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Feasibility of Renewable Energy in Remote Destinations in Nepal

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Solar power, biogas and mini-hydro power are the most used sources of renewable energy in Nepal. There is also large potential of wind power which is not yet utilized. Energy shortage in remote villages of Nepal are a serious problem. Everyday life of people is not easy and finding the best solution to people is challenging. Main objectives of this are to make review of existing energy problems and how to improve situation with locally available renewable sources so that people could improve their living standards.

Bilateral cooperation between Nepal government and donor agencies are carried out to eradicate the energy problem in rural zone of Nepal by providing subsidies in installing renewable energy and deducting VAT on equipment and machineries used in installing renewable energy capacity. Dramatic improvement has been seen in recent years. Particularly, mortality rate has been decreased and women who were responsible for cooking and household activities are highly benefited as renewable energy doesn't emit harmful pollutants. Rural electrification along with grid extension and locally installed capacity of solar power, bio-gas as well as micro-hydro are the best solution to overcome total energy shortage in rural communities.

Keywords	Renewable energy, kerosene lamps, wood fuels, grid extension, solar power, health impacts.

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Birendra K Tiwari
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1 Introduction

The history of electricity generation in Nepal goes back to 1911. Pharping hydropower was the first with production capacity of 500 kW. Today Nepal has total power of 609 MW in integrated power system with the contribution of more than 25 hydroelectric plants. Out of the total electric power 91 percent is contributed from hydroelectric plant and rest 9 percent from diesel plants. [1]

Main goals of this thesis is to find the answers to these questions.

1. How could the remote people utilize renewable and sustainable energy generating locally using available raw materials?
2. What would be the most affordable ways to supply energy even for the poorest?
3. To find out the possible ways in order to regulate and finance the operative mechanism without major disturbances.

Solutions of above questions are the subject of this work. This thesis also gives the overview of the current situation of energy usage in remote zones of Nepal particularly. Feasible solutions for energy crisis installing renewable sources of energy would be the concrete summary of this work.

2 Background and Methodology

Nepal adopts traditional energy consumption in most parts. Except some urban areas, remaining portion of the population completely relay on firewood for cooking whereas kerosene lamps are used for lighting households. All 75 districts have access to electricity facilities, which are mainly owned by Nepal Electricity Authority (NEA). [1] According to ministry of energy more than 25 per cent of entire population is without any power supply.

Nepal's economic and social development is being hampered by its inadequate energy supply. As Nepal doesn't have its own reserved gas, coal or oil. Although it's most significant resources is water, less than one percent of the potential 83 GW of hydropower is currently harnessed. Firewood is the most used energy carrier, counting for more than 70 percent of primary energy consumption. However, its use is

insufficient and poses a threat to the country's forest and at the same time, the indoor air pollution causes potential threat to health. Mains electricity is available in urban areas and some 30 percent of the populations do not have access to it. [2]

Deferred investment on electricity infrastructure has caused scheduled power cuts of up to 18 hours/day during dry season. This situation is expected to get even worse in the future so the private business and commercial entities almost operates by costly diesel generator. The import of petroleum products has exceeded total exports and thereby contributes significantly to Nepal's trade deficit.

In Nepal, during last decade, dissemination of renewable energy in rural areas was effectively promoted with the assistance of the developments partners. Decentralized electricity generation and biogas installations are expected to improve rural living conditions and contribute to a more sustainable use of biomass. Rise of energy costs and prevailing energy scarcity increases attention to the efficient use of energy.

There are several mini hydro power plants that lack the regular function because of lack of either technical manpower or regular maintenance. Government has strategies to improve situation but they lack implementation. People are aware that authorities are always hooked by central political power; they are trying hard with much effort on local power generation which would benefit them in long term. [3]

Three-fourth of the Nepal's population still depends on biomass as the main source of energy for cooking and heating. Majority of them uses open fire with low efficiency causing harmful emissions. Few of them uses dry animal dung as energy source for cooking which is comparably better then wooden fuel. [4]

This study is based on personal observations that are combined to theoretical knowledge. Comparing the available data's and statistics with the energy demand of particular remote zone, analyses are performed and suggestion are given which aims to assist government or concern authorities in order to formulate plans and making strategy for better access to energy utilities. Table 1 shows annual energy deficit in Nepal.

