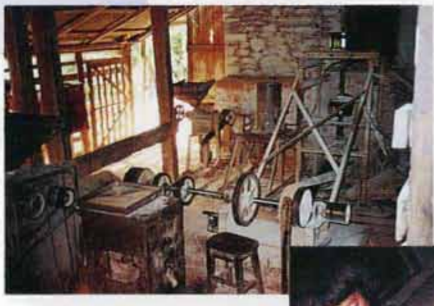
ICIMOD

Renewable Energy Technologies

A Brighter Future



Editor
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Photo Credits : *Kamal Rijal*

Cover Photoes : 1) Wind generator installed at a wind energy demonstration site, Badling, China

2) Solar photovoltaic cell of a solar lantern installed on the roof of a building, Garampani , Nainital, India

3) Micro-hydropower operated agro-processing facilities, along the Prithvi Highway, Nepal

4) Improved Cooking Stoves installed in a household in the Northern Areas, Pakistan

Published by
International Centre for Integrated Mountain Development
G.P.O. Box 3226,
Kathmandu, Nepal

ISBN 92-9115-791-0

Typesetting at
ICIMOD Publications' Unit

Renewable Energy Technologies: A Brighter Future

Policy Options for Mountain Communities in the HKH and Agenda for Action in Nepal

Editor
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International Centre for Integrated Mountain Development (ICIMOD)
Kathmandu, Nepal
May 1998

Preface

Mountain people have always relied on renewable energies, mostly in their natural forms, for their mere survival - be they for cooking food, keeping the house warm, milling grain, ploughing fields, or transporting goods. With the growing aspirations of mountain communities and the rapidly increasing population, energy requirements have increased to a level at which present use and technologies are no longer balanced with the sustainable use of resources.

The potential for sustainable use of renewable energy resources in the Hindu Kush-Himalayas (HKH) by far exceeds the total energy consumption in the region. The gross disparity between the potential and current contribution of most renewable energy sources results in foregone social benefits in terms of environmental protection, economic sustainability, and, to some extent, energy security and widespread distribution of jobs and income compared to conventional energy sources.

Action and programmes for the adoption of renewable energy technologies (RETs) have been initiated in the mountains, but, unfortunately, so far they have not resulted in any significant increase in the use of renewable energy in spite of its great potential. The promotion of RETs is hampered by: i) the absence of appropriate policies to ensure matching of energy resources and technologies with needs; ii) lack of technical, organizational, and financial backstopping; iii) the failure to fully understand the spatial characteristics of the mountains; and iv) the lack of appreciation of socioeconomic and cultural factors. However, there are also several instances in which RET interventions have not only improved the energy situation at household level significantly but have also helped to support the economic productivity of the area.

It is against this background that ICIMOD, with its major mandate of poverty alleviation and environmental conservation, introduced a programme on renewable energy technologies suitable for mountain areas. This programme is guided by an overall mountain perspective for sustainable development formulated by ICIMOD for the Hindu Kush-Himalayan Region.

As part of this programme, a project was implemented on 'Implications of National Policies on the Use of Different Renewable Energy Technologies in Nepal and Selected Other Countries in the Hindu Kush-Himalayas'. It had three components: firstly, national policy studies were undertaken in China, India, Nepal, and Pakistan; secondly, detailed case studies were made of various renewable energy technologies (Biogas, Micro-hydropower, Solar Photovoltaics, Improved Cooking Stoves) in Nepal; and, thirdly, a two-day consultation of regional experts was held at which the studies were discussed.

The present document contains the summarised version of the country studies, the Nepal RET studies, and a policy framework for the sustainable development of RETs in the HKH Region based on the studies and consultation. It also provides broad guidance for designing and implementing energy programmes for mountain communities. Particular emphasis is given to the role of renewable energy technologies that can act as prime movers in diversifying economic activities in mountain areas and, at the same time, also meet the energy requirements of individual households. In this context, we think the document will be of use to energy planners, technology experts and development specialists in national institutions, and NGOs and donor agencies engaged in decentralized rural development.

I would like to extend my sincere appreciation to the study team from the Centre for Rural Technologies, Kathmandu; Mr. V.B. Amatya, Mr. G.R. Shrestha, Mr. R.N. Gongal, Mr. S. Shrestha, and Ms. K. Bajracharya; for carrying out a study on Implications of National Policies on RETs along with detailed case studies of various RETs in Nepal. I also appreciate the work of specialists from other countries, namely, Mr. Zhang Mi from China, Ms. Soma Dutta from India, and Mr. Tajjamul Hussain from Pakistan, in carrying out review studies on 'Implications of National Policies on RETs' in their respective countries and presenting appropriate recommendations for desirable policy shifts.

The Canadian Cooperation Office, Kathmandu, provided generous funding for the study and publication of this document, and this is gratefully acknowledged. Special thanks go to Mr. Jaipal Shrestha, Environment Advisor and SPEF Coordinator, Canadian Cooperation Office, Kathmandu, for his timely comments for improving the quality of this publication.

Dr. Kamal Rijal, Energy Specialist, ICIMOD coordinated the study and the regional experts' consultation. I would like to thank him especially for his efforts in bringing out this document.

Egbert Pelinck
Director General

Abstract

This document reviews renewable energy policies for mountain areas of China, India, Nepal, and Pakistan and highlights the important findings. The main policy issues identified are: a) choice of energy policies, programmes, and institutions is largely dictated by urban and industrial needs; b) a gap exists between policy announcement and programme implementation as reflected in terms of low budgetary allocations for RETs; c) conventional wisdom in energy development (i.e., extension of grid electricity and a marketing network for fossils fuels) prevails without considering the options of decentralized, renewable energy systems; d) energy policies are mostly geared towards reducing the consumption of fuelwood without considering appropriate technological options to suit the sociocultural aspects of mountain communities; e) alleviation of human drudgery and deteriorating health conditions, particularly of women and children in the mountains, still receive low priority designing energy sector intervention programmes; and f) active participation of women in designing household energy programmes is not taken care of holistically even though they are responsible for managing household energy systems.

The document argues that technology design compatible to local conditions, participation of the private sector in the development of RETs, and devices affordable by mountain communities are critical for improving their financial viability.

Four case studies are discussed, namely, Mini- and Micro-hydropower, Solar Photovoltaic Technology, Biogas, and Improved Cooking Stoves. These case studies were carried out in Nepal. Through them various issues pertaining to these RETs are identified. These issues are: management methodology, administrative and financial procedures, technical and financial feasibility of the programme, choice of technology to match the user's needs, and longer term sustainability of the renewable energy programme. The identification of issues has been instrumental in pinpointing the need for programme coordination by adopting a holistic approach with long-term vision in technology promotion; for adopting an integrated approach to the development of RETs; for increasing opportunities for women's participation; for good research, development, and demonstration; for training to improve skills; for technical back-up and monitoring services; for increasing local capabilities and capacities to undertake repair, maintenance, and production of small-scale renewable energy technologies; for generating awareness not only among users but also among planners, developers, and promoters; for emphatic quality control and standardisation; for warranty and insurance to safeguard entrepreneurs and users from loss; and for consideration of social equity for the poor and marginalised mountain populations.

The document proposes a framework for policy recommendations to promote the development of renewable energy resources and technologies and provides broad policy guidelines not only for Nepal but also for the Hindu Kush-Himalayan Region. This framework has six components: a) to recognise and measure the benefits of renewable energy technologies (RETs) with particular emphasis on drudgery reduction; b) to reform energy-price signals so as to provide an equitable environment for each energy source; c) to revamp the energy decision-making process in order to promote decentralized renewable energy technologies and involvement of local-level institutions; d) to change energy users' investment incentives by attracting participation of the private sector and NGOs in manufacturing and promoting RETs; e) to accelerate investments in commercialisation of RETs by supporting RD & D, capacity building, information and awareness generation through public sector or donor funding and by providing attractive incentives to manufacturers; and f) to develop a commercialisation plan for each RET to suit location-specific needs. Finally, the document proposes an agenda for policies and action to promote RETs in Nepal, in addition to proposing technology-specific measures.

Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
ADB/N	Agricultural Development Bank (Nepal)
AEPC	Alternative Energy Promotion Centre
ARECOP	Asia Regional Cooking Stoves' Programme
ATDO	Appropriate Technology Development Organization (Pakistan)
BEW	Butwal Engineering Works (Nepal)
BSP	Biogas Support Programme
BYS	*Balaju Yantra Shala* (Nepal)
CBO	Community Based Organization
CFDD	Community Forestry Development Division
CFDP	Community Forestry Development Programme (Nepal)
COMSATS	Commission on Science and Technology for Sustainable Development in the South (Pakistan)
CRE	Centre for Renewable Energy (Nepal)
CRET	Council for Renewable Energy Technology (Pakistan)
CRT	Centre for Rural Technology (Nepal)
CSD	Self-help Development
CTEVT	Council for Technical Education and Vocational Training
DC	Direct Current
DCS	Development and Consultancy Services
DGNRER	Director General's Office for New and Renewable Energy Resources (Pakistan)
EAST	East Consult
EEC	European Economic Commission
ENERCON	National Energy Conservation Centre (Pakistan)
ESD	Energy Saving Device
EXIM	Export and Import
FAO	Food and Agriculture Organization
FATA	Federally Administered Tribal Areas
FECT	Fuel Efficient Cooking Technology
GGC	Gobar Gas Company
GOP	Government of Pakistan
GTZ	German Agency for Technical Cooperation
HDIP	Hydro-Carbon Development Institute of Pakistan
HKH	Hindu Kush-Himalayas

HMG/N	His Majesty's Government (Nepal)
HP	Horsepower
IAAS	Institute of Agriculture and Animal Science
ICIMOD	International Centre for Integrated Mountain Development
ICS	Improved Cooking Stoves
IFAD	International Fund for Agricultural Development
ILO	International Labour Organization
INGO	International Non-Governmental Organization
IOE	Institute of Engineering
IOF	Institute of Forestry
IREDA	Indian Renewable Energy Development Agency Ltd
IRs	Indian Rupees
ITDG	Intermediate Technology Development Group
JICA	Japan International Cooperation Agency
KFW	Kreditantstaff Für Wiederaufbau
KMI	Kathmandu Metal Industries
KVIC	Khadi and Village Industries' Commission
LEDeG	Ladakh Ecological Development Group (India)
LRMC	Long-run Marginal Cost
MMHP	Micro- and Mini-Hydropower
MMT	Mrigendra Medical Trust
MNES	Ministry of Non-Conventional Energy Sources (India)
MOC	Ministry of Commerce
MOF	Ministry of Finance
MOP	Ministry of Power (India)
MOST	Ministry of Science and Technology (Pakistan)
MPPU	Multipurpose Power Unit
NA-PWD	Northern Area - Pakistan Works Department
NARC	National Agricultural Research Council, Nepal
NDFC	National Development and Finance Committee (Pakistan)
NEA	Nepal Electricity Authority
NGO	Non-Government Organization
NIP	National Institute of Power (Pakistan)
NIST	National Institute of Silicon Technology (Pakistan)
NPC	National Planning Commission (Nepal)
NRB	Nepal Rastra Bank
NRs	Nepalese Rupees
NSA	National Science Association (China)
NWFP	North West Frontier Province (Pakistan)

O&M, O+M	Operation and Maintenance / Organization and Management
PCAT	Pakistan Council of Appropriate Technology
PCRW	Production Credit for Rural Women
PCSIR	Pakistan Council of Scientific and Industrial Research
PEP	Perspective Energy Plan
PHC	Primary Health Centre
PLF	Plant Load Factor
PRs	Pakistani Rupees
PSEDF	Private Sector Energy Development Fund (Pakistan)
R&D	Research and Development
RBB	Rastriya Banijya Bank
RCC	Reinforced Concrete
RD&D	Research, Demonstration and Dissemination
RECAST	Research Centre for Applied Science and Technology
RET	Renewable Energy Technology(ies)
RONAST	Royal Nepal Academy for Science and Technology
RWEDP	Regional Wood Energy Development Programme
SEB	State Electricity Board
SEC	Solar Energy Centre (Pakistan)
SFDP	Small Farmers' Development Programme/Project
SHYDO	Sarhad Hydel Development Organization
SNV-Nepal	Netherlands' Development Organization
SPV	Solar Photovoltaic
SWH	Solar Water Heater
TERI	Tata Energy Research Institute (India)
UMN	United Mission to Nepal
UNCDF	United Natlons Capital Development Fund
UNDP	United Nations Development Programme
UNESCO	United Nations Organizaton for Education, Science, and Culture
UNICEF	United Nations International Children's Fund
USAID	United States' Agency for International Development
VDC	Village Development Councils/Committee
W	Watt
WAPDA	Water and Power Development Authority (Pakistan)
WB	World Bank
WDD	Women's Development Division (Nepal)
WDS	Women Development Section (Nepal)
WECS	Water and Energy Commission Secretariat (Nepal)
WLD	Works and Labour Department

Contents

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	%	13	37	29	5
Area	Million GJ	250	381	210	181
- Fuelwood Extraction					
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.

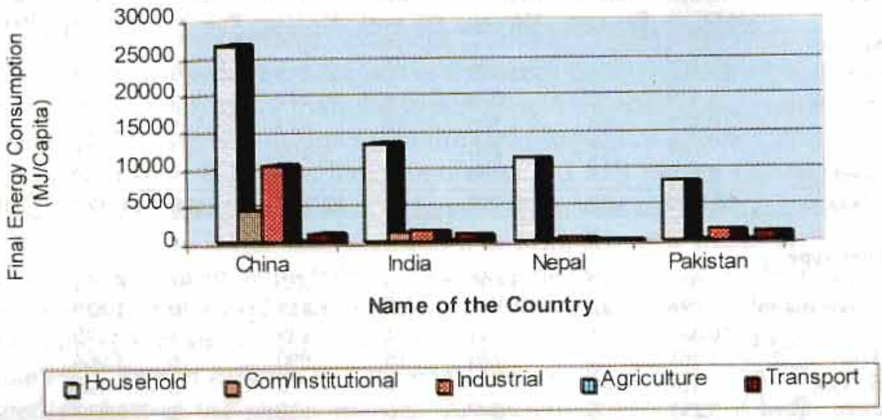
1.1.2 Energy Services in the Major Sectors

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

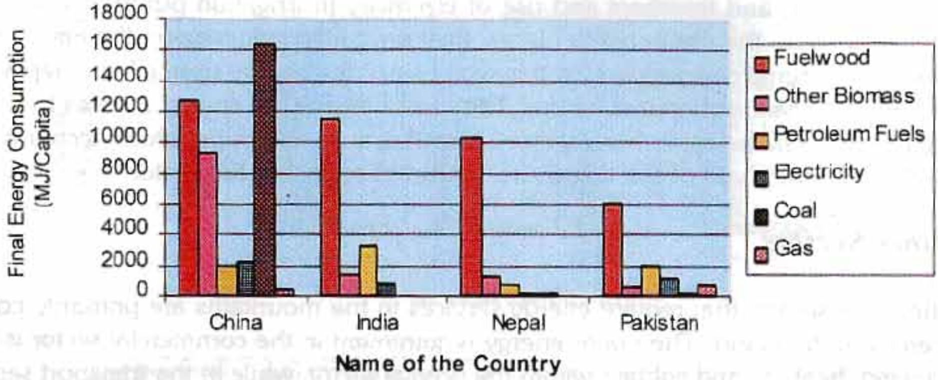
The other sectors that require energy services in the mountains are primarily commerce and transport. The major energy requirement in the commercial sector is for cooking, heating, and lighting within the service sector, while in the transport sector energy is used for operating different kinds of vehicles 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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Chapter 2
Review on Policies and Their Implications for Renewable Energy Technologies in the HKH Region of China

by Zhang Mi [1]

2.1 Background

The energy demand in mountain areas of the Hindu Kush-Himalayan (HKH) Region of China is growing along with the rapid growth of the national economy. The energy consumption pattern in the region largely depends on fuelwood. This heavy dependance has increased the rate of deforestation, soil erosion, flooding, and landslides and in turn reduced agricultural production as a result of poor soil conditions resulting from the diversion of animal dung and agricultural residue from farm to hearth. Also, the direct burning of fuelwood results in a loss of available energy because of very low heat efficiency. It also increases health hazards, due to wood smoke, and the work loads of women and children who are mainly responsible for collecting it.

The region is rich in such renewable energy resources as solar, biomass, hydropower, geothermal, and wind energy, and efforts have been made to introduce renewable energy technologies (RETs) since the 1950s. The diffusion and use of RETs have had a varied history. In some areas of the region, RETs have achieved substantial success, whereas in other places their adoption has been very slow. One of the main factors may have been inadequate national and provincial policies to promote and transfer RETs within the region.

2.1.1 The Socioeconomic Situation of the HKH Region of China

The HKH Region of China consists of the Autonomous Region of Tibet (Xizang Province) and some parts of Yunnan and Sichuan provinces. Tibet occupies a land area of 1,200,000sq.km., is surrounded by the Himalayan, Tanggula, and Kunlun mountains (with an average elevation of more than 4,000m), and shares its border with Bhutan, India, Myanmar, and Nepal. The main rivers are the Yarlungzangbu, the Nu, the Nan Chang, and the Jin Sha rivers, all of which have abundant hydropower potential. In general, harsh climatic conditions prevail, with the mean temperature varying between - 20°C and 16°C, with a nominal amount of rainfall but reasonable sunshine. The population of Tibet is more than four million, the

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majority of whom belong to the *Zang* nationality. The economy largely depends on agriculture and animal husbandry, there being vast natural pasture lands. In recent years, various industries have emerged in Tibet as a result of the government's emphasis on developing infrastructure; industries include hydropower stations, coal mines (for electrification), transport, telecommunications, and educational facilities. There is a rapid growth in manufacturing enterprises on a par with the expansion of investment from the government and private sectors, as well as increasing international assistance or loans for developing this region.

The HKH Region of Yunnan Province covers Dali, Lujiang, Chuxiong, Lijiang, and Baoshan prefectures and is located in the northwest part of the province. The region covers 100,000sq.km. with a mean elevation of more than 1,600m. The population is about 11 million, mainly belonging to the *Yi, Bei, Naxi, Lisu,* and *Han* nationalities. The climate of the region is warmer than that of Tibet, with a yearly mean temperature of 0-7°C in winter and over 16°C in summer. The three main river systems are the Lujiang, Nanchangjiang, and Jinshajiang, which cut across the province. They have abundant hydropower resources. Agriculture is the mainstay of the economy, paddy, wheat, and maize being the main crops. Animal husbandry and tourism play an important role in the economy of Dali and Lijiang prefectures. Besides these, mineral-based industries, such as coal, lead, copper, and marble, make a significant contribution to the economy.

The HKH Region in Sichuan Province consists of Liang Shan, Panzhihua (Dukou), Ya'an, Ganzi, and Aba prefectures (and cities). It covers 318,924sq.km. and is located in the western part of the province. The mean elevation of the area ranges from 2,000 to 3,000m. The population is about 7.82 million and is comprised of the *Zang, Yi, Han,* and *Qiang* nationalities. Four important rivers (Yalong, Dadu, Ming, and Jinsha) run across the region from north to south and join with the Yangzi River; each of them has a huge hydropower potential. The climate in the region is different in the north and the south of the province. In the north, the mean temperature is -6°C in January and 14°C in July, while in the south it is 8-13°C in January and 22-26°C in July. The region primarily grows wheat, paddy, potatoes, maize, and tobacco. Forestry and animal husbandry (cattle, goats, sheep, and yaks) play an important role in the economy of the region, and minerals such as copper, lead, zinc, asbestos, and gold dust are also found.

In the recent past, the Chinese government has begun to give special attention to the development of the region because of the low per capita income of the HKH Region compared not only to other parts of China but also to other parts of the same province.

2.1.2 An Energy Profile of the HKH Region in China

Day by day the demand for energy is growing in the HKH Region both to sustain economic productivity and to increase the standards of living of the population, tandem with the rapid growth of the economy and the increase in the population. The types of energy used for economic productivity are coal and electricity, while household requirements depend on fuels such as wood and crop and animal waste marginally supplemented with coal, electricity, fuel oil, biogas, and solar energy.

The main energy resources available in the region are hydropower, coal, and biomass energy. For example, the total theoretical hydropower potential in Sichuan is 150,000MW, of which 75 per cent is in the HKH Region (SSDC 1988). A similar situation prevails in Tibet and Yunnan.

The development of hydropower represents a significant contribution to the economy of the region. For example, 2,449MW of hydropower have been produced in the HKH Region of Sichuan, with an average annual growth of 13 per cent, since 1985 (SSDC 1988). Besides the development of large hydropower stations with investment from the central government, there are a number of small and micro-hydropower stations, built by the local government and individual communities. These have played an important role in meeting the electricity demand of the region. For example, the theoretical total hydropower in Aba Zhang prefecture of Sichuan is 1,933MW, of which 700MW can be produced. At present, only about 81MW have been produced, 47MW of which are generated from 376 small-scale hydropower stations built with funds from the local government. They allow for a per capita electricity consumption of 200kWh, which is higher than the average national and provincial figures. Yunnan Province possesses 90,000MW of hydropower potential. This is equivalent to a yearly average power generation of 454.5 billion kWh, 23 per cent of the total hydropower production in the country (Zhang 1997). It is difficult to quantify the hydropower potential within the HKH Region, though 40 per cent of this amount is estimated to be available in the HKH Region of Yunnan Province. The exploitation of hydropower resources within the HKH Region is uneven, as a result not only of provincial policies but also because of the amount of funds made available by the local government.

The availability of biomass energy amounts to 11.41 million tonnes of coal equivalent (tce) in the HKH Region of Sichuan Province, as shown in Table 2.1. The average amount of biomass per capita is 3,266kg of coal equivalent (kgce). Similarly, the production of fuelwood in the HKH Region of Yunnan Province amounts to 631,400 tonnes of fuelwood per year, 2,312 million tonnes of crop waste, and 1,086 million tonnes of animal and human waste (Fangxin and Dayou 1997).

Table 2.1: Biomass Resources in the HKH Region of Sichuan (by tce)

Area	Crop waste	Firewood	Animal and Human waste	Total
Ya'an	242,17	349,407	963,576	1,555,158
Panzhihua	208,83	275,236	587,859	1,071,933
Lianshan	1,246,44	1,983,190	399,468	3,629,105
Ganzhi	1,560,04	3,552,164	5,217,825	10,330,029
Aba	822,36	2,406,393	3,347,073	6,575,826
Total	4,079,86	8,566,390	10,515,801	23,162,051

Source: Fangxin and Dayou 1997

The solar radiation on the Yungui Plateau (i.e., Yunnan) is 3,173-5,850MJ/sq.m., and it is believed to be a suitable place for the exploitation of solar energy. Panzhihua City and Ganzhi and Lianshan prefectures of Sichuan Province also have good prerequisites for its exploitation. For example, the total annual sunshine in Panzhihua is 2,709.2 hours with an average annual radiation of 6,280 MJ/sq.m. In Ganzhi it is 2,641.8 hours with 6,392MJ/sq.m. of solar radiation (Fangxin and Dayou 1997).

The effective wind energy density per year in Yunnan ranges from 44.2 to 167.5W within a span of 2,000-6,500 effective hours. This effective density amounts to over 150W/sq.m. available for 3,000 effective utilisation hours over almost half of the region. These are quite favourable conditions for its development in Yunnan Province. Similarly, wind speed exceeds 6m/sec for 500-1,500 hours in a year in most parts of Ganzhi and Aba prefectures of Sichuan, sufficient to be exploited for year-round application (Fangxin and Dayou 1997).

Geothermal energy in Sichuan shows some promise, in view of the 51 spots in Lianshan and 151 in Ganzhi, with an average temperature of 40-60°C (Fangxin and Dayou 1997). Coal for small-scale mining exists in Tibet and in Yunnan Province.

Most of the farmers in the region are found to use fuelwood for household energy requirements. Fuelwood consumption amounts to more than 50 per cent of the total consumption of forest products. Almost 60 per cent of wood consumed in the household sector is required for rural house construction and industrial activities. The consumption of forest products is found to be always over the sustainable supply. Table 2.2 depicts the pattern of household energy consumption in a typical rural hill village of Yunnan Province. The per capita energy consumption for household purposes amounts to 17 GJ, while the average energy consumption in the HKH Region is 27 GJ. Commercial fuel for household activities meets only about 16 per cent of the requirements in rural areas in comparison to almost 35 per cent for the HKH Region as a whole.

Table 2.2: Household Energy Consumption Pattern in a Typical Hill Village of Yunnan Province

Energy Forms	Percentage Share
Fuelwood	68.8%
Coal	12.4%
Crop and animal waste	12.3%
Electricity	4.2%
Fuel oil, biogas, solar, others	2.3%
Total	100.0%
Per capita consumption (GJ)	17.0%

Source: Zhuming et al. 1997

2.2 The RETs Experience in the HKH Region of China

2.2.1 Present Status of RETs

The development of various types of RETs within the region depends on the types of energy resources available, the level of economic development, and national and provincial policies formulated with regarded to these technologies. Generally speaking, the prospects are good throughout the whole of the HKH Region for developing solar, wind, hydropower, and geothermal energiés, not only to meet the local energy demand but also to sustain the industrial growth of the adjoining plains. In addition, there is good potential for biogas plants and efficient biomass stoves within the HKH Region of Yunnan and Sichuan provinces. Efforts are being made to promote RETs, based on their suitability, at local levels. The national policies in principle apply to the HKH Region, and each province, prefecture, and county have their own policies with regard to the development of a particular RET based on the local situation. The development of RETs within the HKH Region of Yunnan and Sichuan is very encouraging, while their development in Tibet is in the initial stages.

The development of decentralized renewable energy technologies has come in for attention as an item on the provincal agenda since the 1980s. Since 1991, the RET programme has received greater commitment from both the central and provincial governments, and this is reflected in their budgetary allocations. At the same time, various types of RET, such as efficient biomass stoves, biogas digesters, microhydropower, and solar and geothermal energy, have been included in the national economic plans and reflected in the social development programmes of the provinces. This will definitely accelerate the installation of RETs within the HKH Region.

2.2.2 RET Development in the HKH Region of Yunnan

The HKH Region in Yunnan accounts for almost 30 per cent of the province's total area. There are still eight million people without electricity in Yunnan, and most of them live in mountain areas. The extension of grid electricity is not possible in many mountainous parts of the province, though there is a great demand for rural electrification. Almost seven million people in Yunnan live below the poverty line, and they account for about nine per cent of the poor people of China. The prevailing level of poverty among the mountain communities as well as the low level of infrastructure is indicative of a subsistence economy. In contrast, some parts of Yunnan Province have undergone rapid economic transformation, with unprecedented growth in the rural economy as well as in village and township enterprises. This has increased the demand for energy, and many areas face an acute shortage of it. There is evidence of a shift in fuel patterns in rural areas of Yunnan. For example, 934,000 rural families were using electric and LPG stoves by the end of 1995 —about 12 per cent of all rural households in Yunnan Province (Zhuming et al. 1997, Mengjie et al. 1997).

In light of this, the promotion of efficient biomass stoves, biogas digesters, and afforestation programmes has received higher priority in the HKH Region of Yunnan. In recent years, the rural energy industry and service system has developed significantly, with the establishment of 22 rural energy service companies employing 125 staff members and operating with a fixed capital of 3.65 million *yuan*. The new and renewable energy programmes that are being pursued within Yunnan Province are briefly highlighted in the following paragraphs.

Table 2.3 enumerates the types of rural energy activities being carried out in Yunnan Province and the energy that has been saved as a result of these activities.

Table 2.3: Rural Energy Development and Utilisation in Yunnan Province (by the end of 1995)

Technologies	Quantity	Energy Saving Natural Unit	tce Equivalent
Efficient Biomass stove	6,440,000 households	6,440,000 tons of wood/year	3,677,000
Biogas digester	138,000 households	276,000 tons of wood/year	157,600
Solar water heater	141,900sq.m	28,000 tons. of coal/year	20,300
Electrical stove	764,000 households		45,800
Efficient tobacco baking	543,000	334,600 tons of coal/year	238,900
Efficient brick-kiln	6,548	378,400 tons of coal/year	270,200
Total		7,461,000 tons of coal/year	11,870,800

Source:Zhuming et al. 1997

Micro-hydropower: The installed capacity of micro-hydropower amounts to 10MW with an annual average power generation of 16.5 million kWh. Though this figure looks impressive, the development of micro-hydropower has been very slow within the HKH Region. For instance, in Dali prefecture 1,254 micro-hydropower plants (8MW) provide electricity to 3,471 households, whereas in Lijiang 136 micro-hydro sets supply electricity to 408 households.

Biogas Digester: The total number of family-sized biogas digesters in Yunnan Province was 138,000 towards the end of 1995. More than 10,000 units per year are being disseminated. The annual gas production per household amounts to 500m^3. Successful implementation of the biogas programme has played an important role in improving the quality not only of rural energy services but also of soil fertility and health and sanitary conditions. The biogas programme within the HKH Region of Yunnan remains marginal. For example, in Lijiang Prefecture the total number of household biogas digesters installed was only 1,262 by 1996, 1,257 of which were operating quite well. In Baoshan there were only 443 household biogas digesters installed, compared to 2,119 in Dali (RESYP 1995, Zhang 1996).

Solar Energy: Solar energy use is expanding rapidly in Yunnan. Two hundred thousand square metres of solar water heating panels are being sold annually thanks to a strong manufacturing capability within the province. This accounts for almost 20 per cent of the total national sales figure. The solar water heaters installed in Dali corresponded to 22,907sq.m. by the end of 1996, though in Baoshan the total was only 7,681sq.m. Also, a big factory has been established to produce solar photovoltaic cells with an annual production capacity of 500kW (RESYP 1995).

Wind Energy: Wind energy development in Yunnan is in the initial stages. Up to now, 230 wind power generators have been set up with a power output of 150-200W each. These units supply power for TV transmission as well as for lighting homes and office buildings (Zhuming et al. 1997).

Geothermal Energy: Geothermal energy has been used widely in more than 20 counties of Yunnan. Baoshan and Lijiang within the HKH Region are employing this source of energy for irrigation, fishing, and paper-making activities.

Efficient Biomass Stoves: The number of efficient biomass stoves distributed has reached 6.44 million, of which 80 per cent are in rural households. This technology has been quite well received within the HKH Region. For example, 500,000 households in Baoshan, 26,425 in Lujiang, and 580,000 in Dali are using these efficient stoves. Out of these, 220,000 households purchased them commercially, an indication of the financial sustainability of the programme (Zhuming et al. 1997, RESYP 1995).

2.2.3 RET Development in the HKH Region in Sichuan

The HKH Region in Sichuan Province covers Ya'an City, Panzhihua City, and Liang Shan, Ganzhi, and Aba prefectures, in the southwest of the province. The total area of the region is 318,924sq.m., i.e., 66 per cent of the total area (485,000sq.m.) of the province. The population is 7.816 million, accounting for 9.3 per cent of the total population (83.63 million) of the province. This region is vast but sparsely populated (Fangxin and Dayou 1997).

The development of RETs within the HKH Region of Sichuan will not only fulfill the energy needs of farmers and herdsmen but also improve sanitation and environmental conditions. For this reason, development of household biogas digesters, efficient stoves, and solar and geothermal energy has been carried out. According to the survey, there are 80,700 household biogas digesters in Liang Shan, Ya'an, and Panzhihua, with an annual biogas yield of 24.21 million cubic metres, 613 solar stoves, 81,600sq.m. of solar water heating panels, 3,900sq.m. of solar greenhouse panelling, 32MWe of solar photovoltaic cells, 10 clusters of geothermal hot springs, covering 80ha for farm irrigation and 3 ha for animal husbandry, and efficient biomass stoves in 444,900 households, as shown in Table 2.4 (Fangxin and Dayou 1997).

2.2.4 RET Development in Tibet

There are no specific government agencies to deal with the development of renewable energy in Tibet. But research on and the development, utilisation, and extension of these technologies have been going on since the 1980s. There is a huge potential for hydropower, solar, wind, and geothermal energy. According to recent information, 60,000 solar cookers, 35,000sq.m. of solar collectors, 120,000sq.m. of solar passive building space, solar lamps equivalent to 800kW, and six photovoltaic power stations (10-30kW) with a total capacity of 105kW have been installed in different parts of Tibet. These facilities are very helpful in the unelectrified areas. Solar stoves, solar water heaters, and solar cells are becoming more and more popular in Tibet. The Yanbajing Geothermal Power Generation Plant in Tibet is the largest such installation (25.18MW) in the country and has an average annual output of

Table 2.4: RET Development in the HKH Region of Sichuan						
Area	Biobas digesters	Solar stoves	Solar water heaters	Solar green-houses	Geothermal sites	Efficient stoves
			← (1,000sq.m.) —>			(1,000 households)
Ya'an	25,100	-	-	-	-	104.7
Panzhihua	14,700	285	18.7	-	-	166.8
Liangshan	40,900	328	62.9	3.9	10	173.4
Total	80,700	613	81.6	3.9	10	444.9

Source: Fangxin and Dayou 1997; Mengjie et al. 1997

9.7 GWh. The hot water coming out of the power plant is used to run an adjoining greenhouse for vegetable farming (Zhenmong et al. 1996, Mengjie et al. 1997).

There is a solar research institute to carry out research and demonstration activities and to prepare a database on solar radiation. There are no manufacturing establishments within Tibet for renewable energy technologies. All of the installed units are imported from parts of China where there are numerous manufacturing and support institutions.

2.2.5 Significant Findings

There is abundant potential for hydropower development in most parts of the HKH Region in the form of small-scale to large-scale plants. However, the present level of use is nominal, primarily because of lack of funds, although sufficient technological capability to deal with construction, power generating equipment, transmission facilities, and the installation and maintenance of small- and micro-hydropower stations is available. The scattered population has a low demand for energy, and, given the fragile mountain ecosystem and lack of funds for large-scale hydropower development, one should consider using existing technical capabilities to install small and micro-hydropower stations below 25MW.

The growth of RETs is usually associated with an increase in rural industrial activities and the need for energy services in households as a result of an increase in household incomes. At the same time, an increase in the number of manufacturing establishments has prompted the rapid promotion of RETs, since they disseminate or market technologies through market mechanisms. Further, local governments have designated a number of counties as rural electrification counties, efficient and biogas counties or integrated rural energy counties, and they have been provided with all the necessary support. This has generated awareness, primarily among consumers, on the use of a particular energy technology, and has demonstrated the factors that have led to its success.

In general, the development of RETs within the HKH Region is in the initial stages, though new and renewable energy technologies have worked successfully in various parts of the country, as depicted in Table 2.5.

Table 2.5: RET Development in China

Description	Installed Capacity	Manufacturing Capability	Average Energy Saving per sq.m.	Energy Saving (M tce)
Solar Energy				
Solar water heaters	2,300,000m^2	326,000m^2	125-150kg ce	279
Passive solar houses	5,000,000m^2	N.A.	30-40kg ce	150
Solar cookers	140,000m^2	N.A.	500-700kg ce	84
Solar greenhouses	225,000ha			
Solar driers	1,314m^2			
Solar photovoltaic cells	3.3MW	4.5 MW		
Small-scale wind Turbines (100W-5 kW)	130,000 units 14.6MW	17 MW		
Biomass Energy				
Fuelwood plantations	5,420,000ha			
Efficient stoves	158,000,000hh			30
Household biogas	5,400,000 units			1
Geothermal Energy				
Hot springs	1,102 units			
Electricity generation	30MW			
Greenhouses	44.5ha			
Pools for aquiculture	205ha			
Heating	1,305,000m^2			
Hydropower				
Micro-hydro	60,000 units 15.65 GW			

New and Renewable Energy Technologies and Products in China, MOA (1995); Zhenming et al. 1996

2.3 Review of Energy Policies and Institutions

Prior to the 1970s, the production and allocation of conventional energy, such as coal, electricity, and oil, were managed according to the National Plan, whereas renewable energy programmes were in the research and demonstration stage, except for the National Biogas Office established within the central government to promote the biogas programme. From the 1980s, biomass, wind, geothermal, tidal, and solar energy programmes were gradually introduced into the National Plan and were administered by several commissions and ministries. Besides them, many energy research institutions and academic organizations were established in the 1980s. There are now research institutions, academic societies, and professional industrial organizations under various commissions and ministries.

There are five organizations responsible for energy programmes at the provincial level: i) Planning Committee; ii) Construction Committee; iii) Committee on Science and Technology; iv) Hydropower Bureau, and v) Village and Township Enterprises. Under the Planning Committee there are three divisions, namely, energy, natural resources, and monitoring divisions. There is an Energy Conservation Office under the Energy Division. The Rural Energy and Environment Office at the county level, under the Construction Committee, is responsible primarily for the extension of biogas, efficient stoves, and solar technologies. The Committee on Science and Technology carries out renewable energy studies relevant at the provincial level. A mini-hydropower development unit of the Hydropower Bureau is responsible for construction activities. The Small Coal-Mining Enterprises' Board falls under Village and Township Enterprises and is a body responsible for the development of coal-mining activities.

The State Commission of Planning is responsible for the overall planning of the energy sector in China and receives input from its provincial- and county-level offices. The State Commission of Economy and Trade, along with the provincial and county offices, is responsible for project management and product development for industrial production. The implementation of energy programmes is carried out by the line ministries (coal, electricity, water, petroleum, forestry, agriculture, and nuclear) along with their provincial- and county-level offices. Scientific research is carried out by various institutions such as the Chinese Academy of Science, State Commission of Science and Technology, and the State Commission of Education along with their provincial- and county-level offices, as well as by universities and colleges.

New and renewable energy technologies need to be appraised, and permission to develop granted by assigned institutions. These institutions are identified in each province by a government body. The implementation of rural energy programmes (primarily new and renewable technologies) falls primarily under the purview of the Ministry of Agriculture.

2.3.1 Components of Energy Policies

The energy policies in China emphasise five major themes. These are: a) focussing on both development and conservation while exploiting renewable energy resources; b) giving priority to human resource development as well as research and development in the field of energy; c) recognising the benefits of renewable energy for the rural economy; d) recognising that energy conservation is a long-term strategic task; and e) increasing funding for the development of RETs. Under each of these major themes, various measures have been taken to promote renewable energy.

Emphasis on Both Development and Conservation of Energy Resources: Various national laws and acts have been made and implemented. These relate to forestry, water resources, coal, and electricity. National law states that all forests, water resources, coal mines, and oil fields are owned by the government. Anyone who wants to develop and use these resources is expected to abide by the national laws and regulations. For example, nobody is allowed to deforest without government permission. Nobody is allowed to open coal mines for private use or build hydropower stations without such permission either. But the government encourages both foreign and domestic investors to invest in such energy development projects Under this overall theme, the following five measures have been taken: a) reforming management systems and allowing developers to fix energy prices; b) relying on modern science and technology; c) making full use of locally available energy resources; d) promoting large-, medium- and small-scale energy enterprises depending on the suitability of the particular place; and e) developing all kinds of energy in an integrated manner and promoting hybrid energy systems (JSE 1996).

Promoting R&D and Human Resource Development: Energy research institutions and training centres for different types of energy have been established under various government departments. The following six measures have been taken: a) extending the application of modern scientific achievements through energy-related industries; b) developing and promoting the adoption of new technologies and processes to reduce high energy consumption in various production processes and to increase energy conversion efficiency; c) strengthening the understanding of the linkage between energy and environment; d) promoting the import of advance energy technology; e) providing regular training programmes on energy management and developing skilled technical personnel; and f) encouraging the establishment of energy institutions both in government and non-government domains.

Recognising the Benefits of Renewable Energy for the Rural Economy: The following measures have been taken to sustain and support the high level of growth in energy consumption (i.e., a projected annual growth of 9.5% in Sichuan Province): a) plans for energy development based on locally available resources to meet county-level demand; b) emphasis on developing particular energy resources at the local level to suit local conditions; c) paying serious attention to employing advanced energy technology while developing rural industries; d) replacing domestic stoves with energy-efficient stoves; and e) carrying out rural energy programmes in a planned and coordinated manner.

Recognising that Energy Conservation is a Long-term Strategic Task: The task of energy conservation needs to be considered as a dynamic process requiring a long-term perspective to achieve the goal of energy conservation. The following measures have been taken to ensure energy conservation: a) strengthening management practices and making suitable laws for energy conservation; b) supporting and strengthening the technical innovation of energy equipment so as to increase efficiency of conversion; c) adjusting economic structures and production to increase the economic benefits of energy use; and d) promoting comprehensive use of energy to increase the utilisation rate and improve environmental quality.

Increasing the Funding for RET Installation: There is a dire need to increase the level of funding for the development of RETs. The following measures can diversify the funding sources and increase the level of funding effectively: a) attracting international investors for big projects to exploit coal, hydropower, oil fields, and natural gas; b) encouraging the financial sustainability of public utilities by allowing them to fix tariffs based on investments they have made; c) promoting joint investment by the government (local or state) and private sector; d) providing favourable loan conditions for manufacturers or developers of micro-hydro, small-scale coal-mining; and solar, wind, and other energy-efficient devices; e) providing tax incentives for renewable energy technologies and energy-efficient devices; and f) putting into practice efficient and transparent fiscal regulations to promote energy sector investors.

2.3.2 Institutional Mechanisms to Implement RETs

In China, most institutes, social and scientific bodies, societies, and similar organizations are directly under government departments or attached to them. For instance, the National Energy Research Institute is under the State Planning Committee. Similarly, the provincial Energy Research Society is attached to the Provincial Planning Committee. Further, the National Solar Energy Society is under the National Science Association (NSA), and the National Biogas Society is under the NSA and the Ministry of Agriculture. Such institutions are working in the energy sector for the government and carry out research programmes and other such activities.

With the development of the economy and other systematic reforms, more and more non-government institutions and academic societies are being formed, some of them under an enterprise or attached to a government agency. But, in management and finance, they are completely independent. The growth of private research institutes has been very fast in recent years because of the encouragement and support provided by the government. State-owned research institutions are not so active nowadays, in times of low funding. Private sector research institutions, however, are operating well through the income they make out of technical consulting services and the transfer of technology and skills, even though they are not financially supported by the state.

The relationship between the various energy institutions and the government departments responsible for the energy sector is well coordinated. Generally, energy institutions provide technical guidance and instruction, while energy departments make plans and allocate funds. The implementation of RETs in the HKH Region of China takes place in the following manner: The State Planning Committee forwards RET programmes to the Provincial Planning Committee, and then to the city and county level, with an allocation of funds for their implementation. At the same time, research programmes are assigned to the relevant institutions or universities. The extension of research grants to these depends on the output of the research programme. Horizontal linkages are established between research institutions and extension agencies involved in the development of RETs.

Most of the HKH Region falls into the minority region of China and therefore receives preferential treatment over other parts of the country. Most of the policies related to taxes, loans, land use, forests, and water have special provisions for the minority region. The minority regions are favoured in terms of the financial incentives they receive. For example, no- or low-interest loans are made available for the construction of biogas digesters, micro-hydro plants, and solar systems, in addition to government subsidies. Also, manufacturers of RETs receive some subsidies and three to five years of tax holiday. Similar provisions are made for the users (mostly herdsmen).

2.3.3 Implementation of Energy Policies at Local Level

Policies issued at the national level alone is not sufficient to promote the development of RETs. These policies, however, have provided broad guidelines for implementing programmes at the village level. The provincial and local governments play a critical role for the realisation of these policies at the village level. The success of RETs in a particular village or county depends on the efforts and initiatives taken by the local governments and, in some instances, how the provincial and local governments supplement national policies.

For instance, the national policy on RETs states that the government will provide subsidies from state funds, tax exemption for biogas companies, low interest loans and discount loans for installation of RETs, and 10sq.m. of land for biogas digesters. Further, the government of Panzhihua City provided with 600,000 *yuan* and the county 300,000 *yuan* for the construction of 4,000 biogas digesters during 1996-1998. Another example comes from Yanbian County in Liang Shan Prefecture where the local government has allocated 10,000 to 20,000 *yuan* to the agriculture sector to support rural energy construction, with the result that investment in this sector is increasing rapidly. Similarly, 50,000 *yuan* per annum from the special development funds for the minority regions of Lianshan, Aba, and Ganzhi prefectures have been provided for supporting the rural energy infrastructure. At the same time, the Department of Forestry provides eight *yuan* for each farm household as a subsidy for improving their cooking stove. Also, the Bank of Agriculture and the Taxation Bureau provide favourable loan conditions for the RET programmes (Fangxin and Dayou 1997).

In Dechang County of Liang Shan Prefecture, the county government has issued a document on 'Strengthening the Rural Energy Infrastructure', which proposes that a budgetary allocation for the creation of a rural energy fund should figure in the financial plan of the county. This fund would be collected from various sources and would be used for research, demonstration, and extension as well as construction. Also, the Commission of Nationalities, Office of Forestry and Tobacco, and Office of Silkworms have made some funds available to support the biogas programme.

The incentives provided by the local government for different RETs varies from village to village, county to county, and province to province in accordance with their needs, and thus the development of RETs in each village differs significantly, based on the initiatives taken by the local government.

