Small Wind Power Development to Reduce the Energy Crisis in Nepal

(A case study of Hanshapur VDC, Pyuthan)

Submitted to:

Central Department of Rural Development

Tribhuvan University

Kirtipur, Kathmandu

In Partial Fulfillment of the Requirements for the Master's Degree in Rural Development (MA)

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TU Reg. No: 5-1-37-58-2000

Exam Roll no. : 2575

February, 2010

ABSTRACT

Nepal is heading towards a crisis through its unsustainable energy use pattern. There is an overwhelming dependence on traditional fuels-fuel wood, agricultural residue and animal dung (accounting for 88% of primary energy use) and fossil fuels (accounting for 11.5% of primary energy use). This gives rise to adverse impacts regarding energy security, environment and human health. Therefore, there is an urgent need to substitute these energy sources with renewable clean energy sources. Fortunately, Nepal has a huge potentiality for promoting renewable energy technologies (RETs).

Access to adequate, affordable, reliable, safe and environmentally benign energy is crucial to achieving the Millennium Development Goals and for improving the lives of poor people across the world. Realizing the fact the Government of Nepal has given priority to promoting RETs and also provides subsidies. However rural poor are deprived / poor of the benefits of the technologies and the government subsidy because they lack the ability to pay the upfront cost required purchasing such technologies. Wind power can bring energy to remote areas outside the electrical grid. It is cheaper to start a wind power system than to wait for long and expensive hydropower project or other types of fuel, which are hard to transport. Nepal could become energy independent if it used the available wind potential. Wind is a renewable resource whereas conventional methods such as coal, natural gas, and oil are non-renewable; wind power does not produce the greenhouse (carbon) emissions like the conventional energy methods.

Four small wind turbines of 400W each capacity with 160Wp Solar PV with 270Ah Battery backup were installed at various places of Hanshapur V.D.C. Ward No-6, Pyuthan as piloting projects. The installation of those systems had been done by Krishna Grill and Engineering Works Pvt. Ltd. while the technical and social back up has been provided by FAEM, Nepal to Krishna Grill. The project sites at Hanshapur VDC were visited after a series of investigations and consultation with the related experts and officials of AEPC. The project sites were not only considered as marginal but ethnic communities are benefited there. The total beneficiary households at Hanshapur VDC are found 27 whereas one Masjid and one School are also benefited there. Small wind power technologies that have been disseminated for those households who use kerosene as a source of energy for lighting purpose in off grid areas of rural Nepal could help in little energy support by the use of it in potential areas.The efforts have been made to aware local people and enhance the level of understanding about the system. Thus, the research is hopeful for the sustainable operation of those installed systems. Furthermore, the close monitoring of the installation is very essential for the sustainable operation as well as other aspects of the installed systems for better up results in near future.

ACKNOWLEDMENTS

I would like to express my sincere gratitude and thanks to Prof. Dr. Mangala Shrestha, Tribhuvan University, Central Department of Rural Development, for her supervision and good advice at every step of this study.

I express my hearty gratitude to Prof. Dr. Pradeep Kumar Khadka, Head of Central Department of Rural Development; Tribhuvan University for his encouragement and cordial cooperation.

I am eternally grateful to my best friend Bibek Kanta Neupane for his encouragement, interactions, suggestions and continuous help during the proposal writing, data collection and analysis, and thesis writing. My heartfelt thanks to local people of the Hanshapur V.D.C, Pyuthan, members of AEPC and Practical Action Nepal for providing valuable information and co-operation in data collection during the interview period and materials providing during the thesis writing.

Love and affection of my family always encourage and inspired me to perform any work intensively. I'm indebted my elder brothers and parents for their inspiration and support in every turn of my life but here I am unable to express my feelings in word. I owe my success to them.

Parmita Chapagain

February, 2010

ACRONYMS/ABBREVIATIONS

AEPC	Alternative Energy Promotion Center
Ah	Ampere hour
CES	Center for Energy Studies
CRE	Center for Renewable Energy
DC	Direct Circuit
DDC	District Development Committee
DFID	Department of International Development
DHM	Department of Meteorology and Hydrology
ESAP	Energy Sector Assistance Program
FGDs	Focus Group Discussions
GEF	Global Environment Facility
GJ	Giga Joule
GoN	Government of Nepal
GWh	Giga Watt hour
HHs	Households
ICIMOD	International Center for Integrated Mountain Development
IoE	Institute of Engineering
ITDG	Intermediate Technology Development Group
Kw	Kilowatt
m	Meter
m/s	Meter per second
MoU	Memorandum of Understanding
NAST	Nepal Academy for Science and Technology
NEA	Nepal Electricity Authority
PV	Photovoltaic
RECAST	Research Center for Applied Science and Technology.
RET	Renewable Energy Technology
SWERA	Solar and Wind Energy Resource Assessment
ToR	Terms of References

TU	Tribhuvan University
UNDP	United Nation Development Program
UNEP	United Nation Environment Program
UNFSSTD	United Nations Financing For Science and Technology for Development
VDC	Village Development Committee
W	Watt
WECS	Water and Energy Commission Secretariat

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CHAPTER-ONE

1. INTRODUCTION

1.1 Background:

The landlocked country Nepal has an area of 147181 km^2. The total population of Himalayan country Nepal is near about 2.6 crore. The employment and economy of the country depend heavily on agriculture because more than 80 percent of the total population lives in rural areas and they have the main occupation as agriculture. Lack of infrastructures like transportation, marketing facility has become a major hurdle for not increasing agricultural production. Majority of the farmers have heavy debts. They can hardly meet their household expenditures for children's education, health care, social obligations etc with the mere small income. Nepal is a poorest country in the world. Except for a few professionals, businessmen and few large farmers, everyone in Nepal is poor but it is rich in the Natural Resources. Development of Renewable Energy Technologies (RETs) as natural resource management is very important for the national development.

Energy requirement and consumption pattern is increasing day by day so that the need of alternative and renewable resource of energy is urgent in order to meet the increasing demand of present world. Wind power can bring energy to remote areas outside the electrical grid. It is cheaper to start a wind power system than to wait for long and expensive hydropower project or other types of fuel, which are hard to transport. Nepal could become energy independent if it used the available wind potential. The utilization of these energy sources can not only significantly reduce the system fuel costs but can also have considerable impact on the system reliability.

Energy is essential to all economic and social development as well as improved quality of life. Electricity is regarded as a fundamental input to many economic activities. Access to electricity for scattered settlements in rural areas represents a major challenge. In many parts of Nepal where there is no electricity, kerosene is used for lighting, and fuel wood for cooking and heating purposes. Development of small wind energy technology is a

major option for the electrification. With limited information so far available, the potential of harnessing energy from wind is not known. Wind power development in Nepal is still at experimental stages. It is believed that, some mountain ridges and valleys appear to be suitable for harnessing of wind energy. The demonstration and dissemination of small wind power technologies are urgent in order to achieve national goal in energy sector. Production of energy from existing wind conditions in the environment is relatively a new subject in Nepal.

Access to energy is urgent need to reduce poverty in Nepal. Nepal's involvement in development of wind energy is quite short. Production of energy from existing wind conditions in the environment is relatively a new subject in Nepal. Electrification is feasible with the help of wind energy resources in the remote rural areas of Nepal where Nepal Electricity Authority (NEA) grid supply is not available.

Alternative Energy Promotion Centre (AEPC) is an apex body of Nepal Government, to promote renewable/alternative energy resources whole over the country. Accordingly, four small wind turbines of 400W each capacity with 160Wp Solar PV with 270Ah Battery backup was installed at Hanshapur, Pyuthan. The installation of those systems has been done by Krishna Grill and Engineering Works Pvt. Ltd.; whereas FAEM-Nepal provided technical support to Krishna Grill[1].

In total 27 households, a Masjid and a School are connected with the system. Uses of wind power to run computer, other electrical devices and lighting purposes is acting as a great socio-economic force in Hanshapur. These wind power plants have replaced kerosene wick lamps in the households connected with system. The wind power reducing expenses required for purchasing kerosene. The local people can use this significant saving for other meaningful expenses such as food, education and health. The wind power plants have contributed to reducing the emission of green house gas. They do not have any adverse effects on the environment. The indoor pollution is one of the major

[1] Source: Alternative Energy Promotion Centre, 2009

causes of different long term diseases in the rural areas. The Wind Power Plants have contributed to reduce the indoor pollution and support for the sustainable use of the available potentially renewable resources. The replacements of kerosene lamp have significantly reduced eye infection in women and children. Thus health cost is also reduced by wind power. Wind power is helpful to achieve education, awareness, information and other economic activities. There is participation from the poorer sections of the community, it also truly empowering socially excluded (Dalits) community. Development of institutional mechanism for sustained operation and management is possible through active participation of local users group.

Establishment of wind power technologies in remote rural sites is a milestone to achieve real fruits of development for ethnic/marginalized group. It also helps to bring socially disadvantaged/vulnerable community in the main stream development. Poverty reduction and energy management both are burning issues today with global climate changes in the world. Where the people are poor, they play vital role of adverse impact on climate change thus development of wind power will contribute significant role to reduce poverty through available access of energy.

However, the efforts are not sufficient, there is need to develop some projects in the areas which has reliable wind mapping data and which will act as a demonstration plant there by attracting more investment to harness the wind power in Nepal.

Challenges in integrating wind energy and poverty reduction in Nepal are; low level of awareness, difficulty of access, to satisfy basic and productive need, meeting the energy demands of the poor, to develop energy self reliant, enhancing energy technology absorption capabilities and to ensure sustainability.

1.2 Statement of the Problem:

The small land locked country Nepal with an area of 147181 sq. km and population around 2.5 crore and it has been estimated that some 32% of population is living below poverty line. Although Nepal is a poor country but it is rich in natural resources. Wind is a natural resource freely available in the hilly areas of Nepal. The development of small

wind power technologies to generate electricity is suitable in the scattered settlements of rural areas having good wind potential. Energy is a major basic need to reduce poverty, thus without energy there is no development. This task is to analyze problems and prospects of wind energy in Nepal

The Hanshapur V.D.C., Pyuthan is located 5km.East from Baddanda; Pyuthan. It is located at an elevation of approximately 970m.a.s.l. It is accessible by a fair weather road. NEA grid supply is not available. The people of this area are mainly farmers. Ethnic groups like Muslims, Magars, Sarki and Kami are living in the area. There is a High School and Health-post at Chava.

The technology currently available to harness the energy of the wind is regarded as a mature renewable energy technology in that it is cost effective and reliable. Where the wind resource is good, energy produced in this way can be cheaper than either solar photovoltaic or diesel generator sets. In remote areas, however, the cost of connection may considerably exceed the cost of meeting local needs through wind or solar battery systems.

The most important factor in the success or failure of any wind energy installation, whether it is commercial wind farm or a small scale battery charging system, is the strength and nature of the wind resource. The average wind speed of a site is a good guide to whether it is suitable for a wind power or not. There is often a perception that wind generators are not suitable for use in a particular area, or even an entire country. This is usually because bad experiences and poor performance in the past have put people off the technology.

In the past, aid agencies have, with the best of intensions, set up inappropriate pilot sites that typically use technology imported from the donor country. The strengths and weaknesses of wind generators may have been misunderstood, and the unfamiliar technology may have been too difficult to repair and run in situ. The other main reason

for failure is the lack of available wind data. Wind speeds measured at ground level at a few sites are often generalized countrywide.

Small wind power projects in Pyuthan district have been chosen as an example for this thesis to analyze how the local people are benefitted and impacted from wind power. The project involves 27 rural families who have connected wind powered electricity. Few are very optimistic about the potential of the project as well as the local benefits and development it could bring. Thus, in order to achieve a holistic view on the potential development benefits or impact on poor people for the utilization of wind power. It is essential to consider a wide range of elements affecting the livelihood of poor people. The livelihood term relates to the range of assets out of which people value their way of living. It is a holistic way of looking at possible impacts of wind power related activities on the everyday life for small-scale farmers in Hanshapur VDC of Pyuthan district.

1.3 Objectives:

The main objective of the study is to determine the wind resource management especially through wind energy potentiality and management practices to reduce the energy crisis on rural community at Hanshapur VDC, Ward No-6; Pyuthan. The study on wind energy in Hanshapur VDC as a primary destination has tried to highlight the rural technology and mobilization of natural resource for economic and social life pattern of the people in surrounding local communities.

The specific objectives of this study are as follows;

- To identify the problems and prospects of wind energy in rural development.
- To analyze the socio-economic and environmental benefits of wind energy.
- To analyze the impacts of wind energy
- To suggest measures for reduction of energy crisis through development of small wind power technologies in the study area.

1.4 Significance of the study:

There are several ethnic, minority and untouchable group residing in Nepal. Rural development effort will succeed only when the local people think that promoted technology and infrastructures for them and that are their own programs. The research study to identify the level of understanding rural technology among local community and it also offers both commitment and concerted efforts from the agencies involved in rural development and strong linkages with supporting agencies.

The efforts made to create awareness and enhance the level of understanding about locally available natural resources and development of RETs. To bring the positive and progressive change in local community of rural areas must have access to electricity/energy. The study attempts to identify the benefits, impacts, problems and give proper recommendations in order to promote RETs especially wind power technology for rural development process. This study will remained more specific to identify the role of small wind power technologies to reduce rural poverty in and around wind power projects implemented at Hanshapur V.D.C., Pyuthan.

1.5 Limitations of the study:

The study covers only selected area within Hanshapur VDC, Pyuthan which is located on the mid-western development region. The present study has following limitations;

- The study covers only selected area within Wind Stations and around project sites.
- The school, VDC office, Health Post, Community Based Organizations, Local Women Group and Youth Clubs are the major sources of information for the proposed study.
- The interview and focus group discussion will be conducted with school and local CBOs and VDC representatives all political parties and other development related institutions (public and private).
- However, the study it itself is limited because of extreme political situation like road strikes, inadequate financial resources and time constraints.

CHAPTER-TWO

2. LITERATURE REVIEW

The study was initiated with the literature review of published documents. Periodic plans of Hanshapur VDC, district profiles, reports, legislation, policies as well as related online internet documents were also reviewed. Similarly related documents available at Alternative Energy Promotion Center (AEPC), Rural Energy Development Program (REDP), Energy Support Assistance Program (ESAP), National Planning Commission (NPC), Water and Energy Commission Secretariats (WECS), Central Bureau of Statistics (CBS), Internet available documents were also reviewed thoroughly.

2.1 Energy and Poverty:

Nepal relies heavily on traditional energy resources, as no significant deposits of fossil fuel are available. Nepalese use the lowest commercial energy (around 500 kWh per capita per year) of all South Asians by far. The total energy consumption in Nepal for the year 2003/04 was 363 million GJ of which the residential sector consumed 90% and agriculture sector 1% as shown in the figure. Based on the fuel type, biomass provided 86% of the total energy consumption, petroleum 9%, which is mainly consumed by urban areas, electricity only 2% and renewable 1% of the total energy consumption (Ghimire 2004, Paper Presented at National Training Workshop on the Integration of Energy and Rural Development of Policies and Program in Nepal).

About 84% of Nepal population lives in rural areas, and agricultural work is the mainstay of the rural population. For the year 2003/04, total rural energy consumption is 288 million GJ of which the rural residential consumed 97%. From end use perspective, of the total energy consumed in rural Nepal, 63.9% was used for cooking, heating accounted for 8.5%, lighting 1.31%, agro processing 3.4%, animal feed preparation 16.5% and others

such as religious occasions and ceremonies 4.3% (Ghimire 2004, Paper Presented at National Training Workshop on the Integration of Energy and Rural Development of Policies and Program in Nepal).

The overriding objective of Nepal's developmental effort is poverty alleviation. The Tenth Plan sole objective is to achieve a remarkable and sustainable reduction in the poverty level in Nepal from 38% of the population at the beginning of the plan period to 30% by the end of the Tenth

Plan and further reduce the poverty ratio to 10% in about fifteen year's time. The national long term vision of alternative energy sector as outlined in Nepal Poverty Reduction Strategy paper explicitly recognizes the role of renewable energy technology in the socio economic development of rural people and aims at "Accelerating economic development, improving living standard of rural people, increasing employment opportunities and maintaining environmental sustainability through the development of rural energy systems." To realize this long term vision the Tenth Plan has set the objective of renewable energy development as "developing and expanding alternative energy as a powerful tool for alleviating poverty, raising purchasing power of the rural people by developing alternative energy technologies based on the local resources, skill and increasing consumption of alternative energy and reducing dependency on imported energy by lowering the cost of installation through the proper utilization of local resources and means. "

The Interim Plan (2006 to present) emphasizes on:

- Increasing the consuming capacity of rural families by developing and extending the alternative energy sources, seen as a powerful tool for poverty alleviation
- Supplying energy for commercialization of the domestic needs and the professions of rural population by developing alternative energy technologies based on local resources and tools.
- Reducing dependency on imported energy sources and reducing negative environmental effects by the proper use of resources and tools of local energy.

