CHAPTER 1
The Relevance of Renewable Energy in the Mountains

by Kamal Rijal

The economies of the Hindu Kush-Himalayan (HKH) Region are characterised by low levels of development reflected in pervasive poverty. Levels of income and development differ within the HKH Region, the strategy adopted for economic growth in each country being different, and the level of natural resource endowment and patterns of energy consumption and energy resource mix varying greatly. Natural resources, specifically forests and water, are threatened by an increasing rate of deforestation due to the food and energy needs of the growing population.

The countries of the HKH Region have a total population of 2,456 million, of which more than five per cent live in the mountains. The average population density in the region amounts to 160 persons per square kilometre, while it is 38 within the Hindu Kush-Himalayas proper. There is, however, substantial variation in the population density in the HKH Region across countries, from 133 in Nepal to 12 in China. A large majority of the population remains without access to safe water or adequate health facilities (Rijal 1996).

The energy resource base of the countries of the HKH Region consists of a combination of traditional and commercial sources, including fuelwood, agricultural residue, animal wastes, hydroelectricity, petroleum, coal, wind, and solar. The present sustainable supply of energy per capita amounts to about four times the total energy consumption, of which 27 per cent is in the form of renewables, though a wide variation is observed among the countries of the region. For example, the supply potential of renewable energy in Afghanistan, Bhutan, Myanmar, Nepal, and Pakistan exceeds 90 per cent of the total potential (i.e., more than seven times the present level of consumption of total annual energy per capita), whereas it is less than the regional average in China and India. The potential of non-renewable fuels exceeds the current level of energy consumption in countries like China and India, whereas it can supplement the energy demand to some extent in countries like Bangladesh, Myanmar, and Pakistan.

In Afghanistan, Bhutan, Nepal, and Myanmar the share of traditional fuels (primarily fuelwood) lies between 70 and 95 per cent, while in China it is less than 25 per cent, and in Bangladesh, India, and Pakistan it lies between 50 and 60 per cent. The large countries of the Region, China and India, consume about 66 and 28 per cent of the total energy, respectively, while the remaining countries consume six per cent.

1.1 An Overview of the Energy Situation in the HKH Region

1.1.1 Energy Resource Availability

The potential of renewable energy resources (primarily hydropower and fuelwood) on a per annum basis (excluding solar power and wind) in the Hindu Kush-Himalayan Region is comparatively more than the present-day total energy requirement (i.e., 3,457 million GJ versus 851 million GJ in the HKH Region of China; 1,388 million GJ versus 588 million GJ in the Indian mountains; 1,519 million GJ versus 259 million GJ in Nepal; and 654 million GJ versus 344 million GJ in the mountains of Pakistan, as shown in Tables 1.1. and 1.2. If a comparison is made of the total availability of hydropower in the HKH Region with the present-day production level, less than one per cent is exploited in China and Nepal, whereas it is less than four per cent in India and about 16 per cent in Pakistan. The extraction of fuelwood in the whole HKH Region exceeds the sustainable supply level, with a few exceptions in isolated pockets of the region such as the eastern mountains of India and in places where accessibility limits the extraction of fuelwood and timber to meet the demands of the adjoining plains.

Table 1.1: Energy Potential and Production in the HKH Region by Country Countries, FY 1994/95

	Unit	China	India	Nepal	Pakistan
Proven Reserves					
- Oil	Million GJ	N. A.	6,682	0	932
- Coal	Million GJ	N. A.	9,141	0	1,568
- Natural Gas	Million GJ	N. A.	5,621	0	4,160
Production per annum					
- Oil	Million GJ	12	219	0	0
- Coal	Million GJ	315	35	0	50
- Natural Gas	Million GJ	276	74	0	353
Life of Reserves					
- Oil	Yrs.		31		
- Coal	Yrs.		262		32
- Natural Gas	Yrs.		76		12
Hydropower					
- Potential	Million GJ	3,207	1,007	1,309	473
- Production	Million GJ	22	36	4	75
Forest Situation					
- Total Forest Area	Sq.km.	215,081	207,484	42,910	42,240
- % of Geographical Area	%	13	37	29	5
- Fuelwood Extraction	Million GJ	250	381	210	181
Total Potential/annum	Million GJ	6,713	1,716	1,519	1,057
- Non-renewable	Million GJ	3,256	328	0	403
- Renewable	Million GJ	3,457	1,388	1,519	654
- Biomass	Million GJ	250	381	210	181
- Hydropower	Million GJ	3,207	1,007	1,309	473

Source: Study estimates based on Abdullah 1996; Bansal 1997; Banskota and Sharma 1997 and Mengjie et al. 1997

Table 1.2: Per Capita Final Energy Consumption Pattern in the HKH Region by Country, FY 1994/95

Descriptions	HKH in MJ/Cap	China Per cent	HKH in MJ/Cap	India Per cent	HKH in MJ/Cap	Nepal Per cent	HKH in MJ/Cap	Pakistan Per cent
By Sector								
Domestic	26,857	62	11,045	76	11,515	91	8,163	70
Commercial	4,440	10	568	4	172	1	258	2
Industrial	10,515	24	1,705	12	613	5	1,580	14
Agriculture	187	<1	220	1	100	<1	229	2
Transport	1,216	3	1,070	7	327	3	1,349	12
Total	**43,214**	**100**	**14,607**	**100**	**12,727**	**100**	**11,577**	**100**
By Fuel Type								
Fuelwood	12,688	29	9,644	66	10,325	81	6,051	52
Other Biomass	9,296	22	1,842	13	1,315	10	1,539	13
Coal	16,337	38	53	<1	139	1	179	2
Pet. Fuels	1,981	5	2,226	15	890	6	1,964	17
Natural Gas	410	<1	0	0	0	0	727	6
Electricity	2,271	5	842	6	137	1	1,117	10
Total	**43,214**	**100**	**14,607**	**100**	**12,727**	**100**	**11,577**	**100**

