POTENTIAL OF RENEWABLE ENERGY TECHNOLOGIES FOR SUSTAINABLE RURAL DEVELOPMENT IN NEPAL

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INTRODUCTION

Majority of people in Nepal live in rural areas and are poor. Though energy is vital for economic development and Integral in domestic purposes, due to their poor economic condition, rural people consume less energy and rely on traditional energy sources. In order to reduce the rural poverty, it is necessary to intensify agricultural productivity and promote more non-farm livelihood activities by increasing small and medium scale enterprise including household-based activities and micro-industries, which require modern form of energy. Similarly, linking energy development with other sectors such as irrigation, agriculture, forestry, transportation, water and sanitation etc. is mandatory for the holistic development of the country.

The total energy consumption in Nepal was estimated to be 8576 million TOE (tones oil equivalent) in 2003. The per capita consumption of energy is 15 Giga Joule (GJ). The energy supply is being provided mostly by traditional and semi-traditional energy sources and some by commercial and modern energy sources.

Regarding energy consumption pattern by fuel type, about 85% energy consumption is traditional fuel wood, agricultural residure and animal waste in the country. The share of commercial energy like coal and petroleum is 12.8%, whereas the share of electricity is only 1.5%. Similarly, the share of renewable is less than 1%. The energy consumption sectors are households (89.05%), industrial (5.25%), commercial (1.33%) transport (3.44%) and agriculture (0.79%) respectively. Thus, household sector is the major energy-consuming sector in the country.

NEED OF RENEWABLE ENERGY TECHNOLOGY FOR RURAL DEVELOPMENT

About 90% rural households still depend upon traditional energy sources like fuel wood, agricultural residue and animal waste for cooking food and kerosene for lighting in Nepal. The consumption of this energy has a negative effect on the quality of lives of the people, since it takes much time to collect wood and causes adverse effects on health. Besides, these traditional energy sources are neither sustainable nor desirable from environmental considerations. Therefore, there is a need to replace or supplement those energy supply systems by modern forms of renewable energy. The available sources for renewable energy development in Nepal are water, sun, wind, biomass, hot spring and so on. These renewable energy sources are un-interruptible and infinitely available due to their widespread complementary technologies, which can accommodate the country's need to diversify supply. Besides, these energy sources are environmentally friendly as

they have very little or no negative impact on Green House Gases (GHG), landscape, climate, and physical and topographical environment.

By exploiting the available energy resources the possible renewable energy technologies, which can generate power, are: pico-hydro and micro-hydro power, biomass related biogas, briquettes, gasifire, liquid bio-fuel, improved cooking stove, solar photovoltaic, solar thermal and wind powered plants. Of these technologies, micro-hydro, biogas, improved cooking stove, solar photovoltaic (PV) home systems and solar water heaters are becoming popular and are at varying stages of commercialization. However, the technologies such as; solar cooker, solar dryer, liquid bio-fuel, briquettes, wind and geothermal are only in research and demonstration stage, which still needs commercialization. The status of development of RETs is presented in the following table:

Table 1: Status of Development or Renewable Energy Technologies in Nepal

Technology	Development status	Institutions involved for development
Micro-hydro	• Availability of resource data • Dissemination • End-use diversification • Commercialization	• AEPC, WECS • REDP • INGO/NGO • CES, TU
Solar PV	• Availability of resource data • Adaptive R & D • Demonstration • Dissemination • Commercialization	• AEPC • REDP • INGO/NGO • CES, TU • RONAST
Biogas	• Fundamental R & D • Adaptive R & D • Dissemination • End-use diversification	• AEPC • BSP/SNV • CES • Other NGO/INGOs
Solar Thermal	• Availability of resource data • Adaptive R & D • Demonstration • Dissemination • Commercialization	• CES, TU • RECAST • NGO/INGOs
Liquid Bio fueld	• Availability of resource data • Adaptive R & D • Demonstration	• CES, TU • RECAST • RONAST • NGO/INGOs
Improved cooking stove	• Fundamental R & D • Adaptive R & D • Dissemination • Dissemination	• RECAST • NGO/INGOs • AEPC • CES
Solid bio-mass	• Availability of resource data • Adaptive R & D	• RONAST • RECAST

Technology	Development status	Institutions involved for development
	• Demonstration	• CES
Wind energy	• Availability of resource data • Adaptive R & D • Demonstration • Dissemination	• AEPC • CES • ITDG
Geothermal	• Fundamental R & D • Availability of Resource data • Adaptive R & D • Demonstration	• CES

Source: RETRUD Conference Paper, CES, IOE, Kathmandu, 2004.

