Renewable energy technologies in Nepal

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Abstract: Nepal, one of the least-developed countries, has a per capita energy consumption of about 336 kilograms of oil equivalent (kgoe), which is much below the world average of 1,474 kgoe. Around 85.27% of the total energy consumption comes from traditional energy resources and only 0.48% from renewable sources. About 40% of the total population has access to electricity. This 40% uses 33% from the national grid and 7% from alternative sources. This paper contains a historical account of the development of renewable energy technologies in Nepal. It focuses on the deployment trend of different renewable energy technologies such as biogas, micro-hydro, water mill, solar thermal and photovoltaic, wind and geothermal energies in the country. The role of stakeholders as well as governmental subsidy for the commercialisation of these technologies is also highlighted.

Keywords: technology; energy resources; deployment; commercialisation; promotional activities; government policy; rural development.


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1 Background of the country

Sandwiched between the two most populous countries in the world – China, in the north and India, in the south – Nepal is a land-locked country. It extends along the Himalayan range, which rises from the Indo-Gangetic plain at an altitude of about 60 m in the south to the crest of the Himalaya reaching more than 8,000 m altitude in the north. Hills and mountains occupy two-third of the country’s land area and about 88% of the population live in rural areas. Agriculture is the mainstay of the economy, accounting for 39% of the gross domestic product (GDP). Industrial activity mainly involves processing of agricultural products including jute, sugarcane, tobacco and grain (World Bank, 2002).

2 Energy resources and consumption

Nepal’s topography gives her an enormous scope for the development of hydropower. It is estimated that Nepal has more than 6,000 rivers, whose total length is around 45,000 km. The theoretical and commercial potentials of hydropower in Nepal are 83,000 MW and 42,000 MW, respectively. However, so far only about 548 MW has been generated by the various hydropower stations (NEA, 2003). Nepal has no proven reserves of natural gas or oil. The country’s confirmed fossil fuel reserve amounts to two million tonnes of coal. Forest areas, which cover about 41% of the landmass of Nepal, are capable of providing a sustainable fuelwood supply of about 15 million metric tonnes (MT) annually (WEC, 2002). No proper wind mapping has so far been conducted in Nepal. Significant wind potential has been reported to be available in Khumbu region and other different districts e.g., Mustang, Palpa, Ramechhap, Karnali Chisapani, Jumla, etc. On an average, Nepal has 6.8 sunshine hours per day, i.e. 2,482 sunshine hours per year with the intensity of solar radiation ranging from 3.6 to 5.9 kWh/m²-day (MOF, 2002). There are several hot springs (Tatopani) found in Nepal but very little study has been made on the known 40 hot springs for the exploitation of this energy source (CES, 2001).

Nepal’s per capita energy consumption of about 336 kilograms of oil equivalent (kgoe) (SCDP, 2001) is much below the world average of 1,474 kgoe (ADB, 2001). In 1998, the total energy demand in the country was estimated to be 7.34 million tonnes of oil equivalent (toe) and it is increasing at an average rate of 3.3% per annum. Traditional energy (fuelwood, agricultural residues and animal dung) provided 85.27% of the total energy consumption in 2002 with most of this biomass energy being used for cooking and heating. Similarly, commercial energy provided about 14.24% and renewable/others provided only 0.48%. About 14% of the total energy demand is met at present by imported petroleum products and coal at a cost of about 40% of Nepal’s total merchandise export. About 40% of the total population has benefited from electricity by the end of 2002. This 40% is reported to include 33% from national grid and 7% from alternative energy (MOF, 2003).

