space-conditioning, livestock feed preparation and other residential end-uses are substantial, the study has focussed on the minimum energy required for basic household activities only -- cooking, lighting and drinking water boiling.

This study has taken the year 2001 to be the Base Year; the projections obtained by the model has been checked for the year 2006 with the actual information (from WECS and other sources) and necessary fine tuning of the model was carried out. Data verifications were made in terms of configuration of basic end-use devices and their energy intensities.

Energy poverty level has been estimated on the basis of qualitative and quantitative requirement of energy to carry out basic residential activities, which has been considered as minimum energy which is required by every individual household. Geographical consideration has been maintained to overview the minimum energy required, while using different energy devices. Energy planning has been carried out by assigning different optional scenarios for reducing energy poverty in the residential sector.

1.9 Information Sources and Management

The study is based on the secondary information, for which extensive secondary data were collected to overview the status of energy consumption and share of different energy source. The secondary information constitutes of data representing total energy consumption in residential sector of Nepal. Residential energy consumption, energy device shares, specific energy consumption were analysed through the secondary information. These data were collected from Water and Energy Commission Secretariat (WECS), Government of Nepal (GoN). Similarly, relevant information was collected and from different literatures published by NPC, National Electricity Authority (NEA), AEPC and programmes under it, Practical Action Nepal, Centre for Rural Technology-Nepal, etc. All these data were reviewed and collated with each other before analysis.

Study has sought extensive participation of relevant institutions by forming an advisory committee. It has helped the study in collecting relevant information on the energy consumption and on-going development activities. The team has also received substantial inputs and suggestions from the committee. Information and outcome of analyses were shared with the advisory committee and comments were taken at various stages of the study. This has helped in identification and reduction of different anomalies in the existing data and information.

All the data collected from different sources were compiled in the MS Excel sheet with a framework that breaks down energy data by development and ecological region of the country. Data were also disaggregated by urban and rural dwellings. Data collected were cross checked and collated considering the development of energy technologies and supplies in the country in different time series. The total energy consumption was projected and contribution of different energy types were compared with the yearly import and generation of energy that led to necessary adjustments that made base-year data consistent with various national data.

FY 2000/01 has been used as the base year of the study. The model's projection for the year 2006, mainly based on household growth, is cross-verified with actual data available from WECS' Energy Synopsis Report-2006, Economic Survey-2007 and information from AEPC. The model is further tuned to ensure proper projections. In another word, the study has used the year 2006 as the model validation/check year.

1.10 Energy Poverty Analysis

Energy consumption which in fact is the conversion of energy to useful work to meet the demand for certain energy services can be measured at various stage of energy supply:

> *Primary energy,* as it occurs in nature, i.e., coal, crude oil, wood, sunlight, uranium, etc. and have not undergone any anthropogenic conversion or transformation.
>
> *Secondary energy,* the energy content of supplied energy to the consumer at the point of end-use. This form of energy may have been transformed from its natural form such as electricity generated from thermal plant or in natural state as in the case of wood fuel
>
> *Useful or end-use energy* is the energy that has been transformed in the form required for actual use, e.g., the heat generated from a hot plate or the mechanical energy applied to air for air circulation.
>
> *Energy Services,* the real energy demand for meeting various needs/purposes by households or end users such as lighting, cooked food, a hot shower, etc.

Energy analysis can be conducted at any of above stage of energy supply. Energy analysis at these different levels can serve different purpose to explain energy consumption behavior. From the perspective of poverty assessment, although the energy services level appears to be the most appropriate, difficulty in measuring them in a common energy unit compelled the study team to look for an alternative. A promising approximation is to measure consumption at the level of useful or end-use energy.

Although the useful or end-use energy for various purposes can be quantified and arithmetic operations can be conducted, it is necessary to understand that purpose and importance of different end-uses are often incomparable as they are not substitutes for one another such as lighting, heating and cooking. The technological sophistications and efficiencies vary widely, similarly, preferences and needs vary widely based on geographical, economic and social situations.

It is important to incorporate traditional energy like wood-fuel, cow-dung, and agricultural residues in energy poverty analysis both in terms of life style, technology, accessibility and affordability. However, problem of incorporating traditional energy in analysis is that they are non-monetized goods and the available data for non-monetary exchanges of goods are not recorded with the same accuracy as monetary exchanges. For traditional energies collected from nature, nobody is obliged or much interested in recording the transactions; therefore, most of the data are estimates or records of surveys. The survey estimates depend on the good will and memory of the respondents, who do not have the possibility of looking up any bills or bank statements to verify what (s)he tells surveyors. Nonetheless, the use of traditional energies cannot be neglected because it is one of the important characteristic of energy analysis specifically in developing countries like Nepal is that they constitute a substantial share (85%) in total energy consumption and they reflect the life style. In many instance, households following a traditional agricultural lifestyle might be considered fairly well-off from energy poverty perspective even if they are self-sufficient in meeting their basic food and energy needs, even if all energy used is non-commercial biomass and technologies used are traditional. When such households goes through a process of change in lifestyles as a result of a massive shift from non-monetized economy and self sufficiency to the market economy and dependency in commercial energy, the energy poverty level may drastically change as a result of lack of access and affordability to commercial energy.

1.11 Energy Poverty Definition

Literature in energy poverty linkage methodology, in general, is quite exhaustive but in developing countries context, empirical evidence of linkage between energy and poverty is relatively less abundant. Nonetheless, methodologies to measure energy poverty linkages can be categorized on their conceptual bases. They are,

a) Economics-based Approaches

Among the most common economic approaches to measuring energy poverty are those that involve defining an "energy/fuel poverty line" analogous to the conventional monetary poverty line. The most common approach in this regard is the average level of energy consumption of persons having a level of income or expenditure officially specified by the poverty line. Other authors such as Goldemberg & Johansson (1995) have defined energy poverty by assessing energy consumption at the aggregate national level in relation to other broader measures of poverty such as the human development index (HDI) or physical quality of life index (PQLI). While such approaches are computationally fairly simple, they only provide a single energy or fuel poverty line, i.e. a single number that is basically a transformation of the monetary poverty line or some other poverty index, and do not, by themselves, add any new insight (Pachauri et al., 2004). Leach (1987) found that share of income spent on energy by poor is normally much greater than that of middle and upper income groups in developed as well as developing countries. The government of the United Kingdom, for instance, defines a fuel poor household "as one which needs to spend more than ten per cent of its income on all fuel use and to heat its home to an adequate standard of warmth" (DTI, 2002). The problem with such a measure is that the energy budget share of a household is a function of many parameters, including energy type, its market price, the efficiencies and the costs of appliances, local climate, family size, ethnicity etc. which all makes it difficult to be used in poverty analysis.

Similarly, to take into account the different efficiencies of the wide range of fuels used by households, another approach for comparing poor and non-poor households adopted by some authors such as Leach (1987) and Foster et al. (2000) is to estimate the "effective price", or "net price" defined as the price per unit of useful energy consumed. It is often the case that poorer households use the most expensive fuels in terms of the price per unit useful energy because poorer households often use the inefficient devices. The result tilts further away from poor households when the annuitized cost of device is taken into consideration. Poorer households are at further disadvantaged positions as compared to richer ones when a comparison of the effective cost of energy per unit useful energy consumed also includes the time costs and transaction costs of gathering or acquiring fuels (Pachauri et al., 2004).

b) Engineering-based Approaches

The engineering-based approach or system analysis based approach estimates the energy required to satisfy basic needs. Goldemberg et al. (1985) estimated that the requirement of direct primary energy to satisfy basic needs is about 500 W per person. Similarly, Pokharel (2002) estimated annual energy required for cooking in Hills of Nepal at 5.5 GJ per capita.

This kind of a calculation rests on a number of assumptions regarding the type of energy consuming equipment (stove, light bulbs, etc.), their sizes, efficiencies and intensity of use. In addition, the approach requires as a first normative step the definition of a set of basic needs. This is a problematic endeavor since basic needs vary with subjective wants, as well as with climate, region, and period in time, age and sex.

Modi et al. (2005) have expressed that energy poverty can also be defined in terms of inability to cook with modern cooking fuels in the poorest households and the lack of minimum lighting energy to read, or for other household and productive activities after sunset. Energy poverty level has been defined as access to 40 KoE per capita per year (equivalent to 35.39 kg of LPG/cap/year) for cooking and 10 KoE (equivalent to about 116.3 kWh/cap/year) for lighting. In the same context, it has been reported that in India, the poor often cannot afford, or may not have access to 50 KoE (Modi et al., 2005).

The methodology allows determining the energy requirements for a normatively defined set of basic needs, based on assumptions regarding the types of energy used, and the sizes, efficiencies and intensities of use for end-use energy equipment. This was found desirable as it allows analysts to capture the climatic and cultural diversity.

c) Poverty and Access to Energy

A number of authors have defined energy poverty in terms of access to energy services (Mark, 1998; Barnett, 2000) as access to more efficient energy sources is directly related to an improvement in peoples' level of well-being. Often it refers to the situation of people in the developing world, the term also implies any quality of life issues relating to lack of access to energy (electricity, heat, or other forms of energy). This is an important complement to a consumption based measure of poverty. This basis adds a dimension in terms of availability of choice to households. Thus, what distinguishes a poor household from a better off one is also the wider range of choice in terms of which fuels to use (more efficient, more convenient, less polluting), and which equipment and appliances to buy. Finding data, however, on access to energy services and appliance is quite difficult. Using data on coverage to indicate access can therefore be problematic as coverage says little about whether households in fact have the ability to access the particular fuel or electricity. In addition, there is often little information available on the quality and security of supply of different fuels and electricity (Pachauri et al., 2004). Energy poverty exists when the required infrastructure is not in place for energy delivery, most often electricity.

Cecelski (2000) succinctly tried to combine all above parameters of energy poverty by stating "the absence of sufficient choice in accessing adequate, affordable, reliable, quality, safe and environmentally benign energy services to support economic and human development". In other words, energy poverty is lack of access to clean liquid/gas fuel, improved supply of solid fuel sources and improved (efficient and clean) cook stoves to perform most basic services (cook food, boil water, lift water for drinking and productive uses, communication, improved health services, improved education services and others) plus some added value to local production. An 'improved energy source' for cooking is one which requires less than 4 hours person per week per household to collect fuel, meets the recommendations of World Health Organization (WHO) for air quality and the overall conversion efficiency is higher than 25 per cent. The air quality, as recommended by MoEST (2009), should have a maximum concentration of CO of 40 mg/m^3 for 1 hour exposure and less than 10 mg/m^3 for 8 hours of exposure.

On the whole the study has adopted definition for energy poverty level as people living below minimum energy consumption level established considering different aspects of energy needs and human development dimension. The study also considers people living under following situation to be below energy poverty where there is inadequate access and choices; lack safety and reliability; and has to depend on inferior quality fuel causing pollution and environmental degradation thereby unsupportive of the economic and human development.

1.12 Energy Poverty Measurement

The initial study concept was based on defining energy poverty as; not having access to the equivalent of 35 kg of LPG/cap/year for cooking and 120 kWh/cap/year. Taking Nepal's energy consumption scenario in consideration and suggestions from Advisory Committee of the study, conclusion had been drawn that defining energy poverty as 35 kg of LPG/cap/year or equivalent for cooking and 120 kWh/cap/year for lighting is less pertinent. Energy poverty measurement in Nepal would require considering at least cooking, lighting and water boiling end-uses. Particularly for the high hill areas, it would also be necessary to consider space heating to measure energy poverty. Further, the energy poverty measurement would be more plausible if it is also possible to incorporate number of other aspects such as quality and quantity of energy use, access to energy and energy using device efficiencies.

Therefore, measurement (or estimate) of energy poverty is done (or arrived) in multiple stages.

a) First Stage (derivation of first parameter): Engineering or process analysis method is used to choose derive minimum useful energy required for various end-uses or basic activities (namely, cooking, lighting[6] and water boiling)[7] which is compared to the existing situation of the country based on available data. A ratio of total primary energy consumption based on current fuel and technology composition

[6] Lighting end-use also includes energy required to operate communication equipments like phone battery chargers and small radios but not television.

[7] Heating/space conditioning is not considered because reliable information on heating in the cold or mountain region is not available

and their respective energy intensity to the total primary energy consumption based on estimated minimum end-use device energy requirement is estimated. The procedure deriving minimum end-use device energy requirement is elaborated in the Section 2.7.2. The ratio when subtracted from 1 would give a value which can be interpreted as a ratio of households living below energy poverty from quantity of energy used perspective.

b) Second Stage (derivation of second parameter): Second parameter is used to capture other qualitative aspects of energy poverty -- quality of energy, access to energy and energy using devices' efficiencies. All households that use devices with efficiency less than 25 per cent, for cooking and drinking water boiling, are considered as households living below energy poverty. Similarly for lighting, households that do not have access to any form or source of electricity are considered as living below energy poverty.

c) Third stage (deriving composite indicator): The figures derived by above methods are given equal importance in deriving percentage of households living energy poverty and first stage composite indicator is derived for all three end-uses. Successively, all three end-uses are further integrated with equal weight to derive a composite energy poverty indicator.

d) Fourth stage (deriving national indicator): Nepal portrays diverse geographic, climatic and ethnic variations that have very strong bearings in energy consumption behaviour. Therefore, estimations of parameters of composite indicator discussed above were made at the disaggregated level. For the purpose, study has used existing five development regions from the East to the West and three geographic regions – Mountains, Hills and Terai, in each development regions. This has resulted into 15 sub-regions all together. Further, each sub-regions are considered consisting Urban and Rural dwellings where exist. The final spatial disaggregation thus comprises 27 sub-sub-regions. The 27 outcomes from third stage is finally combined using weighted average based on number of households in each area.

Thus the final composite energy poverty indicator derived in above four stage encapsulate end-use energy consumption, access, efficiency of three different end-uses catering to basic needs, namely cooking, lighting and drinking water boiling and the country's geographic, climatic and economic variations.

Following sections further elaborate assumptions and analyses described above in depth.

1.13 Assumptions

As described in the Section 2.4, two parameters of energy poverty are further elaborated in terms of assumptions made by the study based on various available literatures.

The first parameter of energy poverty in composite indicator takes into account the quantitative aspect of the current primary energy consumption. The study has considered three different end-uses as basic minimum in analysis.

The second parameter captures other qualitative aspects of energy poverty. As discussed in the Section 2.4, all households that use devices that are less than 25 per cent efficient are considered as living below energy poverty in Cooking and drinking water boiling end-use. However, the Improved Cook Stoves currently promoted in Nepal having 20 per cent efficiency is still taken as improved technology because of its impact on reduction in specific fuel wood consumption and Indoor Air Pollution (IAP). Considering the definition that if any cooking device is able to meet exposure limit of 30 mg/m^3 of CO concentration for 24 hour, it can be regarded as improved technology. A study conducted by Environment and Public Health Organization (ENPHO) in coordination with AEPC has found that the average 24-hr mean CO concentration on using ICS is 8.349 ppm, i.e. equivalent to about 10 mg/m^3. Thus, considering the result of reduction on IAP concentration from 62.34 per cent for CO and 65.73 per cent for $PM_{2.5}$ (ENPHO-AEPC, 2008), ICS has been considered as improved technology for burning biomass in the context of rural Nepal. These considerations are assumed to capture access, convenience, and efficiency in energy consumption status.

1.13.1 Minimum Useful Energy Requirements for Different End-uses

Cooking

Some of the factors considered while deriving energy poverty value for cooking energy are;

- The minimum food calorie, 2250 kcal/day (Pan et. al., 2008) is assumed same in all the ecological regions and settlements.
- Useful energy for cooking: 5.5 GJ/Household/Year in hilly regions (Pokharel, 2002)
- Primary energy for cooking for different devices: Useful energy/devices' respective efficiency, which is shown in the **Annex-2.1**.
- Useful energy requirement in ecological belts other than Hills is derived by multiplying useful energy required for cooking in the Hills by a factor ($\theta/\theta+\Delta\theta$), where, θ is the annual mean temperature of Hilly region and $\Delta\theta$ is the annual mean temperature difference in the respective ecology.

Lighting

Minimum lighting energy requirement, as presented in the **Annex-2.2**, has been estimated considering following assumptions;

- Power rating of electrical bulb: 7 W Compact Fluorescent Lamp (CFL)
- Number of simultaneous operation of CFL/household: 3 ± (5%)
- Average Operation Hour of lamp: 3 hours (Mountains), 3.5 hours (Hills) and 4 hours (Terai)[8]
- Lumen/Watt of CFL: 40 (**Annex-2.3**)
- Radio: 1 in number @ 5 W/ household

[8] People in Hill and Mountains spend lesser time in socio-economic activities in evenings due to geographical condition.

Water Boiling

- Heat energy required for water boiling is dependent on the mass of water required and temperature to be increased raise the temperature, i.e. $Q = f(\Delta\theta)$.
- Mass of water required for drinking used in the analysis has been considered as 5 litres per capita per day (Gleick, 1996).
- Temperature difference factor derived from mean annual temperature in different ecological belt has been used as variable influencing the heat energy requirement. The minimum energy required for drinking water boiling is illustrated in the **Annex-2.4**.
- It is also assumed that all households will boil water for drinking. Other hot water requirements for HH sanitation or other uses are not considered as minimum requirement from energy poverty point of view.
- Even though the study has portrayed the situation of use of thermal energy for water boiling, consumption of thermal energy could be reduced by pasteurizing water through Solar Water Disinfection (SODIS), solar water boiler and other forms of disinfection or purification of water.

1.13.2 Energy Sources and Devices

Energy sources considered in the analysis are biomass, commercial and renewable. The study methodology has incorporated devices for different household end-uses. Devices used for different energy types were identified and quantified from the secondary information for the Base-Year. Biomass energy devices' shares were considered unchanged as found in various survey years for different ecological belt. Since there was not a distinct figure for kerosene devices for lighting in Eastern Development Region (EDR), share of the same from Central Development Region (CDR) has been taken into consideration. Similarly, device shares of biomass energy source for cooking and kerosene for lighting in Mid-Western Development Region (MWDR) and Far-Western Development Region (FWDR) has been taken to be same as that of Western Development Region (WDR) of respective ecological belts, as the region specific data is lacking in the secondary sources of information.

End-use device shares of energy source categories- *commercial* and *renewable* were estimated based on the ratio of average annual primary energy consumption in respective end-uses to the specific energy intensities of respective devices.

Electricity coverage and its ratios in different physiographic/ecological and settlements has been derived from Population Census 2001 published by Central Bureau of Statistics (CBS). The urban and rural electricity access has been estimated from the projection made by CBS in different succeeding years.

1.14 Energy Modelling

Integrated energy plans, which are formulated within the constraints of natural resource endowments, available energy technologies and related institutions, represent the result of a process of matching energy needs with energy supplies. Such energy supply-demand balance essentially represents conciliation between energy demand projections, which is based on the scenarios of economic progress and population growth and as well as on the energy resource assessments and technology evaluations (Codoni et. al., 1985). Energy planning models enable analyses to represent need of usage of following areas of energy planning activities:

i. Energy Supply-Demand Analysis and Balancing
ii. Energy Supply-Demand Management
iii. Assessment of Environmental Impacts
iv. Monitoring and Evaluation of the Project and Programme Implementation

In this study energy modelling is carried out using Long-Range Energy Alternative Planning Model (LEAP) developed by Stockholm Environment Institute (SEI), Boston. It is a computer-based energy accounting, simulation and scenario analysis model, which is designed to support policy makers in evaluating energy policies and developing alternative energy plans. The process of gathering data for a LEAP analysis has proven to be very useful in assessing the adequacy of existing energy-related data and in setting directions for further data collection activities.

A national energy scenario has been developed using this software with regional level disaggregation as described in the Section 2.4. The study has analyzed the current energy consumption and formulated "business-as-usual" scenario also termed as the *Base Case Scenario* that projects future energy consumption based on population and current trend of technology. The *Energy Poverty Reduction (EPR) Scenario* has been formulated to estimate level of interventions required to halve the energy poverty by 2015/16 and complete elimination by 2025/26.

1.15 Energy Information Analysis

1.15.1 Level of Energy Consumption Disaggregation

Energy consumption in the residential sector of the country has been disaggregated with the formulation of energy consumption matrix illustrating different forms of energy, technologies (devices) along the varied physiographical regions and settlements. The main categories of primary energy resources disaggregation used in the study model are as follows;

- Traditional Energy forms: (Fuel wood, Agricultural Residue and Animal Dung)
- Commercial Energy forms: (Grid-fed electricity, LPG and Kerosene)
- Renewable Energy forms: (Solar, Wind, Mini/Micro-Hydro)

Primary energy consumption is disaggregated in the analysis based on demand tree concept of the LEAP Model. The demand tree has been configured as follows;

National Households (Demand Sector)

|→ Development Region (Demand Area)

    |→ Ecological Belt (Demand sub-areas)

        |→ Settlements (Demand sub-areas)

            |→ End-uses

                |→ End-use Devices

The demand tree was formulated considering the National residential sector (Households), which was divided into five areas representing the development regions of the country (EDR, CDR, WDR, MWDR and FWDR). The demand areas were further divided into sub-areas representing ecological belt (Mountains, Hills and Terai) and their respective settlements (Rural and Urban).

Similarly, end-uses (cooking, water boiling, lighting, agro-processing, space conditioning, livestock feeding and others) were arranged for each area. Energy technologies were grouped under the headings of respective end-uses considered in the current account. End-use devices matrix used in the analysis in different activities are presented in the **Annex-3**.

Analysis carried out in the study commenced from the data collection, estimation of specific end-use energy intensities, device shares and total energy consumption. Comparative analysis of total energy consumption with total energy consumption according to the proposed energy poverty value in different planning scenarios in subsequent interval was carried out for respective physiographic/ecological and settlements.

1.15.2 Estimation of Minimum Energy Requirement

Minimum energy required for cooking, water boiling and lighting activities has been estimated considering the minimum basic service that energy has to provide in different physiographic and ecological regions. Methodology adopted to estimate the minimum energy for cooking, water boiling and lighting is;

Cooking

Literatures were reviewed to overview the useful energy required to cook meal in average households of Nepal. Useful energy of 5.5 GJ/household/year has been used in the estimation, based on the controlled cook test results in urban Hilly region of Nepal (Pokharel, 2002). From this useful energy, primary energy required in different ecological belts of Nepal for different cooking devices has been estimated.

Primary energy required for cooking for different end-use devices has been estimated considering their respective efficiency. Assessment of primary energy required for different devices in Mountains and Terai was carried out firstly estimating useful energy required. Cooking energy required for Mountains and Terai was estimated considering the temperature factor of respective regions with hilly region. Average mean yearly temperature was estimated from information received from the Department of Hydrology and Meteorology, GoN.