STATUS OF ELECTRIFICATION IN NEPAL

Out of total 4,174,374 households in the country, only 25.74% have access to electricity by various sources, by NEA grid, micro-hydro and solar home system (SHS). Table 2 below presents the households having connection to electricity from various sources by Development Regions in 2003.

Table 2: Households having Access to Electricity Generated from Various System (2003)

Development Region	% of H/H having connected to electricity (in %)	Total No. of H/H in Census 2001
All Nepal	25.74	4174374
EDR	18.02	1000358
CDR	33.27	1465753
WDR	31.32	863045
MWDR	15.63	479817
FWDR	13.55	365401

Source: Renewable Energy Data of Nepal 2003, Community Awareness Development Center, 2004.

Above Table shows that CDR have the maximum number of households (33.27%) having connection to electricity from national grid, followed by WDR (31.32%). FWDR have the minimum number of households (13.55%), connected to electricity. As electricity connection is correlated with the development of the region or area, it can be said that among the five development regions CDR is highly developed, whereas FWDR is least developed.

Table 3 presents the percentage of electrified households from NEA grid, SHS and Micro-hydro by Development Region.

Table 3: Electrified Households from NEA Grid, SHS and Micro-hydro by Development Region (2003)

Development Region	Electrified Households (in %)			
	NEA Grid	SHS	Micro-hydro	Total Percentage
All Nepal	89.62	3.97	6.42	100.0
EDR	87.60	6.18	6.21	100.0
CDR	96.0	1.31	2.78	100.0
WDR	82.17	6.19	11.64	100.0
MWDR	88.77	3.56	7.67	100.0
FWDR	80.31	7.07	12.69	100.0

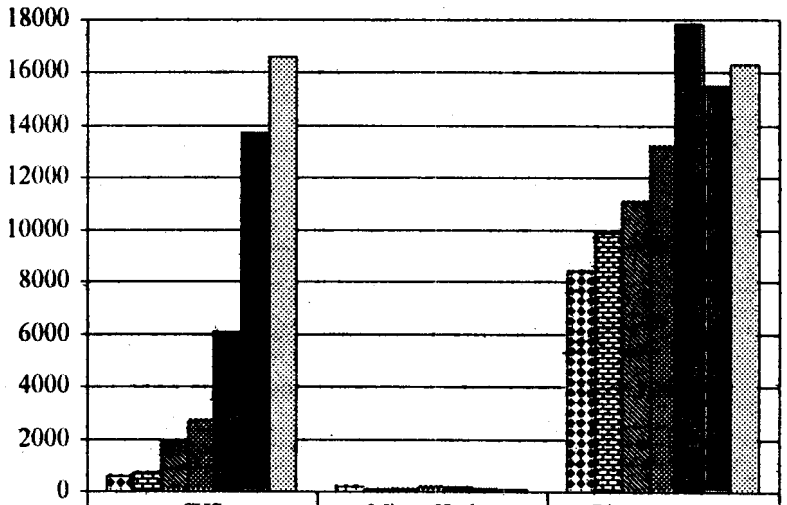
Source: Renewable Energy Data of Nepal 2003, Community Awareness Development Center, 2004.

It is clear from the above Table - 3 that NEA grid is the highest source of electrification (89.62%), in the country followed by Micro-hydro (6.42%) and SHS (3.97%) respectively. NEA grid is the highest supplier of electricity in CDR (96.0%) indicating low supply of electricity from micro-hydro and SHS. However, in FWDR 80.31% households are electrified from NEA grid. Therefore, in that region, 7.07% and 12.69% households are electrified by SHS and mcro-hydro respectively. Similarly, in WDR also application of SHS and micro-hydro are high (6.19% and 11.64%) for electrifying the households, since in that region only 82.17% households are getting electricity from NEA grid. This indicates that due to unfavorable topographical condition and lack of infra-structural development, market of electricity and commercial expansion, WDR and FWDR are getting less electrification from national grid, and thus SHS and micro-hydro providing alternative solution for electrification.

GROWTH OF RETs IN NEPAL

It is clear from the above discussion that RETs are the alternate sources of electrification in remote rural areas and getting popular at present. Table 4 presents the yearly growth of various forms of RETs from 1996/97 to 20002/2003.