About 84% of the total population of Nepal lives in rural areas, and agriculture constitutes the main economic activity of this population. According to a survey conducted by Water and Energy Commission Secretariat (WECs) in 1995, from the energy end-use perspective, the largest amount of energy used was for cooking purposes (65%) in rural households. Similarly, space heating accounted for 8%, agro processing for 3%, water boiling for 2%, lighting for 1%, and miscellaneous other uses (animal feed preparation, religious occasions and ceremonies, etc.) accounted for 21% of the energy used.
3 Need of renewable energy technologies (RETs)

Historically, Nepal’s rural population has been meeting its energy needs from traditional sources such as fuelwood and other biomass resources. This is neither sustainable nor desirable from the environmental considerations as well as from the perspective of the effort to improve the quality of life (CES, 2000). Therefore, there is need to substitute as well as supplement the traditional energy supply system by modern forms of energy. Because of the country’s dependence on imported fossil fuels, the high cost of grid connection and low and scattered population density, a decentralised energy supply system becomes the natural choice. Decentralised new and renewable energy systems such as micro hydro power, solar photovoltaic power, biogas energy, improved cooking stove, etc. provide feasible and environment-friendly energy supply options in rural areas.

4 RETs: historical development, potential and deployment

4.1 Biomass

Although the total annual sustainable fuelwood production from Nepal’s forests is about 15 million MT, only half of the total forest area is accessible for fuelwood collection. Therefore, the accessible fuelwood supply is only about 7 million MT per annum. The agricultural sector produces large amount of residues that could be used as an energy source. In Nepal, about 14 million MT of crop residues and about 3 million MT of animal manure are available annually. However, only 0.9 million MT of crop residues are currently being used for energy purposes (WEC, 2001). Almost 80% of the population still uses fuelwood, supplemented by crop residues and animal manure, as their primary energy source. In the domestic sector, biomass is primarily used in cooking stoves, which have low efficiency. There is a huge potential for biomass technologies such as improved cook stove, gasifier and briquetting.

4.1.1 Improved cooking stove (ICS)

R&D work on ICS have been conducted in Nepal since 1981 at the Research Centre for Applied Science and Technology (RECAST). Some attempts have been made to improve household cooking devices by introducing energy-efficient models in some areas of the country. Since then, RECAST has started R&D work on ICS to achieve the objective of decreasing the consumption of fuelwood (Joshi, 1992). As a result different types of ICS have been designed and developed. The main improvements involved so far are: enclosing of fire, regulating the flow of air into the stove and adding a chimney. These improvements have also led to reduction in carbon monoxide and smoke emission with the objective of reducing detrimental health impacts on the users and their families. Till June 2003, more than 96,000 ICS have been installed in the different parts of the country (REDP, 2003).

4.1.2 Briquetting

Extruder technology using heated-die and screw-press type briquetting machines, imported from Taiwan were first introduced to Nepal in late 1980s. This type of
briquetting machines produce briquettes in a continuous fashion using a screw forcing the raw material through a heated die, but suffered many set-backs, such as the lack of proper training for operation and maintenance and the lack of spare parts. In a coordinated effort, Royal Nepal Academy of Science and Technology (RONAST), Asian Institute of Technology (AIT) and Bangladesh Institute of Technology (BIT), Khulna, simultaneously carried out adaptive research to improve biomass briquetting machines. As a result, RONAST initiated its work by locally assembling a prototype briquetting machine using a die, screw driving shaft, screw housing and screws imported from Bangladesh. After gaining sufficient experience, a complete briquetting machine was fabricated in Nepal with the collaboration support of local industries. Being an agricultural country, Nepal produces substantial amounts of agricultural and forestry processing residues such as rice husk, rice straw, bagasse, cotton stalk, jute stick, almond shells, sawdust, etc., but only a small fraction of the residues produced is used for energy. The major limitation in utilising them for energy is their low bulk densities and high moisture content. Biomass briquetting technology can transform these loose biomass materials into dry, solid briquettes of regular shape, usually cylindrical with a diameter of 5–10 cm, which can be easily stored and transported (Shakya and Shakya, 2002). At present, RONAST and a few other organisations have been involved in the promotional activities of bio-briquettes in the country.