Table 1 Annual Energy Deficit in Nepal [5]

Annual total energy demand	4833.35 GWh
Generated energy from available sources	3850.87 GWh
Yearly Energy Gap	982.48 GWh (20.33%)

3 Energy Generation in Nepal

3.1 Main sources of electricity

Majority of the electricity production are from hydropower. The major hydropower plants with their capacity and annual average production are listed below in Table 2

Table 2 Data showing major operational power plants and their capacities [6]

S.N	Power Plant	Capacity (MW)	Annual Energy (GWh)	Owned by
1	Kaligandaki	144	791	NEA
2	Marsyangdi	69	519	NEA
3	Khimti	60	353	HPL
4	Kulekhani I	60	164	NEA
5	Kulekhani II	32	96	NEA
6	Trishuli	24	292	NEA
7	Modi	15	87	NEA

Until 1990, hydropower development was under the domain of governmental utility (NEA) only. Nowadays there are number of projects already built by the private developers. Private power producers contribute 148 MW of power to the 'Integrated Nepal Power System [6]. There are also many projects which are identified for development. Some of the identified development projects are listed in Table 3.

Table 3 Identified potential hydropower projects [6]

S:N	Project	Capacity (MW)	Type
1	Karnali chisapani	10800	Storage
2	West seti	750	Storage

3	Pancheshwor	6480	Storage
4	Kali Gandaki	660	Storage
5	Budhi Gandaki	600	Storage
6	Dudh Koshi	300	Storage
7	Arun III	402	PROR

3.2 Small Scale Energy Sources

In Nepal, fuel wood is the main source of energy for heating and cooking purposes and forest is the most important sources of fuel for rural and privileged people. About 78 percent of energy consumption is from forest source. The pattern of energy consumption is changing along with the economic growth and urbanization. The uses of traditional sources of energy such as cow dung and agricultural residues decline from 22 percent to 9 percent while the consumption of energy from the commercial sources such as coal, petroleum products and electricity increases from 4 to 12 percent. See figure 1 for more details. However, the major percentage share is still firewood, which collection has adversely affected the growing stock of the natural forest and maturity of plantation forest. [7]

The rural people still depends on firewood to meet their energy demand for cooking and heating purposes due to lack of alternatives sources of energy package at affordable prices. Firewood is still considered as the ‘‘free gift’’ of nature and people are reluctant to pay for it. As many rural people depend on firewood, its consumption has increased along with population growth. [7]

4 Power Supply in Remote Areas

Uses of traditional fuels as energy sources is the major problem existed in remote parts. Low population density and scattered household are another reason for grid connection. This ultimately results in the use of timber as major fuel sources in villages.

4.1 Existing Sources of Energy

Nepal is surrounded by Himalayas, so it is much difficult for the transmission of electricity line in remote communities. People of the subsequent region have traditionally and historically fulfilled their energy demand with biomass, imported kerosene and wood as fuel. Access to hydro power has been always suppressed with geographical barrier. Household energy sources in rural parts of Nepal are shown in Figure 1.

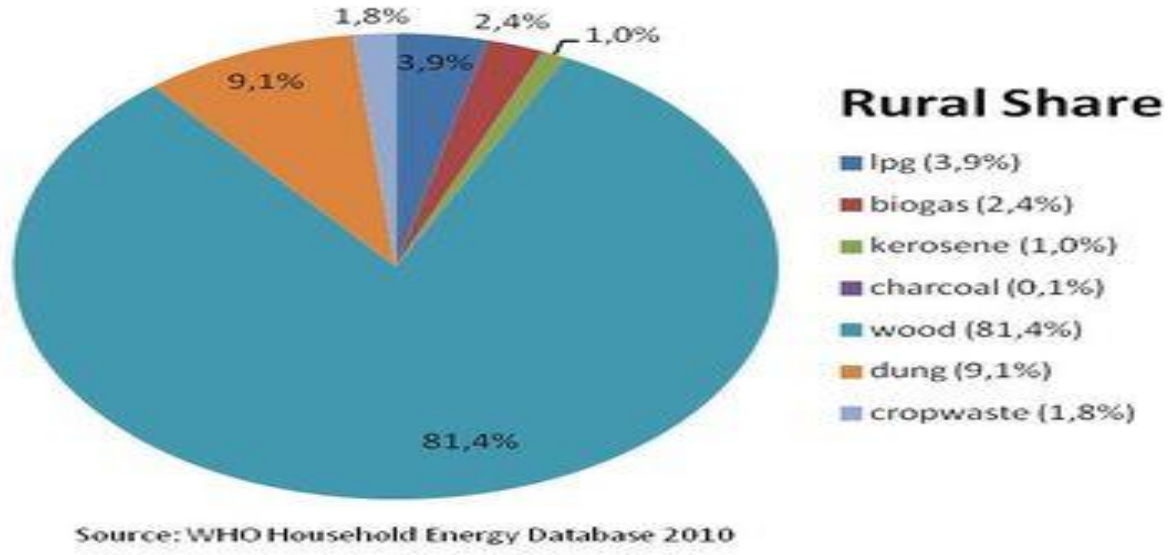

Figure 1 - Household Energy Sources in Rural Part of Nepal [8]

For the rural area, public awareness in local level should be conducted about the importance of biofuel and their dual nature in agriculture. For example, dung can be used as biomass which again can be utilized as agricultural fertilizer.
Small scale hydro power in local level might be feasible to eliminate the lack of energy.