The distinct benefits of the promotion of RETs within the HKH Region is visible in terms of the improvement in quality of life of the villagers and also in terms of the growth in rural cottage industries. For example, the comprehensive use of biogas and bio-manure (the digested residue) has brought great change and benefit to rural areas. Prior to the use of biogas, farmers had to go to distant places to collect firewood, which increased the rate of deforestation and, consequently, soil erosion, landslides, and flooding. Also, indoor air pollution caused by the burning of fuelwood had given rise to significant health hazards (particularly to women and children), and bad sanitary conditions prevailed in the villages caused by (untreated) human and animal wastes. The smoke caused by the burning of firewood has had a bad effect on the eyes and lungs, particularly among women and children. Sanitation has now been improved through the treatment of human and animal wastes with anaerobic fermentation technology. Most of the parasites and disease-spreading bacteria are killed in the biogas digester, and flies and mosquitoes occur less and even disappear because of the clean environment in those villages and townships where biogas is working very well. Further, the occurrence of disease in humans has become less frequent due to better sanitation.

The use of various types of solar appliances has improved the living conditions of the farmers and herdsmen in remote mountainous locations. Villagers are happy to have cooked food, hot water for bathing, lights in the evening, and the chance to listen to radio and watch TV. Also, in many places, the development of small- and micro-hydro has provided electricity in rural and mountainous areas where it would have been next to impossible to extend the grid. All these efforts have greatly changed the life and economy of the people within the HKH Region in China.

2.3.4 Examples of the Successful Implementation of RETs

These policy initiatives are favourable for the development of RETs, not only in China but also within the HKH Region. Box 2.1 highlights a few case examples of how energy policies have become instrumental in promoting the development of renewable energy programmes in the HKH Region of China. At the same time, it is observed that the state pays much more attention to the big energy projects. The development of decentralized small-scale RETs tends to be ignored, and mountain communities are marginalised, even though they possess abundant renewable energy resources which can be developed at the local level. Also, there are no suitable local institutions in many parts of the HKH Region with the responsibility to promote decentralized small-scale renewable energy technologies.

Box 2.2 depicts the chronological events of biogas development and demonstrates that strong political commitment at the highest level and the establishment of decentralized institutions at the village level have been instrumental in achieving the success of the biogas programme in China, and thereby providing an excellent example of RET development to the world community.

In general, the renewable energy programme can be considered quite successful in the HKH Region of China, though there are gaps between policy and hard realities in implementing energy programmes in the region. First of all, most of the existing policies focus primarily on ensuring and sustaining economic development and tend to be biased towards large-scale energy development, with the primary focus on the exploitation of commercial energy resources. Secondly, the government usually tries

Box 2.1: Case Examples of Successful Renewable Energy Programmes

Example 1: The following national rural electrification policies were responsible for the development of hydropower in Aba Zang Minority Prefecture of Sichuan Province.

- The provincial government, autonomous prefectures, and cities are to make a development plan for rural electrification and integrate it into the local power development plan as well as the national economic policy and social development plan.
- The state is to give priority to rural electrification. Key support should be given to minority regions, remote mountain areas, and poor regions.
- The state strongly supports the construction of medium and micro-hydropower stations to promote rural electrification.
- The state encourages and helps rural areas to carry out rural electrification using solar, wind, geothermal, biomass, and other energy resources to increase the rural power supply.
- The electricity price for the agricultural sector should be set on a non-profit or low-profit basis.

Example 2: The following measures have made biogas development a success story in Nanjiang County of Sichuan Province.

- The preparation of the biogas development plan at the district level was based on local conditions.
- More attention was paid to the implementation of policies that strengthened biogas organizations.
- The quality of both biogas construction and personnel was stressed. For example, training received by personnel was a prerequisite for heading a biogas team at village and district levels.
- Regular after-sales' service is ensured through a contract system. In case of poor quality, the contractor is liable for the costs of all repair.
- Incentives are provided to users. For example, the biogas user gets land free of cost from the government, and a cash incentive is provided to cover labour charges for the construction of biogas digesters.
- The setting up of demonstration units is the key for propaganda and extension.

Sources: Rijal (ed.) 1997, Zhang 1997

Box 2.2: Chronological Events of Biogas Development: An Example of Strong Political Commitment

Year	Policy Statement Made	Leader/Institutions
1958	Popularisation of biogas	Mao Tzedong
1959	Extension of biogas programme	Mao Tzedong
1970	Set up biogas offices at province, city, and county levels	Ministry of Agriculture
1980	Developed biogas as an example to the world Introduction of subsidies (IR - 0.21% loan) Provision of free land, Subsidies for construction Free biogas appliances	Deng Xioaping
1981	Provision of 40 million *yuan* each year soft loans	State Commission for Planning/China Agriculture Bank
1984	Tax exemption for biogas companies	Ministry of Finance
1986	Provision of 5 million *yuan* per year for soft loans for construction	Ministry of Finance
1989	Developed biogas in rural areas	Jiang Zeming
1991	Developed biogas to protect the ecological balance	Jiang Zeming
1993	Promulgation of the Law of Agriculture (promoting integrated approach)	

Source: Rijal 1998

to link energy development with economic benefits, and no emphasis is placed on fulfilling the social needs of mountain communities. In most renewable energy technologies, direct economic benefits are not so obvious as with conventional forms of energy. For example, the biogas programme may not bring direct economic benefits, but it does have many positive social, environmental, and ecological impacts. Lastly, the over-dependence of RETs on subsidies may hamper the long-term financial sustainability and commercialisation of these technologies. Also, users may consider these energy supply systems as poor people's fuel options and, with an increase in their income levels, consider abandoning these technologies in favour of commercial fuels.

2.4 Barriers to Dissemination of RETs

The experience of RETs in the HKH Region of China indicates that there are a number of barriers that hamper the proliferation of these technologies in remote mountainous locations — in most cases, subsidy-driven barriers. This raises a serious concern with regard to the long-term financial sustainability of the RET programme. The major barriers identified are as follow.

2.4.1 The 'Unbalanced' Growth of RETs within the Region

In the HKH Region of Sichuan, for instance, only Ya'an, Panzhihua, and Liang Shan prefectures have carried out programmes promoting biogas, solar, and efficient biomass stoves, while in Ganzhi and Aba there are a few cases of the demonstration of various applications of solar energy as well as the installation of micro-hydropower units. In Tibet, solar lanterns, SPV electrification schemes, and a limited number of micro-hydropower units have been distributed. There is a large-scale geothermal plant (25.18MW) in operation in Yangbajin which supplies power to the Lhasa grid. The number of RET installations does vary significantly, not only within the HKH Region but also within prefectures and counties. For instance, there are 17 counties in Liang Shan, and only 10 of them are actively involved in promoting the development of RETs. This clearly indicates the unbalanced growth of RETs within the region, primarily due to the varying emphases placed on the development of RETs by local governments. At the same time, the comparative advantage that renewable energy resources possess in terms of economic and environmental sustainability for remote mountainous locations is not adequately recognised. There is a growing tendency to shift towards fossil fuels to cope with the emerging energy transitions.

2.4.2 Weak Organizational Structure for RET Promotion

There is a limited number of rural energy extension offices within the region that are responsible for the demonstration and dissemination of RETs along with awareness generation. These offices do not possess a sufficient number of skilled personnel to advise, develop, promote, install, repair, and maintain renewable energy technologies. For example, in the rural energy field offices of Ya'an, Panzhihua, and Lianshan very few technical staff are employed, so that the extension of RETs is not only difficult but hard to manage. Even in places like Aba and Ganzhi, there are no organizations to promote RETs. Up to now, there is no government office responsible for coordinating and promoting RETs in Tibet, apart from a solar research institute; and that too is primarily involved in research activities rather than extension work. This is a major shortcoming in terms of promoting RETs in remote mountainous areas. The manufacturers themselves could have established marketing chains in remote mountainous locations but, because of the high cost of extension, they seem to be uninterested in doing so. Manufacturers may be willing to extend their services to remote locations if the government provides incentives to them initially.

2.4.3 Lack of Funds for RET Installation

The HKH Region in China covers largely remote and mountainous areas, the residents of which mostly belong to minority communities, and where a subsistence economy prevails due to the lack of sufficient and suitable infrastructure and industries. Most of the counties survive on subsidies and support received from the government just to meet their daily needs. Therefore, there is very limited scope for generating local funds to meet the technical and administrative expenditure for the RET programme. Because of the weak financial position of many counties in the HKH, demand for RETs is very low, so there are almost no jobs, even for technical personnel, in rural energy extension offices. At the same time, the special funds made available by the government for demonstration, research, and training activities pertaining to RETs are decreasing year by year. Nor are any alternative approaches being conceived.

2.4.4 Lack of a Holistic Approach to RET Development

In many places in China, RETs have contributed to meeting household energy needs and also to increasing the economic efficiency of a particular area. This has been possible primarily because of the holistic approach adopted for the development of RETs. Under such an approach, due consideration is given to the sociocultural needs of the communities as well as to the fact that any resources and technologies are always subject to multiple uses in a subsistence economy. The development of the biogas programme in China provides a good example of this approach, in that it not only meets the energy needs of households but also improves soil fertility and sanitary conditions. In most of the counties of the HKH Region, the local government does not pay adequate attention to the development of RETs in a holistic manner.

2.5 Policy and Institutional Recommendations

The overdependence on the commercial energy supply, and that too in a centralized way, only serves to check the speed of development in the HKH Region, because of its remoteness and the high cost of importing energy from outside the region. There is a huge potential for renewable energy resources in the region. The promotion of RETs is both feasible and desirable in the region not only on account of the scale of related technologies and institutions, the quality and quantity of energy services required, the availability of supply, and the low level of necessary technical skills but also because of the high potential for exploiting traditional knowhow and skills and the high level of community participation. Given this situation, the formulation of suitable policies and institutional mechanisms that favour the growth of RETs is essential so that these interventions within the HKH Region create an atmosphere conducive to greater participation on the part of the private sector, based on proper recognition of the economic, social, and environmental benefits of RETs. The main components identified and recommended for policy and institutional interventions in the context of the HKH Region are as follow.

2.5.1 Adopting a Holistic and Integrated Approach to RET Dissemination

Currently, RETs are being developed independently of one another under a sectoral approach, so that very little coordination exists between various types of RET. The types of energy services offered by a particular RET do not fully meet the diverse energy needs of household and economic production. Complementary features may exist between various types of RETs, and, if coordinated properly, their synergy can be captured. At the same time, a particular type of RET may offer comparative advantages to a particular sector and vice versa. For this to be used, a holistic and integrated approach to the dissemination of renewable energy technologies should be adopted, if they are to contribute significantly to fulfilling the energy needs of the remote mountainous communities in the HKH Region.

2.5.2 Preparing an RET Development Plan Suitable for the Region

An RETs development plan is needed for the HKH Region, with a view to achieving not only economic and environmental but also social and financial sustainability. This plan should be integrated with the economic development plans of the region which take into account the physical limitations of particular locations. The area-based approach should be adopted, since the types of energy demand may differ in terms of both quality and quantity, and the energy supply potentials may also vary dramatically within a short span of kilometres because of the prevailing mountain topography. At the same time, different minority groups are centred in different parts of the HKH Region, each with its own social norms and values. Therefore a renewable energy technology accepted by one community may be rejected by another. A mass-based approach for disseminating RETs may fail completely, as has been noticed in some parts of the region.

2.5.3 Promoting Private Sector Financing in RET Development

Private sector participation in the design, manufacturing, development, and extension of RETs should be promoted; and the role of the government should be that of a facilitator. The cost of the development and extension of RETs is very high, particularly in the HKH Region, for reasons explained earlier. Government funds are in short supply, but if appropriate incentive packages are provided to the private sector, it may be willing to come forward to develop and promote RETs in the region.

2.5.4 Promoting International and Regional Cooperation for RET Transfer

There are various ongoing efforts to develop and improve the technical efficiency, along with major efforts to reduce the production costs, of RETs in the context of an increased awareness of the benefits among the countries of the region as well as at the international level. At the same time, technology developed in China may be accepted well not only in the countries of the region but also in developed countries. It is therefore desirable to exchange information, visits of professionals and technical personnel, and knowledge that is available within each country among the countries of this region and others instead of re-inventing the wheel, or for that matter remaining in isolation. In facilitating this process, international and regional cooperation in the transfer and adaptation of RETs through agencies such as ICIMOD, UNDP, FAO, and ILO may be instrumental. This these type of cooperation should now be promoted more aggressively than heretofore.

2.5.5 Promoting and Building the Capability of RET Manufacturers

Although, in this region, some enterprises producing solar water heaters, solar stoves, micro-hydro and wind power units, and solar cells have been set up, their scale is very limited, with low production, out of date equipment, and lack of technical personnel. On the whole, the RET industry has not been developed in a desirable way. It is suggested that, through market competition, it should be possible to get rid of or merge small factories having lower quality equipment and weak market sales, and to set up new enterprises with modern equipment, a strong technical base, and good quality products, or to establish linkages among enterprises so that the existing comparative advantage of each of them can be realised to lower costs and win a fair share of the market at home and abroad.

2.5.6 Establishing Technical Service/Extension Units for RETs

The dissemination of various types of RET in the region has necessitated the establishment of technical service/extension units for them, not only at prefecture and city levels but also at county, township, and village levels. These units may undertake different types of service such as the sale, installation, adjustment, maintenance, and management of RETs. Based on local conditions, different areas may adopt different modes of management (private/community/cooperative) and ownership. Networks need to be established among these service units within and beyond prefectures and counties.

2.5.7 Strengthening Scientific Research and Training in RETs

The development of RETs is feasible only if continued efforts are made to improve upon existing technologies through scientific research and the popularisation of new products and technologies. The research institutions, manufacturers, and technical service/extension units must cooperate closely so that feedback from field-level experiences is transferred to the research communities and manufacturers for further refinement. All levels of government should strengthen research activities and training programmes by providing adequate funds.

2.5.8 Generating Public Awareness of RET

The extension of RETs needs government propaganda to raise public awareness and understanding. In the HKH Region of China, most of the farmers and herdsmen are illiterate, with little knowledge of RETs. Therefore, it is necessary to start awareness programmes in the form of appropriate demonstration units. In many cases, the concept of a 'self-sufficient energy village' has been an effective means of propaganda and awareness generation. Similarly, awareness campaigns on various types of RET may be promoted through such media as TV, radio, newspapers, and posters.

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Solar water collector fitted on the roof of a bathroom, Lhasa, China

Large-scale biogas plant retrofitted with a boiler suitable for cold climates, China

Chapter 3
Review of Policies and Their Implications for RETs in the context of the Indian Himalayas

by Soma Dutta [1]

3.1 Introduction

India, with its population of about 900 million people, is a supply-constrained economy whose environmental resources are deteriorating at an alarming rate. Traditional biomass fuels (about 250 million tonnes of biomass is consumed every year) provide about one third of the total energy needs and over three fourths of all household energy. Coal, petroleum products, and electricity are the other important fuels. Among other constraints, lack of financial resources has led to inadequate growth in the energy sector, this in turn leading to shortages and shortfalls in all sectors, impeding economic and social growth.

The fragile ecology of the Himalayan belt is probably the worst hit by this ongoing environmental degradation. The people inhabiting the Himalayan region have traditionally had a very concrete relationship with their natural environs, depending on it for most of their subsistence needs, including fuel. In the absence of alternatives, such as fossil fuels, and given their low purchasing power, the people of the Himalayan region continue to depend predominantly on biomass-based fuels. This has led to a reduction in the supply of biomass fuels, meaning that the women have to walk further to collect fuelwood; inferior fuels like animal dung, bushes, weeds, twigs, and roots have to be used; or, in the worst circumstances, wood has to be purchased.

Renewable energy technologies are considered extremely suitable for hilly areas because of features like the decentralized and self-contained nature of operations and the reliance on locally available, non-depleting energy sources. Decentralized renewable energy systems are considered to be highly suitable, especially for off-grid electrification of villages in remote and inaccessible areas where transmission of grid power has been found to be difficult and uneconomical. Though these programmes have been in operation for well over a decade now, it is felt that they have not been able to make a significant impact on the lives of the people, especially considering the magnitude of the existing fuel crisis.

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3.2 Government Initiatives in the Energy Sector

In India, the key initiatives to deliver energy to the masses include the supply of electricity (for lighting, electrical appliances, and irrigation in the rural areas) and distribution of domestic cooking fuels like kerosene and (LPG) at subsidised prices. It should be mentioned that the majority of transactions in biomass, which accounts for about 40 per cent of the primary energy consumption in the country (Ravindranath and Hall 1995), continue to remain outside government control. In the energy sector, initially the major thrust was fuel substitution, namely supplying kerosene through the Public Distribution System (PDS) and power through rural electrification. Over the years, a number of afforestation schemes, such as wastelands' development and social forestry, have also been promoted for augmenting the supply of fuelwood. And finally, renewable energy programmes, including biogas, improved cooking stoves, and solar photovoltaic applications, have been implemented.

3.2.1 The Rural Electrification Programme

This programme is being implemented by the Rural Electrification Corporation (REC) and aims at supplying electricity to all villages. By the end of 1993-94, more than 85 per cent of the 580,000 villages in the country were reported to have been electrified and over 10 million pumps energised (CEA 1996). While this has been an impressive achievement, the number of households having electricity connections is still quite low, only about 30 per cent (Gupta 1997).

One of the important reasons for this is the unaffordability for the majority of people who could otherwise avail themselves of the benefit. The quality of supply has not been consistent either, because of poor loads and long distance transmission and distribution[2]. The energisation of pump sets for irrigation has gone on at a brisk pace, exceeding 10 million out of a total estimated potential of 14.5 million pump sets, but there are still a large number waiting for electricity connections. But an even more serious problem in this sector is the heavy subsidy for electricity given to farmers (in most states, the tariff is negligible — not more than half a rupee per unit). In many cases, the bill collection system, due to the diffused nature of the sector, is expensive and cumbersome. Given the fact that the tariff is extremely low, electricity is consumed in an inefficient and wasteful manner. Because of this, many state electricity boards (SEBs) have been incurring huge losses. Till March 1992, the cumulative loss of SEBs was IRs 41.2 billion (TERI 1996d). Also, the price of power for agriculture has become a major political issue, with middle-income and rich farmers representing a powerful lobby opposing any move to rationalise the pricing structure.

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2 T & D losses due to technical reasons, pilferage, etc are estimated to be 23 per cent of the total power generation in India (TERI 1996d).

An important issue in the rural electrification programme is that, so far, rural electrification has meant extension of the conventional grid and nothing else. There has been no provision for decentralized power generation and distribution. Because of this, remote and inaccessible villages in several parts of the country, where grid extension is neither logistically nor economically viable, have not been able to benefit from rural electrification. It is estimated that about 87,000 villages are still in this category, and a majority of them are not likely to have grid electricity ever. A large proportion of these are in the Hindu Kush-Himalayan (HKH) region.

3.2.2 Supply of Commercial Fuels

Kerosene: Kerosene is being promoted as a subsidised fuel for the poor, the main distribution channel being the PDS. In India, kerosene is a deficit product, with 40 per cent of the requirements being met by imports. During 1994-95, the total consumption of kerosene in the country was about 8.9 million tonnes. Though field-level data on actual use in different sectors are not available, it is estimated that 60 per cent of it is consumed in the rural areas (CMIE 1996), primarily for lighting. According to the 1991 census, 7.2 per cent of households in the country used kerosene as a fuel for cooking. However, while 23.6 per cent of urban households use kerosene for cooking, only 1.3 per cent of the rural households do so (CMIE 1996).

Liquefied Petroleum Gas (LPG): Nearly 85 per cent of the total LPG in the country is consumed as cooking fuel in the domestic sector (CMIE 1996). Between 1980 and 1994, the demand for LPG grew at a rate of 7.5 per cent per year. The primary reasons for this high demand are its popularity as a cooking fuel and the existing subsidy on the fuel (Box 3.1). However, in spite of active promotion by the government, the 1991 census estimated that only 7.94 per cent of households (excluding Jammu and Kashmir) used gas for cooking.

An important issue in the use of LPG in India is that so far the penetration of LPG as a cooking fuel has been mainly in towns and cities rather than villages. Of all urban households in the country, 26.9 per cent use LPG, while only 1.2 per cent of the rural households use this facility (CMIE 1996).

3.2.3 Afforestation for Increasing Fuelwood Availability

A participatory approach to forest management in the form of social forestry (SF) was introduced in the 1970s with the objective of meeting the food, fodder, and fuelwood needs of the communities. During the seventies and eighties, several social forestry experiments were undertaken, significant among these being the Arabari in West Bengal and Sukhomajri in the Shivalik ranges. In 1990, the government of India issued policy instructions to all states to support the participation of local communities and NGOs in the management and conservation of forests.

Box 3.1: Subsidies on Kerosene and LPG: Who Are the Beneficiaries?

The primary issue in the supply of fuels like kerosene and LPG is that of subsidies. Initially, LPG was subsidised for the domestic sector with a view to promoting it as a cooking fuel. However, this has created an ever-growing demand in the urban areas with which the indigenous supply is unable to cope. Though imports of the two petroleum products have increased substantially over the past few years, the actual consumption of these fuels by consumers is greatly constrained by availability. Consumers often have to wait for a long time for LPG connections. As of 1 January 1995, there were 11.4 million customers on the waiting list (CMIE 1996). Also, the continued rationing of kerosene for rural and urban households and the problems experienced in getting even these rationed amounts reflect the restricted availability of the fuels.

Similarly, in the case of kerosene, the motive behind giving subsidies was to provide a clean, cheap, and efficient fuel for the low-income households in rural and urban areas. However, available information indicates that large quantities are pilfered for alternative uses in urban areas, e.g., to adulterate gasoline. As a result, shortages and non-availability are common in the Fair Price Shops, and people often have to buy from the open market, paying a much higher price than that fixed by the government.

The programme operates through forest committees (FC) at the village level and village forest workers (VFW). However, except for a few cases, social forestry programmes have suffered from restricted people's participation and the indifference of local communities. Typically, the management tasks of selecting species, distributing land, marketing produce, etc are looked after by the Forest Department, while the involvement of the people is restricted to the provision of hired labour for planting activities and cooperation in protecting the trees (Foley and Bernard 1984). Further, the afforestation of community lands has led to the curbing of the customary rights of the poor on these degraded lands to graze livestock and collect fuel, fodder, and other non-timber produce (TERI 1996c; Khan and Hasan 1995).

Micro-level studies have indicated that social forestry projects have done little to improve fuelwood supplies for the rural poor (Saxena, undated). It has been observed that wood produced in community forestry projects is rarely used by the rural people for fuelwood. The species' composition of social forestry plantations shows that exotic hybrids of *Eucalyptus* and *Acacia auriculiformis* together formed 80 per cent of the mixed plantations at the national level (Ravindranath and Hall 1995). Eucalyptus alone formed 30 per cent of the trees planted under community forestry programmes, and 71 per cent of farm forestry programmes. As a direct consequence, a large proportion of this wood gets sold in the markets and is not used for subsistence needs.

Farm forestry, which involves planting of trees on farmlands, has been more successful, in terms of numbers of trees surviving. It was hoped that, under this programme, the farmers would grow trees for their subsistence needs. However, trees were planted more for sale as poles or pulpwood rather than for fuelwood. The farm forestry programme is unlikely to benefit those with little or no land, whereas afforestation on common lands can be made to generate substantial benefits for these marginal classes of society. It has already been seen that farm forestry has helped the larger farmers to maximise economic returns from the land.

3.3 Renewable Energy Development in India

3.3.1 Development of Renewable Energy Policy

The first step in the promotion of renewables in India was the formation of CASE (Commission for Alternative Energy Sources) in 1981. The renewable energy programme started in the early eighties, with the setting up of the Department of Non-conventional Energy Sources (DNES) in 1982. In the early 70s, the Department of Science and Technology (DST) looked after solar and wind programmes, while the agriculture and rural development ministries were responsible for the biogas and improved *chulha* programmes. However, even these programmes were launched as national programmes only in the eighties. During the eighties, the emphasis of government initiatives in the renewables' field was to develop and demonstrate the technologies. This was done through large-scale demonstration projects and by subsidising the cost of various renewable energy technologies (RETs) to the users. During this decade, large programmes like the National Project on Biogas Development (NPBD), National Programme on Improved *Chulha*(s) (NPIC), and wind energy development programmes were introduced. The programmes were carried out by nodal agencies in each state in a coordinated implementation of individual programmes. Technology support centres or technical back-up units (TBUs) were also set up in universities and other research institutions. This approach helped to create a large manufacturing base and basic infrastructure; however, none of the technologies was successfully commercialised. The poor commercial demand for RETs was largely a result of poor reliability and the lack of remunerative tariffs and consumer-oriented features.

In line with the economic liberalisation of the economy, the nineties saw a shift in the renewable energy policy towards commercialisation and private sector participation. In 1992, 10 years after being set up, DNES was upgraded into a fully fledged ministry, MNES (Ministry of Non-conventional Energy Sources). Since then, the focus of RET promotion in India has shifted towards market development and commercialisation. The private sector has been strongly encouraged to participate in these programmes, especially wind power generation, by means of fiscal incentives and tax holidays. With these changes as the focus for promoting renewables, a large number of programmes to develop, demonstrate, and commercialise technologies has been introduced by the government. The physical progress of the RET programme is given in Table 3.1.

Table 3.1: Physical Progress of RETs in India

Programme	Cumulative Achievement up to March 1996
Family-sized biogas plants	2.4 million
Community biogas plants	1,623
Improved cooking stoves	22.56 million
Solar thermal systems (collector area)	364,354sq.m.
Solar cookers	406,652
PV water pumps	1,820
PV power units	909.3kWp
PV community lights/TV and community facilities	910
PV domestic lighting units	37,359
PV lanterns	81,059
PV street lights	32,870
Wind pumps	3,158
Wind farms	733MW
Mini-micro hydro	129MW
Biomass-based cogeneration	29MW
Biomass combustion-based power	14MW
Biomass gasifiers/stirling engines	29.62MW

Source: Naidu 1997

3.3.2 Review of RET Programmes

The Biogas Programme: Biogas technology promotion was taken up as a national-level programme with the introduction of the NPBD (National Project on Biogas Development) in 1981-82. Traditionally, it has been the largest among all the renewable energy programmes in terms of funding. The NPBD is promoted as a multi-model, multi-agency programme, so as to incorporate regional variations and to encourage NGOs to participate in the implementation of it. To encourage people to adopt the technology, subsidies partially covering the cost of installation are given to the beneficiaries.

Evaluation studies (NCAER 1989 and 1992) indicate that in spite of the large number of plants installed (over 2.4 million so far), the NPBD has not been an unqualified success. The National Council for Applied Economic Research (NCAER) at the national level, in 1992, surveyed 27,000 owners of biogas plants installed during the seventh plan and reported that 66 per cent of the plants were still in use. The reasons for biogas plants becoming dysfunctional can be broadly divided into two categories: structural (construction-related problems) and operational (usage-related problems). Constructional defects result mainly from the problem of availability of quality construction material, and poor-quality masonry skills. On the operational side, the main problem seems to be a shortage of dung required for initial charging. Many areas also suffer from shortage of dung and water for daily feeding. A recent study carried out by the Tata Energy Research Institute (TERI) (Dutta et al. 1997) showed that underfeeding of dung cannot always be attributed to unavailability. In the majority óf households surveyed in the study, the persons responsible for the feeding of the biogas plant, usually women, do not know the quantities of dung and water that are required to be fed daily. Thus lack of user education is also responsible for the improper mixing of dung and water. The main institutional problems relate to procedural delays in loan sanctioning and the disbursement of subsidies and the turnkey fee by government authorities and the lack of repair and maintenance support for the plants installed.

With all the effort that has gone into the programme, the overall impact of biogas has been rather small. Other important aspects are the potential realisation and penetration rate of the technology. As of now, only 18 per cent of the total potential has been realised, and it is estimated that, at the current rate of penetration, it will take more than 50 years to meet the full potential of biogas plants.

Improved Cooking Stoves: The National Programme on Improved *Chulha*(s) (NPIC) was launched by MNES in 1983 with the objectives of reducing the use of fuelwood; eliminating smoke from kitchens; reducing drudgery among women and improving their health; and generating employment in rural areas. The NPIC is the largest programme in terms of number of devices installed. During the initial years, improved cooking stoves for rural families were almost fully subsidised. Currently, the cooking stoves (fixed mud type) cost about IRs 100, 50 per cent of which has to be met by the beneficiary. The programme also offers incentives to self-employed workers (SEWs), implementing agencies and cooperative stores, fair price shops, and so on which serve as sales' outlets.

Like the NPBD, the performance of the NPIC has been mixed. MNES data show that nationally 72 per cent of the stoves are in use (MNES 1996). Other studies show use levels varying from 33 per cent in West Bengal to 79 per cent in Rajasthan (TERI 1989). The largest drawback of the stove programme is the inability to design stoves that suit local conditions. In large measure, this can be linked to the target-oriented approach adopted for dissemination which is not flexible enough to involve the local people, especially women, in stove design. The main reason for people discarding the improved *chulha*(s) was the inability to cook certain kinds of traditional food on them. Sometimes improper construction or usage also led to more fuel being used than saved. Though it is technically a simple device, proper construction and adherence to design specifications are critical to the success of the stove.

Small Hydropower Generation: The small hydro programme in India is aimed at the development of micro, mini, and small hydro schemes of up to a 3MW capacity for power generation and other applications (MNES 1996). Interest in this sector arose when the Central Electricity Authority (CEA) estimated a potential of about 5,000MW for projects of up to a 5MW in capacity in India in the mid-seventies. CEA has now compiled information on over 1,600 sites with a potential of 7,000MW of up to 15MW unit capacity. Currently, rough estimates of MNES place the potential at 10,000MW.

In order to provide a sharper focus to this renewable source of energy, the responsibility of small hydro development of up to 3MW in capacity was transferred in February 1989 from the Department of Power to MNES. Since then, several new initiatives, such as financial assistance for surveys and investigation, detailed project report (DPR) preparation, and interest subsidy schemes on commercial projects, have been announced by MNES to promote small hydro development in India.

Another significant development in the sector has been the UNDP-GEF sponsored project to prepare a master plan for development of small hydropower in the hilly regions, which has been launched with funding of US$ 7.5 million. Under this project, it is planned to set up 20 commercially viable small hydel demonstration projects, upgrade 100 water mills, train personnel, and involve NGOs and local people in promoting the use of electricity for cooking and other purposes. Apart from the UNDP-GEF projects, the main source of funds for small hydel development is the US$ 70 million made available to IREDA through a World Bank loan to set up irrigation canal/dam-based small hydro projects of up to 15MW in capacity.

Solar Photovoltaic Programme: The SPV programme was initiated in 1975 by the Department of Science and Technology. Central Electronics Limited (CEL) was made responsible for product development, while research on solar cells and the development of photovoltaic materials were entrusted to R&D laboratories and academic institutions.

Today, the SPV programme includes a variety of systems for rural, remote area, and industrial applications. Some examples are self-contained village home lighting and street lighting; solar lanterns; water pumping for drinking and irrigation; telecommunications; and the powering of refrigerators for vaccine storage in rural health centres. Of the PV installations, roughly 30 per cent have been on a commercial, non-subsidised basis for telecommunications, signalling, defence, and similar applications (Mathur 1997). Applications in the rural areas have largely been on a demonstration basis. The main problem with the rural applications has been poor reliability, which is often not due to failure of SPV devices, but a result of substandard system components and poor system design.

Solar Thermal Technologies: The Solar Thermal Energy Programme (STEP) was launched in 1984 to promote the use of solar energy for direct thermal applications such as water heating, space heating/cooling, drying, desalination, cooking, water pumping, and power generation.

Water heating: Solar water heating through flat plate collectors has been a popular programme. This programme, which was based on subsidies and demonstration programmes earlier, was restructured in 1993, with the subsidies being replaced by fiscal incentives offered to manufacturers and soft loans to users. As of now, the market for solar water heaters seems to be restricted to commercial users, such as hostels, hospitals, food-processing industries, and dairies. In the rural areas, almost all the installations have been on a demonstration basis for institutions like hostels, schools, government buildings, and health centres.

Solar cooking: The solar cooker programme was launched in 1982-83 with a central subsidy of IRs 150 and IRs 15 as a service charge for each cooker. The subsidy was withdrawn in 1994; however, MNES still provides grants for publicity, promotion, and demonstration to the state nodal agencies. Currently there are around

60 manufacturers of solar cookers in the country. In its present form, the solar cooker is an inconvenient device marred by inflexibility in product features. The key issue in commercialisation is to develop a more user-friendly and convenient device.

Wind Energy Programme: The wind energy programme is aimed at catalysing the commercialisation of wind power generation on a large scale in the country. A wind resource assessment exercise undertaken by MNES, covering 25 states and union territories, has identified a potential of about 20,000MW. The initial efforts in setting up large wind farms in the late 80s were supported by multilateral agencies, particularly DANIDA. Following the initial experience, the demonstration of large wind farms and the offering of attractive incentives by the government, the wind power sector has grown rapidly in India.

Biomass Gasifiers: The gasifier programme in India was launched in 1986 by MNES with a 3.7kW gasifier based on wood gasification, of which over a thousand systems have been installed to date. An evaluation report (Ramana and Sinha 1995) covering approximately 20 per cent of the gasifiers installed by 14 nodal agencies in India found that a little under 45 per cent of the systems were in use, with just 14 per cent being used in the dual-fuel mode. Over 25 per cent of the gasifiers were either used intermittently (about 7 per cent) or not used at all, the gasifier being a probable means of obtaining, by trade-in, a diesel pump set at a cost lower than the market cost (18%). Nearly 57 per cent were never used after commissioning, while a little under five per cent of them were never commissioned, even though the gasifier had been delivered to the site for installation. Even for the gasifiers working, the field level performances are not very well documented.

3.4 Review of Sectoral Policies with Energy Implications

India has pursued a planned approach to development, with the state playing a vital role in the key sectors, such as banking, basic industries, utilities, and infrastructure. Traditionally, the role of the private sector has been strictly regulated. A departure from this approach was the reform package introduced in 1991 which focused on the investment regime, trade policies, the financial sector, taxation, and public enterprises. The main objectives of this package were to reduce the capital intensity of India's growth process, lessen its reliance on the unsustainable expansion of the public sector, and achieve high and sustainable growth of output and employment.

3.4.1 Energy Planning in India

The first initiative in energy policy in India was the promulgation of the Electricity Supply Act, 1948, during the first five-year plan. It stipulated that power generation should be carefully regulated and sold at economic rates. This period also saw a rapid expansion of large hydropower facilities. The second five-year plan emphasised the development of the capital goods and infrastructural industries through direct government investment, which meant a rapid increase in demand for energy, all these industries being energy-intensive. As a result, the primary emphasis of the third five-year plan was power generation. The next two plans concentrated on building up self-reliance in the energy sector, mainly through antagonisation of equipment for power generation.

The potential of renewable energy technologies was articulated for the first time in the sixth five-year plan. In the sixth plan, the main elements of the energy strategy were the accelerated exploitation of domestic conventional energy resources, effective management of oil demand, energy conservation, exploitation of renewable sources of energy (e.g. forestry and biogas), and increasing investment outlays for R&D in emerging energy technologies.

In the seventh five-year plan, a major policy initiative was to increase the use of coal in households and of electricity in the mass transport sector so as to reduce dependence on oil. The plan stressed the development and accelerated use of renewables in both rural and urban areas.

The eighth plan put emphasis on close cooperation and coordination between the different ministries and departments within the energy sector. It envisaged an integrated approach to solve energy problems, especially those being faced by the rural population. As in previous plans, the emphasis was on indigenous efforts and self-reliance in the energy sector (PC 1992).

In both the eighth and the ninth plans, energy conservation has been identified as a major thrust area in the energy sector. In addition, the following have been identified as other important areas for the ninth plan (CMIE 1996): a) speedy completion of ongoing and approved power projects; b) provision of fiscal incentives and concessions for broadening the involvement of the private sector in the hydro sector; c) autonomy for State Electricity Boards (SEBs) so that they may run in a commercially viable manner; d) steps to reduce the cost of supply, transmission, and distribution (T&D) losses; theft of power; and to improve the Plant Load Factor (PLF); e) use of decentralized energy sources for rural electrification; f) augmentation and improvement of T&D facilities and necessary renovation and modernisation of existing generating stations; and g) special emphasis on cogeneration.

3.4.2 Energy Policy

Energy prices in India are administered and, in general, do not reflect costs. Kerosene is heavily subsidised because it caters to the energy needs of lower-income households in rural and urban areas. Electricity tariffs are also lower than the supply costs, leading to inefficiencies in use, especially in the agricultural sector, and mounting losses for the SEBs. Similarly, LPG, which is actually used mainly by urban middle- and upper-class households, is heavily subsidised. Currently, efforts are being made to rationalise the energy tariff structures. Regional tariff commissions have been constituted by the central government to advise the constituent systems in this respect.

It has been said that the singlemost important constraint being faced in the commercialisation and large-scale dissemination of renewables is the prevailing prices of fossil fuels. As these have been artificially pegged at levels which are much lower than their costs, they render the economics of renewables even more unfavourable than is actually the case.

Though renewables have been identified as a priority area since the sixth plan, the funds made available for the sector do not reflect the same. In the eighth five-year plan, out of the total allocation made to the energy sector, the power sector received 69 per cent; petroleum, 21 per cent; and coal, nine per cent. In contrast to this, allocation for the renewables' sector was 0.8 per cent of the total. Unless these distortions are rectified in the future, renewables can at best be expected to play a peripheral role in the energy scenario in the country.

3.4.3 Power Policy

Power generation in India has traditionally been controlled by the government sector. Currently, several ministries are involved in the formulation of power policy, while the overall planning and coordination at the national level is carried out by the Ministry of Power. Power supply for rural electrification, including energisation of pump sets for irrigation, is the exclusive responsibility of the state electricity boards/corporations and undertakings and electricity departments in the state sector (MOP 1997).

Over the years, the demand for electricity has been increasing at a rate outstripping its availability. Electricity consumption grew at an annual compound rate of 10 per cent during the period from 1950 to 1993-94. Across the country, the SEBs have suffered huge financial losses on account of factors such as the low tariffs charged to the agricultural sector, high T&D losses, and low plant load factors of power plants.

Under the new power policy announced in 1991, the private sector can now set up coal, hydel, gas, wind, or solar projects of any capacity. The package of incentives in the policy overcomes legal, administrative, and financial restraints, and so makes private investment attractive (Box 3.2).

In the recent past, some initiatives have also been taken to create remunerative markets for power generation based on non-conventional energy. Guidelines have been sent to the states on general policies and facilities for wheeling/banking/purchase of power from such projects. It has been proposed that the states consider purchasing such power at a minimum rate of IRs 2.25/kWh (Gupta 1995), which would be escalated at a minimum rate of five per cent every year. In accordance with this, several states have come forward and announced attractive policies for private sector power projects based on non-conventional energy sources.

It is important to mention here that, whereas some of the states have taken initiatives in promoting non-conventionally based power generation, currently neither

Box 3.2: Salient Features of Policy Initiative on Private Sector Participation in Power Generation

Flexibility to SEBs - The SEBs have been provided with the flexibility to negotiate power purchase agreements through the August 1994 amendment to tariff notification, which allows for a determination of tariffs in deviation from the norms laid down in the two-part tariff notification, provided the tariff is less than the normative tariff.

Power purchase agreement (PPA) guidelines - The SEBs have been strengthened in their capability for negotiating PPAs with private promoters directly. Detailed principles for negotiating PPAs for the Indian private power projects have been issued to SEBs.

Competitive bidding for awarding projects - It was decided in January 1993 that no private sector project proposal would be considered by CEA if it is not awarded through competitive bidding.

Captive/co-generation plants - The new power policy advocates, *inter alia*, the sale of excess power to the grid according to mutually agreed rates, access to the transmission grid of the state on payment of wheeling charges, third party access to direct sale of power, etc. Co-generation plants now require the approval of the SEB and CEA only if the plant capacity is more than 25MW. It has also been decided to permit the establishment of captive power plants fully dedicated to an industry/ group of industries by an independent power company without having to go through competitive bidding.

the laws and regulations governing power generation and distribution, nor the periodic modifications effected in these laws, explicitly mention or encourage renewable energy sources. Therefore, regulatory measures must be introduced if RETs are to operate on a level playing field. There is also a need to minimise and simplify the various clearances required for the setting up of RET-based power generation facilities.

3.4.4 Industrial Policy

In recent years, the thrust of the industrial policy in India has been to remove barriers to entry and do away with limits on capacity or investment. The new industrial policy introduced in 1991 and encapsulated in the Industrial Policy Statement of July 1991 restricts only 16 industries for compulsory licensing (for social, security, strategic, or environmental reasons).

Within the Ministry of Industries, several initiatives have been taken to look at the environmental (especially pollution-related) aspects of industries. In energy conservation, the government plays a regulatory as well as a promotional role. Regulatory mechanisms include energy audits, the evaluation of new technology and equipment and the enforcement of energy efficiency norms in equipment and technologies. An interdepartmental fuel efficiency committee has worked out fuel efficiency standards for various industrial sectors, including the automobile industry.

3.4.5 Foreign Investment Policy

Several steps have been taken by the government to dismantle the system of controls and regulations, and now foreign investment is permitted in all industries except in a few reserved for strategic or defence reasons since 1991. The present policy for foreign direct investment and foreign technology transfer agreements does not lay down any restriction in regard to the level of foreign equity holdings or the sectors eligible for foreign investment. At the same time, the additional list of industries eligible for automatic approval of up to 51 per cent foreign equity covers a wide range of industries. Industries eligible for higher (74%) foreign equity include those in the infrastructural sector, non-conventional energy, and a few others. It is expected that the procedure of automatic approval by involving fewer regulations and controls will provide an impetus for foreign investment in the priority sectors.

3.4.6 Export and Import Policy

The main feature of the export and import (EXIM) policy, which has been announced for the period from 1 April 1997 to 31 March 2002, is a reduction in restrictions (MOC 1997). It has been declared that capital goods, raw materials, intermediates, components, consumables, spares, parts, accessories, instruments, and other goods will now be eligible for free importation, which means that they may be imported without any restriction, except to the extent that such imports are regulated by the Negative List of Imports. Further, to help improve infrastructural facilities in the power sector, capital goods supplied to power projects, which are carried out under the procedure of competitive bidding, have been made eligible for a refund of terminal excise duty, as also for special import licenses.

Though the industrial policies, by and large, are favourable towards technology transfer and foreign investment, these two options must be treated with caution. It has been said that an important reason for the rapid expansion of wind farm capacity in India has been the favourable import policies (Kishore 1994). Imports are allowed with concessional or no duties on either components or complete machinery. However, through the generous incentives offered, the import policies have also resulted in foreign wind machine manufacturers being subsidised to a great extent, and this creates favourable markets for them with no attendant gains for the domestic industry such as development of production facilities. It is yet to be seen whether this level of wind farm activities will be sustained if the tax and other import concessions are withdrawn.

3.4.7 Environmental Policies

The main regulatory environmental law in India is the Environmental (Protection) Act, 1986. Other laws, such as the Air (Prevention and Control of Pollution) Act, 1981, and Water (Prevention and Control of Pollution) Act, 1974, are more specific in nature and coverage. Among the other natural resources' protection acts are the Forest (Conservation) Act, 1980, and the Wildlife (Protection) Act, 1972, extended to cover biosphere resources, and the Hazardous Wastes (Management and Handling Rules), 1989. The Central Pollution Control Board and the state boards handle the regulatory functions under the air, water, and environment acts. Ambient standards have been set for air, water, noise, industrial emissions, and effluents, and rules have been designed for managing hazardous wastes. There is a mandatory clearance required on environmental aspects of all projects valued over IRs 500 million. A comprehensive project-specific EIA (Environmental Impact Assessment) report based on four-season measurements (one year) is required to be submitted to a committee (the Impact Assessment Agency), formed by the Ministry of Environment and Forests (MoEF), for environmental clearance.

3.4.8 Forestry Policies

The forestry themes for the sixth (1980-85) and the seventh (1985-90) five-year plans were 'development without destruction' and 'forests for survival' respectively. Since 1985, social forestry efforts were supplemented with wastelands' development works under the National Wastelands' Development Board. The new Forest Policy of 1988 places emphasis on meeting the needs of the local communities and on safeguarding their traditional rights and concessions subject to the carrying capacity of the forests. Under this policy, the domestic requirements of fuelwood, fodder, non-timber forest produce, and construction timber required by the tribals and the rural poor are to be regarded as the first charge on forests. It also emphasises creating a massive people's movement and involving them in the conservation and management of forests. Subsequently, another circular was brought out by the MoEF in June 1990, supporting the involvement of village communities and NGOs in the regeneration, management, and protection of degraded forests.

The real issue in forestry laws and legislation in India does not seem to be one of shortages of fuelwood or fodder, but rather one of control, access, and use of forests. Though the acts vest the power of regulation and management in the state, the most degraded forests are under extreme biotic pressure, and often the rights of the people to use such lands are established.

3.4.9 Social Policies

The eighth five-year plan emphasised human development as the core of all developmental efforts. It emphasised involving people in the process of development by empowering them with adequate financial resources, technical and managerial inputs, and decision-making authority. The *Panchayati Raj* institutions have been revitalised through such recent legislation as the 73rd Constitutional Amendment Bill. State governments have also enacted enabling legislation providing for elected bodies at the village, intermediate, and district levels, with adequate representation for weaker sections and women.