4.1.3 Biogas

The first biogas plant was built in Nepal in 1955 by the late Father B. R. Sauboll, a Belgian teacher at Godavari St. Xavier School (Shakya, 2002). The prototype, a demonstration plant, was fabricated from an old 200-litre drum and a gasholder made of mild steel sheet. In 1968, the Khadi and Village Industries Commission (KVIC) of India built a plant for an exhibition at Kathmandu. During the year 1974–1975, the Department of Agriculture set up a programme to install 250 floating drum types of biogas plants and the Agriculture Development Bank of Nepal (ADBN) provided interest-free loan. In 1974, Development and Consulting Service (DCS) built four floating drum plants of KVIC design. Gobar Gas Tatha Krishi Yantra Vikas Ltd. (Biogas and Agriculture Equipment Development Company Pvt. Ltd., GGC) was formed in 1977 with the joint investment of the United Mission to Nepal (UMN), ADBN and Nepal Fuel Corporation under the DCS biogas extension programme. With the success of biogas development programme and the availability of government subsidies as well as the interests and involvement of non-governmental organisations (NGOs) and donor agencies, several private companies started to get involved (WECS, 2002). A new impetus was added to the biogas programme with the initiation and establishment of the biogas support programme (BSP) in 1992–1993. This programme was launched in collaboration with His Majesty’s Government of Nepal (HMG/N), the Netherlands Development Organisation (SNV–Nepal) and the German Financial Cooperation (KfW) in cooperation with the ADBN, Nepal Bank Limited (NBL), Rastriya Banijya Bank (RBB) and some recognised biogas companies (BSP, 2002).

BSP was established with the aim of developing and disseminating biogas technology as a commercially viable and market-oriented industry. Biogas plant installation and quality have improved rapidly after the establishment of BSP. Following the government policy to encourage private sector participation and realising the fact that a single company alone cannot meet the ever-increasing demand for more biogas plants, about 50
biogas companies have been established under the affiliation of BSP. Similarly, 13 appliances manufacturing workshops have been established and more than 5,000 biogas technicians including biogas masons trained. Currently more than 60 micro finance institutes and three major banks have been involved in biogas lending. All the construction material and appliances are locally produced and available, except for the main gas valve that is imported from neighbouring countries (Bajgain, 2003).

The total number of biogas plants constructed reached about 120,000 by the end of June 2003 (REDP, 2003). These plants are spread over 65 districts of the country. So far, in Nepal, biogas is mainly used for cooking (80%) and lighting (20%). The by-product of biogas, slurry, is used as a fertiliser for crop and vegetable production as well as feeding materials for fish.

The current subsidy provided by Alternative Energy Promotion Centre (AEPC), HMG/N in the biogas with respect to plant size and location is as below (AEPC, 2000):

<table>
<thead>
<tr>
<th>Plant Size (m³)</th>
<th>Terai</th>
<th>Hill</th>
<th>Remote Hill</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>6,500</td>
<td>9,500</td>
<td>11,500</td>
</tr>
<tr>
<td>6</td>
<td>6,500</td>
<td>9,500</td>
<td>11,500</td>
</tr>
<tr>
<td>8</td>
<td>5,500</td>
<td>8,500</td>
<td>10,500</td>
</tr>
<tr>
<td>10</td>
<td>5,500</td>
<td>8,500</td>
<td>10,500</td>
</tr>
</tbody>
</table>

If we look at the technical potentiality of biogas that operates with cattle dung, we can easily calculate the number to exceed 1.4 million in Nepal. Although biogas has reached 65 out of 75 districts, it is not distributed equally. There are several districts where a huge potential of biogas exists but penetration is still low. Furthermore, biogas is still within the relatively rich people and it has to reach to the poorer strata of population in future.

4.2 Hydropower

4.2.1 Improved water mill (IWM)

Traditional water mills have been in use in Nepal since time immemorial. History has it that water mill (known as Ghatta in vernacular) technology was transferred from Tibet to Nepal many years ago. More than 300 years ago, Nepal had good trade with Tibet. At that time Tibet was considered as a ‘bowl of gold’. Though it was difficult to travel across the Himalayas, many Nepalese went to Tibet in search of fortune. Some of the Nepalese who belonged to the Nakarmi (metalworker) caste were fascinated with the Ghatta in Tibet and pioneered its transfer to Nepal, so that finally they could develop the Ghatta in Nepal. These Ghattas have served as an important source of energy and are closely interrelated with the culture of rural villagers. Although the exact number of water mills is not confirmed, an estimate indicates that there may be around 25,000–30,000 water mills providing services. These traditional Ghattas were felt incapable to cope with the increased demand of agro processing because of low efficiency and time-consuming characteristics. Therefore measures were taken to develop IWM to ensure the better use of indigenously available knowledge and resources. The improved water mill is a modified version of the traditional water mill made by replacing
the traditional wooden runner with hydraulically better-shaped metallic runner having cup-shaped buckets. This increases its operational efficiency thus making it more useful with additional machines for oil expelling and electricity generation.