Thus, the useful energy estimation has been carried out as follows,

$$UE_{c_i} = UE_{c_h} . \delta_i \text{ .... } \textbf{(i)}$$

Where, UE_c = Useful energy required for cooking
h = Hills
δ = Ratio of average annual temperature w. r. t. Hills
i = Mountains or Terai

Primary Energy required for cooking has been calculated as follows,

$$PE_{c_{ij}} = \frac{UE_{c_i}}{\eta_j} \quad \text{.................................} \textbf{(ii)}$$

Where, *PE_c* = Primary energy required for cooking
i = Mountains, Hills or Terai
j = Cooking devices
η = Device efficiency

<u>*Drinking Water Boiling*</u>

Minimum energy required for drinking water boiling has been estimated considering the average per-capita water required, according to WHO standard.

Useful energy required for drinking water boiling is calculated as follows,

$$UE_{wb_i} = ms\Delta\theta \quad \text{.................................} \textbf{(iii)}$$

Where, *UE_{wb}* = Useful energy required for water boiling (GJ)
i = Mountains, Hills or Terai
m = mass of water required to boil (kg)
s = specific heat capacity of water = 0.4183 J/g/K
Δθ = temperature differences (in K) (boiling temperature - initial temperature of water)

Primary Energy required for water boiling is estimated as follows,

$$PE_{wb_{ij}} = \frac{UE_{wb_{ij}}}{\eta_j} \quad \text{.................................} \textbf{(iv)}$$

Where, *PE_{wb}* = Primary Energy required for water boiling
j = Water boiling devices
η = Device efficiency

<u>*Lighting*</u>

Minimum energy required for lighting has been estimated considering assumptions presented in earlier section. However, the methodology adopted for estimating minimum energy required for lighting using electric devices and other fuels (biogas and kerosene) are as follows;

i) Electrical Devices

Estimation of minimum total electric energy is carried out as follows,

$$UE_{el_i} = \sum (L_{ij}.H_{ij}) \text{ .... } \textbf{(v)}$$

Where, UE_{el} = Total Electric Energy Demand (kWh/household/year)
i = Mountains, Hills or Terai
j = Lighting devices
L = Electric Loads (kW)
H = Annual Operating hour of devices

As mentioned earlier in assumptions that power rating of CFL used is 7 W, annual lumen-hour has been estimated with respect to 40 lumen/W of CFL. Primary electric energy required for lighting using different devices has been estimated considering the lumen ratio of each device with respect to CFL.

$$PE_{el\,ij} = \frac{Lm_{ij}}{lw_j} \text{ .... } \textbf{(vi)}$$

Where, PE_{el} = Primary electrical energy required
i = Mountains, Hills or Terai
j = Lighting devices
Lm = Lumen-Hour per year
lw = Lumen per kilowatt of electric devices

ii) Other Fuel Lamps

In this case estimation has been carried out comparing the Lumens ratio of CFL and hurricane lamp (Lantern) that uses kerosene.

$$PE_{l_{ij}} = \frac{Lm_{ij}}{lw_j} \text{ .... } \textbf{(vii)}$$

Where, PE_l = Primary lighting energy required.
i = Mountains, Hills or Terai
j = Lighting devices
Lm = Lumen-Hour per year of lighting devices
lw = Lumen per equivalent kilowatt of lighting devices

1.15.3 Specific End-use Energy Consumption

Specific energy consumption in different end-use activities and devices has been calculated on the basis of average annual household energy consumption (GJ/household) of different areas and their corresponding device share derived from secondary information. Estimation of specific end-uses device energy consumption has been carried out as follows;

<u>*Cooking*</u>

Fuel Wood Stoves

Energy Intensity of fuel wood energy conversion devices for cooking was estimated through two stages, one estimating the average fuel wood consumption for cooking and secondly estimating the average end-use devices fuel wood consumption.

Fuel wood has been distributed for devices like mud stoves, improved cook stoves, iron tripod stoves, 3-stone fires and wood gasifier[9]. Total average fuel wood consumption was derived from the secondary sources, on the basis of which average useful energy consumption was derived, considering the weighted average efficiency of end-use devices (Equation i).

$$UE_{fw} = E_{fw} . \eta_{wt} \quad \text{.............................} \ \textbf{(viii)}$$

Where, UE_{fw} = Average Useful Fuel wood Energy Consumption (GJ/household/year)
E_{fw} = Total average Fuel Wood Consumption (GJ/household/ year)
η_{wt} = Average weighted Device Efficiency based on device shares

Specific energy intensities of fuel wood stoves were then estimated considering the calculated useful energy consumption and devices' efficiency.

$$I_{fw\,j} = \frac{UE_{fw}}{\eta_j} \quad \text{.......................................} \ \textbf{(ix)}$$

Where, I_{fw} = Specific Energy Intensity of fuel wood devices (GJ/household /year)
j = Cooking Devices
UE_{fw} = Average useful fuel wood energy consumption (GJ/household /year)
η = Devices Efficiency

The device shares (percentage of Households using particular device) for fuel wood energy conversion were derived from the secondary source, which was further adjusted according to the changes in total fuel wood consumption in subsequent years.

Agricultural-Residue and Animal Waste Stoves

Agricultural residues considered in the study are the on-farm residues, which generally comprised of rice stalks, maize cob and stalks, wheat stalks etc. Specific agricultural residue consumption has been used equivalent to the specific fuel wood consumption of the Iron tripod stoves. Share of the device or stoves using agricultural residues or animal waste as fuel was estimated as follows;

---

[9] Gasifier is a combustion device in which a solid or liquid fuel source (eg, biomass) converts to a gaseous fuel undergoing a thermochemical process known as gasification.

$$D_i = \frac{E_i}{I_{IT}} \quad \text{.. (x)}$$

Where, D = Share of stoves

E = Average primary energy consumption (GJ/household /year)

I_{IT} = Specific energy intensity of iron tripod stoves (GJ/household/year)

i = Agricultural residue or animal waste

Biogas Stoves

Share of biogas stove has been derived from the status of biogas in Nepal in different years (BSP-Nepal, 2009). It has been found that 1 m^3 of biogas can cook 3 meals for a family of 5-6, (Kristoferson, 1991), which has been used to estimate the specific energy consumption of biogas. Hence, specific energy intensity for a biogas stove is taken as net energy that can be delivered from 1 m^3 of biogas with utility factor of 80 per cent round the year.

LPG Stoves

Specific energy intensity of LPG stove has been estimated considering the ratio of efficiency of biogas stove and LPG stove. The device share hence has been estimated from the ratio of average LPG energy consumption (GJ/household/year) and energy intensity (GJ/household) of LPG stove.

Kerosene Pressure Stoves (Bio-fuel Stoves)

Specific energy intensity of kerosene pressure stove has been estimated from the ratio of efficiency of LPG stove and kerosene pressure stove. The device share hence has been estimated from the ratio of average annual kerosene energy consumption (GJ/household) and energy intensity of kerosene pressure stoves (GJ/household). It is assumed that in future, when bio-fuel technology becomes a reality, this stove can be used with minor modification to use bio-fuel with approximately similar efficiencies and energy intensities.

Electric Devices

Specific energy intensities of electrical cooking devices has been estimated from the useful energy required for cooking using mud-stove data multiplied by the ratio of the electrical cooking device to mud-stove efficiency.

Water Boiling

Device share for water boiling using different fuels is assumed to be half of what is required for cooking.

$$I_{wb_j} = 0.5\, I_{c_j} \quad \text{.................................} \ \textbf{(xi)}$$

Where, I_{wb} = Energy Intensity for water boiling (GJ/household/year)
I_c = Energy Intensity for cooking (GJ/household/year)
j = Water Boiling/Cooking Devices

Lighting

Electric devices

Energy Intensities for lighting devices has been estimated as follows;

$$I_{incand} = nWt_i \quad \text{................................} \ \textbf{(xii)}$$

Where, I_{incand} = Energy Intensity of incandescent light (kWh/household/year)
n = Estimated average number of bulbs
W = Power Ratings of bulb (kW)
t = Average operating hours/year
i = Mountains, Hills or Terai

Device shares of electric lighting devices are based on the electrification coverage ratio and its proportion on urban and rural areas in different regions.

Energy intensities for fluorescent and CFL has been estimated considering the efficacy ratio of each other, where it has been assumed that 100 W of Incandescent lamp can be replaced with 20 W of CFL or fluorescent lamps.

$$I_{fl} = \frac{I_{incand}}{5} \quad \text{.....................................} \ \textbf{(xiii)}$$

Where, I_{fl} = Energy Intensity of Fluorescent lamps (kWh/household/year) = Energy Intensity of CFL (I_{cfl})
I_{incand} = Energy Intensity of Incandescent lamp (kWh/household/year)

Biogas Lamps

Device share and specific intensity of biogas used in lighting has been taken as half of that used in cooking. It has been found that 1 m^3 of biogas is equivalent to 60-100 W bulbs for 6 hours (Kristoferson, 1991). Hence, specific energy intensity for a biogas lamp was taken as net energy that can be delivered from 1 m^3 of biogas operating for 4 hours with utility factor of 80 per cent round the year.

Kerosene Lamps

Specific energy intensity of kerosene pressure lamp, commonly known as petromax, has been estimated equivalent to 1 m^3 of biogas for operating 4 hours per day. Energy intensity of lantern (hurricane lamp) was estimated as half of the intensity of petromax. Similarly, energy intensity of kerosene wick lamps has been assumed half of the energy intensity of lantern.

Additional End-Uses

Even though the study is aimed to analyze on energy poverty situation in cooking, water boiling and lighting, additional end-uses were also included in the model. The additional end-uses were incorporated so as to verify the total residential energy consumption of 2001 and 2006 as projected by WECS.

Specific energy intensity for ***space conditioning*** is assumed to be 1/2, 1/3 and 1/4 of energy required for cooking for Mountains, Hills and Terai, respectively, when using cooking stove itself for space heating. However, for electric devices, specific energy intensity was estimated based on the power rating and average annual operating hours. Share of end-use devices were estimated as the ratio of average respective fuel consumption to the respective specific energy intensities.

Specific intensities and device share estimations for ***livestock feeding*** and a***gro-processing*** were carried out in the same manner as that of water boiling.

Energy consumption for cultural activities, rituals and electrical appliances were merged into ***others***. Additional biomass consumed for ***others*** was considered in the same proportion as in cooking activities. Similarly, device shares of electrical appliances considered in this case was adjusted as per the electrical coverage ratio in respective regions.

1.15.4 Primary Energy Consumption

Estimation of total energy consumption in different residential activities was carried out in the planning base year and projection of it in subsequent planning periods. Energy consumption estimation has been carried out as follows,

$$PE = \sum_{i=1}^{n} E_i (I_j .D.H) \quad \text{.......................... (xiv)}$$

Where,
- PE = Total Primary energy consumption in residential activities (GJ/Year)
- E_i = End-uses i = 1 to n
- I = Energy Intensities of end-use devices
- j = End-use devices
- D = Devices shares (in %)
- H = Numbers of Households

1.16 Scenario Formulation and Approaches

Population of households residing below energy poverty in different projection periods were estimated as per the energy poverty parameters adopted in this study, which has been further projected under the Base-case Scenario. Percentage of households residing below energy poverty in 2001 and 2006 are considered as a Baseline Energy Poverty Situation. Energy poverty situation in 2016 and 2026, estimated under the Base-case

Scenario has been a basis for technology intervention perceived under Energy Poverty Reduction Scenario for halving and eliminating energy poverty in the respective period which is the objective of the study. The EPR scenario quantifies the need of energy intervention to halve the projected Base-case energy poverty by the year 2016 and eliminate the projected Base-case energy poverty by the year 2026.

1.16.1 Base-case Scenario

Base-case scenario is the scenario that represents the *business as usual case*, where continuation of current trend of energy and technology intervention is assumed to continue throughout the planning period. In this scenario, end-use device shares of FY 2006 are assumed not to change along with their corresponding energy intensities.

Since, in a household, multiple energy devices and fuels are generally used for a specific end-use, the total share of devices exceeds 100 per cent. The devices shares have been adjusted assuming each household uses a single device-type for a particular end-use. Intervention of convenient energy technologies and increasing access to electricity and modern fuel at a current rate is assumed to continue, they have been represented in the model/analysis by reducing the shares of in-efficient devices, e.g., continuing the trend of biogas and ICS installation, results in reduction of traditional biomass and kerosene stoves. Similarly, increase in access of LPG for cooking, results in decrease in the population depending on kerosene at least.

Intervention of energy and technology mix in the Base Case Scenario is based on following;

Biomass Energy: average annual installation rate of ICS (35,053 units) in Nepal from 2000/01 till 2005/06 and projection at the same rate in subsequent planning period.

Biogas Energy: Projection of biogas installation at the average rate of 16,000 plants annually[10] (BSP-Nepal, 2009).

Solar Home System: average annual installation rate of SHS (13,037 units) in Nepal from 2000/01 till 2005/06 and projection at the same rate in subsequent planning period.

Electricity coverage has been projected considering the usual trend of expansion of National grid and mini-grid supplying electricity to additional 12,900 and 10,000 households per annum, respectively.

1.16.2 Energy Poverty Reduction Scenario

The energy poverty reduction scenario has been formulated considering the objective of the study,

Halving the projected Base-case energy poverty situation in 2015/16

Eliminating the projected Base-case energy poverty by 2025/26

[10] BSP-Nepal has reported that annual rate of biogas plant construction has stagnated around 16,000 in the last 6-7 years and even after the cease of the armed conflict.

For devising EPR scenario, results of base case scenario, basically energy poverty situation in all proposed definition were analyzed. Assessment of percentage of population depending on devices with efficiency less than 20 per cent in base case scenario for FY 2016 and 2026 were estimated, which has been accordingly planned to meet the energy poverty reduction (50 per cent in 2015/16 and completely by 2025/26). EPR scenario thus incorporates the intervention of efficient devices with the estimated minimum energy required for different end-uses in different ecological belts, thereby covering both the proposed definitions.

Intervention of energy and technology mix for the EPR scenario is based on following and is planned accordingly;

Biomass Energy: Target of installing 430,000 ICS, 10,000 Household Gasifiers and 50,000 high altitude ICS during the period of 2007-2012 (Official website, AEPC).

Biogas Energy: Target of installing 200,000 biogas plants in 6 years time frame *(BSP-Nepal, 2009).*

Small Solar Home System (SSHS): The system that uses solar photovoltaic panels smaller than 10 Watt peak and white LED lamps. Target of installing 250,000 SSHS during the period of 2007-2012 (Official website, AEPC).

Solar Home System: The system that uses solar photovoltaic panels larger than 10 Watt peak and CFL or similar lamps. Target of installing 150,000 SHS during the period of 2007-2012 (Official website, AEPC).

Rural electricity coverage and its projection is based on the target of AEPC Mini-Grid Support Programme (MGSP) and continuation of target to increase access to electricity, which has been carried out on the basis of achieving the target of AEPC/GoN to provide electricity for 150,000 households (equivalent to about 20 MW_e) during the period of 2007-2012 (Official website, AEPC).

National grid expansion has been projected to achieve the target of having access to electricity to additional 3 million households by 2026, than that of 2006. The national grid expansion consists of mainstream electrification as well as community based rural electrification.

Thus EPR has been devised considering the target of AEPC for the FY 2011 and has been accordingly continued in-order to meet the objective of the study as described above.

FINDINGS

Energy poverty estimation is a complex process, specifically in the country like Nepal which depends excessively on non-traded biomass energy resources and technologies. Except for cut-timber in some small towns, biomass in general in rural areas is a non-traded commodity (generally firewood are being collected from forests by households themselves) transactions are often not recorded and hence data related to production, trade and consumption is scarce. Different parts of the country are in different stages of economic development and endowed differently in terms of natural resources. As a result, energy and technology mix in Nepal is characterized by use of diverse energy resources and technologies for performing different household activities. The chapter includes estimation of basic minimum energy required for key household end-uses and compares it with the current energy situation in the base-year (2001) and data-check year (2006). The result is the derivation of key parameters of energy poverty situation. The chapter outlines the current energy technology mix and their end-use efficiencies and presents the projected energy poverty situations (2016 and 2026) in Base-case and EPR Scenarios. The technology intervention required in the EPR scenario has also been included in the Chapter.

1.17 Primary Energy Requirement for Basic Needs

The energy poverty reduction is based on the estimated minimum energy required for cooking, water boiling and lighting along with the operation of small electrical devices. Estimated minimum energy requirements for different end-uses are described below;

Cooking

End-use devices considered for cooking are mud-stove, iron tripod, 3-stone fire, ICS, gasifier, biogas stove and charcoal stoves under the category of biomass energy technology. Similarly, kerosene pressure stove, LPG stove, liquid bio-fuels stove, electric heater and rice cooker has been categorized under the commercial fuel technology.

The estimated minimum useful energy required for cooking in Mountains, Hills and Terai regions of the country are 6.88, 5.50 and 4.40 GJ/household/year, respectively, as discussed in the Section 2.5.1. The specific energy consumption of end-use devices, estimated on the basis of device efficiency is shown in the Table 1. The minimum primary energy required for cooking consumption in energy units is given in the **Annex-2.1.**

Table 1: Minimum Primary Energy Required Estimates for Cooking

Ecology/ Devices	*Useful Energy (GJ/HH /Year)*	*Primary Energy Required for Cooking (Natural Units/HH/Year) by Fuel and Device type*										
		Fuel wood				*Charcoal*	*Biogas*	*LPG*	*Kerosene*		*Electricity*	
		TCS	*Iron Tripod/ 3-Stone*	*ICS*	*Gasifier*	*Charcoal Stove*	*Biogas Stove*	*LPG Stove*	*Pressure Stove*	*Wick Stove*	*Clay Heater*	*Rice Cooker*
		Tonne	*Tonne*	*Tonne*	*Tonne*	*Tonne*	*m^3*	*Tonne*	*kl*	*kl*	*MWh*	*MWh*
Mountains	6.88	4.43	8.87	2.22	1.48	1.17	509.3	0.22	0.39	0.44	3.47	2.12
Hills	5.50	3.55	7.10	1.77	1.18	0.94	407.4	0.18	0.31	0.35	2.78	1.70
Terai	4.40	2.84	5.68	1.42	0.95	0.75	325.9	0.14	0.25	0.28	2.22	1.36

(Source: Study Estimates)

The estimation of minimum energy requirement shows that high amount of energy is required when traditional biomass devices are used; hence the energy poverty reduction scenario has focussed on maximisation of use of improved cooking stove, gasifiers and biogas stoves that have 2 to 3 times higher end-use efficiency compared to traditional stove. Similarly, LPG, kerosene/liquid bio-fuel and electric devices are also used as energy intervention to reduce energy poverty reduction, specifically in urban and semi-urban areas.

Lighting and small electrical equipment

Lighting devices have been categorised as above and below energy poverty based on quality of light they provide. Selection of lighting device has been carried out on the basis of minimum lumen required to satisfy the lighting needs and total energy required to provide the estimated minimum lumen-hours.

Minimum energy required for lighting and others (operating basic appliances) has been estimated on the basis of assumption as discussed in the Section 2.5.1. Lighting energy requirement has been estimated considering annual lumen-hour of CFL with power rating of 7W, where it has been found that about 1226.4, 1430.8 and 1635.2 (‘000 lm-hr/year) is required for lighting purpose in Mountains, Hills and Terai, respectively.

Estimated minimum lighting energy required in Mountains, Hills and Terai with different device configuration is shown in the Table 2. It has been found that with the use of CFL, at least 30.7, 35.8 and 40.9 kWh/household/year electric energy is required in Mountains, Hills and Terai, respectively.

Similarly, the annual lumen-hours requirement of kerosene devices is based on the lumens/Watt of Lantern. When lantern is used, it is estimated that about 307, 358 and 409 (‘000 lm-hr/year) is required in Mountains, Hills and Terai, respectively. The estimated minimum energy required for the kerosene-based devices shows that substantial energy is needed if these are used for lighting. Minimum Energy consumption estimation for lighting in their energy units is shown in the **Annex-2.2** including various assumptions.

Table 2: Minimum Lighting Energy Needs

Ecology/ Devices	Minimum Energy Required for Lighting (kWh/HH/Year)						Minimum Energy required for Lighting (l/HH/Year)			
	'000 lumens-hours/Year	CFL (7 Wx4 + Radio)	Fluorescent Lamp	Incandescent Lamp	SHS	SSHS	'000 lumens-hours/Year	Kerosene Tuki[11]	Hurricane Lamp (Lantern)	Gas Lamp
Mountains	1,226	30.7	37.9	122.6	30.7	32.7	307	63.1	210.2	630.7
Hill	1,431	35.8	44.2	143.1	35.8	38.2	358	73.6	245.3	735.8
Terai	1,635	40.9	50.5	163.5	40.9	43.6	409	84.1	280.3	841.0

(Source: Study estimates)

Electric energy consumption has been estimated for over all household activities. However the energy poverty reduction scenarios incorporate devices for lighting and for operating radio and charging phones, based on the electrification ratio.

Water Boiling

The minimum energy required for water boiling has been estimated on the basis of heat required for boiling drinking water at 96^{o}C. Minimum useful energy required to boil drinking water has been estimated 3.17, 3.09 and 3.08 GJ/household/year in Mountains, Hills and Terai, respectively. The estimated minimum energy required for water boiling in different ecology and devices is shown in the Table 3, where it has been found that using traditional biomass devices for the same output, huge amount of energy is required. Hence, end-use device considered in the energy poverty reduction are ICS, charcoal/briquette stoves and gasifier as a biomass devices. Similarly, LPG, pressure stoves and electric devices are also considered as potential end-use device to reduce the energy poverty. Minimum energy required for water boiling in their energy units is shown in the **Annex-2.3.**

Table 3: Minimum Primary Energy required for Water Boiling

Ecology/ Devices	Useful Energy (GJ/HH /Year)	Minimum Energy Required for Water Boiling (Natural units/HH/Year)										
		Fuel wood				Charcoal	Biogas	LPG	Kerosene		Electricity	
		TCS	Iron Tripod/ 3-Stone	ICS	Gasifier	Charcoal Stove	Biogas Stove	LPG Stove	Pressure Stove	Wick Stove	Clay Heater	Electric Kettle
		Tonne	Tonne	Tonne	Tonne	Tonne	m^3	Tonne	kl	kl	MWh	MWh
Mountains	3.17	2.05	4.10	1.02	0.68	0.54	235.2	0.10	0.18	0.20	1.60	0.98
Hill	3.09	2.00	3.99	1.00	0.67	0.53	229.1	0.10	0.18	0.20	1.56	0.95
Terai	3.08	1.99	3.98	0.99	0.66	0.53	228.3	0.10	0.18	0.20	1.56	0.95

(Source: Study estimates)

1.18 Baseline Energy Poverty Situation

1.18.1 Energy Poverty Situation

Composite energy poverty situation estimated in the base-year and verification year for cooking, lighting and water boiling are described in following different end-use sections. The detailed breakdown of the energy poverty situation of all the development regions is

[11] Kerosene Tuki is a traditional lighting device mostly used in rural areas, which contains cotton wick immersed in kerosene bottled in a locally available casing.

shown in the **Annex-5**. The values for first and second parameters of the composite indicator for each end-use are given in the **Annex-4**.

Household below Energy Poverty in Cooking

It has been found that at least 61 and 57 per cent of the total households were below energy poverty in 2001 and 2006, respectively. Estimated percentage of urban and rural households below energy poverty residing in Mountain region in 2001 was around 85 and 78 per cent, and in 2006 it was at least 84 and 76 per cent, respectively.