- Improving and increasing the energy use competency and increasing the access of rural people by reducing the cost of development and installation of alternative sources of energy.

- Development of wind energy and bio-fuels promotion.

Poverty is one of the most fundamental issues, and urgently needs to be addressed. Moving people out of poverty forms a basis of much international development policy. In almost all of the South Asian countries there exist absolute poverty. There are high rates of poverty among rural people, indigenous South Asian and some groups of immigrants. It negatively affects the life chances and opportunities of women and children. Children are vulnerable and dependent, and the effects and impacts of poverty can so easily stultify and distort women and children future lives by robbing them of opportunities to develop their potential. Poverty can be measured in different ways. It is often expressed in relation to a poverty line, a defined income level that is updated regularly. Each measure has advantages and disadvantages, and slightly different methods of estimate and updating may fabricate somewhat different results. As well as measuring family incomes, it is useful to consider the distribution of assets or wealth, which might offer some protection in the event of an income crunch such as hasty unemployment or prolonged illness. People living on low incomes report poor health and the incidence of illness at much higher rates than people on high incomes. This can be due to stress, crowded housing and poor nutrition. Poverty can also lead to homelessness. Both the shortage of low-cost private rental accommodation and continuing high levels of unemployment affect people's ability to pay the rent. Members of families with low incomes often have limited educational opportunities, leading to much narrower employment options. It can also contribute to poor self-esteem and less participation in society. In this way poverty and social exclusion can affect successive generations.

According to the World Energy Assessment, energy services are indispensable for human survival and development. They play a critical role across the whole spectrum of development activities. Of the three billion people living in rural areas in developing countries today, nearly 2 billion still have neither access to nor can pay for modern

energy carriers, such as electricity and/or liquid or gaseous fuels. These energy carriers are to provide essential energy services such as heating for cooking, motive power, lighting and cooling (refrigeration), thus seriously reducing the income opportunities and quality of life. Access to electricity and other modern energy sources is a necessary, but not a sufficient, requirement for economic and social development. The escape from poverty also requires, among other things, clean water, adequate sanitation and health services, a good education system and a communication network. Yet cheap and available energy is indispensable. Electricity provides the best and most efficient form of lighting; household appliances require it. Kerosene and liquefied petroleum gas (LPG) are more energy-efficient cooking fuels than traditional biomass.

In South Asia, millions of women spend hours a day carrying fuel and water, taking away valuable time for other activities. Women in rural areas in South Asia are at the bottom rung of the so-called energy ladder, which associates users of progressively cleaner, more efficient fuels with corresponding higher levels of income. It is a situation that is both a determinant and a manifestation of poverty and inequitable gender relations. Traditional biomass (dung, agriculture residues and fuel wood) is at the bottom rung of the ladder for cooking, with charcoal, then kerosene and finally liquid petroleum gas (LPG) and electricity are towards the top. Traditional rural energy systems are characterized by the use of biomass, in the form of wood, plant residues, dung for heating and cooking, and human energy and or animal energy for motive power. Majority of household energy requirements are biomass energy for cooking. Human energy, measured in energy units, constitutes a small proportion of energy resources consumed compared to other sources. But the labor of women and children are indispensable in making the energy chain work such as the extraction/collection of biomass to its transformation into an energy service such as heat for cooking. The extraction, transport, processing, conversion and distribution are the responsibility and the work of women, girls and boys primarily, according to the social norms which prescribe which activities are the obligations of women and which are those of men. Women are also at the bottom rung of another energy ladder for motive force. They depend entirely on their own motive force and are normally without any other resources such as animal power, mechanical or electrical

devices for such energy transformations. Even where animal power and/or mechanical equipment are available in the household, gender norms, relations of power and division of labor tend to exclude women from use and certainly ownership and control of these assets. This energy situation has tremendous survival and developmental implications since the tasks associated with food preparation are critical to the prevailing agricultural systems. Small landowners engaged in agricultural production make up about three quarters of the rural population. Their production, the main source of rural livelihood and income, is primarily based on human and animal energy that is on muscle power. This motive power requires the biological conversion and storage of food into useful energy. Food intake, crucial for the daily reproduction of human energy for agricultural labor, in turn depends on processing and preparing the food harvested or gathered. The frequent, repetitive tasks associated with post-harvest food preparation, such as provisioning for water, firewood, grinding grain, pressing cooking oil and processing other ingredients are women's responsibilities and obligations. These are in addition to women's other labor inputs in agricultural production and in gathering the wild resources used in food preparation, oil and soap making and other household provisioning needs. Dependence on such traditional energy systems leads to multiple social and economic costs, which are overwhelmingly borne by poor women. Linked to the lower energy efficiency of fuel wood combustion are the higher emissions of sulphur, carbon dioxide and particulates, pollutants resulting from incomplete combustion. The occupational hazards for women and for their young children from exposure to indoor air pollution, smoke and particulates when cooking are the negative impacts in terms of health burns, acute respiratory infections, lung disease, internal disorders and eye problems. Load carrying of fuel and other materials, for example in palm oil processing takes a health toll in terms of injury, miscarriages, and fatigue. Poor women in particular pay a disproportionate price for energy services not only because of the inefficiency and associated health costs. Long hours are spent collecting water and firewood for food preparation and agro processing, as well as the multiple other tasks that sustain rural livelihoods. The arduous and time-consuming nature of women's activities in such energy systems has significant opportunity costs in terms of other activities. These are agricultural production and other

productive and income generating uses of time and energy, as well as time and energy for child care, health, education, rest, social and cultural activities, recreation and personal maintenance. As traditional fuel wood sources and water get increasingly scarce, the costs in terms of women's time and energy become more severe. This can also mean that they need to generate cash to buy firewood that is no longer possible to collect individually and this cash generation in its turn takes time and energy, including marketing time. Widening access to modern energy services can be a catalyst for sustainable human development, given these patterns of energy uses. But increased income is necessary to be able to afford to climb another rung of the energy ladder and release human time and energy for human development purposes. However this increased income is not possible without spending further time and human energy, when usage levels are already very high. Such is the energy-poverty trap which women in South Asia, in particular are struggling to get out of[2].

2.2 Energy Resource Base in Nepal:

The major energy resource base in Nepal consists of biomass, hydroelectricity, petroleum products, natural gas, and coal reserves. Among the entire energy resource base, it is evident that biomass is the dominant resource base of the country with respect to its utilization. Nepal has a huge potential for hydropower production, but currently this remains mostly untapped. Other commercial forms of energy are not known to exist in any significant amounts.

a. Biomass Energy

Nepal relies heavily on biomass fuel as a result of the lack of development of other energy alternatives and the overall poor economic condition of the nation. Fuel wood is the main source of energy in Nepal and will continue to remain so for a long time. The theoretical estimated sustainable annual yield of fuel wood in Nepal is 25.8 million tonnes, or an average of 2.8 tonnes per hectare of forest. However, only 42 per cent, or

[2]Source: Energy and Poverty in South Asia, PDF report

10.8 million tonnes, of the theoretical sustainable supply is accessible. Forest resources are under increasing threat from the burgeoning human and livestock populations and their need to meet annual requirements for fuel wood, fodder, timber, and other minor forest products. About 44,000 ha of forest area is believed to be degraded and deforested annually, while only about 4,000 hectares are reforested. Conversion of forestland for cultivation, high population growth, and a low level of development have all aggravated the pressure on forests throughout Nepal. Where forests are becoming relatively scarce, people are relying increasingly on crop residue and animal waste, resulting in the degradation in fertility of the agricultural land. In 1994/95, the supply of crop residues in the country that could be used as energy was estimated to be 112.13 million tonnes (WECS I 994c, PEP 1995). Likewise the country has 4.8 million tonnes of animal dung annually potentially available as fuel.

b. Hydropower

The hydropower potential of Nepal's river systems is about 83,000 MW, out of which only 25 per cent is potentially available for development (WECS 1996). Hydropower utilization is currently less than one per cent of the proven potential. The total installed hydroelectric generation capacity is 586 MW (NEA 2002). This power has been made available to 878100 consumers through 1962 km of transmission and distribution lines. The national grid represents the overall hydroelectric industry of Nepal as it accounts for almost 98 per cent of the capacity and 99 per cent of the energy supplied. Apart from national grid, both the public and private sectors and independent power producers manage isolated supply systems. At present there are 35 small/mini hydroelectric plants in operation in remote areas of the country.

c. Petroleum, Natural Gas, and Coal

So far no proven reserves of petroleum suitable for commercial exploitation have been found in Nepal. Thus all petroleum products consumed are imported in refined form for direct consumption. The alternative fossil fuel, natural gas, has also not been discovered as yet in any significant amount. Coal is in many countries among the cheapest sources of energy known. Two deposits are believed to have some economic significance, one in

Kathmandu and one in Dang. Even these deposits, however, are believed to be insignificant in terms of the energy demand (WECS 1994).

2.3 Renewable Energy Development Scenario in Nepal

There is a dire need to substitute as well as supplement the traditional energy supply system by modern forms of sustainable energy in terms of resources and technology. Because of the country's dependence on imported fossil fuel, high cost of grid connection and low and scattered population density, a decentralized energy supply system becomes the natural and feasible choice. Decentralized new and renewable energy systems such as micro hydro, solar photo voltaic, biogas, improved cooking stove etc provide feasible and environment friendly energy supply options in rural areas. The most important renewable energy technology in Nepal is related to Pico hydropower and micro hydropower (up to 100 kW), biomass energy (biogas, briquettes, gasifiers, improved cooking stoves), solar photovoltaic (solar home systems, solar PV water pumping, solar battery charging), solar thermal energy (solar water heater, solar dryer, solar cookers etc).

2.4 Government Policies for Promotion of Renewable Energy and Poverty Reduction:

The positive role of renewable energy technology for the fulfillment of energy needs of the rural people was recognized by the National Planning Commission/Nepal during the Seventh Five Year Plan. The Eight Plan (1992-1997) envisaged the need for a coordinating body for large scale promotion of alternative energy technologies in Nepal and Alternative Energy Promotion

Centre (AEPC) was thus established to promote the use of Renewable Energy Technology and act as the government coordinating body. Though renewable energy programs have positive implications on poverty reduction, but this has not been the explicit goal of renewable energy programs in Nepal until the commencement of the Tenth Plan in 2002. A separate subsidy policy has been has also been made effective by Government of Nepal (HMG/N) channeling through the AEPC, for extensive promotion of RETs in the rural areas.

The improved cook stove and biogas programs initially had goals to reduce firewood consumption but now they also justify themselves on health ground and are linked to income generation as well as reduction of women's drudgery. Biogas has been mainly used for cooking and the bio slurry has been used as a high quality fertilizer for increasing agricultural productivity. Few households have used the biogas for lighting. Micro hydro was seen as a technology to reduce drudgery, provide lighting but now the productive end uses are considered as the desired priority. Solar energy has served widely as a home lighting device. Solar energy has also been used for drying and cooking food, powering computers, irrigation and drinking water systems but theses uses are very limited[3].

2.5 Gender Issues in Energy Policies:

By the time the Sixth Five Year Plan (1980-1985) was ratified, HMG/N's emphasis on, women's involvement in all programs and projects, as well as recognition of the legal impediment to their economic empowerment was quite clear. The Eight Five Year Plan (1992- 1997) recognized the need for increasing women's representation at the decision making levels in the government, non government and semi-government sectors, and for monitoring systems for gender discrimination at work. A suitable organization structure for coordination and monitoring of activities relating to women was also envisaged. In spite of the gender mainstreaming exercises performed during the Eighth, Ninth and Tenth plan Period, the Interim does not link gender concern/women's concerns with the energy policy. The energy sector strategy would link alternative energy development with the environment conservation rather than women's drudgery, health and human resource development.

In 1995, Water and Energy Commission Secretariat (WECS) published its guideline for the incorporation of gender issues in water and energy sector. Recommendations addressing gender issues such as gender sensitization, gender disaggregated databases

[3] Source: Alternative Energy Promotion centre, 2009

and commissioning of gender experts in planning and programming have also been included on the 1997 WECS commissioned study on institutional strengthening in rural energy planning and implementation. However the guideline's recommendation has not been successfully practiced in implementation.

2.6 Development of RETs in Nepal:

a. Micro- hydropower

Various kinds of micro-hydro technologies such as propeller turbines, cross flow turbines, Pelton wheels, multipurpose power units (MPPU), peltric sets, and improvements in traditional ghattas (water wheels) with better system efficiency have been developed in the past to tap water resources more effectively. They are mainly used for agro-processing activities, and electricity generation. By 2002 about 1000 improved ghattas have been installed mainly for agro processing activities, in comparison to the traditional ghattas estimated at 25,000, thus providing a huge potential for its improvement to generate rural energy in Nepal (CRT/N, 2002). Since January 2003, Improved Water Mill Support Program has been initiated as part of Government of Nepal and Netherlands Development Organization Program support to Renewable Energy Sectors to develop and disseminate Improved Water Mill (IWM) as a sustainable energy source in the mid hill and high hill district of Nepal. (CRT/N, June 2009)

The distribution of micro-hydro units is influenced, among other things, by proximity to the manufacturer, the extent of development of the region, donor support, and the availability of electricity from NEA. From 1986 onwards the number of micro-hydro plants being installed within accessible areas of the country declined. At present, the NEA has no plans to construct new hydropower plants in the micro range and thus rural areas, especially in the hills and mountains, can only receive electricity through private utility micro-hydro plants. The successes of privately summed Micro-Hydro plants largely depend upon the commercial end use as well as the management capacity of the owner.

b. Solar Energy Technology

Solar energy has been used traditionally for drying such things as crops, clothes, fuel wood, and crop residues. The solar energy potential in Nepal is estimated to be about 26 million MW. Currently there are two types of solar energy technology in the country: solar thermal systems and solar photovoltaic (PV) systems. Solar water heaters and solar dryers are the two main types of solar thermal devices. Of these, solar water heaters are popular in Kathmandu. These heaters are suitable for use throughout the country except in those regions that have long and harsh winters where the temperature falls below freezing point. However, because of the high cost, this technology is too expensive for most people.

Solar cookers were introduced by the Research Centre for Applied Science and Technology (RECAST) in 1977 as parboiling cookers. The Centre for Rural Technology, Nepal (CRT/N) took further initiative to promote Solar Cookers since early 1990's with the government subsidy channeled through Alternative Energy promotion Centre (AEPC). Because of their high cost, this technology has not become popular in the rural areas. Although various types of solar cookers have been developed to reduce cost, efforts to improve the efficiency of solar cookers have yet to be undertaken.

The solar PV (photovoltaic) systems convert solar energy directly into electricity. The NEA has carried out centralized solar photovoltaic-based rural electrification in different locations. The cost of a centralized solar PV-based power system is high, compared to electricity generation by smaller micro-hydropower units. Lately, private entrepreneurs and non-governmental organizations (NGOs) have been showing interest in the dissemination of solar PV home lighting systems. These home systems are gaining popularity in some areas of Nepal (Shrestha and Bajracharya 1998). There are around 57875 PV home systems are installed in the country by the end of 2004 covering 74 districts (Nepal, 2004). Energy Sector Assistance program (ESAP) of Danish Government and AEPC has supported promotion and installation of household PV systems in Nepal.

c. Biogas Technology

Biogas technology is considered to be one of the most promising and sustainable sources of renewable energy in Nepal. At present most biogas plants are in the Terai, but they are gaining popularity in the hill regions as well. The mountain region is unfavorable for biogas production because of the cold climate. It is estimated that there is potential of 1.3 million household biogas plants in the country (Ghimire 1998). By the end of December 2004, 123,395 biogas plants of different sizes have been constructed so far in the country benefiting 860,000 persons directly. Annually biogas plants in Nepal save 239,386 tones of firewood and they replace 3,830,000 litres of kerosene every year (Nepal 2004). There are 72 authorized biogas companies involved in the installation of biogas plants in Nepal. Despite biogas technology being fairly successful at present, a number of technical and institutional problems have emerged that will greatly retard diffusion of this technology. Lack of adequate water supply required for operating the biogas plants in the hills and the mountain areas is often reported as a hindrance to the establishment of such plants. It is also found in some cases that the operation and maintenance of biogas plants has increased the workload for women, as they have to carry more water. Uniformity or standardization of design, installation, construction materials, or supply of accessories has not yet been achieved. Community level biogas plants have not yet been fully developed and promoted. There is still no competent biogas development and promotion unit in the country. Costs are escalating and beyond the affordable limit of poor households. The interaction between designers and end users is poor, which does not help to improve the design (WECS, 1996; Gongal and Shrestha 1998). If all the available dung were to be used for biogas, the potential biogas production would be around 12,000 million m3 per year, which is equivalent to 29 million GJ (about 10% of the present energy consumption) and the use of this dung would not affect agricultural productivity (WECS 1996).