Yearly Growth of RETs



	SHS	Micro Hydro	Bio-gras Plant
1996/97	562	144	8387
1997/98	736	100	9869
1998/99	1899	125	11052
1999/2000	2715	148	13265
2000/001	6082	152	17857
2001/002	13676	82	15527
2002/003	16598	95	16340

Figure 1: Yearly growth of Different Forms of RETs from 1996/97-2002/2003.

Source: Same as Table 2.

There is an increasing trend in the growth of SHS and biogas both in installation and cumulatively. In case of micro-hydro, the number of systems being installed is decreasing. However, cumulatively there is an increase from 747 in 1996/97 to 1281 in 2002/2003.

Thus, due to increasing application of RETs, the consumption pattern of various energy sources in terms of relative share in total energy has changed from 1991. It is presented in the Figure below:

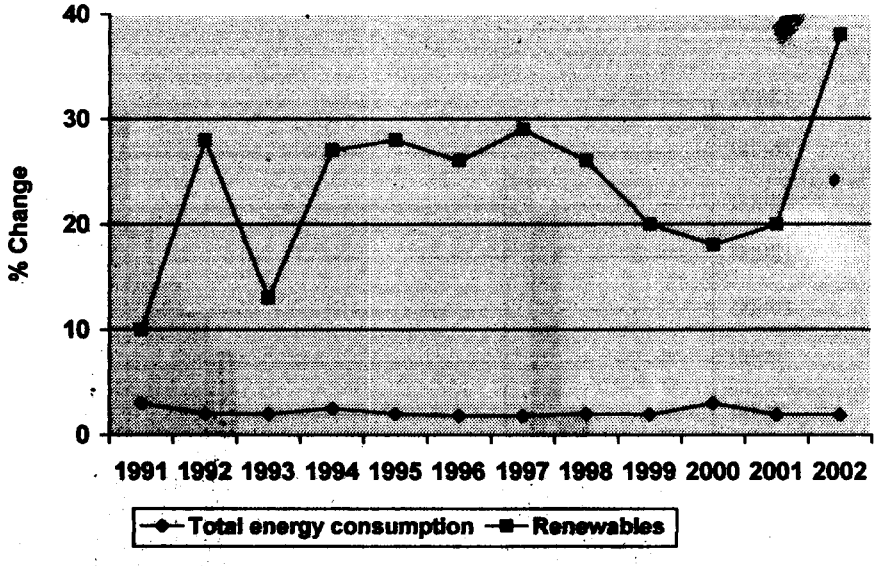


Figure 2: Ratio Change in Energy Consumption (1991-2001)

The consumption of total energy between the census years 1991 and 2001 has increased by an average rate of 3.06%. However, the application rate of RE has increased at an accelerated rate, with intermittent fluctuations and with an average value of 21% over the same period. This date indicates that there is a gradual shift of energy consumption pattern from traditional source to renewable sources (Ministry of Population and Environment, 2003).

The success in providing energy for development depends upon its proper integration in various development activities. It is readily acknowledged that certain economic activities must exist to realize the benefits of electrification. Likewise, other essential requirements include ensuring community participation in rural energy projects and encouraging private and financial sector initiatives in rural development (UN, ESCAP, 2003). Recently, the development programs in Nepal have been integrating energy with other development activities.

RENEWABLE ENERGY POTENTIAL IN NEPAL

Energy is directly related to increasing production of the country. However, sustainable energy development requires efficient use of energy, which also can increase production. The sustainable energy development depends upon the continuous supply of energy sources mobilizing own existing resources. Since

Nepal is rich in supply of resources, such as; water, sun, biomass and wind, there is a great potential for the development of RETs. Appropriate mobilization of these locally available resources provide energy services even for the poor sections of the country.

BIO-MASS POTENTIAL

Being an agriculture based country, Nepal has a plentiful supply of agricultural residue and animal waste. Similarly, the country is rich in forest resources. Therefore, the country has a potential for biomass energy. The rural households take agricultural and livestock farming in an integrated manner. Almost all of the farm households raise cattle or buffalo or both for their subsistence. It is estimated that a total of 28.1 million ton of dung is available per day for biogas production (BSP, 2002). The potential number of biogas plants is estimated to be 1.5 million, of which 62% is in Terai, 37% in hilly region and 1% in mountain region (Ministry of Population and Environment, 2003).