The focus on decentralization and the creation of local institutions, which is clearly a focus of the current social polices, is a good opportunity for the energy sector today. It is now being realised that, in the rural energy programmes, the lack of people's participation (especially among women) in project planning, implementation, and monitoring is an important reason for lacklustre performance. The local institutions created under the *Panchayati Raj* Act provide an opportunity and mechanism for involving local communities in the planning and execution of rural and renewable energy programmes.

It is clear that the success of renewables in India will depend not just on policies in the renewables' sector, but also policies in other sectors. It will also depend on the political commitment as well as the finances made available to the sector. Within the energy sector, it is important to create a level playing field between renewable and other sources of energy. In recent years, some initiatives in this direction have been taken in terms of efforts towards rationalisation of energy prices and creation of a conducive atmosphere for power generation based on non-conventional energy. However, the impact of these on renewables is yet to be seen.

3.5 Energy Systems in the Indian Himalayas

The Indian Himalayas cover an area of 542,700sq.km., spanning 11 states in the northern and north-eastern parts of the country. A population of over 31 million inhabits this area, corresponding to an average population density of 57/km^2. This population density is very low compared to the adjoining plains. Arunachal Pradesh is the most thinly populated region, with a population density of 10/km^2. Another important aspect relating to the composition of these populations is that almost all of them, especially in the north-east, have large tribal segments.

More than 82 per cent of the population of the Indian Himalayas lives in villages with a low level of social and physical infrastructure, including communications. This has direct implications for the energy sector, it being both difficult and expensive to supply commercial fuels to these areas, so that people are forced to rely more on biomass-based fuels. The primary occupation of the people is agriculture, with almost 80 per cent of the work force engaged in this activity. Agriculture in hilly areas is largely rainfed and at a subsistence level. As there are very few industries in these areas, migration rates are high.

3.5.1 The Power Situation

The geographical inaccessibility of the region is the main constraint in supplying conventional fuels to it. More than two thirds of the total hydropower potential (84,000MW) exists in the Himalayan region, a considerable part in the north-east (32,000MW). However, in 1990, hydropower generation in the region was just 0.6 per cent of the estimated annual potential. The potential developed in the north-eastern states to date is only 253MW - 0.8 per cent of the total available potential (Singh and Ramana 1997). Currently, a major portion of electricity generation is through thermal power, followed by hydroelectric and diesel-based projects, as reported in Table 3.2.

Table 3.2: Installed Power Generation Capacity from Different Sources in HKH states (MW)

State	Gas	Steam	Diesel	Hydel	Total
Arunachal Pradesh	-	-	15.8	23.5	39.4
Assam	244.5	330	20.7	2	577.2
Himachal Pradesh	-	-	.1	272.1	272.2
Jammu and Kashmir	150	-	6.8	180.3	337.1
Manipur	-	-	9.4	2.6	12
Meghalaya	-	5	2.1	186.7	193.8
Mizoram	-	-	21.1	3.4	24.4
Nagaland	-	-	3.6	3.2	6.8
Sikkim	-	-	2.7	30.9	33.6
Uttar Pradesh	-	4,064	6.2	1,504.5	5,574.7
West Bengal	100	3,356.4	22.4	46.5	3,525.2

Source: TERI 1996a

Partly responsible for this gross underutilisation is the fact that the construction and maintenance of long transmission lines in hilly terrain requires large investments and long gestation periods. The inaccessibility and difficult terrain are also responsible for the high T&D losses resulting in the very high costs of power supply. A look at the average tariffs charged in these states shows that electricity is heavily subsidised by the government (Table 3.3).

3.5.2 Rural Electrification

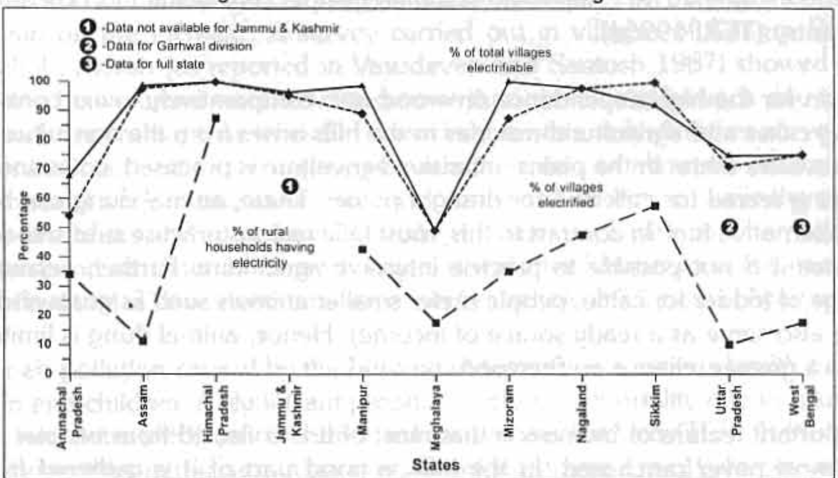
Most of the remote hilly villages in the region have not been electrified so far. Only the more accessible villages have been connected with grid electricity, which is of poor quality with high voltage fluctuations and long hours (and days) with no supplies at all. In other villages, electricity is supplied by diesel generators for lighting purposes. The following figure shows electrified villages as a percentage of the total number of villages as well as a percentage of 'electrifiable' villages. Thus, it can be seen that 50 per cent of the villages in Meghalaya have been electrified, while and the rest are not electrifiable through grid electricity. Figure 3.1 also shows the percentage of rural households with access to electricity.

Table 3.3: Status of Power Generation

State	Unit Cost of Power Supply (in IRs/kWh) (1994-95)	Average Consumer Tariff (in Irs/kWh) (1994-95)	T&D Losses (including unaccounted commer. losses) (%)
Arunachal Pradesh	-	-	42.0
Assam	2.84	1.59	22.4
Himachal Pradesh	1.11	1.09	18.8
Jammu and Kashmir	2.09	3.30	46.4
Manipur	-	-	23.9
Meghalaya	1.67	0.99	17.9
Mizoram	-	-	31.9
Nagaland	-	-	33.5
Sikkim	-	-	22.6
Uttar Pradesh	1.82	1.23	24.4
West Bengal	1.88	1.46	16.0

Source: TERI 1996d

Figure: 3.1 Rural Electrification of HKH Region



Source: TERI 1996d, CMIE 1996

Figure 3.1 Rural Electrification of HKH Region

3.5.3 Domestic Energy Use Patterns

There have been no large-scale energy surveys in the HKH Region. According to NCAER 1981 (a survey on rural energy consumption in the northern states), the annual per capita energy consumed in the hill region was reported to be 251KgCR as compared to 199kgCR for rural northern India. The corresponding per capita figure indicated in NCAER 1985 was 257KgCR for hill areas and 206 for all India (Painuly 1987).

The high dependence on biomass is shown by the census data collected in 1991 (see Tab. 3.4). The table shows that in all Himalayan states, among all fuels, wood

Table 3.4: Distribution of Households by Type of Fuel Used for Cooking (1991 in per cent)

State	Cow dung	Electri-city	Coal/ Coke	Char coal	LPB	Wood	Biogas	Kero-sene	Others
Arunachal Pradesh	0.07	0.22	0.04	0.08	4.40	87.78	0.08	6.35	0.65
Assam	1.45	0.19	0.30	0.47	4.46	87.96	0.09	2.65	2.40
Himachal Pradesh	26.36	0.14	0.44	0.82	12.91	52.10	0.35	5.82	1.00
Manipur	0.28	0.18	0.08	0.44	6.66	85.50	0.39	3.26	3.16
Meghalaya	0.11	0.80	0.26	2.31	3.54	85.35	0.13	6.78	0.58
Mizoram	0.03	0.22	0.02	0.18	8.75	74.83	0.06	14.38	1.50
Nagaland	0.18	0.07	0.06	0.03	2.67	93.11	0.08	3.16	0.64
Sikkim	0.02	0.40	0.34	0.26	2.63	74.47	0.23	21.24	0.42
India (excl. J&K)	15.39	0.31	3.47	0.77	7.94	61.50	0.49	7.16	2.91

Source: CMIE 1996

is the most commonly used. The penetration of commercial fuels, such as electricity, coal, and cooking gas, has been insignificant. Data on the number of LPG domestic users show that the HKH states had less than five per cent of the LPG consumers in the country (TERI 1996d).

A reason for the high dependence on wood and comparatively lower contribution of dung cakes and agricultural residues in the hills arises from the agricultural practises prevalent there. In the plains, intensive agriculture is practised, cows and buffaloes being reared for milk and for draught power. There, animal dung can be used as an alternative fuel. In contrast to this, most hilly regions practise subsistence farming, since it is not possible to practise intensive agriculture. Further, because of a shortage of fodder for cattle, people prefer smaller animals such as goats and sheep (which also serve as a ready source of income). Hence, animal dung is limited and there is a greater reliance on firewood.

An important feature of biomass is that most of it is collected from various sources and almost never purchased. In the hills, a good part of it is gathered from the forests. The NCAER survey (NCAER 1985) showed thatm in rural Meghalaya, almost 70 per cent of the wood used as fuel was being collected from the forests. Because of the cold climate, an important end use of domestic energy is space heating. NCEAR 1985 showed that 92.8 per cent of the households in Himachal Pradesh, 66.7 per cent in Jammu and Kashmir, and 93.9 per cent in Meghalaya were using energy for space heating. At the national level, the percentage of families that use energy for this end use is only 26.8 per cent.

The key features of the energy use pattern in the HKH Region can be summarised thus.

- Energy consumption is dominated by biomass fuels, mainly wood.
- Dependence on biomass resources for fuel is governed by availability (distance from forest).

- Cooking and space heating are the primary end uses of energy.
- Biomass fuels are not usually purchased. They are collected and, for this reason, the cost is in terms of the labour expended to collect it.
- Energy needs are often not the 'felt' needs; there are always more serious and impending one's needing attention.
- Energy systems are closely associated with environmental issues.

3.5.4 Social and Environmental Implications of Energy Use

It is important to note that the heavy reliance on wood has several social and environmental implications. The most serious is probably the impact on women's lives. Women have traditionally shouldered the responsibility for procuring fuelwood for their homes. In the hills, they also participate actively in agricultural operations. In areas where the men migrate seasonally to the plains for employment, the women are left in charge of such operations as well as their home responsibilities, including the collection of fuel and fodder. With forests becoming scarce, the burden on women has been on the increase. A survey carried out in villages of Kangra District in Himachal Pradesh (as reported in Vasudevan and Santosh 1987) showed that 70 per cent of the women were travelling more than six kilometres each day to collect fuelwood, expending four to eight hours daily on this task. Another survey in five villages in Solan and four villages in Shimla indicate that about 60 per cent of the women spent three to four hours per day in fuelwood collection, while the rest spent one to two hours each day. In the Himalayan village of Dwing in Chamoli District, women spend six to ten hours each day and walk five kilometres uphill each day to collect firewood. The average time spent per household is 7.2 hours (Agarwal 1991).

Indoor air pollution caused by the burning of biomass is a serious health hazard for women and children. A significant proportion of infant mortality due to acute respiratory infections (ARI) can be attributed to biomass burning (TERI 1996d). It has been shown that, in the case of traditional cooking stoves, only 10-15 per cent of the heat is used for actual cooking, while the remainder is dissipated in the kitchen in the form of heat and smoke. This problem becomes particularly severe in times of scarcity when households may be forced to switch to inferior and more smoky fuels.

3.6 The RET Experience in the Indian Himalayas

With features such as difficult terrain, inaccessibility, poor infrastructure, the low income levels of the resident population (CMIE 1993), and a large renewable natural resource base (solar, wind, hydro, and biomass resources), the hills provide an ideal niche for the deployment of renewable energy technologies. This has been well recognised by planners, and new and renewable sources of energy (NRSE) in the hilly regions of India have been promoted for the last ten years or so. However, the rate of dissemination in the hill states has been considerably slower than in the rest of the country. Though the figures shown in Table 3.5 appear impressive in

Table 3.5: Installation of Renewable Energy Technologies in the Indian Himalayas

Description	Unit	All India	North-East	H.P.	J. & K.	Sikkim	Total
Family-size biogas Plants	No.	2,367,798	204,293	37,871	1,297	1,606	245,067
Improved cooking stoves	No.	19,611,272	118,556	528,527	256,796	35,965	939,844
Solar thermal systems							
- Domestic type	No.	12,517	18	819	33	21	891
- Industrial type	No.	6,142	151	143	72	26	392
Solar cookers	No.	288,028	1,002	13,349		20	15,373
PV water pumps	No.	463			4		4
PV plants	kWp	N.A.	39				39
PV systems	kWp	3,605	273	39	48	12	372
Windpower	kW	732,600					0
Small and micro-	No.	161	50	13	6	6	75
Hydropower	MW	120	33	9	3	7	52
Biomass gasifiers/ Stirling engines	No.	1,604	10	2	4		16

Note: The north-east region includes Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, and Assam; information on Uttarakhand, the Hill Districts of West Bengal and Assam are not included, since only state-level information is available and only a small percentage of the area falls under the HKH region; information on biogas and wind power is as of March 1996; information on improved cooking stoves, PV water pumps, mini- and micro-hydropower and biomass gasifiers is as of April 1995; information on solar thermal systems, solar cookers, and PV systems is as of March 1993.

Source: TERI 1996d; MNES 1996; CMIE 1996

themselves, it can be seen that they form a very small proportion of the total sum in India. The proportion would be even smaller if the devices which are actually being used are considered.

3.6.1 Small Hydropower Projects

There are a large number of rivers, rivulets, and streams existing naturally in the hills which represent an immense energy potential. Current estimates show that close to 10,000MW of energy can be generated for the country from this source. Out of the 84,044MW of potential already identified, the Indian Himalayas accounts for 76 per cent (63,705MW). Among the hill states, the maximum potential for exploiting small-scale hydropower is in Arunachal Pradesh, followed by Himachal Pradesh and Uttar Pradesh. Interestingly, Himachal Pradesh and Uttar Pradesh are also the states that have the highest proportion of electrification among the hill states.

While hill streams have been harnessed for generating electrical power only since the late nineteenth century in India, use of this technology for mechanical power applications has been prevalent for hundreds of years. In hill villages, traditional water mills are used extensively for agro-processing and cottage industry applications. Though the exact number of such water mills is not known, it is estimated that there may be around 200,000 sites in operation today (Kumar 1997).

There are a number of agencies looking after the small hydro sector in the Himalayan states. Though there is no uniformity in the institutional set-up across states, agencies like the Power Department, state electricity boards, and state-level nodal agencies for development of renewables are involved in all the states. The following table lists the various agencies involved in the mini-micro hydel sector and their responsibilities in the HKH states. In some states, a few NGOs are also playing an active role in this sector.

Some evaluations have been carried out by different agencies to assess the performance of existing small hydro systems. Many of these schemes are still under construction, and hence their performance has yet to be seen. An evaluation of RETs installed under the North-eastern Council (NEC) plan in the North-eastern States (TERI 1996b) showed that several systems which were sanctioned in 1989-90 have still not been completed. The time and cost overruns have been mainly due to financial constraints and inadequate management (TERI 1994a). In the case of non-operational plants, the primary reasons for their shutdown are damage caused by floods during monsoon and damage in components which have never been repaired. Another study which reviewed and documented the status of Mini- Micro-hydropower (MMHP) in India (TERI 1994a) showed that most of the functional plants are operating at sub-optimal capacity (Box 3.3).

Box 3.3: Poor Performance of MMHP in India

Low load factors - As the village-based systems are being used for domestic applications, mainly lighting, the peak load timings are very short. In the absence of industries using this energy, most units remain underloaded for a large part of the day. When the load is below the power generation capacity of the power plant, the power generated is itself reduced by reducing the throughput to the power plant, which means a highly sub-optimal use of energy.

Technical constraints and operational problems - MMHP installations have been facing a number of technical and operational problems, such as:

- silting during the monsoon season, which damages the turbine;
- damage to civil works caused by floods, which occur almost every year; and
- absence of workshop facilities, which makes it time-consuming and expensive to transport the defective components to a workshop for repair.

People's involvement - In most MMHP installations, efforts are not made to involve the users or the local people in the planning, execution, operation, and maintenance of the systems. As a result, when these systems develop some snag or failure, users simply revert to the traditional systems and do not bother to inform the implementing agency about the problem.

Source: TERI 1994a

3.6.2 Improved Cooking stoves

The performance of cooking stoves has been evaluated by several agencies in terms of fuelwood conservation, the reduction or removal of smoke from kitchens, reduction in cooking time, and employment generation. A study conducted by TERI in the Garhwal Hills of Uttar Pradesh (TERI 1992) revealed that 54 per cent of the beneficiaries were using the improved cooking stoves for cooking all their meals, while another 17 per cent used them only during winter, and 17 per cent did not use them at all. The main problems faced by the users were: a) difficulty in cooking preparations such as tea and rotis; b) smallness of the firebox door, which required additional effort in terms of chopping the wood into small pieces; c) frequent choking of the smoke passage; and d) strong winds restricting the smoke exit and resulting in flame coming out of the mouth of the stove.

A more recent study (TERI 1994b) showed that: a) people find it inconvenient to chop wood into small pieces for the improved cooking stoves; and b) users modify the cooking stove according to their requirements (often decreasing the efficiency of the improved models in the process). Another recent study carried out in the North-eastern states by TERI (TERI 1996b) showed that the overall acceptance of the improved, fixed mud cooking stoves has been low. The primary reason for this is the incompatibility between the traditional cooking practises of the people and the features of the models introduced under the NPIC. In the hilly parts of the North-eastern states, the traditional cooking stove performs the multiple functions of cooking, space heating, smoking and drying of food articles and, at times, lighting. The commonly promoted fixed, smokeless models have not been able to address these requirements, and hence have had a limited acceptability. The other significant reason in the area is that, even though the overall biomass resource base is deteriorating rapidly, wood is still abundantly available in most of the North-eastern states. As a result, people do not really feel the need to conserve fuelwood (Singh and Ramana 1997).

3.6.3 Biogas Plants

Micro-level studies and evaluations indicate that in spite of the higher level of subsidies offered in the hills, biogas plants there have not performed satisfactorily. In the North-east, biogas plants have been installed mainly for institutions, not for individuals. Consequently, the 'real' response to the technology is difficult to gauge. An evaluation revealed that in the seven states, 24 per cent of the surveyed plants were found to be in use (TERI 1996b). The main reasons for their not functioning were shortage of dung and lack of maintenance for the installed plants. Further, most plants in the region were installed in the eighties and are of the floating dome- KVIC model type. These have a metal gas holder, which requires regular painting to prevent corrosion. Most KVIC plants were found to be corroded and lying in a state of disrepair at the time of the survey. Out of the 83 KVIC plants surveyed, only 11 were in use.

3.6.4 Solar PV Technology

There are some climatic constraints in promoting solar PV technology in hilly areas. These include the high number of cloudy days and shading caused by surrounding hills. TERI 1996c revealed that nearly 50 per cent of the village-based systems in the North-eastern states are currently non-functional. The main problem with PV systems is that the users are not accountable for the maintenance of the systems, which are heavily subsidised. Users display an indifferent attitude, especially in the case of devices installed for community use, such as street lighting systems, and problems of vandalism and thefts are common. The difficult terrain and poor infrastructure also result in unavailability of spare components, component failure, and lack of trained technicians for the large-scale dissemination of these devices. Notwithstanding the importance of these handicaps, the biggest obstacle to programme dissemination is a lack of training in system maintenance for users. Other common operational problems are batteries discharging, tube lights becoming non-functional, and difficulty in procuring distilled water.

3.6.5 Solar Thermal Systems

The overall performance of solar thermal devices in the hill regions has been mixed. TERI 1996c revealed that, apart from Arunachal Pradesh, the functional performances of the systems installed under the NEC schemes have been less than 50 per cent. The main operational problems faced in the operation of SWHs in the hilly regions are damage caused by rains, hailstorms, and floods; breakage of glass panels; rust formation; degradation of insulation material over time; and pipeline leakages.

3.6.6 Biomass Gasifiers

Biomass gasifiers for electrical applications have not been successful in the hilly regions. In the north-eastern states, wood-based gasifiers have been promoted as demonstration units by the lumber industry and by a few silk reeling units. There are two main reasons for the poor performance of these systems (Singh and Ramana 1997). Firstly, as the gasifiers require wood chopped in small pieces, their operation calls for extra manpower, which increases the cost of operation. Further, as electricity is heavily subsidised (the tariff for the industry is between IRs 2.5 - 3 per unit), the cost of generating electricity with a gasifier works out to more than purchasing it from the SEB. Gasifier-generated power costs roughly IRs 2.37 per unit, without taking into account the cost of investment. Thus, in the present scenario of subsidised tariffs for electricity, gasifiers for power generation remain an unviable option for small industries. Though there have been too few attempts from which to generalise, gasifiers, when used for thermal applications, have worked well.

3.7 The Institutional Framework and a Policy Review of RETs in the Indian Himalayas

3.7.1 The Institutional Framework for the Implementation of RET Programmes

The apex body responsible for the dissemination of RETs in India is the MNES. In the nineties, in line with the rising expectations from renewables, several institutional changes were effected in the institutional framework for the implementation of RET programmes. The most significant among these was the restructuring of the MNES. In July 1993, the MNES was restructured on the basis of the end use of technologies and is now organized into the following groups: a) Rural Energy I, which covers biogas, improved cooking stoves, and biomass programmes; b) Rural Energy II, which is responsible for lighting and water pumping end uses, rural applications for solar thermal technology, and human and animal energy; c) Urban and Industrial Energy, which pertains to domestic energy and process heating; passive architecture; urban, municipal, and industrial wastes; and energy conservation; d) Power, which is responsible for power generation through wind, small hydro, bio-energy, co-generation, and grid-connected solar applications; and e) New Technologies, covering geo-thermal energy, alternative vehicle fuels, ocean energy, and the tidal energy programme. The main advantage of this restructuring was that now each sector consists of integrated programmes to meet the different energy needs.

The main financing agency for renewables in India is the Indian Renewable Energy Development Agency (IREDA) - a separate financial institution set up in 1987 by the MNES to play a key role in implementing renewable energy programmes by offering loans on soft terms to users and manufacturers of the different RETs. A few of the state governments and state electricity boards have also adopted guidelines and policies aimed at promoting renewable energy projects in their states. In addition to funding from the government, IREDA has been successful in getting funds from multilateral and bilateral donor agencies.

Nationalised banks also provide loans directly to users for some RETs. In rural areas, financing biogas plants through banks is quite an established practise. Each state has a designated lead bank which coordinates loan facilities within the state. At the central level, the National Bank for Agriculture and Rural Development (NABARD) is responsible for overall coordination.

The RET programmes in each state are implemented by a number of government and non-government agencies. Typically, NPBD is looked after by the agricultural department or the state agro-industries corporation, 'NPIC by the Rural Development or *Panchayati Raj* department; solar, thermal, and SPV programmes by the state energy development agency', and small hydro by the power department or the state electricity board. In most states, these government departments are also looking after many other programmes and projects. For example, the rural development department in most states is responsible for all activities pertaining to rural development such as health and sanitation, rural roads, minor and medium irrigation, and soil and water conservation.

3.7.2 Review of RET Policies in the HKH Region

For all the RETs, special provisions in the form of additional incentives and subsidies have been designed for the hill states, in view of the inaccessibility and remoteness of these areas as well as the low purchasing power of the people inhabiting them. In this section, these policies have been reviewed and analysed for each of the RETs.

Small Hydropower: For small hydropower generation, the MNES provides subsidies and IREDA provides soft loans for construction of small hydro projects. Under its capital subsidy scheme, the ministry has so far supported 90 projects aggregating to a capacity of around 104MW in 17 states (Garg 1997). Under the subsidy scheme, the MNES provides a maximum capitalised interest subsidy of IRs 11.2 million perMW for SHP projects of up to 3MW capacity in the hills. For projects of up to 100kW in capacity, a capital subsidy of up to IRs 15,000 per kW is also given. Currently, the ministry also provides 100 per cent support for detailed survey and investigation and 50 per cent support for detailed project report preparation, subject to certain benchmarks. Several state governments have also allocated funds for small hydropower development.

A scheme for decentralized power supply through lightweight portable micro-hydel sets of up to 15kW in capacity was introduced in the eighth plan. Fifty demonstration sets have been distributed to seven states for installation and evaluation. The ministry has met the costs of the sets, while local bodies are supposed to incur the expenditure for civil works and transmission links. Up to September 1996, 15 sets had been installed in West Bengal (WB), Uttar Pradesh (UP), Jammu and Kashmir (J&K), and Himachal Pradesh.

The ministry has been encouraging state governments to develop and announce incentive packages to attract private sector participation in the implementation, operation, and maintenance of small hydro schemes. As of now, amongst the Himalayan states, such initiatives have been taken only by UP and Himachal Pradesh. The key features of these incentive packages (which mainly provide for the wheeling and banking of power generated, a floor level buy-back rate for generated electricity, and third party sales of the generated electricity) are shown in Table 3.6.

In spite of these efforts by the states to promote small-scale hydropower through special provisions to attract the private sector, the level of development has not met expectations, either in terms of the scale of intervention or the performance of installed devices. Only Uttar Pradesh and Himachal Pradesh have framed policies to attract private sector participation. Even in Himachal Pradesh (HP), the entrepreneurs who have applied for developing small hydropower plants are from outside

Table 3.6: Incentives Offered by State Governments to the Private Sector for Small Hydropower Generation

Items	Uttar Pradesh	Himachal Pradesh
Rates/Charges for:		
Wheeling	2 per cent of energy generated 2.5 per cent for sale to third party	2 per cent of energy generated
Banking	Allowed for one year	Allowed with additional charges
Buy back by SEB	IRs. 2.25/kWh	IRs. 2.25/kWh
Third party sale	Allowed	Allowed
Incentives:		
Concessions	-	No sales tax on power generation and transmission equipment and building material. Income tax exemption for 5 years and 30 per cent exemption for 5 years thereafter.
Royalty on water	10 per cent of electricity generated	No royalty up to 1MW capacity for the first five years and 10 per cent thereafter; 10 per cent royalty on installed capacity from 1MW to 3MW.
Single window agency	Non-conventional Energy Development Agency (< 3MW); UP Laghu Jal Vidyut Nigam (>3MW)	HP state electricity board/HIM-URJA

Source: Compiled from MNES 1996 and TERI 1996a

the state (TERI 1996a). The incentives and facilities offered by the state governments are usually not clear, nor is there any transparency. As a result of this, private investors are not fully convinced of suitable returns from the venture. Also, only UP and J&K have created a separate agency for the installation of small- mini- micro-hydropower projects.

Improved Cooking Stoves: The MNES provides certain additional incentives for the adoption of improved cooking stoves in the hills, compared to the plains. All beneficiaries are eligible to receive 50 per cent of the cost of a portable *chulha* (in the plains this level of subsidy is offered only to the Scheduled Caste and Scheduled Tribe categories). In addition, high altitude metallic *chulha*(s) are also promoted in the hills; and for these 50 per cent of the cost is subsidised.

There is a number of implementation- and programme-related factors responsible for the limited acceptance of improved cooking stoves in the hills. Some of the important issues are a) incompatibility of stove design with traditional lifestyles and cooking practices; b) inadequate R&D on suitable models; and c) unsuitable mode of programme dissemination.

Biogas Plants: The central government subsidy given to beneficiaries in the hills is almost double the amount given in the plains (for a $2m^3$ plant, IRs 3,200 compared to IRs 1,800 in the plains). Most of the hill state governments also give additional subsidies for biogas plant installation. A state like Arunachal Pradesh (AP) provides a 90 per cent subsidy on biogas plants, while Manipur gives IRs 1,500 per biogas plant in addition to the central subsidy.

There are some basic problems with respect to the operation of biogas plants in the hills.

Dung Availability - As the cattle are left to graze in the open, the availability of dung for the biogas plants is poor.

Water Shortage - A 2m^3 capacity biogas plant requires 50 litres of water every day. Water is, however, fast becoming a scarce commodity in most hill areas (CSE 1997). As a result, the women are forced to spend more time and effort fetching water. A village-level study showed that 57 per cent of the women in Almora spend more than three hours daily fetching water for their homes (Vasudevan and Santosh 1987). Thus water scarcity is a serious issue in the adoption and success of the technology.

Ambient Temperature - The existing biogas plant models function optimally at an ambient temperature of around 35°C. At low temperatures, bacterial activity slows down, resulting in a substantial decrease in gas generation, and stops completely below 10°C. As the ambient temperature in winter falls to significantly low levels in the hills, gas output goes down.

The main policy issue in the case of biogas plants for the hilly regions is that of suitability of existing designs and models for the specific climatic conditions of the hills. The first major initiative in developing models suited for the hills was the development and inclusion of the Swastik model biogas plant in the MNES's approved list for the NPBD.

Solar PV Technology - As with other renewables, the state provides subsidies for PV devices. Arunachal Pradesh (AP), for instance, gives free solar lanterns to small villages (less than 50 households). All beneficiaries in the hilly areas also get a subsidy of 50 per cent of the cost of all systems under the socially oriented schemes of the MNES (MNES 1996). At present, a solar lantern programme is also being supported by GEF, which is executed by IREDA.

The primary issue in the promotion of solar PV devices in India is the cost factor. Power generation through PV is an expensive proposition. At the present rates, a PV system for electricity generation costs about IRs 400/Wp, or IRs 400 million per MW, which is roughly 10 times the investment cost for a thermal power plant (Kishore 1997). The energy costs are in the range of IRs 25-30/kWh. A comparison of the cost of Indian PV modules with the international prices shows that it is unlikely that PV electricity will become cheaper in the near future in India.

It has been said that SPV electricity makes economic sense for very remote villages where the cost of extending the grid to the location is higher than that of installing an SPV system. But this is true only of very small loads. In reality, once SPV lighting is provided to a village, the demand for other amenities, such as fans and heaters, is likely to increase. The SPV system is unlikely to be able to meet the increased demand, and the grid may after all have to be extended, thus defeating the purpose of the SPV system.

Solar Thermal Systems: Solar thermal devices have been promoted primarily as demonstration programmes or at such institutions as government hospitals and primary health centres. Community solar water heaters (SWHs), like other community use devices, face the problem of indifference on the part of users, including lack of regular maintenance. Some states, such as Assam, are now developing management systems whereby the users will be required to pay a monthly service charge to be used for repair and maintenance of the systems.

3.7.3 Learning from RET Experiences

The experience of RETs in the hill states shows that there are several lacunae in the existing set-up which hinder their performance. These are related to areas like policy and planning, implementation procedures, and the institutional framework. There are technology-specific barriers as well as ones common to all programmes and technologies. The basic constraints on the diffusion of technologies in hill regions are related to geographical and physical infrastructure. The low levels of income and awareness among the population hinder the adoption of technologies and necessitate subsidising their cost, at least for the majority of the target group. Additionally, the difficult terrain and working conditions, along with the poor physical infrastructure, make it extremely difficult to put in place repair and maintenance networks, and this adversely affects the reliability and performance of the installed devices.

Cost and Financing Barriers

High Cost of Renewables - Currently, the majority of RETs are not defensible purely on economic grounds. As compared to conventional fuels, they cost more, in terms of both initial investment requirements and in terms of cost of energy (Ramana and Sinha 1995).

Pricing of Commercial Fuels - In the case of renewables in India, the high subsidies on commercial fuels such as electricity and diesel (the subsidies in hill states are higher still) are largely responsible for the unfavourable market economics bearing on RETs.

Policy and Planning Barriers

Mismatch between Technologies and Local Needs and Preferences - In many of the programmes, little attention has been paid to the issue of matching technologies with people's needs. Many a time, technologies have been promoted with the expectation that the people will modify their lifestyles in accordance with the technology.

Dissemination Approach - Most rural and renewable energy programmes have been run as centralized target-oriented programmes exclusive of other programmes (TERI 1996c). However, experience suggests that, for determining the feasibility or adaptability of a particular technology or programme, it is important to consider the priorities of the intended target group and bring about an integration of various development programmes (TERI 1992) as required.

Supply-side Planning - The promotion of renewables in the hills has largely meant making RET devices available to consumers. The issue of demand-side management has not been given adequate attention. The traditional supply-oriented approach to meeting the energy needs of the people has had several other drawbacks: not enough attention has been paid to social, cultural, family, and religious practises; efficient technologies have been introduced in areas where traditional and 'preferred' fuels like wood are available abundantly and free of cost; the felt needs of the people have not been taken into account; and the identification of target groups for information dissemination and training has been faulty (Rijal 1997).

Failure to Incorporate the Interlinkages between Components of Livelihood Systems - A distinguishing feature of mountain economies is that the various sub-systems of the natural resource base, such as the agricultural economy, fuel, fodder, cattle rearing, and water, are closely interlinked. This interdependence manifests itself in many ways and has implications for both energy and non-energy sectors. The current policies do not take into account this vital aspect of mountain ecology.

Absence of a Reliable Database - As the potential of renewables is extremely site-specific, especially in mountainous regions, weather data should be recorded very closely over a period of time at a series of weather stations. For technologies like solar, wind, and hydropower, adequate and accurate basic data have not been collected so far. At times, decisions are based on incomplete data, and this has led to poor system performance.

Institutional Constraints

Multiplicity of Agencies and Duplication of Effort - Most of the hill states have different government departments implementing renewable energy programmes.

As all these departments have their own programmes, renewables are often accorded lower priority. Further, as most of the implementing agencies are already understaffed and accessibility in hilly areas is difficult, it becomes difficult for the implementing agencies to provide adequate maintenance support for the installed devices.

Lack of Monitoring Mechanisms - Experience has shown that the monitoring mechanisms for renewable energy programmes are often ineffective (TERI 1994b, TERI 1996b). This is primarily because of a lack of accountability and proper reporting mechanisms in the programmes.

Low Level of Participation of NGOs and Local Bodies - Except for the NPBD and NPIC, the participation of local institutions and NGOs in RET promotion has been minimal. Experience has shown that NGOs can contribute significantly to certain stages of the implementation process such as the identification of appropriate interventions, the motivation to adopt the technology, and the repair and maintenance of the installed systems. There are a large number of NGOs working in the HKH Region; however, till now, their strengths have not been harnessed effectively.

Technological Barriers

Lack of Local Manufacturing Capabilities - Insufficient efforts have been made to develop local manufacturing facilities for the RETs in the hill states. As a result, all the equipment has to be imported from the plains, leading to increase in costs.

Low R&D Investments in RETs - Product development for many of the technologies has not reached the stage at which they can be taken up for large-scale dissemination. R&D has still to come to grips with several climatic and weather-related constraints that these technologies face.

3.7.4 Issues in National RET Policy

There are several issues and constraints that hinder the development of the renewables' sector as a whole. The three most important issues are outlined below.

Economics of RETs

Compared to conventional energy sources, RETs have not been economically viable, because of various technological and other constraints (refer to Table 3.7). The problem is heightened by the fact that the market prices of most fossil fuels are heavily subsidised by the government, creating an imbalance in the overall pricing structure.

Inadequate Budgetary Allocations

The cumulative government expenditure on the renewable energy sector between 1980 and 1992 was in the range of IRs 12 billion (Mathur 1997). This compared poorly with the power sector, where the investment was over IRs 800 billion. In the eighth plan (1992-97), the allocation to renewables was less than one per cent of the total funds allocated to the energy sector.

Table 3.7: Cost of Energy from Various Technologies

Technology	Unit	Capital cost (IRs/Unit)	Cost of energy (IRs/kWh)
Centralised Power Generation			
- Wind farm	kW	30,000	3.15
- Small hydro	kW	30,000	1.65
- Coal thermal[1]	kW	25,000	
300km	ton	413	1.13
800km	ton	543	1.26
1,000km	ton	595	1.31
Decentralized Power Generation			
- Solar photovoltaic	kWp	220,000	20.69
- Gasifier			
- Agro-waste	kW	10,500	1.23
- Wood-waste	kW	7,500	1.49
- Biogas dual-fuel	kW	9,500	0.42
Grid Connections[2]			
1km		43,000	1.31
5km		215,000	1.85
10km		430,000	2.52
15km		645,000	3.19

1 Coal cost with transport cost @ IRs 0.26/t-km and marginal pithead cost of IRs 335/t; PLF 55 per cent; coal consumption 0.7kg/kWh.

2 Contribution of distribution line for different distances from 33kV grid.

Source:Ramana and Sinha 1995

Inadequate Emphasis on R&D

R&D efforts in renewables in India have been lacking in several respects. The R&D expenditure of the MNES is in the range of five per cent of the total annual spending. In the past, most of the research expenditure has been used for training, resource assessment, evaluation, and demonstrations, and a very small proportion for basic technology development or improvement.

In the rural context, the main shortcoming of the research programme has been the inability to develop models and designs specifically suited for mountain areas. In this context, it may be mentioned that between 1976 and 1993 more than half the total expenditure on research in renewables was spent on wind energy (54%), followed by solar photovoltaic (10%), while biogas and improved cooking stoves, which are the largest programmes, received only nine per cent of the total allocation (TERI 1994b). Finally, no specific efforts have been made to collate the research findings and consolidate the efforts of the different institutions.

3.7.5 Future Directions in Renewable Energy Development

Some changes are taking place in renewable energy policies at national level. The MNES has chalked out an ambitious programme for the expansion of the renewables sector. Currently, the ministry is in the process of formulating a comprehensive renewable energy policy which will cover government, industry, research institutions, non-government organizations, local communities, and users (Gupta 1997). The main thrust of this policy is to create awareness, foster development and demonstration, accelerate commercialisation, and help to create an effective institutional structure and delivery mechanism for planning, development, installation, operation, maintenance, and repair. The ministry also plans to introduce special legislation to promote renewables.

3.8 Target Areas and Future Directions for Renewable Energy Policy

In the context of the Indian Himalayas, it is clear that a far greater emphasis will have to be placed on renewables if they are to make a meaningful contribution to the existing energy systems. The overall thrust of the policy will have to be on developing low-cost, efficient technologies suited to local conditions.

3.8.1 Recommendations for Specific Technologies

Mini- Micro-hydropower

In the last decade or so, there have been commendable efforts both by the MNES and state governments to develop small-scale hydropower. However, there are still several problem areas which need to be addressed. These are: a) poor loads of mini/micro hydel power stations; b) operational and technical problems; c) inadequate maintenance support for installed systems; d) accordance of low priority to MMHP projects by the SEBs and state-level power departments; e) slow pace of private sector participation; f) absence of a manufacturing base in the hill states; and g) delays in project execution, leading to time and cost overruns.

National and state policies are needed to come to grips with the above issues. Some initiatives and policy measures that can help in this direction are:

- collection and compilation of basic data and baseline information in a ready-to-use form,
- commissioning of studies on developing strategies for load development,
- setting up of state-level agencies exclusively responsible for developing the small-scale hydropower sector,
- involving NGOs and local institutions in planning, installing, and maintaining at the village level, and
- developing a regional manufacturing base for small hydropower equipment.

Improved Cooking Stoves

Though there are several lacunae in the programme, improved cooking stoves are still the most feasible option existing among various renewables. Some specific recommendations to improve the performance of the programme are as follow.

- R&D to concentrate on developing devices which are efficient and more convenient to use.
- For dissemination, focus attention on specific areas. The best market for improved stoves will be found in areas, generally conurbation areas where there is excessive demand for biomass and people are forced to buy fuel.

Biogas Technology

As of now, none of the existing models, *Deen Bandhu*, KVIC, or Swastik, are really appropriate for dissemination in the hills; for example, KVIC, because of the heavy weight of the gas holder and the deep excavation it needs, and *Deen Bandhu*, because of the difficulty in cutting a spherical foundation for it, which means that the model cannot be constructed in areas with stony strata. The primary focus should be on developing new models suitable for hilly regions, preferably prefabricated ones, so that the involvement of local masons can be minimised.

Solar PV Technology

SPV technology should be used for very specific applications only or for those having a high social value such as storing medicines and drugs in remote primary health centres (PHCs), or for supplying drinking water in a water-scarce area. It is a well-established fact that, given the substantial investment required, these devices will have to be subsidised for the foreseeable future. Experience has shown that setting up local-based repair and maintenance systems can go a long way to improve the programme performance of solar PV technology.

Biomass Gasifiers

The gasifiers' programme for electricity generation is still in the design and development stage, and a reliable and cost-effective technology needs to be developed before it can be taken up for large-scale dissemination.

Solar Thermal Systems

The main problem with the current flat-plate, collector-type solar water heaters (SWHs) is scale formation, leading to blockage of the pipes after a few years. In their present form, SWHs are not suitable for hilly and cold regions, since they cannot be used in sub-zero temperatures. There have been some efforts in this direction by a few NGOs, such as LEDeG in Leh; however, there is still a long way to go to commercialisation and large-scale dissemination.

Solar Cookers

For many hill areas, solar cookers would be ideal, since there is enough sunshine available and the prevalent food habits (preparations mainly involve boiling) are suitable for the use of solar cookers. The main problem with the solar cooker programme has been that it has not reached the right target group of low-income households. It has been purchased and used primarily by high-income groups, for use as a cooking device along with LPG stoves. Also, there is a need to make the appliance more user-friendly and flexible if it is to have a larger market.

Wind Energy

Very few wind energy systems have been installed so far in the hilly states. Most of the HKH Region falls within the low wind speed area (<1.39m/s) (Mani and Mooley 1983). However, there are some pockets in the Northeast where the average wind speed is about 8m/s, and such areas have been found suitable for wind pumps and, to some extent, for aero-generators (TERI 1996b). If wind power is to make a substantial contribution to the hilly regions, more emphasis will have to be placed on basic resource assessment studies and wind mapping in more locations.

Other Areas of Research

In addition to these technologies, there are certain others that are in the development and demonstration stages. These include solar heating of buildings through solar passive architecture, and this has been tried in areas such as Leh. However, none of the projects has gone beyond the demonstration stage yet. Another possible application is the use of greenhouses for the growing of horticultural crops to extend the agricultural year. This technology is already being promoted as part of a government programme in Ladakh, however, applications in other areas have been negligible.

The issues that have not received adequate attention so far are the following.

Applications for Space Heating - In all hill areas, space heating consumes a great deal of energy (NCAER 1985). The traditional devices used for space heating are *bukharis* and open-hearth cooking stoves, which are extremely inefficient (Gadgil 1987).

Efficiency Improvements in Household Appliances - End use efficiency of electrical appliances can make a considerable difference given that the cost of electricity is very high.

3.8.2 Dissemination and Implementation of RETs

Geographical Focus and Cluster Approach

To create the maximum impact, any dissemination strategy should have a geographical focus, i.e., a concentrated deployment of a particular technology, based on a careful matching of technologies with needs and resource base. For example, improved cooking stoves that save on wood should be promoted in areas with fuel scarcity. Such areas will include geographical pockets with high population density and a heavy stress on forest resources. This will help to realise economies of scale in the installation of devices, thus reducing the costs of transporting material and equipment, and also facilitating better monitoring and repair services.

Prioritisation of Technologies for Dissemination

One problem with renewable energy technology promotion in India, which is especially pertinent to the hilly areas, is that they were disseminated before they had reached a sufficient degree of maturity or before local factors had been taken into account adequately. This aggressive promotion led to unreasonably high expectations on the part of these areas. In the context of hills, the promotion of wood-based gasifiers in the North-east is one such example. Similarly, even though the technical constraints of solar thermal systems for the hill climate have not yet been resolved, such systems are being promoted actively. This has led to failures in the field.

Hence, there is a strong case for prioritising technologies based on their stages of development and suitability to hill conditions, in order to focus on those that are cost-effective and have the greatest chance of success.

Involvement of NGOs and Local Institutions

In light of the difficult geographical conditions and the limited manpower and physical infrastructure available to implementing agencies, there is a strong case for involving NGOs in the dissemination of RETs. NGOs can be involved in training village communities in the upkeep and maintenance of systems and the development of local maintenance networks.

3.9 Conclusions

In conclusion, it should be reiterated that the energy needs and use patterns of the people living in the hills are very specific, and quite different from those in the plains. Thus, the basic policy requirement in the hills is to focus on the needs of the people and to tailor interventions according to them. In the context of renewable energy development in the hills, the policy will have to (a) focus on developing options that are suitable for local needs, (b) prioritise technologies for dissemination, (c) set in place efficient and workable systems for the repair and maintenance of technologies, and finally (d) rationalise price distortions caused by the existing pricing of commercial fuels. Lastly, the interlinkages existing within the mountain ecologies need to be understood and incorporatd into the policy framework. Unless these issues are addressed at the policy level, the impact of interventions will, at best, be short-term.