The current state of development of biogas in Nepal is largely the result of incentives provided by Nepal Government. A plan for the installation of biogas plants was first incorporated in the Seventh Five Year Plan (1985-90). During this plan period both capital and interest subsidies for the biogas programme were provided by the government through the Agricultural Development Bank. This subsidy programme is now being

continued with the assistance of the Government of the Netherlands. Cost effective designs, long-term biogas development programs, as well as institutional and credit/incentive mechanisms are required to further exploit their potential.

d. Improved Cooking Stoves (ICS)

Improved cooking stoves have the potential to save the fuel wood used for household cooking.

About 11 million tonnes of fuel wood are burnt annually for cooking alone. Theoretically, it is possible to reduce fuel wood consumption for cooking by 50 per cent. ICS have an efficiency factor in the range of 15 to 30 per cent, whereas the efficiency of traditional mud stoves varies from 3 to 15 per cent. There are various types of ICS and the efficiency of these stoves varies (Bajracharya and Gongal 1998). The amount of fuel wood saved depends among other things on the type of ICS, the condition of the fuel wood, the type and amount of food prepared, and the type of pots used for cooking. Even with a low performance of 11 per cent fuel wood savings, estimates indicate that one ICS can save an average of 1 tonne of fuel wood annually.

Since the introduction of ICS in the early 1950s, more than 200,000 ICSs have been installed. However, the actual status of ICS currently in use is not available. After the initiation of AEPC/

ESAP supported by the Danish Government assisted ICS promotion program in 1999, ICS is gaining popularity in the mid hills of Nepal. From 2001 as of March 2008, 2, 50,000 ICS have been installed in the country under this program in various hilly districts of Nepal (AEPC 2009).

e. Wind Power

This technology is still in its initial experiment phase. A wind power system was installed in Kagbeni to generate about 20kW of electrical power (annual energy of 50MWh) but was damaged as a result of the poor design. The high installation cost (about US $6,800 per kWh) did not justify further development (WECS 1994). Now, 3.4KW electricity has been generated in Nepal by wind power.

2.7 Energy Consumption Pattern:

Residential Sector

About 92 percent of total energy is consumed in residential sector, which is characterized by three words: rural population, biomass and inefficient energy use. Rural population comprises of over 80 percent of total population, who do not have access and affordability to commercial fuels such as kerosene and LPG. As a result, about 90 percent of total residential energy is consumed in the rural areas. Of total residential energy needs, almost 80 percent is met by fuel wood alone and mainly for cooking.

Industrial Sector

The energy consumed by the industrial sector was about 15 PJ in 2005, almost one third of which was supplied by biomass sources. Petroleum products, coal and electricity were other major energy sources. In terms of end-uses, the consumption for motive power and process heat was almost 60 percent.

Commercial Sector

In 2004, the energy consumption in commercial activities was about 5.1 PJ, of which 80 percent was used for cooking and about 10 percent for lighting. In terms of fuel use, almost 70 percent of energy needs was provided by petroleum products, electricity and coal and the rest by biomass.

Transport Sector

Tax liberalization, push for global concept on economy has led to an increase in transport activities. Between 1986 and 2004, the energy consumption in transport sector has increased by almost seven folds, mainly because of increases in road and rail services. Of about 10.7 PJ of energy consumed in 2004, almost 84 percent was consumed in road and 16 percent in air transport.

Agriculture Sector

Water pumping for irrigation, land preparation for cultivation and harvesting are direct energy consuming agricultural activities. The use of animate energy for agricultural

activities has not been considered here. The total energy consumption in the agriculture sector is about 0.6 PJ, of which almost half is used for pump and another half for land preparation and other activities.

2.8 Energy and Environment:

The growing population, shrinking accessibility to available resources and unexplored energy potential have posed a big challenge to sustainable development. Nepal has recognized the environmental problems and endorsed Agenda 21 and Kyoto Protocol. As a commitment to such recognition, Ministry of Science and Environment has been established and Environmental Protection Act (1995) has been promulgated. Energy related environmental concerns are complex. In general, the over exploitation of accessed forest areas, under exploitation of water resources, diversion of agricultural residues for fuel and increasing import and use of fossil fuels have been major environmental concerns. The sections below detail some of the concerns with forestry (largest energy supplier at present) and hydropower (potential for largest energy supply in the future).

Forestry Sector

Forest related adverse environmental impacts are the consequences of agriculture land expansion and fuel wood extraction. Between 1964 and 1985, natural forests were reduced by 570,000 ha, of which about 380,000 ha are used for cultivation. [4]During the same period, only about 70,000 ha were reclaimed through plantations. The energy balance shows that if Nepal was to promote only sustainable fuel wood supply then it cannot meet even half of the current fuel wood demand, which clearly indicates forest area encroachment for energy purpose. Such encroachment for fuel and cultivation has resulted in degrading forest supply capability, decreasing water retaining capacity of soil and increasing in soil erosion. The annual soil erosion rate is estimated to vary between 7

[4] Bhadra, B., 1990, Forest Resources: Nepal, in Energy Systems and the Environment Approaches to Impact Assessment in Asian Developing countries, ed. P. Hills & K.V. Ramani, Asian and Pacific Development Centre, Malaysia.

MT/ha and 570 MT/ha.[5] The loss in forest area and its density has also resulted in an ecologically fragile agriculture system. Health hazards associated with fuel wood burning are immediate and persistent. Because of poor ventilation in households, the concentration of suspended particles is estimated to be as high as 3.9 mg/m3 and that of carbon monoxide as 380 ppm. With installations of more smokeless efficient fuel wood stoves (SEFS) such implications can be reduced in rural areas.[6]

Fuel wood consumption in Nepal cannot be replaced in the near future and, therefore, the sustainability of forestry sector would remain a question until that time. The support of developed country, as mentioned in articles 10 and 11 of the Kyoto Protocol, becomes important in managing forests and supplying alternative form of energy sources.

2.9 Small Wind Energy Development in Nepal:

The wind energy technology can be a reliable alternative source of power for Nepalese at a time when load-shedding hours are being extended every passing week. According to experts, around 3,000 MW of power can be generated through wind energy in Nepal. They claim that the Kathmandu Valley alone has potential to generate 70 MW power.

Wind power can bring energy to remote areas outside the electrical grid. It is cheaper to start a wind power system than to wait for long and expensive hydropower project or other types of fuel, which are hard to transport. Nepal could become energy independent if it used the available wind potential.

Experts estimate that Rs.150 M is required to produce 1 MW of electricity through wind energy compared to hydroelectricity. This technology could play a vital role to address the existing power crisis since power can be produced within eight to twelve months.

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[5] Sharma, C.K., 1988, Natural Hazards and Man-made Impacts in the Nepal Himalaya, Puspa Sharma, Kathmandu.

[6] Pokharel, S. and Chandrashekar, M., 1994, Biomass Resources as Energy in Nepal, Natural Resources Forum, 18(3):225-230.

Wind is a renewable resource whereas conventional methods such as coal, natural gas, and oil are non-renewable; wind power does not produce the greenhouse (carbon) emissions like the conventional energy methods. This technology relies on wind velocity, higher the velocity, the better the potential. Energy is generated when the wind speed reaches about 10 miles per hour, and a speed of 25 miles per hour allows the turbines to generate at their rated capacity. They shut down when the wind exceeds 55 miles per hour. Although wind speed varies according to the time of day, season, height above ground, and terrain, the proper placement of a wind turbine in a breezy location away from large obstructions enhances its performance.

A turbine and switchgear are mounted at the top of each tower in a casing called a nacelle, and blades are attached to the turbine. The turbines use moving air to produce power by transferring the wind's momentum to the rotor blades and localizing that energy in a single rotating shaft.

In 1989 Nepal Electricity Authority (NEA), took initiative to produce power through wind energy by installing two wind generators of 10 KW capacities but the project did not run after some months due to lack of technical and infrastructure development.

The only significant achievement in wind energy extraction was made in 1990 when a 20 KW wind turbine was installed to supply lighting energy to 70 households in the western part of the country. However, this unit is not in use at present due to technical reasons. Until there is enough data on wind velocity, it is difficult to estimate the exact wind energy potential in Nepal.

The utilization of these energy sources can not only significantly reduce the system fuel costs but can also have considerable impact on the system reliability. Wind power can be utilized as an unconventional source of power. It is merely air in motion, set up and continually regenerated by small fraction of isolation reaction the outer atmosphere.

It is estimated that nature is generating 1.67 X 1015 Kwh annually but only a small fraction of this can be harnessed for use in the other forms

Experts says that generating energy through installing big hydro projects costs double the annual budget of Nepal, which is why Nepal have failed to develop hydropower potential. Through wind potential up to 400 megawatts of power can be generated within one year.

In the Northern region of Nepal wind energy is available, but the exact potential is yet to be estimated. According to the Alternative Energy Promotion Center (AEPC) various hilly regions including Kathmandu, Makwanpur, Kagbeni, Ramechhap, Thini, Palpa, Mustang, Manang, Pyuthan, Phakhel, Okhaldhunga, Myagdi, Kaski, Nagarkot and several other parts of the country could be the possible sites for developing wind energy.

The government has targeted to generate 20 megawatt of electricity through wind energy within the year 2066. For this, under the Public-Private-Partnership (PPP) programme, government has announced generating 20 MW wind energy from the hills surrounding the Kathmandu Valley. As a part of commencing the current fiscal year as a 'Alternative Energy Year' it has also allotted Rs.203.1 million to develop alternative energy.

The domestic and foreign alternative energy experts claim that the utilization of wind power for heating and lighting will lessen degradation of the local environment. It will control deforestation and erosion, watershed damage as well as the usage of kerosene and animal dung vital for protecting the environment and increasing agricultural productivity. Thus, renewable source of energy can substantially replace wood. Figuring the world wind power utilization, China, USA, Spain, Germany along with India have more wind power potential than their current consumption. Until now around 94,000 MW of power has been generated through wind energy technology in the world.

Of the total energy generated Germany stands highest wind energy producer with 22,000 MW, Spain 11,615 MW, and the United States 11,603 MW. Similarly, India has also generated 6,270MW.

Nepal's capacity is not only limited to 82,000 megawatt hydropower potential but there are other alternative areas of power generation. According to the AEPC with the help of anemometer it has been recording the speed of wind in seven places and generated 2.5

KW electricity in Pyuthan. The AEPC has already begun feasibility study to run pilot projects in Sitapaila of Kathmandu, Palpa and Pyuthan.

Though there is a need of successful implementation of such sustainable alternate energy potential. The increasing load shedding can be well addressed in a short period if continuous support of the government, non-government as well as private and foreign donor concentrated on bringing effective plans and policy to develop wind power energy.

Encouragement to the private sector will be crucial in developing wind technology. Government should provide subsidies and give low interest loan to those willing to develop alternate energy system in Nepal.

Therefore, the present need and challenge to Nepal is to seek alternative energy sources and develop technology and innovation to improve the economic viability and develop sustainable energy in line to uprooting the existing drastic blackouts.

2.9.1 Past History:

The past efforts were undertaken for the development of few small projects such as Ramechhap, Rampur, Khumaltar and Jomsom. The Research Centre for Applied Science and Technology (RECAST) was involved in promotion of wind energy. Two wind turbines were installed at Kirtipur, Kathmandu and at Jhapa. These two were notable projects for demonstration of water pumping and electricity generation by using mechanical gears.

Nepal Electricity Authority (NEA) played a vital role to produce electricity from wind power in earlier time. The initiation was carried out at Kagbeni of Mustang district. Two wind turbines of each capacity 10 kW were installed in 1989 as a demonstration project. However, within the three months period, blade and tower of the wind generator were broken. The main reason reported was structural failure to withstand the gusty wind speed. (Source: WECS, 2002)

2.9.2 Present Scenario:

a. Alternative Energy Promotion Centre (AEPC)

Alternative Energy Promotion Centre (AEPC) is a National Executing Agency of Nepal Government to develop and promote RETs in Nepal. AEPC has supported to promote/develop small Wind Solar PV Hybrid Systems in various places of Nepal. Alternative Energy Promotion Center (AEPC) has major role to develop wind power, government policies and programs formulation, implementation and monitoring as well.

Table: 2. 1 AEPC supported project locations in six places.

S.N.	Location/ District	Beneficiary types	Remarks
1	Jogepani/ Palpa	School (Lipin Devi Primary School)	10 PL tubes electrifying classroom and, possibility of operating a PC
2	Bhimdhunga/ Kathmandu	Households and a Shop	12 PL tubes benefited backward Giri and Pariyar families.
3	Neta/ Pyuthan	Households and a Shop	10 backward B.K. (Dalit) families and 5 Muslim families are benefited.
4	Kaskot/ Pyuthan	Households and a Masjid	8 poor Muslim households are electrified.
5	Chava/Pyuthan	School (Saraswati Secondary School)	4 CFL Lights electrifying office room, laboratory and operating a computer.
6	Kaskot/ Pyuthan	Households	5 poor Dalit's Settlements at Kaskot are electrified.

Criteria of the Potential Sites for Establishing Wind Power Projects by AEPC:

- The basic criteria for selection of project sites for establishing the wind power projects is as follows, however, it will be finalized after discussion between AEPC and the consultant:

- The locations should have annual mean wind speed greater than 3 m/s as far as possible;
- The location should be within public places such as school, health post, VDC/DDC building;
- Not reachable by the NEA National Grid in the next 3-5 years if possible.
- Each Wind Turbine Generator should be between 300-400 Watt capacities.
- The tower should have enough strength to bear the load of the wind turbine generator set and the two anemometers.
- In order to accommodate the wind turbine and anemometers in the same tower, the height of the tower should be 20 m above ground level so that the two anemometers can be placed at 10m and 20m height agl.

Subsidy Policy by AEPC:

1. The energy demand can be met to some extent by exploiting wind energy, if we consider the topography and climate of Nepal. Mechanical and electrical energy can be generated by wind energy. However, potential areas for wind energy exploitation have not been fully explored. The present effort of wind data collection and wind mapping will be continued.
2. Feasible wind electrification projects based on wind chargers to provide lights in village will be provided subsidy at a rate similar to solar home system based on number of households served by each installation.
3. The financial and technical support will be provided for pilot projects of wind if the electricity generated from it is to provide in the remote areas where there is no access of national grid.

Basis for Subsidy:

- Sites that are rural and not electrified by any other means are eligible for subsidy provided that are the wind turbines installations benefit Nepalese citizens.
- Feasibility study, design and installation process of wind energy projects should be performed by qualified engineers.
- The wind turbine should be between 100 Watt and 1000 Watt capacity.
- Each household should obtain 7 kWh electricity every month in average.
- Pre-qualified company or institution should install components certified by Renewable Energy Test Stations (RETs) or that follow international standards. (Source: www.aepc.gov.np)

b. Practical Action Nepal

Practical Action is an INGO working in various developmental activities. Practical Action Nepal, formerly Intermediate Technology Development Group (ITDG) has started working on wind energy technology development in Nepal since 2001. It was primarily focused on technology transfer of small scale wind turbines, development and demonstration of small scale stand alone wind generators as an alternative source of clean energy to rural poor.

Initially, Practical Action Nepal studied the design and specifications of Wind Turbine Generators under the project Small Wind Energy Systems for Battery Charging, 2001 funded by DFID (Department of International Development, UK). Based on the learning of the past initiatives in wind energy development, Practical Action Nepal has explored the potential wind sites in Nepal through a field study and verification. Due to unavailability of reliable wind resource maps and wind data, the interventions had to be based on field survey, observation and enquiry with communities and collection of instant 3-4 hrs wind data at the sites. The instant wind data recorded in the sites found varied from 3.5 m/sec as minimum to 5 m/sec at maximum.

The wind power installation initiated by Practical Action with a local manufacturer Krishna Grill is one of the success stories of wind energy technologies in terms of rural

electrification. The Practical Action Nepal has already installed small wind turbines for electricity in 7 different places: Mainamaimi VDC of Udayapur, Phakel VDC of Makwanpur, Phalamkhani VDC of Parbat, Chisapani of Kailali, Batasedada of Palpa, Kapricahaur of Surkhet and Luprang of Gorkha district (Source: Practical Action Nepal, 2008).

c. Krishna Grill and Engineering Works (Pvt.) Ltd

The potential to use wind energy has also been explored to some extent though it's quite short. Since last 24 years Krishna Grills & Engineering Works owner have researched and developed some windmill and wind turbines for lifting the water to irrigation of land and electricity for the light for rural areas where the main grid line is not accessed. There are many areas where the wind recourses are available within the country. Some areas has been identified as potential wind energy sites and different organization like ITDG (Practical Action) are working for the promotion of the wind energy in some parts as a pilot project and in these projects Krishna Grill Engineering Works (Pvt.) Ltd. has worked as a partner to ITDG. The Krishna Grill & Engineering Works (Pvt.) Ltd. is the pioneer company who manufactured and installed within the country.