MICRO-HYDRO POTENTIAL

Nepal is rich is water resources. There are 6000 large and small rivers in the country. Therefore, the potential to generate power from micro-hydro is estimated to be 83000 MW. Out of this, 42000 MW generation of power is feasible. However, the power used so far from this technology is about 550 MW contributing to less than 2% of national energy share in Nepal. (NEA, 2004).

WIND ENERGY POTENTIAL

There is a potential of wind energy in many hilly and mountain regions of Nepal. However, the systematic wind map has not been carried out yet. Wind power potential of 200 MW in 12–Km corridor from Kagbeni to Chusang has been estimated. About 500 GWH energy from the wind can be generated annually in this region (CBS, 1998). Similarly, Mustang and Khumbu Region in eastern mountain is also identified as a potential area for large-scale exploration of wind energy. Besides these areas, many other hilly parts of the country; such as Karnali River along with the East-West High Way, Batase Danda of Palpa, Rampur of Chitwan, Tarahara of Sunsari, Arun Valley, etc. have small-scale wind energy potential. The nature of wind energy pattern indicates that small-scale wind turbine is feasible for meeting lighting supporting communication as TV, radio needs of the people in those areas (ITDG, 2003).

SOLAR POWER POTENTIAL

The country has 300 sunny days per annum and thus is very rich in solar power potential.

The average solar insulation is 4.5 kWh/m2/day.

Using PV module @ 12% efficiency, total energy generated will be 0.12* 4.5* 147,181 = 80,000 GWh/day=17.7 TW

This energy generated will be more than energy required for fulfilling the whole energy demand of the country.

The total estimated world energy demand at present is about 13 TW. If we use just 0.01% of the total area of Nepal, we can generate solar electricity of 8 GWh/day, that is 2920 GWh/year (which is more than the energy generated by NEA in the year 2003 amounting 2261 GWh/year). The PV power used until now is about 3 MW and the SHS used so far is 75000. (CES, IOU, 2003).

SUBSIDY POLICY ON RETs OF HMG/N

The success in providing energy for development depends upon proper integration of development activities. It is widely acknowledged that certain economic activities must exist to realize the benefits of electrification. Other essential requirements include ensuring community participation in rural energy projects and encouraging private and financial sector initiatives in rural development (UN, ESCAP, 2003).

However, subsidy on RE systems for the under developed countries like Nepal is needed due to the following reasons:

- Cost of providing electric service to rural areas is high because of low population density;
- Low purchasing power of rural population makes the provision of electric service to rural areas generally not commercially viable;
- Lack of industry results in sparse demand, which is concentrated around peak hours;
- Collection of payment from rural consumers may be difficult (Hertzmark, 2004). The development programs in Nepal at present have been integrating energy and development, especially with rural development. Since electricity from national grid could not be achieved due to various geographic and other reasons, RETs are playing a vital role and also are viable for sustainable energy development. For the promotion and development of RETs, subsidy is considered important and government is providing subsidy for some of the RETs.
- The HMG/N is providing subsidy for RE consumers in the following forms;
- Subsidies for the capital component of either a grid connection or for the purchase of distributed generation equipment, and
- Low interest and/or moratorium on interest for some period by banks on loans to rural electricity providers under a government scheme for rural electricity service companies.

PROBLEMS IN THE DEVELOPMENT OF RETs

Though there is a vast potential of RETs, the present consumption of RE is less than 1% in the country. The problems in developing, promoting and disseminating RETs in rural areas seem to be (i) high initial capital cost; (ii) inadequate rural credit system; (iii) lack of continuous energy supply from the ReTs; (iv) inefficient institutional base; (v) sporadic availability of low cost

information and services; (vi) lack of awareness among rural people, (vii) insufficient research and development.

Besides, these problems, there are also various barriers in disseminating the RETs in the country, some of which are shown in the following Table:

Table 4: Barriers to Large-scale Dissemination of RETs

RETs	Barriers
Micro- and Mini-Hydro	• Inadequae work on developing strategy • Non availability of basic field data • Insufficient end-uses other than lighting • Technical and operational problems
Improved Cooking Stoves (ICS)	• Incompatibility of existing models with the traditional life-style • Lack of information dissemination • Inadequate attention in research and development
Bio-gas	• Less access by ultra-poor and disadvantaged people • Issues of low temperature in high Mountains • Low dung availability from small farms
Solar Photovoltaic	• High initial investment • Lack of repair and maintenance facility at local level • No subsidy for SHS with low watt PV module
Solar Thermal System	• Technology not yet suitable for the mountain region • No subsidy
Bio-mass Gasifiers	• Un-economical due to subsidized electricity and diesel • Inadequate research and development
Wind Energy system	• Non-availability of wind monitoring and mapping data for many places • Inadequate research and development

Source: Ministry of Science and Technology, 2003.