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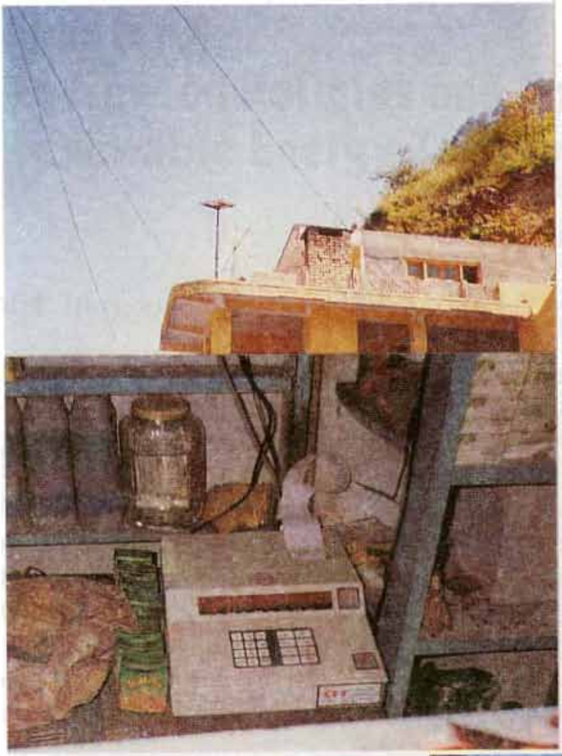
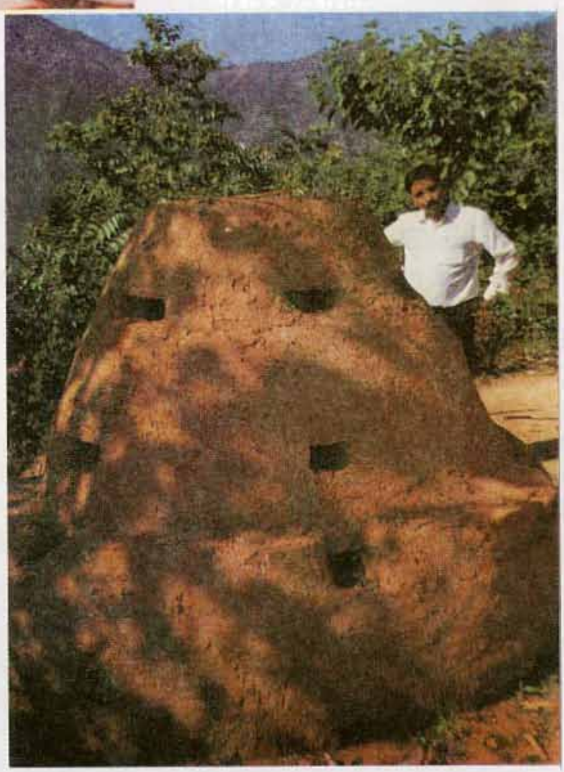


Solar photovoltaic home system (35 watts) installed on the roof of a commercial building for lighting purposes and to operate the fax machine during power cuts, Garampani, Nainital, India



Mud and stone-built charing drum on the demonstration site of the Himalayan Environmental Studies and Conservation Organization (HESCO), Chamoli (Garhwal), India

Chapter 4
Review on Policies and Their Implications on Renewable Energy Technologies in Nepal

by V.B Amatya[1] and G.R. Shrestha[2]

4.1 Introduction

Ninety per cent of Nepal's population live in rural areas, and it is the agricultural sector that is the mainstay of the rural population. This sector contributes about 41 per cent (1995/96) to the real national GDP, even if the trend is downward (MOF, 1996). However, this sector still provides employment to more than 80 per cent of the economically active population. The industrial and service sectors (including tourism) are the next major contributors to the national economy, but their contribution to the rural economy is very small. Historically, as mentioned in the first chapter, Nepal's rural populations have been meeting their energy needs from traditional sources such as fuelwood and other biomass resources. The use of modern forms of energy – electricity, kerosene, and diesel – is comparatively new, and in many rural areas they have yet to be introduced.

Two major characteristics of energy systems in Nepal are excessive dependence on biomass energy and very low efficiency in its use. An excessive dependence on biomass energy involves a trade-off in agricultural productivity, the crop residues and animal wastes being diverted from farms, where they supplement soil nutrition, to stoves and hearths to provide heat energy needs. Diverse energy-consumption patterns, due to different geographic, cultural, and economic settings, and a very low level of energy consumption, as a result of widespread poverty, are some of the other important characteristics. Other aspects that have direct and/or indirect implications on the economic and financial viability of energy systems are people's inability to afford commercial forms of energy and a lack of resources for proper development.

The development and promotion of renewable energy technologies (RETs) so far have relied upon government and donor agency assistance in the form of subsidies and grants. This does not necessarily mean that these technologies are financially unattractive. Given a level playing-field, it can be demonstrated that RETs can rea-

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sonably compete with other conventional alternatives. Also, the proper design and implementation of these technologies can serve socioeconomic and environmental concerns. The contribution of these technologies to meeting overall energy needs has been, however, very small, and the success of these technologies in Nepal varies widely.

Failure or less than anticipated results may have been the outcome of a lack of comprehensive national policies to promote and develop RETs. This is assuming that problems and issues of a technical nature can be resolved in a straightforward manner, while problems and issues institutional, economic, and socioeconomic in scope need more rigorous policies.

At first, it is important to examine the linkages between various sectoral policies that have direct and indirect implications for the development of RETs. Further, linkages between broader national policies and sectoral policies are also important. Policies without appropriate programmes and projects can do more harm than good, and hence policies should always be analysed in tandem with programmes and projects. Often vagueness and generality in policy statements are encountered, sometimes intentionally, for political reasons, and sometimes due to incomplete information. This aspect has also been considered in reviewing and analysing the issue. At the same time, socioeconomic concerns, which include a whole range of institutional issues, such as financing the rural economy, culture and tradition, as well as the evolution of energy use behaviour, need to examined. The characteristics of renewable energy resource — for example, their heterogeneity, low energy density, and small-scale and dispersed nature —call for complex location-specific data for any meaningful analysis, but these are not always available.

The success of strategies to implement the policies depends not only upon the adequacy of institutions and institutional linkages and programmes, but also on budgetary allocations and legislative rules and regulations. Also, the implications of each policy vary widely for the parties concerned. For example, policies intended to ensure social equity will have different implications for entrepreneurs, financing institutions, and end users. Therefore, the perspective and opinions of each party need to be given due consideration.

4.2 Energy Consumption Pattern and Resource Availability

Nepal's per capita annual energy consumption, 0.3 toe (14.06 GJ), is one of the lowest in the world. Per capita commercial energy consumption, 30kg of oil equivalent, is also very low compared to other countries of the sub-region. However, the growth of commercial energy consumption has been high, about 8.4 per cent per annum. The electricity supply is limited to about 14 per cent of the total population. The rural population, which makes up about 90 per cent of the total, has very limited access to electricity (4%) (Amatya 1997).

The rural residential sector alone consumes about 84 per cent of the total energy. However, if only commercial energy (including new and renewable energy) is considered, then this figure falls to only 45 per cent. Table 4.1 depicts sectoral energy consumption by fuel type, with available rural-urban disaggregation (WECS 1997). In rural areas, in the absence of electricity, most of the lighting is done with kerosene lamp. In the urban areas too, due to declining fuelwood availability and the increasing electricity tariff, kerosene and LPG are increasingly used for cooking.

Table 4.1: Energy Consumption, 1995/96, by Sector and Fuel Type ('000 toe)

Energy\Sector	Residential			Commercial	Industrial	Agricultural	Transport	Total	Per cent
	Rural	Urban	Total	R/U	R/U	R	R/U		
Traditional									
Fuelwood	4,508	238	4,747	18	168	0	0	4,933	80.6
Agri residue	192	30	222	0	7	0	0	229	3.7
Animal dung	365	35	399	0	0	0	0	399	6.5
Conventional									
Coal/coke	0	0	0	7	59	0	0	67	1.1
Petroleum products	70	37	107	48	30	46	177	408	6.7
Grid dlectricity	7	22	29	10	30	2	0	71	1.2
Non-Conventional									
Decentralised electricity	1	0	0	0	0	0	0	1	0.0
Gaseous Fuel (biogas)	8	0	8	0	0	0	0	8	0.1
Total	5,151	362	5,512	84	296	48	178	6,117	100.0
Per cent	84.2	5.9	90.1	1.4	4.8	0.8	2.9	100.0	

Note: R=Rural, U=Urban

4.2.1 Energy Resources

The energy resources of Nepal consist of a combination of traditional and commercial sources of energy, including biomass, hydropower, and alternative forms of energy. Petroleum fuel and coal are imported from other countries. In spite of its large theoretical hydropower potential of 83,000MW, of which 42,000MW is established to be technically feasible, Nepal has developed only 250MW of hydropower to date, which supplies about one per cent of the total energy requirements (WECS 1994). Fuelwood accounts for 80 per cent of energy consumption, and it is mainly consumed in rural Nepal (Amatya and Kharel 1997). Public, community, and private forests and private land are the major sources of fuelwood. These resources are depleting rapidly as a result of overexploitation and lack of adequate management. Other biomass sources — agricultural residue and animal waste — provide for about 10 per cent of the energy requirement. Imported petroleum and coal together make up about eight per cent of the total consumption.

Biomass, as a source of energy, mainly consists of fuelwood, agricultural residue, and animal dung. The biomass available for energy purposes on a sustainable basis was estimated to be about 23 million tonnes in FY 1991/92, of which fuelwood based upon accessible forest accounted for 33 per cent, agricultural residue 53 per cent, and animal dung 14 per cent (NPC 1995). Fuelwood is used in traditional stoves of various kinds or improved, more efficient stoves for cooking and space heating energy. There is a marked imbalance between the sustainable supply of fuelwood and consumption at present (Amatya and Kharal 1997). Agricultural residue, although it can be converted to briquettes for more efficient use, is used in an unprocessed form for energy purposes. Alternatively, it can be converted to biogas without losing nutrients. Dung and agricultural residue both have other important uses (fertilizer and fodder) which compete with their use as fuel.

4.2.2 Renewable Energy Resources and Technologies

Energy forms that are not conventionally used or which are new and renewable are considered alternative or renewable energy. They include resources like solar, wind, and geothermal power and newer technologies that improve use efficiency such as biogas, improved cooking stoves (ICS), micro-hydro, and biomass briquettes.

Micro-Hydro

The traditional water wheel (less than 1kW) has been in use in rural Nepal for centuries. Nepal has made significant progress in the private sector in developing and using its water resources for producing power, particularly in the micro range (up to 100kW), over the past three decades, and now has a total manufacturing capacity of more than 2MW per year (WECS 1994). Some of the manufacturers have capabilities of manufacturing turbine casing, penstock pipes, electro-mechanical equipment, and other accessories for hydropower plants of up to 15MW in capacity (Earth Consult 1995). The factors that have contributed to bringing the micro-hydro development programme to the present stage are, i) relatively low capital investment requirements, ii) short construction periods, iii) local geography that provides micro-hydro potential, iv) simple to operate, v) government incentives and, recently, vi) delicensing of plants.

The present subsidy on micro-hydro installation is limited to the cost of electrical equipment and transmission and distribution systems. The amount of subsidy is 75 per cent in remote mountainous districts and 50 per cent for the remaining districts. The present subsidy policy does not differentiate between stand-alone and add-on plants. The installation rate of micro-hydro projects has slowed down recently, and this can be substantiated by the investment trend of ADB/N. The progress over the past two years is shown in Table 4.2.

Biogas

The interest in biogas began only in 1975/76, an 'Agriculture Year' to boost agricultural production. The Gobar Gas *Tatha Krishi Yantra Vikas* Limited, popularly known as the Gobar Gas Company (GGC), was established in the year 1977 to promote

Table 4.2: Investment in Micro-hydro Power (in '000 Rs)

(1993/94)			(1994/95)		
Target	Achievement	Per Cent	Target	Achievement	Per Cent
12,152	7,265	60%	17,001	2,774	16%

Source: ADB/N

biogas technology. In 1992, the Biogas Support Programme (BSP) was 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 (BSP 1994/95). As a result of the privatisation policy and implementation of the Biogas Support Programme, more than 41 new biogas companies have been established. Nonetheless, the success of biogas development programmes can mainly be attributed to the availability of subsidies and the involvement of a number of INGOs and donor agencies.

Solar Energy

Solar water heaters are produced and marketed locally. In the Kathmandu Valley alone, there are about 35 manufacturers involved in manufacturing and installation. Another use of solar water heaters is for preheating water in industries as part of process heating. Currently they are being used to preheat water in some carpet industries (WECS 1995a). Recently efforts have been made to develop solar driers for large-scale crop drying. They have yet to be commercialised. With effective R&D efforts and proper dissemination approaches, solar driers and cookers have a fair chance of replacing fuelwood and kerosene, especially in rural households.

Another important area of solar energy use has been electricity generation from solar photovoltaic (PV) systems. Private companies have started manufacturing, installing, promoting, and providing service for household- and community-sized PV system packages (CRE 1994). Although very capital-intensive, the household solar PV unit is emerging as an important alternative energy source for rural household lighting where options such as hydropower are technically not feasible.

Wind Power

Wind power development in Nepal is still in the experimental stages. So far, no contribution has been made by wind energy to meet the energy needs of the country. A 30kW wind power plant was installed by the Nepal Electricity Authority (NEA) in Kagbeni, Mustang, but was heavily damaged by high winds after only a few months of operation. At present, NEA is implementing a Wind Power Development Project, and a few private workshops are involved in the fabrication of windmills for pump irrigation purposes. 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 (WECS 1995a).

Improved Cooking Stoves (ICS)

Since 1980, when the ICS programme began in earnest, HMG/N has played an important role in promoting and disseminating. The only large-scale ICS programme carried out in Nepal has been through the Community Forestry Development Division (CFDD). About 44,000 insert-type stoves were distributed, of which 35 per cent are believed to be in operation. At present, the ceramic insert-type design has been abandoned in favour of stoves built on site using locally available materials and skills. A number of NGOs and INGOs have included ICS as an integral part of their overall development objectives and programmes. Stressing user motivation and education, these organizations are beginning to show some success in their efforts to introduce improved stoves on a sustainable basis.

Briquetting Technology

The use of rice husk has been on the increase for industrial heating and process heating purposes. Several private manufacturers produce briquettes, many of them are located in the *Terai* region where there is plenty of rice husk available. Briquettes are also being produced using sawdust as the raw material. There is a possibility of briquettes replacing kerosene, fuelwood, and coal in the domestic and industrial sectors (WECS 1994).

4.3 A Review of Energy Policies and Programmes

A specific policy for energy development was not stated until the Fifth Five Year Plan (1975-80). This energy policy covered only hydropower and forestry sectors up through the Sixth Plan (1980-85). In the Seventh Plan, the government began to attach due importance to the development of alternative energy for socioeconomic development. It provided subsidies for the installation of biogas plants and micro-hydro turbines. Improved cooking stoves were distributed through various establishments in order to promote them (NPC 1981, 1995).

The Eighth Five Year Development Plan of Nepal was a turning point for Nepal which embraced a market-oriented, liberal economic policy for the development of the country. The Eighth Plan (1992-97) focussed on sustainable economic growth, poverty alleviation, and the reduction of regional imbalance as its principle objectives and devoted a comprehensive section to the energy sector; and this included alternative energy. In the planning history of Nepal, the effectiveness of the private and non-government sectors in development activities was emphasised for the first time. In order to facilitate the activities of the private sector and NGOs, the plan also recognised the need to simplify administrative procedures, speed up the decision-making process, and liberalise government policies and the implementation of these policies (NPC 1981, 1985, and 1992).

The Eighth Plan recognised that the sustainable economic growth through which economic prosperity can be achieved would require proper management of bio-physical resources so as not to deplete them. If properly translated into programmes, this would entail the development of renewable resources. In the energy sector, therefore, harnessing renewable energy resources is inevitable. The means to attain sustainable economic growth, as made clear in the plan document, are community participation and involvement of the private sector in economic activities. Implementing programmes that have higher comparative advantages and taking care to ensure social equity in development activities are also highlighted. Also mentioned was the fact that high population growth and the resulting excessive demand on biophysical resources needed to be controlled (NPC 1992). The plan document enumerated ten priority sectors, including energy and rural infrastructural development, but did not rank them. On the whole, the number of programmes outlined that achieved their objectives during the plan period was found to be disproportionately low. During FY 1996/97, of the total investment budget for hydropower and energy generation, only 0.3 per cent was allocated for the micro-hydropower sector and 1.7 per cent for the biogas programme, as depicted in Table 4.3.

Table 4.3: Budget Allocation for RET Subsidies and Total Energy (Rs in millions)

S.N	Description	Amount
a.	Total budget for energy sector	5,848
b.	Budget for alternate energy	119
c.	Budget for biogas	99
d.	Budget for micro-hydro subsidy	17.5
e.	Budget for solar and wind	2.5
	Per centage (d/a)	0.03

Source: Annual budget, Ministry of Finance

Energy pricing policies play a major role in the success of energy policy and the achievement of its objectives. Table 4.4 summarises the major energy pricing observations and their implications.

4.4 A Review of Sectoral Policies with Implications for RETs

4.4.1 Water Resources and Electricity

Policies on water resources and electricity are perhaps the most important sectors that influence the development of RETs. Tables 4.5 and 4.6 summarise water resources' development and electricity development policies and their implications for RETs.

4.4.2 Industrial Policy

The Industrial Enterprises Act 1992 was enacted in 1992 and followed by an industrial policy statement. Some of the policies defined in the act and their implications are highlighted in Table 4.7. There are some differences regarding industrial policies/acts and hydropower development policies/acts. These differences are summarised in Table 4.8.

Table 4.4: Energy Pricing and Its Implications

Policy Statement	Implication
Fuelwood prices in most urban areas are above their long-term marginal costs	The supply of fuelwood from the Timber Corporation of Nepal (TCN) depots used to be insufficient to have an impact on fuelwood prices. At present, TCN has discontinued supplying fuelwood to the market. Instead, fuelwood is auctioned by the TCN at the source to private sector suppliers for supply to urban areas. The price of fuelwood is, therefore, determined by market forces. However, the poor are not directly affected by the prices because they rarely purchase fuelwood.
LPG, kerosene, and diesel are subsidised and gasoline is heavily taxed	Energy pricing subsidies are a difficult tool with which to reach the poor because of their limited purchasing power and the difficulty of ensuring that intended benefits reach them. For example, whereas kerosene for lighting is an important fuel for some urban and rural poor, kerosene is mostly not used by these groups. The price difference between gasoline and kerosene has led to mixing kerosene in gasoline, with adverse urban environmental consequences, and possibly some additional engine wear.
Electricity is priced below its economic costs adjusted for financial requirements upon different customer classes, e.g., households, transport, irrigation	Petroleum products and electricity are only available to a minority of the population, mainly in the urban areas. The poor have limited access because of the prohibitive cost arising from the lack of supply infrastructure. High costs of end-use devices and connection also affect access to these modern forms of energy for the poor.

Source: deLucia 1994

Table 4.5: Water Resource Policy and Its Implications

Policy Statement	Implications
Licenses not required for running water mills or water grinders as a cottage industry	No fiscal or other facilities can be made available to the industry without industry registration.
The government can acquire and develop water resources for the purpose of extensive public use and turn them over to a users' association.	Industrialists/entrepreneurs may be hesitant to invest in and install micro-hydro units.
Hydroelectricity has been ranked fourth in priority for water resources' use.	High risks for entrepreneurs investing in micro-hydro - there have been cases of closure of micro-hydro projects due to diversion of water resources for irrigation purposes, e.g. micro-hydro projects in Dhading District.

Source: EDC 1996.

Table 4.6: Hydropower Development Policy and Its Implications

Policy Statement	Implications
Investment may be made in a national, foreign, or joint venture of national and/or foreign funds.	The private sector is taking the initiative to install micro-hydro power. The pace has been slow due to limited subsidies. The private sector is attracted to peltric sets. Foreign nationals are investing in technology transfer and small hydro projects.
Concessional loans to generate and distribute electricity	An interest rate of 16 per cent plus one per cent service charge and a loan period of from 5-7 years cannot be considered a concessional loan. Timely availability of loans is preferred.
Waiving license requirement for surveys, generation, transmission, and distribution	No fiscal or other facilities can be made available without registration as an industry.
Customs duty facility	Customs duty is levied on alternators imported for micro-hydro generators, whereas no customs' duty is levied on alternators for diesel/petrol generators. Since the cost of diesel engines is lower than that of micro-hydro projects, diesel engines are competing with micro-hydro plants.
Micro-hydro plants may be replaced by small hydropower plant/grids.	Lack of clarity over compensation has created a dispute between NEA and the micro-hydro plant in *Tamghas* (WECS 1994).
NEA will provide compensation if it extends its grid to existing private power in the form of micro-hydro, etc.	NEA is hesitant to extend its grid in areas where there are micro-hydro installations.
Source: EDC 1996	

Table 4.7: Industrial Policies and Their Implications

Policy Statement	Implications
Removal of licensing and registration for industries.	No fiscal or other facilities can be made available without registration as an industry, which nullifies the facility.
Industries manufacturing fuel-saving devices and hydropower generation and distribution fall under national priority industries.	Industrialists/entrepreneurs are attracted to investing in such industries due to the increased facilities.
Rebate on duties and no levy of double sales' tax.	Local manufacturers who do not import bulk quantities of raw materials will have to depend on local supplies. The availability of supplies is of greater importance for industries than duty rebates. Industries are required to pay duties on supplies due to the vagueness of classification in the tariff structure.
No double sales' tax will be levied on the raw materials and products of any industry.	Industries either do not pay or pay only nominal duties on the import of material, whereas they have to pay 15 per cent sales' tax on purchases from local manufacturers or the local market.
Source: MOI 1992, 1992a.	

Table 4.8: Differences in Facilities Accorded by the Electricity Act 1992 and by the Acts Pertaining to Industries

Electricity Act, Hydropower Development Policy	Industrial Enterprises Act
1. No income tax on generating, transmitting, and distributing hydroelectricity up to 1,000kW.	1. No cottage industry shall be subject to sales' tax, excise duty, or income tax.
2. License for the generation, transmission, and distribution of hydroelectricity lowered to 10 per cent below the prevailing rate.	2. Industries entitled to reduction in tax rate by five per cent.
3. License for hydroelectricity generation, transmission, and distribution exempted from income tax for 15 years from the date of generation, transmission, and distribution.	3. Energy-based industries exempted from income tax for five years from the date of commercial production.
4. License for hydroelectricity transmission for distribution exempted from income tax for 10 years.	4. National priority industries (hydropower generation and distribution) entitled to an additional two years of exemption.
5. License operators and managers or purchasers of hydro-electricity generation plants owned by HMG/N exempted from income tax for 5 years.	5. Cottage and small-scale industries are reserved for Nepalese citizens only. Foreign investment of up to 100 per cent is allowed in medium and large-scale industries only.
6. One hundred per cent investment by one or more foreign investors for power projects, including generation, transmission, and distribution, is allowed immaterial of the size of the project.	6. Industries will not be nationalised.
7. Projects become the property of the government on expiry of the license period.	

Source: EDC 1996 and MOI 1992, 1992a

4.4.3 Trade and Credit Policy

The objectives of trade policy in Nepal have been export promotion, import regulation, and trade diversification. A summary of trade policies and their implications is given in Table 4.9.

The Eighth Plan aims to increase priority sector investment by commercial banks to 15 per cent of their total loan amounts. An anomaly in this regard has been observed, some commercial banks preferring to be penalised rather than mobilise their resources for priority sector lending. Financial institutions have full freedom to fix their rates of interest on credit and deposits within guidelines set by the Nepal Rastra Bank. In 1992 the statutory liquidity ratio (SLR)[3] was lowered to 22 per cent from 24 per cent, which was one of the measures regularly advocated by the financial sector. Table 4.10 summarises credit policies and their implications.

With regard to RET development, government policy explicitly states that credit will be extended to the private sector on a priority basis for the development of small hydroelectricity projects, biogas, solar, wind, etc.

3 The statutory liquidity ratio is defined as the ratio of investment in government treasury bills or bonds issued by the Nepal Rastra Bank to the total deposits collected by the bank.

Table 4.9: Trade Policies and Their Implications

Policy statements	Implications
Waiving of the quantitative restriction and licensing system and provision of foreign exchange facilities - Convertibility of Nepalese currency for current accounts Import of materials from India Abolition of the export tax and simplification of the duty drawback system Adjustment in customs' duties.	While no specific facilities for energy-related industries have been made, such industries are likely to gain from these policies. However, there have been some problems in implementation of the policies. For instance, industries exporting to third countries in convertible currency find no problem in exporting, whereas export to India has some constraints regarding local component contents (they are being waived too under a recent arrangement with India).
Nepalese raw material and labour content requirement for export to India	Export to India faces some problems regarding local component contents. Under a recent trade agreement with India which has done away with this condition, this issue will likely be resolved.

Table 4.10: Credit Policy and Its Implications

Policy Statement	Implications
Committing 12 per cent of total loan portfolio to priority sector lending	Commercial banks are reluctant to invest in priority sector lending due to lack of expertise and high operation costs. Nepal Bank Ltd and Rastriya Banijya Bank have been financing alternative energy, mainly biogas, under BSP since 1995/96. Other joint venture banks do not fulfil the requirement and prefer to be penalised. Recently some commercial banks have started lending priority sector financing funds to some NGOs at a concessional interest rate for relending.
Freedom to fix rates of interest on credit	A concessional loan facility does not seem to have been provided for rural and alternative energy projects. Borrowers prefer timely availability of credit to interest subsidy.
Credit will be extended to the private sector on a priority basis	The budget allocated to rural and alternative energy financing by major financial institutions is limited.
Simplify and upgrade the quality of loan procedures	Delays in the sanctioning of loans are mainly due to the non-cooperative attitude of bank staff and policy.
Lowering of statutory liquidity ratio	No implication since commercial banks' lending activities in the rural energy sector is very nominal.

4.5 Policy Issues in the Dissemination and Development of RETs

Energy sector planning has gone through major changes, mainly due to international influence and the emergence of a focus on a market-based and liberalised economy. The focus on socioeconomic and environmental concerns specifically related to poverty alleviation has also been seen as a paradigm shift in planning. Energy planning in Nepal started in the 1970s with an assessment of the supply-demand gap and then planning how to fill these gaps. Resulting plans and programmes were based upon planners' 'We know what is good for you' syndrome. The recent focus on a bottom-up approach, or participatory planning, at the local level and the sprouting of a liberalised market-based economy is slowly replacing older paradigms.

The shift was inevitable, given the diverse characteristics of renewable energy resources, the numerous barriers to its dissemination, and the need to link these programmes to broader national development goals. Some of the major barriers are:

- the need for high capital costs due to the non-continuous availability, low density, and non-dispatchability of renewable energy;
- inadequate rural credit systems; and
- lack of the necessary institutional base for information and services.

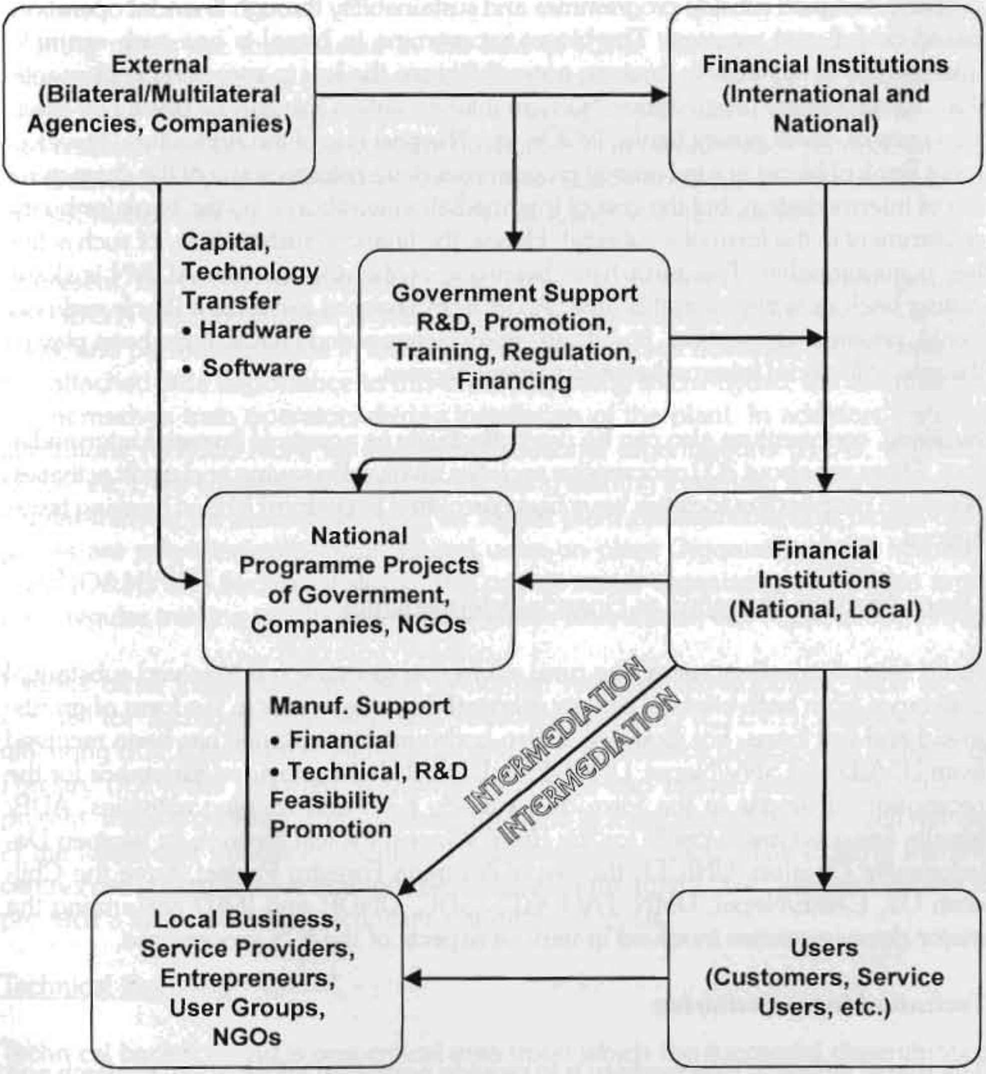
In spite of all these problems, accomplishments in the development and dissemination of renewable resources like biogas and micro-hydro in Nepal are commendable. Solar photovoltaic is now following a similar path. Micro-hydro dissemination picked up during the late 1980s but had slowed down in the 1990s and is facing problems that were once thought to be trivial. The improved cooking stove programme, which initially was almost a total failure, is gaining momentum. Similarly, the biogas programme, which was sluggish in the 1980s, has attained a very high growth rate in the 1990s. These trends demonstrate that the problems are dynamic, and that solutions need to be sought and timely action taken as they surface. The lead time required for the government between problem identification and action is usually long compared to private sector NGOs and has been the main reason for the need to mobilise NGOs and the private sector within the development programme; a programme which needs attention to micro-level details.

4.5.1 Intermediation

Access to the relevant suppliers is critical to rural energy investor/user choice (CRT & deLucia 1997). This access is dependent on institutions already in place in terms of available technologies, financing, information, and a host of other particulars, including sociocultural factors. In spite of the possibility of access to various options, the lack of one or more necessary institutional set-ups may result in non-access. Therefore, it is necessary to distinguish between potential and actual access.

Most rural people do not have access to the full range of possible options due to technical as well as institutional reasons. Sociocultural parameters aside, it is therefore obvious that the role of financial and technical intermediaries can be of immense help to convert whatever potential access to energy exists into actual access. Providing adequate energy, specifically in a commercial form, to rural areas logically requires a range of efforts from others apart from providers and users of the technologies. These efforts are generally called intermediation. Given the prevailing forms of rural technologies and institutional set-ups, the range of intermediation required can be classified broadly into technical intermediation, such as information dissemination, and technical support (pre- and post-installation), and financing and management intermediation such as debt financing and management support in the form of training, etc. Figure 4.1 illustrates the interaction among various agencies involved in rural commercial energy activities with specifically financial and technical intermediary roles.

Figure 4.1: Organizational Linkages within and the Scope of Rural Commercial Energy Activities



Financial Intermediaries

Financing relatively small sustainable energy investments in rural areas poses challenges. According to a rural credit survey conducted by the Nepal Rastra Bank, only about 25 per cent of the credit need is met by institutional sources (CRT&deLA 1994). The financing of rural energy programmes needs to be looked at from two angles: access to financial services and the sustainability of services in the long run. Financial sustainability can be achieved by financing institutions limiting their services to less risky projects and locations, but this means poorer access in rural areas and hence does not address the social equity aspect of development. The trade-off between these two is very delicate and requires sacrifice on the part of one or the other. Access can be improved through properly designed subsidy programmes and sustainability through financial operations based on full cost recovery. The biogas programme in Nepal is one such example. Intermediation activities to improve accessibility are the key to successful implementation of rural energy programmes. Such an intermediation role can be played by extension units of development banks, NGOs, etc. The past role of the Agricultural Development Bank of Nepal in rural energy programmes demonstrates some of the characteristics of intermediation, but the cost of intermediation was borne by the bank (or by the government in the form of a subsidy). Hence, the financial sustainability of such activities is questionable. This must have been one of the reasons why ADB/N is slowly cutting back its activities in this area. Apart from financial institutions (bank and non-bank), private sector entities, specifically manufacturers and NGOs, have been playing the role of financial intermediaries to varying degrees.

Similarly, cooperatives also can be used effectively as agents of financial intermediation. There are about 300 cooperative societies involved in saving and credit activities. Nineteen cooperative societies have been permitted to perform limited banking transactions.

<u>Donor Agencies Operating as Financial Intermediaries</u>

Apart from domestic sources, the rural energy programme has received substantial assistance from both bilateral and multilateral donor agencies in the form of grants-in-aid and soft loans. For example, micro-hydro grant assistance has been received from USAID and SNV/Nepal. UNCDF and SNV/N have provided assistance for the promotion of biogas in the form of a subsidy fund and training activities. ADB/Manila financed micro-credit for the Rural Women Project through its Women Development Division. UNICEF, the Nepal-Australia Forestry Project, Save the Children US, CARE/Nepal, UMN, FAO, GTZ, SDC, UNDP, and IFAD are among the major donor agencies involved in various aspects of the ICS programme.

Technical Intermediaries

The role of technical intermediary is to provide necessary information, research and development, technical services, training, etc. Considering the players in the rural energy scenario, rural energy investment usually has an investor (e.g., NEA and micro-hydro entrepreneurs), energy service user (often the investor, as in biogas and ICS), technology supplier, and financing agency (e.g., ADB/N). Unlike large utilities like NEA, local entrepreneurs and also end users generally lack technical skills, namely, the information and capability to cope with technical intricacies. In order to improve financial viability, training to operators (often the entrepreneur) to ensure smooth technical operations is important. Equally important is developing the management skills for doing the job in a business-like manner rather than as a hobby or household activity.

Training

Training needs are multifaceted in the field of RETs. Various studies and reports have indicated that there is an urgent need to produce a cadre of lower, middle, and higher level technicians and motivators engaged in promotion, technical services, and research and development in the field of RETs in Nepal. Trade schools, such as the Butwal Technical School and Balaju Technical School, have contributed to the field of micro-hydro by producing a cadre of lower level technicians.

At present, the private sector is playing a key role in training end users and promoters. ADB/N used to organize regular training for micro-hydro operators, ICS technicians, and persons involved in financial and management activities, but at present it has attached little importance to this area. Regarding micro-hydro, the manufacturers themselves train operators during installation of the plant. In addition, national institutions (WECS, NEA) as well as international organizations (ITDG, ICIMOD, UNDP, etc.), are currently engaged in preparing training materials. BSP is organizing regular training for masons working on biogas plant construction, and biogas companies are providing orientation to end users on plant Organization and Management (O&M) and the use of slurry. The private sector organization CRT also organizes regular training to ICS technicians, *ghatta* technicians, etc. (CRT 1995, 1996).

Various other institutions involved in human resource development, such as the Council for Technical Education and Vocational Training (CTEVT), Institute of Engineering (IOE), Institute of Agriculture and Animal Science (IAAS), and Institute of Forestry (IOF), are involved in producing middle and higher level technicians. At present, there is no specific programme for RETs in these institutes. Gaps still remain at the lower and middle levels of technical human resources. The existing training centres could play a more leading role by reorienting their curriculum and course to produce a cadre of skilled technicians at different levels.

Technical Backstopping

Technical backstopping is one critical area upon which the successful dissemination of RETs depends. The biogas dissemination programme has realised this and is providing strong technical backstopping through biogas companies. Very few ICSs installed during the Community Forestry Development Programme and Production Credit for Rural Women (PCRW) programme are currently in use, because of a lack of continuous backstopping. Similarly, micro-hydro dissemination in Dhading District is experiencing technical problems because of lack of appropriate backstop facilities. Technical backstopping becomes all the more critical for the technology disseminated in remote rural areas, given the fact that communication and transport take longer. For instance, the electricity component of the MPPU installed in Patmara VDC, Jumla, could not be made operational over a long period and virtually had to be abandoned, with a loss of investment on the generator, transmission, and household wiring. Similarly, it took more than half a year to get technical services to repair its electronic load controller.

4.5.2 Financing

The Agricultural Development Bank, Nepal, not only provides loan facilities but also channelises subsidies. The ADB/N assures local entrepreneurs of the necessary capital for investment through its loan and subsidy programme. On an average, 80 per cent of the total cost of a project is financed in the form of a loan repayable over five to seven years. The rest of the cost is borne by the entrepreneur in kind or cash. The provision of a capital subsidy minimises the entrepreneur's contribution, which helps attract private investment.

The ADB/N is one of the original major promoters and shareholders of the Biogas Company. It also assisted in installing 23,872 biogas plants, during a period of 20 years from FY 1975/76 to FY 1994/95, and financed five solar PV sets to or run water pumps with a total capacity of 7.6kW. During the current fiscal year it has financed household solar PV systems with a subsidy from HMG/N. Apart from the ADB/N, other private sector banks, viz., Nepal Bank Limited and Rastriya Banijya Bank, have been financing rural energy programmes (mainly biogas) since 1995/96 under their priority sector lending programme. Some joint venture banks are also following suit by mobilising NGOs.

One burning issue, however, involves the recent steps taken by the Agricultural Development Bank to withdraw technical support for development of RETs by closing its appropriate technology units. This has created a void in the development of RETs, since no other agencies have taken up the activities that were performed by these units in the past. Other issues pertaining to the financing of RETs are highlighted below.

Flexible Financing Schemes and Productive End Use: Important Preconditions

Rigid banking procedures, the high front-end cost of RETs, and the low risk- bearing capacity of rural entrepreneurs all add up to an environment detrimental to the development of RETs. Most of these barriers need to be addressed through innovative initiatives.

Cumbersome Bank Procedures

Banking procedures are found to be quite rigid in the terms and conditions of financing, especially as regards collateral. Banks and financial institutions do have programmes, such as hire purchase, in which a purchased item can act as a guarantee for financing, but this arrangement is not applied in financing RETs.

High Pre-Investment Costs and Low Risk-Bearing Capacity of Rural Entrepreneurs Hinders RET Development

RETs in general involve a high investment cost compared to conventional alternatives. This is the main reason for the slow dissemination of the household solar photovoltaic, which costs about NRs 30,000 for a 35-watt system for lighting and TV. From a user's perspective this is tremendously high compared to other alternative sources, viz., kerosene, grid connection (where available), micro-hydro, etc. It is observable that only the richer levels of society have installed SPV systems; the technology being out of reach of the poorer members of the community.

The high pre-investment cost, including the cost of surveys and feasibility studies, also has affected the growth of RETs. Generally, these services are provided by manufacturers and NGOs. Recently, HMG/N made a provision to provide a subsidy for feasibility studies of RETs. However, nothing has been mentioned about the allocated budget and procedure of disbursement.

Consumptive Rather than Productive Use Deters Financial Viability: The Need to Diversify End Uses

It is a fact that, in almost all micro-hydro plants, supplying electricity for lighting alone is not financially viable, due to the low load factor (recall the case of the Urthu micro-hydro plant in case studies). Similarly, most peltric sets have been acquired by the efforts of a group of households joining together to buy and install the equipment for electrical facilities, mainly for lighting. Often these peltric sets do not provide opportunities for end use diversification because of their smaller size. It is seen that entrepreneurs who have been able to integrate such end uses are operating successfully in financial terms.

4.5.3 Appropriate Tax and Other Incentives (Subsidies): A Need to Reform

In order to analyse the subsidy policy, it is necessary, as with any other policy, to see it in the light of development objectives. These objectives range over social equity (income redistribution), economic growth, environmental concerns, liberalisation of the economy, regional balance in economic development activities, etc. As the objectives become more explicit and well defined, it becomes easier to analyse whether the subsidy policies and programmes agree with the development objective.

Subsidies in the energy sector can broadly be distinguished as price subsidies and capital subsidies. The Nepal Electricity Authority's lifeline tariff and incremental block tariff for residential consumers are examples of a price subsidy and cross-price subsidy. Similarly, among the petroleum products marketed by the Nepal Oil Corporation, diesel and kerosene are supplied at a subsidised rate, i.e., below the cost of supply to NOC at most locations in Nepal. The capital subsidies for installing various rural alternative energy technologies, such as micro-hydro, biogas, and solar photovoltaic, are examples of subsidies that have assumed different shapes and sizes in the past. The subsidy for alternative energy has widely been referred to as being inappropriate, inadequate, and inconsistent in many reports and publications (ITDG 1995, Nepal 1996).

There are, however, other aspects apart from financial returns on which the proper operation and sustainability of alternative energy projects depend such as adequate training, R&D, and end-use promotion. If these 'software' aspects of the project needed to be carried out by the manufacturers themselves, costs would eventually add up. Therefore such assistance, if provided by the government or outside agencies, is called parallel financing or a software subsidy.

Table 4.11 shows the major direct HMG subsidies for the year 1996/97. How much is spent in parallel financing is very difficult to determine because programmes, such as training, R&D, and information dissemination, are spread over many agencies — including GOs and NGOs.

Table 4.11: Major Budget Allocations of Subsidies for the FY 1996/97 (in '000 NRs)

Purpose	Amount	Percentage
Food (price and transport)	224,500	21
Fertilizer (price and transport)	600,000	57
Irrigation	110,000	11
Biogas	99,000	9
Rural electrification	20,000	2
(Solar photovoltaic and micro-hydro)		
	1,053,500	100

Source: Annual Expenditure Budget, Ministry of Finance, 1996/97

The Need to Analyse and Formulate Subsidy Policy on a Par with Budget Allocations

Barring some exceptions, it is commonly found that subsidy policies generally do not meet target-based criteria. In fact, adequate analyses are rarely carried out. In spite of good intentions, subsidies can have negative impacts if they are improperly designed and implemented. This is especially true when resource availability tends to be a constraint. For example, the limited amount of 2.5 million rupees allocated for a 50 per cent subsidy for solar PV in the year 1996/97 was barely sufficient to finance 200 units. This resulted in a flood of demand for solar PV, but neither the government nor ADB/N, through which the subsidy is channelled, has been able to meet the demand; the consequence being a quota and suppressed demand. In spite of the good intention of promoting dissemination, the immediate demand has possibly been suppressed in anticipation that the subsidy will be available in coming years. There are also equity concerns with regard to such subsidies. Often beneficiaries of subsidies tend to be a group not envisaged under the overall national development objective.

Inconsistent Subsidies

The present solar PV subsidy does not address equity or development concerns well when compared with micro-hydro installations, which have a substantial potential for providing energy for productive use and for generating income and employment opportunity. Compared with the micro-hydro subsidy, by which only the electrical components of the system excluding household connection and wiring are subsidised, the subsidy for solar PV is provided as a complete package, including house wiring and even the purchase of fixtures. There is inconsistency (Box 4.1) and the need for a cohesive, objective, and target-oriented subsidy policy (Box 4.2).

Box 4.1: Examples of Inconsistent Subsidies on RETs in Nepal

During the Seventh Plan period, 84 plants were installed, and, during the first three-year period of it, 156 plants were financed by ADB/N. ADB/N has so far distributed NRs 24.28 million in subsidies for rural electrification to private entrepreneurs. The subsidy on rural electrification was introduced in 1985, but discontinued in 1986. It was reintroduced again in 1988, and in 1989 again discontinued until 1992. The government started releasing subsidies once more from 1993. Inconsistent subsidy policy is one of the major grievances of the micro-hydro sector. A similar story can be traced in the history of biogas subsidies. Unpredictability and inconsistency with respect to subsidies affect investment decisions, and hence are the major impediments to dissemination. ADB/N loan investments for turbines during FY 1993/94 were NRs 7.3 million, and this dropped to NRs 2.8 million in 1994/95. Loan investment was 60 per cent measured against the target, and it dropped to 16 per cent over the same period. The percentage of outstanding loans overdue was 44 per cent in 1993/94, and 60 per cent in 1994/95. It is reported that, during the current year, only about half of the subsidy budget has been used, indicating a further slowing of pace in micro-hydro installation.

Is Existing Subsidy Policy Instrumental in Widening Social Disparity?

The social equity issue in the existing subsidy policy is very prominent. The present subsidy policy framework on biogas allows very limited access to subsidies for the poor. The poor usually lack access to finance, since they cannot fulfill the collateral conditions of the Biogas Support Programme's participating banks. In spite of their

Box 4.2: Justification of and Limits to Existing Solar PV Subsidies

In spite of justifications put forward in favour of subsidies, in the long run the latter are difficult to continue if tangible benefits in terms of socioeconomic development are not forthcoming. According to one study (WLG/WECS 1995), with an electricity price of NRs 60 per kWh, the economic and financial IRR are 11.7 and 10.4 percentage rates of return, respectively; whereas for the same electricity price micro-hydro yields 34.9 and 32.1 percentage rates of return respectively. The limited cash savings from kerosene were in some cases significantly counterbalanced by SPV system maintenance costs related to bulb replacement (WLG/WECS 1995). Therefore, the subsidy for solar PV cannot be justified based upon economic criteria alone. The other criteria for a subsidy need to be clearly mentioned in the policy document. However, it is important to note that household PV systems provide substantially better quality and cleaner light than kerosene. Source: CRT and de Lucia 1997.

capability to make monthly payments, and their having enough animals to fulfill the raw material requirements for biogas digesters, the poor cannot avail themselves of the existing subsidy. Therefore, access to subsidies, particularly for biogas and solar PV, is limited to the richer individuals and communities. A flat subsidy rate for all sizes of biogas plants reduces the cost of energy from smaller plants targetted at low-income farmers (Table 4.12).