5 Energy Production Potential in Nepal

5.1 Renewable Energy

Renewable energy are the most prominent sources of energy and also an alternative form of energy where high transmission lines and grid extension are challenging. Past couple of decades, government and various organizations has been active in

increasing the production of renewable energy. Also, various donor agencies are actively working in remote parts of the country along with mutual cooperation with the local people.

5.1.1 Solar Energy

In Nepal about 300 days in a year are sunny. There is a great potential of solar energy especially in remote parts of the country where solar cookers and PV system would provide households with clean and sustainable energy.

5.1.1.1 Solar Cooker

Solar cooker is being used in most rural area as alternative for fuel. It uses heat of the sun as energy sources and concentrates it to the heating pot. More than 85,000 Bhutanese refugees have been solar cooking their meals in a refugee camp in Nepal. Also in the mountainous and trekking areas of Nepal, solar cooker are used in order to make tea and also for heating water. Also, 50 percent subsidy of its market value is given on using solar cooker in Nepal. In Figure 2 there is an example of solar cooker.

Figure 2 - A Solar Cooker [9]

5.1.1.2 Solar dryer

Solar dryer, utilizing the heat of the sun, are mostly used for food and crop dryer mostly in lower regions of Nepal. Also in industrial drying process it is important from energy conservation point of view. Heat of the sun can also help in purifying water. It might

have extensive use in rural parts, taking into account its contribution to fuel wood saving and drying of agricultural products without quality deterioration. It also contributes in rural household income, as well. So, subsidies are provided to family sized solar dryers as well as the solar dryers which could use in commercial purposes. In Figure 3 there is an example of solar dryer.

Figure 3 - Solar Dryer [9]

5.1.1.3 Solar distillation

Solar distillation also uses sun light as the medium of heat for distilling water. A solar collector is placed at the bottom of the box that is selectively coated black from inside. To cover the mouth of the box a glass cover is used and is placed in a slanting position so that when the water gets collected on the glass, it flows toward a collecting vessel. When the sun ray enters the box, it heats the collector that immediately transmits it to the water and turns it into vapor. When the vapor comes in contact with the glass cover, the vapor condenses because of the cool temperature on the outside and turns into water droplets. The droplets on the slanted glass slowly move down and get collected in a collecting vessel. In Figure 4 there is an example of solar distillation.

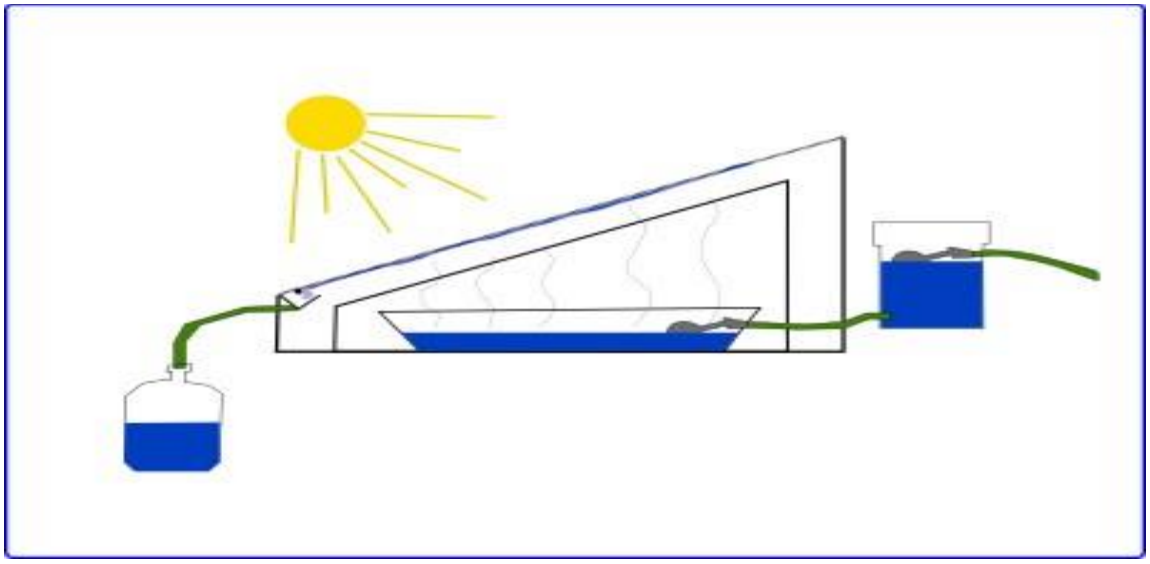

Figure 4 - Example of Solar Distillation [10]

5.1.1.4 Photovoltaic System (PV)

Photovoltaic energy is the most important and feasible way to overcome energy shortage in remote parts of Nepal. In PV system produces electricity when exposed to sunlight. In Nepal most of the days in year are sunny, it is suitable to install PV system. As there is back up system, energy stored in daytimes can be in night for lighting purposes. Installation are carried on roof of building so useful land are not harmed. In Figure 5 there is an example of PV system installed in remote village of Nepal.