EDR is found to have the highest occurrence of energy poverty (about 68 per cent in the FY 2001 and 66 per cent in 2006) from the cooking energy perspective; while MWDR is found to be in relatively better situation from the cooking energy point of view compared to other development regions as shown in the Table 4. More detailed breakdown of the Table 4 is given in the **Annex-5.1**.

Table 4: Percentage of Households below Energy Poverty in Cooking by Regions

Years	***2001***	***2006***
Nepal	60.9	57.4
Development Region		
EDR	67.8	65.8
CDR	55.9	52.7
WDR	64.3	58.8
MWDR	54.2	49.5
FWDR	63.7	61.0
Ecological Belt		
Mountains	78.2	76.5
Hills	63.7	57.7
Terai	55.3	53.9
Place of Dwelling		
Urban	53.4	52.2
Rural	62.3	58.6

Source: Study Findings

Households below Energy Poverty in Lighting

Estimation of households below energy poverty in Lighting shows that about 62 per cent and 60 per cent of the total national households, respectively, were below energy poverty in 2001 and 2006. The FWDR has been found energy poor in lighting in comparison to other regions in 2001. The Table 5 below shows percentages of households below poverty in various regions/belts etc. More detailed breakdown of the Table 5 is given in the **Annex-5.2**.

Table 5: Percentage of Households below Energy Poverty in Lighting by Regions

Years	*2001*	*2006*
Nepal	62.1	60.4
Development Region		
EDR	73.3	70.6
CDR	46.6	46.0
WDR	64.3	60.5
MWDR	71.8	71.4
FWDR	73.8	73.6
Ecological Belt		
Mountains	70.9	71.4
Hills	56.3	53.7
Terai	66.5	65.4
Place of Dwelling		
Urban	20.7	18.2
Rural	69.7	69.9

Source: Study Findings

Households below Energy Poverty in Water Boiling

Estimated shares of households below energy poverty in water boiling were about 91 and 88 per cent of the total household in 2001 and 2006, respectively. EDR has been found relatively energy poor in comparison to other development regions as shown in the Table 6. Similarly, significant number of Terai households has also been found below energy poverty than that of Hills and Mountains in 2001 and 2006.

Energy poverty situation for water boiling in urban dwellings in 2001 and 2006 has been found to be about 68 and 69 per cent, respectively. In addition to this about 95 and 92 per cent of rural dwellings were found below energy poverty in 2001 and 2006, respectively. More detailed breakdown of the Table 6 is given in the **Annex-5.3**.

Table 6: Percentage of Households below Energy Poverty in Water Boiling by Regions

Years	*2001*	*2006*
Nepal	91.0	88.0
Development Region		
EDR	96.1	94.3
CDR	86.1	83.4
WDR	92.8	88.7
MWDR	95.0	89.8
FWDR	86.9	85.2
Ecological Belt		
Mountains	95.1	93.3
Hills	85.8	80.2
Terai	95.7	95.1
Place of Dwelling		
Urban	68.1	69.0
Rural	95.3	92.3

Source: Study Findings

1.18.2 Overall Energy Poverty Situation of Nepal

Overall energy poverty situation has been outlined based on the composite energy poverty indicators of cooking, lighting and water boiling. At least 71 per cent and 68 per cent of households at a national level was estimated to be living below energy poverty in 2001 and 2006, respectively. The analysis has shown that the EDR has relatively high energy poverty. About 79 per cent and 77 per cent of the EDR households were below energy poverty in 2001 and 2006, respectively. Among all the development regions, CDR has lower energy poverty situation (about 63 and 61 percent in 2001 and 2006, respectively).

Table 7: Overall Energy Poverty Situation of the Country

Years	***2001***	***2006***
Nepal	71.3	68.6
Development Region		
EDR	79.1	76.9
CDR	62.9	60.7
WDR	73.8	69.3
MWDR	73.6	70.2
FWDR	74.8	73.3
Ecological Belt		
Mountains	81.4	80.4
Hills	68.6	63.9
Terai	72.5	71.5
Place of Dwelling		
Urban	47.4	46.4
Rural	75.8	73.6

Source: Study findings

Likewise, energy poverty was higher in Mountain region of the country than other regions as shown in the Table 7. About 76 and 74 per cent of the rural dwellings were below energy poverty in 2001 and 2006, respectively.

1.18.3 Energy Poverty and HDI Situation

Energy poverty situation for cooking, lighting and drinking water boiling in FY 2001 has been correlated with HDI of the different regions of the country. The overall energy poverty situation in FY 2000/01 has been found higher in most of the Mountain regions of the Country. It has been found that in comparison to the urban settlements, the rural settlements are relatively poorer as shown in the Figure 1. In addition to this, the HDI values of different regions of the country are shown in the Figure 2.

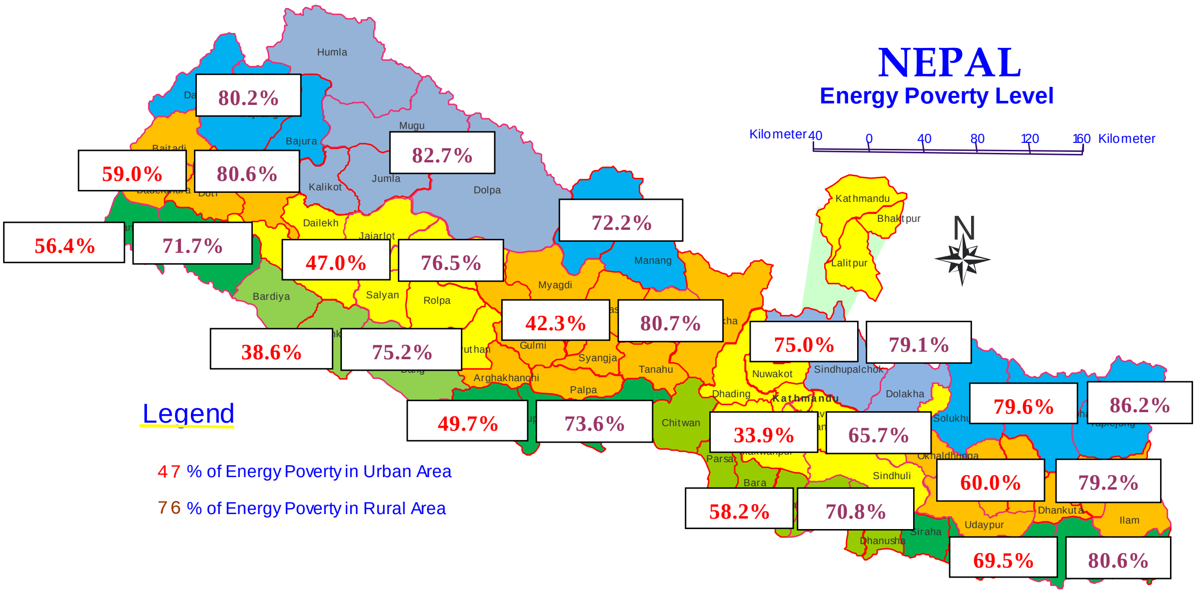

Figure 1: Overall Energy Poverty Situation, 2001

Map Source: Published GoN Maps, Value source: Study findings

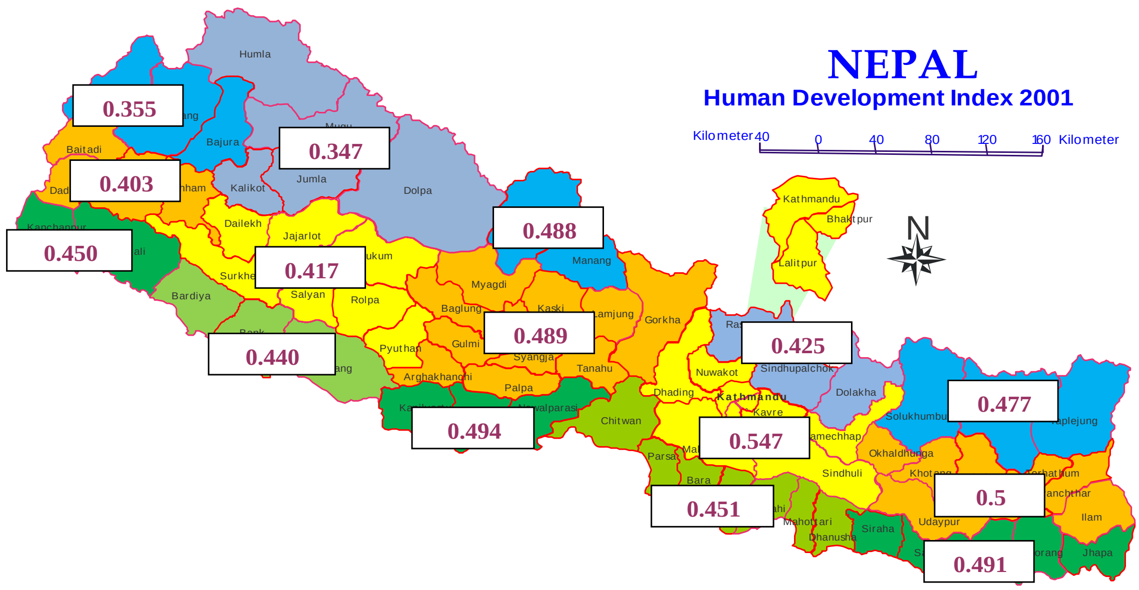

Figure 2: Human Development Indices by Regions, 2001

Map Source: Published GoN Maps, Value source: UNDP, 2004

A significant correlation can be seen between HDI and overall energy poverty ranking values, as shown in the Figure 3. WDR Mountains, which do not have any urban settlements, has higher HDI value (0.488) among all other Mountain regions of the country. The overall energy poverty situation of the WDR Mountain was also lower than mountain settlements of other development regions.

Similarly, CDR Hills has the highest HDI (0.547) among all the regions. The energy poverty situation in CDR Hills has also been found considerably better than others.

Among the Terai belt, WDR has the highest HDI (0.494); however the energy poverty situation does not signify the presence of higher HDI in Western Terai.

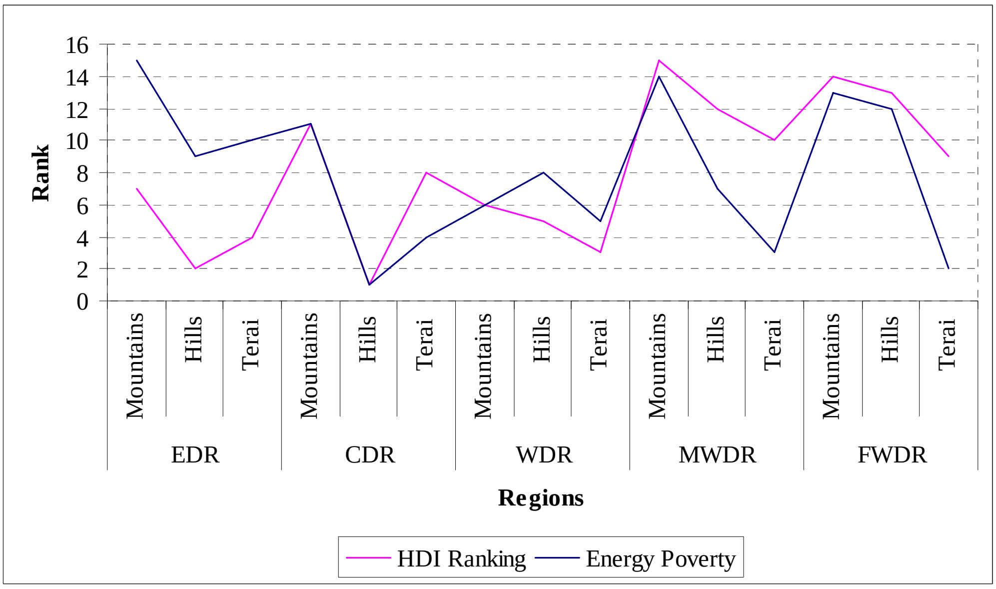

Figure 3: Relation between HDI Ranking and Overall Energy Poverty

1.19 Projection of Energy Poverty Situation

Projection of energy poverty situation is based on the envisaged and/or planned technology interventions in different scenario. Two different projections of energy poverty situation have been carried out– i) Base-case Scenario, where past trend of energy development and shares of end-use device has been considered to continue, ii) Energy Poverty Reduction (EPR) Scenario, where technology intervention are planned to achieve halving and eliminating the projected Base-case energy poverty situation by 2016 and 2026, respectively, as discussed earlier in the Section 2.8.2. The estimation of energy poverty situation makes use of Household projections based on Population Projection for Nepal 2002-2021, published by CBS. The projections for households and household size are given in the **Annex-6**. The projected energy poverty situation and its reduction planning are described as follows:

1.19.1 Base-case Scenario

Projection of household below energy poverty in cooking, water boiling and lighting is based on the continuity of current trend of energy development and practice of cooking. Projections of energy poverty situation for different end-uses are as follows;

Energy Poverty in Cooking

Energy poverty situation projected in cooking under the Base-case Scenario showed that more than 77 per cent of the urban households present in the Mountain regions of all the development regions can be below energy poverty in 2016 and 2026. CDR has been found with lower energy poverty population in compared to other development regions.

EDR Hills and Terai, both urban and rural, seemed to be poorer in energy in the projected years.

While looking into the energy poverty situation at the macro level, the Base-case Scenario shows that at least 47 and 40 per cent of the total projected national residential sector in 2016 and 2026 correspondingly, will be below energy poverty. Energy poverty situation in rural areas are anticipated to be around 53 and 49 per cent of the total rural population in 2016 and 2026, respectively, which is based on the target set by AEPC on ICS, biogas, wood gasifier for up to 2011 and further continuation of these programmes at same scale in future. It has been estimated that about 39 and 22 per cent of the total urban households in 2016 and 2026 could be below energy poverty in the current trend projections.

Energy poverty situation in EDR seems very high compared to other, where nearly 63 and 61 per cent of the total EDR households can be below energy poverty in 2016 and 2026, respectively. Similarly, households in FWDR residing below energy poverty are projected to be about 57 and 52 per cent of the total households in 2016 and 2026, respectively, as shown in the Table 8. Projected energy poverty situation for other development regions have been estimated lower than the EDR and FWDR as shown in the Table 8.

Table 8: Energy Poverty Projection for Cooking by Regions

Years	***2016***	***2026***
Nepal	49.6	39.9
Development Region		
EDR	63.3	60.8
CDR	40.6	25.1
WDR	49.9	37.6
MWDR	43.1	36.4
FWDR	57.1	52.5
Ecological Belt		
Mountains	74.5	73.3
Hills	44.6	29.1
Terai	50.7	45.4
Place of Dwelling		
Urban	39.5	22.0
Rural	53.0	48.7

Source: Study Findings

Energy Poverty in Lighting

Projection of energy poverty situation in the Base-case Scenario for lighting is based on the un-reliable electricity supply that has been prevailing in the country. The energy poverty situation for lighting under the Base-case Scenario for both fiscal years 2015/16 and 2025/26 has been projected to be the highest in FWDR compared to others.

Hence, under the Base-case scenario out of total households of the country in 2016 and 2026, almost 52 and 46 per cent, respectively, have been expected to be residing below energy poverty. EDR, WDR, MWDR and FWDR are expected to have more of their households below energy poverty in comparison to that of CDR in 2016 and 2026 as shown in the Table 9. On the basis of increasing trend in grid and off-grid expansion in

Hilly region, it has been expected to have lesser energy poverty in comparison to the Mountain and Terai. Urban areas have been found above energy poverty, due to higher access of electricity than that of rural areas, as shown in the Table 9.

Table 9: Energy Poverty Projection for Lighting by Regions

Years	***2016***	***2026***
Nepal	51.8	46.5
Development Region		
EDR	63.0	58.8
CDR	37.3	32.5
WDR	49.4	41.0
MWDR	64.2	59.3
FWDR	66.9	62.8
Ecological Belt		
Mountains	63.7	60.1
Hills	44.4	38.1
Terai	57.5	52.7
Place of Dwelling		
Urban	16.1	17.1
Rural	63.7	60.8

Source: Study Findings

Energy Poverty in Water Boiling

It has been found that, till date, extensively traditional biomass devices are being used for water boiling in Nepal. The projected energy poverty situation for water boiling is the highest in Terai region compared to other ecological belts of the Country for both fiscal years (2015/16 and 2025/26).

Hence, with the continuation of existing trend of energy and technology input for water boiling throughout the planning period, households residing below energy poverty is expected to be as 82 and 76 per cent of the total population in 2016 and 2026, respectively, as shown in the Table 10.

Table 10: Energy Poverty Projection for Water Boiling by Regions

Years	***2016***	***2026***
Nepal	82.0	75.8
Development Region		
EDR	92.0	89.9
CDR	74.9	63.8
WDR	81.7	76.3
MWDR	82.5	77.3
FWDR	83.4	82.5
Ecological Belt		
Mountains	91.1	89.8
Hills	69.4	58.7
Terai	93.4	90.9
Place of Dwelling		
Urban	64.1	57.9
Rural	88.0	84.7

Source: Study Findings

All the development regions have been expected to continue to prevailing energy poverty in 2016 and 2026 with the continued trend of using energy for water boiling. Continued use of mud-stoves, agriculture-residues and electric clay stoves with higher energy intensity is likely to produce energy poor households with total shares of around 64 and 58 per cent of total urban households of the country in 2016 and 2026, respectively. Similarly, more than 88 and 84 per cent of rural household of the country has been expected to be residing below energy poverty in 2016 and 2026.

Overall Energy Poverty Projection for Nepal

The overall projected composite energy poverty index of Nepal has been found to be about 61 per cent in 2016 and 54 per cent in 2026. EDR seems to be residing more in energy poverty than others, if the existing energy technologies and resources are mobilized in the current trend. About 73 and 70 per cent of EDR dwellings will be below energy poverty in 2016 and 2026, respectively, as shown in the Table 11.

Table 11: Overall Energy Poverty Projection

Years	*2016*	*2026*
Nepal	61.2	54.1
Development Region		
EDR	72.8	69.8
CDR	50.9	40.4
WDR	60.3	51.6
MWDR	63.3	57.7
FWDR	69.2	65.9
Ecological Belt		
Mountains	76.4	74.4
Hills	52.8	42.0
Terai	67.2	63.0
Place of Dwelling		
Urban	39.9	32.3
Rural	68.2	64.7

Source: Study Findings

Among the Mountain regions, WDR Mountains is projected to have the least occurrence of energy poverty in the years 2016 and 2026. CDR Hills is likely to be above energy poverty by 2016 with continuation of the current trend. In case of Terai region, MWDR Terai is projected to have less energy poverty in 2016 and 2026. The overall energy poverty projection for the years 2016 and 2017 are shown in the Figures 4 and 5, respectively.

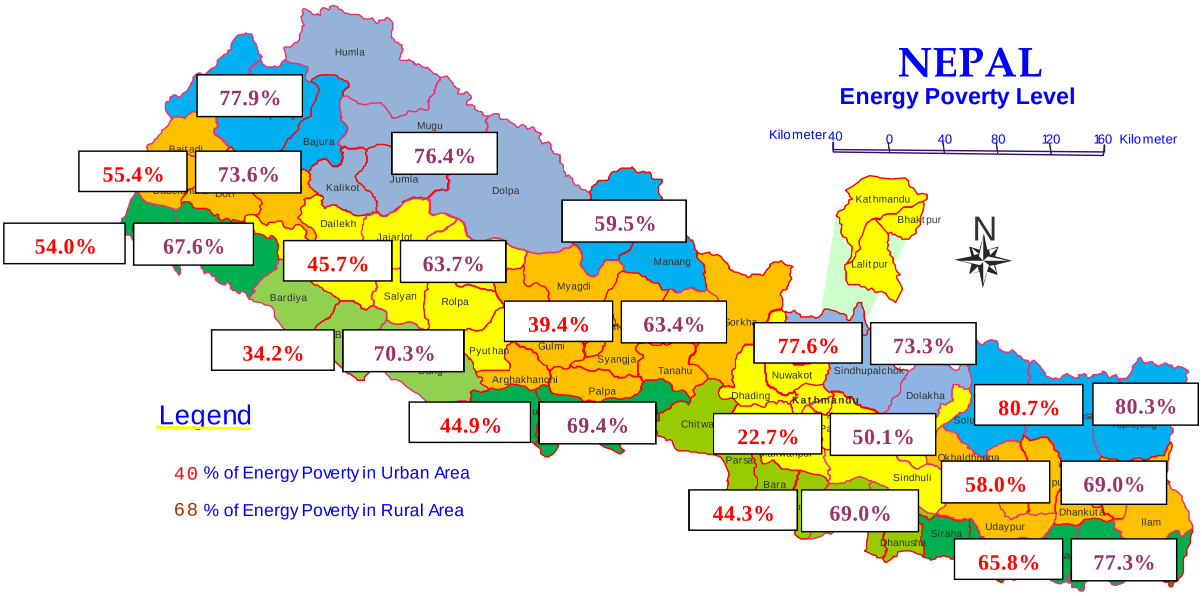

Figure 4: Overall Energy Poverty Projection, 2016

Map Source: Published GoN Maps, Value source: Study findings

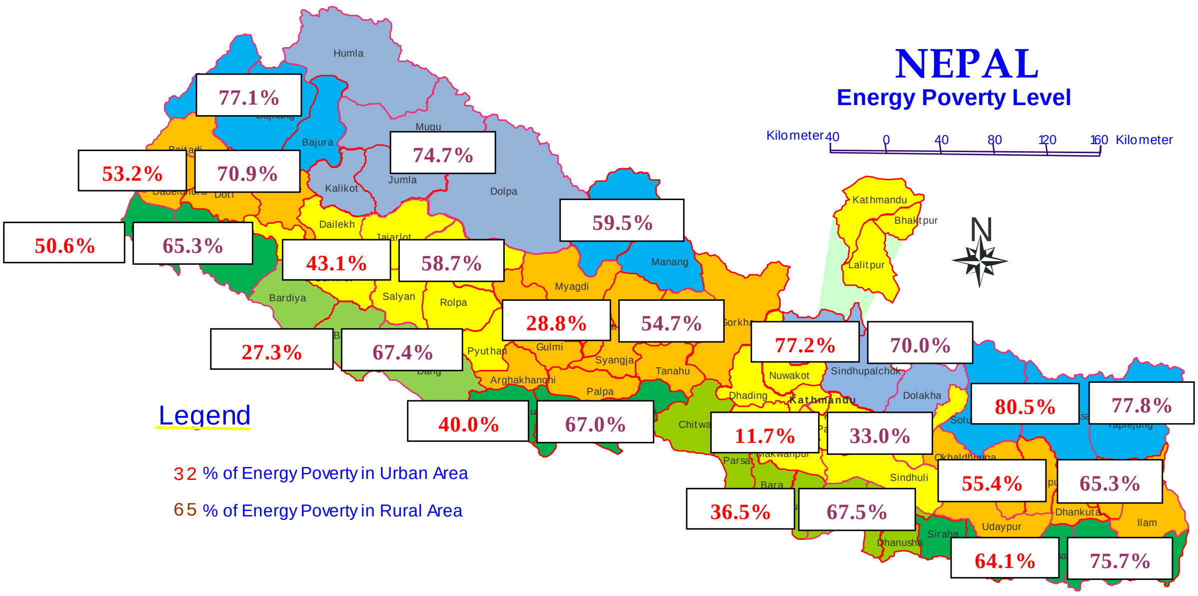

Figure 5: Overall Energy Poverty Projection, 2026

Map Source: Published GoN Maps, Value source: Study findings

Technology Mix in Base Case Scenario

Technology and energy mix in this case is based in the order of present growth of alternative energy technologies as well as demand trend of commercial energy. As discussed earlier, the growth of energy technologies beyond 2011 for technology like ICS, gasifier, biogas, and off-grid electricity is projected at their average annual installation rate between 2001 and 2006.