Source: Study estimates based on Abdullah 1997; Bansal 1997; Banskota and Sharma 1997; and Mengjie et al. 1997

The potential for non-renewable energy is almost equal to the potential of hydropower in the HKH Region of China, India, and Pakistan, whereas availability of fossil fuels in Nepal is insignificant, indicating the diverse pattern of energy availability within the HKH Region. This is also true if average figures of energy supply within different localities of any particular country are compared. In general, the availability of renewable energy increases and the availability of non-renewable energy decreases as we ascend the mountains.

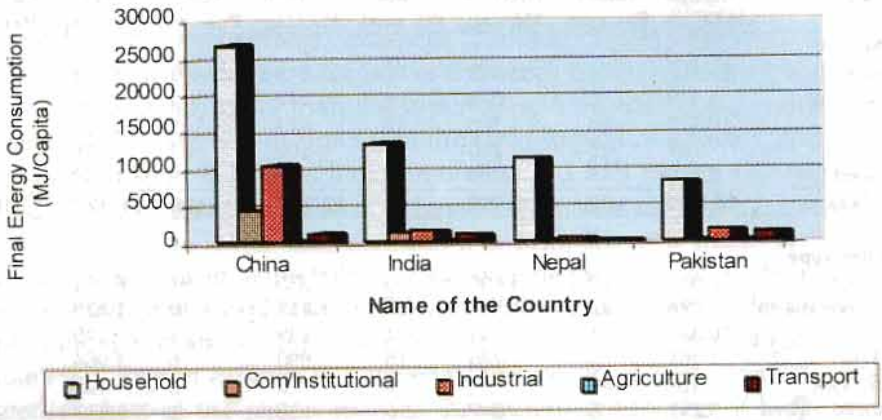
1.1.2 Energy Services in the Major Sectors

The major sectors of energy consumption in the mountain areas are households and cottage industries. These sectors require 88 per cent of the total energy consumed in the mountain areas of India, while the corresponding figures are 84 per cent in Pakistan and 96 per cent in Nepal (Fig. 1.1).

Household Sector

The energy needs of households are cooking, lighting, space-heating, and the operation of household appliances. Cooking and heating constitute major components of household energy needs. A variety of traditional cooking and heating stoves fired by biomass fuels is used. The purchase of household energy appliances, such as rice cookers, radios, and television sets, depends on the income levels of the people, cost of appliances, and availability of electricity. Urban households use these pieces of equipment more often. Lighting energy needs are met mainly by kerosene and electricity. Although electrical lamps are more efficient and offer greater user-

Figure 1.1: Final Energy Consumption Pattern by Sectors, 1994/95 in the HKH Region of Different Countries



convenience compared to kerosene lamps, the choice between the two depends primarily on the extent of the electricity supply and the high costs of electricity connections in mountain areas, even at subsidised prices. For example, typical energy requirements in the household sector in the mountain areas of Nepal break down into 32 per cent for cooking and 56 per cent for heating, while in the hills of Nepal the break down is 40 per cent for cooking and 36 per cent for heating, the rest being consumed for lighting and operating electrical appliances, as well as boiling water and carrying out agro-processing activities.

Cottage Industries

Many cottage industries (such as agro-processing, charcoal-making facilities, potteries, bakeries, ironworks, woodworks, and village workshops) are operated as family enterprises on a micro-scale. The energy required for cottage industries is used for heat for processing lighting and motive power. Lighting requirements are invariably met by electricity in electrified villages and by kerosene in unelectrified ones. The heat required for processing in ironworks, potteries, and bakeries is provided by fuelwood and other biomass fuels, although in the HKH Region of China coal is used extensively for this purpose. Motive power requirements are met by electricity, diesel, and kerosene, where available, or else by human labour using mechanical equipment. In agro-based activities, such as crop-drying, the use of biomass is widespread. With the increase in rural electrification and greater availability of commercial fuels, there has been a steady transition from traditional to commercial sources of energy supply.

Agricultural Sector

In agriculture energy is used for land preparation, cultivation, irrigation, harvest, post-harvest processing, storage, and the transportation of agricultural inputs and outputs. The bulk of energy inputs in land preparation, cultivation, post-harvest processing, and agriculture-related transport is in the form of human and animal labour, the degree of mechanisation being generally low. Although use of diesel in tractors, tillers, and threshers and use of electricity in irrigation pump-sets are observed to be on the rise in many places, they have little influence on the amount of traditional energy consumption in this sector since the energy source being replaced is that of human and animal labour. The use of traditional energy sources to meet energy needs in the agricultural sector is mainly for drying crops, which accounts for a relatively low share of the aggregate consumption within the sector.