Figure 5 - Household PV System in Sinduli, Nepal [11]

5.1.2 Wind energy

Wind power utilizes energy in wind and turns it to electricity with the help of wind turbine. In Nepal, wind energy is not in use. A 10 kW wind generator was installed in Kagbeni Mustang, by Nepal electricity in 1985. It was broken soon after its installation. Nepalese government is planning to increase wind energy capacity to 20 MW within Kathmandu and nearby surroundings. [9]

Although there are many location with required flow of wind to generate power, irregularities in speed of wind is a major problem. Nepalese government is planning to generate electricity from various locations during certain period of year and supply power through electrical grid. In order to achieve the target, the government have been constantly involved in wind related survey. [9]

5.1.3 Hydropower

Hydropower utilizes energy in water and turns it to electricity with the help of turbine. Nepal is one of the richest countries in the world in term of water resources. But, potential of water are not being utilized. Generation and consumption of hydro energy in Nepal is minimum. The perennial nature and flow gradients of Nepal's land structure provide appropriate condition for the development of hydropower. Easy resources like glaciers in Himalayas and fast flowing rivers in hilly and lower parts of country are available if could be utilized to generate electricity. In term of electrical energy Nepal have the potential of 727,000 GWh power generations. Installed capacity is just 600 MW which is significantly low compared to actual capacity. Government intend to promote private sector as well as international investment in hydro energy which results in expanding the electricity production and grid connection.

Hydropower is the major sources of energy generation in Nepal. Fast flowing river and glaciers in high altitude shows the viable potentiality of power generation in Nepal. Almost every parts of country are gifted with flowing rivers making hydro power generation possible. Demand of electricity forced to generate small and medium scale power plant in numerous part of the country through public investment. Water is used as dual source; electricity production and agriculture. Existed major hydropower plant along with their capacities is shown in Table 2.

Energy generation shown in Table 2 is not enough to fulfill electricity demand. The best possible way to meet the demand is further construction of power plant with higher generation capacity. As water is abundant in every parts of Nepal, large scale

hydropower would be feasible in many parts which could be supplied to rural area through grid extension. Production cost can be shared among communities as investment. In long term it is economical. Despite of having numerous small and medium scale hydropower plants existing in Nepal, energy supplied is lacking in privileged zone.

Also small scale plants could be feasible in rural communities. Small scale hydropower and their respective power generation capacities are given below in Table 4.

Table 4Small Hydropower Plant, Nepal [12]

Plant	Capacity (MW)	Owner
Indrawati Hydropower Project	7.5	National Hydropower company
Puwa Hydropower Plant	6.2	Nepal Electricity Authority
Andhikhola Hydropower Plant	5.1	Butwal Power Company
Chatara Hydropower Project	3.2	Nepal Electricity Authority
Panauti Hydropower Project	2.4	Nepal Electricity Authority

Small scale hydropower is a reliable in remote parts as it only needs 2 feet height and flowing water as major components. Electricity could be easily connected to the desired location without any difficulty through grid connection. Low-cost, versatility and durability of small hydro production would help to meet energy demand to local level. For developing countries like Nepal; it would be suitable to access energy demand. [12]

6 Goals and Strategic Planning by Nepal Government

Government is developing Central Renewable Energy Fund (CREF) which aims to consolidate and streamline present and future funding for the mini and micro Renewable Energy Technologies (RET) through one way channel which helps to monitor the progress of project. This will neutralize the existing system and incorporates new features attracting investor and private sector participation. CREF will provides subsidies and technical assistance (TA), as well as soft loans for the development and expansion of micro, mini, small electricity, solar energy, wind energy

and biogas, and improved cooking stoves, while not excluding applications arising from other form of alternative energy. [13]

Government of Nepal has made several incentives for promotion of renewable energy technologies. Even government excuses taxes for this kind of item related to renewable energy production, which are explained in detail below.

1. In recommendation of Alternative Energy Promotion Center (APEC), government provides tax exemptions on machinery and instruments used for generating energy from solar, biogas and wind resources; as well as tubular batteries used in solar PV systems.
2. Upon the recommendation of APEC, zero VAT is levied on solar batteries produced locally.
3. A concessionary 1% custom duty is applicable on the imports of machinery and parts of the following alternative energy technologies.
    - Upon the recommendation of AEPC, non-locally manufactured equipment, parts and accessories related to hydropower generation, transmission and distribution.
    - Raw materials imported for manufacturing micro hydro power equipment, parts and accessories locally.
    - Wind mill related equipment, accessories and parts.
    - Solar energy equipment, parts and accessories; tubular batteries for PV system.
    - Biogas related equipment, parts and accessories.
    - Import of raw materials for the production of batteries used in solar PV systems.
    - Bio-stove
    - Bio-energy related equipment, parts, accessories and chemicals.