The power output ranges from 0.5 kW to 3 kW with a lifespan of ten hours, this technology has a grinding capacity ranging between 20 kg and 50 kg maize per hour. By mid June 2003, about 903 water mills have already been improved in about 42 hilly districts of Nepal (CRT/N, 2003). If the Ghattas are improved for electricity generation, a subsidy of amount NRs. 27,000/kW is provided by HMG/N (AEPC, 2000).

4.2.2 *Micro hydropower (MHP)*

Hydro electricity production in Nepal dates back to the early twentieth century. Pharping plant of 500 kW was developed in 1911 A.D., and thereafter came Sundarijal and Panauti, in 1936 and 1965, respectively. These schemes might have come to practice following the example of the traditional Himalayan mills built by people who after all knew their environs best. Installing micro-hydro also happened because aid agencies wanted to avoid the ecologically unacceptable procedure of wool dyeing. However, due to the problem of bureaucratic obstacles, the first plant through the private sector became operational in 1970s in Butwal, in western Nepal. Since the focus was laid primarily on large-scale power generation through large hydro and thermal means, the micro hydro potential remained untapped. The real development of MHP emerged since 1980. Moreover, when the government introduced subsidy policy in 1981, during the first four years (1981–1985), although only 10 MHP plants were installed with the total power capacity of 90 kW, in the year of 1985 altogether 23 schemes, generating 166 kW were installed (Rizal, Yamada and Ueda, 2003). There exists a huge hydropower potential and an ever-increasing market, and as of June 2003, a total of 2065 micro-hydro schemes, with an installed capacity of over 14,000 kW have been installed (REDP, 2003).

HMG/N has introduced a new subsidy policy, which provides a subsidy of NRs. 70,000/kW for schemes above 3 kW and NRs. 55,000 for Peltric Set (up to 3 kW). There is also transport subsidy of NRs. 8,750 to NRs. 21,000/kW depending upon the location of the plants from the nearest road head to compensate for the heavy transport cost for plants in remote areas. Similarly, NRs. 35,000/kW or 50% of cost for rehabilitation projects is also available. There is an investment ceiling per kW of NRs. 150,000 (AEPC, 2000).

MHP projects are environment friendly. However, depending on location of site and scheme types, trees may have to be removed in marginal areas. Although it does not involve construction of dams and no rehabilitation problem arises, suitable arrangements have to be made in case of formation of small reservoirs. It is true that the extent of ecological and environmental degradation through MHP plants are very negligible, however, there is a need to plan clear development strategies and implement them to multiply the positive impacts on tourism, community forest, water supply and irrigation, employment, agro-processing, community health, etc.
4.3 Solar energy

4.3.1 Solar photovoltaic (PV)

Use of solar PV technology for rural electrification in Nepal and even globally is not very long. Nepal saw the first case of rural electrification through PV when three mini grid PV systems were installed in 1988/1989 with French government support (Rai and Piya, 2003). One of the three systems stopped operating within a year of installation, making the policy makers and other key players sceptical about the viability of the technology for rural electrification. However, the popularity of solar home systems (SHS) has rapidly increased since the first SHS demonstration project in 1993, where 36 Wp SHSs were installed in 67 households in Pulimerang. By the end of 1999, more than 2,600 units, with a total generation capacity of about 100 kWP, were installed in Nepal. The estimated market potential is huge and about 2,500 kWP of photovoltaic power is currently being used in various public and private sectors (telecommunication, utility supply, stand alone, water supply, aviation, etc.). Stand-alone system contributes above 1,600 kWP with more than 44,000 SHSs installed as of July 2003 in 71 districts of the country. The trend of SHSs installation has been raised dramatically after 2000 due to the subsidy policy implemented by AEPC/HMG. Till mid-July 2003, 40 solar PV pumping units have been installed (REDP, 2003).