Other Sectors

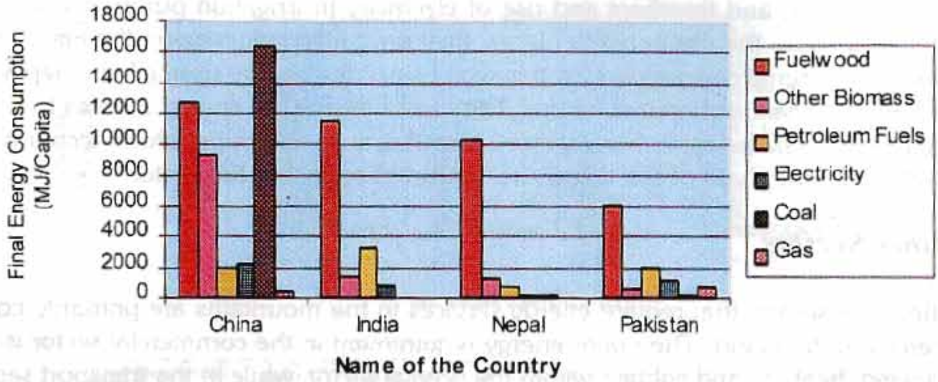
The other sectors that require energy services in the mountains are primarily commerce and transport. The major energy requirement in the commercial sector is for cooking, heating, and lighting within the service sector, while in the transport sector energy is used for operating different kinds of vehicles to supplement the extensive use of animals, as observed in rugged mountain areas.

1.1.3 Final Energy Consumption Patterns

The per capita final energy consumption in the HKH Region of India and Pakistan (Table 1.2) is lower than the national average consumption, while the two are comparable in China. The contribution of biomass fuels is substantially higher in the HKH Region compared to the country as a whole. For example, in India, the contribution of biomass fuels in the HKH Region is 79 per cent, while it accounts for 47 per cent in the whole country. The same is true in the HKH Region of China and Pakistan. This trend indicates that mountain regions are, in general, marginalised in terms of access to commercial fuels and are so heavily dependent on biomass fuels that a substantial proportion of agricultural residue and animal dung are diverted from the farm to the fireplace. This situation is worsened by the low level of efficiency of these fuels, which are a health hazard, particularly for women who are the managers, producers, and users of energy at the household level.

The main providers of energy within the HKH Region are biomass fuels (fuelwood, agriculture residue, and animal dung) and commercial fuels (petroleum fuels, coal, and natural gas), though the percentage of these fuels used varies drastically between the HKH Region of each country, as depicted in Figure 1.2. Per capita consumption of the total final energy in the HKH Region of China is almost four times that of the mountain areas of India, Nepal, or Pakistan, while in terms of biomass fuels it is more than double. Similarly, the household level consumption of energy in the HKH Region of China is more than double that of the hills and mountains of India, Nepal, and Pakistan, while commercial and industrial sector consumptions are almost 10 times more in China, indicating the contributions of the industrial and service sectors of the economy.

Figure 1.2 Final Energy Consumption Pattern by Fuel Type, 1994/95 in the HKH Region of Different Countries



1.1.4 Trends in Energy Availability and Use in the HKH Region

The trends of energy resource availability clearly indicate that the HKH Region possesses sufficient renewable energy resources, which are distributed evenly throughout the mountain region. In general, renewable energy resources have the following distinct features: i) low energy density; ii) low calorific value; iii) high bulk density; iv) low grade of energy, primarily available as heat energy in its natural form; v) low conversion efficiency; and vi) high conversion costs. These features make mountain energy resources vulnerable in terms of energy usage for productive purposes, but they are more suitable for meeting the various needs of mountain communities at the subsistence level.

In general, the trend in energy use within the HKH Region is as follows: i) use of biomass predominates, fuelwood being the principal source of energy; ii) the domestic sector is a major consumer of energy; iii) demand for energy is increasing as a result of agricultural diversification and intensification, rural industrialisation, and the increasing number of tourists; iv) the need for heat, primarily for cooking and space heating, is comparatively greater than the need for motive power as an input to production; v) the demand for fuelwood exceeds sustainable supply, and thus the process of destruction on the margins is a common phenomenon in much of the region; vi) fuelwood is becoming scarce and the time taken for its collection is increasing; vii) the continuous extraction of fuelwood from the forests results in a transition within biomass resources, degrading the environment; and viii) access to and availability of energy technologies are improving, but not sufficiently to result in reduction of human drudgery. All this has a host of environmental consequences, such as the loss of forests and woodlands and health hazards associated with indoor air pollution; and a whole range of social and economic impacts arising from fuel collection and use, the responsibility for which falls disproportionately on the shoulders of women and children.

The socioeconomic factors are crucial in understanding the energy use pattern. Some of these in the mountains are: population dynamics and urbanisation, rise in income and energy transition, process of industrialisation, diversification and intensification of agriculture, and improvement in living standards, though it goes without saying that many other factors may significantly influence energy use. These factors need to be clearly understood and taken into account for sustainable development of energy in the context of the mountain region.

Given these energy consumption and availability trends in the mountains, the type of energy use pattern or mix that is sustainable environmentally and financially is a major policy issue being faced by planners in the HKH Region.

1.2 Why Renewable Energy Technologies in the Mountains?

Energy must be viewed as a means of fulfilling the social and economic objectives of the mountain population. In this context, the development of energy is essential for four distinct reasons. First, the minimum level of energy required to meet the basic needs of the communities, such as cooking and space heating, is of prime importance and must be ensured. Second, the provision of energy is essential to meet the social objective of alleviating human drudgery (particularly that of women, children, and the economically poorer section of the population). Third, energy is also required to sustain and support economic activities (newly emerging or traditional ones). Finally, the development of the energy supply infrastructure should be conceived in such a way that it plays the leading role in increasing the productivity of mountain areas, thereby increasing the economic efficiency of resource use.

Additionally, development of the energy resources available in abundance and/or renewable in nature must be conceived as an economic necessity. These resources should be marketed to other parts of the country or to neighbouring countries in order to increase the incomes of mountain communities and help to eradicate poverty. It is also equally important to realise that the production, transformation, use, and marketing of energy resources lead to environmental degradation as well as deterioration of human health.