Government has also offered tax exemption for the first 7 years and 50 percent income tax for the next 3 years, as per the Budget speech 2011 it is also provided that: ‘’Income tax will be fully exempted for the first ten years for hydropower project commencing their construction before 24 august 2014 and starting commercial production before mid-April 2018. [13]

7 SWOT Analysis

Strength, weakness, opportunities and threats are analysed while writing this work. Many positive things could be obtained.

7.1 Advantages of distributed production

Several parts of the country are without the reach of power supply. As known fact, electricity transmission is not an easy solution due to land structure and spread living of community. But if locally developed project like solar PV, biogas, solar cooker and micro hydro project are conducted, rural people can take lot of advantages which ultimately upgrade the life standard.

7.1.1 Health benefits

In many regions of the developing countries, people are compelled to use wood as primary fuels for cooking and kerosene for lightening purposes. There is a huge possibility of producing hydropower from Local River as in Nepal most of the rivers are fast flowing, turbine rotation and thus generation of decentralized renewable energy is possible. So, there is great potential of distributing energy in the local level which enhanced the life and helps to reduce currently used traditional sources of energy. For example kerosene and wood fuels are completely replaced by electricity. Same process can be applied through bio gas production as biogas can be used instead of wood fuels and lightening for household is also possible. Using alternative renewable energy source, air emission can be reduced completely which ultimately have good impact in health system of people. Also this might be the absolute idea for the non-electrified communities where access to energy supply is huge problem due to either topography or other technical problems.

Indoor pollutants from kerosene lamps include multiple hazardous elements, with concentration of particularly unhealthful particles an order of magnitude higher than health guidelines. Kerosene combustion is responsible for higher incidence of tuberculosis. Researchers found the odds of having tuberculosis are nine times greater for women using kerosene than those who uses electric light. Particularly, carbon emission from wood fuels and kerosene are the major component degrading air quality which can be replaced by either biogas production or solar installation. As solar energy

is perpetual and biofuels are easily getable in rural villages, there is huge potential to install such renewable energy system.

Living in a rural area and poor household is related with risk of child mortality. Indoor air pollution (IAP) resulting from the burning of coal, fuel and animal dung which are used as cooking food and heating homes are major environmental risk factor and a threat to public health. Carbon monoxide, Sulphur oxides, nitrogen oxides, particulates, benzene, formaldehydes, arsenic and lead are the product of domestic fuel used. High level of such emission is from cooking process, as child spent most of the time with mothers, they are vulnerable group and most likely to be affected. [14]

As the primary source of energy for household purpose is wood and charcoal, children under 5 years of age have high possibility of respiratory infection due to the emission of many harmful gases. Development of immune system and organ as a whole of children get affected. So, eradication of this entire problem is the use of energy which could replace those existed method. Each and every household has the potential to replace old method of cooking and lighting and replace by new energy system.

7.1.2 Education benefits

Nepal is a mountainous and landlocked country. More than 80 percent of the population lives in rural part of the country where electrification and transportation are still lacking. Lack of education is resulting chronic poverty in the country. Millions of children are deprived of education. There is no means of light source for study at home. Most common sources of lighting for study purpose are kerosene lamp. The same lamp is supposed to share at kitchen and all other areas in house. The lack of illumination leads to situation that children can't study during dark hours. Low education level is a devastating problem in developing countries where the solutions are although challenging but negligence from government and political parties makes it further complex. The only idea to overcome the problem is to use locally available resources and techniques. As agriculture and animal farming is the major occupation in villages of Nepal, logical utilization of animal dung along with human excreta for the production of biogas is possible in every houses of the village. Few lamps would light over the night with the energy from biogas plant. Student groups can utilize the light locally produced for their education purposes.