The amount of subsidy provided by AEPC/HMG on solar PV technology is as given below in Table 2 (AEPC, 2000).

Table 2  Subsidy amount (NRs) on SHS

<table>
<thead>
<tr>
<th>Capacity (Wp)</th>
<th>Hill/Terai</th>
<th>Far Hill</th>
<th>Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>10, 20, 30</td>
<td>50%*</td>
<td>50%*</td>
<td>50%*</td>
</tr>
<tr>
<td>&gt;30</td>
<td>8,000**</td>
<td>10,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Public welfare organisation</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>Solar pumps (up to 500 Wp)</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
</tr>
</tbody>
</table>

*But not exceeding NRs. 8,000.
**Reduction by 10% per year since 2003.

Electricity through an SHS typically sized between 30 and 50 Wp suits the requirement of rural households well. It also makes a tremendous difference in the living of the rural people. Electricity not only provides them with bright, clean and safe light but it also gives them opportunity to operate other appliances for information, education and entertainment. A survey conducted in 2002 on the users of 20 village development committees (VDCs) of 13 districts shows 77.33% of SHS users use electricity to operate radios, 37.44% to operate cassette players, 50.24% to operate TV and 8.06% to operate VCD layers (WEC, 2001). The technology would be beneficial for distance learning education programme also. The Centre for Renewable Energy (CRE), one of the solar PV technology promoters in Nepal, installed a PV-powered computer education system in Shree Divas Public Secondary School in Udindhunga of Tanahu district. After commissioning in October 2002, the system is functioning properly, except for problems
in the computer due to human errors. A specially trained teacher conducts computer education classes providing the facility to 12 students in this remote school.

4.3.2 Tukimara (white LED lamps)
CRE initiated an adaptive research programme to develop an alternative to d.c. fluorescent lamps using white light-emitting diodes (LED) and developed three prototype white LED lamps for SHSs. It collaborated with a local company Sunrays Co. Pvt Ltd. based in Kathmandu to commercially produce white LED lamps developed through the adaptive research. The lamp named Tukimara (literally means Kerosene Killer) contains three white LEDs and a storage capacity of 4.5 Ah provided by rechargeable NiCd batteries. Batteries can be recharged though a 6 V or 12 V dc power supply, such as the one provided by SHS. The lamps used locally made fibreglass reflectors. Two years of field trials with four lamps provided to several users confirmed trouble free operation and indicated very high user satisfaction. A more powerful version of lamp with six white LEDs has also been developed to meet the requirements of commercial users such as hotels, guesthouses and shops (CRE, 2003).

4.3.3 Solar water heater (SWH)
The development of solar thermal conversion devices started in Nepal in early 1960s. A locally made SWH installed on the premises of the Department of Mines and Geology was the first in Nepal. Based from other reports, the first prototype SWH was manufactured in 1968 by late Rev. B. R. Saubolle and the Asha Brothers in Kathmandu. Further records showed that Plumbing Division of Balaju Yantra Shala (BYS) has contributed to developing SWH since 1974. After considerable experiments and development, improved SWHs were supplied by BYS to the hostel of Budhanilkantha School in 1975. This was the first unit installed for public use, which brought favourable response among public and initiated the market attracting a number of manufacturers for manufacturing and installation of SWHs for domestic and commercial applications. The development of SWHs received further support at the then newly established sanitary section of the Mechanical Training Centre in Balaju with support from Helvetas Switzerland (WECS, 1997). Through continuous improvements in design, fabrication and installation as well as through a combination of efforts of private companies and technical institutions, the efficiency of SWHs was greatly improved. The market of SWHs increased in such a way that more and more SWH manufacturers are emerging in Kathmandu.

Until 1992 there was a record of 35 solar SWHs manufacturers registered with the Department of Cottage and Small Industries. There were 90 unregistered manufacturers in Kathmandu valley alone. It is estimated that presently there are more than 200 workshops making SWHs in Nepal. Likewise, more than 30,000 households in Nepal have already installed SWHs in their home and out of them about 80% are said to be installed within Kathmandu valley alone (Shrestha et al., 2003).