In the past, the choice of a particular type of energy was based on the availability of and access to certain energy resources and technologies at affordable prices. But increasing environmental awareness has made the environmental costs associated with the development of energy an important factor in the choice of energy mix in the mountains.

The suitability of an energy resource and technology mix, institution, and financing mechanism needs to be judged not only on the basis of the quality and quantity of energy services required but also in the context of the physical environment (i.e., mountain specificities), so as to maximise the social and economic benefits. Mountain specificities, such as inaccessibility, fragility, marginality, and diversity, determine the feasibility and suitability of certain types of energy forms. The opportunities that exist in the mountains include a huge potential for the use of renewable energy and indigenous technical knowledge systems for operating traditional institutions and technologies and for maintaining an ecological balance.

In this context, the choices are very straightforward: the primary consideration should be based on the nature of energy resources, that is to say, the extent to which they are renewable. Further, the energy services required in the mountains are primarily of low quality (the main energy required is heat). This indicates the important role that the suitability of renewable energy resources (including biomass) will play in the context of the HKH Region. It is also important to recognise that biomass energy is not a non-renewable fuel, if used and exploited judiciously. This means that the rate of extraction of biomass fuel should not exceed the rate of replenishment, so that a sustainable yield of biomass fuel is consumed rather than exploited rampantly.

It is also clear that the quantity of energy services required in the mountains is quite low owing to the scattered settlement pattern and lack of infrastructural development. This, together with the fact that mountains are extremely scale-sensitive because of their fragile nature, makes decentralized energy systems more viable. The small-scale interventions in mountain communities are also less risky compared to large-scale interventions, be they road or dam construction or a massive flow of natural resources, in other areas to meet the potential market demands.

The suitability of decentralized renewable energy systems in the context of mountain areas entails an appropriate choice of institutions in order to make these systems operational, and, in this respect, the scale of institutions becomes quite crucial. Community-based participatory institutions are more suitable for the promotion and development of decentralized renewable energy systems.

At the same time, the suitability and relevance of a particular type of energy need to be examined not only from the perspective of the energy demand structures and their associated environmental impacts but also from that of their implications for income redistribution. For example, the provision of energy has implications for income redistribution, especially when it becomes available to some and not to others (individual families, selected valleys) and when it is supplied at a subsidised rate, as is especially the case with grid electricity which not only compares favourably with the rates for subsidised petroleum fuels (i.e., kerosene and LPG), but is also much more convenient. Another important aspect is the income generated from the production of the various energy sources (Box 1.1).

Development processes in the mountains should thus be accompanied by energy technology interventions which include, but are not limited to: i) increased renewable energy technology supply infrastructures; ii) increased use of efficient devices that bring about improvement in economic efficiency; iii) higher value use of energy forms; iv) introduction and/or increased use of energy conversion devices to allevi-

Box 1.1: Mountain Energy Resources: A Vehicle for Income Generation

A case in point is the hydropower generated in the northern mountain areas of Pakistan, which is a major source of revenue for the province in the form of a development surcharge. Similarly, the introduction of the concept of a wheeling charge has prompted many entrepreneurs to exploit water resources available in Himachal Pradesh in India in order to supply electricity to adjoining states with substantial industrial infrastructure. This results in additional income for Himachal, which in turn can be used to meet the development aspirations of its own population.

ate human drudgery and boost productivity; and v) an increase in productivity which facilitates off-farm employment.

1.3 Status of Renewable Energy Technologies in the HKH Region

The new and renewable energy systems that are operational within the HKH Region are primarily: biomass-related technologies (improved cooking stoves, biomass gasifiers, biogas plants), solar technologies (solar cookers, photovoltaic systems for water pumping and lighting, solar water heaters, solar greenhouses, solar driers), wind pumps and turbines, and mini- and micro-hydropower. Table 1.3 summarises the number of installations within the HKH Region of China, India, Nepal, and Pakistan. It is to be noted that this is the cumulative number of plant installations, but it is difficult to identify how many of them are operational. Review of a number

Table 1.3: Installation of Renewable Energy Technologies in the HKH Region

Descriptions	Unit	India 1/	China	Nepal	Pakistan
Family-size Biogas Plants	No. of Units	245,067	82,624	32,000	1,134
Improved Cookstoves	No. of Units	939,844	1,541,325	90,000	68,000
Solar Thermal Systems	Sq. m.	2,958	111,288	>10,000	N. A
- Industrial type	Sq. m.	1,176			
- Domestic type	Sq. m.	1,782			
Solar Cookers	No. of Units	14,371	60,000	Neg.	
Solar Greenhouses		N. A.	3,900		
PV Water Pumps	kWp	4			
PV Systems	kWp	372		300	234
Wind Turbines	MW			30	
Mini- & Micro-hydropower	MW	52	N. A.	5	18.8
Biomass Gasifiers/Stirling Engines	No. of Units	16			

Note: 1/ Information on biogas and wind power is as of March 1996; improved cooking stoves, PV water pumps, mini and micro-hydropower, and biomass gasifiers as of April 1995; and solar thermal systems, solar cookers and PV systems as of March 1993. Information on Uttarakhand, the Hill Districts of West Bengal (Assam is not included).