It is found in the Base-case Scenario that energy poverty projection for cooking and water boiling reaches to around 49 per cent in 2016 and 40 per cent in 2026 of the total national population of respective years. Shares of modern/improved technologies is expected to be only about 32 and 46 per cent of the total household in 2016 and 2026, respectively, whereas the remaining shares are covered by traditional devices as shown in the Figure 6.

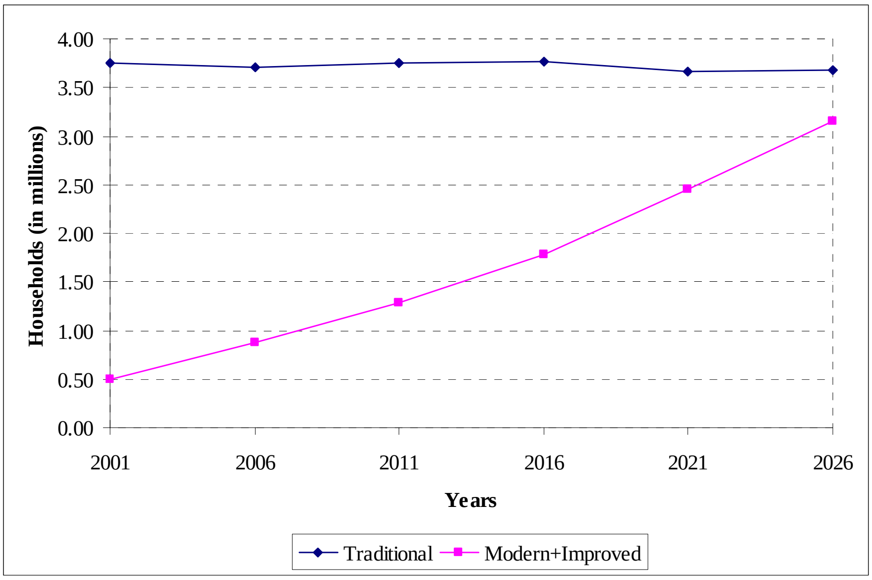

Figure 6: Projection of Technology Intervention of Thermal Devices in Base Case Scenario

By 2026, it is expected that at least 40 per cent of the total households of the country will still remain below poverty, whereas only 60 per cent of households may have access to grid and off-grid (Mini-hydro, SHS and SSHS) technology. Thus, the grid expansion and at the meantime the present growth of alternative energy technologies still has to be continued at least at the same rate beyond 2011, as AEPC/ESAP has set up its target.

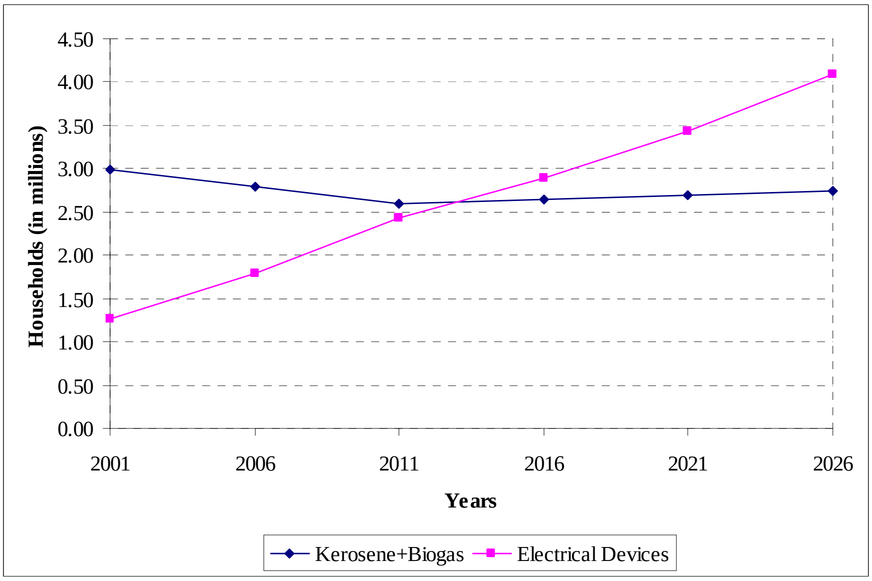

Figure 7: Projection of Technology Intervention of Lighting Devices in Base Case Scenario

1.19.2 Energy Poverty Reduction Scenario and Setting Energy Target

Energy poverty reduction is based on the projected energy poverty situation derived from Base-case Scenario. Reducing energy poverty by half in 2016 means, reducing energy poverty situation of Base Case Scenario of that year by 50 per cent and to eliminate the energy poverty by 2026 is to reduce the energy poverty situation of Base-case scenario of 2026 to zero. To eliminate the energy poverty in rural areas and urban areas, equal importance has been given in the interventions of efficient biomass energy technologies and other commercial energy technologies as well.

Setting Energy Target for Cooking and Water Boiling

Setting targets of energy technology for cooking and water boiling is carried out considering the trend of consumption of different fuel types till 2006 and projection of it with required proportion to meet the objective of reducing energy poverty in subsequent years. Rural areas where biomass energy is massively used, intervention of improved biomass energy technologies like ICS, gasifiers, biogas are proposed to alleviate energy poverty by 2026. Intervention of biogas technology in the study since is carried out only for cooking; continuation of larger share in use of electric devices and kerosene pressure stoves for water boiling has been continued accordingly. Meanwhile, share of ICS, gasifiers and LPG stoves proposed for water boiling are similar to that of cooking.

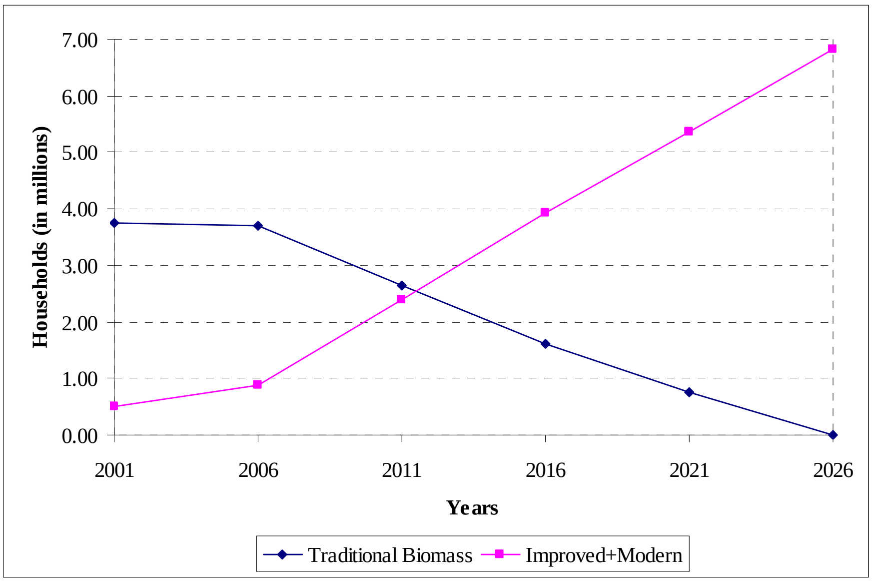

Figure 8: EPR End-Use Device Target Setting for Cooking and Water Boiling

Setting Energy Target for Lighting

Setting energy target for lighting to reduce energy poverty incorporates increasing access of reliable centralised and decentralised electricity and lighting devices. The study has set up lighting energy target with increasing access of electricity (grid/off-grid) along with the promotion of efficient lighting devices like CFL and white LEDs.

Halving energy poverty situation in 2016 compared to energy poverty projected in base case scenario can be achieved only if expansion of grid, promotion of mini-hydro, solar technologies with CFL and WLED lamps is carried out with a target of providing access to more than 81 per cent of the total households by 2016 as shown in the Figure 9.

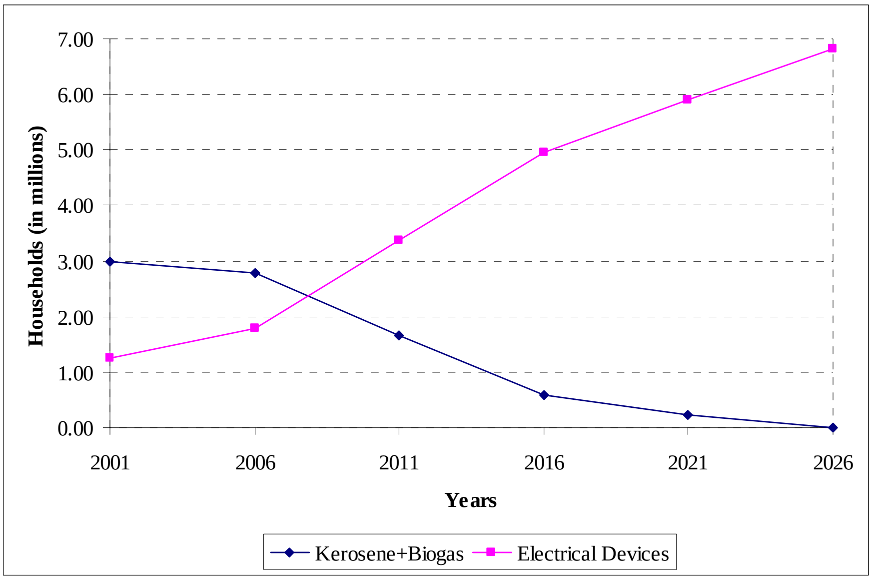

Figure 9: Target Setting for Lighting Devices in EPR Scenario

Technology Intervention Needed for Energy Poverty Reduction Scenario

Cooking and Water Boiling

To reduce the energy poverty by half in 2016, at least 35 and 36 per cent of the total households of 2016 should have access to improved biomass technologies (ICS, gasifier, biogas and briquette stoves) and commercial energy technology (LPG stove, pressure stoves, electric clay heater and electric cooker/kettle), respectively. In pressure stoves, bio-fuels can partially substitute kerosene, but in case of low pick up of bio-fuel technology in Nepal, kerosene alone can act as one of the important fuel mix.

Furthermore, to eliminate the energy poverty by 2026, improved biomass technology should provide its services to at least 46 per cent of the households present in 2026. Share of commercial energy technologies to eliminate the poverty has been estimated as about 54 per cent of the total population of 2026 as shown in the Figure 10.

Table 12: Target for Technological Intervention under EPR Scenario

(in '000 HHs)

S.N.	*Years*	*2001*	*2006*	*2011*	*2016*	*2021*	*2026*
	Household with Cooking Devices/ Total Households	**4,253**	**4,577**	**5,035**	**5,541**	**6,124**	**6,821**
1	ICS	80	285	782	1,279	1,740	2,201
2	Gasifier	0	0	67	133	159	185
3	Biogas	78	157	339	521	632	744
4	LPG	66	129	590	1,051	1,686	2,322
5	Kerosene/Liquid Bio-fuel	192	199	259	319	324	329
6	Electric Devices	81	97	357	616	824	1,032
7	Briquette	4	4	5	5	6	7
8	Traditional Biomass	3,751	3,705	2,637	1,616	751	0

Source: Study Findings

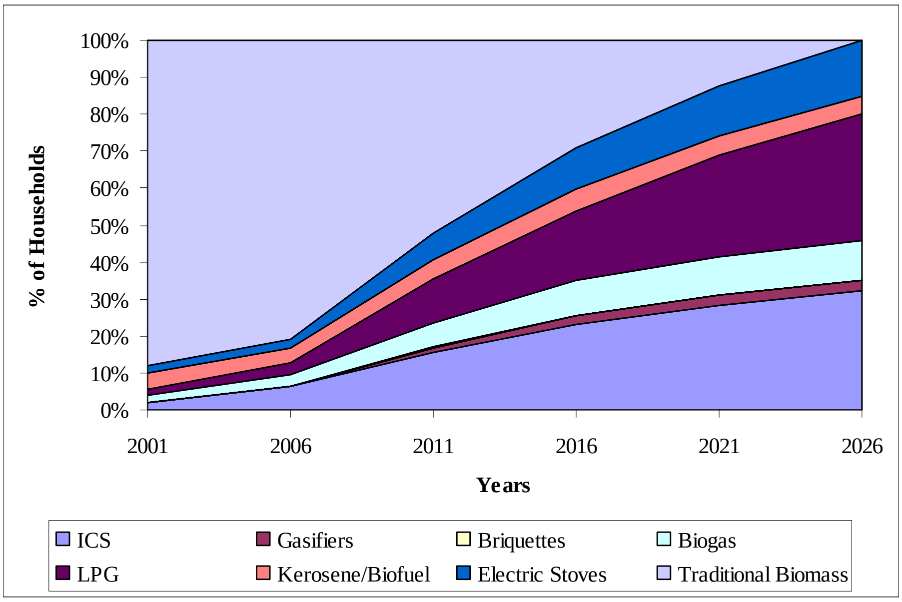

Figure 10: Projected Intervention of Cooking Energy Technologies

Lighting

In order to half energy poverty in lighting by 2016, electricity through national grid should be accessible to at least 61 per cent of households; micro-hydro plants should supply electricity to at least 8 per cent whereas SHS and SSHS should be available to at least 11 and 10 per cent of HHs, respectively. Eliminating energy poverty in 2026 needs access of electricity to at least 78 per cent of households through national and mini grid supports. Rest can be supplied through intervention of SHS and SSHS.

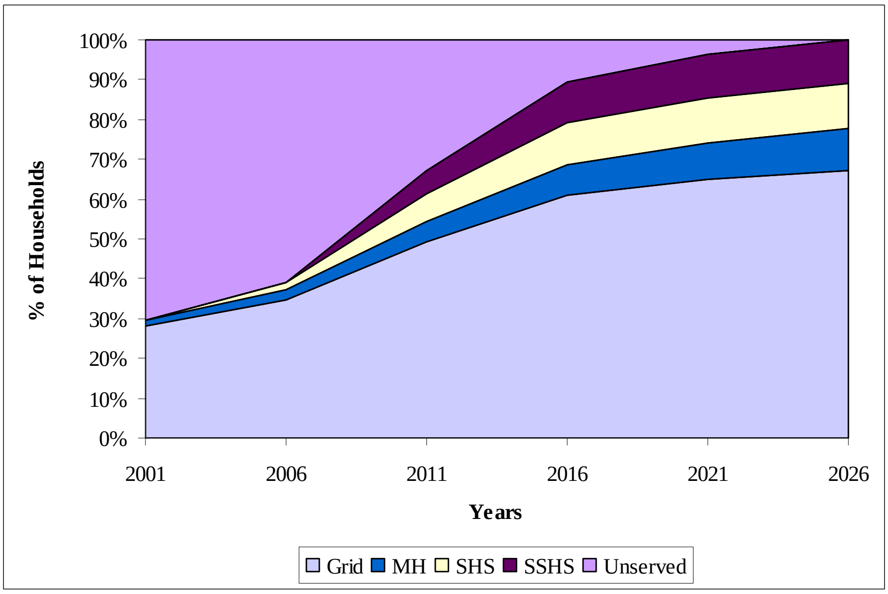

Figure 11: Projected Combination of Electricity Generation Technologies

Lighting devices intervened in the EPR scenario comprises of promotion of efficient lights like CFL and fluorescent lamps in areas, where grid and off-grid (MHP) has been providing their services. To reduce the energy poverty by half of the Base-case situation in 2016, diffusion of incandescent lamp should be gradually reduced to 26 per cent of the households with the increment of CFL diffusion to at least 9 per cent of the total households present in 2016. Similarly, SHS and SSHS should be promoted to at least 11 and 10 per cent of the total households present in 2016.

Table 13: Households with End-Use Device Intervention to Reduce Energy Poverty in Lighting

(in '000 HHs)

S.N.	*Years*	*2001*	*2006*	*2011*	*2016*	*2021*	*2026*
	Household with Lighting Devices/ Total Households	**4,253**	**4,577**	**5,035**	**5,541**	**6,124**	**6,821**
1	Incandescent Lamps	625	848	1,136	1,425	1,374	1,324
2	Fluorescent Lamps	625	848	1,374	1,900	2,274	2,648
3	CFLs	0	NA	237	475	900	1,324
4	SPV Lamps	12	96	346	597	686	775
5	SSHS	0	0	281	563	656	749

Source: Study Findings

In the same manner, for eliminating energy poverty by 2026, users depending on incandescent lamp should be at the most 19 per cent, where at least 39 and 19 per cent of the grid and off-grid users has to be promoted with efficient lighting devices like Fluorescent and CFL, respectively. The share of total households using SHS and SSHS has been estimated at about 11 per cent each.

1.20 Projected Total Primary Energy Consumption

During the course of planning, the total primary energy consumption for basic activities (cooking, lighting, and water boiling) has been overviewed in two different scenarios.

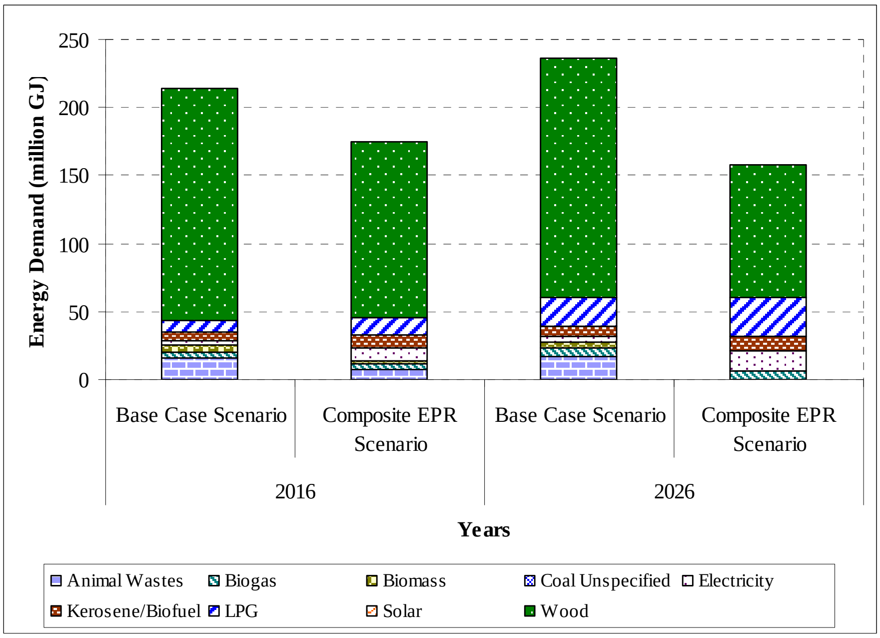

Figure 12: Projected Total Primary Energy Consumption

In Base-case Scenario, the total primary energy consumption in 2016 and 2026 has been anticipated to be 213.75 and 236.74 million GJ, respectively. In EPR Scenario, the total consumption for basic needs seems to be decreasing as the intervened technologies have greater efficiencies, hence lowering the consumption. The total primary energy consumption for basic needs in EPR Scenario has been projected as 174.61 million GJ in 2016 and 158.2 million GJ in 2026.

INSTITUTIONAL ARRANGEMENT AND INVESTMENT

The Chapter outlines the institutional arrangements of the country. A brief introduction to the existing key government and non-government institutions involved in the energy development is also portrayed in the chapter. Investment required for the technology intervention, essential for reducing energy poverty has also been discussed in the Chapter. The restructuring of the energy stakeholders required according to the projected energy demand in the country has also been discussed.

1.21 Institutional Arrangement

The 10th Five Year Plan indicated numerous reforms within public administration, governance & decentralization, finance sector, energy sector and private sector. The existing and required institutional arrangement, which has a direct or indirect relationship with the energy sector, according to its major operation areas are discussed in the following Section. The Mid Term Plan 2008-11 has given continuity to the initiatives of 10th Plan with increased focus on Poor and comparatively less developed region of the country, specifically, Karnali and surrounding region.

1.21.1 Existing Key Government Institutions

Nepal has undertaken planned energy development after the intervention of five years development plan of the country. Major Key institutions involved in the energy development in the country are;

National Planning Commission

NPC is the advisory body for formulating development plans and policies of the country under the directives of the National Development Council (Official Website, NPC). It is mandatory that the central level annual plans, policies and projects should be approved by the NPC before its implementation. The Commission explores and allocates resources for economic development and works as a central agency for monitoring, evaluating and facilitating the implementation of development plans, policies and programmes. The Commission prepares a periodic (five-year) development plan of the country which comprehensively outlines the national development goals, objectives and strategies.

Nepal entered into the planned energy development from the 7th Five Year Plan (1985-1990), but the goal of poverty alleviation through renewable energy program came into action with the commencement of the 10th Plan (2002-2007). A Three Years Interim Plan has been formulated which targets on covering additional 15 per cent of the population to have access to electricity service through national grid and off-grid mechanisms.

Ministry of Water Resources[12]

The Ministry of Water Resources (MoWR) is responsible for the proper utilization and management of water resources of the country. Development of plans, policies and their implementation for conservation, regulation and utilization of water resources; management of production of energy for the expansion of industrial and economic activities; and construction and maintenance of irrigation facilities are some of the major objectives of this ministry (Official website, MoWR). Department of Electricity Development is administered by the ministry. This department is responsible for assisting MoWR in implementation of overall government policies related to power/electricity sector. The major functions of the Department are to ensure transparency of regulatory framework, accommodate, promote and facilitate private sector's participation in power sector by providing "One Window" service and license to power projects.

The major organizations related to power and energy in the country, WECS and NEA are also supervised by the MoWR. The primary responsibility of WECS is to assist Government of Nepal, the MoWR and other related agencies in the formulation of policies and planning of projects in the water resources and energy sectors (Official website, WECS). The primary objective of NEA is to generate, transmit and distribute adequate, reliable and affordable power by planning, constructing, operating and maintaining all generation, transmission and distribution facilities in Nepal's power system both interconnected and isolated (Official website, NEA). In order to promote community participation in rural electrification, GoN has declared a policy, whereby 80 per cent of the capital cost of electrification will be provided by the government, provided that, the community bears the balance 20 per cent of the cost. Community Rural Electrification Department of NEA implements and supervises the community based rural electrification works.