4.3.4 Solar drying
The Research Centre for Applied Science and Technology (RECAST) introduced a simple, inexpensive and environment-friendly solar drying technology in 1976 in the country. They have been developed and used for drying different kinds of agricultural,
horticultural and medicinal products including cash crops. Their operations are based on either direct drying (solar cabinet dryer) or indirect drying (some versions of solar rack dryers) or mixed drying (solar tunnel dryers and some other versions of solar rack dryers) (RECAST, 2002). With the exception of solar tunnel dryers and large size solar rack dryers, which are based on forced circulation of airflow, most of the dryers developed so far run on natural circulation of airflow. Among them the most popular dryers in Nepal are solar cabinet dryers, solar rack dryers and solar tunnel dryers. Several individuals and farmers have been extensively using solar cabinet dryers. Similarly, solar rack dryers and solar tunnel dryers are being used for small-scale commercial and industrial purposes. Today a new concept about hybrid solar/biomass drying technology is emerging. Based on these technologies some 11 types of solar dryers have been put into use in different parts of the country for drying a variety of products. The number of solar dryers installed in different parts of the country till July 2003 is around 2,246 (Joshi, Gewali and Bhandari, 2003). Out of them, 1,768 are solar cabinet dryers, 47 are solar rack dryers, six are solar tunnel dryers, one is hybrid solar/biomass rack dryer, 120 are domestic box dryers and 304 are others. Most of these dryers are installed in Kathmandu valley and its suburbs. At present the government has announced 50% subsidy on the total cost of solar dryers (but not exceeding NRs. 10,000). This subsidy amount may be up to 70% and 95% depending upon the purpose (if commercial) and site of installation (if remote mountains), respectively. At present, there are about 400 solar cookers installed within the country. The subsidy provided on these devices is 50% (but not exceeding NRs. 3,750) (AEPCC, 2000).

4.4 Wind energy

Wind is still one of the non-harnessed energy resources in Nepal. It is not yet known on the national scale how big its potential in the country is. Studies indicate that wind potential for power generation is favourable for the Palpa, Mustang and Khumbu regions of Nepal. In Kali Gandaki between Jomsom and Chusang alone potential of 200 MW has been estimated which, if fully utilised, can supply the energy of 500 GWh/year (Dangrid, 1992).

In the past sporadic efforts have been made to utilise the wind energy specially for lift irrigation purposes in which international donor agencies, private manufacturers, R&D institutions and even individuals were involved. Two wind turbines of 10 kW installed capacity were installed in Kagbeni of Mustang district for US$150,000. But they also collapsed after 2–3 months of operation (Dangrid, 1992). Thus the past experiences in harnessing wind energy were not encouraging. The main problems being faced in the promotion of wind systems are: lack of reliable data, high initial cost, unavailability of technical manpower in the country and the extreme heterogeneity of the topography.

A pilot project for demonstration and dissemination is being carried out by various organisations such as AEPCC, Intermediate Technology Development Group (ITDG), RECAST, etc. ITDG has installed five 200 W wind turbines at various locations such as Kavre, Palpa, Makawanpur, Chiosapani (Karnali) and Udayapur for the stand-alone system whereas RECAST has installed one 400 W wind turbine at Nagarkot for demonstration purposes.
4.5 Geothermal energy

The exploitation of geothermal resources dates back to Roman times, with early efforts made to harness water for medical and domestic applications. These geothermal resources are highly significant in developing countries like Nepal where no indigenous fossil fuel resources exist. Preliminary works to locate these resources were started in early 1980s. But only very little study has been made on the 40 hot springs found in different districts, e.g., Darchula, Bajhang, Jumla, Mustang, Myagdi, Sindhupalchowk, etc. of the country. Some of the hot springs are partially used as therapeutic purposes and recreation purpose only (CES, 2001).