Krishna Grill and Engineering works (P) Ltd, Biratnagar, Nepal one of the Renewable Energy Technology (RET) manufacturer in Nepal, is currently manufacturing the small-scale wind turbines in Nepal. Krishna Grill has also installed four Wind- Solar PV Hybrid Systems in Hanshapur V.D.C. of Pyuthan District and two wind power systems installed in Haibung VDC of Sindhupalchowk district; all those pilot projects were funded by AEPC.

2.10 Wind Data Measurement:

2.10.1 Role of DHM:

The Department of Hydrology and Meteorology (DHM) already has been collected wind data in several meteorological stations (about 64 Stations) spread throughout the country for last several years. The recorded wind data by DHM were mainly for agriculture purpose. In most of the stations the anemometer heights were in the range of 2m to 3m.

Some anemometers were kept in the roof of the station building making the heights of 4m-5m and even 10m from the ground, thus recorded data were not much useful for wind energy development. The most potential sites suggested by DHM were Kagbeni, Thakmarpha, Annapurna, Kanjuiroba, Langtang and Khumbu Valleys. (Source: DHM, 2006)

2.10.2 Role of Alternative Energy Promotion Centre (AEPC):

Wind data in windy areas is currently being collected in various places in Nepal. Those collected wind data have been analyzed with computer software and the energy potential of those sites has already been found out. The two potential sites Thini and Kagbeni of Mustang district have good wind potential and there is possibility of large scale wind farming. The five anemometer stations were handed over to AEPC in 2002 by Water and Energy Commission Secretariat (WECS). Due to some technical reasons, one of the stations located at Butwal was shifted to Palpa from September 2003. Alternative Energy Promotion Center (AEPC) has been installed anemometers in two stations Phakhel-Makwanpur and Neta-Pyuthan for continuous monitoring of recorded wind data in 2007. Currently, an anemometer has been installed at Timal Danda of Kavre[7].

Table: 2. 2 the following table highlights of the wind measured stations in various parts of Nepal (Source: AEPC, 2009)

Station No	Station Name	Available Data Period		Remarks
		From	To	
00100	Nagarkot	June 2001	April 2006	
00120	Butwal	March 2001	August 2003	Shifted to Palpa
00150	Palpa	September 2003	December 2006	
00220	Thini	April 2001	January 2007	

[7] Source: Establishment of wind power pilot projects in two sites, Report 2009, AEPC

00230	Kagbeni	April 2001	February 2006	
00250	Okhaldhunga	April 2001	August 2005	
00300	Ramechhap	July 2005	October 2007	
00400	Phakhel	Oct 2007	To date	
00500	Neta	Dec 2007	To date	

The Solar and Wind Energy Resource Assessment (SWERA) project was conducted by Alternative Energy Promotion Centre in join in-country partnership with Center for Energy Studies/IoE, Pulchowk. The analysis of high potential area has been assessed based on the available data and certain assumptions. SWERA has focused only the area within 15 km from the existing national electricity grid. But the study was also carried out in Annapurna Conservation Area, one of the protected areas of Nepal. There is also good wind speed available.

By considering commercially viable wind power density (WPD) 300w/$m^{2,}$ there is 6047 sq. km area with the aforesaid 300 or greater than 300 WPD. If 10% of the area is considered as feasible for wind energy production, then the huge amount of power can be generated from the wind. It is estimated 3000 MW of electricity can be generated from wind energy only which is far greater than electricity demand of Nepal (Source; SWERA Report 2008, AEPC).

Assessment of Wind Resources Potential

Wind resources map has been based on the Risø 50m agl wind potential map of 5 km resolution for Nepal. The analysis of high potential area has been assessed based on the available data and certain assumptions. In this analysis, only the area within 15 km from the existing national electricity grid has been considered as the potential area as there is14 existence of 11 kV transmission line. This assumption has been made on the basis that power generated from wind farm within 15km of the national grid will be viable for grid connection considering the topography of Nepal. This analysis is basically bounded to the area connectable to the grid. Though there are some high wind energy potential areas in

Nepal which are far from the grid, they are not considered in this analysis. Exceptionally, Annapurna Conservation Area, which is one of the protected areas of Nepal, has been considered and analyzed separately provided that there is high demand for electricity as well as high potentiality of wind energy in this conservation area. Very steep and difficult terrain with slope greater than 450 has been also removed from the analysis. Protected, densely populated and forest areas have been removed for the analysis. Wind power density less than or equal to 100 Watt/m2 are not useful for wind energy harnessing. WPD greater than 200 Watt/ m2 are normally taken for consideration for non grid connected power generation while greater than 300 Watt/ m2 are considered as grid connectivity wind energy in developing countries. The analysis shows area above 300 Watt/ m2 composed of 97 sq km and with 5 MW installed per sq km, yields 489 MW. These areas have been calculated on a conservative basis so that the exploitable area for wind energy can be increased by covering greater area from the national grid and specially analyzed in specific areas with greater wind energy potential.

Wind Potential Assessment in Annapurna Conservation Area

Annapurna Conservation Area is one of the famous trekking and tourist destinations in the world. Being one of the famous trekking destinations; demand of electricity for local people and tourist is very high but being a conservation area, it has definitely fragile ecosystem and any man made activity should be limited. Moreover, physical development should be initiated with in-depth research and analysis with regards to ecological, cultural and natural perspective. People in this area still depend upon traditional energy resources; such as firewood kerosene and other petroleum products to fulfill the energy demand except in some potential places where solar and micro hydropower in use for the lightning purposes. In this context it should be noted that Annapurna Conservation Area is one of the high wind energy potential areas of Nepal. Land use pattern shows that barren land and small pasture land are dominant and forested areas are at minority land cover unlike the other national parks of Terai and hilly regions of Nepal where densely forested area are the dominant land cover. Though in international practices, conservation and protected areas are not chosen for wind farming, the ACAP region has a different case. Hence it can be concluded from the

aforementioned reason. Wind farming would not only help in conservation of environment and forest but it would help in reducing many environment related problems in the ACAP area. In this way, the protected area can be made pollution free or less polluted by generating wind energy which finally helps in the sustainable development of the area with clean energy in fragile ecosystem region.

By the analysis, it has found that ACAP area covers 143 sq km above WPD 300 Watt/ m2 and with 5 MW installed per sq km yields 716 MW which is very huge amount in case of Nepal which have very low power generation from green energy source. In this assessment also, wind resource potential mapping has been done in the buffer region of 10km from the existing grid (grid connected wind resource potential mapping) so that the power generated from the wind energy could be integrated into national grid without huge cost of transmission and distribution. If the total conservation area is considered, then the wind energy potential will be definitely much higher than the aforesaid wind power potential (Source; SWERA Report 2008, AEPC).

Gross Wind Potential of Nepal

By considering commercially viable wind power density (WPD) 300 w/m^2, there is 6074 sq. km area with the aforesaid 300 or greater than 300 WPD. If 10% of the area is considered as feasible for wind energy production, then the huge amount of power can be generated from the wind. From aforesaid figure, 10% of the 6074 sq. km i.e 607.4 sq. km at the rate of 5 MW per sq. km, 3000 MW of electricity can be generated from wind energy only which is far greater than electricity demand of Nepal[8].

[8] Source: Solar and Wind Energy Resource Assessment in Nepal, July 2008

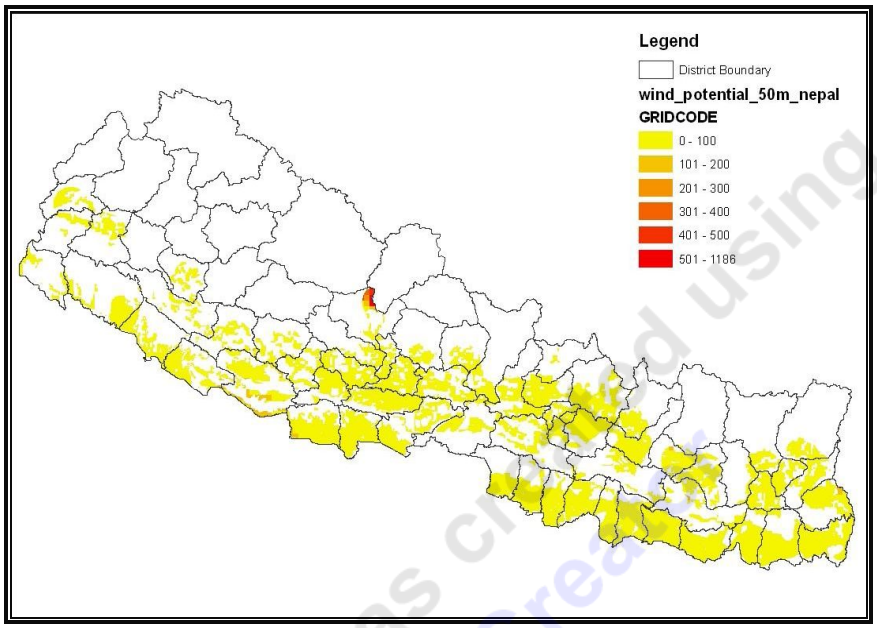

Figure: 2. 1 Wind power potential in Nepal (Source: Adopted from SWERA Report, July 2008)

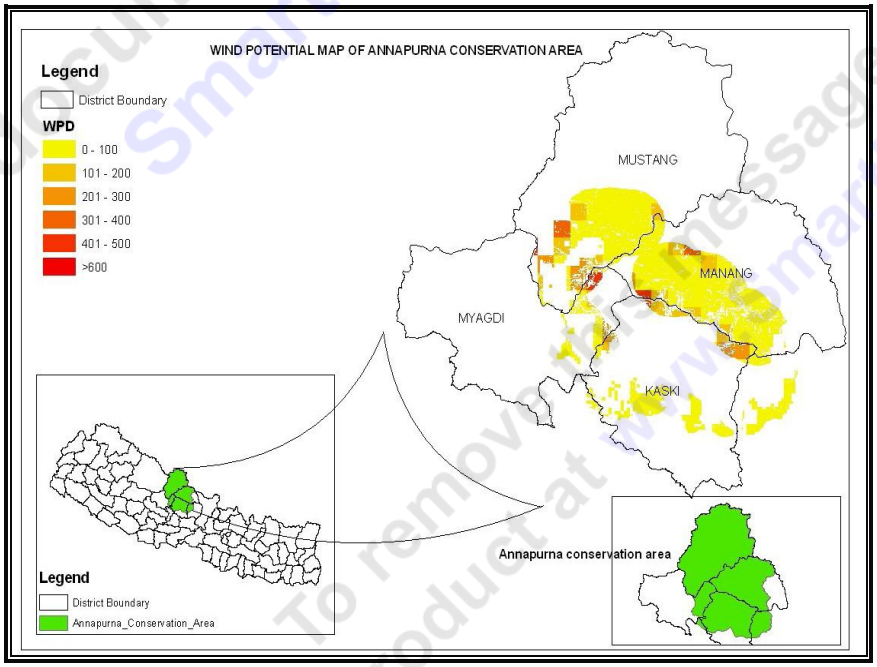

Figure: 2. 2 Wind power potential in Annapurna Conservation Area (Source: SWERA Report, July 2008)

CHAPTER-THREE

3. RESEARCH METHODOLOGY

In this chapter the data collection, the selected theory and the different methodological considerations regarding the theory and case of choice, the elaboration of the indicators all are presented. The study was carried out using primary as well as secondary information. For primary information, various organizations and people involved in development, promotion and dissemination of technologies were contacted using formatted questionnaire. Sources of secondary information were various published and unpublished reports, technical manuals, bulletins, brochures etc.

3.1 Rationale for the selection of the study site:

The study is expected to find out the reasons for small wind power development to reduce the energy crisis in Nepal. The study area had got clarify about the efficient use of wind and its impact on the life of the people. They have had got the electricity as the

primary source from the use of the system where there is lack of national grid system. The consumption pattern of kerosene had been reduced gradually and the study hour of student had been increased due to the use of wind power.

3.2 Nature and Sources of data:

The study is based largely on both secondary as well as primary data. Primary information was obtained to assess the status of wind energy in Hanshapur VDC of Pyuthan District from field visit. Secondary source materials were drawn from printed literatures, websites, journals, proceedings, books and reports prepared by the concerned authorities.

3.3 Sampling Procedure:

Two different sets of questionnaires were designed, one for VDC level information collection and the other for households survey. The survey checklist designed is presented in the Annex 1 of this report. Hanshapur VDC of Pyuthan district was selected for this study. The study area was visited and survey and planning activities conducted with the help of a local staff of VDC.

Interviews and focus group discussions were carried out with the following to collect the primary data and information.

- The VDC secretary and the representatives
- The community people,
- The concerned officials of district level organizations, line agencies and the CBOs.

In total 20 respondents who are the direct user group and the local people of the small wind power generation in the study area for the study was selected by random sampling. Since the study population is limited and it was difficult to select the sample respondents. However structured questionnaire were asked for 20 people whose households were connected with wind power systems at Hanshapur VDC of Pyuthan district.

3.4 Research Design:

The ultimate target of this study is to identify the efficiency, problems and prospects of wind power in Hanshapur VDC of Pyuthan district. The design to the study is made to derive conclusion answer to the subject matter. This study followed the combination of exploratory or formulative, descriptive and diagnostic research design. The research study assesses the status and potentialities of wind energy use in the study areas and the way it is being used at present. It also determines the different aspects of wind power uses for of peoples' life as energy, income and for clean environment.

3.5 Data collection, Techniques and Tools:

The tools used to obtain information for this study were formal and informal interview with key informants and literature survey. The structured questionnaire, checklist, field observations were operationalized for collecting primary information.

The primary data have been collected by using the following techniques and tools.

Table: 3. 1 Tools and Technique

S.N.	Techniques	Tools
1.	Interview	Structured questionnaire /interview guide
2.	Observation	Checklist

I. Interviews/FGDs:

Interviews were taken to gather information regarding forest, rural enterprises, available rural technologies with the concerned line agencies and stakeholders in the district. Ex-chairpersons and key informants from the study VDC were also interviewed. Information obtained through these interviews was useful in arriving at a firsthand picture of the study area and later verified and triangulated during FGDs and questionnaire survey. FGDs were conducted in local level. The key informant interview has included interaction with knowledgeable persons, school teacher, local learned person, members of Mothers

Group, etc to collect the information on wind power activities. Resource maps are prepared during FGDs, and information collected through interviews was also verified.

II. Observation:

The study areas and farming sites, farming pattern, involvement of family members were observed using checklist**.** The places of research study were visited based on information gained from FGDs. Development of wind power and its impact on socio-economic status was focused. Likewise, settlements/places favorable to use/promote wind power were also observed. For the survey, an appropriate checklist has been devised.

3.6 Data analysis:

After completion of field survey/interview schedule from primary data collection, data had been coded preceded. Various computer software programmed had been taken and simple statistical tools like; table, graphs has been used for data analysis. In this process, descriptive methods were used for qualitative data. The data has been presented on the tables and graphs/figures according to the study. Some photographs have been presented wherever they are useful. In order to meet the objectives of the study; all findings, results, conclusion and recommendations are compiled as a final report. The final report is submitted according to format prescribed by Central Department of Rural Development of University campus, Kirtipur, Kathmandu.

CHAPTER-FOUR

4. DATA ANALYSIS AND INTERPRETATION

The purpose of this chapter is to analyze the livelihood impact for the small-scale farmers producing and further use of wind powered electricity at Hanshapur VDC of Pyuthan district. Subsequently, the case study of Hanshapur VDC and the status of established wind power projects is reviewed in relation to the rural livelihood in order to analyze the possible impacts, positive as well as negative, on the livelihood of rural family.