Other barriers in progress of RETs include:

- Lack of trained personnel
- Poor resource assessment
- Insufficient field experiments
- Lack of infra-structure for decentralized delivery system
- Lack of market support
- Non-existence of financial incentives
- Social inertia

POLICIES OF RENEWABLE ENERGY IN THE 10TH FIVE YEAR PLAN-2002-2007

The over all goal of the 10th Five Year Plan is reduction of poverty in the country. There is a positive co-relation between renewable energy use and poverty reduction.

Therefore, it is important to mention the achievement of the 9th Five Year Plan and recent policy mentioned in the 10th Five Year Plan of HMG.

ACHIEVEMENT OF 9TH FIVE YEAR PLAN

The achievements made with regard to RET in the 9th Five-Year Plan are as follows:

Micro-Hydro Plant

With regard to installation of MHP power, 4459 KW was installed (63% of the target);

Biogas Plant

Rural households installed a total of 59,678 biogas plants (66% of the target);

Improved Cooking Stove

With regard to ICS a total of 51,100 ICS have been installed in rural households (20% of the target);

Solar Home System

Maximum number of SHS (23,570) has been installed in the rural households, (62% of the target);

Solar Dryer/Cooker

413 solar dryer/cooker has been achieved during the plan period (more than 100% of the target);

Solar mapping has been conducted in 5 districts;

Wind Energy

Wind mapping has been conducted in 7 districts of the country;

Geothermal Energy

Geothermal site and investigation has been made in 1 district.

Besides these achievements, 20 year RE Perspective Plan has been formed and subsidy policy of 2057 has been implemented. Masters in science in Renewable Energy Engineering has been started at CES/IOE in TU.

POLICIES WITH REGARD TO RETs IN THE 10TH FIVE YEAR PLAN

- Promotion of Micro-hydro, solar, wind energy and ICS in rural areas;
- Development and distribution of alternative energy for raising living standards of rural people;

- Encourage community and private sectors in development and distribution of the alternative energy;
- Promotion of information technology through rural electrification by alternative energy;
- Establishments of rural energy fund for the sustainable development of rural energy;
- Research on cost reduction of alternative energy technology and transfer.

CONCLUSION

Economic development must be supported by sustainable energy services, which can be provided by RETs in rural areas. In an under developed country like Nepal, RETs are of great importance for rural development. The important ReTs, which are presently being used in Nepal, are: micro-hydro, biogas, ICS, Solar Photovoltaic, Solar thermal and wind energy. These technologies offer economic potential, but various problems and barriers are currently hindering their development and promotion. For a number of these technologies, HMG/N is providing a financial subsidy and this should be continued for some years. The successful development of RETs requires motivation of end-users by education, provision of information, training, sound research and development, and awareness by the rural community of available financial assistance. Also crucial for its success is the participation of the rural community in discovering the diversity of uses to which RETs can be applied.

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ANNEX

ACRONYMS/ABBREVIATION

AEP	-	Alternative Energy Promotion Center
BSP	-	Biogas Support Program
CES	-	Center for Energy Studies
CDR	-	Central Development Region
CBS	-	Central Bureau of Statistics
EDR	-	Eastern Development Region
FWDR	-	Far Western Development Region
HMG/N	-	His Majesty's Government/Nepal
INGO	-	International Non-governmental Organization
ICS	-	Improved cooking Stove
IOE	-	Institute of Engineering
NGO	-	Non Governmental Organization
TU	-	Tribhuvan University
MWDR	-	Mid Western Development Region
NEA	-	Nepal Electricity authority
REDP	-	Renewable Energy Development Program
RECAST	-	Research Centrer for Applied Science and Technology
RET	-	Renewable Energy Technology
RONAST	-	Royal Nepal Academy for Science and Technology
SHS	-	Solar Home System
WDR	-	Western Development Region
WECS	-	Water and Energy Commission Secretariat