Ministry of Forests and Soil Conservation

The Ministry of Forest and Soil Conservation (MoFSC) is responsible for formulating policies for overall national and sectoral development of forestry sectors (WECS, 2001). The main objective of this ministry is the sustainable development of forest resources. The Department of Forests is the main organization responsible for the protection, management and utilization of national's forest for the development of nation. The main objective of the department is the sustainable management of forest through people participation. The Timber Corporation of Nepal (TCN) is a public enterprise established for the marketing and distribution of timber and fuel wood in the country. Harvesting, collection and transportation activities for both construction timber and fuel wood are carried out by the TCN.

Ministry of Commerce and Supplies

The Ministry of Commerce and Supplies (MoCS) is responsible for policy formulation, planning and their implementation in the commercial sector and essential commodities

[12] The ministry has recently been divided into Ministry of Energy and Ministry of Irrigation. However, scope of jurisdiction of Ministry of Energy has not been fully known/expanded as the current mandate is limited to hydropower only.

(Official website, MoCS). The premier institution for imports/sales of commercial fuel in the country, Nepal Oil Corporation (NOC) is supervised by this ministry. NOC is headquartered in Kathmandu, and has 5 regional offices, Branch Offices, Fuel Depots, Aviation Fuel Depots, with total existing storage capacity of 71,742.3 kl and employing 440 permanent work forces (Official website, NOC).

***Ministry of Environment, Science and Technology*[13]**

The MoEST has been involved in the promotion of alternative energy technologies through AEPC. Currently, AEPC activities are supported by various donor programmes, including ESAP funded by Danish International Development Agency (DANIDA) and the Government of Norway, Biogas Support Programme (BSP) funded by SNV and Kreditanstalt für Wiederaufbau - Development Bank of Germany (KfW), Rural Energy Development Programme (REDP) funded by the World Bank and UNDP, and IWM Project funded by SNV. The European Union is also one of the funding agencies to the GoN, which has signed agreement to support AEPC’s Renewable Energy Technologies (RETs) development activities and started its implementation.

Some of the key programs facilitated by AEPC are;

Energy Sector Assistance Programme

The ESAP is currently looking after National Biomass Energy Components, Solar Support Programme and MGSP. Besides these programmes, the ESAP has been giving institutional support to rural energy sector and been providing financial assistance to rural energy investments through Rural Energy Fund. The AEPC is the executing agency of the programme and implemented by the ESAP Programme Office. The components are implemented at field level by communities, private commercial sector and by I/NGOs. AEPC/ESAP has been supported by about 10 regional service providers scattered in different regions of the country to promote ICS, Mini/micro hydro plants and SHS. Similarly, about 26 pre-qualified registered solar manufacturing companies has been found supporting AEPC/ESAP to promote SHS in different rural region of the country.

Rural Energy Sector Support Programme

Improved Water Mill Support Programme and Biogas Support Programme are the key component of the RESSP, supported by the SNV. The BSP was initiated in July 1992 to develop and promote the use of biogas in Nepal. The programme was initially funded by the Directorate General for International Cooperation of the Netherlands of the Netherlands government through SNV in Nepal. GoN through AEPC and Government of Germany through KfW also started funding the BSP from Phase-III onwards. The BSP Phase-IV is currently being implemented, which has been extended till June 2010. AEPC is the executing agency and BSP-Nepal is the implementing agency (BSP-Nepal, 2008). The programme has reached more than 67 districts of the country. The Agriculture Development Bank Limited and about 180 micro finance institutions (MFIs) provide

[13] The ministry has recently been divided into Ministry of Environment and Ministry of Science and Technology.

credit to biogas users. These MFIs receive wholesale loan from Biogas Credit Unit of AEPC.

Rural Energy Development Programme

REDP was initiated as a pilot programme with the financial and technical assistance of the UNDP in five districts on 16 August 1996; the REDP was expanded to 10 districts in 1998 and to 15 districts in 2000. The REDP supports the institutionalization of rural energy development agencies, formulating energy related policies, helping to develop integrated energy plans at the district level, mobilization of community members and private entrepreneurs to plan, implement and operate integrated rural energy systems. REDP has also helped in the formation of District Energy Committee and District Energy Fund such that district level energy programs are coordinated and made sustainable. In its third phase, the REDP is supporting the GoN to implement the Rural Energy Policy 2006 in all 75 districts.

1.21.2 NGOs and INGOs

Many NGOs are active in the energy sector, especially in the area of biomass energy and as service providers in off-grid electrification as described above, in different programs of AEPC/ESAP. Most are oriented towards all aspects of rural development within very limited geographical areas, while a few are more technology specific like BSP-Nepal, Centre for Rural Technology (CRT/N), Centre for Renewable Energy (CRE) and Himalayan Light Foundation. In addition, there are various forums and networks that represent the civil society like Clean Energy Nepal (CEN), Gender in Energy and Water Network (GEWNet), etc. Similarly, INGOs like Winrock International and Practical Action in Nepal are active in the energy sector, where Winrock has been found active in the area of organization of cooperatives for electricity supply and user associations, while Practical Action is mainly involved in the promotion of small scale wind energy technologies and biomass energy technologies like ICS and smoke hoods to control the indoor air pollution.

Further, a large number of institutions like International Union for Conservation of Nature (IUCN), International Centre for Integrated Mountain Development (ICIMOD), UNDP, World Food Programme (WFP) and numerous INGOs & NGOs, mainly through rural development programmes are involved in energy sector.

1.21.3 Academic and Research Institutions

Academic and research institutions like Center for Energy Studies (CES), Research Centre for Applied Science and Technology (RECAST), Nepal Academy of Science and Technology (NAST) and School of Engineering of Kathmandu University (SOE/KU) are involved in the research and development of energy technologies.

1.21.4 Private Sectors

There are a number of private sectors involved in different energy development program of the country. Private sector contributes about 152 MW of the total power connected to the national grid. In 2001, Independent Power Producers' Association, Nepal was established with the intention of encouraging the private sector to work in the area of hydropower in Nepal. One of its main purposes is to act as a link between the private sector and government organizations involved in developing hydropower in the country.

In the alternative energy sector, certified suppliers and manufacturers of mini grids and solar home systems have organized themselves in national associations like Nepal Biogas Promotion Group, National Micro-hydro Development Association & Solar Electric Manufacturers' Association Nepal, representing the private sector towards GoN as members of steering committees.

Similarly, about 16 and 26 Mini/micro hydro consultancy firms are registered in the production of micro-hydro power plants with production capacity of 100 kW and 60 kW, respectively. BSP-Nepal has been supported by about 72 private biogas companies scattered in different regions of the country.

1.21.5 Micro-Finance Institutions and Cooperatives

The unfortunate reality in the renewable energy sector of Nepal is that maximum RET subsidy went unnoticed by poor households as they were unaware about the technology, and were unable to bear the risk of investing additional money for RET systems. By the time rural households became more aware of the RETs, the cost of the systems started to go up. Even with current trend of upward revisions in subsidy and increase in confidence to purchase the technology by poor the up-front cost is still an issue needs to be tackled. The role of affordable credit, therefore, will play a vital role in making RETs accessible to poor households. RET potential in rural areas, strategic location of MFIs and the energy needs of the rural poor serve as drivers to promote RET.

The target of EPR cannot be achieved unless the access to improved energy services is increased along with people's capability to pay for energy services. Experiences in Nepal and outside showed that financing interventions are necessary at both the demand and supply sides to promote micro financing on RETs. Demand side interventions include increasing awareness on technology and financing options, promotion of productive uses of energy for increasing income of the rural poor. Supply side interventions include capacity building of MFIs, wholesale financiers and energy companies; facilitating flow of funds from wholesalers to the MFIs; building working relationships among energy companies and MFIs; lobbying for favorable policy environment. MFIs can provide credit to rural poor for acquiring RETs. It has also been found that there is an annual financing need of over NRs. 1 billion for small scale RETs, which can be an immediate market for MFIs in Nepal (Basnet et. al.). There is also a wide scope of commercial/development banks for investment opportunities, where they can also work together with MFIs to fulfill energy demand.

A number of MFIs have been involved in the sector of Biogas and Micro-hydro in Nepal; however, to meet the target of EPR Plan, MFIs still needs to be scaled up, so that most of remote areas can have service of finance. In addition to this other financing opportunities should be explored for increasing access of technologies in every part of the country.

1.22 Investment Analysis for EPR

The investment analysis in the study incorporates the capital investment required for the intervention of energy technology; however the operation cost likely to represent the energy cost of LPG and kerosene is not included. Estimation of funds required for the installation and promotion of alternative energy technologies, as targeted in the EPR scenario, has been carried out on the basis of breakdown of investment in terms of Technical Assistance, Subsidy and Users' Contribution. In the basis of estimated costs of AEPC/ESAP projects, the total investment requirement for different technologies is depicted in the **Annex-7**.

The study has estimated that about 11.22 EUR is the unit cost of mud ICS, in which about 4.77 EUR/household is estimated to be users' contribution. In addition to this, 40-50 EUR per household is required for Gasifier and Metallic Stoves. The total cost required for installation of Mini/micro hydro plant has been estimated to vary from 316 to 572 EUR/household based on programme approach; refer to the **Annex-8.1** for details. Similarly, the intervention of SHS and SSHS for realising EPR scenario will costs about 209.72 EUR/household in average. In the same manner, the overall cost of installation of biogas plants has been found to be about 307.10 EUR/household. These unit costs also include programme overhead, subsidy and users' contribution and other costs as depicted in the **Annex-8.1**.

The total investment for the promotion of biomass energy stoves (mud ICS) has been estimated to be about 5 million EUR in each five years period between 2006 and 2026. The additional investment of about 6 million EUR for the period of 2006-2011 and 2011-2016 is required for disseminating high altitude metallic stoves and gasifiers. Likewise, for the period between 2016 and 2026, additional 8 million EUR is required for the high altitude stove and gasifiers. Thus, the total investment thus in the case of Improved Biomass Stoves will be about 11 million EUR in different phases of 2006/11 and 2011/16. Similarly, about 8.5 million EUR is additional investment required for each period of 2016/21 and 2021/26, as shown in the Table 14. Intervention of mini/micro hydro technology needs a total investment of more than 55 million EUR in each phases of the planning period (2011-2026). Investment requirement for the estimated solar energy interventions (photovoltaic) in the form of Solar Home System (SHS) and Small Solar Home System (SSHS) range from 112 million EUR in first two periods and 38 million EUR in last two periods. Intervention of biogas technology needs a total investment of about 180 million EUR to eliminate energy poverty by 2026. The detail breakdown of total investments required for different technologies is given in the **Annex-8.2**.

Table 14: Investment in Alternative Energy Technologies to meet the EPR Target

Technology	*Target for EPR (x1000 households)*				*Tentative investment (million EUR)*			
	2006-11	*2011-16*	*2016-21*	*2021-26*	*2006-11*	*2011-16*	*2016-21*	*2021-26*
Biomass Stoves	563	563	487	487	10.85	10.85	8.42	8.42
Micro-Hydro	161	150	150	150	56	55.1	55.1	55.1
Solar Energy	532	532	182	182	111.6	111.6	38.2	38.2
Biogas	182	182	112	112	55.9	55.9	34.3	34.3
				Total	**234.4**	**233.5**	**136.0**	**136.0**

Source: Study Findings

Alternative energy technologies only cannot be sufficient to meet the objective of energy poverty reduction within the time frame of 20 years, thus intervention needs a mix of commercial energy technologies also. The projected demand of commercial energy like LPG and Kerosene, clearly illustrates that a substantial number of households can be shifted towards it, provided there is normal and reliable supply.

Table 15: Projected Commercial Energy Demand

Fuel	*Unit*	*Current Consumption*	*Projected Consumption*	
Year		*2006*	*2016*	*2026*
LPG	'000 MT	46.9	274.3	603.6
Kerosene	'000 kl	196.9	253.0	289.5

Source: Study Findings

The Table 15, shows that the country has infrastructure to store and distribute 46.9 ('000 MT) of LPG and 196.9 ('000 kl) of Kerosene. The projected energy demand in the study for LPG for 2016 and 2026 has been found, respectively, about 6 and 13 folds greater than that of 2006. Likewise, the projected demand of Kerosene in 2016 and 2026 has been found around 1.3 and 1.5 times greater than that of 2006. This reveals that the existing infrastructure of NOC should be increased by multiple folds to be able to supply the projected energy demand in 2016 and 2026.

Similarly, the estimated additional power required satisfying the basic residential needs in five year time periods between FY 2011-2016, 2016-2021 and 2021-2026 has been estimated to be about 150.3 MW, 99.8 MW and 99.8 MW, respectively. It needs more involvement of private sectors and international agencies to achieve the additional power demand that has been anticipated in the residential basic needs only. The investment required for national grid expansion to meet the objective of the study is based on the assumption that per kW, 6 households can be benefited. The estimated total investment required for grid expansion from 2011 to 2026 is 1.35 billion EUR as shown in the Table 16.

Table 16: Investment in National Grid Expansion to meet the EPR Target

S.N	*Particulars*	*Unit*	*Estimated Cost/MW*	*2011-2016*	*2016-2021*	*2021-2026*
1	Generation	'000 EUR/MW	1,885.2	283,405.2	188,114.1	188,114.1
2	Transmission	'000 EUR/MW	1,131.1	170,043.1	112,868.5	112,868.5
3	Distribution	'000 EUR/HH	0.14	127,532.3	84,651.3	84,651.3
			Total Investment ('000 EUR)	**580,980.6**	**385,633.9**	**385,633.9**

Source: Study Findings

Institutional Strengthening and Restructuring for EPR

Institutional arrangement needed for energy development should have prime objective of mitigating constraints like;

- Lack of interdisciplinary co-ordination for energy development
- Lack of access to efficient technologies, where affordability is major problem
- Lack of presence of MFI in remote areas that can lead towards supporting the pro-poor
- Lack of adequate capacity development of service providers
- Lack of adequate presence of service providers in rural areas

The immediate policy needed, to attract people towards electric devices, is to issue reasonable tariff structure for domestic appliances, basically cooking and lighting, where Government should also provide tax-incentives for purchasing these products. Similarly, government should normalize the reliable supply of Kerosene and LPG.

On the part of alternative energy technologies, the growth of RETs in the country till date is not satisfactory, even though AEPC has been present since 1996. Increment in the capacity of current regional service providers and private organizations can accelerate the growth to some extent, but the proposed energy mix to alleviate energy poverty needs more involvement of private institutions/organizations to be established in different parts of the country. To achieve the goal of energy poverty reduction, extensive participation of private organizations and I/NGOs is needed, while AEPC can monitor and evaluate the progress.

Some of the specific activities that are necessary in the energy sector development are;

Increase in the Grid Expansion

For eliminating energy poverty, one of the efforts needed is the extensive expansion of national grid electricity with a reliable supply. With a reliable supply and awareness of people to the use of efficient electric devices for cooking, water boiling and lighting, the total energy consumption for basic needs can be optimized, which can be used on other productive end-uses for economic development. The service needs identification and working towards optimizing or mitigating constraints of hydro-power development like;

- specific regulatory actions needed to promote private investment
- tariff fixation as per the sectoral consumption
- sustainable options for arranging power exchange across the border
- solution to any transmission constraints to hydropower development and
- initiatives required improving governance and accountability in the sector

Strengthening the Regional and Local Service Centers for up-scaling RETs

Alternative Energy Technologies like ICS, Gasifiers, Biogas, MHP and SHS are exclusively needed to be up-scaled to reduce the energy poverty. The existing institutional mechanism should have to bring strong policies for strengthening capacity of regional service centers and service providers. From the trend of ICS and biogas installation in the past five years, it has been found that the proposed intervention of ICS and biogas is at least 3 times than that has been made in the previous periods. Thus, at least by 3 fold the private sectors, service providers and I/NGOs need to be strengthened where AEPC can provide its supportive role.

Quality Assurance

Dissemination of qualitative products and mechanism for effective/efficient monitoring of it is necessary for ensuring end-users satisfaction. Alternative Energy promotion centre, in the part of RETs should maintain and strongly implement Quality Guidelines for providing qualitative service to the end-users.

Research and Development

There is wide space for research and development in the energy sector of the country, which can ensure optimum energy utilization along with the promotion of alternative energy technologies. The EPR scenario has proposed biogas technology, which has been limited in Terai and Hilly region of country till date, needed to be intervened in Mountain region in an adequate percentage. Necessary research in reducing technical limitation of biogas technology for making compatible in Mountain region is necessary. Similarly, the constraints of dependency on imported RETs products and accessories needs to be mitigated by developing products and accessories locally, which ensure availability at a reasonable price and after-sale service. Till date, small wind turbines are imported as well as technology is transformed from foreign countries. With due course of learning, it is a dire need to carry out research on wind turbines, generators and wind charge controllers according to the available wind resource pattern of the country.

In the same context, the EPR scenario has been found necessity of increased supply of kerosene as a cooking fuel in rural and peri-urban areas of the country, when past trend of kerosene consumption was extrapolated throughout the planning period. The demand of kerosene fuel for cooking can be partially substituted by liquid bio-fuel energy/technologies like fuel-ethanol and bio-diesel stoves, which has been found successful in many countries. Promotion of bio-fuel to operate kerosene stoves, with ample of R&D not only substitute fossil fuel but also supports in curtailing loss of national economy.

CONCLUSION AND RECOMMENDATION

1.23 Conclusion

Energy poverty reduction is a complex process for a country like Nepal, which is highly dependent on biomass energy resources and technologies. Energy and technology mix in Nepal is characterized by use of different energy sources and technologies for performing different household activities. Identifying targets for eliminating energy poverty is difficult because energy needs are highly diverse. First, country needs affordable and reliable access to energy in order to carry out basic needs. Second, countries need energy to alleviate many broader conditions that can prevent people from contributing to and benefiting from economic growth. Third, the agro-ecology, geography, and unique composition of the local economy also matter in determining the type of energy carriers and services that are required. Even though, these constraints exist in the country; energy target in the study has been set up by analysing the existing trend of energy development and population covered by such intervention for performing basic needs.

Energy Poverty reduction and intervention of technologies to do so can be concluded as follows;

Cooking and Water Boiling

The projected energy poverty situation for cooking in Base-case Scenario in 2016 and 2026 on two proposed definitions can be halved and eliminated, respectively, if at least 3.92 millions households of 2016 and 100 per cent of 2026 population can have access to modern and improved technologies.

50 per cent energy poverty reduction in 2016 needs at least 1.28 million households served by ICS, 0.13 million households by gasifier and availability of biogas to 0.52 million households. Similarly, 1.05, 0.32 and 0.62 million households need to be served with LPG, kerosene/liquid bio-fuel and electric cooking devices, which still have at least 1.62 million households depending on traditional biomass stoves.

Eliminating energy poverty by 2026, needs 100 per cent of the households with access to improved technology, where estimated number of households with ICS should be 2.20 million. Similarly, 0.19, 0.74, 2.32, 0.33 millions of households should have access to gasifiers, biogas, LPG and kerosene/liquid bio-fuel stoves, respectively,. Availability of electric devices in 2026 has been estimated to be required for at least to 1.03 million households to eliminate the energy poverty.

Lighting

In order to half energy poverty in lighting by 2016, at least 61 per cent of households need access of electricity through national grid. Rural electrification program needs to be continued, which can supply electricity to at least 8 per cent of households through MHP and 21 per cent of households through SHS and SSHS.

Electricity coverage estimated by 2026 to eliminate energy poverty is at least 78 per cent through national and mini grid; whereas rest of the households needs access to electricity through SHS and SSHS.

Looking towards halving energy poverty in 2016, at least 26 per cent incandescent lamp users needs to be substituted by CFL and fluorescent lamps. Projected share of CFL for which, has been found 9 per cent and rest fluorescent lamps.

For eliminating energy poverty, the proposed scenario showed that at the most only 19 per cent of households need to be using incandescent lamps. The share of households with lighting devices like fluorescent, CFL, SHS and SSHS required in that period is 39, 19, 11, and 11 per cent, respectively.

Institutional and Policy Arrangement

The study identified that the major problems in the energy sector are insufficient funding and fragmented institutional approaches. The study also identified the challenge for the policy direction for rural energy development as: "*……providing modern energy access to rural Nepal at a lower cost by creating an enabling environment and decentralized institutional mechanism*." The study advocates that rural energy solutions cannot be viable without subsidy and states that subsidy policy should address social equity and geographical remoteness issues. At the mean time, the study also proposes for increasing access of alternative energy technology like SHS in peri-urban as well as urban areas of the country.

For the proposed scale of alternative energy development more involvement of private sectors and I/NGOs is required, while AEPC can provide its supportive role under the umbrella of a regulatory body. Harmonization among different stakeholders seems necessary. The GoN needs a long term energy development package, where capacity development, institutional strengthening and extension of services and areas can be focused.

Accessibility of efficient energy technology since is one of the means of reducing and eliminating energy poverty in the long run, promotion of efficient end-use devices should be highly encouraged by providing incentives, awareness campaign and demonstration activities. Research and development for switching towards liquid bio-fuel stoves instead of kerosene stoves, construction of RETs products and accessories locally should be given top most priority.

Investment Required

It is also an utmost need to encourage the investment on hydro-power, which can ensure the targeted coverage required to eliminate energy poverty drawn by the study.

For reducing energy poverty by half in 2016 and eliminating by 2026, intensive intervention of alternative energy technologies is required. The investment necessary to cover up those interventions in different time series has been estimated as around 234.4 million EUR (2006-2011), 233.5 million EUR (2011-2016) and 136 million EUR each in 2016-2021 and 2021-2026, considering the overall alternative energy program cost. In addition, additional investment in grid expansion will also be necessary which is estimated at about 1.35 billion EUR.

1.24 Recommendation

The study represents the minimum energy need of the country and need of technology intervention for reducing energy poverty in Nepal. As, WECS is also undertaking a study "…..*Energy Resource Strategy*", it is recommended to set a coherent target of energy development, which could help in optimizing energy demand and supply of the country. There is also a need of perfect harmony/coordination among different energy stakeholders so that energy development and its status can be monitored externally.

Recommendation on Policy Regime

It is highly recommended that the Rural Energy Policy should accommodate the institutional strategy, which should focus on "…..*harmonizing the efforts of the agencies involved in promotion and development of RETs*." Similarly, institutional hindrances in the promotion of rural electrification like the division of rural electrification between two ministries, namely, the MoWR and the MoEST should be mitigated by the establishment of appropriate institutional mechanism for effective coordination of the development activities in these two areas.

An appropriate institutional mechanism should be designed not only to coordinate rural electrification activities but also other energy sub sectors including NEA and WECS (currently under MoWR), NOC (currently under MoCS), AEPC (currently under MoEST) and Ministry of Forestry. A detail feasibility of such proposal needs to be studied to avoid creation of additional complexities. It is also recommended that different I/NGOs and Private Sectors working in energy sector should be responsible to the regulatory body. I/NGOs can provide their role through technical support and management of energy development program under the assistance of executing bodies.

Alternative energy development at the local level should be strengthened by increasing the capacity of Energy Support Units established in different District Development Committees, where supportive role can be provided by AEPC.

The current rural energy subsidy policy is under heavy debate being criticized for not addressing the rural development needs and affordability of the rural population. The current rural energy policy in this regard has a lot of scope for improvement, specifically in achieving coherency in subsidy for various technological options. A close interdisciplinary coordination among different organization should be maintained in the development of energy sector.