5 Stakeholders involved in the promotion of RETs

5.1 Bank and financial institutions

The Agriculture Development Bank of Nepal (ADBAN): ADBN, with its large network of field offices scattered in the rural areas, is committed in the field of renewable energy development in Nepal. The bank has been providing credit support to MHP development, SHS and biogas installation in the rural area. Bank credit has been made available for MHP and Biogas plant installation for more than 25 years. However, credit on SHS has been introduced since 1995–1996. Till June 2002, it alone had invested over NRs. 146.6 million for the implementation of MHP projects, NRs. 155.4 million for biogas and 51.3 million for SHS installation. Being the pioneer in this area, the bank is represented on the board of AEFC (ADBN, 2002).

Local commercial banks have also started to act as financing intermediaries for the development of RET by participating in various programmes under the priority sector lending.

5.2 Non-government organisations

INGOs such as International Centre for Integrated Mountain Development (ICIMOD), ITDG, Winrock International have been engaged in the active promotion, development and dissemination of RETs. Similarly, many NGOs such as CRE, CRT, Foundation of Sustainable Technology (FoST), Nepal Biogas Promotion Group (NBPG), Association of Solar Thermal Energy Devices (ASTED), etc. have been involved in the continuous promotion of these technologies.

5.3 Donor agencies

Various donor agencies such as USAID, SNV/Nepal, SDC, ESAP/Danida, UNDP, UNICEF, etc. have been involved in the promotion of various RETs through financial support in the form of grant-aid and soft-loan.
5.4 Private sector

They are responsible for the success of RET systems through the quality service of the RET systems installation. HMG/N has initiated various policies and programmes to encourage them by tax exemption, loan granting scheme, etc.

5.5 Government institutions

The government institutions, such as the National Planning Commission (NPC), Ministry of Science and Technology (MOST), Water and Energy Commission Secretariat (WECS) Ministry of Finance, etc. influence the RETs development policies and programmes.

Alternative Energy Promotion Centre (AEPC): The overall objective of AEPC is to popularise and promote the use of RETs to raise the living standards of the rural people to protect the environment and to develop commercially viable alternative energy industries in the country. Now, it has been working in the 75 districts of the country in the field of mini and micro hydropower, biomass including biogas, solar energy, wind energy, improved cook stove and other alternative energy sources. It is the apex body of the government for strategic planning and policy formulation for RETs in Nepal. AEPC created a substantial demand on RETs by channelising the government's subsidy programme. In order to meet this growing demand it also has qualified some non-governmental organisations to develop and promote RETs.

5.6 Users

Users are the main factors whose awareness and information about RETs cause widespread demand of technology. Experiences have shown that only the demand-driven RETs would become successful. These activities will directly affect the effectiveness and sustainability of the programme undertaken for fulfilling their energy requirement. The active participation of the users is the vital RET projects if it is to succeed.

5.7 Research institutions

Institutions such as Royal Nepal Academy of Science and Technology (RONAST), Research Centre for Applied Science and Technology (RECAST), Centre for Energy Studies (CES), etc. are involved in different levels of R&D activities focused on the development of cheap, socially adoptable, economically viable and sustainable RETs that can be directly implemented in the focused area. Institutes such as CES and Council for Technical Education and Vocational Training (CTEVT) are involved in human resource development at different levels for the successful planning, designing, installation, operation and maintenance of RET projects.

Research Centre for Applied Science and Technology (RECAST): It is one of the four research centres in Tribhuvan University, Nepal. RECAST was established in 1977, with the objectives of undertaking research in development and promotion of indigenous technology, identification of exogenous technologies appropriate to Nepal and their technical adaptation and conduction of research on basic and applied sciences. RECAST has a specialised division for energy development and processes various laboratory and fabrication facilities and trained technical personnel.
RECAST has been actively involved in many renewable energy programmes including promotion of biofuel, improved cooking stoves, development of micro-hydro systems, solar thermal devices, biomass gasification, construction of biogas digesters and field experiments with wind generators.

Royal Nepal Academy of Science and Technology (RONAST): It was established in 1982 by a royal ordinance as an independent body with the objectives of advancement of science and technology, improvement of indigenous technologies, promotion of research and facilitation of technology transfer. RONAST conducts in-house research, science and technology promotion activities, and provide analytical and support services for other research institutions.