4.1 Community Access to Different Facilities:

Table: 4. 1 Community access to different facilities

S.N.	Facilities	Whether within Community Yes ….1, No…..2	If not within Community, then distance from the Center of the Community (km)
01	Hospital	2	75
02	Health Center	1	0
03	Pharmacy	2	10
04	Primary School	1	0
05	High School	1	0
06	Secondary School	2	10
07	College/ University	2	35
08	Post Office	1	0
09	Milk Booth	2	9
10	Provision/ Grocery Shop	2	7
11	Market	1	0
12	Rice Mill/ Wheat Mill	2	5
13	Bus Station	2	5
15	Bank	2	55
16	NGO	1	0
17	Agriculture Extn. Office	2	7
18	Paved Road	2	55
19	Unpaved Road	1	0

Data Source: Primary field Survey

From the above mentioned table, the accessibility pattern of the area is clearly identified. There can be easily access of the primary facilities as unpaved road for walking, transportation, post-office for the communication, access to education by the primary and high school, market for shopping of daily needs and agro products, helping agency as NGO within the community of the study area. Near to the others facilities like rice mill and bus station is 5km, grocery and agriculture extension is 7km, milk booth is 9km, secondary school and pharmacy is 10km, university 35km, paved road and bank is 55km, and the hospital is 75km away from the community centre.

4.2 Family's Main Sources of Income:

Table: 4. 2 Family main sources of income

Main Sources of Income	Total Number of Responses
Agriculture	20
Animal Husbandry	15
Trade/Business	5
Job Holder	3
Others	7
Total	**50**

Data Source: Primary Field Survey, 2066

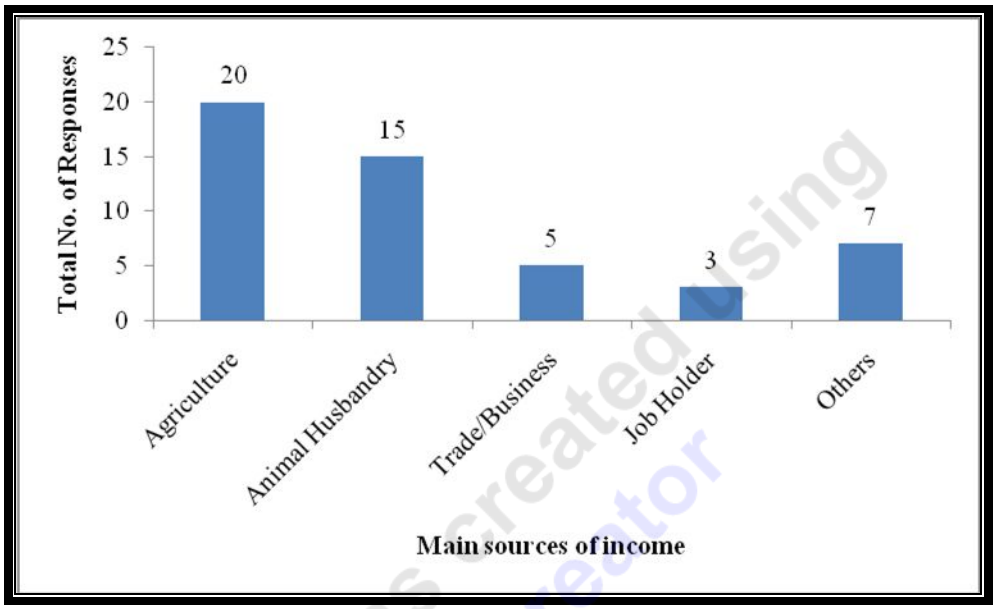

Figure: 4. 1 Main sources of family's income

Figure 4.1 display the total no. of responses for the sources of family income. The response was largely varied by sources of income. The higher responses was found for the agriculture (20) followed by animal husbandry (15), others (7), trade/business (5), job holder (3). Therefore the analysis shows that the agriculture is the pre-dominated or the main source of income and is four times greater than trade/business.

4.3 Cooking Energy Sources:

Table: 4. 3 Cooking energy sources

Used Cooking Energy Types	Total Number of Responses	Percentage
Firewood	20	65
Kerosene	2	6
Biogas	0	0
LPG	0	0
Crop Residue	5	16
Cow dung cakes	4	13
Others	0	0
Total	**31**	

Data Source: Primary Field Survey, 2066

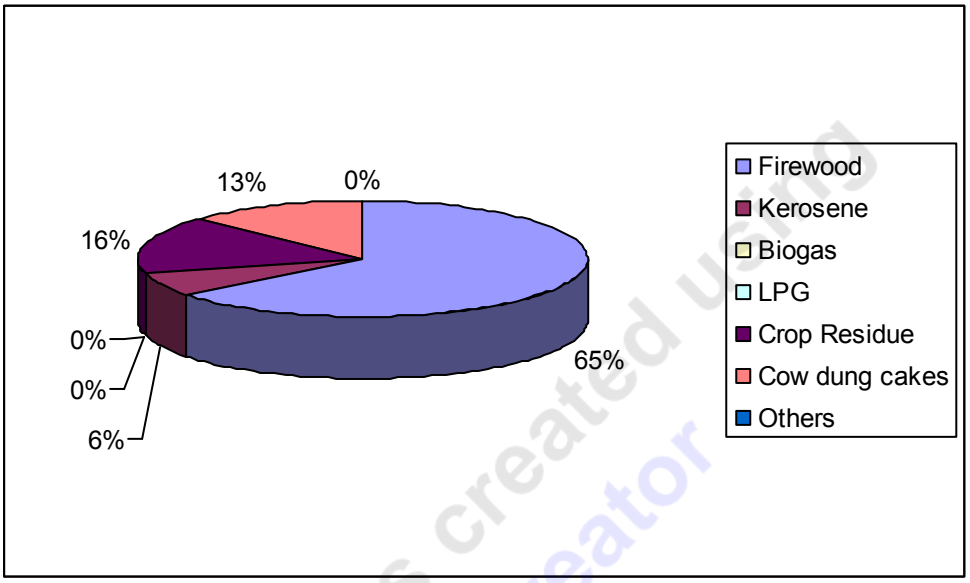

Figure: 4. 2 cooking energy sources at project sites of Hanshapur VDC

The people have not used the biogas, LPG and other sources as the cooking resources in the study area. Among 31 respondents, 65 percent of the people used firewood, 6 percent used kerosene, 16 percent crop residue, and 13 percent cow dung cake for the cooking energy sources that is easily clarified in by the figure 4.2.

4.4 Trend of Lighting Energy Types:

Table: 4. 4 Trend of lighting energy types

Used Lighting Energy Types	Total Number of Responses
Electricity from Wind	15
Kerosene	3
Solar Home System	1
Batteries	2
Candles	3
Others	0
Total	**24**

Data Source: Primary Field Survey, 2066

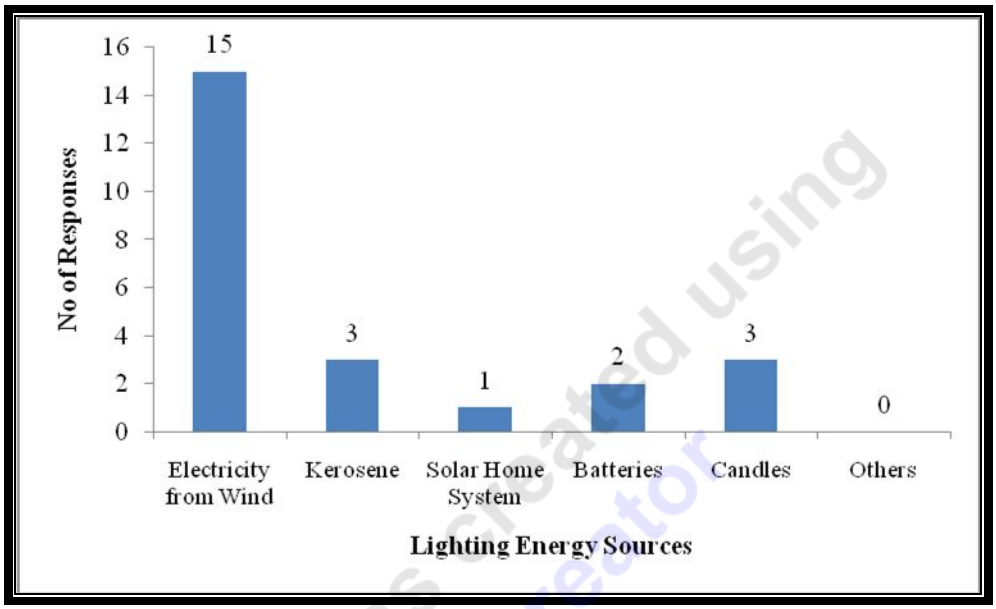

Figure: 4. 3 the trend of lighting energy sources at project sites of Hanshapur VDC

After the installation of the wind energy project, most of the using trend for lighting energy purpose is the electricity produced by the wind among the 15 responses which is five times greater than that the use of kerosene and candles that is the only no. 3 of responses, the use of batteries using responses is 2 the solar home system is 1 which can be easily identified by the figure 4.3.

4.5 Household Appliances at Project Sites:

Table: 4. 5 Household appliances at project sites

Used Household Appliances	Total Number of Responses
Radio	17
Television	0
Mobiles	5
Others	0
Total	**22**

Data Source: Primary Field Survey, 2066

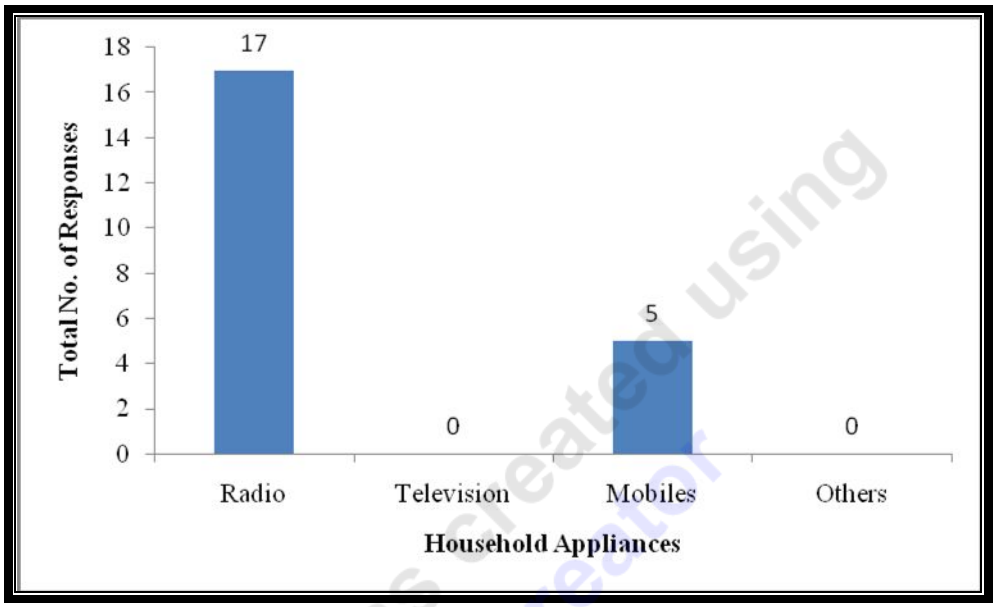

Figure: 4. 4 Household appliances at project sites of Hanshapur VDC

In total 22 responses, 17 respondents were found to be used radio; five respondents were found for the use of mobiles charge whereas no respondents were found to use Television and other home appliances through wind powered electricity due to its low capacity.

4.6 Quality of Electricity Produced from Wind Solar PV Hybrid System:

Table: 4. 6 Quality of electricity produced from Wind Solar PV hybrid system

Quality of Electricity	Total Number of Responses
Excellent	2
Fully Satisfactory	5
Almost Satisfactory	2
Poor	8
I don't Know	3
Total	**20**

Data Source: Primary Field Survey, 2066

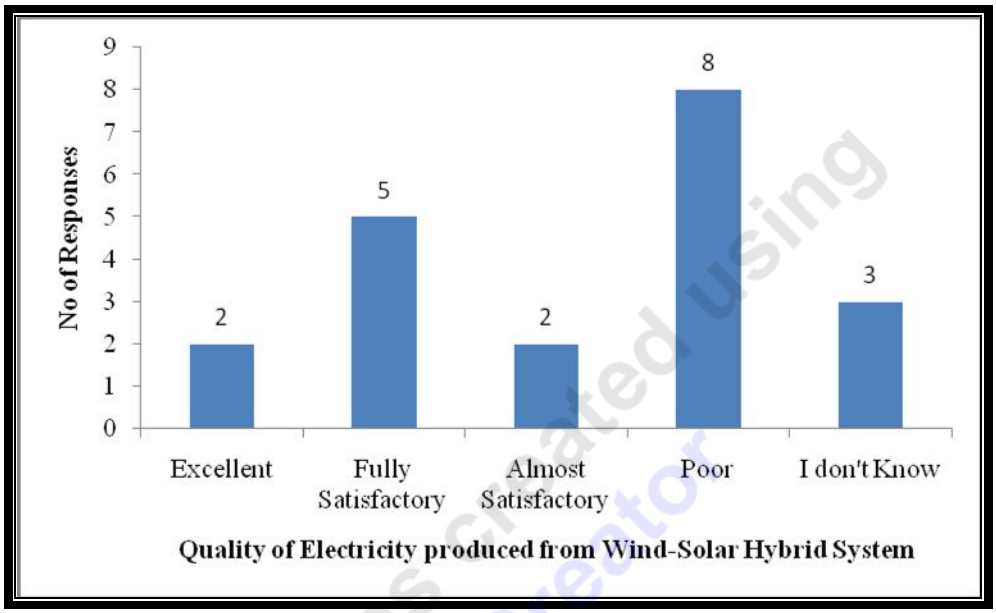

Figure: 4. 5 Quality of electricity produced from wind solar PV hybrid system

Among the 20 responses, the quality of electricity produced from wind solar PV hybrid system had been analyzed in figure 4.5. Accordingly, 8 responses were for poor quality of electricity produced by the system. Similarly, 5 responses were fully satisfied, 3 responses don't know about the system, and 2 responses were told that it is excellent and almost satisfactory too by the wind-solar hybrid system electricity generation.

4.7 AEPC Dealing Complains:

Table: 4. 7 AEPC dealing complains

Dealing About Complains	**Total Number of Responses**
Always	3
Sometimes	5
Never	10
I don't know	2
Total	**20**

Data Source: Primary Field Survey, 2066

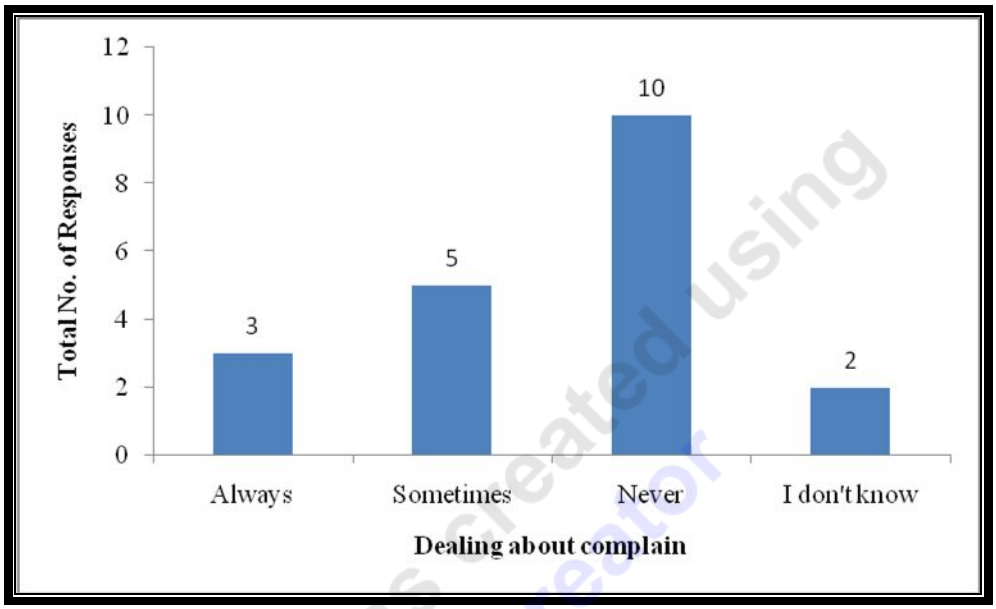

Figure: 4. 6 AEPC dealing about complain

Among the 20 responses, complain dealing about the main supporting agency AEPC for the project area has been identified. According to figure 4.6, 10 responses said that AEPC can never deal with complains ahead and leads on the higher rank which is twice as much as sometimes done that is 5 no. of responses, always deal with 3 responses and 2 responses are unknown responses.