7.1.3 Economic Benefits

Everything consumed in the country are an imported items. Even daily cosmetics are imported from neighboring countries. Nepalese are compelled to spend their fertile time in collecting woods and timber for fuel. Women in developing countries couldn't even think beyond domestic activities like cooking and cleaning. Economic growth of a country is often a result as local technologies and resources increases their independence in supplying the energy needs of the citizens. The growth of an industry demands an increase workforce. Renewable energy production is typically more labor intensive then current fossil fuel energy, so the number of worker is expected to increase proportionately with the amount of renewable energy created, reports the Organization of economic co-operation and development (OECD). [15]
For example, in the small town of Darbang, Nepal, the local economy has been booming since the construction of micro-hydro plant in 2009. A village once completely in the dark, now has a metal workshop, furniture and cement manufacturing companies and poultry and dairy farms. The micro-hydro plant provides energy to all these industries as well as over 700 households in the surrounding area. [16]

Renewable energy production is more labor oriented process than fossil energy extraction. The concept of power project in the rural part is not a quick process. It might take few month or years for accomplishment. Although, technical part of the project are handled by skilled manpower imported while non-skilled and semi-skilled task provides lot of job opportunities to the local market. Let us consider a micro hydropower project is commenced and aims to finish in 5 month from starting date; construction of damn and transportation of raw materials need labor forces. In such project, priorities are given to local people. Similar case is applied in bio plant construction and solar installation.

7.1.4 An Effect to Energy Cost

Nepal's national grid (total length is 4,346 km) is the sole property of Nepal Electricity Authority (NEA) which is designed, maintained and conducted by NEA themselves. One-third of the total population of Nepal is connected with grid electricity. Remaining two-third (20 million inhabitants) is compelled to live using locally available energy resources for cooking and lighting. NEA tried to connect the grid to most rural villages of Nepal but suffer from extensive loss of power through high line losses, overloading,

poor reliability and most importantly poor theft. Further the remote and mountainous areas of Nepal are not only a challenge from technical and geographic point of view, but are sparsely populated, with few consumers per square km, with low energy demands and low expected load growth. As a result, consumers are charged with a flat rate, if at all, which provides no incentives to conserve electricity. [17]

A viable option to grid extension is the generation of electricity within, or near to, a community, using locally available renewable resources. Remote Area Power Supply (RAPS) system has been a popular mechanism in rural region. RAPS are a power generating system, generating electricity for rural homes and communities. Such systems are small scale (usually < 50KWp) self-contained units providing electricity independent of the main electricity grid or mini grid network. A RAPS system that has a combination of energy sources such as wind generator, solar panels, battery storage or inverter is called a hybrid RAPS system. For the remote part of Nepal a RAPS system usually solar PV panels or wind generator. RAPS systems are designed with 20 years of life expectancy, and it is economical considering the average life cycle cost from production to its end phase. As it is locally available technology and easy to operate using renewable sources of energy, unlike electricity grid, renewable energy techniques are far better and economical in context to rural area. [17] Figure 6 shows high voltage transmission line in some part of Nepal.

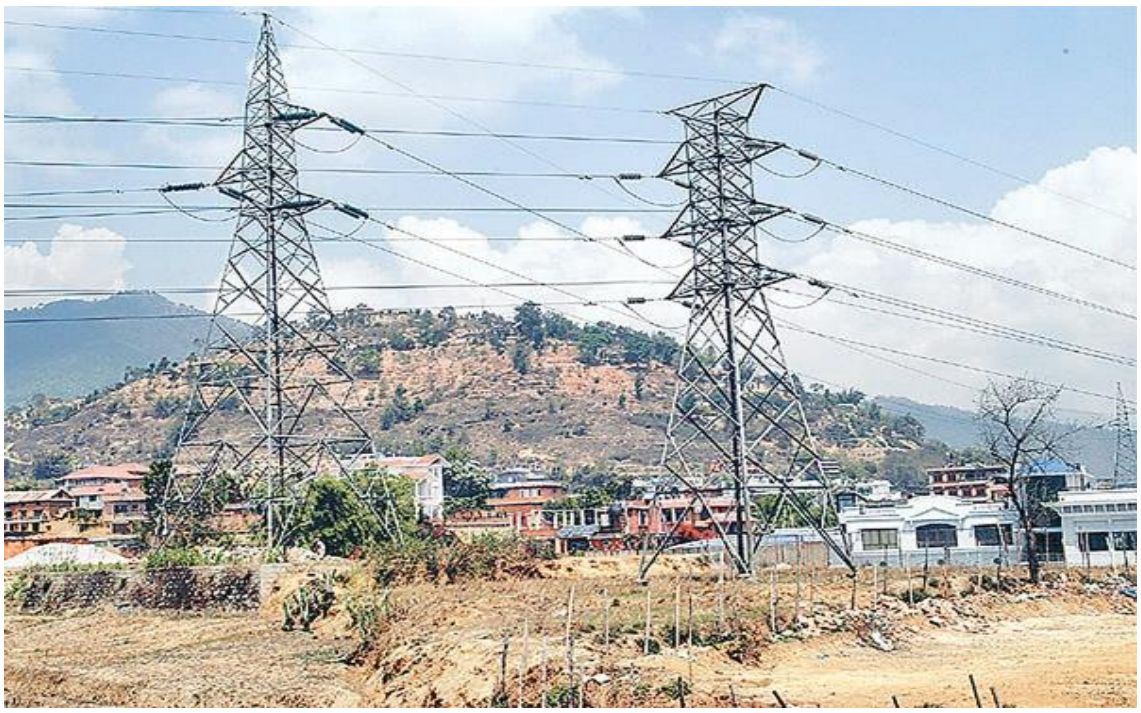

Figure 6 - Transmission of Electricity Line in Nepal [18]