Table 4.12: Cost of Biogas for Different Sizes of Biogas Plants in the Hills 1996/97 (before and after subsidies)

Size (m^3)	Total Investment Before (Rs)	Total Investment After (Rs)	Yearly Cost Before (Rs)	Yearly Cost After (Rs)	Yearly Gas Production (m^3)	Cost of Biogas Before (NRs/ m^3)	Cost of Biogas After (NRs/ m^3)
4	17,481	7,481	3898	1668	350	11.14	4.77
6	20,256	10,256	4,517	2,287	525	8.60	4.36
8	23,885	13,885	5,326	3,096	700	7.61	4.42
10	27,355	17,355	6,100	3,870	875	6.97	4.42
15	34,342	24,342	7,658	5,428	1,315	5.82	4.13
20	41,962	31,962	9,358	7,128	1,750	5.35	4.07

Source: Updated from BSP sources using GGC prices

An Unfair Diesel Subsidy

A study conducted by New Era (1993) found that, out of 25 micro-hydro schemes looked into, 20 had overdue loans despite the fact that 19 had generated enough income to service the debt. The study considered that five of the 25 were economically not viable, since many competing mills, mainly diesel mills, had been set up in the vicinity. Poor management was identified as the main reason for faulty repayment of bank loans (New Era 1993). Investment for diesel generators and mills being less costly than for micro-hydro projects, diesel engines are competing with micro-hydro plants. This may be mainly due to the subsidy on diesel equipment and its relative ease of operation.

Tax Policy: Unfavourable for Renewable Energy Development

The availability of tax and duty exemption on the import of renewable energy-related material and equipment is provided for at various levels, in acts and rules and regulations. However, in practice, availing oneself of such facilities is found to be very cumbersome. In spite of such facilities, manufacturers, particularly in the micro-hydro field, are generally supplied through local market channels and end up not using such facilities. One of the underlying problems is that demand for RET-related equipment and accessories is sporadic. In contrast, it is not uncommon to see the import duty on alternators for micro-hydro being as much as 40 per cent, whereas the organized import of diesel generator sets gets by with much less. This, in turn, increases the final delivery price of RETs. The recent organized import of main valves for biogas digesters and photovoltaic panels resulted in users taking advantage of the tax facilities.

4.5.4 Gender Concerns: A Neglected Dimension

Women play key roles in the collection, management, and use of energy resources and technologies. These multifaceted roles and responsibilities force them to face a number of problems. The growing scarcity of fuelwood and other biomass resources adds hours to a woman's work-day (WECS 1995a). There are renewable energy technologies that offer significant potential in terms of reducing women's drudgery and improving health conditions. For example, the ICS, an improved version of the traditional cooking stove, has had a positive impact on addressing gender concerns. Similarly, the impact of other RETs, such as biogas (ADB/N, SNV-Nepal, and GGC, 1994), micro-hydro, and solar PV, is found to have had a positive effect on women's daily work load, their living conditions, and economic empowerment (East Consult 1994).

While most energy-related policies and programmes have great implications in one way or the other, none of the policy statements have made any reference to the importance of gender roles in the energy sector and the involvement of women in energy development programmes. Thus, energy sector policies are found to be completely blind to gender issues from both a practical and strategic point of view (CRT & deLucia 1997).

It seems that the role of women in and relationship with energy-related sectors have yet to be well understood by policy-makers (who are usually male). Policies seem to have been formulated on the premise that development is a gender-neutral process, that participation of men and women in the development process is an automatic phenomenon, and that both men and women benefit equally from development. This assumption is a distortion of the real situation, given that women lag behind men in the socioeconomic, legal, and political spheres of life and that women's roles, needs, concerns, and constraints greatly differ from those of men. Until women's practical and strategic needs are addressed and internalised by policies, and gender-based programmes planned and implemented, the rural energy programmes are likely to remain ineffective and unsustainable.

4.5.5 Legislative and Regulatory Issues

The Need to Differentiate RETs by Modes of Ownership and Management

Technologies have inherent characteristics, based in part on their degree of technical sophistication, scale, and mode of management. In the case of micro-hydro, its degree of sophistication and its scale range from the traditional *ghatta* to the pelton turbine — including add-on and stand-alone electrification units, each with its own characteristics. These characteristics also vary distinctly according to the mode of ownership and management. Different modes of ownership and management will require different levels and kinds of support for successful operation. The implications of these different modes of ownership and management for policy are generally neglected in policies relating to RETs and Energy Saving Devices (ESDs). The various modes of ownership and management are private, community, and corporate (or limited liability). All of these modes, have their own advantages and disadvantages. Community-based management and ownership fosters participation, local resource mobilisation, reduced cost, easier conflict resolution, distributed risks, etc. Private and corporate-based modes, on the other hand, foster zeal, innovative ideas, entrepreneurship, etc. Scarcity and risks tend to bring the community together for resource management. However, for successful operation it has been found that an agent needs to be present who is capable of enforcing rules acceptable to the community (Wade 1988). In the absence of such an enforcer, free-wheeling behaviour prevails, resulting in partial or full failure of the operation.

Property Rights' Issues

Water Rights' Issues

The Water Resources' Act 1996 prioritised the use of water resources, with the generation of hydroelectricity ranking fourth in order after drinking water, irrigation, and agricultural uses. The law does not specify any right of prior use of water resources for micro-hydropower (MHP) projects. This caused the closure of the Charaundi micro-hydro plant in Dhading District, the water that was used to generate power having been diverted for an irrigation project (Bishaltar Irrigation Project).

This sort of problem is very prominent when private companies or individuals own the micro-hydro station. Understandings and water-sharing arrangements are usually functional when an individual is able to collaborate with the community or when the micro-hydro unit is installed as a community venture. In any case, the individual entrepreneur is always at the mercy of the community, since existing laws do not provide any protection in the form of water rights for the micro-hydro entrepreneur.

Forest Rights' Issues

The implications of policies and legislative measures on forests and their management are important for renewable energy development. Renewable energy technologies in many ways divert or reduce the demand for firewood from forests. The productive use renewable energy technologies are geared to could, however, put additional pressure on forests if such production is based upon raw materials found in them such as timber.

With community forestry becoming more successful as a mode of forest management, as envisaged by the Forestry Sector Master Plan, property rights' issues, such as the degree of control over the management and use of forest products, are becoming important. The community management mode, which is still in the process of evolution, with varying degrees of support from the government, is bound to become standard. The government's institutional setup, however, is not yet fully geared up, either physically or in terms of human resources. The traditional bureaucracy within the forest sector will take time to fully accept the community-based approach.

As in the case of water resources, disputes occur among locals over rights over forests, and this has been found to be a serious hurdle, causing delays in their being handed over to the community.

R&D and the Intellectual Property Right Issue

Research and development (R&D), specifically in its adaptive capacity, is a critical aspect of RET and ESD development in Nepal. Biogas plant design, turbine design, and local adaptation of the design of solar PV, ICS, and wind power units are examples of such R&D. In order to adapt these technologies to the prevailing situation, R&D needs to be strongly focussed. So far, research activities have been carried out either by the private sector and such NGOs as BYS, DCS, and ITDG, or by research agencies like RECAST and RONAST. When it come to investment in research by the private sector, patent and intellectual property laws have to be effectively in place; otherwise the private sector will shun away from such investment.

4.5.6 Warranties, Standardisation, and Guidelines

Standardisation of Equipment and Safety Guidelines for Construction and Operation of RETs

There are no formal guidelines or mandatory safety provisions established for the construction and operation of RETs. Due to unprotected belts and rotating parts of machines, particularly in the case of micro-hydro installations, there have been a number of accidents that could have been avoided if proper protection measures had been taken. Similarly, design standardisation is not practised. The lack of a formal standardisation of procedures and guidelines has resulted in errors, again, especially in micro-hydro. Standardisation and quality control in the implementation of the BSP programme have been achieved to a reasonable level. The number of biogas plant in operation has increased in recent years.

The Issue of Warranties and Design Guidelines

Warranties are an important mechanism to ensure quality output from manufacturers. They ensure that manufacturers or suppliers of services and equipment are made responsible for what they specify or promise to deliver. In the absence of warranties, manufacturers will get away with inferior equipment and after-sales' services. Often, unrealistic assumptions are made in economic and socioeconomic analyses to make schemes seem financially viable.

4.5.7 Lack of Sectoral Integration and Linkages

Energy issues are currently not well addressed in rural development programmes. These issues are considered in a non-integrated fashion by individual line agencies and institutions (for example, rural electrification by NEA, community afforestation by the Ministry of Forests (MOF), biogas and micro-hydro by ADB/N, and ICS by the Women's Development Programme in the Ministry of Local Development). Local development offices at the district level, and in branches of the Forestry Department and Nepal Electricity Authority, formulate individual programmes for implementation and submit them to their respective central offices.

RETs have demonstrated that they can be instrumental in providing electricity in rural areas at a different level. Solar PV household units do not cater to power needs but can provide electrical lighting in remote rural areas that otherwise would never be electrified. Micro-hydro and other RETs have the capability of providing rural energy in a modern form that can be instrumental in bringing much needed economic development. The issue is, then, what comprises rural electrification and what not. Should the direct public investments and subsidies for infrastructure apply to these different levels of rural energisation differently? How are the spin-offs, ranging from hygienic and health benefits, awareness building, and access to information, communications, etc treated in decision-making processes relating to public investment?

The most commonly touted feature of RETs is their fuel-saving and replacement capability: improved stoves reduce the need for fuelwood, MH and biogas take over for kerosene and fuelwood, and solar PV for kerosene. This in itself is an important aspect of RETs, but more important are the further spin-offs stated above. Often these benefits are so important, especially in terms of their backward and forward linkages, that energy bonuses and the unit cost of energy become unimportant. Opening up communications with solar PV is one such benefit, awareness and increased learning opportunities are others, and there are many more such benefits.

Addressing social equity in terms of access to technology through financial and necessary institutional arrangements has been practically absent in programmes related to RET development. Often it is found that the poorer segment of society has been forgotten on the design and implementation of these programmes.

4.5.8 Institutional Arrangements and Issues

Inadequate Institutional Infrastructure and Commitment to Technology Promotion and Dissemination

Currently, lack of the institutional capability once upheld by Appropriate Technology Units (ATUs) of ADB/N is causing serious setbacks to the promotional activities of RETs. A lack of adequate support from government and donor agencies is often cited as the reason for the withdrawal of ADB/N from these activities. The private sector and NGOs are gearing up to take on the role of ATUs but have not been very effective due to lack of appropriate funding and institutional support.

Weak Central Coordination and Monitoring

There is no Ministry or Department of Energy in Nepal. The Water and Energy Commission Secretariat (WECS) has been instrumental in generating necessary information on RETs for planning, through surveys, investigations, and studies, which in turn lead to policy recommendations. At one point in time (the early 1990s), there was a half-hearted effort by WECS to coordinate and promote renewable energy development and channel some funds into training and research. However, these efforts got crowded out by large national issues of water resources' development.

Although the Alternative Energy Promotion Centre under the Ministry of Science and Technology has come into existence recently to take over this responsibility, it may be some time before it becomes fully functional. This is especially likely given its inherited organizational characteristics, it having been established as a wing of HMG/N, complete with red tape, other types of bureaucratic inefficiency, and a lack of financial commitment.

Apart from the National Planning Commission's regular budgetary allocation and monitoring, there is no coordination and monitoring of the RET programme at a national level. One exception is the programme on biogas, the Biogas Support Programme, which is governed by a board. This is due to donor funds being available for the programme — a reflection of the government's indifference towards and donor-driven nature of the RET programme in Nepal.

4.6 Conclusions and Recommendations

4.6.1 General Conclusion

Based on a review of relevant policies and various case studies, it can be concluded that, in spite of some major unresolved issues, Nepal has made remarkable progress in the development and dissemination of RETs. Progress made in the dissemination of biogas is phenomenal, and this is specifically due to the establishment of an institutional set-up overlooking the programme in an integrated manner. Another factor, which has helped in the success of the biogas programme, is availability of funds for the programme and donor commitment. In the case of other RETs, such commitment and support is lacking. For example, micro-hydro development is infested with lots of technical problems, such as a low load factor, quality control, and high up-front costs, and institutional issues, such as water rights and adequate back-up services. The solar photovoltaic programme is in the early stages, the major issues being related to social equity, its very limited linkage to economic activity, and an inadequate and inappropriate subsidy policy. There is hardly any programme to speak of in wind energy, and the improved fuel-efficient cooking stove (ICS) programme has in the past had a misguided target-driven approach. In the ICS programme, the latter and a lack of users' participation at the design and planning level, have meant that a majority of installed stoves are unused. There are, however, positive developments taking place in the ICS programme. Users' participation and the mobilisation of NGOs and the private sector recently have proven to be a better path for ICS development.

In spite of the merits and demerits of the different technologies (a function of their spatially specific advantages and load versus output characteristics), unconventional technology stands out as an important option at individual locations. Under unfavourable hydrological and/or smaller load conditions, solar photovoltaics can be an attractive proposition. Output maximisation, cost minimisation, socioeconomic concerns, and financial sustainability should be the key criteria in devising policies in this respect. Policy should avoid disturbing market forces unless the need arises to address socioeconomic concerns and market imperfections.

4.6.2 Recommendations

In order to accelerate the development and dissemination of renewable energy technologies to help the rural economy grow in line with overall national development objectives, the issues identified in the previous section need to be resolved. The following recommendations are made.

Legislative and Regulatory Action

Appropriate legislative and regulatory frameworks are necessary preconditions for the development of enterprises. Micro-hydro and other renewable technologies are environmentally sound options and need to be encouraged. Policies should be oriented to providing a level playing field in the market for RETs and ESDs alongside other energy options. Legislative and regulatory measures are also crucial for the necessary protection of investments. Prior or formal users of resources should be guaranteed adequate property rights so that other users do not hamper or come into conflict with them. In addition to the priority specification of resource use, as in the case of water, existing users' rights along the lower stream must be explicit. Similarly, appropriate legislation is necessary to safeguard intellectual property rights in order that responsibility for R&D can pass to the private sector. In order to safeguard common users' interests, there is an urgent need to develop warranty and technical standards for manufacturing and construction that incorporate safety guidelines.

Financial and Economic Measures

In order to make RETs financially more viable, it is necessary to improve the revenue generated or benefit realised. Especially in the case of micro-hydro, it is found that the load factor of plants is often less than 25 per cent, which translates into the underutilisation of investment. Since costs cannot be reduced, the only way to improve financial performance is to improve revenue. To achieve this, especially in cases like micro-hydro, increasing the load factor in order to use the investment in a productive manner is necessary. For example, the attempt to promote knitting and tailoring in Pulimarang by women entrepreneurs is a remarkable example of the productive end use of a solar photovoltaic lighting system. In this respect, the government, NGOs, and the private sector can play a positive role by providing the necessary training to entrepreneurs and by conducting awareness programmes.

Most important, however, is to see that RETs become financially sustainable propositions. In other words, they should be developed in such a manner that all forms of subsidies can be removed in due course of time. In order to achieve this, they should be provided with a level playing field in terms of subsidies and cross-subsidies, taxes, duties, and other support that distort market functioning. We cannot expect solar photovoltaic or micro-hydro to compete with kerosene lighting and diesel generators if fuel and equipment are taxed unevenly.

A General Subsidy Framework

There is no framework upon which subsidy policies are based. The framework for subsidy policy should be explicit and made public. There is a need to differentiate between rural electric lighting and village electrification. The former provides limited services without opportunities to develop backward-forward economic activities in the rural area, whereas fully fledged electrification provides unlimited economic opportunities. In addition, there is also a need to improve the continuity of the subsidy programme and its predictability in order to avoid investment shunning by the private sector.

Simplified Banking Procedures and Special Programmes to Enable the Poor to Access RETs

The general impression entrepreneurs have about banking procedures is that, for a variety of reasons, they are cumbersome and take a long time. It is also found that interest rates are not uniform among banks. It is therefore desirable that banking procedures be simplified and interest rates and other conditions on loans be unified. Similarly, there is a need to develop special programmes to ensure increased access to RETs by the poor.

The Need for a Holistic Approach in RET Development

It is important to realise that not all benefits from programmes like ICS can be quantified, one example being hygiene and the health of family members, particularly women and children. Environmental benefits that accrue from savings in fuelwood are also important, even though they may not look very significant in financial terms. Similarly, the micro-hydro programme should be looked at as a starting point for other economic activities that may develop due to the availability of power and the related generation of income and employment.

Therefore, it is necessary to refocus the RET programme so that it acts as a 'catalyst' to rural economic activities rather than as a purely technical programme, the level of government support being proportioned according to social and environmental benefits.

Gender Concerns Must Be Reflected Adequately

As an entry point, HMG/N energy sector agencies should provide credit facilities and subsidies for time- and energy-saving technologies. With these facilities, women will have access to technology that will give them the extra time needed for skill development, and confidence-building and income-generating activities. Once women have access to and control of income, they will be able to invest in other technologies or directly in their families (WECS 1997). A major obstacle to meeting the basic needs of poor rural families is the lack of productive resources and the time available to women for the fulfilment of their triple role as managers, producers, and users of energy. Women could prove to be effective in initiating development activities and especially in motivating and mobilising other rural women and men as well. Development efforts without the participation of rural women are sure to fail since most rural activities are women-oriented, and women have an intimate relationship with energy, environment, economy, and natural resource management.

Devising Effective Institutional Set-ups

Institutional responsibility for the energy sector is spread over many entities, including many ministries, departments, and other sectoral and sub-sectoral entities. The level of commitment for the development of RETs has been inadequate, and efforts have been half-hearted. The level of commitment in terms of programme and budgetary allocation for RETs needs to be increased drastically. Also, the institutional and financial sustainability of the programme needs to be seriously reconsidered. The government has demonstrated its commitment by establishing Alternative Energy Promotion Centre (AEPC), and a matching programme and budget are highly awaited. The primary focus of AEPC should be of the coordination and monitoring of RET programmes, with provision for a decentralized technical backstop facility.

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Dome-type biogas plant installed in the Panchkhal Valley, Kabhrepalanchok, Nepal

Improved Cooking Stove installed in a hill village in Nepal

Chapter 5
Review on Policies and Their Implications on Renewable Energy Technologies in the Context of the HKH Region of Pakistan

by Tajammul Hussain[1]

5.1 Background

Most of the population of the mountain region in Pakistan live below the poverty line. Not surprisingly, the energy consumption is very low, with biomass fuel (firewood, dung, crop residue, etc) accounting for about 80 per cent of it. Most of this is consumed by households, since no significant industries exist.

The Hindu Kush-Himalayan (HKH) Region in Pakistan includes the Northern Mountains and the dry Western Mountains. The Northern Mountains take in the Northwest Frontier Province (NWFP), Federally Administered Tribal Areas (FATA), Azad Jammu and Kashmir (AJK), and the Northern Areas. This territory has a population of 22.937 million and covers an area of 174,572sq.km. (Abdullah 1997). Most of the land is used for farming, livestock breeding, grazing, or forestry, depending upon altitude, climate, and socioeconomic conditions. Most of it, too, is steeply mountainous, with only a very small amount of flat area available for cultivation; otherwise it generally supports only natural vegetation. The pastures are grazed at higher elevations, between 1,500 to 3,300m, in the summer only, but they are grazed throughout the year at lower levels. In the winter, animals are fed on hay made from grasses cut in the area. Most of the population are subsistence farmers who manage to meet only the bare minimum needs of food and fodder for their households.

The Western Mountains include Balochistan Province, with a total estimated population of 6.738 million. The total land area of the region amounts to 302,454sq.km., and most of the land is arid (Abdullah 1997). The main economic activity revolves round the livestock industry (one third of the land is used as rangeland), less than three per cent of the area being exploited for fruits and vegetables by using scarce groundwater resources. The export trade from the province is in coal, gas, mutton, hides, and temperate fruits and vegetables.

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5.2 Energy Supply Potentials and Consumption Patterns

There is no production of oil in mountain areas, and a uniform fixed price prevails for oil products. Indeed, the availability of oil in substantial quantities in the far-flung mountain area could cause problems. The main gas fields in the Western Mountains are located in Sui, Pirkoh, and Loti. The annual production of gas from these fields has remained nearly constant, at 325,000 to 350,000 million cu.ft., during the last five years. The balance of recoverable reserves of gas in Balochistan amounts to 4.1 trillion cu.ft. and there is a 5,293km gas distribution pipeline in the mountain areas (60% in the Northern and 40% in Western mountains). For the FY 1994/95, the production of coal amounted to 1.6 million tonnes in the mountains, 97.4 per cent of which was produced in Balochistan. The total estimated reserves of coal in mountain areas amount to 54 million tonnes.

The Northern Mountains are rich in hydropower resources. According to some estimates these areas have a potential of 30,000MW. At present, the installed capacity of hydropower amounts to 4,726MW—generating 22,858 GWh in NWFP, of which it consumes 8,245 GWh, thus making the provinces net exporters of electricity to other provinces (Sharma et al. 1997). The Master Plan for the development of small hydropower identified 116 sites with a total potential of 400MW as feasible. At the same time, the identified potential of medium hydel schemes is 770MW, ranging from 10MW to 150MW.

Public forest areas in the mountains (76% of the total forest area in Pakistan), including coniferous forests (58%), scrub (33%), riverine forests (1%), farmland trees (4%), and irrigated and linear plantations (4%), provide most of the wood required for domestic and industrial purposes within both the mountains and plains in Pakistan. About 14 per cent of the Northern Mountains is covered by forest, though a significant variation in forest cover, from 15 to 60 per cent, is observed if an analysis is made at the district level. The Northern and Western Mountains contribute 82 per cent and 18 per cent respectively of the total forest area in the mountains. The Northern Mountains are dominated by coniferous forest area (70%) and scrub (21%); the Western Mountains by scrub forest (85%). One estimate of supply potential indicates that coniferous forest contributes almost 51 per cent, farmland 25 per cent, and scrub forest nine per cent of the annual sustainable yield in the mountains (GOP 1992).

The use of other biomass resources (namely, agricultural residue and animal dung) is increasing in mountain areas due to growing deficits of wood. The exact amount of biomass residue available is not known, but various studies have indicated that these resources are also used as fuel, fodder, and fertilizer. The tendency to divert these residues to cooking and heating needs, instead of using them as fodder and fertilizer, is a great concern in the mountain areas of Pakistan.

In FY 1994/95, the per capita final energy consumption in the mountains of Pakistan amounted to 11.6 GJ (10.5 GJ in the Northern Mountains and 15.1 GJ in the Western Mountains). The share of various forms of energy varies between the Northern and Western Mountains. Table 5.1 compares the per capita final energy use pattern between the Northern and Western mountains of Pakistan. For example, the share of fuelwood in the total final energy amounts to 46 per cent in the Northern, while it is 66 per cent in the Western Mountains. The contribution of 'other' biomass (i.e., agricultural residue and animal dung) to total biomass fuels in the Northern Mountains is 26 per cent, and 10 per cent in the Western Mountains. This is indicative of the high biomass fuel consumption in the Western compared to the Northern Mountains. The harsh climatic conditions of the Western Mountains combined with the scarcity of fuelwood, forces the area to depend primarily on imports from outside Balochistan Province. Also, there is a high demand for fuelwood from the Northern Mountains from the adjoining plains where it fetches a good price, so local residents are tempted to save fuelwood in order to earn cash.

Table 5.1: Per Capita Final Energy Consumption Pattern in the Mountains of Pakistan, FY 1994/95

Descriptions	Western Mountains		Northern Mountains		Mountain Total
	MJ/Capita	Per cent	MJ/Capita	Per cent	'000 GJ
By sector					
Rural households	12,024	65	7,028	56	204,884
Urban households	11,835	14	7,024	11	37,087
Comm/institutional	222	1	268	2	7,639
Industrial	1,350	9	1,648	16	46,886
Agriculture	202	2	236	2	6,785
Transport	1,393	9	1,335	13	40,019
Total	15,186	100	10,515	100	343,550
By fuel type					
Fuelwood	10,094	66	4,864	46	179,573
Other biomass	1,003	7	1,697	16	45,687
Coal	585	4	59	1	5,304
Petroleum fuels	2,102	14	1,923	18	58,271
Natural gas	421	3	871	8	21,570
Electricity	982	6	1,157	11	33,146
Total	15,186	100	10,515	100	343,550
Total population (thousands)	6,738		22,937		29,675
Rural	5,526		19,699		25,225
Urban	1,212		3,238		4,450

Source: Abdullah (1997); Rijal (1997)

The share of commercial fuels in terms of total final energy amounts to about 34 per cent in the mountains, with a variation in the share of commercial fuels (i.e., 38% in the Northern and 27% in the Western Mountains), but the per capita consumption remains almost the same. Among the commercial fuels, petroleum fuels contribute about 49 per cent, electricity 28 per cent, natural gas 18 per cent, and coal five per cent in the mountains. The share of petroleum fuels and electricity remains almost the same in both mountain areas, while the share of natural gas is dominant in the Northern Mountains (per capita natural gas consumption is almost double), and coal dominates the energy scene in the Western Mountains (per capita coal consumption is almost 10 times more), reflecting the accessibility of these fuels as well as the types of industries that are operational there.

The rural domestic sector primarily depends on biomass fuels (98% in the Western and 92% in the Northern Mountains), while such dependence is much less in the urban domestic sector (50-55%), because of the patterns of energy supply and demand infrastructure. The urban domestic sector of the Northern Mountains is dominated by natural gas (70%) and electricity (22%) and that of the Western Mountains by electricity (51%) and natural gas (33%). This is due to the higher per capita electricity consumption in the urban domestic sector of the Western Mountains (almost four times more than the Northern Mountains), despite the per capita total electricity consumption in the Northern Mountains being 1.2 times more than in the Western Mountains.

The industrial sector of the mountain economy of Pakistan is dominated by the supply of commercial fuels (70-80%). The industrial sector of the Western Mountains is dominated by coal (54%) and the Northern Mountains by natural gas and electricity (69%). However, industries in the Northern Mountains consume more in terms of per capita energy. This is because of the location and the types of industry that prevail in these mountain areas. The agricultural sector of the Northern Mountains consumes more electricity (168 MJ per capita) than the Western Mountains (111 MJ per capita), which reflects the agricultural mechanisation as well as availability of electricity within the former.

More than 90 per cent of all biomass fuel is consumed by the domestic sector in the Western Mountains, while seven per cent of it is required by the industrial sector. A similar pattern of consumption is observed in the Northern Mountains. The sectoral consumption pattern of commercial fuel shows that 24 per cent of it is required in the domestic sector, 34 per cent in transport, 27 per cent in industry, eight per cent in commerce, and seven per cent in agriculture in the mountains of Pakistan, with minor variations over time. The biggest consumers of electricity are the domestic (40%) and industrial (35%) sectors in the Eastern Mountains, and the same is true of the Western Mountains, though these industries (45%) consume more than the domestic sector (35%).

In absolute terms, the Western Mountains consume almost 1.5 times more energy than the Northern Mountains, though the per capita commercial energy consumption is higher in the Northern Mountains. Other striking differences are that: a) the household sector in the Western Mountains consumes about 80 per cent of the total final energy and in the Northern Mountains less than 70 per cent; b) the final energy consumed in the industrial and transport sectors of the Northern Mountains is higher than in these sectors in the Western Mountains; and c) the commercial fuel consumed in the Northern Mountains is higher than in the Western Mountains. The energy consumption trend reflects the inadequacy of the commercial energy supply infrastructure in the Western Mountains, as well as the low level of industrial development and transport infrastructure.

5.2.1 The Present Status of Renewable Energy Technologies

The development of renewable sources of energy opens up the prospect of increasing the indigenous energy supply and thereby contributing to greater self-sufficiency. The development of renewable energy also creates new options for responding to the energy requirements of the rural domestic sector. The role of renewable energy technology should be perceived as a dynamic interaction between resources, technologies, and the present and future energy requirements for the social and economic uplift of the region. Recent studies have shown that hydroelectricity has been the cheapest source of renewable energy. However, biomass, wind energy, and direct solar energy have already been installed. Wind energy is the second cheapest option of renewable energy available, while solar thermal energy offers another option which can be used for space and water heating.

The government of Pakistan has made the following renewable energy programmes a national high priority (UNESCO 1996).

- The installation of a 1MW solar thermal power plant in the desert area of Pakistan
- Model houses self-sufficient in terms of energy
- PV telecommunications' systems for rural areas
- Biomass plants using agricultural and municipal wastes
- Solar desalination pilot project
- Community solar driers for drying grains, fruits, vegetables, etc
- Biogas plants to meet the domestic fuel needs of rural areas.

Micro- and Mini-Hydropower Plants

The HKH Region in Pakistan, especially the NWFP, enjoys high rainfall and possesses numerous snow-peak mountains, making it rich in water resources with vast hydropower potential. Most of the large rivers of Pakistan originate in these mountain ranges, which have been blessed with good forests and minerals. There is an abundance of perennial streams and waterfalls that can be successfully exploited to generate electricity and motive power by means of micro- and mini-hydropower (MMHP) plants. These plants have several advantages over other conventional energy systems, including large hydropower. These power plants can be installed near the village where it is needed by the user community. It is a fairly simple technology with low capital investment.

It may be noted that the recoverable potential of hydroelectric power in Pakistan has been estimated to be nearly 35,000MW, only 3,330MW of which have so far been exploited — which is only 14 per cent of the total energy from commercial fuel (HDIP 1995 and 1996).

The main government agency in Pakistan, Water and Power Development Authority (WAPDA), has found it difficult to implement and run projects of below five MW in capacity. Therefore, power plants installed below this capacity range have been handed over to the Irrigation Department of the NWFP. Other organizations have also been created or upgraded to undertake the installation and maintenance of MMHP plants. In the northern areas (Gilgit and Baltistan), the task of MMHP plant construction and operation has been assigned to the Northern Area Public Works' Department (NAPWD) in the NWFP and Sarhad Hydel Development Organization (SHYDO), a provincial organization of the NWFP.

There are a total of 64 MMHP plants with a total capacity of 17MW operated by these government agencies. Other organizations engaged in the promotion of micro-hydropower (MHP) plants (up to 100kW in capacity) are the Pakistan Council of Appropriate Technology (PCAT) and the Aga Khan Rural Support Development Programmes (AKRSP). Both these organizations have installed MHP stand-alone plants of lower capacity, owned by the local communities or individuals, with a total capacity of 2,334kW from 181 units. A detailed account of the MMHP plants installed by various agencies as of June 1997 is given in Table 5.2.

Table 5.2: The Number of MMHP Installations in Mountain Areas of Pakistan

Area	Number of plants	Total Capacity (kW)	Average Capacity (kW)	Implementing Agency
Northern Areas	77	14,633		
Government-owned	47	13,940	297	NA-PWD
Community-owned	30	693	23	AKRSP/PCAT
NWFP	163	4,342		
Government-owned	12	2,700	225	SHYDO (Government)
Community-owned	151	1,642	11	PCAT
AJK	5	574		
Government-owned	5	574	95	AJK-PWD
Community-owned				
Total	245	19,549		
Government-owned	64	17,214	267	
Community-owned	181	2,335	13	

Source: PCAT, SHYDO, NA-PWD and AJK-PWD.

Problems with MMHP Installations

The challenge of planning and providing rural electrification has not been satisfactorily met in Pakistan. All aspects of rural life from food processing to factories, from enterprise to entertainment, suffer from a lack of available and reliable electricity. Though modest progress has been made, there is little evidence of well-established sustainable systems serving rural areas. Quite often, rural electrification is based on subsidies that are justified by political priorities exempted from the economic, ecological, and social criteria of socioeconomic development. This has been particularly true for the MMHP schemes in the NWFP and the Northern Areas. Many plants installed by the government agencies have ceased operations or remained inoperative for a major part of the year. Far from demonstrating sustainable development, most have failed to demonstrate even institutional and operational stability. The following are the main causes responsible for this situation (SHYDO, undated, Siraj 1995): a) mismatch between plant capacity and energy demand; b) inappropriate equipment, most of which is imported; c) lack of trained personnel; d) repair and maintenance performed as in other routine government departments, through tendering, etc; e) failure to identify the local energy market; and f) limited private sector involvement.

Except in the case of the AKRSP and PCAT, which work in close collaboration with the local communities, all other MMHP plants installed in Pakistan are operated and maintained by public sector organizations, which act more or less like power utility companies. This results in a heavy bureaucratic organizational structure which makes the operation of the system more complicated. In case of any breakdown in the plant, which is quite frequent in MMHP schemes, the repair is made according to normal government procedures involving tendering, etc. This takes a long time, sometimes more than a year. During this period, the local people use diesel generators to meet their power demands. Customers have to make a great effort to get a power connection. These departments are not geared to carry out their own research and development activities, so their staff are unable to undertake any innovations, and, in case of major breakdowns, assistance is sought from overseas' equipment manufacturers at very high costs. The power supply from these plants is not too reliable, particularly from MMHP plants, and is often erratic.

Biogas Plants

Biogas is a clean and cheap fuel. About 60 per cent of it is inflammable methane gas; the rest of the constituents are carbon dioxide (30-35%), hydrogen sulphide, carbon monoxide in traces, and water vapour. This gas can be used for cooking and lighting. Biogas is produced from cattle dung in a biogas plant through a process called digestion.

There are about 30 million cows and buffaloes in Pakistan. The total dung available per day in the country works out to between 300 and 450 million kg, assuming that each animal daily produces 10-15kg of droppings. The total number of biogas plants that can be installed in Pakistan may well exceed one million (Sarhandi, no date). In addition to producing gas, efficient biogas plants also provide nitrogenous fertilizer. This bio-fertilizer is highly suitable for the land, being better than many chemical fertilizers. The suitability of biogas plants for mountain areas is constrained by the low temperatures.

PCAT was established in 1974 and biogas plant designs were procured through the Intermediate Technology Development Group (ITDG), London. These designs were tried out in some places, but with little success. In 1976, the Appropriate Technology Development Organization (ATDO, later renamed PCAT) obtained the design of Chinese biogas plants through the Chinese Embassy in Pakistan, and these were installed in different places. Twenty-one such plants were erected throughout the country in sizes of 10, 20, and 50 cubic metres. These designs consisted of a dome-shaped reinforced concrete (RCC) roof and brick masonry. Some problems encountered in the Chinese design were: a) gas pressure was not constant, and this affected the burning efficiency; b) difficulty in the construction of a good quality dome by local masons; and c) the use of costly forms of work and associated transport. Afterwards, an Indian design was adopted, with some modifications according to local needs, to reduce costs. The modifications made were: a) the central partition wall was removed; b) slide supports were provided for the gas holder instead of a central guide; c) the thickness of the wall of the fermentation chamber was reduced from 9" to 4 ½"; d) the outlet pipe was removed and the digested slurry was allowed to drain from the top of the fermentation chamber (Shehryar 1995).

There are altogether 1,134 biogas units installed in the NWFP and Balochistan Province (HDIP 1996). Most of these plants belong to individuals who have paid the entire cost of construction, through PCAT may have provided technical assistance and supervisory services during their installation.

Solar Energy Technologies

The mountain areas of Pakistan are blessed with plenty of sunshine. The daily average solar radiation is four to six kWh/sq.m. in the HKH Region (Sheikh, no date, Raza et al. 1995). People are beginning to use solar enerty for a large number of applications.

<u>Solar Thermal Technologies</u> - This technology has been successfully developed in Pakistan for water heating and space heating, and is now being commercialised. An average family-size solar water heater of 30 gallons costs PRs 13,000, and space heating systems cost PRs 7/cu.ft. In view of the low per capita income of the HKH Region, it is difficult to commercialise. However, NGOs and government agencies are installing such systems in schools and community service centres. At the same time, NGOs are active in promoting solar driers for drying fruit in mountain areas in order to develop this as a cottage industry. Solar cookers have been developed by PCAT, PCSIR, and NIST but have not been disseminated in rural areas due to economic and social factors.

<u>Solar Photovoltaic</u> - About seven solar stations have been installed in various parts of the Northern Areas and Balochistan, with a total capacity of 234kW (HDIP 1996). These systems, installed by various donor agencies during the late 1980s for village lighting, are not in operation because of maintenance problems.

Wind Energy

Wind can be used to produce useful work for a variety of applications, such as pumping water, grinding food, or producing electricity. However, Pakistan has made very little headway in tapping this resource. DGNRER initiated a programme during the late 1980s to install a few wind generators and wind pumps. For example, one unit with a capacity of 20kW installed in Khurkhera, Lesbella District, Balochistan, is currently not in operation. The plight of wind pumps installed in Balochistan (per comm. DGNRER) is similar.

In 1985, with a budget of PRs 2.8 million, PCAT undertook to gain experience in the design and operation of wind technologies. However, no significant progress has been made so far. The council installed a few wind-measuring devices in Balochistan, but it is not clear to what extent the information on wind velocity has strengthened Pakistan's knowledge about the potential of wind resources in the country (PCAT 1992; Shehryar 1995). All wind data are received through the Pakistan Meteorological Department, but they do not seem to be reliable.

Improved Biomass Stoves

Most of the energy consumption takes place in the household for cooking, lighting, and water and space heating. More than 60 per cent of such needs in the NWFP and 80 per cent in Balochistan are met by fuelwood, and five to 10 per cent by dung cakes. The government's major emphasis on plantations has led the Forest Department and NGOs to launch afforestation programmes. About 90,000 acres of forest land have been leased for afforestation (GOP 1993). Social forestry has been encouraged and incentives, such as the selling of saplings at subsidised rates, have been provided.

Besides these efforts, energy-efficient cooking stoves have been designed by PCSIR and PCAT, and an improved design of the traditional stove has increased its use from 43 to 50 per cent and resulted in a 50 per cent saving of firewood. The front baffle controls availability of oxygen to the firewood, and the rate of burning, thus economising on firewood. The cavities around the cooling surfaces diminish heat loss, while the baffle at the outlet, i.e. near the chimney, traps the residual heat for subsidiary uses when the cooking stove is not in use. The chimney is cheaply made by recycling vegetable ghee tins. The stoves are made of traditional and easily available local materials, and the cost per stove is between PRs 50 and 80. The simplicity of design renders it very easy to construct in the remote mountains. So far 68,000 stoves have been distributed in rural areas of the NWFP and Balochistan by PCAT&DGNRER (Sarhandi 1996).

PCAT started the Fuel-efficient Cooking Technology (FECT) project in collaboration with GTZ to achieve fuel savings of up to 25-40 per cent in 150,000 households from 1990 to 1993 (Sarhandi 1996). This involved disseminating improved cooking/heating stoves and establishing bakeries as part of a viable system leading to the commercial dissemination of improved cooking devices through the private sector. The training and transfer of technology is carried out through five centres in the NWFP and four in Balochistan.

More than half the population of the country are women, the majority of them living in rural areas. Plagued by illiteracy, rural women face great hardships associated with motherhood, poor health conditions, and social constraints in their daily life. With this in mind, a pilot project was prepared in consultation with the International Labour Organization (ILO). The UNDP provided financial assistance, and PCAT implemented the project primarily for women; this involved the training in and dissemination of techniques for constructing cooking stoves.

Efficient Electrical Devices

Lighting Fixtures: When fluorescent tubes are fitted with an electronic choke electricity consumption is saved by up to 70 per cent. The private sector introduced this high-performance light fixture. The government has announced duty exemptions for its electronic components which will drastically reduce the price of the electronic chock (Maher, no date).

Main Findings

Poverty is one of the major obstacles in the adoption of RETs. Government efforts to introduce micro- and mini-hydelpower through NGOs like the Aga Khan Rural Development Board and international agencies (GTZ) have been successful.

Generally, RETs are capital-intensive. The private sector is not capable of investing in RET development. However, experience has shown that RETs can be successfully managed and maintained by local communities. Mountain communities should be encouraged to exploit the locally available resources to meet their growing energy needs, since sufficient potential exists.

5.2.2 Institutional Bodies for the Implementation of RET Programmes

Currently, several organizations are involved in various aspects of RET. The **Ministry of Science and Technology** (MOST) organizes various RET-related activities through the following institutions which are under its administrative control.

The **National Institute of Silicon Technology (NIST)** is an R&D institute created to develop solar photovoltaic technology. Solar cells have been developed by the institute. A 100-watt PV system was installed in 1994 at the Edhi Trust Medical Post in Islamabad.

The **Pakistan Council for Appropriate Technology (PCAT)**, previously ATDO, an administrative unit under MOST, has introduced different programmes to promote technologies that use the available resources of particular areas for the welfare of the people. The programmes include renewable energy, food processing and preservation, and water and sanitation in order of priority. Some work has also been planned to address environmental issues, housing, and income-generating technologies.

The PCAT has had reasonable success in the dissemination of micro-hydropower plants, having installed 200 units. In addition, 40 more potential sites have been identified, and work on these sites is in different stages of development. Similar progress has been achieved in the energy conservation and wind turbine programmes. The PCAT intends to augment its role in the design, fabrication, and development of energy-efficient appliances that increase self-reliance.

The **Pakistan Council for Scientific and Industrial Research (PCSIR)** has offices in Peshawar (NWFP) and Quetta (Balochistan), in addition to Karachi, Lahore, and Islamabad. The council is engaged in research and development of solar thermal technologies.

The **Solar Energy Centre (Hyderabad)** promotes solar thermal technologies. This centre has installed a solar desalination plant to make potable water from the Indian Ocean Gawadar Beach area, in Balochistan. Windmill and solar thermal programmes are in progress.

The **National Institute of Power (NIP)** has been engaged in the development of micro-hydropower plants in the mountainous areas of the NWFP. Recently this organization was closed by the government.

The **Energy Wing of the Ministry of Planning and Development** has been responsible for the overall planning and coordination of energy sector activities, while the Planning Commission undertakes studies on remote power generation, energy conservation, and renewable energy technologies.

The Directorate General of New and Renewable Energy Resources (DGNRER) under the administrative control of the Ministry of Petroleum and Natural Resources had installed several photovoltaic power systems (12 stations) in primarily rural, mountainous areas. Several biogas plants have been installed, but most of them are not functioning properly. Recently, this organization has merged with WAPDA.

SHYDO is a provincial (NWFP) organization and is responsible for power generation. With German Technical Assistance (GTZ), it has installed a number of mini-hydelpower plants in the province.

The **Northern Area - Pakistan Works' Department (NA - PWD)** carries out activities in developing mini-hydropower plants in the Northern Areas (NWFP). A number of power plants has already been installed, and those are being maintained by local communities.

The **National Energy Conservation Centre (ENERCON)** has initiated many studies in order to collect basic information, mainly on questions of commercial energy, which will serve as a benchmark in the planning and development process and, in particular, be used to work out options for the development of various forms of energy, including biomass.

5.2.3 A Review of Renewable Energy Policies and Programmes

The federal government is giving priority to developing RETs in Pakistan through the private and public sectors. The National Technology Policy has advocated that the renewable energy resources be exploited. The Eighth Five Year Plan (1993 - 98) clearly stated that the demonstration and promotion of renewable energy technologies are the primary responsibility of the organizations concerned (GOP 1994). Pilot systems were to be established in far-flung areas.

The government has an energy policy which also covers RETs in general but lacks political will and commitment. The provincial policies generally take the federal lead, the result being that very little has been done at the provincial level except in the field of micro-hydro power. There is no integrated plan for the development of RETs in the country, in general, and in the HKH Region in particular. Most institutions are working in isolation without any major impact.

Legislation and Regulatory Mechanisms

The government has legislation regulating the cutting of trees in order to prevent deforestation. This law is being implemented by the Forest Department through regular monitoring. In case of violations, strong action is taken by the concerned government agencies. On the other hand, due to poverty, the population is compelled to resort to cutting trees for their day-to-day fuel requirements. In addition, wood contractors also indulge in unlawful activities and take away trees to sell on the market or use for buildings.

A law has been promulgated to allow water in the rivers to be used for generating power. At the provincial level, the sites for micro- and mini-powerhydel plants have been allocated to the public sector. The government has encouraged this by decreasing the import duty on turbines that are not manufactured locally.

No standard has yet been devised on RET equipment at the national or provincial levels. It may be noted that the Institute of Standards has the needed authority, but no work has been carried out on this by them.

Economic Incentives

The price of conventional fossil fuels is to be gradually brought in line with international tariffs by phasing out the subsidy available on the import of oil. The government provides a subsidy on the price of kerosene and LPG within the HKH Region (Sharma et al. 1997). If the price of conventional fuel is not subsidised there is a possibility that mountain communities will slowly shift to RETs.

The government provides concessions on import duties for RETs, and a tax holiday of five years has been given for setting up industries based on solar energy technology in the country. Also, the import duty has been reduced (20%) on the import of turbines. No soft loans are available for RETs. However, loans for setting up cottage industries are available, and they can be used for the manufacture of RETs.