4.8 Problems for Sustainability of Installed Wind Solar PV Hybrid Systems:

Table: 4. 8 Problems for sustainability

Problems for Sustainability	Total Number of Responses
Technical	2
Managerial	8
Socio-cultural	5
Financial	12
I don't Know	2
Total	**29**

Data Source: Primary Field Survey, 2066

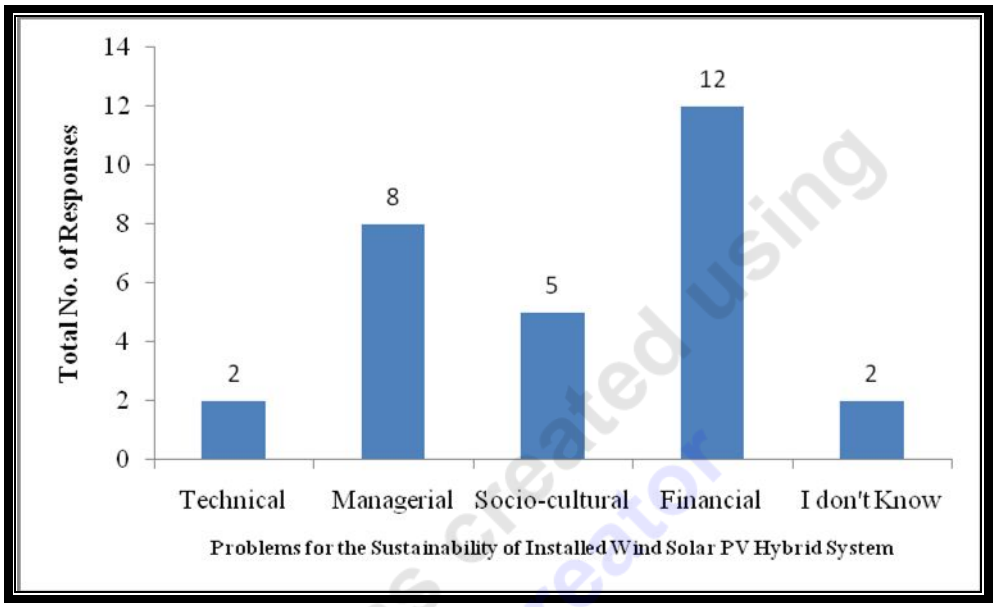

Figure: 4. 7 Problems for the Sustainability of the Projects

Problems for the sustainability of the installed wind solar PV hybrid system had been analyzed from figure 4.7; Financial problem had been the pre-dominated with the no. of responses 12 followed by managerial 8, socio-economic 5, technical problems 2 and unknown responses 2.

4.9 Role of Management Committees:

Table: 4. 9 Role of management committees

Role of Management Committee	Total Number of Responses
Excellent	1
Fully Satisfactory	3
Almost Satisfactory	5
Poor	10
I don't know	1
Total	**20**

Data Source: Primary Field Survey, 2066

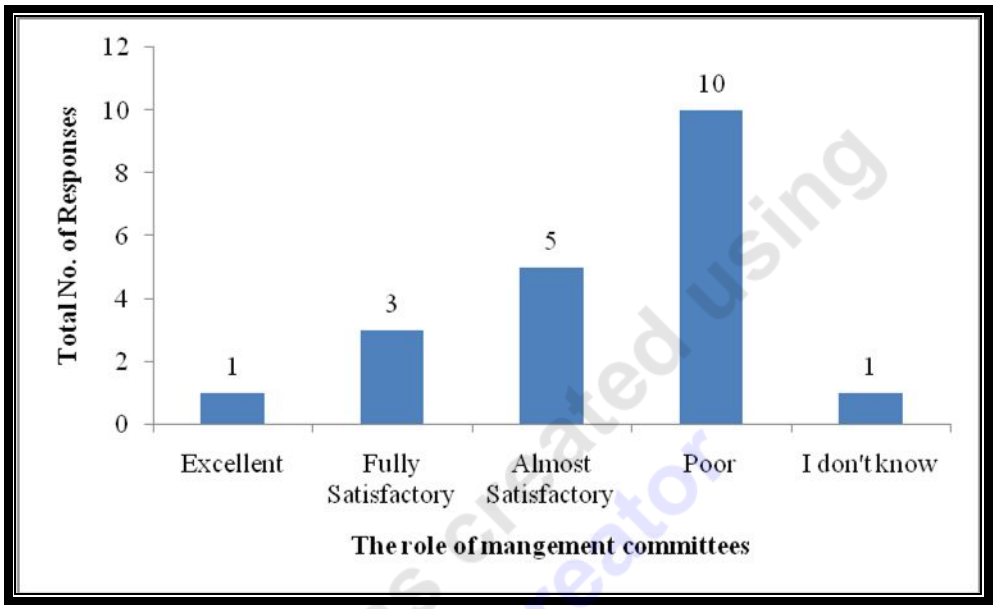

Figure: 4. 8 Role of Management Committees of Wind power projects at Hanshapur VDC

Figure 4.8 display the total 20 responses for analysis of the role of management committees in the system area. The response was largely varied and the higher responses was found to be 10 for the poor quality of the management committee followed by almost satisfactory 5, fully satisfactory 3, excellent 1, and unknown responses 1.

4.10 Households of Hanshapur VDC

Table: 4. 10 Households of Hanshapur VDC

SN	Description	Household Numbers
	Dalits Households	147
	Ethnic Households	432
	Others Households	59
	Total	**638**

*Source: Village Development Programs 2065 B.S. (Hanshapur), Pyuthan

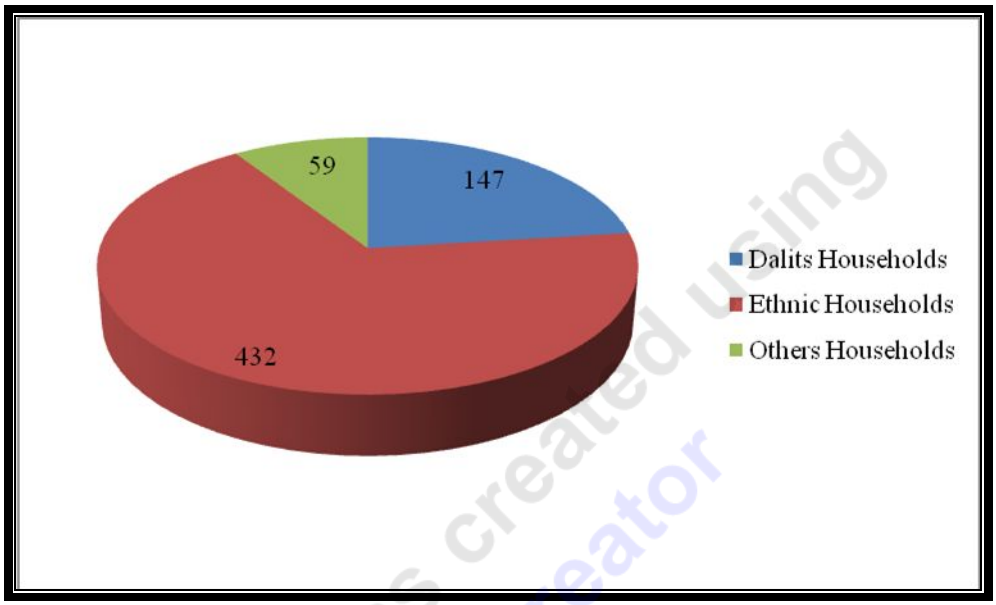

Figure: 4. 9 Total households at Hanshapur VDC

Among the 638 household, there were 147 households of dalits, 432 households of ethnic groups and 59 households of another community in the study area at Hanshapur VDC of Pyuthan district.

CHAPTER-FIVE

5. FINDINGS

5.1 Utilization of Energy produced from Wind Solar hybrid system at Masjid in Kaskot:

The Masjid was established on 2011 B.S. The teacher of Masjid is called Mulbi. According to Muslim culture, it is necessary to pray Nawaj five times a day. Firstly before sunrise it is Nawaj of Fajir whereas last one is Nawaj of Isha. The duration of Isha Nawaj will approximately 45 minutes during night.

One day in the year, the day of Shuvabarat; the Muslim people must pray Nawaj of Nafil for whole night in Masjid. Before the installation of the wind solar PV hybrid system they were using oil lamp for lighting purpose in their occasion like of Shuvabarat. Now the situation has been changed totally. The led lamp from the energy produced from the new installed system gives more light than before and easy to handle it with switch. They feel very easy to use electrical lamp instead of oil lamp. The Muslim people were so happy after white led bulb kept in Masjid area. Whole Muslim community felt benefited after having the electricity in the Masjid.

Beside this, other Muslims also will be benefited during festivals like Id, Roja Moharrum, and Bakra Id etc. They were not using bulb but also mike and speakers at the celebration of such occasions and functions at the Masjid. Thus the people were almost satisfied from the system.

The Muslim community is still backward in the name of education, so better the education better will be their life standards. Education is one of the best indicators for the Human Development Index (HDI). Thus it will automatically help for the up-liftment of such communities and they should come on the line of development. Then only Rural Development leads to be success and help for the reduction of poverty, diseases and generation of awareness in different activities for the Nation Development.

5.2 Utilization of Energy produced from Wind –Solar Hybrid systems at Rural Settlements of Hanshapur VDC, Pyuthan:

Electrification through small wind energy technology is used in isolated settlements of Hanshapur VDC. The reduction in the consumption of kerosene is definitely supported for economic activities and other public welfare. Before this wind power installation all households were using kerosene lamp. Currently, total 27 households, 1 Masjid and 1 school are using the electricity generated by wind solar PV hybrid systems for lighting purpose and other electrical devices.

Table: 5. 1 Use of electric appliances at Neta

HH No	Name of owner	Number of appliances	Type & Watts	Application
1	Roj Mahamad	1	4 Watts, Long Life CFL	Light
2	Askar Ali	1	4 Watts, Long Life CFL	Light
3	Sahamad Miyan	1	4 Watts, Long Life CFL	Light
4	Mamadin Miyan	1	4 Watts, Long Life CFL	Light
5	Jalil Miyan	1	4 Watts, Long Life CFL	Light
6	Shivalal B.K.	1	2.5 Watts, Long Life CFL	Light
7	Bal Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light
8	Krishna Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light
9	Santa Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light
10	Nara Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light
11	Man Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light
12	Nek Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light
13	Kul Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light
14	Jit Bahadur B. K.	1	2.5 Watts, w/led bulb type	Light

Data Source: Primary Field Survey, 2066

In totality the use of wind energy generated is for the lighting purposes which are the only one CFL of either 4 or 2.5 watts per household at Neta from each individual household.

Table: 5. 2 Use of electric appliances at Kaskot A

HH No	Name of owner	Number of appliances	Type & Watts	Application
1	Abdul Ajad	2	2.5 Watts , w/led bulb type	Light
2	Safar Ali	2	2.5 Watts , w/led bulb type	Light
3	Ahammad Miyan	2	2.5 Watts , w/led bulb type	Light
4	Hakim Miyan	2	2.5 Watts , w/led bulb type	Light
5	Halima Khatum	1	2.5 Watts , w/led bulb type	Light
6	Samsodin Miyan	2	2.5 Watts , w/led bulb type	Light
7	Hakit Miyan	2	2.5 Watts , w/led bulb type	Light
8	Rafi Mohammad Miyan	2	2.5 Watts , w/led bulb type	Light

Data Source: Primary Field Survey, 2066

In totality the use of wind energy generated is for the lighting purposes which are the only one CFL of 2.5 watts per household at Kaskot A from each individual household.

Table: 5. 3 Use of electric appliances at Kaskot (Sarki Households)

HH No	Name of owner	Number of appliances	Type & Watts	Application
1	Tom Bahadur Samat	1	4 Watts, Long Life CFL	Light
2	Suntali Samat	1	4 Watts, Long Life CFL	Light
3	Tan Bahadur Samat	1	4 Watts, Long Life CFL	Light
4	Shuk Bahadur Samat	1	4 Watts, Long Life CFL	Light
5	Mahamad Ali	1	4 Watts, Long Life CFL	Light

Data Source: Primary Field Survey

In totality the use of wind energy generated is for the lighting purposes which are the only one CFL of 4 watts per household at Kaskot from each individual household.

Table: 5. 4 Use of electric appliances at School

S. N.	Name of owner	Number of appliances	Application

1	School	4	Light
2	School	1	Computer
3	School Teacher	Power Socket	Mobile Charge

After the installation of the wind energy project in the area, the facilities of the school have been better than before because there have been 4 bulbs for lighting purpose, 1 computer for education supports and the school teacher are using mobiles for the communication through the use of power socket for mobile charger.

5.3 Impact of Wind Solar PV Hybrid System Before and After Installation:

Table: 5. 5 Impact of electricity before and after the installation at Kaskot A (Danda)

SN	Name of Owner	Total number of students	Before Installation of Wind System		After Installation of Wind System		Remarks
			Study hours	Kerosene (ltrs/m)	Study Hours	Kerosene (ltrs/m)	
1	Abdul Ajad	2	1.5	1	3	-	There is no kerosene consumption after installation.
2	Safar Ali	-	-	3	-	-	
3	Ahamad Miyan	2	1	2	2	-	
4	Hakim Miyan	3	1.5	2	3	-	
5	Nasir Miyan	2	1	2.5	2	-	
6	Samsudin Miyan	3	1	3	2	-	
7	Hakit Miyan	1	1	2	2	-	
8	Rafik Miyan	3	1	4	2	-	

Data Source: Primary Field Survey, 2066

Above table illustrates that, the average study hours of student before the installation of wind energy system was found to be only 1 hour and kerosene consumption is 2.43 liter per month. But after the installation of wind energy system it has been changed totally and the average study hours would have been increased to 2 hours. The capacity of improvement within system has increased at about twice than that of previous technology they used and no kerosene consumption for lightening process after the installation of

wind energy technology. Thus it has saved money of 2-3 liter of kerosene per month per household.

Table: 5. 6 Impact of electricity before and after the installation at Neta

SN	Name of Owner	Total number of students	Before Installation of Wind System		After Installation of Wind System		Remarks
			Study hours	Kerosene (ltrs/m)	Study hours	Kerosene (ltrs/m)	
1	Shiva Lal B.K.	-	-	3	-	-	There is no kerosene consumption after installation.
2	Bal Bahadur B.K.	1	1.5	2	3	-	
3	Krishna Bahadur B.K	2	1	2	2.5	-	
4	Santa Bahadur B.K	-	-	1	-	-	
5	Nara Bahadur B.K	2	1	3	2	-	
6	Man Bahadur B.K	3	1	2	2.5	-	
7	Nek Bahadur B.K	1	1.5	2	2	-	
8	Kul Bahadur B.K	3	2	3	3	-	
9	Jit Bahadur B.K	2	1	4	3	-	

Data Source: Primary Field Survey, 2066

Above table illustrates that, the average study hours of student before the installation of wind energy system was found to be only 1 hour and kerosene consumption is 2.44 litre per month. But after the installation of wind energy system it has been changed totally and the average study hours would have been increased to 2 hours. The capacity of improvement within system has increased at about twice than that of previous technology they used and no kerosene consumption for lightening process after the installation of wind energy technology. Thus it has saved money of 2-3 liter of kerosene per month per household.

5.4 Total Benefited Population at Hanshapur VDC by Wind Power:

a. Details of beneficiaries at Neta:

In Neta, the benefited total population from wind-solar PV hybrid system was 83. Among them 42 people were male and 41 people were female which include 30 children. There were total 23 students from 14 households. The female population has been the most benefited that is clearly identified from the table below.

Table: 5. 7 Details of beneficiaries at Neta

S.N.	Male	Female	Children	Student	Total
1	2	3	1	-	5
2	2	1	-	1	3
3	2	4	4	1	6
4	3	1	2	-	4
5	4	5	5	4	9
6	3	3	4	3	6
7	2	3	3	1	5
8	4	3	2	2	7
9	3	3	1	-	6
10	5	4	4	3	9
11	2	3	1	-	5
12	3	2	-	2	5
13	4	4	2	3	8
14	3	2	1	3	5
Total	42	41	30	23	83

Data Source: Primary Field Survey, 2066

b. Details of beneficiaries at Kaskot A:

At Kaskot A, the benefited total population from wind-solar PV hybrid system was 85. Among them 42 people were male and 43 people were female which include 30 children. There were total 22 students from 8 households. The female population has been the most benefited.

Table: 5. 8 Details of beneficiaries at Kaskot A

S.N.	Male	Female	Children	Student	Total
1	13	14	8	6	27
2	2	2	1	-	4
3	2	4	4	3	6
4	4	3	5	4	7
5	6	2	3	2	8
6	5	8	3	3	13
7	4	3	2	2	7
8	6	7	4	2	13
Total	**42**	**43**	**30**	**22**	**85**

Data Source: Primary Field Survey, 2066

c. Details of beneficiaries at Kaskot B:

In Kaskot B, the benefited total population from wind-solar PV hybrid system was 40. Among them 19 people were male and 21 people were female which include 11 children. There were total 11 students from 5 households. The female population has been the most benefited.