Source: Amayta et al. 1997; Dutta 1997; Hussain 1997; Zhang 1997.

of evaluation reports indicates that some of these technologies are gaining momentum in some areas but have failed in others due to various reasons. For example, the biogas programmes in Nepal and China can be considered to be quite successful, although they have also inherited a number of constraints on their steady growth. By contrast, such programmes have failed in Pakistan. Mini- and micro-hydropower development is gaining momentum in Pakistan and India, although there has been a decline in the number of installations in Nepal. With regard to improved cooking stoves, results within the HKH Region have been mixed. A number of pertinent issues relating to new and renewable energy systems will be summarised after discussing the status of these technologies within the HKH Region of each country.

1.3.1 The HKH Region of China

The development of new and renewable energy technologies in the HKH Region is quite impressive in terms of the number of installations, although it is not clear what percentage of these is functional. For example, there are about 82,624 family-sized biogas plants, 1.5 million improved cooking stoves, 111,288sq.m. of solar water heaters, 60,000 solar cookers, and 3,900sq.m. of solar greenhouses (Zhang 1997). Besides these, large-scale biogas plants to treat waste material products from townships, hospitals, and alcohol processing units are also operational. There are a number of small-scale coalmine enterprises within the HKH Region of China, primarily in the provinces of Sichuan and Yunnan.

The HKH Region of China is suitable for solar energy applications as solar radiation ranges between 335 - 921 kJ per cm^2 (equivalent to 2,800-3,000 hours of sunshine) there. During the mid-90s, five million sq.m. of passive solar building was carried out in China, and this reduced the use of coal by 20-40kg per sq.m. per year, with a return of 15-20 per cent on initial investments. It is a common feature in Tibet that most of the public sector residential houses have been retrofitted with sun spaces and trombe-walls. Solar water heaters of the flat-plate type are in operation, but recently vacuum tube solar water heaters have been developed and are being produced commercially. These systems are suitable for mountain areas, since they do not suffer from extreme climatic conditions. There are seven factories producing photovoltaic cells in China with a total production capacity of 4.5MW annually (Zhang 1997).

A good manufacturing base exists within China. For example, 78 manufacturers are involved in the construction of small, mini and micro-hydropower stations in China, of which 17 are located in the provinces of Yunnan and Sichaun — parts of which fall within the HKH Region. The annual production of micro hydro units in the capacity range of from 0.1 - 15kW amounts to 26,000. Similarly, there are 9,867 institutions and 30,895 technicians involved in household-type biogas dissemination. There are eight technology service institutions that are capable of designing large-scale biogas plants for waste treatment and seven institutions with the capability of designing solar buildings. There are about 300 manufacturers of solar water heaters, five service institutions for solar cookers, and four service institutions and eight manufacturers for solar photovoltaic systems (Zhang 1997).

1.3.2 The Indian Himalayas

The status of renewable energy technologies in the context of the Indian Himalayas is depicted in Box 1.2. Improved cooking stoves and family-sized biogas plants are the most widely distributed technologies within the Indian Himalayas. Various evaluation reports on biogas plants and improved cooking stoves indicate that the percentage of functional biogas plants varies between 65 to 90 per cent and 50 to 65 per cent among various states (Dutta 1997). At present, 376kW solar PV systems are in operation, primarily for lighting, although it is not clear how many of them are functional. This technology seems feasible in areas where houses are scattered and where it is not economically possible to extend the grid. The western mountains (Uttarakhand, Himachal Pradesh, and Jammu and Kashmir) show significant potential for application of solar energy technologies, and a number of private and public institutions are promoting these technologies. For example, solar photovoltaic home systems and street lighting facilities are being installed enthusiastically in Ladakh. Also, the use of solar greenhouses is on the rise there.

The Indian mountains are a good site for the installation of mini- and micro-hydropower stations since they have almost 2,000MW of potential in these areas, but at present only about 52MW is exploited (Dutta 1997). Almost all mechanical workshops have the capability of constructing mini- and micro-hydropower plants, if appropriate designs are provided.

Manufacturing of various renewable energy systems has improved in India as a result of promotional efforts on the part of the government. There are 74 manufacturers of solar photovoltaic and wind power systems, and, while capable of servicing as well, they are located outside the HKH Region. Household-type biogas systems have been installed all over India, primarily by the Khadi and Village Industries' Commission (KVIC). The local craftsmen produce improved cooking stoves. Several gasifier designs are available and numerous mechanical workshops located all over India are capable of producing these units (Dutta 1997).

1.3.3 The HKH Region of Pakistan

Though the exact extent and nature of new and renewable energy resources in the mountain areas of Pakistan are not available, cursory data on the number of sunny days and some measured insolation values indicate a high potential for solar energy. Ten solar photovoltaic power stations, totalling 194kW, installed in the NWFP and Balochistan (Hussain 1997) are, however, out of order, and have not been in working condition for a long time. At the same time, the occurrence of hot springs all over the Indus and Balochistan basins does indicate the potential for commercial exploitation of geothermal energy for power generation and for low heat applica-