Rural Electrification Policy

The rural electrification programme is an integral part of the programme to uplift the socioeconomic conditions, living standards, and productive capacity of 70 per cent of the rural population. WAPDA, SHYDO, NA-PWD and PCAT are engaged in village electrification, having provided electricity to 60,144 villages in Pakistan during the period from 1985 to 1996, including the Northern Areas. The supply of electricity is erratic, and most of the areas suffer frequent load-shedding (WAPDA 1996 and 1997).

Afforestation Programme Policies

The total area under forests has been estimated at 4.20 million hectares or 4.8 per cent of the total geographical area of the country. This is inadequate to meet the growing demand for timber and wood, and at the same time to conserve and protect the environment. The existing forests are classified as 42.8 per cent coniferous, 37.6 per cent scrub, 7.6 per cent mangrove, and 6.5 per cent riverain. Irrigated forests account for 5.1 per cent and linear plantations for 0.4 per cent of the area. A long-term goal of the forest policy is to increase the forest area from the current level of 4.8 per cent to 10 per cent in the next fifteen years (GOP 1992 and 1993).

During the Eighth Plan (GOP 1994), high priority has been accorded to the development of forestry, watershed, and rangelands. Intensive forest management was carried out on government forests, and farm forestry promoted on private land to meet the growing demand for timber and firewood. The degradation of the watershed was arrested through afforestation, soil conservation, and proper management practices. In the case of rangelands, programmes for reseeding depleted areas with nutritious, high-yielding grasses and planting of fodder trees were promoted to meet the feed requirements of livestock.

The productivity of forests has been low. Some of the important factors for low productivity include poor regeneration and the low stocking of coniferous forests, faulty logging practices, deterioration of soil fertility, inadequate irrigation, poor quality of planting material, overgrazing, and demand for arable land for crop cultivation (GOP 1993).

The public sector organizations have also chalked out a plan to acquire 90,000 acres of vacant farmland on lease for afforestation (GOP 1993; Sharma et al. 1997). Progress in increasing forest area has been limited due mainly to financial and social constraints. Social forestry programmes have been started to involve peasants in tree-growing campaigns. These efforts have resulted in an area covering up to 47,000 hectares of farmland annually coming under various social forestry and watershed management programmes.

Private Sector Hydropower Generation Policy

Private investors are free to propose the implementation of a hydropower project at any location and opt for any type of equipment. Current policy covers all feasible hydropower plants with capacities of up to 300MW either the run-of-the-river type or the type with nominal absorption of daily flow fluctuations. A feasibility study needs to be prepared within the private sector in accordance with the criteria laid down by the World Bank or Asian Development Bank. Private power generation companies have been exempted from corporate tax on income earned from the sale of electricity. Companies are allowed to import all types of plants and equipment for generation, transmission, and distribution without payment of any sales' tax, flood relief, and other surcharges, and the import license fee. Only a customs' duty of two per cent on imported machinery needs to be paid (GOP 1996).

Policies on RETs

MMHP: The government of Pakistan attaches high priority to development of indigenous energy resources. The policy focusess on increasing the availability of electrical energy to all villages. In this context, the government has identified 100 feasible sites for micro-hydropower plants (<100kW) with a total capacity of 1,213kW and 89 feasible sites for mini- and small-hydropower (>100 and <15MW) with a total capacity of 350MW in the northern mountain areas.

Biogas Plants: The government has recently approved the installation of 20,000 biogas plants by PCAT in the rural areas with the help of an international agency. COMSATS is also going to install community biogas plants in about 50 houses with the help of UNESCO. This project has already been approved and will be implemented during 1997-98.

Financing and Private Sector Initiatives in the Energy Sector

Policy and Strategy: Participation of the private sector in power generation was finally permitted in 1985. However, physical progress remained slow. Except for the identification, documentation, and processing of projects with donor agencies, no significant progress was achieved during the Seventh Plan. The Eighth Plan (GOP 1994) envisaged that the private sector would play a key role in investment, production, distribution, research and development, human resource development, and the generation and mobilisation of resources. The main elements of the strategy to support this role would be the following:

- adoption of appropriate fiscal, monetary, trade, exchange rate, industrial, and other policies to attract private investment (domestic and foreign);
- expanding infrastructural facilities in the public sector, with the participation of the private sector;
- developing human resources;
- ensuring macroeconomic stability;
- maintaining law and order; and
- effectively using the exchange rate to sustain the competitive position of Pakistan without triggering a decline in productivity.

As a measure of financial support for the energy sector, where the private sector is relatively cautious because of the nature of the projects, the government has set up a Private Sector Energy Development Fund (PSEDF).

Indigenisation in Manufacturing: Maximum emphasis is to be laid on manufacturing energy sector equipment in Pakistan: The following measures are proposed.

- Efforts will be made to standardise the design and size of suitable power plants, and the participation of local industries in manufacturing them (partially or wholly) will be promoted. WAPDA will adopt the standardised designs of the plants and make them publicly known to promote indigenous manufacturing.
- WAPDA would maximise indigenous content in power plants. Further, special advantages will be given to the local components of manufacturers.
- NDFC will finance facilities and equipment manufactured locally. Similarly, other financial support will be organized to assist the local manufacturing industry.
- Joint ventures with foreign companies will be encouraged.
- Import of turn-key projects will not be ordinarily allowed.

Due to government policy, micro- and mini-hydropower plants are being installed by NGOs. The private sector has acquired some potential sites for MMHP plants. The Aga Khan Board for Rural Development has already installed MMHP plants.

5.2.4 Policy Issues Affecting RET Development

It is evident from the discussions that Pakistan in general has a poor record in this field, very little having been done so far to accelerate the development and commercialisation of renewable energy technologies in the country. A host of factors has impeded renewable energy technologies from making any meaningful contribution to alleviating the country's perennial energy problems. However, the following six factors stand out.

a) The nation has lacked a clear-cut and comprehensive national policy at the top for the development of RETs.
b) The high initial costs of most RETs have made them beyond the reach of most individual consumers or private enterprises.
c) Market distortions and imperfections have made energy from renewable sources appear more expensive than from non-renewable energy resources.
d) Suitable financial mechanisms and incentives have not been devised to promote pre-competitive but highly promising RETs.
e) The country has lacked the institutional capacity for indigenous planning and development of more challenging RETs.
f) Old planning tools and decision-making practices have not been conducive to fair competition between renewable energy sources and conventional fossil fuel options.

First and foremost, there is a need for a comprehensive national and provincial RET plan to strategically guide the development and deployment of renewable energy technologies in applications in which they can more realistically compete with conventional energy conversion technologies and by which their superior features can be exploited to the nation's best advantage. Since such a plan does not exist, most efforts made to make use of RETs have remained at best piecemeal and incoherent and thus have not led to the creation of sustainable markets for them. No special policies have been devised to ease the diffusion of renewable technologies into society, which is essential for commercialising these pre-competitive technologies. In the absence of interest and a clear-cut programme from the government, the systems that were installed have not been able to deliver the services for which they were designed, to the disillusionment of the owners and the detriment (i.e., eventual abandoning) of the projects.

Second, a major hurdle to RETs gaining a wider commercial acceptance has been their high initial costs which have placed them beyond the reach of even the most well-to-do energy consumers. This was true not only of renewable technologies designed for electricity production but other less sophisticated, direct energy conversion systems such as the passive solar heating of buildings, solar water heating, 'daylighting', and industrial heat production from biomass and solar thermal processes.

Third, the fuel and electricity market in the country has also remained distorted during the past few decades, and made the cost differential between renewable technologies and the alternatives to them based on conventional fuel appear much wider than it would have been otherwise. Production and consumption subsidies have kept the prices of competing fossil fuels for power production rather low, while electricity tariffs have been kept below their long-range marginal costs (LMRC) and, since fossil fuel prices do not fully reflect their relative environmental costs, the technologies based on them have looked deceptively good compared to RETs. Subsidies on diesel and kerosene fuels have compelled consumers to ignore energy-producing possibilities on remote sites from renewables such as solar, wind, or biomass, while artificially low prices for natural gas do not encourage consumers to search for alternative means to fulfill their heating needs from solar options.

Fourth, investment in capital-intensive and commercially untested renewable technologies have been beyond the reach of individual consumers, and, for most, private enterprises represent high-risk capital ventures. Suitable financing mechanisms are needed from the government to give a boost to young but upcoming renewable technologies. No such incentives have been considered necessary or have been devised to facilitate consumers in bearing the high initial costs of RETs. Even the small subsidy provided by the government on the installation of biogas units was later withdrawn, and the technical support from the government for proper upkeep of these units has not kept up with the demand placed on it. MMHP plants in the region can attract private investment if the national grid is extended to the Northern Areas and WAPDA signs an agreement on the purchase of electricity. The potential hydel power can be exploited as a cooperative effort between private and government agencies.

Fifth, since most RETs use resources that are diffuse, site-specific, and slated for distribution, they have therefore entailed much more detailed and rigorous site and resource analyses than are commonly required for conventional energy systems. Data on resource availability and the temporal variation in it, and the institutional capacity needed to match resource and technology to local needs, are not available. RETs are based on intermittent sources like the sun, wind, or rainfall and, therefore, entail some form of storage or back-up system to ensure uninterrupted supply, which adds considerably to their already high capital costs. The country needs indigenous R&D to search for cheaper storage or back-up for these systems and innovative ways to lessen the associated cost burdens. This capacity does not exist, and its lack is to the disadvantage of RETs.

The scientific and technological infrastructure required for undertaking R&D on RETs does not adequately exist. The poor institutional set-up does not allow for experimenting with new and innovative uses of renewable technologies in search of applications for which the labour-intensive nature of RETs could have been exploited to the region's advantage. At the same time, human resource development in the context of RETs is not significant. The development of the craftsmanship necessary to construct and maintain RETs is essential for the sustainability of the RET programme.

Sixth, energy planning in Pakistan is carried out by using tools that were developed by international lenders and development assistance agencies for comparing more established and centralized energy supply alternatives. The old rules established for comparing power generation alternatives have not been conducive to technologies, such as the renewables, the unique features of which (such as environmental soundness, modularity, lack of fuel dependence, and supply diversification) are not easily comparable using conventional planning tools. Those beholden to these rules thus were biased towards conventional fuel options when making decisions. Further, funding from international agencies has also been more easily available for less risky and more established energy schemes built around conventional fuels.

In general, power utilities are much better placed to experiment with these new and capital-intensive energy technologies in their systems. However, they have lacked the internal R&D capability for tackling unfamiliar technologies such as RETs. Despite their better position vis-à-vis this responsibility, they are simply not interested in what they do not consider to be part of their mission. They remain more preoccupied with issues of more immediate concern, such as operational and financial problems, than with developing, acquiring, or maintaining unfamiliar renewable technologies.

5.3 Conclusion and Recommendations

RETs contribute practically nothing to the HKH Region's energy supply, if the contribution made by large-scale hydropower is excluded from consideration. Most of the biogas plants installed as demonstration projects are non-functional today, owing to the lack of adequate maintenance and management. No assessment has been made by planners and decision-makers of ways to develop RETs in the region. No visionary RET policy exists at national or provincial levels, and hence no integrated plan has been devised to support it. The following conclusions bring together various recommendations to promote the development of RETs, particularly in the HKH Region of Pakistan.

The Need for Policies and Plans for RETs

There should be clear-cut policies on the various RETs. These should be drawn from an integrated plan to develop RETs in the country in general and in the HKH Region of Pakistan in particular. The plan should include an assessment of energy needs and yearly development targets. These targets should be clearly assigned to the organizations concerned. The Ministry of Planning, in association with other ministries, should develop such a plan and ensure its implementation through the responsible ministry.

Development of Institutional Capability for RET Promotion

Currently, various institutions are involved in the development, promotion, and demonstration of RETs in the HKH Region without any collaboration. Research and development do not provide an adequate base from which to produce or adopt RETs in accordance with the local environment. This is due to a lack of interest or motivation on the part of researchers and managers. The major obstacle is scarcity of funds.

There is a lack of initiative in the development of human resources among personnel working in the field of renewable energy technologies. There is a need for grassroots' level institutions within the region, and locally available manpower should be trained to produce and manufacture RET products such as cooking stoves, solar cookers, and solar water heaters.

Implementation and Monitoring of the RET Programme

The RET programme should be implemented by the assigned agency in collaboration with the local community. Various programmes related to RETs were and are being implemented, but they are not properly monitored. This has resulted in breakdowns and the loss or abandoning of various hydro, biogas, windmill, and solar photovoltaic (SPV) plants. It is, therefore, proposed that a local agency (with the participation of beneficiaries) should be established to manage and maintain RET projects. Traditional local social systems can also be used for this purpose so as to reduce management costs and deliver affordable energy. Innovation may also be encouraged in order to develop and improve the performance of the RET programme. The government should finance such development ventures.

Financial and Economic Incentives

Since RET programmes are capital-intensive (except afforestation, for which free saplings are provided), the prevailing low-income pattern of the mountains makes it mandatory that the government finance RET programmes, i.e., MMHP, biogas, and solar energy. International agencies may also be approached for funding in pursuance of a global environmental policy. This is only achievable if the government is willing to allocate reasonable funds for RET development.

Market reforms are also desirable in order to reduce the cost of RET-based products and industries. The government has announced the tax-free import of solar energy-based products, and this should be extended to all RETs. Similarly, the five-year tax holiday announced for the solar energy field should be extended to other RET equipment as well.

Economic incentives, such as soft loans, should be provided to entrepreneurs willing to establish an industry within the region, as the cost of transporting raw material is quite high under the prevailing mountain conditions. Legislative protection is needed to motivate potential private concerns to invest in the HKH Region.

Poverty Alleviation — Essential for RET Deployment

The main obstacle to the implementation and use of RETs in the HKH Region is the fact that commercialisation of RETs will only be possible when the prevailing patterns of poverty are eliminated. This can occur if production is increased through the deployment of various energy technologies that exploit the available resources within the region. The role of RETs for the alleviation of poverty in mountain communities is both feasible and desirable. A few examples are cited below.

Traditional farming has to be overhauled. Value-added crops could be sown for marketing in the plains for better returns and fruits conserved (dried). Crop residue needs to be preserved for winter use as livestock feed. In addition, there are a number of fast-growing tree species available to provide income from the sale of fuelwood. All of these requirements can be met with the judicious application of RETs.

Trained manpower (craftsmanship) should be motivated to develop a cottage industry for the manufacture of the basic tools of agriculture (in line with appropriate technology), energy-efficient devices, and other local goods (beekeeping and silkworm production) according to the potential of particular locations within the region. The government should provide soft loans to establish small cottage industries or businesses that employ RETs.

In view of the subsistence economy of the area, a cooperative system should be introduced at the community level, and loans should be granted to boost economic activities. Programmes to uplift women in rural areas by developing handicraft work should be implemented. Cooperative societies can initiate RET programmes at the community level, along with other development activities such as health care centres, telephone facilities, and the supply of potable drinking water. These activities should incorporate a conscious effort to use RETs rather than conventional fossil fuels.

5.3.1 A Proposed Policy for RET Development

The Government of Pakistan, in collaboration with the Government of NWFP and Balochistan, should formulate a policy for the development of renewable energy technologies in the region. An integrated renewable energy development plan should be framed, keeping in mind the HKH Region's needs. The proposed renewable energy policies should have the following features.

Continue Afforestation Efforts

a) New forestry areas would be earmarked, developed, and promoted on private lands to meet the growing demand for firewood. This should be done through economic and financial incentives provided by the government.

b) Improvement in the maintenance of forests by the government.

c) Improvement in the market structure for firewood and crop residue.

Encourage the Rational Use of Energy

The development and promotion of rational energy use require that efficient technologies for the production and consumption of energy be stimulated through economic incentives and tax rebates.

Encourage Commercialisation of RETs

a) **Micro- and mini-hydropower** plants should be encouraged in the private sector. This could be achieved if SHYDO, NA-PWD, and WAPDA ensure the purchase of power. This is possible if the national grid is extended to the HKH Region.

b) **Wind** surveys for the assessment of potential sites should be conducted.

c) **Wind and solar** electrification and water pumping demonstration units should be installed by the government agencies. Solar thermal technologies should be demonstrated initially by the government agencies at community centres and promoted so as to develop and commercialise RETs. Appropriate funds should be allocated.

d) **Biogas** plants should also be installed for demonstration purposes. Training should be imparted to the people so that the local community is able to build and operate biogas plants independently.

Provide Financial and Economic Incentives

a) Duty should be lifted from the import of RET equipment, and a tax holiday should be provided to set up RET-based industries.

b) Sales' tax and excise duty should be lifted from the sale of RET equipment.

Promote Institutional Development

a) Institutions should be established at the grass-roots' level.

b) Regular training programmes should be organized to upgrade the craftsmanship of local entrepreneurs.

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Plight of solar photovoltaic electrification scheme (30kW) due to lack of maintenance in the Northern Areas of Pakistan

Different types of improved biomass stoves demonstrated at an environmental fair in Peshawar, Pakistan

Chapter 6
A Case Study of Micro-hydropower in Nepal

By S. Shrestha[1] and V. B. Amatya[2]

6.1 Introduction

Water wheels are effective devices for converting the motion of flowing water to steady mechanical power for the generation of electricity. Basically four types of unit are considered for rural applications. These are: i) traditional water wheel; ii) multi-purpose power unit; iii) cross-flow turbine; and iv) peltric-set, as shown in Figure 6.1.

For centuries, traditional water wheels have been made in Nepal using indigenous skills and materials. As a result, there is little conformity in design or performance; and replacement parts must be handcrafted to match the original. These units are limited to an output of about one HP and can be used for grinding only. Wood is the most common construction material and is used for all parts of the wheel except the main points of rotation where steel sleeves or rudimentary bearings are installed (Rijal 1993). The water for these units is typically supplied through an existing irrigation canal or a short diversion from a river. A wooden chute directs this flow to the exposed blades.

The multi-purpose power unit is basically an improvement on the traditional water wheel. There is a marked increase in unit efficiency because of an improved blade design and closed penstock. Though the unit is not powerful enough to drive all of the machinery simultaneously, the equipment can be changed easily, by disconnecting one drive belt and connecting another from a generator, for example. These devices are available in Nepal as off-the-shelf plants with capacities ranging between five and 20HP and are suitable for operation as an electrical add-on system, which can be disassembled for transport and easily reassembled on site (ICIMOD and CRT 1998).

Lower capacity (5-15kW) cross-flow turbine units are particularly suitable for electrical add-on systems, while medium capacity (25-50kW) units are suitable for electri-

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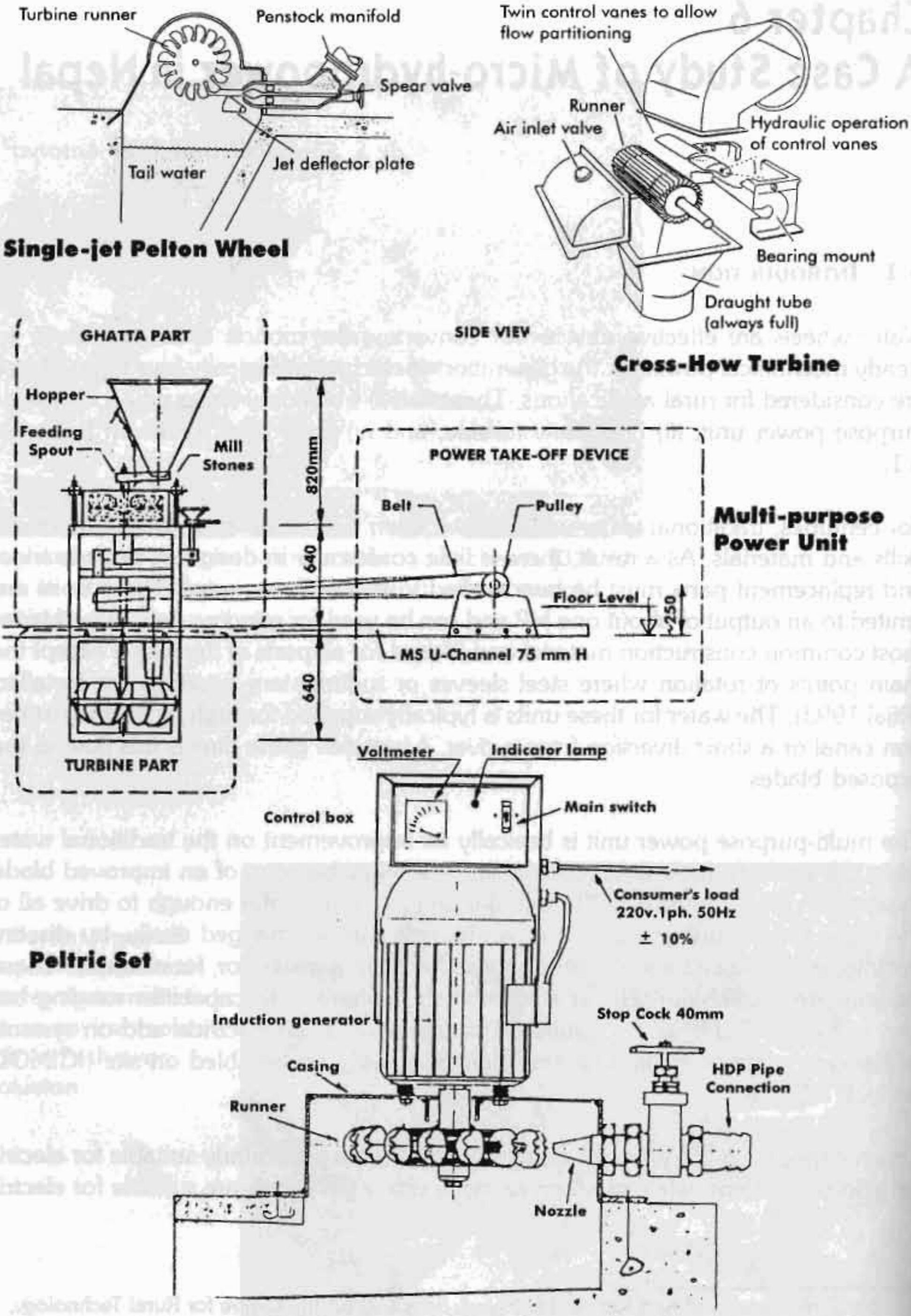


Figure 6.1: Different types of Micro-hydropower Plants

cal power production. The basic design of this type of turbine is a cylindrical runner with curved blades fixed on the outer rim. Water enters from the top or front, flows through the blades, thus crossing the blade twice as it passes across the runner. The flow of water occurs in a closed system. These turbines display characteristics of both impulse and reaction turbines (PEP 1995).

A peltric set is a small vertical shaft Pelton turbine with a generator co-axially coupled with it. It generates electricity from a small quantity of water which falls from a great height on the turbine to operate it. Such a device is the simplest form of combined turbine and generator, the turbine being of the impulse type and the generator of the induction type. An impulse turbine derives its power from the water pressure caused by a high head that accelerates the water through a nozzle, allowing it to strike a number of specially designed buckets attached round the periphery of the wheel. The induction generator produces electricity when it revolves at its designed speed, given the right number of excitation capacitors (CRT and ICIMOD 1998). It can be operated with a small quantity of water: 2.5-20 litres per second; and a falling head of 45-50m of gross head. Power output is 600W- 5kW at 220V single phase.

The traditional water wheel (less than 1kW) is found throughout rural Nepal. It is estimated that there are over 25,000 such traditional *ghatta*(s) (GATE 1983) in operation, meeting the agro-processing energy needs of the scattered villages in the hilly and mountainous regions. Of them, about 350 units have been improved to a power output in the range of one to three kW. There are 947 units of micro-hydropower (3-30kW) with the installed capacity of 8.6MW (Table 6.1 and Fig. 6.2) out of which 311 units (2.65MW) are for electricity generation. In addition, there are more than 131 units of recently developed peltric sets (1-5kW) in the hills. Such sets are being used increasingly for electrification by individual as well as groups of households.

Table 6.1: The Number of Micro-hydropower Installations in Nepal (1995)

Development	Mountain		Hill		Terai		Total	
Region	No.	kW	No.	kW	No.	kW	No	kW
Micro- Hydropower Plants								
Eastern	23	279	75	766	4	25	102	1,070
Central	56	526	164	1,453	11	105	231	2,084
Western	14	178	358	3,218	11	89	383	3,485
Mid-western	21	272	156	1,247	14	94	191	1,613
Far-western	14	162	26	218	0	0	40	379
Total	**128**	**1,415**	**779**	**6,902**	**40**	**313**	**947**	**8,630**
Peltric Sets								
Eastern	10	2	80	7	0	0	90	9
Central	1	2	1	1	0	0	2	3
Western	1	5	32	3	1	3	34	11
Mid-western	3	1	1	4	0	0	4	5
Far-western	1	2	0	0	0	0	1	2
Total:	**16**	**11**	**114**	**15**	**1**	**3**	**131**	**29**

Source: WECS 1995

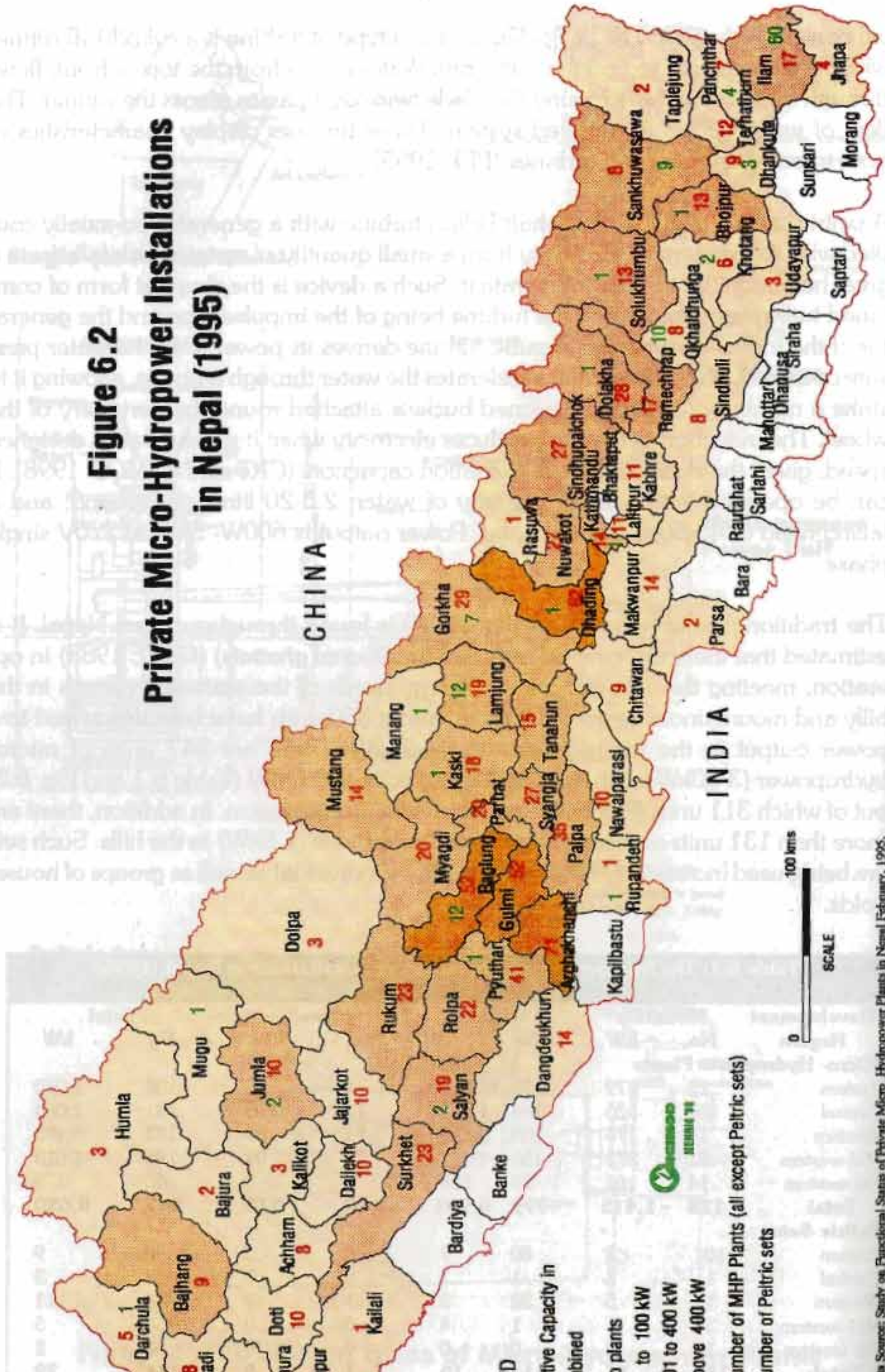


Figure 6.2
Private Micro-Hydropower Installations in Nepal (1995)

The investment cost of micro-hydropower plants is site-specific, the average installation cost varying from NRs 75,000 to 125,000 per kW. The average O&M costs of micro-hydro plants vary widely, depending on the type of ownership (individual, group, or community), location of the site, end uses, and type of turbine. Various studies show that the O&M costs vary from as low as two to three per cent to as high as 50-60 per cent of the total project cost.

The factors that have contributed to bringing the micro-hydro development programme to its present stage are the relatively low capital investment requirements, short construction periods, existence of large micro-hydro potential, indigenous technology of Nepali manufacturers, simple operation, government incentives in the form of loans and subsidies, and the involvement and interest of many international agencies.

6.2 Intermediation and Private Sector Participation

The role of financial intermediary is being played by the Agricultural Development Bank of Nepal (ADB/N). In the mid-seventies, it started to promote micro-hydropower for agro-processing in rural areas in order to stimulate the rural economy. ADB/N creates groups of small farmers, under the Small Farmer Development Project (SFDP), where this technology is feasible. Since 1993/94, it has handed over the management of 31 SFDPs to their group members, after converting them to cooperative societies. Wholesale lending (loan fund) is made available to these societies by ADB/N for relending to their members in order to minimise operational costs. Apart from domestic financial sources, grant and loan assistance is being received from bilateral and multilateral donor agencies such as USAID and SNV/Nepal.

The role of technical intermediary is being carried out by investors (NEA, micro-hydro entrepreneurs), though upgrading of technical and operational skills is hampered by the acute shortage of trained technicians. Still, national institutions (WECS, NEA) as well as international organizations such as ITDG, ICIMOD, and UNDP are currently engaged in preparing training materials, while at the same time examining the socioeconomic, cultural, and institutional issues, along with the safety concerns, that ensure the sustainability of micro-hydro installations. Manufacturers themselves train operators during the installation of micro-hydro plants despite the fact that they lack managerial skills. CRT, it is true, organizes regular training programmes for *ghatta* technicians. Nevertheless, there is a gap in terms of institutions that can provide technical backstopping, a function that the successful dissemination of micro-hydro depends upon.

There is limited research and development activities with regard to micro-hydropower development. Some sporadic research activities have been carried out by the Development Consulting Service (DCS), Intermediate Technology Development Group (ITDG), Deutsche Gesellschaft fur Technishe Zusammenarbeit (GTZ), RECAST, Balaju

Yantra Shala (BYS), and Kathmandu Metal Industries (KMI) for the development of suitable technologies to improve efficiency (e.g., innovation of low-cost MPPUs, improved *ghatta*(s), and peltric units) and appliances to promote end-use diversification (e.g., low-wattage cookers, and electric driers).

There is a well-developed manufacturing capability within Nepal for the construction of micro-hydro plants. Swiss Technical Assistance support to BYS and United Mission to Nepal's (UMN) support to DCS have been instrumental to the rapid growth of the micro-hydro construction industry. The development and promotion of micro-hydropower is being handled mainly by the private sector. At present, there are about nine manufacturers of turbines and accessories (see Box 6.1) capable of manufacturing turbine equipment up to 300kW, and they are located mainly in Kathmandu and Butwal. Some of them have a built-in capability to produce turbine casing, penstock pipes, electro-mechanical equipment, and other accessories for hydropower plants up to 15MW in capacity. The total manufacturing capacity of all the manufacturers is more than 2MW per year.

Box 6.1: Micro-hydro Manufacturers and Their Activities

Manufacturers	Activities
Balaju Yantra Shala (BYS)	Established in 1960, BYS is a joint-venture project of the Nepal Industrial Development Corporation (NIDC) and Swiss Development Corporation (SDC) Assistance, formerly SATA. Besides other products, it manufactures cross-flow turbines and associated equipment. It has exported micro-hydro turbines and equipment to some Asian and African countries and has support from the Swiss Development Corporation for research and development activities. SKAT, a Swiss agency for the promotion of appropriate technology, is also working closely with BYS.
Development and Consulting Services (DCS)	Established jointly by HMG/N and UMN in 1970, DCS conducts survey, design, and installation activities for micro-hydropower plants. Butwal Engineering Works (BEW) supplies water turbines to DCS. ITDG has financially and technically supported the DCS rural electrification project.
Nepal Yantra Shala and Engineering (NYSE)	Established in 1975, NYSE makes products ranging from improved grinding wheels to cross-flow turbines.
Kathmandu Metal Industries (KMI)	KMI is Nepal's oldest turbine-manufacturing workshop. It designed the first MPPU, and currently manufactures cross-flow and Pelton turbines. Recently, it started manufacturing peltric sets for small power outputs.
National Structure and Engineering Co. (NSECO)	NSECO was established in 1966. It manufactures cross-flow and water turbines.
National Power Producers (NPP)	NPP is a mechanical workshop which manufactures electric controls, induction generator controllers, and electric load controllers.
Nepal Hydro and Electric P. Ltd.	Set up jointly in 1985 by Butwal Engineering Works (BEW), UMN/DCS, and Kvarner, a Norwegian company, it has secured the technical support needed to produce turbines, governers, and related equipment in the range of 100-1,000kW.
Nepal Machine and Steel Structures (NMSS)	Established in 1986 as a private company, NMSS manufactures water turbines and related equipment.
Thapa Engineering Industry (TEI)	Set up in 1973, TEI specialises in cross-flow turbines.

The companies manufacturing micro-hydro in Nepal have instituted the Association of Micro-Hydro Manufacturers (AMHM) as a platform for the development of the micro-hydro industry and micro-hydro sector. The association has set common standards for the industry. It is also playing a leading role in creating awareness about micro-hydropower by organizing exhibitions, publishing a newsletter, and conducting training programmes.

6.3 The Subsidy Scheme

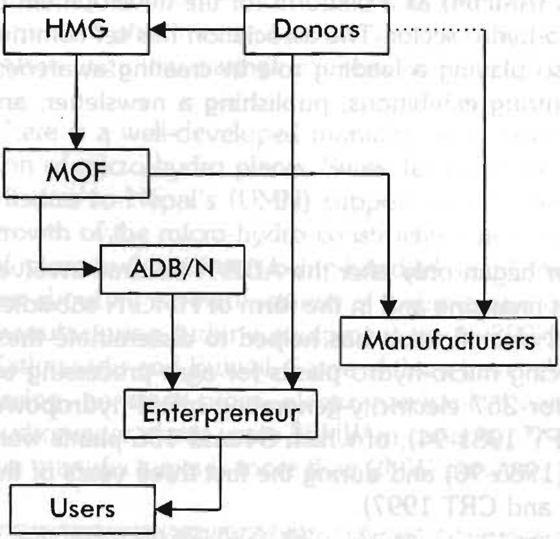
Extensive use of micro-hydropower began only after the ADB/N became involved in its promotion in the form of debt financing and in the form of HMG/N subsidies. The provision of subsidies for rural electrification has helped to disseminate these units more speedily. Besides financing micro-hydro plants for agro-processing activities, ADB/N provided backing for 257 electricity-generating micro-hydropower plants over a period of 14 years (FY 1981-94), of which 84 and 156 plants were installed during the Seventh Plan (1985-90) and during the first three years of the Eighth Plan, respectively, (deLucia and CRT 1997).

The subsidy on rural electrification was introduced in 1985, but discontinued in 1986. It was reintroduced in 1988 and once more discontinued from 1990 until 1992. The government again started releasing subsidies from 1993. The inconsistency in the implementation of the subsidy scheme is one of the reasons that manufacturers have not been able to rely solely on the income generated from the construction of micro-hydro plants; they do not see an assured market, and the risk involved is high because of government vacillation. For example, the annual turnover from micro-hydro amounts to less than five per cent in the case of BYS.

The present policy makes provision for subsidies only on the cost of electrical equipment and transmission and distribution systems. The subsidy is 75 per cent in remote mountainous districts and 50 per cent in the remaining districts. It does not differentiate between stand-alone (exclusively for electricity generation) and add-on plants (agro-processing equipment and generators), 20-40 per cent of the total plant cost being covered depending on project configuration. ADB/N is responsible for channelising the subsidies. It not only provides loans and subsidies but also assistance for surveys, feasibility studies, promotion, and training. The existing micro-hydropower subsidy flow mechanism is depicted in Figure 6.3. In the case of peltric installations, a subsidy is also provided for the cost of up to 100m of polythene pipe used in penstocks.

Foreign donors have also been assisting micro-hydro projects. For example, USAID, working through the Private Rural Electrification Project, provided a capital subsidy (40-50% depending on site), training, and administrative support to three micro-hydropower projects (deLucia and CRT 1997).

Figure 6.3 Flow of Micro-hydro Subsidies



The amount of subsidy provided for micro-hydropower is nominal if compared with the total investment budget for the hydropower sector. For example, the subsidy on micro-hydropower amounted to 0.3 per cent of the total expenditure in the power sector for FY 1996/97. This accounted for 15 per cent of all subsidies allocated to alternative energy programmes.

The existing subsidy policy on micro-hydropower does not take into account the remoteness of sites and transportation costs. Because of the mountain topography, there are many areas that are far from the few roads available. The level of subsidy should be linked to transportation costs rather than being awarded on a district basis.

The present scheme excludes subsidy facilities for self-financed projects, since subsidies are channelled through ADB/N to loan-financed projects only. Entrepreneurs who borrow from banks are required to pay interest on the subsidy until it is liquidated, which sometimes takes a few months. Such borrowers are required to provide land and buildings as collateral in order to be eligible for bank loans. They may not have sufficient land, or land values may be too low in rural areas to cover the cost of a micro-hydro project. This lack of physical collateral has kept entrepreneurs from taking advantage of subsidies.

6.4 Issues and Options

Various issues identified from case studies are related to policy and institutional matters, economic and social questions, and technical factors. These are briefly summarised in Table 6.2 and discussed in the following. Based on the issues identified, appropriate options are also discussed.

6.4.1 Water Rights

Water rights are among the critical issues identified in the case of the Charaundi electrification scheme. The diversion of water supplying the micro-hydro plant for irrigation shut the plant down. In the Water Resources Act, 1992, priority is given to irrigation over hydropower, but it is not clear whether an irrigation scheme can

Table 6.2: Issues Pertaining to Micro-hydropower Plants

Case Study	Policy/strategy	Institutional	Economical	Technological	Social
Ghandruk micro-hydro	Water rights of the non-beneficiaries of MHP	a) Critical role of technical and financial intermediaries on the success of MHP b) A syndrome of dependency of the community on Annapurna Conservation Area Project (ACAP)	Outside financial support is the critical component of MHP	Low load factor and quality testing of equipment necessary before installation	a) Coherent educated community of Gurungs a key factor for successful community management
Barpak micro-hydro	a) Lack of a legal framework to protect the interests of the utility company b) Harassment during establishment of the plant	a) Lack of technical and managerial support in the initial phase, and of monitoring after installment b) An exceptional example of successful micro-hydro in a remote area/Entrepreneur should have the following qualities: • leadership and enthusiasm • managerial capabilities • sound economic background	a) The time lag between the installation and the load factor increases up to break-even point and upsets the financial output of the plant envisaged during the feasibility study.	a) Poor technical know-how increases the investment cost; poor transmission poles b) Risk of floods and landslides to MH plant	a) Coherent educated community of Gurungs a key factor for successful community management
Salleri Chialsa mini-hydro		a) innovative management practices lead to better plant performance b) Lack of coordinated effort on rural industrial development c) Cumbersome procedures for bank loans coupled with high interest rates		Need for active research on appropriate technology for rural industrialisation and electricity applications in rural settings	
Sikles micro-hydro		a) An organized and cohesive community is one of the reasons for the success b) Support of technical and financial intermediaries (ACAP) is also a key factor in its success	a) Lack of loan accountability b) Flat tariff leads to high load factor	a) Need for active research on productive end use of micro-hydro for rural industrialisation	a) Need for encouraging villagers to invest in their village

Case Study	Policy/strategy	Institutional	Economical	Technological	Social
Improved *Ghatta* in Jumla	a) Need for policy-level emphasis on promotion of improved *ghatta*	a) Support of technical and financial intermediaries (CRT/CSD) is critical for the technology dissemination	a) Community-owned/managed *ghatta* in rural setting where no charge is collected	a) Enough room for improvement in wooden chutes, vibrators, grinding stones, etc	
Urthu, Jumla micro-hydro	a) Need for policy-level encouragement of rural industrialisation through emphasis on productive end uses	a) Need to strengthen the organizational, managerial, and technical skills of the community before installing community-owned/managed MH plant	a) Need for training in transparent and simple book- and record-keeping systems b) Need for revenue-generating productive end-use applications	a) Lack of timely service on the part of the manufacturer b) Need for clear-cut guidelines for project feasibility studies	
Pancha Krishna MH, pioneer of Dhading	a) Insensitive subsidy policy on canal construction and micro-hydro mill	a) Lack of security of MH plant with respect to possible future water source use (drinking water and irrigation)	-	a) Long earthwork canal of individually-owned MH plant is difficult to maintain b) Natural calamities cause frequent damage	
Charaundi, Dhading micro-hydro mill	a) Water rights' problem due to the later development of an irrigation project using the same source	-	a) Higher interest rate from the bank b) Poor book and record keeping system	a) High maintenance costs of the long earthwork canal b) Competition from the diesel mill due to subsidy on diesel and absence of locational barriers	
Kali Daha, Dhading micro-hydro	Need of clear-cut policy on damage due to floods and landslides	-	-	a) High maintenance cost of long earthwork canal	

Source: ICIMOD 1993; WECS/UNDP 1994 ; WECS 1995; IUCN/CRT 1996; and detailed field surveys carried out by the study team divert water that is already in use for hydropower generation. In the case of such diversion, compensation provisions for the plant need to be made explicit.

6.4.2 Promotion of the Multiple Use of Water Resources

The multiple use of water resources, such as peltric units and fish farming (as in the case of Pancha Krishna), trout culture in micro-hydro water canals, sprinkler irrigation in peltrics, tail end water use in irrigation, and the use of peltrics in break pressure tanks, should be promoted.

6.4.3 Choice of Technology

The dissemination of smaller units such as improved *ghatta*(s), can bring positive advances in performance over the traditional *ghatta* and economic gains to marginalised *ghattera*(s), and also reduce drudgery at the household level (CRT 1995), as in the case of Urthu. During the planning phase, therefore, these smaller units should be given due importance.

6.4.4 The Increase of Diesel Engine Mills

An increase in the number of mills operated by diesel engine and a reduction in the operation of micro-plants is one of the major observations made during the field survey. The constraints faced by micro-hydro plants, such as location, water resource utilisation, the high maintenance cost of a long canal, and lack of subsidy for the mechanical components (as against the high subsidy for diesel), are a few reasons for this.

6.4.5 The Need to Differentiate among Management Practices for Micro-hydro Technologies

There are various technologies and management practices within micro-hydro, and they require an in-depth understanding and set of policies for making them financially viable and technically and environmentally sound. *Ghatta*(s), improved *ghatta*(s), peltric sets, stand-alone generating plants, turbines with a mechanical drive only and those with an electric add-on are a few relevant parts of the classification. On the basis of these technologies one should differentiate between policies, so that, for instance the improved *ghatta* used for electrification in Urthu and Ghandruk is not dealt with at the same level as uniform policy tools. There is also a distinct need to classify micro-hydro according to the mode of management. Different modes of management will require different levels and kinds of support. Indeed, they play a vital role in the successful operation of the plant. For example, plants managed by *private entrepreneurs* require strong zeal, innovative ideas, good management capabilities, social commitment, and leadership from the entrepreneur. The electrification of Barpak is an excellent example of such a scheme. It has been found that an agent (third party) needs to be present who is capable of enforcing community-accepted rules for the successful operation of *community-managed plants*. Further, strong community organization, democratic leadership, technical and managerial skill enhancement, and continuous technical back-up are necessary pre-conditions for making micro-hydro ventures successful, as illustrated by the Ghandruk and Sikles electrification schemes. Salleri Chialsa's innovative management approach (i.e., *limited liability* or *public company plant*) is a good example of a professionally managed scheme which has led to the financially successful operation of the plant and, thereby, contributed to the overall development of the rural area through rural industrialisation.

6.4.6 Unrealistic Project Feasibility Study

An accurate project feasibility study and design are essential for the success of any enterprise. The overambitious projection of use of electricity by villagers in feasibility studies is one of the main reasons for failure (deLucia and CRT 1997). Similarly, unrealistic provisions for the maintenance of long earthwork canals and inaccurate head/discharge measurements have forced many micro-hydro entrepreneurs to face financial loss and often bankruptcy. In preparing a feasibility study, it is important to recognise the implications of the assumptions one is making about the socioeconomic base, the technical and managerial capabilities of the community, and market potential (or load estimation). For example, the micro-hydro plant of Saroj Adhikary in Jogimara has not been operational since its installation due to faulty survey and design.