Table: 5. 9 Details of beneficiaries at Kaskot B

S.N.	Male	Female	Children	Student	Total
1	3	6	3	2	9
2	3	4	2	2	7
3	4	3	2	3	7
4	7	5	3	4	12
5	2	3	1	0	5
Total	**19**	**21**	**11**	**11**	**40**

Data Source: Primary Field Survey, 2066

d. Details of beneficiaries at School:

Table: 5. 10 Details of beneficiaries at School

S.N.	Teachers			Students						Total
	Male	Female	Total	Male	Female	Dalit	Ethnic	Muslim	Others	
1	12	2	14	328	297	93	425	53	54	625

Data Source: Primary Field Survey

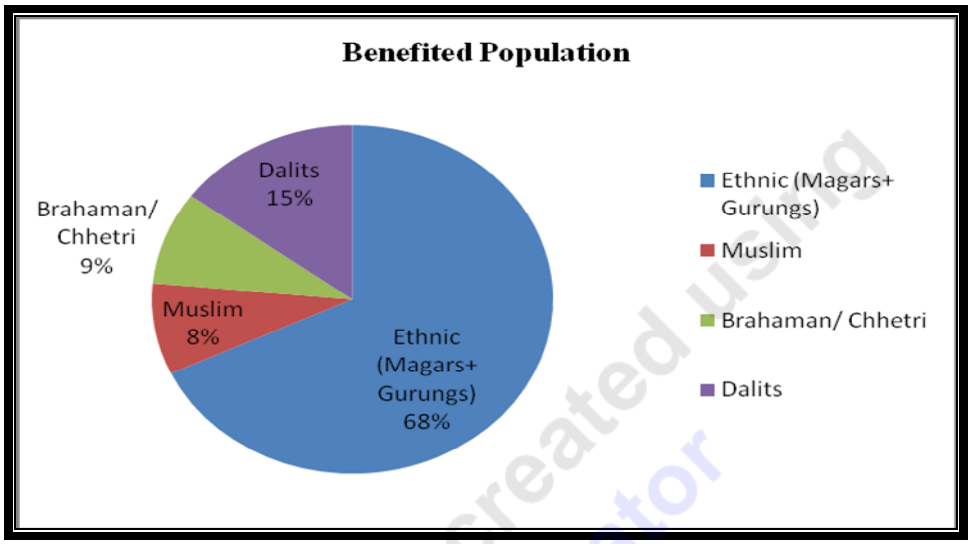

Figure: 5. 1 benefited population at School

Figure 5.1 can describe that the most benefited population is ethnic group 68%, then after dalits 15%, Brahman/Chhetri 9% and Muslim 9% in descending order at school. Thus the ethnic population has got more benefit from the system at the school in the study area.

5.5 Technical Parameters of Installed Each System:

5.5.1 Battery

Type	: Deep cycle
Manufacturing Company	: Rahmafrooz (Volta)
Capacity	: 45AH*6= 270 AH
Discharge Rate	: C 20 %
Voltage	: 12 Volts

5.5.2 Solar PV

Company	: BP Solar
Capacity	: 160 Watts
Voltage output	: 12 Volts
Average solar radiation	: 5.5 hours/day

5.5.3 Wind Power

Capacity	: 400 Watts , 3 Blade rotors
Voltage output	: 12 Volts
Tower Height	: 13 m
Current	: 270 Ah

5.5.3 Wind Power:

Capacity	: 400 Watts, 3 Blade rotors
Voltage output	: 12 Volts
Tower Height	: 10-13 m
Current	: 270Ah

5.5.4 Data Logger:

There was no recorded wind data in the time of pre-feasibility study. Wind speed measurement for one week and local people were major bases for the establishment of wind solar PV hybrid systems at Hanshapur VDC, Pyuthan. Without adequate data on wind speed, it is difficult to harness electricity from wind energy. However, in both sites installed systems were running smoothly.

Wind data in high wind areas is currently being collected in various places in Nepal. Wind data logger has also been installed by Alternative Energy Promotion Center (AEPC) to monitor continuous wind speed at the site Neta nearby wind plant.

5.6 The Management of the Systems:

The four user's committees had already been formed within the community in order to ensure the successful operation and maintenance after the installation completed. All management committees were found responsible for the sustainable management of installed system. The committees have also appointed four Operators of wind-solar PV hybrid system from among them.

5.6.1 Management Committees:

A. The Wind-Solar PV Hybrid System

User Committee Kaskot A

Hanshapur VDC, 6 Pyuthan

Chairperson : Rafi Mohammad Miyan

Member of Secretary : Abdul Ajad (Operator)

Member : Halima Khatum

Member : Shamsudin Miyan

Member : Ahamad Miyan

Member : Manufa Khatum

Member : Putali Miyan

Member : Hakim Miyan

Member : Representative from Masjid.

Member : Representative from VDC.

B. The Wind-Solar PV Hybrid System

User Committee Neta

Hanshapur VDC, 6 Pyuthan

Chairperson : Shiva Lal B. K. (Operator)

Member Secretary : Jit Bahadur B. K.

Member : Kul Bahadur B. K.

Member : Nek Bahadur B. K.

Member : Man Bahadur B. K.

Member : Nara Bahadur B. K.

Member : Santa Bahadur B. K.

Member : Krishna Bahadur B. K.

Member : Bal Bahadur B. K.

Member : Representative from VDC.

C. The Wind-Solar PV Hybrid System

User Committee Kaskot B

Hanshapur VDC, 6 Pyuthan

Chairperson : Mr. Mahamad Ali

Member of Secretary	: Mr. Jun Bahadur Samat
Member	: Mr. Tan Bahadur Samat
Member	: Mrs. Suntali Samat
Member	: Mr. Tom Bahadur Samat
Member	: Representative from VDC.

D. The Wind-Solar PV Hybrid System

User Committee Saraswati Secondary School, Chava

Hanshapur VDC, 6 Pyuthan

Chairperson	: Mr. Gopal Bahadur K.C.
Member of Secretary	: Mr. Laxman G.C.
Member	: Mr. Jhag Bahadur BK
Member	: Mr. Rudramani Bhushal
Member	: Mr. Himalayan Rijal
Member	: Representative from VDC.

The management committees have been collected monthly tariff of NRs.25 at Kaskot A and Neta in both while NRs.30 for Kaskot B. And school collects NRs.500 per month from the establishment date of the system intervention. But the collected money has not been used for any system maintenance and the technocrat's brought from outside for their uses for new houses build up and extra other activities in the school for the system.

5.6.2 The role of Operators:

The operators are from the user groups within the community. The major role is for the switch on and off the MCB as per suggested by the technician. The operator must switch on at 5 pm and switch off at 7 am daily as their regular routine. And noticeable point is to take daily records of lighting hours of bulbs, wind mill running (fan moving) hours, volt s and load ampere in the meter etc. The protection of batteries, solar panel, controller box, wires etc is their major responsibilities. And to take care of and checking of wires on pole, to check battery and addition of distilled water as per necessity for finding out that

all the equipments are working perfectly or not. These are their duties for the management of system for their community needs.

5.7 Environmental Perspective at Study Area:

5.7.1 Socio-economic and Culture Environment:

The impact assessment on socioeconomic and culture environment highlights significant positive and negative impacts due to project construction and operation. The social, economical and cultural impacts have been predicted based upon the availability of primary data of project sites. Local people are very positive towards the proposed project and there is no seriously project affected families. It can be said that, if people perceive benefits then cultural and religious barrier do not affect for technological acceptance. The public health and situation in the project area is rather poor. There are no toilet facilities and open defecation along the forest is a common practice. The drinking water supply is also a difficult task for local women. Due to the poor economic condition and unemployment, the male of the family are forced to migrate from village.

Generally local indigenous people have an historical relationship with their lands and holistic traditional scientific knowledge of natural resource and the environment. The process to empower indigenous communities should recognize their values, traditional knowledge and resource management practices and their dependence on renewable resources. Thus, their participation in local and national rural sustainable development decisions should be strengthened. Without considering the social and economic status of local people, development projects in Nepal sometimes run into problems because they are unable to maintain a socio-cultural relationship with the local communities. There were also some problems emerged to block the progress of project but all issues have mitigated locally.

In Hanshapur, to address the need of local people; there should ensure development programs provided with a healthy environment, improved living standards, education and more employment opportunities. Most of the respondents were so happy with a query related to the demand driven technologies in surrounding Hanshapur VDC. They are

positive to install wind power plants, biogas, Improved Cooking Stoves but need of financial support from government and other donor agencies.

5.7.2 Community Forest:

Local people have been involved in the development, conservation, management and sustainable use of community forest. In the project area forests are important natural resources and play an important role in protecting the both physical and biological environments. Forests are sources of firewood, fodder, timber and medicines as well as being primary source of income. Community forest has large amount of fund raised through trade of woods and other taxes. The existing committee of Paluthan community forest has provided financial assistance on education, health and in other social welfare programs. The main forest types are *shorea robusta*, *castanopsis indica, schima wallichi etc.*

5.7.3 Disturbance to wildlife population:

The possible adverse impacts on species diversity of local wildlife population will be minimal. The frequency of wildlife species visiting the area is very low due to sparse vegetation and frequent human interference. No residential species are reported to be available in the area. Noise and vibration produced by project activities during night time operations negligible.

5.7.4 Access Road:

The fair weather/seasonal agricultural road from Baddanda to Hanshapur is being constructed. This will have positive impacts to the local people and their socio-economic conditions as well.

5.7.5 Decrease in dependence on fuel:

Wood is the major sources of heating and cooking that is the main causes of deforestation. People use kerosene lamp for lighting purpose during night. Generally 3 to 4 liters kerosene consumed by people of influence area per month. The supply of electricity produced from Wind-Solar PV hybrid to surrounding area in a reliable way will decrease dependence of local households on imported highly expensive kerosene

consumption. The main beneficial impact of the project is to increases the use of wind energy for light purpose instead of kerosene lamp. The replacements of kerosene lamp have significantly reduced eye infection in women and children. Thus health cost will also be reduced by wind power.

5.7.6 Opportunity:

The local two operators might get an opportunity for such employment and they will have an opportunity to raise economy. In addition to this, local women of the project site will have a good chance for starting night literacy classes. The school has also chance to organize different income generating activities.

5.7.7 Air, Noise and Water pollution:

After the starting of the project, there is a non significant effect of Air, Noise and Water pollution. Noise pollution due to fan rotation is also acceptable noise level. The wind power plants have contributed to reducing the emission of green house gas. They do not have any adverse effects on the environment. The indoor pollution is one of the major causes of different long term diseases in the rural areas. The Wind- Solar (PV) Hybrid systems have contributed to reduce the indoor pollution and support for the sustainable use of the available potentially renewable resources.

5.7.8 Slope instability and erosion:

Due to complex interaction between water, soil and topography, the slope failure, landslide and mass wasting are the common features in the hill ecological region. The soils encountered within the project sites are mainly of alluvial, colluvial and residual types. However it seems there is no possibility of landslides around the project sites.

5.7.9 Batteries Management:

The management of batteries for sustainability is a major challenge in perspective of environmental protection. Due to lack of awareness in local people, they can ignore /misuse of deep cycle batteries. The careful management of batteries should be taken as an important priority for the development of wind energy. Furthermore, batteries suffer damage from deep discharge and it becomes useless more quickly. Regular monitoring of

batteries and addition of distilled water timely are the most essential key factors for sustainability.

Box- 1: a student satisfied with Wind Solar PV Hybrid System at Hanshapur VDC

 Rajish Ali, the student of the school and Masjid too has utilized both modern information technologies like computer in school and celebration of their occasion like Roja Moharrum, and Bakra Id etc.in Masjid. He including other Muslims was not using bulb but also mike and speakers at the celebration of such occasions and functions at the Masjid. Thus the people were almost satisfied from the system.

5.8 Issues and Challenges:

Renewable Energy Technologies are simple and affordable technologies for the rural people in Nepal. However several issues are there to tackle with for a sustainable and equitable distribution and appropriate utilization of Renewable Energy Technologies for rural development. Rural communities of Nepal are credited to maintain traditional knowledge through their indigenous institutions which follow the social norms, resolve local disputes and mobilize local community for common causes and minimize the tragedy of common properties. Deforestation and environmental pollution are common concerns in Hanshapur VDC also.

- **Need Identification:** There is no investment friendly environment because the local people are unable to identify own needs. Lack of real need identification and locally appropriate alternatives for energy sources by the local poor people.
- **Migration and displacement problem:** Due to the poor economic condition, insecure socio-political scenario and unemployment, the male of the family are forced to migrate, which directly affects the sustainable operation of new entered technologies.

- **Illiteracy:** The majority of rural population is illiterate, which causes difficulty in making people understand need, importance and proper use of new technologies for their socio-economic development. Awareness about RETs among local people of Hanshapur is also low.
- **Manipulation and miss matching of priorities:** Poor people are often voiceless and powerless; they are unable to claim own right if their subsidies/assistance fund is misused. Thus purchasing power of rural people needs to be increased by income generating activities. The credit facility is not easy for rural poor. The real needy people are deprived from it.

- **Socio-cultural barrier:** Nepalese society is bounded with many traditional values, social beliefs and cultural norms. Sometimes, these make to the modern technology acceptance. For example, orthodox people do not use the biogas to prepare their meal because there is connection of toilet.

- **Crosscutting issues:** Crosscutting issues at Hanshapur VDC were Poverty reduction, gender issue, socio-cultural and economic issues. Likewise, inadequate development fund on local government institutions, non uniformity in implementation of the programs and donor driven policy and trickle down approach are also issues and challenges to develop renewable energy sectors.

- **Planning and policies:** Lack of long term energy plans and policies to develop and integrated with the overall development of rural community.

- **Coordination:** Rural development is multi-dimensionary in approach so interlinking with other subjects matter is difficult.

- **Education and training:** It is only limited in urban areas and that may not be beneficial for those vulnerable people in rural areas.

- **Inadequate subsidy and credit facility:** The minimum subsidy and quota of RETs are not sufficient and credit facility is not easy for rural people who have low level of income source.

- **Research and Design:** There is huge gap between these two areas and the developing activities were only done on the previously study area only due to the sufficient materials availability.

- **Geographical factors:** Transportation and communication facilities are not sufficient due to the topographic condition of our country.

- **Instable political system:** The frequent changing in the system causes changes in policies and strategies is a most important threat for the development activities.

5.9 Renewable Energy for Sustainable Rural Development:

Sustainable development is related to the quality of life. The degradation of the environment that denies the human society of these services can undermine the goals of development. If the benefits of economic growth and rising incomes are offset by the costs imposed on health and the quality of life by pollution then this cannot be called development. Without adequate environmental protection, development will be undermined and without development, resources will be inadequate for investment and environmental protection will fail. After the emergence of sustainable development, this would imply that development is based only on renewable resources, used at a rate at which they regenerate and leading to emissions and wastes that can be decomposed and digested by nature. The both developed and developing countries should focus on sustainable development strategies, policies and investments that will encourage more efficient use of resources and adoption of better technologies and practices that cause less environmental harm. Adoption of Renewable Energy Technologies would mitigate the negative effects of current patterns of using energy sources, prevent further degradation

of environment and the same time eliminate poverty and make development lasting and sustainable.

The wise use of available renewable energy is the essential vehicle to drive the progress and prosperity. Without economic growth, employment and poverty reduction, sustainable development remains a major issue forever. Local resource identification and mobilization is essential to meet the requirement of local people. The clean development mechanism (CDM) is more effective in renewable energy sector for sustainable development. Without enough supply of energy in rural areas, rural development is not possible. In this context, the renewable sources for the energy supply in these isolated and deprived rural areas because the renewable energy resources are locally available in isolated clusters also.

In Hanshapur, few households have been used wind powered electricity which is a part of renewable energy and are contributed pollution free environment. Thus, it is hopeful for the sustainable rural development. Renewable energy can replace the demand of commercial energy in the rural areas. These sources of energy will not create any adverse effect on the environment. Thus, the sources of renewable energy are very suitable according to the topographical setting and the settlement patterns of the country for the fulfillment of the demand of energy in rural areas. By using the improved cooking stoves (ICS) and the briquette technique, the efficiency of the loose biomasses and the firewood can be increased. These all techniques of the bio-gas, biomass will reduce the indoor pollutions on the one hand and on the other hand, they will support for the sustainable use of potentially renewable resources as an alternative source in the present context of the fossil fuel oil crisis.

5.9.1 Technology Development and Transfer:

Collection of information on technologies is the first action to know what is available and how it has been used. Studies on the effectiveness and applicability of traditional and modern technologies are equally helpful to develop locally suitable technologies, promote their transfer and use. There is an emerging need for developing technologies for the promotion of renewable energy in rural areas. Furthermore, rural Nepal would not be

in a position to develop sophisticated technologies and hence should focus on appropriate technologies.