Technology Promotion

Cooking energy technologies like ICS, Gasifiers, and biogas are the major RETs, which should be promoted in rural areas of the country. Access to lighting energy should be increased with grid and off-grid extension in rural areas. SHS system which has been made a key component of rural energy development should also be focussed in urban areas. Efficient energy end-use devices should be promoted, where lighting device like incandescent lamps should be gradually replaced by efficient CFL and Fluorescent lamps. Consideration should also be given to reducing import duty for energy efficient appliances.

Reliability of Energy Supply

Reliability is one of the major factors for choosing fuels for daily household use. Unless and until, reliable supply of energy is maintained, it would be difficult for consumer to get convinced for switching towards it. Power outages are inevitable in Nepal, however all necessarily and controlled stoppages in supply for repair works and load shedding should be pre-informed and limited within the informed time period. Commercial energy sources like electricity, LPG, kerosene are regarded as efficient energy carrier compared to the traditional biomass energy source that has been used till date. Limitations like un-affordability, un-availability of efficient devices should be mitigated with expansion of market, for which government should provide incentives to entrepreneurs.

Review of Energy Pricing Policy

Pricing is a key factor that influences the way people make their decision to switch energy technologies. For example, the higher price of electricity discourages population to switch towards electric end-use devices. Similarly, prices of fossil-fuel needs to reviewed, too, to reflect the real cost of supply. Environmentally unfriendly energy may be taxed to promote and support more sustainable energy infrastructures like renewable energies. More efforts in energy conservation and loss reduction will help in decreasing prices of energy, specifically electricity, which is the main renewable resource of Nepal; thereby encouraging more sustainable energy sector development in Nepal. It is also necessary for the state to ensure that basic minimum quantity of quality energy to meet basic needs is facilitated at a lower tariff to address poor's access. Cross-subsidy may be continued to achieve these objective. The rural-urban divide in access to energy can also be addressed through appropriate energy pricing policy.

Financing on Energy Sector

National and international donors need to be attracted to support the Hydro Power development of the country. Similarly, for alternative energy sector, different kinds of financing models like Franchising (at remote places where MFIs are not present or do not have adequate capital to invest on Energy sector), Revolving funds, Vendor Financing (credit and installment basis) and leasing can be adopted to increase access to poor people, as appropriate, should be started or continued. A proper regulatory framework for establishing different model of finance should be established to attract maximum beneficiaries.

Capacity Building

Energy poverty alleviation can only be possible if all the available energy mix is promoted as per the affordability and acceptability of people. The intensive intervention of alternative energy technologies needs more involvement of private sectors, and I/NGOs. It is also recommended that capacity buildings of service providers has to be increased with formal and informal trainings/workshops and vocational trainings. At the mean time to eliminate the knowledge gap at the grass root level, consumer based knowledge campaign about energy technology and energy efficiency is also essential.

Research and Development

Extensive research and development is necessary in energy development in Nepal. Research activities ascertaining information like efficiencies of different end-use devices and financial implication drawn so from can be potentially cashed to encourage people to switch over other convenient and efficient technologies. More efforts are required to carry out research and development on potentiality of increasing efficiency of ICS (mud stove). It is also recommended to undertake a research and development towards utilizing liquid bio-fuel as a cooking fuel, which can potentially substitute kerosene fuel. In order to capitalize the wind resource of the country, significant research and development is required to build up wind turbine. Significant resource assessment of wind velocity and financial and economical viability studies must be carried out to promote wind energy technologies in the country.

Recommendations for Further Studies

As can be perceived, one would have liked to cover many more aspects of energy poverty in a study of this nature and level of rigour. The current study is fully based on secondary data and information and some energy poverty specific data from field with the sole purpose to address the energy poverty could have made the study more useful. Due to time and resource constraint, it was not possible to conduct field and lab researches to obtain energy poverty specific data and information.

Nonetheless, the study still makes important first-step towards understanding energy poverty situation in Nepal. We, therefore, would recommend future researches and studies to strengthen the information and understanding required to address energy poverty issues. Some of the field where the future research and surveys can focus are:

a) Diversity in minimum energy requirement to live a decent life in Nepal in various regions.

b) Exploring energy resources and their utilisation technologies from the energy poverty perspective.

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Glossary

Bio-fuel: Fuel derived from organic matters. For e.g. biogas (gaseous bio-fuel derived from animal/human waste), fuel ethanol (liquid bio-fuel derived from by-product of starch containing biomass products), bio-diesel (liquid bio-fuel derived from oil bearing seeds).

Calorific Value: The heat content of energy carrier usually expressed in terms of GJ per natural unit.

Efficiency: The efficiency gives the effectiveness of the energy conversion and of the energy transmission. It describes the ratio between the energy supplied and the energy input. A solar cell efficiency of 35 per cent conveys that 35 per cent of the incoming solar energy can be converted into electrical energy.

End-use: Any specific activity that requires energy (such as cooking, space heating/cooling, water heating)

Energy Intensity: The average energy consumption of some device or end-use per unit of activity. Examples of activity measures are households, floor space, passenger-kilometres and tonne-kilometres.

Energy-mix: Combination of different energy sources.

HDI: An index used to rank countries by level of "human development", which usually also implies whether a country is a developed, developing, or underdeveloped country. The HDI combines normalized measures of life expectancy, literacy, educational attainment, and GDP per capita for countries worldwide.

Lumen: The unit of illumination on a screen or other surface. One lumen is the light of one candle power on each square foot of a surface of a sphere at a radius of one foot from the light source.

Micro-hydro Power Plant: Decentralized source of electric energy with production capacity ranging from 5 to 100 kW.

Mini-hydro Power Plant: Decentralized source of electric energy with production capacity ranging from 0.1 to 1 MW.

Primary Energy: Energy that has not been subjected to any conversion or transformation process. Primary energy is energy contained in raw fuels and any other forms of energy received by a system as input to the system.

Technology-mix: Combination of different energy end-use technologies.

Useful Energy: Energy generated from the primary energy resources through the application of respective energy technologies and devices.

ANNEXURE

Annex-1: Terms of Reference

1. Background

Energy is a pre-requisite for revolutionary changes in society in terms of technology, work, economics and environment. It is a crucial input in the development process. In Nepal, the huge demand for energy to facilitate economic growth and social development is largely met with biomass fuels. It accounts to almost about 86 per cent and the remaining 14 per cent is being met by commercial sources consisting of fossil fuels and electricity. Nepal has adequate energy resource base, except for fossil fuels. In spite of having huge hydropower potential (83,000 MW), only 556.4 MW has been harnessed so far. According to the Government of Nepal's Tenth Five Year Plan, about 40 per cent of the total population has benefited from electricity, consisting of 33 per cent from the national grid and 7 per cent from alternative energy. The links between energy, environment and sustainable development present a difficult paradox to Government of Nepal. The extension of energy services to people remains to be one of the key instruments for alleviating poverty, but with the current scenario of national investments in energy, it is less likely that the energy poverty can be halved by 2015.

1.1 Defining Energy Poverty

Those people are considered in 'energy poverty' if they do not have access to at least **the equivalent of 35 kg LPG for cooking per capita per year** from liquid and/or gas fuels or from improved supply of solid fuel sources and improved (efficient and clean) cook stoves; and **120 kWh electricity per capita per year for lighting**, access to most basic services (drinking water, communication, improved health services, education improved services and others) plus some added value to local production.

An 'improved energy source' for cooking is one which requires less than 4 hours person per week per household to collect fuel, meets the recommendations of WHO for air quality (maximum concentration of CO of 30mg/M^3 for 1 hour period and less than 10mg/M^3 for periods 8 hours of exposure), and the overall conversion efficiency is higher than 25 per cent.

2. Rationale of the Study

Practical Action Nepal office has a long history of working in renewable energy sector in Nepal. It has worked for the promotion and development of various renewable energy technologies including micro-hydro power, improved cook stoves with chimneys, small wind systems etc. in Nepal over the last 25 years. Practical Action in Nepal has gained certain credibility among the government/other agencies in the development sector of small scaled renewable energy. It has entered into a Memorandum of Agreement with Alternative Energy Promotion Center (AEPC under Ministry of Science and Technology of the Government of Nepal) last year to assist in - revising, modifying subsidy and subsidy delivery mechanisms on small wind energy systems; transferring advanced/efficient technologies in micro-hydro sector. It has also started to build networks with national energy sector stakeholders to share experiences, resources to work for developing and up-scaling alternative energy sector in Nepal.

It is of great importance now to coordinate all the efforts and to work towards setting a **concrete national target** and realize energy as a basic right of people. It is also imperative to come up with a **valid national document** that the concerned Ministries/government agencies should own for them to be able to rationally allocate resources annually/periodically and in addition, could be used to seek commitments from bilateral and multi-lateral donors to reducing/eliminating energy poverty in the country. This is equally relevant at the changing political context as well where the agenda of developing renewable energy particularly, hydro-power sector has given a topmost priority.

3. Objectives

The main objective of the study is to establish an outline plan of how energy poverty could be halved in the country by 2015 and eliminated entirely by 2025. The specific objectives are:

i. To assess a baseline of energy poverty situation;
ii. To analyze the energy resource assessments and energy demand assessments;
iii. To assess national policy and institutional arrangements;
iv. To set a target/outline plan to reduce energy poverty;
v. To recommend the necessary changes in terms of investments needs, policy instruments, institutional arrangements, capacity needs, choice of technology mix etc.

4. Scope of Work

It is very clear from the given ToR that the scope of the work will consist of the following:

i. The assessment of the location and numbers of people in the country (rural and urban) that falls below the 'energy poverty' standard established as mentioned above.
ii. Calculation of the number of people who will need to be provided access to – electricity; and to improved/cleaner energy source for cooking
iii. Assessment of existing national capacities – public, private and non-government sectors in delivering the energy services
iv. Assessment of various energy mix and appropriate options for different target groups
v. Assessment of the typical cost per capita of delivery of each chosen energy option in various environments
vi. Preparation of plan showing:
    - Size of population(under energy poverty) to be targeted/covered by 2025
    - Technology mix required to achieve this coverage (Number of people for each technology)
    - Annual rate of progress required for each technology type to achieve total coverage by 2025
    - Annual cost for doing these activities (this will be done by using today's prices including the inflation effect over period to 2025)
vii. Assessment of investment needs to deliver the plans by comparing existing trend of investments and allocation of resources in each of the energy technology)
viii. Make recommendations based on the above as what changes are required in terms of national human resource capacities, investments capacities, technology mix, institutional arrangements, policy and regulatory instruments, and others as deemed necessary.

5. Expected Output

The expected outputs of the study will be:

5.1. Energy Synopsis Report consisting of analysis of existing situation covering i) to v) of 3 above and;

5.2. A Long Term National Energy Poverty Reduction Plan consisting of the analysis of rest of all covering vi) to viii) above in 3.

6. Study Methodology

The study methodology consists of following:

6.1 Preparatory works

The assignment will start with formation of study and planning team. The team will consist of the professionals and experts from energy field. Practical Action will coordinate and facilitate the study team which will be led by the members of AEPC or WECS. This is because of our intention for study to be more authentic and that it should be owned by the government and they should take the responsibility in facilitating the implementation of the plans afterwards. The team will also comprise of advisory members from Planning Commission, Nepal Electricity Authority, GTZ/SHPP, SNV, Winrock International, ICIMOD, DANIDA and NORAD for additional advisory inputs. The team will employ other support assistant for report preparation/logistics arrangements and others. The study team will do the desk study, identify the entire reference materials available, divide the roles and responsibility of each team member, and finalize the procedures/tools/checklists for further works as stipulated below.

6.2 Data/information collection

The study will largely be based on the review of secondary information available. The Energy Synopsis Report 2006 and Draft Energy Sector Strategy which is currently being prepared by WECS will be heavily relied on for this. Other available reports of Practical Action Projects including most recent reports such as Survey Report on Potentials Testing of SCORE Stoves, District Energy Planning Reports of Gorkha and Rasuwa districts (under preparation), Evaluation of Community Managed Micro-hydro Plants, IAP Policy Review Report will be used. Apart from these, reports from other programmes (Rural Energy Development Programme(REDP)/UNDP, District Carpet Mapping for MHP, Min-grid Support Plan, Biomass Energy support plan by Energy Sector Assistance Programme, Reports from GTZ's Small Hydro Promotion Programme, Renewable Energy project Support Office of Winrock International) will also be used at maximum possible. Plans of Nepal Electricity Authority and National Census Reports will also be referred to for electricity coverage, future plans, assessing population growth trends and energy demand forecasting.

Similarly, for confirming with district statistics on electricity and energy services coverage, the District Energy and Environment Sections (DEES) in 72 districts working under direct technical support of Rural Energy Development Programme (REDP/UNDP) will be mobilized to assess primary information on energy usage, supply and coverage. This will be done through filling of formatted checklists to be validated by REDP/AEPC.

6.3 Data analysis

All the data/information collected/gathered form different sources will be compiled, studied and analysed by the team using appropriate tool/software if required particularly for primary information collected from DEES.

6.4 Consultative meetings and workshops

It is necessary that the information studied and analysed need to be verified at various levels. For this, we propose to have consultative meetings with relevant stakeholders to seek additional information/inputs and to make the plans in a more participatory ways.

6.4.1 Regional level consultative meetings

Five regional consultative meetings (one in each development region) will be conducted. The purpose of these consultative meetings will be to share the assessed baselines and situations with regional/district representatives who have major stake in energy sector, peoples' representatives, and further assess the energy needs/requirements specifically for economic/institutional uses apart from household uses. It is also to validate the energy resource assessments at district/regional levels.

6.4.2 National consultative meetings with Major Investors/Donors and other stakeholders including I/NGOs

The purpose of this consultative meeting is to gather the information on the trend of investments being made on different energy mix in the country. This will also help to determine the costs of energy service delivery for various energy options. It will also assist in assessing further their short/medium/long term investments plans in energy sector in the country.

6.5 Report preparation

Two separate reports as outputs mentioned above in section 5 will be prepared by the team.

i. Updated National Energy Synopsis Report will cover national baselines of Energy Poverty situation, energy needs and demand analysis, stakeholders' analysis including their capacities, potentials of energy mix and resource assessments according to various ecological zones and target groups with different purchasing capacities etc.

ii. National Energy Poverty Reduction Plan (at least 20 years) by projecting target population coverage, investment requirements (annually and in total) for different types of energy mixes for various populations, requirements for capacity building. The institutional arrangements aspects and policy measures as implementation strategies will be equally given emphasis to deliver/implement the plans.

6.6 Sharing of Outputs

A national level consultative meeting will be held to seek feedback/input/comments from all relevant national stakeholders to finalize the plans and prepare implementation strategies.

7. Inputs (Team Composition)

The professionals will consist of a Team Leader, a Co-ordinator, Energy and Planning Experts, a Research Assistant. The proposed professionals and their brief job descriptions will be as follows:

Professional	***Nos.***	***Organization***	***Responsibility***	***Input (time)***
Aim-3, Team Leader	1	Practical Action	Overall guidance and support (intermittent inputs)	1 Month
Coordinator/ Energy Expert	1	Practical Action	Coordinate the overall task and planning work with intermittent inputs	9 Months (short term)
Energy and Planning Experts	1	WECS	Planning team members (intermittent inputs)	2 Months
	1	AEPC		
Other Energy experts		SNV, ICIMOD, NEA, Planning Commission, GTZ, Winrock	As Advisory members (Intermittent inputs)	2 Months
Research Assistant/ support staff	1	Practical Action	Data/information collection, compilation, formatting & other assistant to the coordinator and study team	9 Months (short term)

8. Time Line

The assignment will be completed as much as possible within the time frame of 9 months. However, when coordinating with government counterparts, it was sometimes difficult to achieve target outputs in stipulated timeframe. It is therefore, the reason why Practical Action will take the lead for overall coordination of the study.

Annex-2: Estimation of Minimum Energy Requirement

Annex-2.1: Minimum Energy Required for Cooking

Ecology/ Devices	*Minimum End-Use Device Energy Required (GJ/household/year)*										
	Fuel wood				***Charcoal***	***Biogas***	***LPG***	***Kerosene***		***Electricity***	
	TCS	***Iron Tripod/ 3-Stone***	***ICS***	***Gasifier***	***Charcoal Stove***	***Biogas Stove***	***LPG Stove***	***Pressure Stove***	***Wick Stove***	***Clay Heater***	***Rice Cooker***
	10%	***5%***	***20%***	***30%***	***20%***	***60%***	***65%***	***50%***	***45%***	***55%***	***90%***
Mountain	68.8	137.5	34.4	22.9	34.4	11.5	10.6	13.8	15.3	12.5	7.6
Hills	55.0	110.0	27.5	18.3	27.5	9.2	8.5	11.0	12.2	10.0	6.1
Terai	44.0	88.0	22.0	14.7	22.0	7.3	6.8	8.8	9. 8	8.0	4.9

(Source: Study Estimates)

Annex-2.2: Minimum Energy Required for Lighting

Ecology/ Devices	*Minimum Primary Energy Required (kWh/household/year) for Electric Devices*					*Minimum Primary Energy Required (GJ/household/year) for Kerosene Devices*		
	CFL (7 W)	***Fluorescent Lamps (40 W)***	***Incandescent Lamps (40W)***	***SHS (7 W)***	***SSHS (0.03 W)***	***Kerosene Tuki (5 lm)***	***Lantern (50 lm)***	***Gas Lamp (1000 lm)***
Mountain	30.7	37.9	122.6	30.7	32.7	2.2	7.4	22.1
Hill	35.8	44.2	143.1	35.8	38.2	2.6	8.6	26.1
Terai	40.9	50.5	163.5	40.9	43.6	2.9	9.8	29.4

(Source: Study Estimates)

Annex-2.3: Lumens of Lighting Devices

S.N	*Devices*	*Energy Source*	*Intensity (lumens)*	*Efficacy (lumens/W)*
1	Candle	Paraffin wax	1	0.01
2	Oil lamp (wick)	Kerosene	1-10	0.01-0.1
3	Hurricane lamp (wick)	Kerosene	10-100	0.1-0.2
4	Oil lamp (mantle)	Kerosene	1000	1
5	Gas lamp (mantle)	LPG (e.g. butane or biogas)	1000	1
6	White Light Emitting Diode 1W	Electricity	25 – 50	25 - 50
7	Filament lamp 3W	Electricity	10	3
8	Filament lamp 40W	Electricity	400	10
9	Filament lamp 100W	Electricity	1300	13

(Source: Practical Answers, Rural Lighting)

Annex-2.4: Minimum Energy Required for Water Boiling

Ecology/ Devices	*Minimum End-use Device Energy Required (GJ/household/year)*										
	Fuel wood				*Charcoal*	*Biogas*	*LPG*	*Kerosene*		*Electricity*	
	TCS	*Iron Tripod/ 3-Stone*	*ICS*	*Gasifier*	*Charcoal Stove*	*Biogas Stove*	*LPG Stove*	*Pressure Stove*	*Wick Stove*	*Clay Heater*	*Electric Kettle*
	10%	*5%*	*20%*	*30%*	*20%*	*60%*	*65%*	*50%*	*45%*	*55%*	*90%*
Mountain	31.8	63.5	15.9	10.6	15.9	5.3	4.9	6.4	7.1	5.8	3.5
Hills	30.9	61.9	15.5	10.3	15.5	5.2	4.8	6.2	6.9	5.6	3.4
Terai	30.8	61.6	15.4	10.3	15.4	5.1	4.7	6.2	6.9	5.6	3.4

(Source: Study Estimates)

Annex-3: End-use Devices Considered in Different End-uses

S.N.	***End-use Devices/ End-uses***	***Cooking***	***Water Boiling***	***Lighting***	***Space Conditioning***	***Agro-Processing***	***Livestock Feeding***	***Others***
1	Fuel Wood Mud Stoves	√	√		√	√	√	√
2	Fuel Wood Iron Tripod stoves	√						
3	Fuel Wood Three Stone Fire Stoves	√						
4	Improved Fuel Wood Stoves	√	√		√	√	√	√
5	Wood Gasifier	√	√					
6	Animal Waste Stoves	√	√		√	√	√	√
7	Agric Residue Stoves	√	√		√	√	√	√
8	Charcoal Stoves	√	√		√	√	√	√
9	Biogas Stoves	√						
10	LPG Stoves	√	√			√		√
11	Kerosene Stoves	√	√			√		√
12	Electric Clay Stoves	√	√					
13	Electric Rice Cooker	√						
14	Electric Heater				√			
15	Kerosene Heater				√			
16	LPG Heater				√			
17	Electric Fan				√			
18	Incandescent Lamps			√				
19	Fluorescent Lamps			√				
20	Compact Fluorescent Lamps			√				
21	Solar PV Lamps			√				
22	SSHS			√				
23	Biogas Lamps			√				
24	Kerosene Wick Lamps			√				
25	Petromax			√				
26	Lantern			√				
27	Electric Appliances							√

Annex-4: Estimation of Households below Energy Poverty

Annex-4.1: Percentage of Households below Energy Poverty for Eastern Development Region

According to Parameter - 1

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
EDR	**41.2**	**41.5**	**42.7**	**43.6**
Mountains	65.8	65.8	65.9	65.9
Urban	69.0	69.0	69.0	69.0
Rural	65.6	65.5	65.5	65.5
Hills	49.8	49.8	50.9	51.8
Urban	70.9	70.6	70.0	68.2
Rural	48.4	48.2	48.8	49.3
Terai	34.0	34.4	35.7	36.9
Urban	57.0	56.4	55.5	52.9
Rural	29.4	29.1	28.7	28.3
Urban	59.5	59.0	58.2	55.8
Rural	38.6	38.5	38.8	39.3

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
EDR	**69.8**	**72.9**	**69.9**	**68.6**
Mountains	64.2	73.6	73.2	72.8
Urban	53.8	66.9	66.9	66.5
Rural	64.9	74.1	73.9	73.7
Hills	67.4	72.4	70.2	67.6
Urban	0.0	0.0	0.0	0.0
Rural	71.8	78.1	77.9	77.8
Terai	71.7	73.1	69.3	68.6
Urban	35.8	29.9	30.2	41.1
Rural	78.8	83.4	83.3	83.2
Urban	31.0	26.7	26.9	35.8
Rural	75.4	80.9	80.6	80.4

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
EDR	**95.9**	**95.2**	**94.2**	**93.4**
Mountains	99.5	98.8	98.1	97.6
Urban	99.5	99.5	99.5	99.5
Rural	99.5	98.8	97.9	97.3
Hills	94.6	92.8	90.8	89.4
Urban	87.3	87.3	87.0	86.4
Rural	95.1	93.2	91.2	89.9
Terai	96.1	95.9	95.4	94.8
Urban	90.8	90.8	90.7	90.4
Rural	97.1	97.1	97.1	97.1
Urban	90.6	90.6	90.4	90.1
Rural	96.6	96.0	95.2	94.5