7.1.5 Effect on a Global Warming

All sources of energy have certain impact on environment. Fossil fuels, coal, timber, natural gases-harms the ecosystem and nature at some point for example damage to public health, water pollution, extinction of wild life habitat and global warming emissions. Comparatively sustainable and renewable energy do less harm than globally used coal and petroleum products. [19]

Energy sources like wind energy, solar energy, biogas and hydroelectric production don't emit global warming gases. Atmosphere is overloaded with carbon dioxide and other global warming emissions, which traps heat steadily and drive up the planet's temperature creating significant harmful impacts on our health, eco-system and climate. According to data aggregated by the International Panel on Climate Change, life-cycle global warming emissions associated with renewable energy –including manufacturing, installation, operation and maintenance and dismantling and decommissioning are minimal compared to fossil fuels.

8 Remote Electrification Ideas

Electrification is the process of powering or supplying power to a certain area. The known fact is, Nepal suffered with power cut off almost in all season and up to 18 hours a day. In order to improve life of villagers some possible actions are listed and explained in chapter 8.1 to 8.4. In chapter a case study on Sarunkhola village is described.

8.1 Grid Extension

In order to provide energy to remote region, electricity from power plant to user can be linked through electricity grid. Although it's quite difficult and challenging due to geographical structure of land in Nepal, but not impossible if government really wants to do. For this local people should give pressure to central government through their elected representatives.

8.2 Solar Power Systems

Potential of solar energy in rural part of Nepal is the best solution to overcome power shortage. Over 300 days in a year are sunny day in Nepal where the sun energy can

be utilized properly storing the heat during day and is converted to energy through inverters. As once installed, works for around 25-30 years with low maintenance and without emitting any harmful gases. Well design PV system with battery backup is important for example students to do their home works and study during night time when sun does not shine. In area where electricity supply via grid connection, solar power system is the best available technique. A lot of villages now investing to PV systems in individual home with the support of government and international agencies.

8.3 Biogas Production

Farming is the primary occupation of Nepalese. Buffalos, goat, cow etc. are the common animals in everyone's house in village. Utilization of animal dung and manure along with human excreta to produce biogas (see figure 7) might be the useful and possible solution to overcome power shortage and deforestation problems caused. As the existed fuel for fire and cooking are forest wood, biogas also helps in afforestation. Biogas use would also help to improve health especially women and infants when replacing wood fuels by bio stoves. The cost of fix-dome biogas plants are relatively low. It is a simple structure made from locally available materials like stone, cement and few metal parts. The plant can be estimated more than 20 years. Figure 7 shows a typical Bio-Gas Digester.

Figure 7- Typical Bio-Gas Generation System [20]

8.4 Micro-Hydro Power

Topography of the mountainous country suits perfectly the condition for the generation of electricity also in small scale. With the minimum flow of water, large amount of energy can be produced with minimal impact to ecosystem. This system is entirely independent of grid or can be connected to grid, if available, to sell possible surplus energy. The objective of micro-hydro power production is to distribute energy within small range of local communities

Micro-hydro village electrification (MHVE) is part of larger national power development project in Nepal to improve access to (rural) electricity services and to promote private participation. As Nepal government is determined to micro-hydro generation in rural area, different level people and communities would certainly take benefits in long term.

8.5 A Case Study of Sarunkhola Village

Sarunkhola is a remote village in western Nepal. There are approximately 150 households. Majority of inhabitants did not had any idea about modern energy system. They did not even had knowledge about renewable energy which could be generated locally. In 2001 Japanese International Cooperation Association (JICA) was interested in developing the village exploring renewable locally available sources of energy. Here are two examples explaining how JICA in collaboration with local people brought quick changes.

Case 1 - JICA commenced a project called '*Afno Gau Afai Banau'.* The meaning was 'develop your village yourself'. JICA announced to provide complete subsidy if villagers wanted to installed Bio-gas reactor. People were happy and started to make reactor immediately. Technical helps and imported machinery import were delivered by JICA. A few weeks later, every households in village were utilizing bio gas for cooking and few lamps for lighting. Unnecessary bio waste were utilized and also people lived comfortable lives especially women who used to spent several hours on daily basic for cooking and collecting wood fuels.

Case 2 - One year later in same village, a new innovative idea was initiated. People wanted to generate micro-hydro power locally, utilizing public fund and manpower.