Box 1.2: Status of Renewable Energy Technologies (RETs) in the Indian Himalayas

Technology	**Status**
Biogas Plant	High subsidy; dung can be scarce, water shortages, ambient temperature etc.; has not performed well; lack of maintenance due to remoteness; need for R&D and appropriate technology
Improved Cooking stove	50 per cent subsidy; inability to design stoves that suit local conditions; improper construction and short life of the device; metal portables better accepted in the north-eastern states
Micro- & Mini-hydropower	Up to 3MW capacity; installed capacity is 93.21MW; potential of 10,000MW in the HKH Region; MNES provides subsidies; MNES has been encouraging the state governments to develop and announce incentive packages to attract private sector participation; IREDA provides soft loans; operating at sub-optimal capacity due to load factor problems, technical constraints, organizational set-ups, lack of private sector participation and manufacturing base, lack of people's involvement, etc
SPV Technology	Applications are for minor irrigation and drinking water supply, street and domestic lights, solar lanterns, lighting for schools, hostels, etc.; heavily subsidised; SPV pumps installed on a demonstration basis; the only device which is fully functional is the solar lantern; problems of climatic constraints, lack of technicians in dissemination programmes, lack of users' training, discharging of batteries, high difficult terrain, and poor infrastructure, etc.
Solar Thermal	Subsidies withdrawn by MNES, but some of the states have continued, e.g., there is a 90 per cent device cost subsidy in Arunanchal Pradesh; mainly for community uses such as hospitals and health centres; mixed performance; functioning level, except in Arunanchal Pradesh, is less than 50 per cent; new management system introduced in Assam; problem of damage by rains, hailstorms, and floods in the hilly regions.
Biomass Gasifier	Not successful in the hilly regions; costly; unviable options for small industries; thermal applications have worked well; detailed scientific study has not been carried out.

Source: Dutta 1997

tions, primarily for the tourist market. There is a possibility of exploiting the wind potential in gorges and valleys throughout the mountains, but further investigation is essential.

The mountain areas of Pakistan are fortunate in terms of the potential of mini- and micro-hydropower (MMHP), which is about 500MW. MMHP plants have been quite successful in the northern mountains, and about 245 plants with a 18.8MW capacity installed by various government and non-government organizations are in operation (Hussian 1997).

Some designs for improved cooking stoves that appeared to be efficient under laboratory conditions have been unsuitable in the field. By now about 65,000 fuel-efficient cooking stoves have been distributed to various parts of the NWFP. About 4,165 biogas plants have been installed all over the country, of which 1,134 are in the NWFP, Balochistan, and AJK. Very few plants, however, are in operation, and the biogas programme can be said to have failed miserably in Pakistan (Hussain 1997).

1.3.4 Nepal

Energy forms that are not conventionally used or new and renewable forms are considered alternative energy in Nepal. They primarily include: micro-hydropower, biogas, solar, and improved cooking stoves. Compared to other countries in the region, Nepal has made significant progress in developing and using its water resources for producing power, particularly in the micro range (up to 100kW), over the past three decades. A good micro-hydro technology manufacturing base has already been established in the country. The delicensing of plants of up to 100kW in capacity by the government in 1984 helped in its development in the private sector, and the recent delicensing of plants of up to 1,000kW has further encouraged the development. Currently, there are over 900 micro-hydro installations in the private sector in about 59 of the 75 districts of the country. The total capacity of these installations is about 5MW (Amatya et al. 1997).

The success of biogas development programmes in Nepal can be attributed to the availability of government subsidies, as well as the interest and involvement of a number of INGOs and donor agencies and private biogas companies that started coming up after 1990. As a result of the government privatisation policy, many new biogas companies have been established (at present they number 36). The initial floating drum design has been replaced by a concrete fixed dome type of design based on the Chinese model. Efforts are being made by various agencies to reduce the cost of the dome type biogas digester plants of different sizes. The number of biogas plants installed exceeds 32,000. The Biogas Support Programme (BSP) has been set up as a joint venture between ADB/N, recognised biogas companies, and the Netherlands' Development Organization (SNV-Nepal) to support the biogas programme through subsidies, quality control, and training.

Traditionally, solar energy is still used for drying purposes, mainly in the area of agricultural products. A significant modern use of solar energy has been in water heating. Another important area of solar energy use has been electricity generation from solar photovoltaic (SPV) systems. According to one estimate, more than 6,000 units of 50W module SPV systems are in use in different parts of the country under the Nepal Telecommunications' Corporation. Similarly, the technical and economic viabilities of SPV systems in water pumping for irrigation and drinking water purposes are also being tested. The Nepal Electricity Authority has installed SPV stations of 30-50kW capacity in such remote parts of the country as Simikot (Humla), Gamgadi (Mugu), and Tatopani for rural electrification purposes (Amatya et al. 1997). Private entrepreneurs and NGOs have been showing interest in the promotion and dissemination of SPV home lighting systems.

Appreciating the usefulness of ICS, rural development organizations have been promoting this simple, cheap technology for many years. Since 1980, when the ICS programme began in earnest, HMG/N has played an important role in promoting and disseminating it. The only large scale ICS programme carried out in Nepal has been through the CFDD, but it was suspended in 1991. So far about 90,000 of the various types of ICS (Amatya et al. 1997) have been promoted and disseminated by the government, NGOs, and private sector agencies.

Wind power development in Nepal is still in the experimental stages, and so far no contribution has been made by wind energy to meeting the energy needs of the country. The main obstacles to harnessing and using wind energy in Nepal are the absence of reliable wind data for proper assessment of wind energy and adequate adaptive R&D efforts (PEP Project 1995).

1.3.5 Main Findings

The pace of dissemination of new and renewable energy technologies in the HKH Region of China is slower than in the rest of the country. In China, excellent manufacturing capabilities exist for such technologies, but the lack of institutions in the HKH Region to promote them as well as their low acceptability in the prevailing socioeconomic conditions hamper large-scale diffusion there.

The experience with RETs in the hill states of India shows that there are several shortcomings in areas such as policy and planning, implementation procedures, and the institutional framework. There are technology-specific barriers as well as problems common to all programmes and technologies. The barriers to large-scale dissemination of the different technologies are summarised in Box 1.3.