6.4.7 Accountability of Services Provided for Feasibility Studies and Designs

The accountability of surveyors and manufacturers needs to be ensured through appropriate institutional mechanisms. The cost of a feasibility study should be reimbursed regardless of the project's feasibility. However, the question poses some problems. One solution would be that a third party, a consulting firm or micro-hydro association, in a manner acceptable to the manufacturer, entrepreneur, and bank, conduct the feasibility study. The cost of the study would eventually be borne by the entrepreneur if the project is implemented. Otherwise the cost would have to be reimbursed to the consultant through making available some kind of funding from the bank. There is also some need for a financial commitment on the part of the entrepreneur during feasibility studies to ensure genuine interest.

6.4.8 Technical Back-up and Monitoring

Technical back-up and monitoring is one of the main issues in the field of micro-hydropower. As a bank is a financing agency, it monitors only from a financial perspective, while manufacturers are by nature profit-making entrepreneurs, their main concern being the sales' volume of their micro-hydro equipment. There is no agency to monitor the performance of micro-hydropower plants. According to the micro-hydro owners, bank officials, and manufacturers interviewed, "There should be a monitoring and backstopping agency to improve the technical and managerial capabilities of the micro-hydro manager to make the micro-hydro plant a technically, economically, and environmentally sound venture."

6.4.9 Insurance of and Warranties on Plants

A case study of micro-hydropower in Dhading has revealed that serious damage was done to plants due to the floods in BS 2040 and 2051. This was the reason, for example, why Pancha Krishna discontinued operation of this plant in Malekhu. In order to save entrepreneurs from such calamities, insurance should be made mandatory. Similarly, long-term warranties provided by manufacturers could be instrumental in avoiding losses that may accrue to the plant owner due to manufacturing defects.

6.4.10 Training of Operators

Most of the micro-hydro plant operators interviewed have not received structured training (CRT 1995). Availability of trained operators is a prerequisite for the successful operation of micro-hydro plants. Offering structured training should be made mandatory for manufacturers, while there is also a need for them to provide 'training to trainers of training skills'. Most of the micro-hydro plant owners and managers need training regarding the management of plants (simple record and account keeping, simple business skills, etc).

6.4.11 Quality Control and Standardisation

According to farmers interviewed, the micro-hydro plants installed in the initial stages during the 1980s are of better quality than those being installed at present. The quality of raw material used, the safety code to be followed during installation, and the rated power of turbines and generators need to be standardised; many complaints having been voiced by plant owners in this respect. There is also a need to have a monitoring agency for the quality control and standardisation of installed micro-hydro plants.

6.4.12 End Use Diversification

It is observed in almost all micro-hydro plants (except peltrics) that supplying electricity for lighting alone is not financially viable due to the low load factor. Technologies have been established for diversified end uses such as agricultural processing (grinding *chakki*, hulling, pressing oil pounding, *chiura* (beaten rice), shelling, etc.). There is a need for research on and development and promotion of the other innovative technologies needed locally, including cold storage, small dairy operations, ice production, crop or fruit drying, power looms, carpet weaving, rural transportation, wood carving, handmade paper, and food processing. These developments will not only increase the profitability of plants by increasing the load factor but also bring positive changes to the village economy through rural industrialisation. A special fund should be allocated for such technology research and development.

6.4.13 Maintenance of Earthen Canals

The characteristics of feeding canals are one of the critical factors determining the smooth operation of micro-hydro plants. High seepage, damage from frequent landslides and floods, and blockage result in high maintenance costs and the unreliability of plant operations. The availability of construction manuals and an enforced code of standards for constructing canals will result in reduced costs for maintenance.

6.4.14 Gender Issues

Since agro-processing, cooking, and weaving activities are primarily carried out by women, use of hydropower can be expected to have a significant impact on women's work loads, increase their productivity, and improve their health conditions (see Tab. 6.3). The installation of MHP has not only reduced the drudgery of women but also altered the division of labour between the sexes. For example, previously only women were involved in grinding and husking operations, but, after the installation of MHP, male family members also carry loads for processing. Regarding the participation of women in the planning, implementation, operation, and management of micro-hydro plants, no documentation exists. As there is no gender-oriented policy for the development of micro-hydro, it may be assumed that women's participation in micro-hydro projects, particularly the aspects of them just mentioned, is either non-existent or quite negligible.

Table 6.3: Women's Daily Allocation of Time before and after the Installation of a Micro-hydro Units

Time	Before	Time	After	Remarks
3:00-4:00	Get up, do grinding and husking	3:00-4:00	Sleep	
4:00-5:00	Cook animal food and feed cattle, do cleaning	4:00-6:00	Get up, cook animal Food, and do cleaning	
6:00-7:00	Make fire, fetch water, milk cow and boil milk, prepare for puja	6:00-7:00	Make fire, fetch water, milk cow and boil milk, prepare for puja	
7:00-8:00	Prepare breakfast, feed children, send children to school, feed men, and eat themselves	7:00-8:00	Prepare breakfast prepare, feed children, send children to school, feed men, and eat themselves	
8:00-10:00	Prepare lunch	8:00-10:00	Prepare lunch	
		10:00-11:00	Rest	
10:00-11:00	Collect grass, fuelwood, and fodder for animals	10:00-11:00	Collect grass, fuelwood, and fodder for animals	
11:00-12:00	Lunchtime, clean utensils and house	11:00-12:00	Lunchtime, clean utensils and house	Collect fuelwood once a week
12:00-14:00	Provide water for animals and do grinding and husking	12:00-14:00	Provide water for animals	
14:00-15:00	Prepare *khaja* and do cleaning	14:00-15:00	Prepare *khaja* and do cleaning	
15:00-17:00	Collect grass, fuelwood	15:00-17:00	Collect grass, fuelwood, sometimes go to mill for grinding	Sometimes her husband and son help to carry grain to the mill
17:00-18:00	Prepare animal food	17:00-18:00	Prepare animal food	
18:00-21:00	Cook dinner, feed children, feed adults, and eat	18:00-21:00	Cook dinner, feed children, feed adults, and eat	
21:00-23:00	Clean utensils and sleep	21:00-23:00	Clean utensils and sleep	

Source: Field study (Gajuri) and A Gender Analysis Vols. I and II, Dolkha-Ramechhap Community Forestry, Resource persons: Mrs. Sunmaya Shrestha and Mrs. Panch Kishna Shrestha

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Chapter 7
A Case Study of the Biogas Programme in Nepal

By R.N. Gongal[1] and S. Shrestha[2]

7.1 Introduction

Biogas is produced by the anaerobic digestion of organic wastes and water, for which an airtight digester is a prerequisite. The digestion process ferments the organic materials in the presence of a natural mixed bacteria culture and produces gaseous products and a liquid effluent. The gas consists of a mixture of methane (50-60%), carbon dioxide (30-40%), and other gases, including hydrogen, nitrogen, and hydrogen sulphide. Hydrogen sulphide gives biogas a slightly pungent smell. Biogas is colourless and non-toxic. Its yield rate is temperature-dependent, the optimum temperature being 33°C. Biogas is mainly used for cooking and lighting and sometimes as a fuel for internal combustion engines. The mixing ratio of diesel to biogas is theoretically 20:80, but a 40:60 ratio is frequently reported by users. The effluent is used as a wet or sun-dried fertilizer, and is superior to green manure in nutrient content. The digestion process reduces the level of pathogens within the dung and therefore may generate public health benefits (Rijal 1993, PEP 1995). The two main types of biogas plants are the floating steel drum (Indian design) and fixed-dome (Chinese design) models, as shown in Figure 7.1 (CRT and ICIMOD 1998).

The drum type consists of underground two-compartment chamber digester pits with a floating steel drum gas holder. Slurry is fed into the base of one chamber from a cemented inlet pipe. The gas rises and is collected inside the drum, while the effluent overflows into the second chamber. Then the slurry is expelled through an outlet pipe, which is situated at a lower level than the inlet pipe. The few modifications to a biogas plant designed by the Khadi and Village Industries' Commission (KVIC) to suit Nepalese conditions are as follow: the pit tapers down into the ground; gas is removed through a central guide pipe; and the two-compartment chamber has been designed. The floating drum holds 60 per cent of the daily rated gas output. The gas pressure, which is supplied by the weight of the drum, is 10cm of water head (WECS 1987, Rijal 1993). The gas drum has to be prefabricated in a workshop and carried to the plant site.

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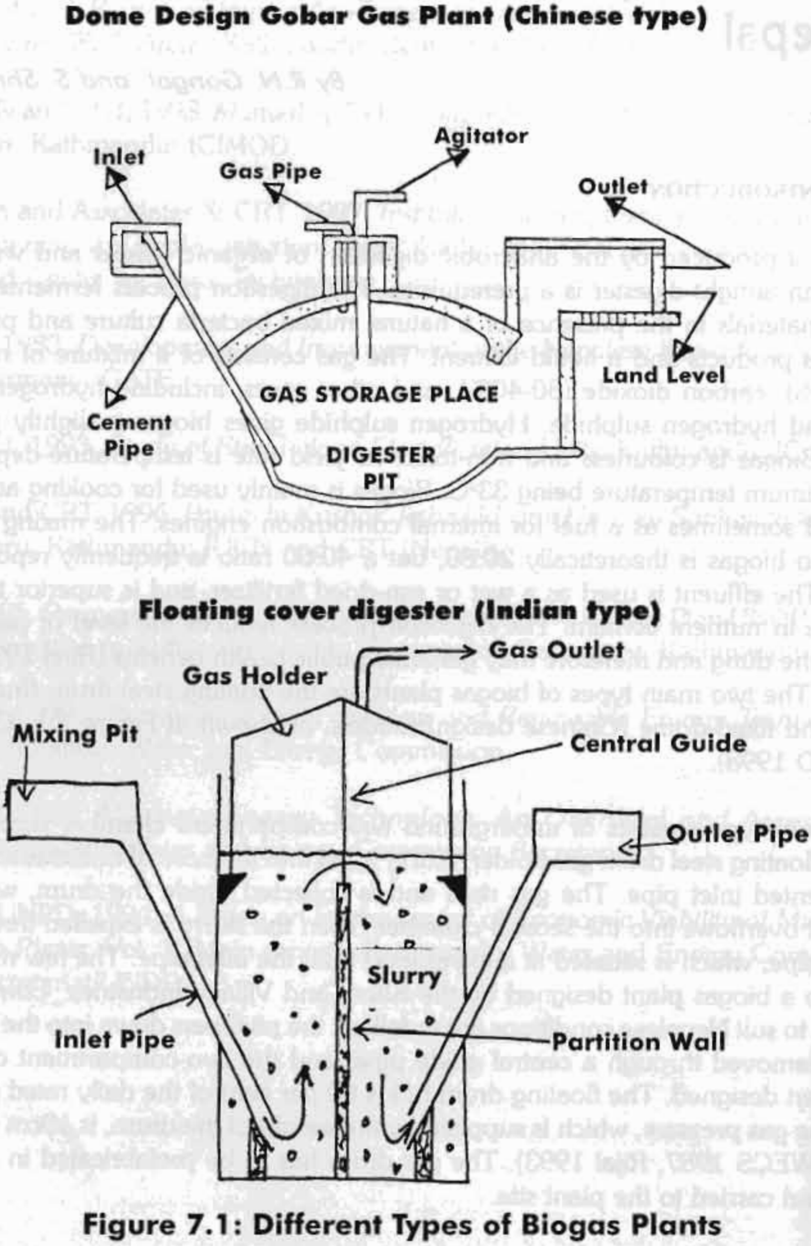


Figure 7.1: Different Types of Biogas Plants

As the steel drums are expensive and difficult to transport, the fixed-roof gas plant, called the dome type, eliminates this component. As the gas forms, instead of pushing the drum up, it pushes the slurry down, forcing it into the input and outflow chamber. When the gas is used, the pressure diminishes, and the slurry flows back into the main pit. The plants have been modified slightly for use in Nepal. The major modification is a fixed stirrer which breaks the crest on the surface of the slurry in the plant and thereby maximises gas production (Rijal 1993). It can be constructed at the site with locally available materials (except cement and GI pipes), so currently 80 per cent of the biogas plants in the country are of the dome type (van Nes and Lam 1997).

After the installation of a biogas plant, the owner has to feed the digester with the required quantity of dung and water. The dung, collected from the livestock stall, is poured into a dung-mixing pit, and an equal amount of water is added. The components are mixed by hand or foot until no lumps are left, since the pressure of lumps may reduce biogas production. All plants manufactured in Nepal are of the continuous feed type, so the digester must be loaded daily with the required amount of dung and water for a particular capacity.

Dung from cattle is the main potential source of biogas in Nepal. The possible contribution of human waste is not big, but such waste is available on every farm, and important in relation to sanitation. Besides the supply of dung, other limiting factors for biogas plant installation are water and altitude (temperature). It is estimated that 1.5 million households can install biogas plants that are technically feasible (BSP 1994-95). This figure is almost three times more than the number of households that have access to electricity (i.e., 14% of the total population). The rate of installation of family-sized biogas plants has shown unprecedented growth in the past. This trend is expected to continue in the next ten years. More and more people are becoming involved in biogas as users, technicians, extension workers, researchers, trainers, supervisors, and investors.

The history of biogas development in Nepal began with the fabrication and installation of a prototype unit at Godavari in 1955. It was made using an old 200-litre oil drum and a gasholder made of mild steel sheet. No real interest in biogas was forthcoming until the fiscal year 1975/76, which was designated as 'Agriculture Year' to boost farm production. A special plan for biogas promotion was developed, and 199 plants were built by various contractors with interest-free loans made available by ADB/N (WECS 1987).

In 1977, the *Gobar* Gas *Tatha Krishi Yantra Vikas* Ltd. (Biogas and Agricultural Equipment Development Company), popularly known as the Gobar Gas Company (GGC), was established for the promotion of biogas technology, as a joint venture investment of the ADB/N, the Development and Consulting Services (DCS) of the United Mission to Nepal, and the Fuel Corporation of Nepal (now called Timber

Corporation of Nepal). The Biogas Company was backed by a Research and Fabrication Unit in Butwal and sales and service centres at strategic locations in the *Terai* and Inner *Terai* regions (WECS 1987). Due to the success of biogas development programmes and the availability of a government subsidy, as well as the interest and involvement of a number of INGOs and donor agencies, private biogas companies started coming up after 1990 following the government privatisation policy (Khandelwal 1996).

The floating drum design encountered a number of technical problems and has now been replaced by a concrete fixed-dome type design based on the Chinese model. There are already 32,119 biogas plants in place (Fig. 7.2 and Table 7.1), and more than 90 per cent of them are functional (New Era 1995); the target having been to build 30,000 family-size biogas plants (NPC 1992) during the Eighth Five Year Plan period (1992-97).

Table 7.1: The Number of Biogas Plants Installed in Nepal (FY 1996/97)

Development Region	Physiographic Zone Mountain	Hill	Terai	Total
No. of Biogas Plants (FY 1996-97)				
Eastern	37	1,010	5,097	6,144
Central	277	3,506	4,891	8,674
Western	0	10,633	2,855	13,488
Mid-western	0	836	1,831	2,667
Far-western	4	43	1,099	1,146
Total	318	16,028	15,773	32,119
Potential HHs for Biogas Plants				
Eastern	2,695	111,858	271,640	386,193
Central	3,741	132,603	299,892	436,236
Western	131	187,180	149,880	337,191
Mid-western	2,951	121,693	94,072	218,716
Far-western	2,118	40,497	76,441	119,056
Total:	11,636	593,831	891,925	1,497,392

Source: BSP 1994-95

The Biogas Support Programme (BSP) was set up in 1992 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, training, etc (BSP 1994/95). A third phase of the programme has been proposed for the time period 1996/97-1999/2000, with the target of installing 100,000 biogas plants. It has been estimated that a subsidy of NRs 750 million and a loan investment of NRs 1,080 million will be required to achieve this target.

The cost of biogas plants has shot up by12-16 per cent within the span of a year and now amounts to NRs 24,056 for 10m³ unit. The increase in the cost of material (mainly cement) and in biogas companies' overheads are the main causes of this price hike. However, given an inflation averaging 10 per cent annually, the real price of biogas plants has fallen considerably (i.e., about 20% in the past five years).

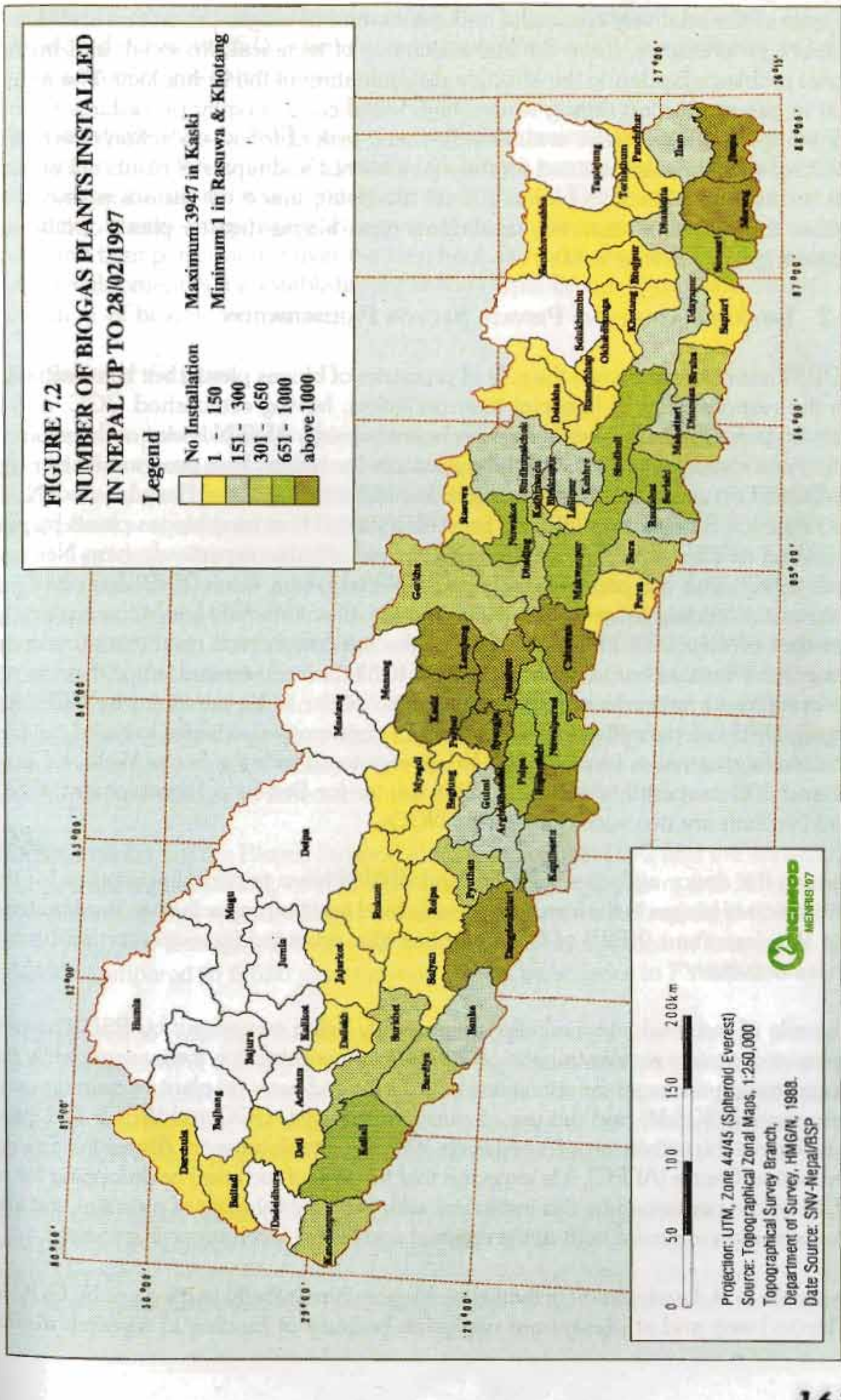


FIGURE 7.2
NUMBER OF BIOGAS PLANTS INSTALLED IN NEPAL UP TO 28/02/1997

In spite of the relatively successful implementation of biogas promotion and development programmes, there are still a number of technical, financial, and institutional problems hindering the effective dissemination of the technology. The reduction in gas production during winter, high initial costs, lengthy procedures for obtaining information, loans, and subsidies, and lack of follow-up action due to the shortage of technicians trained for the maintenance and repair of plants are among the technology-related problems. Efforts are being made by various agencies to reduce the cost of the currently used dome type, biogas digester plants of different sizes ranging from four to $50m^3$.

7.2 Intermediation and Private Sector Participation

ADB/N has not only played the role of promoter of biogas plants, but has also taken on the responsibility of financial intermediation, having established GGC, and is now engaged in channelling the government subsidy. ADB/N is one of the promoters of and shareholders in GGC. It implements the biogas loan programme through its 422 SFDP network. Other commercial banks, including Nepal Bank Limited (NBL) and Rastriya Banijya Bank (RBB), have also started financing biogas plants by participating in BSP through their 39 and 29 field offices, respectively (van Nes and Lam 1997). This has come about because Nepal Rastra Bank (NRB) launched priority sector-lending programmes which require all commercial banks to earmark 12 per cent of their total loan portfolios for the agriculture and rural energy sectors. Other joint-venture banks generally do not fulfill this requirement, since they do not have sufficient networks in rural areas and so prefer to be penalised by NRB. Recently, NRB has permitted 24 NGOs and 19 cooperative societies to carry out limited banking activities (out of 3,500 NGOs registered with the Social Welfare Council and 300 cooperative societies). The Centre for Self-help Development (CSD) and Nirdhan are two such noteworthy NGOs.

Among the donor agencies, UNCDF and SNV/N have provided assistance for the promotion of biogas in the form of a subsidy fund and training activities. Kreditantstatt Für Wiederaufbau (KFW) of Germany has also provided financing for BSP third-phase activities.

The role of technical intermediation is currently being carried out by BSP. The programme organizes regular training on biogas plant construction for masons, while the biogas companies organize orientation courses for end users on plant organization and management (O&M) and the use of slurry. In the past, GGC and WECS had been carrying out this activity on a limited scale. With the establishment of Alternative Energy Promotion Centre (AEPC), it is expected that the task of technical backstopping for all RETs will be performed by this institution, with the establishment of a central unit and the expansion of similar units at the regional and district levels according to need.

Research and development activities on biogas were initially carried out by GGC in a limited way and at present are negligible because of funding to research institutions like RECAST, RONAST, and the Nepal Agricultural Research Council (NARC). GGC closed down its R&D activities on biogas after the BSP's recognition of other private sector biogas companies.

After the introduction of BSP, various private companies have been set up for the construction of biogas plants. At present, 41 biogas companies are officially recognised for the construction and maintenance of plants. The involvement of the private sector is very encouraging. However, many of the organizations are inexperienced and their performance over the long haul has to be awaited. Another encouraging development is the establishment of the Nepal Biogas Promotion Group, an association of biogas companies.

7.3 Subsidy Scheme

In the beginning the biogas programme was primarily based on external assistance. This included community biogas plants built under SFDP programmes of ADB/N which were funded by UNDP, UNICEF, USAID, and UMN. A subsidy for household biogas plants was received from UNCDF. During the Agricultural Year (FY 1995/96) interest-free loans were provided to set up biogas plants. A subsidy of NRs 5,500 per plant was provided under a special Rice Crops Programme (FY 1983/84) in four *Terai* districts. During FY 1985 and 1986, a fifty per cent interest subsidy was provided on bank loans, but this was discontinued in FY 1987 (WECS 1987). Again, a 25 per cent capital subsidy for 6 and 10m^3 plants was available during FY 1988 and 1989, but it too was withdrawn in FY 1990 during the interim government after the advent of multi-party democracy (deLucia and CRT 1997). It was observed that the frequent change in subsidy policy made farmers hesitant to commit themselves to installing biogas plants, as reflected in the fluctuating trend in the installation rate.

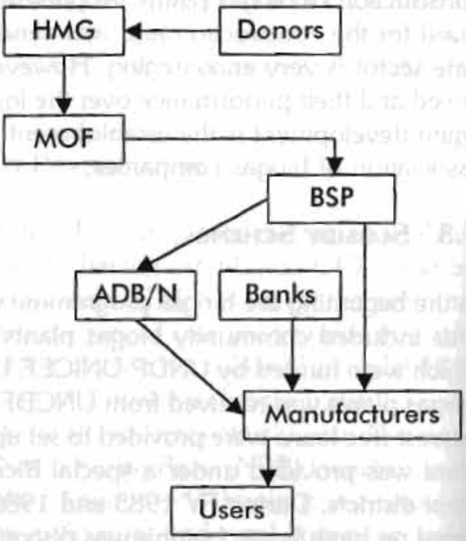
With the initiation of the Biogas Support Programme in FY 1992 and the announcement of a flat capital subsidy of NRs 7,000 and 10,000 in the *Terai* and Hills respectively, the installation rate for all sizes of biogas plants increased rapidly (MOF 1996a and 1996b). For example, a total of 24,410 plants was installed in four years (FY 1992-95) compared to 6,620 plants during the 18 years prior to FY 1992.

It is important to note that the success of the biogas programme was not primarily due to the amount of subsidy provided but to the way it was integrated with a host of other issues related to the promotion of biogas plants. These included quality control, encouragement to the private sector to engage in fair competition, monitoring and supervision, promotion, and institutional development.

The flat-rate capital subsidy brought down the cost of energy produced from small-sized plants (from NRs 11.14 to 4.77 in the Hills for 4m^3) to almost the same level as that of big plants (from NRs 5.35 to 4.07 in the Hills for 20m^3). This type of subsidy scheme encouraged farmers to install small biogas plants, which were less susceptible to underfeeding as well as being affordable to middle-income farmers. The higher rate of subsidy resulted in a higher rate of installation in the Hills (i.e., 55% of the total installations).

Since the subsidy is now administered through BSP instead of ADB/N (Fig. 7.3), it has been possible to reduce the transaction costs to farmers willing to finance the plants themselves, since they need not go through the loan procedures required by ADB/N. BSP pays the subsidy directly to construction companies upon completion of the plant.

Figure 7.3: Flow of Biogas Subsidy



7.4 Issues and Options

A summary of the issues identified from the individual case study is presented in Table 7.2, and detailed discussions on various issues and options are presented below.

Table 7.2: Issues Pertaining to the Biogas Programme

Case Study	Policy/Strategy	Institutional	Financial/ Economical	Technological	Social
Biogas dissemination in Dhaitar, Mahadevsthan	Need for policy- and strategy-level emphases on linking biogas dissemination with livestock development	An agricultural extension network is needed for the proper use of slurry	Dissemination of plants among upper economic classes of villagers. Need for action research on dissemination of plants among lower economic classes.	Need for action research on reducing the cost of the biogas plant's effective use of slurry. Toilet-fed biogas sets to be encouraged.	Need for awareness campaign on the proper use of slurry and toilet-fed biogas plants
Deen Bandhu biogas plant in Chitwan	Need for policy- and strategy-level encouragement of action research on participatory/innovative biogas dissemination programmes		Deen Bandhu plant is found to be 25 per cent cheaper than GGC model	Need for trained (skilled) masons	Need for awareness campaign on the proper use of slurry and toilet-fed biogas plants

7.4.1 Dissemination of Biogas Plants to Lower Economic Classes

The biogas owners interviewed all belonging to the middle or upper economic classes, among whom there is an increasing demand for biogas. The study team came to the conclusion that the technology cannot penetrate through to the lower economic classes due to the high investment cost, lack of collateral for credit, and small numbers of livestock. Biogas plants need to be distributed to low-income villagers.

7.4.2 The Effect of Demonstrations

Almost all plant owners interviewed said that they installed biogas only after they were convinced that it worked well in their neighbourhood. They do not believe the advantages of biogas on hearsay alone. A biogas promoter or developer should carefully identify progressive farmers willing to install a biogas plant and let other village residents come to see the benefits of biogas for themselves, the target-driven approach not having worked in the past. Some resilience is necessary.

7.4.3 Linking the Livestock Development Programme with Biogas

In Dhaitar, most farmers rear buffaloes for milk. The livestock extension workers working in the village were not familiar with biogas technology. BSP should be integrated with the Livestock Development Programme.

7.4.4 Toilet-fed Biogas Plants

Most of the biogas plants in Dhaitar area are attached to toilets. Though users realise the advantages to health and sanitation with gas production from a toilet attachment, they cannot find labourers willing to apply the slurry to their fields. Awareness needs to be increased and appropriate tools/equipment (such as trolleys) for handling slurry need to be developed.

7.4.5 Use of Slurry

Almost none of the biogas owners are informed about the efficient use of slurry. Generally they allow the slurry to dry in the pit before applying it to their fields. An awareness campaign needs to be launched to impart proper composting techniques and technologies for the efficient use of slurry. The agricultural extension workers of the Department of Agriculture should also be involved in this campaign.

7.4.6 Structure and Level of Subsidies

The positive results of a flat-rate subsidy were observed to a remarkable extent in Dhaitar. In the early eighties, oversized biogas plants were constructed and most of them were later abandoned due to lack of dung. At present, most of the plants are $8m^3$ in size, matching the livestock and gas requirements. This has also encouraged the construction of small biogas plants by farmers who own fewer cattle.

7.4.7 Research and Development

From the case study, the following R&D-related issues were identified: a) poor performance of the biogas lamp; b) sub-optimal use of biogas slurry; and c) reducing the cost of installing a plant. There is a need to develop and promote a low-cost biogas plant suitable for low-income farmers. In this context, the dissemination strategy and performance of the "*Deen Bandhu*" biogas model (Box 7.1) have brought about encouraging results in Chitwan. Similar action research programmes to promote low-cost biogas plants should be launched, with all due care.

Box 7.1: *Deen Bandhu* Biogas Plant at Chitwan

The Integrated Rural Community Development Centre (IRCDC), an NGO, has been involved in constructing several self-help biogas plants, based on the *Deen Bandhu* model as an action research programme, outside the Royal Chitwan National Park since 1993. The project is located in Kumroj VDC in Chitwan District. The main ethnic groups in the villages are the *Tharu*(s), *Brahmin*(s), and *Chettri*(s). The objectives are to introduce low-cost plants by using local materials as an alternative source of energy in order to support and to protect the Royal Chitwan National Park as a model programme, and also to prepare a community-based biogas programme as a means of conserving biodiversity. So far, five biogas plants have been constructed in five wards with a NRs 10,000 subsidy per plant, and there are plans to construct 45 additional plants in the future. Households are identified by a ward-level Biogas Committee as suitable for plant installation. The plant owner provides sand, stones, and unskilled labour, while cement, rods, stovepipes, and skilled labour are provided by the NGO. After the plant's installation, the owner plants five saplings on his own land and 75 saplings in the community forest area that is monitored by the Committee. With the installation of a biogas plant, the consumption of a *bhari* (a local basket full) of fuelwood and use of one to two litres per month of kerosene are saved. The biogas lamp has helped children to study for more hours per day, and women get relief from smoke, heat, and drudgery by cooking over biogas stoves. The nutrient content of biogas slurry is superior to that of traditional compost, but an orientation course is required for its efficient use by farmers. The *Deen Bandhu* model biogas plant is 25 per cent cheaper than the Chinese model. Moreover, the participation of the members by contributing labour and local materials has helped make the programme sustainable.

Source: BZB 1997

7.4.8 Standardisation and Quality Control

The strict enforcement of quality and standardisation by BSP has helped to reduce the operational failure of biogas plants. Still, manufacturers are claiming that it has halted cost-cutting innovations since only one type of design is approved for construction by the BSP.

7.4.9 Gender Issues

Results of various studies (ADB/N et al. 1994, EAST Consult 1994, WECS 1995, WECS 1997, Keizer 1993 and 1994, Britt 1994) have indicated that biogas has a time-saving effect on women's work loads in most instances. The average amount of time saved as a result of biogas use ranges from two to four and a half hours per day (see Table 7.3). The studies mention that cooking, collecting water and fuelwood, and cleaning utensils are the activities most dramatically affected by the introduction of biogas. The time thus freed can ultimately be used for income-generating activities, which can be seen as another indirect contribution to the expansion of technology within the economy. This generally positive assessment, however, needs to be qualified. The water requirement of biogas plants is a commonly neglected aspect . Another work-related problem for women that biogas installations entail arises from the resulting shift from cattle grazing to stall feeding and the accompanying increased collection of fodder. These are good examples of how gender perception creates a distorted optimal solution, the men ignoring the water and fodder requirements under the implicit assumption that women will somehow manage.

Table 7.3: Women's Daily Allocation of Time before and after The Installation of a Biogas Plant

Time	Before	Time	After	Remarks
4:00-6:00	Get up, make fire, fetch water, milk cow and boil milk, prepare for *puja*, cook animal food, and do cleaning	4:00- 6:00	Get up, make fire, fetch water, milk cow and boil milk, prepare for *puja*, cook animal food, and do cleaning	
7:00-9:00	Prepare lunch and eat	7:00-900	Prepare lunch and eat	
9:00-10:00	Send children to school	9:00-10:00	Send children to school	
10:00-12:00	Clean utensils	10:00-12:00	Feed animals, clean animal shed, and (within half an hour) clean utensils	Before it took two hours to clean utensils
13:00-14:00	Feed animals, clean animal shed	12:00-15:00	Sleep and sometimes chat with friends in friend's tea shop	
14:00-16:00	Prepare *khaja* (snack) eat, and clean up	15:00-16:00	Prepare *khaja*, eat, and clean up	
16:00-18:00	Fuelwood collection	17:00-19:00	Prepare food for animals and feed them	
18:00-1900	Prepare food for animals and feed and clean them	19:00-21:00	Dinner preparation, eating, and cleaning utensils	Collect fuelwood once a week
19:00-21:00	Prepare dinner, eat, and clean utensils	21:00-22:00	Chat with family Members	
21:00-23:00	Prepare essential things and go to bed	22:00	Go to bed	

Source: Field study (Kabhre, Mahadevsthan), source persons: Mrs Indira Khadka and Mrs Krishna Kumari Shrestha

It is doubtful whether the overall work load on women is in reality reduced because women having access to biogas were found working longer hours than before its introduction, having simply substituted one labour activity for another. However, it has definitely provided an opportunity for them to perform their activities in a more relaxed manner, whether these involve tending their babies or spending time in income-generating activities.

Further, as women in general do not have access to and control over productive resources, they do not, or cannot, own biogas plants. In addition, they do not seem to be actively involved in the implementation and management of the biogas programme.

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Chapter 8
A Case Study of the Improved Cooking Stove Programme

By K. Bajracharya[1] and R.N. Gongal[2]

8.1 Introduction

In most households of the mountain areas of Nepal, the most common method of cooking, particularly in rural areas, is on an open fire or traditional stove in which all types of biomass can be burned. In Nepal, most of the cooking and heating needs are provided by a centrally-located hearth in the living area. A sturdy iron tripod that supports a cooking pot is placed above the hearth. Traditional stoves are made from carefully selected clay mixed with chopped straw and sometimes with cow dung. The size and arrangement of the holes for the pots vary according to the needs and wishes of the users. In traditional stoves, the pot rests on three raised supports to allow flue gas to escape from the bottom.

With most of these stoves, whether of the tripod stand or traditional type, the heat under the pot is regulated simply by adding or removing the fuel. Fuel burned in them may include wood, straw, dung, and rice husk. The patterns of cooking with these stoves vary greatly throughout the country. Variations depend upon climate, local customs, family structures, the type of food being cooked, ethnicity, and economic status. Some meals require long periods of boiling and simmering; others depend on quick heating or frying.

The improved cooking stove (ICS) is a simple, low-cost technology that offers multiple benefits to its users, including efficiency savings of between 18 and 42 per cent of the fuelwood consumed by traditional stoves (Shakya 1985, Sulpya 1984). It works on the principle of increasing the concentration of heat directly under the first cooking pot and then channelling the heat to the second burner to cook two pots at once. It conserves heat and reduces heat dissipation with minimum waste. It is reported that about 33 per cent of ICS users in Surkhet District have demonstrated changes in work patterns because the ICS cooked faster and food is kept warmer for a longer period of time (Health Development Project, Surkhet 1992).

There are several improved stove designs in Nepal (Fig. 8.1). The most common stove prior to 1990 was the improved insert type stove. This two-pot stove is made

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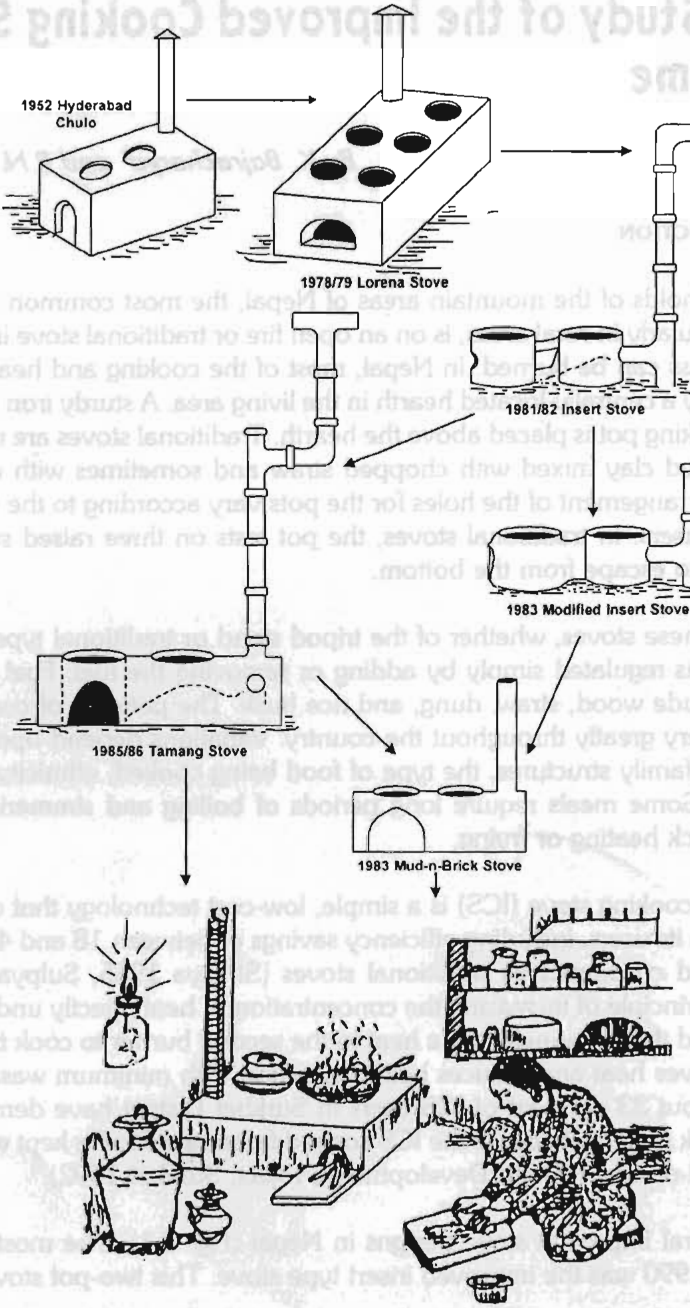

Figure 8.1: ICS Development in Nepal

from three separate ceramic pieces and a clay chimney. It is surrounded by a mud mix. The three pieces are: a firebox, to which the first tunnel is attached, a separate second hole for a pot with a baffle attached, and a rear tunnel attached to the chimney base. There are no doors, dampers, or grates. The cooking pot rests on the mud surround rather than on the ceramic stove. Nowadays, mud-built stoves are becoming popular. They are made of mud mortar consisting of three parts mud/earth, two parts straw/husk and one part animal dung. The whole structure is smoothly plastered with this uniform mixture. Iron plates can be fitted on the pot-holes as stands for vessels. This model has two openings for cooking pots, one behind the other. The pot-holes are round in shape, the bottom of the pot fitting snugly on them. Fuelwood is burned beneath the first opening. The fire and heat travel from the first opening to the second, heating up the pots on them. The smoke produced inside the stove exits through a chimney made of unburnt clay bricks and dung.

The amount of fuel saved depends upon the comparative efficiency of the ICS versus the traditional stove. Potential fuelwood savings with the ICS range from 25.6 to 40 per cent compared to 16 per cent fuel efficiency use of the traditional stove (Sulpya 1991). The efficiency of a stove depends primarily on its burning rate and heat loss from it. The burning rate of a cooking stove is a function of the size and dimensions of the combustion chamber, amount of fuelwood, and availability of oxygen in the combustion chamber. Further, the cooking pot should be placed so that there is no flame coming out along the side of it. All these factors help to increase the efficiency of the ICS, which in turn results in savings in fuelwood compared to the traditional stove (Rijal 1987, Rijal 1993).

Various rural development organizations in Nepal have been promoting this simple and cheap technology for many years. For example, the ICS programme was first implemented by the Department of Agriculture during the early 1950s using Indian models. It was only during the Sixth Plan (1980-85) period, however, that ICS took on momentum as RECAST and the Community Forestry Development Programme (CFDP) collaborated under a UNDP/FAO-funded programme to promote this technology. The only large-scale ICS programme carried out in Nepal has been through CFDP, and it was suspended in 1991 (PEP 1995).

So far, about 90,000 ICS of various types have been promoted and disseminated by the government, NGOs, and private sector agencies. Initially, the ceramic insert type stove was prefabricated and distributed to users free of cost. About 44,000 insert type stoves were distributed, but only 35 per cent are believed to be still in operation since they were not suitable for many rural applications. At present, the ceramic insert type design has been abandoned in favour of stoves built on site using locally-available materials and skills (i.e., mud stoves). It is believed that about 44,000 such mud stoves have been installed, of which more than 90 per cent are still in operation.

Recently, several NGOs and INGOs working in the areas of literacy, health, and sanitation; women's development; energy; and environment, and which include the Nepal-Australia Forestry Project, Save the Children Fund, CARE/Nepal, UMN, UNICEF, FAO, US Peace Corps, GTZ, UNDO, EEC, and IFAD, have made the ICS an integral part of their programme. They have primarily emphasized user motivation and education and are beginning to show success in their efforts to introduce improved stoves on a sustainable basis.

Some of the problems in ICS use are concerned with inflexibility of use for diverse purposes, people's social and religious beliefs, failure of the government to carry out strong promotional programmes, lack of proper education and training for the users, availability of and accessibility to free biomass resources as the main source of rural energy, lack of adequate involvement of women in ICS programmes, and lack of financial and institutional support to local NGOs and research institutions. In spite of these problems, the ICS development and promotion programme has been relatively successful as a new and renewable energy promotion programme in Nepal and has great potential for reducing fuelwood consumption because of the simple and familiar technology (Shrestha 1996).

8.2 Intermediation and Private Sector Participation

The SFDP of ADB/N has also distributed the insert type ICSs at nominal cost, as did the CFDP and Production Credit for Rural Women (PCRW) programme prior to 1990, but these were not adopted in many places due to various technical and sociocultural reasons. Since then, installation of locally built ICS has taken place mainly at environmental project sites supported by UNICEF.

Like ADB/N, the private sector organization, Centre for Rural Technology (CRT), is organizing regular training for ICS technicians. CRT is also coordinating an ICS network that it initiated in 1993 (CRT 1993) within the country by bringing together NGOs, INGOs, donor agencies, research institutions, and interested government departments, with the support of the Asia Regional Cooking Stoves' Programme (ARECOP). Various NGOs and INGOs are playing a leading role in the promotion and dissemination of improved cooking stoves. For example, CARE/Nepal has been integrating the ICS component into its community development programmes, mainly in Bajura, Kabhre, and Lamjung (CARE 1996). Except for expensive models like the cast-iron heater stoves, the cost of actual installation represents a small portion of the overall cost. The major costs of the ICS programme are R&D, promotion, and dissemination and training. So far these activities have been covered by the donors and HMG/N grant assistance. However, there is no integrated programme to promote ICSs, most of the activities carried out recently having been sporadic in nature.

Some R&D activities are being carried out by RECAST to develop large-scale improved cooking stoves, but the R&D programme for ICS is generally poor due to lack of funding. The Mrigendra Medical Trust (MMT) has been studying the effects of ICS smoke exposure among women. For example, MMT's studies show that ICS reduces smoke exposure to one third of the usual level (Pandey et al. 1990).

8.3 Subsidy Schemes

The stoves installed during the 1980s were mostly distributed free of cost to interested households in rural areas. At present, there is no unified programme for providing subsidies for the installation and use of ICSs. NGOs and government programmes have individual financial assistance or subsidies for ICS installation. For instance, CSD's cast-iron stoves in Jumla, which is the most expensive model so far disseminated, are eligible for a subsidy NRs 2,000. Other clay models, which cost around NRs 200, including labour, are generally given a subsidy for the cost of installation, and this is mostly mobilised by NGOs.

8.4 Issues and Options

A summary of the issues identified from the case study is presented in Table 8.1, and options are discussed below.