Firstly, voluntary donation of money from public was collected. Some of them even donated their land. Secondly, one month unpaid labor service from each household was made compulsory. Thirdly, Governmental subsidy for renewable energy plant installation was taken and 35 kW hydropower plant was commissioned. Although power is supplied only in night time, project brought few employment opportunities, generation of water mill and people could replace kerosene lamps and wood fuels which brought incredible changes in village. In this case only technical support was provided by JICA.

9 Discussion and Conclusions

Nepal remains a country where more than 60 percent of the population lives in the countryside in scattered household. With rapid increasing rate of population, it's difficult to provide power to everyone. Despite having tremendous amount of water resources and skilled manpower, geographical structure of Nepal has been a challenge.

Agriculture is the main profession in Nepal and almost only profession for people living in countryside. Scientific and productive agriculture needs many infrastructures of development like electricity, water availability and modern tools. Illiteracy has been a subject of concern mostly in rural area. Students are compelled to use kerosene lamp for illumination and forest wood as cooking fuel. These have negative impact on human health and environment because they emit harmful emissions.

In villages of most developing countries, animal farming is main occupation. Many parts of the country are deprived of power means. People are compelled to live their lives in dark and only traditional equipment for lighting like candles, kerosene lamps and wooden fuels are used light sources. If electricity would be generated locally, it would bring benefits for example entertainment and education purposes. Also lighting, cooking and washing would come more modern.

Different projects are launched recently in order to create change and replace the old energy system. Possible potential of renewable energy are studied and many survey are undergoing. Due to availability of fast flowing river in almost every part of Nepal, emphasis are given in producing local hydropower with capacity to withstand local villages. Small projects with less than 1MW energy production are significant for

villages. The main use of energy is to power for lighting, cooking food using electric stoves and electronic utilities. Policies should be formulated linking local, government and private sector, considering the socio-economic and environmental aspects. Implementation of governmental policies discussed in chapter 6 is vital to obtain the goal.

10 Bibliography

1. History of Nepal.[internet],posted 26th jan 2012 [cited 2015 jan 1]. Available from: http://electricitysoni.blogspot.fi/2012/01/history-of-nepal.html

2. CBS, 2013 Nepal in figures 2013 central bureau of statistics, National Planning Commission Secretariat, Government of Nepal.

3. CBS, 2011 Nepal Living Standards Survey 2010/11, statistical report volume 1, Central bureau of Statistics, National Planning Commission Secretariat, Government of Nepal.

4. Nepal energy efficiency programme, clean cooking. Available from: http://energyefficiency.gov.np/article-component2

5. Nepal hydropower overview. Available from http://www.hidcl.org.np/nepal-hydropower.php

6. Hydropower in Nepal. Available from: http://www.ippan.org.np/HPinNepal.html
7. Fuel wood as source of energy in Nepal. Posted March 3, 2010. Cited from http://forestrycomponents.blogspot.fi/2010/03/fuel-wood-as-source-of-energy-in-nepal.html

8. Nepal energy situation. Available from:

https://www.google.com/search?q=energy+consumption+in+nepal+village

9. Solar energy system, Product and services. Available from

http://nepalsolar.com/products.php

10. Available from: http://www.appropedia.org/images/5/59/Still_diagram_side.jpg
11. Swogun energy pvt. ltd, Available from: http://www.swogun.org.np/

12. List of major hydropower in Nepal. Available from

http://bossnepal.com/list-of-major-hydropower-stations-in-nepal/

13. [PDF] Government of Nepal Scaling-up Renewable Energy Context. Available from: https://www.google.com/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=goals%20nepal%20government%20renewable%20energy
14. The effect of solid fuels used in childhood mortality in Nigeria: evidence from 2011 cross-sectional household survey. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4290397/
15. How renewable energy can contribute to the growth of our country. Available from: http://homeguides.sfgate.com/renewable-energy-can-contribute-growth-country-79353.html
16. Rural Nepal lights up with renewable energy, by Kathleen Egan. Updated on July 26 2014. Available from: http://www.borgenmagazine.com/rural-nepal-lights-renewable-energy/
17. Renewable energy village power systems for remote and improvised Himalayan villages in Nepal, Grid connection. Available from: http://www.udc.edu/docs/cere/Zahnd.pdf
18. High Voltage transmission line. Available from: https://www.google.com/search?q=big+electricity+transmission+pole+in+kali+gaki+nepal&rlz=1C1PRFE_enFI680FI680&espv=2&biw=1366&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiIm9qy15bMAhWoF5oKHRI5A_AQ_AUIBigB#imgrc=LJ7kc-S0PUsQEM%3A
19. Environmental impacts of renewable energy technologies. Available from: http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-of.html#.VxfjcPl97IV
20. The Bio-Gas Digester.Available from: : https://bopdesigner.files.wordpress.com/2012/01/biogasstory_v2.png