Pakistan lacked a clear-cut and comprehensive national policy for development of renewable energy technologies. Because of this, the Director General's Office for New and Renewable Energy Resources (DGNRER) is non-functional. Still, action is

Box 1.3: Barriers to the Dissemination of RETs

Technology	Barrier to Large-scale Dissemination
Micro- & Mini-Hydro	Inadequate work on load developing strategy. Basic field data not available. Technical and operational problems not solved yet
Improved Cooking stove	Existing models incompatible with the region's traditional lifestyle; inadequate attention to R&D
Biogas Plant	Issues of low temperature and low dung availability not resolved
Solar Photovoltaic	High initial investment requirement
Solar Thermal System	Technology not yet suitable for the mountains
Biomass Gasifier	Uneconomical, because of subsidised electricity and diesel
Wind Energy	Wind monitoring and mapping data not available for many places

Source: Dutta 1997

being taken to create a new Council for Renewable Energy Technology (CRET) by merging PCAT, NIST, and the Solar Energy Centre of PCSIR.

Nepal has made remarkable progress in the development and dissemination of some RETs, such as biogas, and less so in other cases such as micro-hydropower. Some technologies are in the initial phases of dissemination, among them SPV home systems and Peltric sets. For example, progress made in the biogas sector has been phenomenal, because of an institutional set-up that monitors the programme in an integrated manner, with emphasis on the proper channelisation of subsidies, quality control and standardisation, insurance charges for operation and mainteinitianance, and development of training packages to promote private sector activities. The same cannot be said about other RETs. For example, micro-hydropower development is plagued with such problems as low load factors, the frequent need for repair and maintenance of water channels, high up-front capital costs even after subsidies, lack of desirable quality control, lack of back-up services in most areas, and unresolved institutional issues of water rights. The success achieved in disseminating SPV home systems has been questioned, subsidies having benefitted primarily the affluent members of the community, with no or limited linkages to income-generating and development activities. The latest programme on improved cooking stoves failed miserably because of the wrong approach to meet the necessary targets and because it catered to cooking needs alone and neglected space heating and other household needs.

The conventional approach is to make energy technologies available to mountain consumers whether they suit or fulfill their requirements or not. This approach has not been effective in the mountains since not enough attention is given to social, cultural, family, and religious practices. Also, the felt needs of the mountain people are not taken into account, and the groups targetted for technology intervention have not been provided with proper information and training to run and operate the system. In most cases, renewable energy technologies need operational skills at a household or community level. For example, household-level operational skills and acceptance are needed in the case of improved cooking stoves, solar cookers, solar water heaters, or solar photovoltaic home systems, whereas for micro-hydro, community afforestation, biomass gasifiers, or diesel generators, it is community-level skills and acceptance that are required to make them functional.

In general, new and renewable energy technologies have the following characteristics: i) modular in nature (i.e., suitable for small-scale applications); ii) high up-front capital costs; iii) intermittency in supplying energy; and iv) lack of dispatchability in respect of distribution and storage. These characteristics make these systems less desirable in many instances, but they may be more suitable in particular contexts. For example, in a place where energy requirements in terms of both quantity and density, are low, then these systems may be more suitable than costly transmission and distribution lines, particularly in mountain areas. On the other hand, the intermittent nature of the availability of solar and wind energy either necessitates expensive storage systems or can only partially fulfill energy requirements, so that additional investments for back-up systems are required. Most of these technologies possess location-specific comparative advantages, and hence a blanket approach to technology dissemination tends to fail. Each and every technology needs to be examined in terms of its suitability for a given place. This requires careful planning and application of the technology. In addition, mountain areas in general display diverse sociocultural patterns, and each and every technology needs to be examined to assess whether its intervention would conflict with the traditional practices and norms of mountain communities.

There is quite a reasonable capability for manufacturing these technologies, but due to the lack of institutions to promote them and a low level of acceptability under the given socioeconomic conditions, large-scale diffusion is difficult. Also, the dissemination of renewable energy technologies in the HKH area of any particular country is slower than in the rest of that country.

The principal barriers to the dissemination and promotion of RETs within the HKH Region have been: high up-front capital costs, inadequate rural credit systems, the lack of a continuous energy supply, an insufficient institutional base, and the sporadic availability of low-cost information and services.

1.4 Renewable Energy Policy Issues in the HKH

The choice of energy policies and programmes in the countries of the HKH Region is mostly dictated by the urban and industrial needs of the economy to supplement and sustain economic productivity rather than by the social objective of fulfilling the basic energy needs of the marginalised poor or of reducing drudgery, particularly that of women and children. In addition, the issue of environmental sustainability has never been seriously considered in developing, procuring, and extracting energy.

The national policy for developing rural energy in China states that policies should be framed according to local conditions, and that various forms of energy should be exploited based on their availability locally in order to provide practical benefits to local communities. This statement has provided impetus for the development of renewable energy technologies. A strong political commitment at the highest level and the establishment of decentralized institutions at village and county levels are excellent examples of providing impetus to the development of RETs. However, such efforts have not been adequate in the context of the HKH Region of China. In particular, the main constraints to the development of RETs are the lack of regional focus, technical personnel, local-level financing institutions, adequate attention from local governments, and public awareness.

The future energy strategy that was proposed for India emphasised a gradual shift from non-renewable energy resources to renewable ones, with increasing attention to demand management, conservation, and efficiency. The Eighth Five-year Plan (1992-97) and the subsequent strategy and action plan specified the installation of renewable energy technologies (1,900-2,000MW) during the plan period. The funds made available for the renewable energy sector do not, however, reflect this emphasis. What the action plan for funding envisages is the mobilisation of institutional financing and private sector investment stimulated through development of entrepreneurship and a package of incentives. To facilitate this, major policy changes have been made to encourage market development and women's participation, and to minimise subsidies for fossil fuels so as to reduce the existing price distortion between renewable and conventional energy sources.