According to Parameter - 2

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
EDR	**94.5**	**90.1**	**84.0**	**78.0**
Mountains	99.7	96.2	91.9	89.4
Urban	99.8	99.8	99.8	99.8
Rural	99.7	95.9	91.1	87.9
Hills	88.0	78.6	67.3	60.3
Urban	92.9	92.2	89.5	82.7
Rural	87.6	77.5	64.9	56.9
Terai	97.0	95.0	91.3	85.3
Urban	94.8	93.6	89.1	77.7
Rural	97.5	95.4	92.0	89.2
Urban	94.7	93.6	89.5	79.3
Rural	94.4	89.5	82.6	77.5

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
EDR	**76.8**	**68.4**	**56.2**	**49.1**
Mountains	85.4	74.1	60.0	52.4
Urban	55.6	50.7	49.0	48.0
Rural	87.3	75.9	61.2	53.1
Hills	78.5	69.5	56.5	48.9
Urban	14.7	12.4	9.5	7.6
Rural	82.7	74.1	61.7	55.1
Terai	74.9	67.1	55.5	48.7
Urban	41.6	36.9	34.8	33.4
Rural	81.4	74.3	63.0	56.9
Urban	38.0	33.7	31.4	30.0
Rural	82.3	74.4	62.4	55.9

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
EDR	**96.3**	**93.4**	**89.7**	**86.4**
Mountains	100.0	96.8	92.9	90.6
Urban	100.0	100.0	100.0	100.0
Rural	100.0	96.6	92.2	89.3
Hills	89.5	81.2	71.7	66.1
Urban	94.2	93.8	92.0	87.4
Rural	89.2	80.2	69.5	62.8
Terai	99.1	98.9	98.2	95.9
Urban	97.4	96.8	94.6	89.1
Rural	99.5	99.5	99.5	99.5
Urban	97.0	96.5	94.4	89.2
Rural	96.2	92.8	88.6	85.4

Annex-4.2: Percentage of Households below Energy Poverty for Central Development Region

According to Parameter - 1

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
CDR	**30.2**	**30.9**	**23.2**	**11.0**
Mountains	68.1	68.3	68.5	68.6
Urban	71.4	71.4	71.4	71.4
Rural	68.0	68.1	68.2	68.3
Hills	45.8	47.2	32.3	9.6
Urban	51.8	54.2	25.4	0.0
Rural	42.3	42.0	42.1	42.0
Terai	7.8	7.9	6.2	2.8
Urban	36.6	32.7	17.1	0.0
Rural	4.1	4.0	3.8	3.7
Urban	48.6	49.5	24.1	1.0
Rural	24.8	24.2	22.7	20.2

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
CDR	**34.4**	**43.5**	**38.9**	**36.1**
Mountains	34.1	53.8	54.6	55.1
Urban	24.6	46.6	46.5	45.4
Rural	34.5	54.2	55.2	56.1
Hills	18.0	23.4	14.5	7.3
Urban	0.0	0.0	0.0	0.0
Rural	28.4	41.1	34.9	31.8
Terai	51.4	62.5	61.5	62.7
Urban	53.6	45.4	45.6	55.4
Rural	51.2	65.2	65.1	65.0
Urban	12.6	11.1	11.1	13.4
Rural	40.8	55.3	54.8	57.0

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
CDR	**92.2**	**91.5**	**87.3**	**79.5**
Mountains	99.4	98.5	97.3	96.5
Urban	99.5	99.5	99.5	99.5
Rural	99.4	98.4	97.1	96.2
Hills	87.9	86.7	78.5	62.7
Urban	76.3	79.1	71.8	58.4
Rural	94.6	92.4	87.9	77.3
Terai	95.5	95.3	94.8	93.9
Urban	89.6	89.3	88.1	86.4
Rural	96.3	96.3	96.3	96.3
Urban	79.7	81.7	75.9	65.4
Rural	95.9	95.1	93.8	92.4

According to Parameter - 2

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
CDR	**81.6**	**74.5**	**57.9**	**39.2**
Mountains	98.5	91.3	82.5	77.4
Urban	99.0	99.0	99.0	99.0
Rural	98.5	90.9	81.3	75.3
Hills	68.1	56.4	30.2	0.6
Urban	29.1	27.9	15.7	0.5
Rural	90.7	78.0	50.7	0.8
Terai	92.7	90.3	82.4	72.5
Urban	60.2	55.9	32.9	11.3
Rural	96.9	95.7	93.5	92.0
Urban	51.9	50.0	35.0	20.7
Rural	94.6	84.5	66.2	38.6

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
CDR	**58.8**	**48.5**	**35.7**	**28.8**
Mountains	73.2	66.0	53.1	45.6
Urban	55.6	50.7	49.0	48.0
Rural	74.1	66.8	53.4	45.4
Hills	42.2	29.5	16.4	10.0
Urban	14.7	12.4	5.3	5.3
Rural	58.0	42.4	32.0	26.0
Terai	73.5	65.2	52.8	45.4
Urban	41.6	36.9	34.8	33.4
Rural	77.6	69.6	56.8	49.2
Urban	32.6	29.3	27.3	29.5
Rural	66.2	54.8	42.8	35.8

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
CDR	**80.0**	**75.3**	**62.5**	**48.1**
Mountains	100.0	93.5	85.4	80.7
Urban	100.0	100.0	100.0	100.0
Rural	100.0	93.1	84.3	78.7
Hills	62.4	54.3	32.8	9.3
Urban	31.3	30.1	18.3	6.1
Rural	80.3	72.7	53.1	20.2
Terai	95.0	93.9	89.2	82.6
Urban	67.5	64.0	47.4	32.4
Rural	98.5	98.5	98.6	98.6
Urban	56.6	55.2	44.4	36.0
Rural	90.3	83.0	69.0	49.9

Annex-4.3: Percentage of Households below Energy Poverty for Western Development Region

According to Parameter - 1

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
WDR	**42.9**	**42.4**	**41.8**	**35.8**
Mountains	19.4	19.4	19.4	19.4
Urban	-	-	-	-
Rural	19.4	19.4	19.4	19.4
Hills	63.2	62.2	60.9	51.3
Urban	66.2	63.4	58.3	27.9
Rural	62.7	62.0	61.6	61.0
Terai	3.4	3.7	4.8	5.5
Urban	29.1	26.8	25.8	22.2
Rural	0.0	0.0	0.0	0.0
Urban	55.1	52.4	48.5	26.2
Rural	41.1	40.5	40.1	39.4

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
WDR	**58.0**	**61.3**	**55.1**	**48.4**
Mountains	55.8	33.9	10.9	10.9
Urban	-	-	-	-
Rural	55.8	33.9	10.9	10.9
Hills	56.2	59.9	53.7	46.8
Urban	0.0	0.0	0.0	0.0
Rural	65.4	71.7	69.1	66.3
Terai	61.4	64.4	58.5	52.3
Urban	6.9	0.0	0.0	0.0
Rural	68.6	74.7	71.9	69.4
Urban	2.1	0.0	0.0	0.0
Rural	66.4	72.5	69.6	66.9

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
WDR	**98.1**	**98.8**	**97.7**	**96.9**
Mountains	99.1	99.1	99.1	99.1
Urban	-	-	-	-
Rural	99.1	99.1	99.1	99.1
Hills	97.3	98.3	96.8	95.5
Urban	83.6	97.6	97.8	98.2
Rural	99.5	98.5	96.5	94.4
Terai	99.6	99.6	99.6	99.6
Urban	98.7	98.7	98.7	98.9
Rural	99.8	99.8	99.8	99.8
Urban	88.1	97.9	98.0	98.4
Rural	99.6	98.9	97.6	96.3

According to Parameter - 2

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
WDR	**85.7**	**75.2**	**57.9**	**39.4**
Mountains	99.4	99.4	99.4	99.4
Urban	-	-	-	-
Rural	99.4	99.4	99.4	99.4
Hills	79.9	65.3	41.7	18.2
Urban	60.2	56.6	42.5	9.8
Rural	83.1	67.0	41.5	21.6
Terai	96.9	94.3	89.1	80.3
Urban	92.8	90.2	80.0	55.7
Rural	97.4	95.0	91.1	88.3
Urban	70.0	66.7	53.7	23.6
Rural	88.1	76.8	59.0	45.5

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
WDR	**70.7**	**59.8**	**43.7**	**33.5**
Mountains	59.2	36.9	28.0	28.0
Urban	-	-	-	-
Rural	59.2	36.9	28.0	28.0
Hills	71.4	59.6	42.5	31.8
Urban	28.5	24.6	22.1	20.5
Rural	78.3	66.5	48.4	36.5
Terai	69.6	60.4	46.3	37.0
Urban	21.2	18.1	15.4	13.6
Rural	76.1	67.2	53.4	44.6
Urban	26.3	22.7	20.1	18.4
Rural	77.4	66.5	50.0	39.3

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
WDR	**87.5**	**78.7**	**65.6**	**55.7**
Mountains	100.0	100.0	100.0	100.0
Urban	-	-	-	-
Rural	100.0	100.0	100.0	100.0
Hills	84.1	71.2	52.7	39.1
Urban	15.2	15.2	15.6	16.3
Rural	95.3	82.2	63.3	48.5
Terai	94.1	93.0	90.5	87.6
Urban	49.3	49.3	49.5	49.8
Rural	100.0	100.0	100.0	100.0
Urban	25.4	25.4	25.7	26.3
Rural	96.9	88.4	76.2	66.9

Annex-4.4: Percentage of Households below Energy Poverty for Mid-Western Development Region

According to Parameter - 1

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
MWDR	**14.6**	**14.4**	**14.7**	**13.9**
Mountains	20.8	20.8	20.8	20.8
Urban	-	-	-	-
Rural	20.8	20.8	20.8	20.8
Hills	15.9	15.8	17.0	17.8
Urban	24.9	22.7	22.1	20.4
Rural	15.5	15.5	16.6	17.6
Terai	11.3	10.8	10.2	7.1
Urban	13.3	10.7	8.1	0.0
Rural	10.9	10.9	10.9	10.9
Urban	16.1	13.6	11.5	4.9
Rural	14.5	14.5	15.2	15.9

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
MWDR	**61.9**	**69.5**	**67.1**	**64.4**
Mountains	87.2	90.0	89.0	88.2
Urban	-	-	-	-
Rural	87.2	90.0	89.0	88.2
Hills	65.7	74.7	74.1	73.5
Urban	29.3	40.1	39.8	41.5
Rural	67.3	76.4	76.5	76.5
Terai	50.2	57.5	52.4	46.4
Urban	0.0	0.0	0.0	0.0
Rural	60.2	71.3	71.2	71.1
Urban	7.1	9.7	9.6	10.0
Rural	67.0	76.2	76.2	76.3

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
MWDR	**98.8**	**96.9**	**94.1**	**91.9**
Mountains	99.1	99.1	99.1	99.1
Urban	-	-	-	-
Rural	99.1	99.1	99.1	99.1
Hills	98.7	95.4	90.4	86.6
Urban	97.2	97.3	97.4	97.7
Rural	98.7	95.3	89.9	85.6
Terai	99.0	98.4	97.5	96.8
Urban	94.9	95.2	95.3	95.6
Rural	99.8	99.1	98.2	97.5
Urban	95.5	95.7	95.8	96.1
Rural	99.2	97.1	93.8	91.0

According to Parameter - 2

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
MWDR	**93.8**	**84.7**	**71.5**	**58.8**
Mountains	100.0	100.0	100.0	100.0
Urban	-	-	-	-
Rural	100.0	100.0	100.0	100.0
Hills	92.7	79.2	61.9	50.4
Urban	63.0	59.5	53.5	39.4
Rural	94.0	80.2	62.5	51.5
Terai	93.5	87.7	76.4	58.7
Urban	77.8	75.0	61.7	29.6
Rural	96.5	90.7	81.7	74.2
Urban	74.2	71.2	59.7	32.0
Rural	95.6	86.2	73.4	64.7

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
MWDR	**81.6**	**73.3**	**61.3**	**54.2**
Mountains	90.3	73.6	51.0	41.4
Urban	-	-	-	-
Rural	90.3	73.6	51.0	41.4
Hills	86.4	79.0	69.4	63.8
Urban	28.5	24.6	22.1	20.5
Rural	88.8	81.7	72.7	67.8
Terai	73.3	65.9	53.5	45.2
Urban	21.2	18.1	15.4	13.6
Rural	83.5	77.4	67.2	62.0
Urban	23.0	19.7	17.0	15.3
Rural	87.1	79.3	68.3	62.7

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
MWDR	**91.1**	**82.7**	**71.0**	**62.7**
Mountains	98.7	98.7	98.7	98.7
Urban	-	-	-	-
Rural	98.7	98.7	98.7	98.7
Hills	92.4	79.2	62.5	52.3
Urban	38.9	38.9	39.0	39.4
Rural	94.6	81.2	64.2	53.5
Terai	87.5	82.9	74.6	66.6
Urban	24.4	24.4	24.7	25.2
Rural	100.0	96.9	92.4	88.7
Urban	27.9	27.9	28.1	28.6
Rural	97.0	88.7	77.7	70.2

Annex-4.5: Percentage of Households below Energy Poverty for Far-Western Development Region

According to Parameter - 1

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
FWDR	**32.4**	**32.3**	**32.3**	**31.9**
Mountains	60.6	60.5	60.5	60.5
Urban	-	-	-	-
Rural	60.6	60.5	60.5	60.5
Hills	49.7	48.9	47.6	45.9
Urban	11.4	9.5	9.2	8.4
Rural	52.9	52.9	53.1	53.3
Terai	3.8	4.1	5.3	6.0
Urban	18.3	16.8	16.1	14.0
Rural	0.0	0.0	0.0	0.0
Urban	16.5	14.9	14.3	12.5
Rural	34.5	35.0	36.4	38.3

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
FWDR	**65.9**	**72.8**	**70.8**	**69.2**
Mountains	68.6	77.1	77.0	76.9
Urban	-	-	-	-
Rural	68.6	77.1	77.0	76.9
Hills	74.5	81.2	81.1	81.4
Urban	87.1	83.7	83.0	85.0
Rural	73.4	80.9	80.8	80.7
Terai	56.8	63.2	58.5	54.4
Urban	23.1	27.8	25.9	28.3
Rural	65.5	74.5	74.4	74.3
Urban	39.8	42.4	40.8	43.1
Rural	69.4	77.7	77.7	77.7

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
FWDR	**76.5**	**75.8**	**76.0**	**76.4**
Mountains	58.3	58.3	58.3	58.3
Urban	-	-	-	-
Rural	58.3	58.3	58.3	58.3
Hills	75.8	73.5	72.7	72.2
Urban	70.3	70.4	70.5	70.6
Rural	76.3	73.8	73.0	72.5
Terai	85.4	85.8	87.0	88.4
Urban	95.9	95.9	96.0	96.0
Rural	82.6	82.6	82.6	82.6
Urban	89.2	89.3	89.3	89.4
Rural	74.8	73.6	72.9	72.1

According to Parameter - 2

Cooking

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
FWDR	**95.0**	**89.8**	**82.0**	**73.0**
Mountains	100.0	99.8	99.6	99.5
Urban	-	-	-	-
Rural	100.0	99.8	99.6	99.5
Hills	92.6	84.9	74.2	65.2
Urban	61.5	58.4	52.7	39.2
Rural	95.2	87.7	77.3	70.4
Terai	95.0	89.7	81.2	68.2
Urban	89.0	87.1	79.3	60.4
Rural	96.5	90.5	82.2	74.2
Urban	81.8	79.6	72.4	54.8
Rural	96.8	91.4	84.2	79.0

Lighting

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
FWDR	**81.6**	**74.4**	**63.0**	**56.4**
Mountains	93.9	85.8	72.1	67.7
Urban	-	-	-	-
Rural	93.9	85.8	72.1	67.7
Hills	85.4	80.2	72.7	68.2
Urban	28.5	24.6	22.1	20.5
Rural	90.2	85.9	80.0	77.7
Terai	72.5	63.8	49.8	40.3
Urban	21.3	18.1	15.4	13.6
Rural	85.7	78.4	66.6	60.7
Urban	23.2	19.8	17.1	15.4
Rural	89.3	83.1	73.5	69.8

Water Boiling

	Baseline		*Base-Case*	
	2001	*2006*	*2016*	*2026*
FWDR	**97.4**	**94.6**	**90.9**	**88.6**
Mountains	100.0	100.0	100.0	100.0
Urban	-	-	-	-
Rural	100.0	100.0	100.0	100.0
Hills	95.3	88.4	79.7	74.7
Urban	94.9	94.9	95.0	95.4
Rural	95.3	87.8	77.5	70.6
Terai	98.1	97.8	97.1	96.3
Urban	91.0	91.0	91.1	91.4
Rural	100.0	100.0	100.0	100.0
Urban	92.0	92.0	92.1	92.4
Rural	98.1	95.0	90.6	87.3

Annex-5: Overall Energy Poverty Situation and Projection

Annex-5.1: Percentage of Households below Energy Poverty for Cooking

Development Region	***Ecological Region***	***Baseline Situation***						***Base-case Projection***					
		2001			***2006***			***2016***			***2026***		
		Urban	***Rural***	***Total***	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***
EDR	**Total**	**77.1**	**66.5**	**67.8**	**76.3**	**64.0**	**65.8**	**73.9**	**60.7**	**63.3**	**67.6**	**58.4**	**60.8**
	Mountain	84.4	82.6	82.7	84.4	80.7	81.0	84.4	78.3	78.9	84.4	76.7	77.7
	Hills	81.9	68.0	68.9	81.4	62.9	64.2	79.7	56.9	59.1	75.4	53.1	56.1
	Terai	75.9	63.4	65.5	75.0	62.2	64.7	72.3	60.4	63.5	65.3	58.8	61.1
CDR	**Total**	**42.9**	**59.7**	**55.9**	**42.5**	**56.5**	**52.7**	**22.5**	**50.9**	**40.6**	**2.7**	**45.6**	**25.1**
	Mountain	85.2	83.2	83.3	85.2	79.5	79.8	85.2	74.8	75.5	85.2	71.8	73.0
	Hills	40.4	66.5	56.9	41.1	60.0	51.8	20.5	46.4	31.3	0.3	21.4	5.1
	Terai	48.4	50.5	50.3	44.3	49.8	49.1	25.0	48.7	44.3	5.7	47.8	37.7
WDR	**Total**	**62.5**	**64.6**	**64.3**	**59.6**	**58.6**	**58.8**	**51.1**	**49.6**	**49.9**	**24.9**	**42.5**	**37.6**
	Mountain	-	59.4	59.4	-	59.4	59.4	-	59.4	59.4	-	59.4	59.4
	Hills	63.2	72.9	71.5	60.0	64.5	63.7	50.4	51.6	51.3	18.8	41.3	34.7
	Terai	61.0	48.7	50.2	58.5	47.5	49.0	52.9	45.6	46.9	39.0	44.1	42.9
MWDR	**Total**	**45.2**	**55.0**	**54.2**	**42.4**	**50.3**	**49.5**	**35.6**	**44.3**	**43.1**	**18.5**	**40.3**	**36.4**
	Mountain	-	60.4	60.4	-	60.4	60.4	-	60.4	60.4	-	60.4	60.4
	Hills	44.0	54.7	54.3	41.1	47.8	47.5	37.8	39.6	39.5	29.9	34.5	34.1
	Terai	45.6	53.7	52.4	42.8	50.8	49.2	34.9	46.3	43.3	14.8	42.6	32.9
FWDR	**Total**	**49.2**	**65.7**	**63.7**	**47.2**	**63.2**	**61.0**	**43.3**	**60.3**	**57.1**	**33.7**	**58.6**	**52.5**
	Mountain	-	80.3	80.3	-	80.2	80.2	-	80.1	80.1	-	80.0	80.0
	Hills	36.4	74.1	71.1	33.9	70.3	66.9	30.9	65.2	60.9	23.8	61.8	55.5
	Terai	53.7	48.3	49.4	52.0	45.2	46.9	47.7	41.1	43.3	37.2	37.1	37.1
Nepal	**Total**	**53.4**	**62.3**	**60.9**	**52.2**	**58.6**	**57.4**	**39.5**	**53.0**	**49.6**	**22.0**	**48.7**	**39.9**
	Mountain	84.8	78.0	78.2	84.8	76.2	76.5	84.8	73.9	74.5	84.8	72.5	73.3
	Hills	47.4	67.5	63.7	47.0	60.7	57.7	30.7	50.6	44.6	9.6	42.0	29.1
	Terai	60.3	54.5	55.3	58.0	53.1	53.9	49.6	51.0	50.7	36.4	49.3	45.4

Annex-5.2: Percentage of Households below Energy Poverty for Lighting

Development Region	***Ecological Region***	***Baseline Situation***						***Base-case Projection***					
		2001			***2006***			***2016***			***2026***		
		Urban	***Rural***	***Total***	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***
EDR	**Total**	**34.5**	**78.9**	**73.3**	**30.2**	**77.6**	**70.6**	**29.2**	**71.5**	**63.0**	**32.9**	**68.1**	**58.8**
	Mountain	54.7	76.1	74.8	58.8	75.0	73.9	58.0	67.5	66.6	57.2	63.4	62.6
	Hills	7.4	77.3	72.9	6.2	76.1	71.0	4.7	69.8	63.3	3.8	66.5	58.2
	Terai	38.7	80.1	73.3	33.4	78.9	70.1	32.5	73.1	62.4	37.2	70.0	58.7
CDR	**Total**	**17.1**	**55.3**	**46.6**	**14.8**	**57.4**	**46.0**	**11.9**	**51.8**	**37.3**	**12.9**	**50.5**	**32.5**
	Mountain	40.1	54.3	53.7	48.7	60.5	59.9	47.8	54.3	53.9	46.7	50.7	50.4
	Hills	7.4	43.2	30.1	6.2	41.7	26.4	2.6	33.4	15.4	2.6	28.9	8.6
	Terai	47.6	64.4	62.4	41.2	67.4	63.9	40.2	60.9	57.2	44.4	57.1	54.0
WDR	**Total**	**14.2**	**71.9**	**64.3**	**11.3**	**69.5**	**60.5**	**10.0**	**59.8**	**49.4**	**9.2**	**53.1**	**41.0**
	Mountain	-	57.5	57.5	-	35.4	35.4	-	19.4	19.4	-	19.4	19.4
	Hills	14.3	71.8	63.8	12.3	69.1	59.8	11.1	58.7	48.1	10.2	51.4	39.3
	Terai	14.1	72.3	65.5	9.1	71.0	62.4	7.7	62.6	52.4	6.8	57.0	44.6
MWDR	**Total**	**15.0**	**77.0**	**71.8**	**14.7**	**77.7**	**71.4**	**13.3**	**72.2**	**64.2**	**12.6**	**69.5**	**59.3**
	Mountain	-	88.7	88.7	-	81.8	81.8	-	70.0	70.0	-	64.8	64.8
	Hills	28.9	78.1	76.1	32.4	79.1	76.8	31.0	74.6	71.7	31.0	72.2	68.6
	Terai	10.6	71.8	61.7	9.1	74.3	61.7	7.7	69.2	53.0	6.8	66.5	45.8
FWDR	**Total**	**31.5**	**79.4**	**73.8**	**31.1**	**80.4**	**73.6**	**29.0**	**75.6**	**66.9**	**29.2**	**73.7**	**62.8**
	Mountain	-	81.3	81.3	-	81.5	81.5	-	74.5	74.5	-	72.3	72.3
	Hills	57.8	81.8	79.9	54.2	83.4	80.7	52.5	80.4	76.9	52.7	79.2	74.8
	Terai	22.2	75.6	64.6	22.9	76.4	63.5	20.6	70.5	54.2	20.9	67.5	47.4
Nepal	**Total**	**20.7**	**69.7**	**62.1**	**18.2**	**69.9**	**60.4**	**16.1**	**63.7**	**51.8**	**17.1**	**60.8**	**46.5**
	Mountain	47.2	71.7	70.9	53.6	72.0	71.4	52.7	64.3	63.7	51.8	60.7	60.1
	Hills	11.0	66.8	56.3	9.7	66.3	53.7	6.9	60.5	44.4	6.6	58.9	38.1
	Terai	32.8	72.1	66.5	28.4	72.9	65.4	27.2	66.5	57.5	29.9	62.6	52.7