RONAST possesses several research facilities including well-equipped research laboratories, instrumentation unit, library, computer centre, radiation measurement station and a solar energy equipment testing station. RONAST has been actively involved in several renewable energy projects involving a PV pumping, biomass briquetting and testing of solar thermal and photovoltaic equipment.

5.8 Quality control body

An independent body like Nepal Bureau of Standard can play a very important role in controlling the quality of the components/devices/systems of the RETs so that a healthy competition among the suppliers can be initiated and quality assurance can be granted to the users. Recently, a solar energy test station (SETS) has been established at RONAST with the aim of performing quality assurance of solar electricity systems. Some other quality testing stations are either established or are in the process of being established.

6 Governmental policy

The positive role of alternative energy technology for the fulfilment of energy needs of the rural people have been recognised by the National Planning Commission, Nepal during the Seventh Five Year Plan (1987–1992). The Eighth Plan (1992–1997) envisaged the need of a coordinating body for a large-scale promotion of alternative energy technologies in Nepal and the AEPC was thus established to promote the use of RETs and act as the government coordinating body.

In Ninth Five Year Plan (1997–2002), HMG/N had planned the following installations in the country; its achievements are also detailed.

- 38,000 units of solar PV home systems (79% achievement)
- 90,000 biogas plant (66% achievement)
- 250,000 improved cooking stoves in about 45 district of the country (20% achievement)
- Generation of extra 5,261kW of electricity through pico and micro-hydropower (63% achievement).
The current Tenth Five Year Plan (2002–2007) emphasises (Shrestha et al., 2003):

- increasing the consumption capacity of rural families by developing and extending the alternative energy sources, seen as a powerful tool in poverty alleviation
- supplying energy for commercialisation of domestic needs and the professions of rural people by developing alternative energy technologies based on local resources and tools
- reducing dependence on imported energy sources and reducing negative environmental effects by the proper use of resources and tools of local energy
- by 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.

In the current Tenth Five Year Plan (2002–2007), HMG/N plans to install the following (NPC, 2002):

- 52,000 units of solar PV home systems
- 200,000 biogas plants
- 250,000 improved cooking stoves in about 45 districts of the country
- Generation of extra 10,000 kW of electricity through pico and micro-hydropower.

7 Environmental concern

In order to reduce the adverse environmental effects of the use of conventional fuels, there is a great need for the appropriate adaptation and mitigation measures emphasising on the increased use of renewable forms of energy, enhancement of energy efficiency measures, protecting and enhancement of sinks of GHGs, i.e. forestation, etc., RETs-based energy projects are seen as one of the best energy alternatives as renewable energy resources are virtually interruptible and available infinitely. In addition, RETs have widespread complementary technologies fitting well into Nepal’s need to diversify energy supply. One of the major contributions of RETs is its potential to reduce GHG emissions.

It seems very important for a country such as Nepal, having faced with the problem of excessive foreign currency reserve expenditure on commercial fuel import and increasing deforestation, to implement clean development mechanism (CDM), based on RET, which focuses on commercial fuel substitution as well as reduction of unsustainable fuel wood consumption. In order to implement CDM, Nepal needs to be prepared with different prior-implementation requirements consisting of detailed studies on localised and time-specific energy demand and supply system, energy consumption pattern and adaptability, emission factors determination, proposal development as well as setting up of appropriate institutional mechanisms.
8 Conclusion

Needless to state that technically feasible, economically viable and environment-friendly technologies, RETs are the major option for rural people in Nepal to access the modern needs of energy. Nepal does have some successful implementations of RETs such as biogas, microhydro, solar thermal and photovoltaic, etc. In Nepali context, there exists a large potential of renewable energy resources to be exploited for future use. It is important that further R&D work be done for exploitation of the immature technologies such as wind, geothermal, etc. In addition, local capability development in terms of RETs awareness and technical backup know-how is crucial for sustainability of RETs. Policy makers are well advised to look into need-based RETs and sustainable subsidy policies in the use of RETs.

References