In the case of Nepal, the Eighth Plan document (1992-1997) allocated NRs 1,650 million for renewable energy technologies, of which 20 per cent was to be met by the government to install 30,000 biogas plants, 5,000 solar water heaters, 2,500 solar driers, 5,000 solar cookers, and 250,000 improved cooking stoves (National Planning Commission [NPC] 1992). This amounted to less than 1.5 per cent of the total funds allocated for the energy sector, excluding investment in the forestry sector. This clearly indicates the gap between policy statements and programme implementation.

Energy development in the mountain areas of Pakistan is dominated by the extension of grid electricity and petroleum product supplies to rural areas. The plan document does not recognise the role of other sources of renewable energy (solar, wind, biogas, and geothermal), and no special effort has been made to formulate energy plans for mountain areas as such. The various issues in national- and provincial-level policies that have hampered the promotion of RETs in Pakistan are: i) at the top level, the nation has lacked a clear-cut and comprehensive national policy for the development of renewable technologies; ii) the high initial costs of most renewable technologies has meant that they are beyond the reach of most individual consumers or private enterprises; c) market distortions and imperfections have made energy from renewables appear more expensive than energy from conventional technologies; and d) the country has lacked the institutional capacity for planning, developing, and financing more innovative renewable technologies.

The rapid and sustained growth of new and renewable energy technologies demands appropriate industrial, fiscal, and other policies in addition to alternative energy, hydropower, and forest policies. At the same time, social and environmental policies play an important role in meeting the equity concerns of the poor in the mountains.

For example, policies to promote forestry and energy development in the HKH Region were initially geared towards reducing the consumption of fuelwood through the intervention of improved cooking stoves. These interventions failed in the absence of a proper evaluation of the multiplicity of traditional technologies and because of insufficient regard for the sociocultural aspects affecting the mountain population. Also, consumption of fuelwood has primarily been considered the main cause of deforestation. Other requirements, such as fodder for livestock, land required for cultivation due to low productivity, and the large-scale felling of timber, have never been given due attention while designing energy technology options.

At the same time, the alleviation of human drudgery and deteriorating health conditions, particularly among women and children, as well as decreasing soil fertility, have never been considered seriously. Instead, in almost all national policies, the social objective of ensuring the minimum level of energy to meet the basic needs of the population and to improve living standards in the hills and mountains is believed to have been accomplished with the provision of electricity. Therefore, rural electrification has always emphasised the illumination of small towns and peripheral areas rather than fulfilling the potential for motive power that would lead to economic transformation in the hills and mountains through productive units. It is considered as part of a welfare package, the price of electricity having always been subsidised. The underpricing of electricity during the eighties and up until the present has led to a rapid increase in demand, and this has resulted in an increasing reliance on thermal generation and subsequently in high emission of pollutants. Also, the interference with the day-to-day management and pricing structure is identified as a major institutional problem in the countries of the HKH Region. Government interference, in most the cases, is believed to have adversely affected least-cost investment decisions, thereby not only resulting in inadequate management, weak planning, inefficient operations and maintenance, high losses, and poor financial monitoring control and revenue collection but also hampering the growth of renewable energy technologies in general.

Energy planning investments have, for the most part, been biased in favour of large schemes, and emphasis has always been placed on the expansion of supply rather than on the potential of energy demand management. Adequate policy statements have been made to promote decentralized renewable energy systems and end-use appliances within the HKH Region. However, these statements are not supported by appropriate research and development or by institutional and financial backing in the form of programmes and budgetary allocations and, therefore, a substantial gap between policy statements and implementation prevails.

The role of women and policies for women's development have direct implications for the development of decentralized renewable energy technologies. Though policies on women's development have linkages with energy issues, they are not specifically addressing energy concerns and do not specify whether and how women's active participation will increase in the planning and implementing of renewable energy development programmes.

1.5 Need for Renewable Energy Technology Policy

It is not that options are not available. There are, however, RETs available within the HKH Region and beyond which have enormous potential and linkages with synergy potentials to reduce the existing imbalance in energy supply and demand, while also decreasing socioeconomic and environmental stresses in the mountains. Programmes for the adoption of these technologies have been initiated in the mountains, in the realisation of their comparative advantages, but unfortunately only with limited success, insofar as they have not resulted in any significant increase in the use of renewable energy in spite of the existence of substantial potential.

It is now well recognised that this is not primarily due to the non-availability of technologies that save energy, diminish adverse environmental impacts, and reduce life cycle costs to consumers, but more to the lack of comprehensive national policies to promote the transfer and diffusion of efficient renewable energy technologies in the context of mountain areas. These technologies may not be popularly adopted unless mechanisms for their transfer — be they organizational and institutional or financial — are improved, impediments to their adoption removed, and the issue of affordability appropriately addressed.

Promotion of RETs has been hampered as a result of both lack of information and awareness of policies that are inadequate for ensuring appropriate matching of energy resources and technologies with the need to provide technical, organizational, and financial backstopping. In addition, the failure to take into account the spatial characteristics of the mountains and the prevailing socioeconomic and cultural factors has also led to the failure of RET interventions. It is equally true that, in several instances, RET interventions have not only improved the energy situation at the household level significantly, but have also helped to support the economic productivity of an area.

The challenge is how to make the right choice. In this context, the formulation and adoption of a suitable renewable energy policy for the mountains are deemed necessary in order to ensure the sustainability of not only the biophysical resources but also the social and economic capital without interference from the outside.

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