Annex-5.3: Percentage of Households below Energy Poverty for Water Boiling

Development Region	Ecological Region	Baseline Situation						Base-case Projection					
		2001			2006			2016			2026		
		Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
EDR	**Total**	**93.8**	**96.4**	**96.1**	**93.5**	**94.4**	**94.3**	**92.4**	**91.9**	**92.0**	**89.7**	**89.9**	**89.9**
	Mountain	99.8	99.7	99.7	99.8	97.7	97.8	99.8	95.0	95.5	99.8	93.3	94.1
	Hills	90.8	92.2	92.1	90.5	86.7	87.0	89.5	80.4	81.3	86.9	76.4	77.7
	Terai	94.1	98.3	97.6	93.8	98.3	97.4	92.6	98.3	96.8	89.7	98.3	95.3
CDR	**Total**	**60.2**	**93.8**	**86.1**	**60.3**	**91.8**	**83.4**	**51.1**	**88.5**	**74.9**	**39.4**	**86.1**	**63.8**
	Mountain	99.7	99.7	99.7	99.7	95.8	96.0	99.7	90.7	91.4	99.7	87.5	88.6
	Hills	53.8	87.4	75.1	54.6	82.5	70.5	45.1	70.5	55.7	32.2	48.8	36.0
	Terai	78.5	97.4	95.2	76.6	97.4	94.6	67.8	97.4	92.0	59.4	97.4	88.3
WDR	**Total**	**56.8**	**98.3**	**92.8**	**61.6**	**93.7**	**88.7**	**61.9**	**86.9**	**81.7**	**62.4**	**81.6**	**76.3**
	Mountain	-	99.6	99.6	-	99.6	99.6	-	99.6	99.6	-	99.6	99.6
	Hills	49.4	97.4	90.7	56.4	90.3	84.8	56.7	79.9	74.7	57.2	71.5	67.3
	Terai	74.0	99.9	96.8	74.0	99.9	96.3	74.1	99.9	95.1	74.3	99.9	93.6
MWDR	**Total**	**61.7**	**98.1**	**95.0**	**61.8**	**92.9**	**89.8**	**62.0**	**85.8**	**82.5**	**62.4**	**80.6**	**77.3**
	Mountain	-	98.9	98.9	-	98.9	98.9	-	98.9	98.9	-	98.9	98.9
	Hills	68.1	96.7	95.5	68.1	88.3	87.3	68.2	77.0	76.4	68.5	69.6	69.5
	Terai	59.7	99.9	93.3	59.8	98.0	90.6	60.0	95.3	86.0	60.4	93.1	81.7
FWDR	**Total**	**90.6**	**86.4**	**86.9**	**90.6**	**84.3**	**85.2**	**90.7**	**81.8**	**83.4**	**90.9**	**79.7**	**82.5**
	Mountain	-	79.1	79.1	-	79.1	79.1	-	79.1	79.1	-	79.1	79.1
	Hills	82.6	85.8	85.5	82.7	80.8	81.0	82.8	75.3	76.2	83.0	71.5	73.4
	Terai	93.4	91.3	91.7	93.4	91.3	91.8	93.5	91.3	92.0	93.7	91.3	92.3
Nepal	**Total**	**68.1**	**95.3**	**91.0**	**69.0**	**92.3**	**88.0**	**64.1**	**88.0**	**82.0**	**57.9**	**84.7**	**75.8**
	Mountain	99.7	94.9	95.1	99.7	93.1	93.3	99.7	90.7	91.1	99.7	89.2	89.8
	Hills	56.1	92.7	85.8	58.1	86.5	80.2	51.6	77.1	69.4	42.9	69.2	58.7
	Terai	83.1	97.9	95.7	82.5	97.7	95.1	79.6	97.4	93.4	76.4	97.3	90.9

Annex-5.4: Percentage of Households below Composite Energy Poverty (Average for Cooking, Lighting and Water Boiling)

Development Region	***Ecological Region***	***Baseline Situation***						***Base-case Projection***					
		2001			***2006***			***2016***			***2026***		
		Urban	***Rural***	***Total***	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***
EDR	**Total**	**68.5**	**80.6**	**79.1**	**66.7**	**78.7**	**76.9**	**65.2**	**74.7**	**72.8**	**63.4**	**72.2**	**69.8**
	Mountain	79.6	86.2	85.8	81.0	84.5	84.2	80.7	80.3	80.3	80.5	77.8	78.1
	Hills	60.0	79.2	78.0	59.4	75.2	74.1	58.0	69.0	67.9	55.4	65.3	64.0
	Terai	69.5	80.6	78.8	67.4	79.8	77.4	65.8	77.3	74.3	64.1	75.7	71.7
CDR	**Total**	**40.0**	**69.6**	**62.9**	**39.2**	**68.5**	**60.7**	**28.5**	**63.7**	**50.9**	**18.4**	**60.7**	**40.4**
	Mountain	75.0	79.1	78.9	77.9	78.6	78.5	77.6	73.3	73.6	77.2	70.0	70.7
	Hills	33.9	65.7	54.0	34.0	61.4	49.6	22.7	50.1	34.1	11.7	33.0	16.6
	Terai	58.2	70.8	69.3	54.0	71.5	69.2	44.3	69.0	64.5	36.5	67.5	60.0
WDR	**Total**	**44.5**	**78.3**	**73.8**	**44.2**	**73.9**	**69.3**	**41.0**	**65.4**	**60.3**	**32.1**	**59.0**	**51.6**
	Mountain	-	72.2	72.2	-	64.8	64.8	-	59.5	59.5	-	59.5	59.5
	Hills	42.3	80.7	75.4	42.9	74.6	69.4	39.4	63.4	58.1	28.8	54.7	47.1
	Terai	49.7	73.6	70.8	47.2	72.8	69.3	44.9	69.4	64.8	40.0	67.0	60.4
MWDR	**Total**	**40.6**	**76.7**	**73.6**	**39.6**	**73.6**	**70.2**	**37.0**	**67.4**	**63.3**	**31.1**	**63.4**	**57.7**
	Mountain	-	82.7	82.7	-	80.4	80.4	-	76.4	76.4	-	74.7	74.7
	Hills	47.0	76.5	75.3	47.2	71.7	70.5	45.7	63.7	62.5	43.1	58.7	57.4
	Terai	38.6	75.2	69.1	37.2	74.4	67.2	34.2	70.3	60.8	27.3	67.4	53.5
FWDR	**Total**	**57.1**	**77.2**	**74.8**	**56.3**	**76.0**	**73.3**	**54.3**	**72.5**	**69.2**	**51.3**	**70.7**	**65.9**
	Mountain	-	80.2	80.2	-	80.3	80.3	-	77.9	77.9	-	77.1	77.1
	Hills	59.0	80.6	78.9	56.9	78.1	76.2	55.4	73.6	71.3	53.2	70.9	67.9
	Terai	56.4	71.7	68.6	56.1	71.0	67.4	54.0	67.6	63.2	50.6	65.3	58.9
Nepal	**Total**	**47.4**	**75.8**	**71.3**	**46.4**	**73.6**	**68.6**	**39.9**	**68.2**	**61.2**	**32.3**	**64.7**	**54.1**
	Mountain	77.2	81.5	81.4	79.4	80.4	80.4	79.1	76.3	76.4	78.8	74.1	74.4
	Hills	38.1	75.7	68.6	38.2	71.2	63.9	29.7	62.8	52.8	19.7	56.7	42.0
	Terai	58.7	74.8	72.5	56.3	74.6	71.5	52.1	71.6	67.2	47.6	69.7	63.0

Annex-6: Estimation of Households

Annex-6.1: Households Projection according to Physiographical/Ecological and Settlements of Nepal (units in millions)

Ecology	*2001*			*2006*			*2011*			*2016*			*2021*			*2026*		
	Total	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*
Nepal	**4.25**	**0.66**	**3.59**	**4.58**	**0.84**	**3.74**	**5.04**	**1.08**	**3.96**	**5.54**	**1.38**	**4.16**	**6.12**	**1.76**	**4.36**	**6.82**	**2.24**	**4.58**
EDR	**1.01**	**0.13**	**0.89**	**1.09**	**0.16**	**0.93**	**1.20**	**0.21**	**0.99**	**1.32**	**0.26**	**1.06**	**1.46**	**0.34**	**1.12**	**1.62**	**0.43**	**1.20**
Terai	0.63	0.10	0.52	0.67	0.13	0.54	0.74	0.17	0.57	0.82	0.21	0.60	0.90	0.27	0.63	1.00	0.35	0.66
Hills	0.31	0.02	0.29	0.33	0.02	0.31	0.37	0.03	0.33	0.40	0.04	0.36	0.45	0.05	0.39	0.50	0.07	0.43
Mountains	0.08	0.005	0.07	0.08	0.01	0.08	0.09	0.01	0.08	0.10	0.01	0.09	0.11	0.01	0.10	0.12	0.02	0.11
CDR	**1.48**	**0.34**	**1.14**	**1.59**	**0.42**	**1.16**	**1.75**	**0.55**	**1.20**	**1.92**	**0.70**	**1.23**	**2.12**	**0.89**	**1.24**	**2.37**	**1.13**	**1.23**
Terai	0.67	0.08	0.59	0.72	0.10	0.62	0.79	0.13	0.67	0.87	0.16	0.71	0.97	0.20	0.76	1.08	0.26	0.82
Hills	0.69	0.25	0.44	0.74	0.32	0.42	0.82	0.41	0.41	0.90	0.53	0.37	1.00	0.67	0.32	1.11	0.86	0.25
Mountains	0.11	0.005	0.11	0.12	0.01	0.11	0.13	0.01	0.12	0.15	0.01	0.14	0.16	0.01	0.15	0.18	0.02	0.16
WDR	**0.86**	**0.11**	**0.75**	**0.93**	**0.14**	**0.79**	**1.02**	**0.18**	**0.84**	**1.12**	**0.24**	**0.89**	**1.24**	**0.30**	**0.94**	**1.38**	**0.38**	**1.00**
Terai	0.29	0.03	0.26	0.31	0.04	0.27	0.34	0.06	0.29	0.38	0.07	0.31	0.42	0.09	0.33	0.46	0.11	0.35
Hills	0.57	0.08	0.49	0.61	0.10	0.51	0.67	0.13	0.54	0.74	0.16	0.58	0.82	0.21	0.61	0.91	0.27	0.64
Mountains	0.01	—	0.01	0.01	—	0.01	0.01	—	0.01	0.01	—	0.01	0.01	—	0.01	0.01	—	0.01
MWDR	**0.53**	**0.05**	**0.49**	**0.57**	**0.06**	**0.52**	**0.63**	**0.07**	**0.56**	**0.70**	**0.09**	**0.60**	**0.77**	**0.12**	**0.65**	**0.86**	**0.15**	**0.70**
Terai	0.21	0.03	0.17	0.23	0.04	0.18	0.25	0.06	0.19	0.27	0.07	0.20	0.30	0.09	0.21	0.34	0.12	0.22
Hills	0.27	0.01	0.26	0.29	0.01	0.28	0.32	0.02	0.30	0.35	0.02	0.33	0.39	0.03	0.36	0.43	0.04	0.40
Mountains	0.06	—	0.06	0.06	—	0.06	0.07	—	0.07	0.07	—	0.07	0.08	—	0.08	0.09	—	0.09
FWDR	**0.37**	**0.04**	**0.32**	**0.40**	**0.05**	**0.34**	**0.43**	**0.07**	**0.37**	**0.48**	**0.09**	**0.39**	**0.53**	**0.11**	**0.42**	**0.59**	**0.15**	**0.44**
Terai	0.15	0.03	0.12	0.17	0.04	0.13	0.18	0.05	0.13	0.20	0.07	0.14	0.22	0.08	0.14	0.25	0.11	0.14
Hills	0.14	0.01	0.13	0.15	0.01	0.14	0.17	0.02	0.15	0.19	0.02	0.16	0.21	0.03	0.18	0.23	0.04	0.19
Mountains	0.07	—	0.07	0.08	—	0.08	0.08	—	0.08	0.09	—	0.09	0.10	—	0.10	0.11	—	0.11

(Source: Estimation based on Medium Fertility Decline Variant, as published by CBS, 2003)

Annex-6.2: Household Size Projection according to Physiographical/Ecological and Settlements of Nepal

Ecology	*2001*			*2006*			*2011*			*2016*			*2021*			*2026*		
	Total	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*
Nepal	**5.44**	**4.86**	**5.55**	**5.66**	**5.15**	**5.77**	**5.68**	**5.18**	**5.81**	**5.65**	**5.18**	**5.81**	**5.58**	**5.14**	**5.76**	**5.43**	**5.06**	**5.61**
EDR	**5.28**	**4.91**	**5.33**	**5.43**	**5.20**	**5.47**	**5.41**	**5.24**	**5.44**	**5.36**	**5.24**	**5.38**	**5.29**	**5.20**	**5.31**	**5.14**	**5.12**	**5.15**
Terai	5.27	4.95	5.33	5.46	5.24	5.51	5.47	5.28	5.52	5.43	5.28	5.49	5.36	5.23	5.42	5.22	5.15	5.25
Hills	5.32	4.78	5.35	5.42	5.06	5.45	5.35	5.10	5.38	5.27	5.10	5.29	5.20	5.06	5.22	5.06	4.98	5.07
Mountains	5.20	4.71	5.23	5.27	4.99	5.29	5.17	5.03	5.18	5.06	5.03	5.07	5.00	4.99	5.00	4.86	4.91	4.85
CDR	**5.44**	**4.78**	**5.64**	**5.70**	**5.07**	**5.93**	**5.76**	**5.11**	**6.06**	**5.77**	**5.11**	**6.14**	**5.69**	**5.06**	**6.14**	**5.53**	**4.98**	**6.04**
Terai	5.86	5.36	5.93	6.13	5.67	6.21	6.19	5.72	6.28	6.19	5.72	6.29	6.11	5.67	6.22	5.94	5.58	6.05
Hills	5.12	4.62	5.41	5.39	4.89	5.76	5.47	4.93	6.01	5.49	4.93	6.28	5.42	4.89	6.52	5.27	4.81	6.83
Mountains	4.94	4.46	4.96	5.06	4.73	5.07	5.01	4.76	5.03	4.94	4.77	4.96	4.88	4.73	4.89	4.74	4.65	4.75
WDR	**5.30**	**4.60**	**5.40**	**5.46**	**4.87**	**5.57**	**5.45**	**4.90**	**5.57**	**5.40**	**4.91**	**5.53**	**5.33**	**4.86**	**5.48**	**5.18**	**4.79**	**5.34**
Terai	6.06	5.24	6.17	6.37	5.55	6.50	6.45	5.59	6.61	6.46	5.59	6.66	6.38	5.54	6.60	6.20	5.46	6.44
Hills	4.91	4.32	5.01	5.01	4.58	5.09	4.95	4.61	5.02	4.87	4.61	4.94	4.80	4.57	4.88	4.67	4.50	4.74
Mountains	4.89	—	4.89	5.12	—	5.12	5.18	—	5.18	5.20	—	5.20	5.14	—	5.14	5.00	—	5.00
MWDR	**5.64**	**5.08**	**5.69**	**5.86**	**5.38**	**5.91**	**5.87**	**5.42**	**5.93**	**5.85**	**5.42**	**5.92**	**5.77**	**5.38**	**5.85**	**5.61**	**5.29**	**5.68**
Terai	5.88	5.23	6.01	6.18	5.54	6.34	6.31	5.58	6.53	6.29	5.58	6.54	6.20	5.53	6.50	6.03	5.45	6.35
Hills	5.46	4.62	5.50	5.63	4.90	5.67	5.58	4.93	5.62	5.56	4.94	5.60	5.48	4.89	5.53	5.33	4.82	5.38
Mountains	5.58	—	5.58	5.73	—	5.73	5.64	—	5.64	5.62	—	5.62	5.55	—	5.55	5.39	—	5.39
FWDR	**5.96**	**5.72**	**6.00**	**6.26**	**6.06**	**6.29**	**6.32**	**6.10**	**6.37**	**6.33**	**6.10**	**6.39**	**6.25**	**6.05**	**6.31**	**6.08**	**5.96**	**6.12**
Terai	6.43	5.89	6.58	6.92	6.24	7.14	7.14	6.28	7.48	7.27	6.28	7.74	7.17	6.23	7.74	6.97	6.13	7.62
Hills	5.59	5.24	5.62	5.74	5.55	5.76	5.70	5.59	5.71	5.62	5.59	5.63	5.55	5.55	5.55	5.40	5.46	5.39
Mountains	5.68	—	5.68	5.84	—	5.84	5.80	—	5.80	5.73	—	5.73	5.65	—	5.65	5.50	—	5.50

(Source: Estimation based on Medium Fertility Decline Variant, as published by CBS, 2003)

Annex-7: Committed Funding in Alternative Energy Technologies

S.N	RE Components/Activities	Executing Agency / Starting Agr. Period / Currency	*Committed Funding Amount in Million*													*Total @*	*HH Served in x1000 (estimated target)*	*Cost per HH*
			ESAP1+BDG		*ESAP-2 #*													
			Danida	*Norway*	*Danida*	*Norway*	*ADB*	*Fund Gap*	*GoN**	*EC*	*HMG**	*KfW*	*SNV*	*UNDP*	*Wbank*	*1999-2009 10 years*		
			7 years	*Oct-06 3 years*	*Jan-07 5 years*	*Jan-07 5 years*	*Jan-07 5 years*	*Jan-07 2 years*	*Jan-07 5 years*	*Jul 06 5 years*		*Jul 06 7 years*	*Jun 06 6 years*	*Dec 06 5 years*	*Jul 06 5 years*			
			DKK	*NoK*	*DKK*	*NoK*	*USD*	*EUR*	*NPR*	*EUR*	*NPR*	*EUR*	*EUR*	*USD*	*USD*	*EUR*		*EUR*
1	Biomass Energy Stoves	AEPC/ESAP	11.30	1.40	11.20	11.90			61.70		6.50					5.40	500.00	10.80
2	Micro-Hydro	AEPC/ESAP	38.70	17.50	44.20	32.70		4.00	260.50		9.40					24.30	200.00	121.60
3	Solar Energy	AEPC/ESAP	36.70	5.30	42.00	30.40		4.00	261.50		9.40					21.90	215.00	102.00
4	Credit Schemes for MH and SHS	AEPC/ESAP			29.50		10.00		19.50							12.00		
5	Grid Extension (Kailali-Kanchanpur)	NEA/ESAP*	85.90													11.50	50.00	230.40
6	Micro-Hydro	AEPC/REDP												1.40	5.50		25.00	
7	Improved Water Mill	AEPC/SNV									205.80		0.70			5.40	100.00	54.30
8	Institutional Solar	AEPC/EC								15.00	56.70					2.90	100.00	29.00
9	Biogas	AEPC/BSP									386.60	15.70	4.00			15.60	200.00	78.00
10	Grid Extension Others	NEA/ESAP*							16.40		18.70					23.80		
11	Institutional Strengthening,	AEPC/	17.00		27.60											6.40		
	cross cutting themes and	ESAP/SNV									2.50		0.60			0.60		
	Total		**189.60**	**24.20**	**154.50**	**75.00**	**10.00**	**8.00**	**619.60**	**15.00**	**695.60**	**15.70**	**5.30**	**1.40**	**5.50**	**129.80**	**1390.00**	**93.51**
	Cross Country exchange rate EUR		7.45	8.74	7.45	8.74	1.33	1.00	104.76	1	104.76	1	1	1.3261	1.3261			
	Total in EUR		25.46	2.77	20.75	8.58	7.54	8.00	5.91	15.00	6.64	15.70	5.30	1.06	4.15	**126.85**		
	Total in NPR (Exchange rate 1 EUR =104.76 NRs dated 27.04.09)		2381	259	1940	802	705	748	553	1403	621	1468	496	99	388	**11862**		
	Donor-wise total household beneficiaries		**350**		**800**					**100**		**200**		**40**				

* GoN matching funds for various programmes

Expected Fundings for positively appraisal ESAP-2 Programme

.@ Total Commitments for the period excluding GoN counterpart funding starting July 2006 stands at 96.4 Million EUR

Annex-8: Estimation on Investment for Alternative Energy Technologies

Annex-8.1: Cost per Households for Alternative Energy Technologies

Technology	***Cost/HH***			
	Users Contribution (EUR/HH)	***Subsidy***	***Technical Assistance Cost***	***Program Cost***
Biomass Energy Stoves#	4.77		6.45	11.22
Micro-Hydro (MGSP)	155.12	143.18	17.70	316.00
Solar Energy	153.67	50.71	5.34	209.72
Micro-Hydro (REDP)	155.12	143.18	273.7*	572.00
Biogas	143.18	85.91	78.00	307.10

* includes substantial costs to cover end-use and community mobilization

High Altitude stove subsidy not included and includes mud stove cost only

Annex-8.2: Estimation of Total Investment Required for Alternative Energy Technologies

Technology	***Cost/ HH (EUR)***	***Target for EPR (x1000 households)***				***Tentative investment (million EUR)***			
		2006-11	***2011-16***	***2016-21***	***2021-26***	***2006-11***	***2011-16***	***2016-21***	***2021-26***
Biomass Energy Stoves (Mud ICS)	11.22	447	447	411	411	5.01	5.01	4.62	4.62
Biomass Energy Stoves (Metallic Stoves and Gasifiers)	50.00	117	117	76	76	5.84	5.84	3.80	3.80
Total Biomass Stoves	**61.22**	**563**	**563**	**487**	**487**	**10.85**	**10.85**	**8.42**	**8.42**
Micro-Hydro (MGSP)	316.00	141	120	120	120	44.6	37.9	37.9	37.9
Solar Energy	209.72	532	532	182	182	111.6	111.6	38.2	38.2
Micro-Hydro (REDP)	572.00	20	30	30	30	11.4	17.2	17.2	17.2
Biogas	307.10	182	182	112	112	55.9	55.9	34.3	34.3
					Total	**234.4**	**233.5**	**136.0**	**136.0**