At present Nepal has low level of the technological and managerial capacity to handle modern technologies. Unless people know how to solve the problem, it would be extremely difficult to manage technology. Awareness among the people about RETs is urgently needed at local level.

5.9.2 The Role of Women in development of RETs:

The time spent by women in fieldwork, animal husbandry, food processing and fuel wood, fodder and water collection is nearly double that of men. Furthermore, women are the victims of environment pollution and beneficiaries of technology management. Without literacy and awareness among the people the development process cannot be sustainable. The awareness and literacy level of rural women can be increased by RETs. RETs are helpful to achieve education, awareness, information and other economic activities. Hence it is necessary to create awareness of renewable energy resources on what they can do for sustainable rural development and technology management. Bringing women into the mainstream of development process is essential before any kind of technology intervention.

5.9.3 Benefits from Uses of Wind Powered Electricity:

- **Saving of batteries and kerosene:**

The use of wind powered electricity replaces the batteries and kerosene, which has to be collected from the nearby market and is difficult to get regular. Use of wind powered electricity reduces expenses required for purchasing kerosene and batteries.

- **Saving of Time and money:**

The use of wind powered electricity in rural household where is no grid connection helps to save time required for collecting kerosene and firewood collection. It is also effective for money saving. The saved time and money can be used for other income generating activities.

- **Health Improvements:**

Wind powered electricity is smokeless and pollution free. The use of electricity in kitchen and study room helps to reduce eye infection in women and children.

- **Benefits to the Women:**

The study conducted in Hanshapur has identified benefits in the form of having adequate time for childcare, peaceful and clean environment in the household, decrease in the rate of diseases occurrence and kerosene collection. However, women were victims of indoor pollution and now the situation has been changed; they are beneficiaries from wind solar PV hybrid system. However, there is need to promote other RETs as far as possible.

- **Environmental Benefits:**

The introduction of wind solar PV hybrid systems at Hanshapur VDC has significantly contributed to minimize the environmental pollution in local level. The indoor pollution is one of the major causes of different long term diseases in the rural areas. Those installed plants have contributed to reduce the indoor pollution and support for the sustainable use of the available potentially renewable resources.

- **Sustainability:**

It is the most important benefits for the present and future generation by the use of this technology.

5.9.4 Challenges in Integrating Energy and Rural Development:

Attempts to promote rural development to eradicate poverty must include efforts to ensure energy supply in rural area, not an end in itself but as an integral component. Ensuring basic human needs lies at the core of the rural development concerns, and energy services to rural people should be one of the central objectives. Following are the major challenges in Nepal to integrate energy and rural development.

• Overcoming lack of scale and difficulty of access

The small scale and wide geographical spread of rural settlements pose particular problems for meeting their development needs.

• Satisfying basic and productive energy needs

The high incidence of rural poverty and low-income levels of the rural people mean that satisfying basic energy needs is much more critical in the rural context.

• Meeting energy needs of the poor

The real challenge in meeting the energy needs of the rural poor is, of course, to remove or mitigate the conditions that perpetuate poverty. Access to basic, clean energy services is essential for sustainable development and poverty eradication, and provides major benefits in the areas of health, literacy and equity. However, over two billion people today have no access to modern energy services. The issue of energy choice is fundamental to the great challenge facing the world at the beginning of the 21st century – how to eliminate the obscene levels of poverty without further polluting the planet. Millions can be lifted out of poverty without ruining the planet with the help of clean sustainable energy.

• Developing energy self-reliance

There are limits beyond which self-sufficiency cannot be pursued; economic development can strengthen rural self-reliance by providing the means to access different energy options.

• Managing rural energy transitions

Modernizing rural energy supplies means a higher degree of monetization of rural energy markets and of rural economies as a whole.

• Enhancing energy technology absorption capabilities

Rural energy users are required to not only adopt sophisticated technologies, but to also learn to operate, maintain and utilize them effectively. Equipping them to accept such multiplicity of roles is a major aspect of rural energy development.

• Ensuring the sustainability of Wind energy sources

This call for a close understanding of the interrelationship between efficient production processes and end-use activities, both for energy and non-energy applications, also, more importantly, land use changes.

5.9.5 Outcomes of the study:

- Study has found that marginal and ethnic communities are benefited thus the dissemination and demonstration of same type technology to the other parts of the country is possible.
- Electrical power is helpful to achieve education, awareness, and information. Moreover, the available time due to the introduction of electricity can be used effectively and beneficially for education as well an income generating activities.
- Use of wind energy reduces expenses required for purchasing kerosene. The use of this renewable energy in lighting the households is not only making the households brighter but also saving the outgoing cash.
- The researcher observed that the users are getting benefited with having adequate time for child care, neat and clean environment of the households.
- The user's committees formed on four sites were found responsible for the sustainable operation and maintenance of the system. They are managing the system very well.
- In these days, efforts were also made to invite Radio Journalists to visit the sites and reported on the successes of activities. Such efforts have provided opportunities to see the progress from the third eye. The demonstration of wind energy system as an alternative source of clean energy for the rural development in the off grid areas is helping to aware many people.

Box- 2: Wind energy to improve the livelihood of the poor section of the Nepali Society

 A quarry related with the benefit of wind energy, Mr.Tan Bahadur Samat near the hybrid system is much more satisfied with the use of the system and give no comment because the system had been working properly till the establish time for lighting

purposes, he had been able to save his money on consumption of kerosene, listening to the radios for information, saving of money and time would be applied for more income generating activities.

CHAPTER-SIX

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion:

In developing countries like Nepal, large parts of population are scattered over scarcely populated rural areas, with long distances between small villages and low energy consumption in villages. In such situation, the traditional technologies of energy supply, e.g. grid extension, become impracticable. Instead, the decentralized renewable energy sources appears to be the most appropriate solution for energy needs of developing countries and their poor rural and remote regions. Small wind turbines represent a good,

economically viable and environmental friendly solution to provide remote villages with light and electricity. However, the development of renewable energy systems in poor countries should not lead to the situation when the dependency of the country on external energy, fuel supply or transportation is replaced by a new dependency, on expensive materials and equipment, very special maintenance know-how and development aid.

Alternative Energy Promotion Centre (AEPC) is an apex body of Nepal Government to promote renewable energy all over the country. In order to promote wind energy technology in future, demonstration and dissemination of such type of pilot projects is extremely necessary. Considering this fact, AEPC has started to install Wind-Solar PV hybrid system as piloting projects. Accordingly, four small wind turbines of 400W each capacity with 160Wp Solar PV with 270Ah Battery backup were installed at various places of Hanshapur V.D.C. Ward No-6, Pyuthan. The installation of those systems has been done by Krishna Grill and Engineering Works Pvt. Ltd. while the technical and social back up has been provided by FAEM, Nepal to Krishna Grill.

The wind technology helps in socio-economic development of the rural poor in every sector such as health, education, gender development etc. It directly helps in the women's night literacy classes and they can feel comfortable to work inside kitchen (drudgery reduction and pollution free environment), reduced drudgery of men and women from walking long distances and carrying loads of kerosene and fuel wood, children can read & write and do their home –works during nights, reduction in use of kerosene wick lamps and woods at home have significantly reduced the indoor air pollution, eye irritations and headaches, improved room cleanliness. It would directly beneficial to the saving of money of kerosene consumption up to 2-3 liters/month/HH. The user's group has access to the modern use of information and communication system because of the utilization of home appliances like radios.

The project sites at Hanshapur VDC were visited after a series of investigations and consultation with the related experts and officials of AEPC. The project sites were not only considered as marginal but ethnic communities are benefited there. The total

beneficiary households at Hanshapur VDC are found 27 whereas 1 Masjid and 1 School are also benefited there.

The efforts have been made to aware local people and enhance the level of understanding about the system. Thus, the researcher is hopeful for the sustainable operation of those installed systems. Furthermore, the close monitoring of the installation/monitoring is very essential for the sustainable operation as well as other aspects of the installed systems.

It is obvious that the person directly benefited from the system seems happy but people of the surrounding who weren't able to connect electricity seem unhappy.

Access to information is another important impact of wind power. Upon installation of wind power, indoor household environment has improved noticeably. Smoke free environment induces better health condition especially in reducing the respiratory and eye diseases. Moreover, it helps to in keeping neat and clean environment. Thus it had helped for the reduction of minimum energy crisis in rural Nepal.

6.2 Recommendations:

- Further analysis and research is required for assessing the whole and micro-level potential of the solar and wind resource of Nepal. Users are deprived of getting after sales service of repair and maintenance. In some of the cases they have to wait for even two or three months to get repaired their ill hybrid system. Service centre should be made available locally to promote and strengthen after sales service accordingly. It is also strongly suggested that there should have provision of both technical and financial support and training to the local people including women.

- Effective government policy, planning, subsidy program to be set with clear implementing strategies. Taking into consideration of the disadvantage group, special provision should be made in policy to accommodate ultra poor section of the society.

- Conduction of promotional activities, awareness campaigns including home visits, video show, training and workshops at community and districts level. Dissemination of information materials like posters, pictorial manual (most preferably in local language and with local contact address)

- Coordination between households, community, local governments and central government with the involvement of donor agencies need to strengthened to scaling-up successful technologies.

- Government assistance in dissemination, technical advice, quality control, and monitoring and evaluation.

- Encouragement of the active participation of woman and dalits (disadvantage group), and promotion of income generating activities that is micro-enterprises electrical based.

- Training and upgrading of the related software is required for the local people or the user's group otherwise technocrats should be available at the time of needed and maintenance.

- Since the country has limited number of data measurement station, Preference should be given to expand the station network in the country in order to fine tune the modeling. It is thus recommended that program should be continued in the remote and very remote area where access to poor electricity supply. This could be specifically helpful in scaling up the wind power as commercial enterprises.

- Due to the topographical variation of the country micro level of modeling is required for wind energy resource assessment.

- Since the study has shown good wind potential at most places in Nepal, it is wise to apply wind-solar hybrid system at places which do not have consistent wind flow and generated electricity should be used for off grid systems and moreover, places with high wind energy should be connected to the grid and that could save

the water used to produce electricity from high dam projects such as Kulekhani hydro electricity projects during windy part of a day.

- Since there is no need of high wind speed for the small wind turbines, small system less than 400 watt could be installed to electrify the rural areas without long term data for the large capacity of power for electricity and other electrical appliances for better up results.

- In order to ensure the energy self-reliance and independence, the renewable energy systems for developing countries should be inexpensive in production and in service, reliable and durable, and producible locally, from local materials and with the use of the local equipment. The costs of wind turbines can be reduced, and the wind energy technology can be made more attractive for developing countries, if the natural, locally available materials, notably wood, are used to produce parts of the wind turbines instead of or along with conventional composite materials. The problems of the low cost wind energy technologies, challenges and achievements in this area would have been far better for low–cost materials in wind energy technologies.

- Timely monitoring and evaluation of the implemented and installed system must be done by the working agencies on the study area.

- The wind-solar hybrid system would be more beneficial on launching off-grid system of rural Nepal not only but also in the urban area which have potential of such RETs because of getting rid of load-shedding / power-cut problems is only the solution.

- Education is the most beneficial parameter of the Wind Solar PV Hybrid system installation. Almost all users express satisfaction over educational performance of their children after installation of wind power plants. It is strongly recommended that wind power promotional activities should be tied up with different donor agencies related to non formal education, girl child education.

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ANNEXURE:

Questionnaire:

A. For local people/user of Wind Energy:

1. District Name:
2. VDC Name:

3. Ward No.:

4. Name of the Respondent:

5. Sex: Male ☐ Female ☐

6. What is your family religion?

A. Hindu ☐ B. Muslim ☐ C. Buddhist ☐ D. Other (Specify) ☐

7. What are your family's main sources of income? Please rank of importance,

A. Agriculture ☐

B. Animal Husbandry ☐

C. Trade /Business (Specify) ☐

D. Service (Specify) ☐

E. Other (Specify) ☐

8. How much land do you have? ----------

9. How many cattle do you have?

A. Cow ☐ B. Buffalo ☐ C. Goat ☐ D. Chicken ☐

E. Pig ☐

10. How many family members are in your family? .....

11. Details of the family members of the family

SN	Relationship to (I)	Ethnic group	Sex	Age	Marital status	Education level	Occupation
I	Self						
II							
III							
IV							
V							

VI							
VII							
VII							
IX							
X							

12. What is the trend of using energy sources?

A. Cooking energy sources

- Firewood ☐
- Kerosene ☐
- Biogas ☐
- LPG ☐
- Crop residue ☐
- Cow dung cakes ☐
- Others ☐

B. Lighting energy resources

- Electricity ☐
- Kerosene ☐
- S/SHS ☐
- Batteries ☐
- Others ☐

C. Household appliances

- Radio ☐

☐

- Television
- Others

13. Do you know about wind energy? Yes ☐ No ☐

14. How do you know about the wind energy?

15. When the wind energy project had been installed? .....

16. Who directly involve in the management practices of the project?

- Self
- Donor agency
- Committee

17. Is the subsidy had been given to the project?

18. Which company had been involved? .....

19. What are the roles of donor agency in the project area?

……

……

……

20. What are the roles of Manufacture Company in the project area?

……

…….....

……..

21. Is the solar PV hybrid system is effective?

22. If not why?

…….

…….

23. Is the wind and solar potential is favorable for all seasons?

24. Is all the system working properly?

25. If not what are the reasons?

……..

……

26. Are the workings agencies involve in the project come on monitoring and evaluation of the program timely?

27. Would you have any complains or suggestion for them?

……

.....

28. What are the technical difficulties of the system?

- Battery disposal

29. What are the social difficulties of the system?

…….

……

30. Is the current flow is AC/DC current?

31. Is that any problem on any equipment related to the current above?

…….

32. Is there any problem in the distribution of line through distance on the settlement area?

……

33. What are the uses of wind energy?

A. Electricity

No. of lamps	Using hours

B. Micro industry

C. Other applications

34. Would you get satisfaction from the use of wind energy? Yes ☐ No ☐

35. If No why, give reasons.

……

……..

……

36. What are the problems of using the wind energy?

……

……..

37. What are the impacts/ benefits of the wind energy?

Kerosene consumption		Battery consumption		Education		Health sector		Tourism/other economic activities		Income generating activities	
Before	After	Before	After	Before	After	Before	After	Before	After	Before	After

38. What are the benefits from small wind energy technologies?

a. _____

b. _____

c. _____

d._____

39. Who are the most beneficiaries from the project?

- Gender
- Group

40. What are the roles of the other organizations for the poverty reduction in the area?

……

……

……....

B. For Institution:

1. District Name : 2. VDC Name:

3. Name of the Respondent: 4. Ward No:

Drinking Water Sources:

5. Where does your school get its drinking water?

Stone tap ☐ Pipe ☐ Tube well ☐ Stream water ☐

6. Walking distance from School;

Less than 10 min ☐ 10-30 min ☐ 30-60 min ☐ over 60 min ☐

Education Indicators:

SN	School Level	No of Teachers			No. of Students		
		Total	Male	Female	Total	Male	Female
1	Primary						
2	Middle						
3	High						

S.N.	Major Caste	In Percent (%)
1		
2		
3		
4		
5		
6		
7		
Total		

Infrastructure Indicators:

SN	Description	Total
1	Buildings	
2	Classroom	
3	Toilets	
4	Library	
5	Laboratory	
6	Temple	
7	Telephone	
8	Health facilities	
10	Computers	

7. From how far (time/distance) do student come to study in the school? ☐

Energy Sources:

8. Do you know about wind energy? A. Yes ☐ B. No ☐

9. Please identify which of the following you use, how much, where get it from and what you use it for;

S.N	Description	Amount Used/Month	Uses
1	Firewood		
2	Kerosene		
3	Batteries		
4	Crop Residue		
5	Cow dung cakes		
6	Solar		
7	Gas		
		Fuel wood= per load Kerosene= per liter	1= cooking 2= heating 3= lighting 4= other

*Cost price of Kerosene = *Cost price of Batteries (dry cell) =

10. How did you manage the expenses in your school?

……

11. The donor agencies involved supporting for the school;

A.

B.

C.

D.

12. What are the main incomes sources of your school?

A.

B.

C.

D.

13. What are the works does you can do when electricity will be produce through wind?

A.

B.

C.

D.

14. What do you feel for the establishment of wind-solar PV hybrid system?

……

……

15. How you can manage wind –solar PV hybrid system?

……

……

16. Do you think the need of any type of training that will helpful to manage wind –solar PV hybrid system?

……

17. Have you got any trainings regarding to the renewable energy?

……

18. How much interest do you give for buying computers?

A. Very high ☐ B. High ☐ C. Low ☐

19. Is there any possibility to disseminate and demonstrate such type of technology in future? ☐ ☐

A. Yes B. No

20. What suggestions do you want to give for the sustainability of the project?

……

……