Table 8.1: Issues Pertaining to the Improved Cooking Stove Programme

Institutional	Economical	Technology	Social
Sporadic dissemination programme Intermittent dissemination and lack of continual effort Lack of monitoring agency Need for a strong research agency	Construction of ICSs by using local materials/ skills is sustainable	Need for appropriate alternative designs matching the needs of users Cooking with agri-residue Adapting to house structure and climatic factors Space heating requirement	Need for training of local stove technician Social/ritual factors to be considered ICS dissemination to be linked with house/kitchen improvement programme

Source: deLucia and CRT 1997 and field surveys carried out by the study team

8.4.1 An Intermittent and Diluted Programme

The ICS dissemination programme was a 'one off' type, intermittent and diluted programme. Lack of continuity and long-term vision are among the reasons why the output from these programmes has been poor. For example, after the termination of the environmental project under the PCRW programme, most of the WDS stopped dissemination of ICSs, as in the case of Mangalpur.

8.4.2 Technical Follow-Up and Back-Up

Lack of monitoring and follow-up is an important reason for the low adoption rate; for example, something as simple as a chimney being blocked by soot has led to discontinued use of ICSs in many cases. Again, users need the ICS to be improved as time goes on, so continuous technical back-up and follow-up on ICS dissemination are required.

8.4.3 Matching the Local Requirements

The needs of ICSs and the environment in which they are used are diverse. The same ICS cannot be disseminated to the *Terai* and the high hills. The type of fuel used, cooking habits, the types of food cooked, house design, and other specific requirements of the user/area need to be considered during dissemination. For example, the fear of fire hazard from the chimney was one of the main reasons for the low adoption, rate in Bayarban.

8.4.4 Use of Local Materials and Building Up Capabilities

After learning from the CFDP ceramic stove distribution programme, the ICSs were disseminated with better vision, approaches, and technology. The use of local materials and training of ICS technicians at the local level are positive aspects of the new programmes.

8.4.5 Fixed ICS Design

From the case studies, it was found that the fixed design of ICSs is one reason for its low adoption rate. The fixed-design ICSs failed to meet the requirements of users in many cases: i.e., animal feed preparation, space heating, use of agricultural residue as fuel, and *raksi* preparation. Not fulfilling requirements not only results in the rejection of ICSs but also creates a negative effect on the new technology. Serious R&D efforts are required, and technicians/motivators should be equipped with a wide the range of ICS designs to match the needs of the user.

8.4.6 Fuel Consumption

Reducing fuel consumption is one of the foremost objectives of the ICS dissemination programme, but whether this has taken place or not has not properly been assessed. Sometimes it is found that fuel consumption increases after the dissemination of ICSs (as in the case of Urthu – a twofold increase in fuel consumption over the traditional stove).

8.4.7 Research and Development

The identified R&D needs from the case studies are: a) low-cost ICSs for space heating with smoke removal; b) ICSs free from fire hazard; c) development of versatile ICSs capable of operating off different fuels (including crop residue); d) effective chimney construction; e) ICSs for big families, and one allowing *raksi* preparation, animal feed preparation, etc; e) reduction of cooking time; and f) need to incorporate sociocultural factors.

8.4.8 Technology Transfer to the Villagers

The selection of ICS technician plays a vital role in the ICS dissemination programme. A technician should be otherwise unemployed, of local origin, innovative, with good motivational skills, and preferably a woman (Box 8.1). At least two technicians should be trained in a similar environment on the construction and operation and maintenance of ICSs. The importance of each component of ICS should be thoroughly relevant to the user, and the user should be involved in choosing the location of the ICS installation.

8.4.9 Level of Subsidy

Except for the ICS disseminated in Jumla, the only cost an ICS entails is for the installation, since local materials are used. The user's participation during installation should be encouraged. The main cost incurred during the dissemination of ICSs is that of training ICS technicians and promoting the product, and this requires a subsidy. There should also be efforts to develop appropriate models/designs of ICS for commercial distribution.

8.4.10 Gender Issues

Women's refusal to accept and use the 'improved' stoves has been blamed by energy planners for the failure of ICS programmes. However, the blame could be more correctly placed on stove project planners who did not assess social and economic factors and user behaviour. For example, adequate consideration was not given to the religious and cultural customs of users while designing the stoves. Also, the active participation of women has not been mobilised for the stove programme. In many instances, men were consulted and selected for stove training to the neglect of women, and this resulted in the failure of the improved stove programme prior to 1990. However, with the dissemination of improved mud stoves, the time spent by women on collecting firewood, cooking, and cleaning pots/pans has been reduced (See Tab. 8.2). The money and time spent gathering fuelwood can be saved. There is also the positive impact on the general health of women derived from not being exposed to smoke. Further, installation by trained women promoters creates employment and generates income (CRT 1996).

A possible improvement in the health conditions of women through ICS dissemination has not yet been recognised. Instead forest conservation was and still is the major concern of many ICS programmes. In many instances, an incorrect design and faulty positioning of the chimney have created a reverse flow of air from chimney to stove, thereby making the kitchen smoky instead of smokeless.

Box 8.1: Case Story of an ICS Promoter and User

Mrs. Ganesh Kumari Bhandari lives in Bungkot Village of Gorkha District. There are three members in her family, including herself. They own a small teashop. She did not get a chance to study and hence has remained illiterate. Her husband, a teacher, died 15 years ago. After his death she could not live with her husband's family. She moved to her present location on her own and purchased two *ropani*(s) of land and established the teashop with great difficulty. She realised the need to earn money to ensure a better future for her children. She was attracted to income-generating activities, but due to lack of money, she could not invest in big business. Two years ago, the Production Credit for Rural Women (PCRW) project was run by the Women's Development Division (WDD) in her village, and she installed a latrine with its assistance was provided with an ICS for NRs 20. After installation of the ICS she noticed improvement in the kitchen environment, although she was not fully comfortable while cooking. Later she realised that the stove was improperly fixed to the iron tripod. She went to the PCRW office and told them about the problem, but her problem was not attended to, so she decided to take training on ICS. The WDD and CRT (Gorkha Branch Office) suggested that she participate in ICS training so that she could herself construct ICSs and generate income. She took a training course organized by the CRT on the installation and use of ICSs. After training she exploited her new skills as an additional income-generating activity. She started by experimenting with her own ICS, reconstructing it. Then she began to install ICSs in neighbours' houses. She usually asked the household women to prepare the soil, and during her first visit she made the chimney block and bricks for the cooking stove body and let them dry. The next day she would assemble the cooking stove. How many cooking stoves she can install in a day depends on her initial preparation and the help from the women of the household. If everything goes smoothly, she can build four to five cooking stoves a day. So far she has installed 73 ICSs in her village. She gets NRs 120 per ICS installation. The demand for ICSs is increasing rapidly, and she has even extended her service to another village. Now she earns enough money and is able to save some for her children's future. She is happy to have an ICS and to promote it as well. Her economic condition is improving due to her success in promoting ICS and earning from this.

Source: Field survey conducted by the study team.

Table 8.2: Women's Daily Allocation of Time before and after ICS Installation

Time	Before	Time	After	Remarks
4:00	Get up, make fire, cook animal food and, clean	4:00	Get up, make fire, cook animal food and clean	
5:00	Fetch water, prepare tea and *khaja*, (snack) boil milk, and make ghee (butter)	5:00	Fetch water, prepare tea and *khaja*, boil milk, and make ghee (butter)	
6:30	Feed children, send children to school, feed men, and eat themselves	6:30	Feed children, send children to school, feed men, and eat themselves	
7:00-8:00	Cook rice, serve grass, and other food to animals, cook food	7:00-7:30	Cook rice, serve grass to animals, serve other food to animals, cook food	
9:00-11:00	Serve food (lunch), eat (lunch), clean utensils, fetch water, clean cow dung in the cowshed	8:00-10:00	Serve food (lunch), eat (lunch), clean utensils, fetch water, clean cowdung in the cowshed	
		10:00-11:00	Rest	
12:00-12:45	Do household work (washing clothes, weaving), prepare *khaja*	12:00-12:45	Do household work (washing clothes, weaving), prepare *khaja*	
12:45-18:30	Collect fuelwood, work in field (according to season) weeding, levelling, etc.	12:45-18:30	Collect fuelwood, work in field (according to season) weeding, levelling, etc.	Collect fuelwood once a week
19:00-21:00	Cook dinner, feed children, feed adults, and eat	19:00-21:30	Cook dinner, feed children, feed adults, eat, clean utensils, prepare the essential things for next day	
21:00-23:00	Clean utensils, prepare essential things for the next day and sleep	21:30-23:00	Sometimes chat with family members and sleep	

Source: Field study (Bunkot Gorkha), source persons: Mrs Ganesh Kumari Bhadari, Ms Srijana Bhandari, and Mrs Purna Kumari Khanal.

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Chapter 9
A Case Study of Solar Photovoltaic Technology in Nepal

By S. Shrestha[1] and K. Bajracharya[2]

9.1 Introduction

The radiation from of the sun can be captured and converted into heat and/or electricity. A distinction must be made between beam and diffuse radiation. The former reaches the receiving surface in a straight line from the sun, while the latter is reflected in the atmosphere by clouds, dust, etc. This leads to different systems of solar energy.

Traditionally, solar energy is still used for drying purposes, mainly as these relate to agricultural products. Recently, efforts have been made to develop solar driers for large-scale crop drying. Attempts have also been made to develop solar cookers by some NGOs, private organizations/workshops, and research institutions (WECS 1995). They have yet to be developed on a commercial scale. With effective R&D efforts and proper dissemination approaches, solar driers and cookers do have the potential to replace fuelwood and kerosene, especially in rural households.

A significant use of solar energy has been for heating water in households as well as in hospitals, schools, hotels, and lodges. Solar water heaters are produced and marketed commercially. In the Kathmandu Valley alone, there are more than 35 companies devoted to their manufacture. Another use of solar water heaters is in preheating water for industries requiring process heating. Currently they are being used to preheat water for some carpet industries.

Another important use for solar energy is generation of electricity from solar photovoltaic (SPV) systems. Solar energy provides the required amount of electricity effectively and safely. A typical system may include (i) solar cell modules, (ii) an array structure and foundations, (iii) a voltage regulator and other controls, (iv) a storage battery and enclosures, (v) instruments, (vi) power cables, buses, and switch gears, and (vii) an electrical grounding network. The module, the basic building block of the system (CRT and ICIMOD 1998), consists of a number of solar cells electrically interconnected and encapsulated within a supporting structure (Fig. 9.1). Solar cells,

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usually in the form of thin films or wafers, are semiconductor devices that convert 3-25 per cent of the incident solar energy into DC electricity, with efficiencies depending on illumination-spectrum intensity, solar cell design, material, and temperatures.

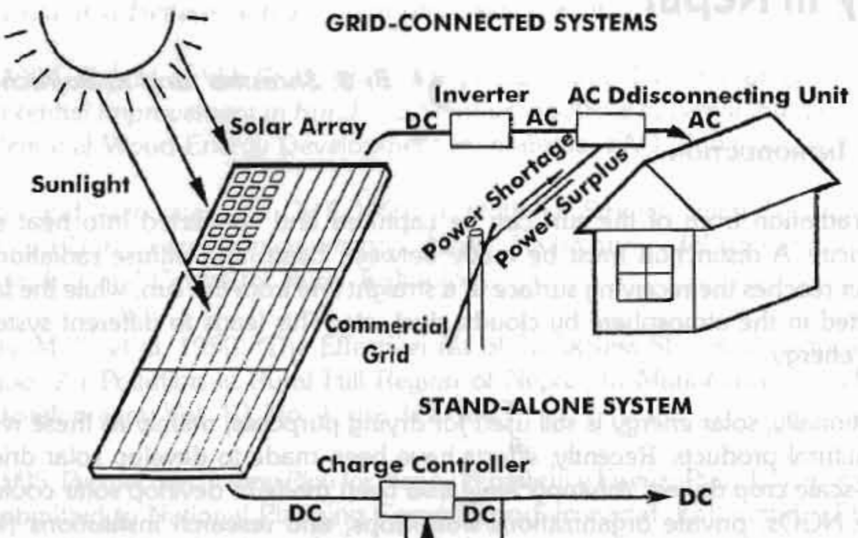

Figure 9.1: Solar Photovoltaic System

Solar cells convert light directly into electricity by a process called the photovoltaic effect, and these cells are most commonly made of silicon. The modules are available in sizes ranging from two to 50 watts (Rijal 1993). Large power outputs from a single source can be obtained by combining modules. The size of a system for a given use depends on the solar radiation available. This analysis is concerned with stand-alone power stations, which require batteries for storage. Medium capacity (5-50kW) solar PV stations can be employed to pump water; operate refrigerators; radios and TV sets; and to light incandescent bulbs and fluorescent tubes, but currently they are very expensive.

The attractions of photovoltaic arrays include the absence of moving parts, very slow degradation of properly sealed cells, the possibility of sizing modular systems from a few watts to kilowatts, and they are extremely simple to use.

Nepal has a high potential for harnessing solar energy. The monthly daily global solar radiation in Nepal varies from 120 to 260W/m^2, with the annual total sunshine duration ranging from 1,900 to 2,500 hours (Rijal 1984).

Use of SPV technology was introduced as early as 1962 when the first PV system was set up in Bhadrapur, and which is reportedly still working. Solar PV systems have been used extensively in telecommunications. According to one estimate (WLG and WECS 1995), more than 6,000 units of 50 W module PV systems are in use in different parts of the country by the Nepal Telecommunications' Corporation. Similarly, the technical and economic viability of solar PV systems for pumping water for irrigation and drinking water purposes is also being tested.

The Nepal Electricity Authority (NEA) has installed PV stations of 30-50kW in capacity in remote parts of the country, such as Simikot in Humla, Gamgadi in Mugu, and Tatopani, for purposes of rural electrification (WECS 1994). However, the performance of these PV stations has not been very satisfactory, due mainly to their overly elaborate and expensive, centralized design and lack of proper maintenance support.

Lately, private entrepreneurs and NGOs have been showing interest in the promotion and dissemination of solar PV home lighting systems. The cost of PV home systems (30-35W) ranges from NRs 30,000 to 35,000 depending on the system's capabilities and facilities. These home systems are becoming popular in several areas of Nepal (deLucia and CRT 1997).

9.2 Intermediation and Private Sector Participation

ADB/N has financed five solar PV pumps, with a total capacity of 7.6kW, and PV home systems for rural electrification. A number of NGOs, including Centre for Renewable Energy (CRE), mobilised donor assistance (Solar Electric Lighting Fund, USA) to implement solar PV home systems in Pullimarang, Tanahu (CRE 1994).

At present, there are three registered PV manufacturers in Nepal. The main products of these companies are solar photovoltaic modules and solar balance of systems, such as charge controllers, inverters, and lanterns. These private companies have begun to install, promote, and provide service to household- and community-sized PV system packages commercially.

RONAST is involved in research on and demonstration of SPV pumping systems and solar lanterns for which it receives support from JICA.

9.3 Subsidy Scheme

His Majesty's Government of Nepal (HMG/N) introduced a subsidy scheme for household PV systems to take effect from FY 1996/97. Fifty per cent of the capital cost is subsidised for these systems. The subsidy is being channellised through ADB/N, with financing terms of 16 per cent interest over a maximum period of 10 years. HMG/N provides a 75 per cent capital subsidy on solar PV systems for irrigation purposes. There is no capital subsidy for solar heaters, solar driers, and solar cookers.

9.4 Issues and Options

A summary of the issues identified pertaining to SPV technology from the individual case study is presented in Table 9.1, and a detailed discussion and options are presented below.

9.4.1 Demarcation of Regions for Solar PV Dissemination

It is observed that, in Kabhre, solar PV systems have been disseminated in the area where the national grid is going to be extended in the near future. Duplication of effort and wastage of the resources can be minimised by demarcating areas for PV installation.

9.4.2 Subsidy Level

In Kabhre one of the foremost reasons for the increasing demand of PV systems is the high subsidy, i.e., 50 per cent of the total cost. The field study team realised that there is a need to restructure the subsidy level by considering the equity issue, subsidies provided to other RETs, productive end uses, and the forward and backward linkages of the technology disseminated. To create a level playing field for the promotion of solar PV technology, it is necessary to review the subsidy policy for solar PV systems in relation to other RETs and energy resources.

9.4.3 Technological Constraints

The PV system is found to be appropriate in low power demand situations. PV systems are equipped exactly to supply power to rural telecommunication systems and have replaced the diesel generator. Low power conversion efficiency, storage problems, and dependence on climate are among the technological constraints. Some solar home systems installed in Kabhre are unable to generate light on rainy days in the monsoon season. Again, the users should be well trained in judicious use of the energy produced from solar PV systems.

9.4.4 Suitability of Stand-alone PV Systems

Through the experience of dealing with concentrated solar PV systems in Mugu and Humla and stand-alone solar PV systems in Kabhre and Pulimarang, it can be concluded that stand-alone systems are more appropriate than concentrated systems in the rural areas of Nepal, because of transmission difficulties and managerial constraints. It is found to be cheaper than grid electricity when the grid point is located more than 40km from the load centre. It is also found that, if the demand is very low,

Table 9.1: Issues Pertaining to Solar PV Electrification

Case Study	Policy/strategy	Economical	Technology	Social
PV electrification in Timilsina *Gaun*, Kavre	a) Lack of policy-level emphasis on equity issue of PV electrification b) Need for demarcation of areas suitable for PV electrification (e.g., areas which will not be connected to the grid for the coming 10 years / areas where MH is not feasible)	a) Installed by upper- class villagers b) Disseminated as a status symbol c) Lack of linkage between PV electrification and income-generating activities	a) Frequent overloading of bulbs b) Technologically, stand-alone systems are more appropriate for rural electrification	a) Developed as a status symbol b) TV has exposed the villagers to outside information and knowledge
PV electrification in Pulimerang	-	a) Installed by upper-class villagers b) Some initiatives are under way to link PV lighting with income-generating activities	a) Lack of overcharge controller b) Technologically, stand-alone systems are more appropriate for rural electrification	a) Almost all 80/82 households of the village are covered b) TV has brought social interaction among the villagers c) Local technical manpower development is one positive outcome.
PV electrification in Simikot	-	a) High installation cost b) Lack of linkage between income-generating and household lighting	a) Centralized PV systems are not technically appropriate for remote areas	-
Sundarighat water pumping project	Research project	High investment cost	Unsolved technical problems	-
Rural telecommunications	-	Found to be economical for low-load conditions of rural telecommunications	Low maintenance	-

less than 300W, solar PV is cheaper than diesel generators and micro-hydro plants (e.g. for telecommunications' services). It is also preferred in locations where diesel engines do not start because of low temperatures at high altitudes. As PV technology is environmentally friendly, simple, and not too costly to operate, it is worth promoting under the above-mentioned conditions.

9.4.5 Research and Development

Research and development pertaining to the adoption of solar PV technology are necessary for successful dissemination of the technology.

9.4.6 Institutional Aspects

The role and responsibilities of government and semi-government organizations involved in the development and promotion of PV technology need to be clear. The Alternative Energy Promotion Centre (AEPC) should play a leading and facilitating role in coordinating government, semi-government, non-government, and private sector activities related to the development and promotion of the technology.

9.4.7 Disseminating as a Status Symbol

In Kabhre, it has been observed that solar PV systems are installed in economically prosperous households. It was also realised that the villagers consider the solar PV system to be a status symbol. Apart from the heavy subsidy (50%), this is one main reason for the increasing demand.

9.4.8 Linking with Income-Generating and Rural Development Activities

The subsidy provided for solar PV systems can only be justified if it is linked with income-generating and social development activities. The promotion of a bag-making enterprise (handicraft) in Pulimarang is a remarkable attempt at productive end use of a SPV system. Similarly, the use of SPV systems to conduct literacy classes in the evening, educate through TV, and providing SPV light to health posts are a few of the positive social development activities that were witnessed in Pulimarang. There is a great opportunity to integrate SPV technology dissemination with income-generating and rural development activities.

9.4.9 High Costs and the Need for Innovative Funding

The cost involved in SPV installation is one of the major reasons for its slow dissemination. NRs 30,000 for a 35-watt system for lighting is very high compared to other alternative sources, viz., kerosene, biogas, grid connection, or micro-hydropower. It was realised during the field study that only the richer sections of society have installed such systems — the technology being out of the reach of poorer members of the community. The SPV systems for pumping water in Sundarighat and Bode have shown similar results. For promotion of the technology in remote areas (populated mainly by low-income groups), innovative funding approaches need to be identified. There is also an urgent need for policy guidelines that consider it qualifiable for prioritised credit arrangements together with a subsidy for its dissemination.

9.4.10 Gender Issues

Solar PV and the advent of television in the villages has provided opportunities for women to become knowledgeable about the external environment. Better lighting conditions in houses also help to ease household chores which are generally the responsibility of women. Better lighting in the evening means that women can use the evening for income-generating activities (Table 9.2).

Table 9.2: Daily Allocation of Women's Time before and after SPV Installation

Time	Before	Time	After	Remarks
4:00	Get up, milk cows, make a fire, cook food for the animals, and clean	4:00-6:00	Get up, milk cows, make a fire, cook food for the animals and clean	
6:00-7:00	Fetch water, prepare tea and *khaja*	6:00-7:00	Feed cattle, prepare tea and *khaja*	
7:00-10:00	Prepare lunch, feed children, send children to school, feed men, and eat themselves	7:00-10:00	Prepare lunch, feed children, send children to school, feed men, and eat themselves	
10:00-11:00	Clean utensils	10:00-11:00	Clean utensils	
9:00-11:00	Fetch water, feed animals, clean cow dung in the cow shed	11:00-13:00	Fetch water, feed animals, clean cow dung in the cow shed	
14:00	Prepare *khaja* (snack)	14:00	Prepare *khaja*	
15:00-16:00	Tea time and cleaning time	15:00-16:00	Tea time and cleaning time	
16:00-18:00	Fetch water, collect fuelwood	16:00-18:00	Fetch water, collect fuelwood	Help daughter for collecting fuelwood
18:00-21:30	Cook dinner, feed children, feed adults, and eat	18:00-20:00	Cook dinner, feed children, feed adults, eat, and clean utensils	
21:30-	Sleep	20:00-22:00	TV time	Children study during this time
	Sleep	22:00-23:00	Clean utensils, prepare essential things for next day, and sleep	

Source: Field study (Kabhre, Phulbari, and Sarasaun Kharka VDC); source persons: Mrs Suvadra Pathak and Mrs Krishna Kumari Adhikari

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Chapter 10
An Agenda for Formulating and Implementing Policies for RET Promotion in Nepal

by Kamal Rijal

10.1 Factors Influencing the Adoption of RETs

There are several factors that have prompted the adoption of renewable energy technologies in Nepal. Some of these factors, which may be instrumental in promoting RETs, are briefly discussed, and due consideration is given to these factors while formulating policies for Nepal.

10.1.1 Favourable and Coherent Regulatory Framework and National Policies

The Eighth Five-Year Plan document of Nepal recognised that sustainable economic growth, the only means by which economic prosperity can be achieved, would require proper management of bio-physical resources to prevent their depletion (NPC 1992). If this is properly translated into a programme, it will mean that the development of renewable resources is a must. For this to happen, favourable and consistent policies, acts, and regulations are required to promote the development of renewable energy resources. In many instances, however, various policies and acts contradict each other in terms of incentives and regulations. These anomalies and contradictions should be removed.

There are several acts and other forms of legislation that dictate ownership over natural resources and intellectual property rights to various technologies, ensure standardisation and safety measures for technologies, and provide various incentives that are instrumental for the development of RETs.

Water Resources' Act

The Water Resources' Act vests the ownership of water in the state and prioritises the use of water. The production of electricity ranks fourth in order after drinking water, irrigation, and agricultural uses. The act does not specify the right of prior use of water resources for mini- and micro-hydropower projects, and this has resulted in a conflict over water use. An individual entrepreneur is always at the mercy of the community. This problem does not arise if the plant is owned and operated by the community. However, some of the underlying causes of water use conflicts related to micro-hydropower are: a) the limited availability of land results in the intensification of agriculture, which in turn requires water for irrigation; b) there are competing demands upon the same rivulets/small rivers for irrigation and micro-hydropower; and c) devolution of government funding to Village Development Coommittee (VDC) has increased the capability of communities to compete for the use of water for irrigation, on the one hand, and, on the other, delicensing of micro-hydropower plants of up to 1,000kW has attracted private entrepreneurs to the construction of micro-hydropower for electrification (Amatya et al. 1997, PEP 1995). These factors lead to the realisation that, in conducting feasibility studies for micro-hydropower projects, it is essential to assign the use of water resources in an integrated fashion so that the needs of competing users and potential future uses are taken into consideration, at least during the economic life of the proposed scheme.

Forestry Act

The Forestry Act defines the ownership of forest land and the degree of control over the management and use of forest products, a step instrumental for the successful implementation of the community forestry approach, which is becoming more successful in terms of managing forest resources. Disputes among users and stakeholders over the rights to forest resources have broken out and have caused delays in the transfer of forests to local communities (Amatya et al. 1997, deLucia and CRT 1997). These issues need further in-depth analysis. Also, the community management mode, which is still in the process of evolution with varying degrees of support from the government, neither has adequate human resources nor a satisfactory physical set-up. It may take some time to change the mind-set of forest sector bureaucrats to the point where they give proper recognition to the community-based approach to forest management.

Intellectual Property Rights

Intellectual property rights should be designed so as to ensure active initiative by the private and public sectors in partnership for research and development into RETs. Modified designs for biogas plants and water turbines, the innovation of MPPUs and peltrics, local adaptation of the design of a balanced SPV system, and an ICS with chimney hood are examples of such initiatives. The public sector funding available for R&D on RETs is nominal, and private sector funding needs to be encouraged, but to do so patent and intellectual property laws will have to be effectively in place. Unless there are such laws, the private sector will avoid investing out of fear that others may take advantage of their investments. For example, peltric sets developed by KMI have been freely reverse-engineered or copied by others in the absence of laws relating to patent and intellectual property rights (Amatya et al. 1997).

Standardisation, Safety, Warranties, and Insurance

There are no formal guidelines or mandatory safety provisions for the construction and operation of RETs. For example, there has been a number of accidents due to unprotected belts and rotating parts of turbines and agro-processing facilities. These could have been avoided if proper safety measures had been taken. Similarly, design standardisation is not practised in the case of micro-hydropower plants. Often equipment supplied by manufacturers is not based on proper design considerations. Lack of formal standardisation for procedures and guidelines has resulted in errors in flow measurements and demand estimates during feasibility studies for micro-hydropower projects. Strict enforcement of standards may result in the successful implementation of the RET programme. For example, one of the reasons for the success of the biogas programme in Nepal is the enforcement of standards imposed by BSP while administering the subsidy (Amatya et al. 1997, PEP 1995, deLucia, and CRT 1997).

The experience has been that warranties are an important factor in ensuring quality output from manufacturers of RETs, in that suppliers of services are made responsible for what they promise to deliver. It is observed that, in the absence of warranties, manufacturers get away with inferior equipment, parts, and after-sales' services. A case in point is the proliferation of sub-standard solar water heaters in Kathmandu. Similarly, technical services provided by consultants for carrying out feasibility studies for RETs may be inferior in the absence of a code of ethics. In both cases, users of services suffer. There will be extra costs associated with warranties; since service providers will have to spend adequate amounts of time and money to ensure the quality of their products, these costs will have to be borne by the users.

Case studies of micro-hydropower plants have revealed that plants are damaged due to flooding (Amatya et al. 1997). These risks can be covered through insurance schemes, but only large-scale projects are being insured at present. If a similar practice can be put in place or made mandatory for RETs against theft, fire, floods, landslides, and injury, the financial risk to entrepreneurs and users can be greatly minimised. Recently, an insurance company in Nepal agreed to provide insurance for solar home systems.

Subsidies and Incentives

In many a case, subsidies and incentives have played a critical role in popularising RETs in Nepal. But, frequently changing and inconsistent government policies have demonstrated the very erratic nature of the renewable energy sector (PEP 1995, deLucia and CRT 1997, Rijal 1997). This has happened because there is no coherent framework for the provision of subsidies and incentives, not only within a specific renewable energy technology but also among them. The provision of subsidies and incentives should primarily be based on economic and social equity analysis. In fact, it was observed from case studies that most households that own solar home systems or even biogas plants belonged to a high-income group in the village (Amatya et al. 1997). This was because of the high investment cost and the need for collateral to secure bank financing. The result of the analysis, as presented in Box 10.1, demonstrates that inconsistency prevails in subsidy schemes. Coherent, objective, and target-oriented subsidy policies for RETs need to be developed.

Box 10.1 Attributes and Benefit Assessment of Selected RETs

Description	Micro-hydro	Peltric Set	Solar PV
- Capacity	10 kW	2 kW	35Wp
- Cost (NRs.)	1,000,000	250,000	33,000
Subsidy 1/ (NRs.)	250,000	125,000	16,500
Benefits			
- Connections + B&W TV	2x40W lamps + B&W TV	2x40W lamps + B&W TV	2x11W CFL
- No. of households (100 W/hh)	100	20	1
Subsidy (NRs./hh)	2, 500	6,250	16,500
Cost per hh (NRs.)	7,500	6,250	16,500
Other benefits			
Opportunity to operate mill and income-generating activities	High	Very limited	None
- Benefits accessible to	All hhs	All hhs	Only Upper income group can afford
- Imported components in manufacturing	Very small	Very small	Very large
- Operation & maintenance	Difficult but generates local employment	Relatively easier and provides Employment	O&M easy
- Construction period	Long gestation period	Relatively short period	No gestation period

Note: 1/- based on existing subsidy scheme.
Source: Amatya et al. 1997

At the same time, the existing subsidy for diesel and the initial capital cost of diesel mills and generators are comparatively lower than micro-hydropower installations, and there is added flexibility in the choice of plant location. This has prompted entrepreneurs to install diesel mills instead of micro-hydropower, even though the operating cost is higher.

Tax and Customs' Duties

The exemption from taxes and duties on the import of renewable energy-related materials and equipment is the subject of acts and regulations. However, in practice, availing oneself of those facilities is cumbersome, because of the low volume of imports of RET-related equipment and accessories. For example, manufacturers of micro-hydropower plants generally are supplied through the local market and end up paying as much as 40% in import duties, whereas the organized import of diesel generator sets costs much less (Amatya et al. 1997, deLucia and CRT 1997). Recently, the organized import of equipment, such as main valves for biogas plants and photovoltaic panels, resulted in exemption from customs' duty. In this context, the organized import of RET equipment for which the various components have been standardised may prove beneficial. Manufacturers' associations (biogas and micro-hydropower) can take such initiatives.

10.1.2 Recognising Location Specificities

Underestimating biophysical factors has led to wrong choices of energy mix – in terms of technologies, institutions, and financing mechanisms. For example, certain conditions prevailing in mountain areas, such as inaccessibility, marginality, and fragility, have implications for the energy sector. Inaccessibility means high costs for energy supply systems, given the lack of infrastructural development (Rijal 1996a). Also, the demand for energy is low, both qualitatively and quantitatively, among the sparse settlements, as a consequence of low resource capability and a decrease in productivity induced by environmental fragility.

Furthermore, no distinction is made between centralized and decentralized energy systems in terms of varying suitability based on location-specific conditions. Still, the conventional wisdom is to provide electricity by extension of the grid network, assuming it to be a welfare package, and therefore electricity tariffs have always been subsidised without considering the high cost of grid extension (Sharma et al. 1997). This has seriously hampered the search for alternative methods of providing electricity in mountain areas.

10.1.3 Matching Energy Needs with Locally Available Resources

Matching energy needs with energy systems is in itself a complex process and should be viewed as an integral part of the matching process. First of all, one has to determine what needs are of prime importance, and which particular activities require energy, in order to match energy needs with renewable energy technologies. Continuous consultation with the communities involved is an essential step in preventing imposition of outside biases. Too often, energy planners autonomously decide what is needed for the people (e.g., cooking needs to the neglect of space heating). If communities do not play a significant role in selecting which needs must be met first, they are not likely to actively support the process of introducing the technology, assist in any necessary modifications, or maintain the energy system (Banskota and Rijal 1996, Rijal 1996b).

Once energy needs are defined, the process of narrowing down the range of technological options should begin. The preliminary screening of energy systems is the first component of actual matching of needs and technologies. The important characteristics of each energy need are identified and compared with the characteristics of each available unit to determine how the system fits the energy need, as depicted in Box 10.2. Following this, the energy resource should be evaluated based on physical availability, including daily, seasonal, and annual variation and constraints on its use, such as ownership of resources, cultural and/or economic restrictions on use, and conflicting use of the same resources.

Box 10.2: Matching Cooking and Space Heating Needs with Available Resources

Key characterisation criteria
- Temperature of output
- Time of day of output
- Sociocultural factors (with specific emphasis on gender)
- Environmental criteria

Best matches with need
- Biomass
- Passive solar
- Building orientation and insulation

Other possible matches
- Micro-hydro (electric)
- Kerosene
- Diesel (electric)

Advantages of best-match technologies
- No energy transformation required
- Biomass energy systems do not depend directly on climatic variations: they are easily stored and eliminate the need to store output energy; biomass combustion is the most acceptable and convenient technology; the answer to shortages of fuelwood may be to introduce more efficient space-heating technology or to accelerate biomass production through planting
- Proper building orientation will increase the heat flow inside the house
- Insulation will reduce heat losses from the building envelope

Problems with other possible energy sources
- Electricity is a high-grade energy and is undesirable for heat applications
- High cost of transporting kerosene and diesel
- Conversion inefficiencies

Source: Rijal 1996b, Rijal 1996c

10.1.4 Choice of Technology and the Dissemination Approach

At the global level, a greater interest in the development of renewable energies emerged after the oil crisis of the 1970s. Mountain people, however, have always relied on renewable energies, mostly in their natural forms, though the era of cheap fossil fuels during the 1980s prompted many to shy away from renewable energy development. This situation worsened as donors view technical assistance as a market promotion effort, while governments tend to view subsidies as a social obligation, without properly understanding the dynamics of technology transfer processes in the context of mountain areas. In tackling this problem, renewable energy technologies were demonstrated and disseminated without proper programme designs or a holistic approach. RETs were not capable of meeting the multiple user needs at affordable prices. Most of these new technological interventions were capable of fulfilling only particular needs, in contrast to traditional technologies that were able to fulfill multiple needs. For example, traditional cooking stoves in the mountains met cooking, space heating, and drying needs, while improved cooking stoves meet only cooking needs (RWEDP and ICIMOD 1997). Research into and development of renewable energy technologies have never received the attention they deserve, and no technological innovations have occurred. This is particularly unfortunate for the regions that have tremendous potential in terms of renewable energy technologies. Also, the absence of standardisation of components and parts has led to a weak local manufacturing base and service capabilities.

Most of the time, RETs have been disseminated before they have had time to mature, and communities have been forced to venture into unknown waters. The role of the government has never been clear to consumers or to developers. They are not sure whether the government is trying to minimise their risks or to provide a mechanism that offers opportunities for government employees or NGOs to serve their own interests.

Economic and financial assessments and calculations are needed before technological choices are made, in order to optimise the synergy of sectoral linkages and achieve sustainability. The economic costs of alternative energy options have never been considered; rather, a blanket approach to disseminating technology has been followed (e.g., a target-oriented approach prevailed over demand-driven or process-oriented approaches).

10.1.5 Integrating Gender Concerns into Programme Development

Every stakeholder should be involved in the development and use of energy, and more emphasis should be given to ensure the active participation of women in the design and implementation of energy programmes, since they play key roles in managing, procuring, and using various energy resources and technologies at the household level. Promotional activities do not recognise the sociocultural implications of technology adaptation, these programmes, in most cases, being gender blind. It seems that no priority is given to the specific needs of users (i.e., women) while promoting RETs. Indigenous knowledge and local women's institutions are not used properly in managing energy systems. No attention is given to ensuring that women are not left out while promoting new and renewable energy technologies in mountain communities, in spite of the fact that they are the ones managing household energy systems (deLucia and CRT 1997).

10.1.6 Recognising the Social and Cultural Dimensions

Most of the households in Nepal meet many of their energy needs outside the monetary economy. These households want to maintain self-sufficiency within their own community, if not within the household. However, money and markets are becoming more important. Cash is required to meet a growing number of needs, including the need for energy. The sociocultural aspects of RET intervention are of particular importance where the adopters of the technology lie mainly outside the cash economy. In addition, many productive relationships among the mountain people are still structured by kinship and the caste system, and these factors must be taken into account. The following conditions appear to increase the chances for sociocultural acceptability with regard to RETs in Nepal (Rijal 1996b, Rijal 1996c).

Compatibility with the Existing Organization of Work

An understanding of indigenous systems of organizing work is important to the successful introduction of RETs. For example, firewood collection and food preparation are usually carried out by women, and efforts to train women to construct stoves have resulted in them accepting ICSs, as depicted from case studies (Amatya et al. 1997).

Integration with the Social Structure

Compatibility with the existing social structure, family organization, system of stratification based on caste, ethnicity, gender — is also a factor in gaining acceptance of RETs. For example, the relationship of RET intervention to the social structure is exemplified by the successful operation of community-owned rather than individually - or privately-owned micro-hydropower plants. Also, the ethnic homogeneity of a community results in less conflict in the management and use of locally available resources (Amatya et al. 1997).

Accommodation to Authority

Understanding the local political system - the organization for making and enforcing community-wide decisions, settling disputes, and regulating relationships with neighbouring people — and how it relates to RETs will improve the chances of RETs being adopted (Rijal 1996c). Strong leadership within the community increases the risk-taking capability of the community as a whole and makes it willing to accept innovative ideas and technologies.

10.1.7 Promoting Technical and Economic Acceptability

A review of case studies and field surveys carried out in Nepal shows that several factors increase the technical and economic acceptability of RETs (Rijal 1996b, Rijal 1996c). These are outlined below.

Structural Simplicity and Scale

Simplicity facilitates the acquisition and maintenance of technologies. It also lessens the risk of dependence on external support for operation, repair, and maintenance and minimises the need for extensive capital investment. For example, locally built mud-chimney stoves constructed by women entrepreneurs have this simplicity and are gaining popularity in the Hills (Amatya et al. 1997).

Reasonable Cost of Technology

The network of distribution must allow for the disposition of RETs at a cost that most people can meet. The more localised the manufacture and distribution of RETs, the more widespread their adaptation is likely to be, since they will better meet local conditions. For example, the *Deen Bandhu* biogas model is gaining popularity among low-income households (deLucia and CRT 1997). Indeed, the rapid increase in the number of biogas manufacturers has led to a decrease in the real price of biogas plants during the last five years.

Use of Familiar Technology

Employing familiar technology and materials wherever possible increases technological acceptability by lessening learning requirements. The use of local materials and craftmanship will also increase diffusion. One of the reasons for the success of micro-hydropower technology in Nepal can be attributed to this factor; for example, the traditional water wheel (*ghatta*) is still being used for agro-processing activities (Amatya et al. 1997). Another example is the locally built mud-chimney stoves which are gaining momentum because they primarily use local materials and craftsmanship.

Employment of Familiar Techniques

If the techniques for designing, manufacturing, and operating are familiar, the advantage is clear. Reliance on these methods minimises the need for special training and for external supervision. For example, the recent introduction of back boilers with chimney stoves has led to their being readily adopted by the people of Ghandruk (Amatya et al. 1997).

Integration with Existing Technology

The economic advantages of an innovation that fits readily into an existing technological management system are evident. This integration minimises the capital and/or labour costs of adopting traditional production patterns. For example, the integration of the multi-purpose power unit (MPPU) or improved *ghatta,* with traditional methods of grinding grains have increased acceptance in the hills of Nepal (Amatya et al. 1997).

10.1.8 Role of Financial Intermediaries

The role of financial intermediaries is critical for the successful implementation of the RET programme, as they create access to financial services and so ensure sustainability of services in the long run. Primarily, ADB/N has played the role of financial intermediary through its extension offices by providing loans and channelling the government subsidies made available for RETs. In the past, the cost of such intermediation was borne by the bank, but recently BSP is bearing the cost of intermediation in the case of the biogas programme, although eventually it should be borne by the beneficiaries themselves (deLucia and CRT 1997). A properly designed subsidy programme, along with the financial operation of RETs, based on full-cost recovery, are minimum prerequisites to financial sustainability. The biogas programme is one such example of a subsidy scheme which was designed properly through the initiative of BSP (Amatya et al. 1997). In some instances, a microhydropower project has been successful in achieving financial sustainability through end-use diversification (e.g., introduction of low-wattage cookers, use of electricity for making handmade paper). Though the bank is playing the role of intermediation and financing is available, complaints heard during the field survey included the following: the loan disbursement procedure is cumbersome, the valuation of collateral is on an *ad hoc* basis, and financial resources are almost always accessible to influential people within the community. In this context, access to financial resources needs to be improved so that it becomes transparent and flexible enough to accommodate the poor and marginalised (Amatya et al. 1997, deLucia and CRT 1997).

10.1.9 Choice of Institutions

The evolution of energy-related decision-making as a supply-side activity has resulted in the creation of centralized planning institutions. This has resulted in a lack of decentralized institutions to manage the energy sector, so that no institutional capability exists at local level. However, the quantity and quality of energy required by remote and mountain communities, and the availability of local energy resources, call for decentralized renewable energy systems. They, in turn, require local-level decentralized institutions. Also, demand-side agencies (rural development bodies) operating at the local level do not see their role in terms of managing the energy sector and believe that this falls under the purview of energy-related institutions such as government-run electricity and forest departments, fuelwood supply depots, and oil depots (Rijal 1997).

The suitability of decentralized renewable energy systems in the context of remote and mountainous areas entails the 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 found to be more suitable for the promotion and development of decentralized renewable energy systems in the hills and mountains, since the social fabric of these communities is such that they rely on interdependence, which cannot be found in heterogenous urban communities. The successful implementation of micro-hydropower installations at Ghandruk and Sikles provides good examples (Amatya et al. 1997). However, there are instances of failure as well, in cases where communities and/or beneficiaries are not involved from the planning stage in such interventions.

10.2 Framework for Policy Recommendations

The approach adopted for the overall planning and programme development of the energy sector has undergone major changes because of donor influence and the competing demand for scarce capital resources, as well as as a result of the emerging focus on market-based and liberalised economies. This shift has led to realisation of the need for competitive behaviour within the energy sector, on the one hand, but, on the other hand, it has resulted in an increase in the supply cost of energy in remote mountainous locations. The need for competitiveness has prompted energy developers to focus on short-range profits to the neglect of long-term social and environmental considerations. It is in this context that there is a need for the promulgation and institutionalisation of policies that lead to the right choice of energy mix to ensure net long-term social and environmental benefits. Such policies have special relevance for mountain areas where the options available are limited due to the physical and socioeconomic environment. It is necessary that a niche be captured in terms of the availability of renewable energy resources with the potential not only to meet local energy needs but also to supplement the energy needs of the adjoining plains, so that the increasing economic aspirations of mountain communities are fulfilled. It is ironical that mountain communities are not in a position to take advantage of these niches due to lack of suitable renewable energy technologies to fulfill their energy needs in tune with their sociocultural background and economic conditions. At the same time, lack of proper mechanisms to ensure the retention of benefits accruing to them from mountain-specific resources (fuelwood or hydropower) marginalises these communities and makes them dependent on outside interventions.

The following framework for policy recommendations, consisting of six components to promote the development of renewable energy resources and technologies, can provide broad policy guidelines not only for Nepal but also for the HKH Region as a whole. These are (Rijal 1997, Rijal 1998) as follow.

a) Recognise and measure the benefits of RET with particular emphasis on drudgery reduction
b) Reform energy price signals to provide a level playing field for each energy source
c) Revamp the energy decision-making process to promote decentralized renewable energy technologies and the involvement of local institutions
d) Change energy users' investment incentives by attracting private sector and NGO participation in manufacturing and promoting RETs
e) Accelerate investments in the commercialisation of RETs by supporting research and development and setting up demonstration units (RD&D), capacity building, information, and awareness generation through public sector or donor funding and by providing attractive incentives to manufacturers
f) Develop a commercialisation plan for each RET to suit location-specific needs

10.2.1 Recognise and Measure the Benefits of Renewable Energy

It is crucial to recognise the long-term economic, social, and environmental benefits of renewable energy resources and technologies to establish their comparative advantage and sustainability convincingly, particularly in mountain areas. The exploitation of RETs would result in reducing the level of emissions from the use of fossil fuels and in ensuring an economic sustainability that is often not attainable in energy markets. RETs are more likely to increase energy supply security, since the availability of renewable energy is more equitable in terms of geographical distribution. In particular, availability of energy reduces the regular drudgery faced by women and children. In addition, there is an increased opportunity that the social and economic benefits of exploiting renewable energy resources and technologies will be equitably distributed, since access to these resources is more equitable in terms of gender and income characteristics. The equitable distribution of the benefits of RETs is further improved by the need for decentralized institutional structures for their use.

10.2.2 Reform Energy-price Signals

The growth of renewable energy technologies will be feasible only if the price of various forms of energy reflects their long-term social and economic benefits. The prevailing price structure of various forms of energy resources favours the overexploitation of fossil fuels and biomass fuels beyond their regenerative capabilities. This situation is further aggravated by the low purchasing power of the mountain population. There is an urgent need to reform energy prices in order to reflect the true economic cost of resources, taking into consideration the costs of mitigating environmental damage. This can be achieved by internalising the social costs of exploiting various sources of energy and thereby subsequently influencing the choice of energy supply. There are packages available in terms of energy taxes. The levels of subsidy that various forms of energy receive are not properly understood, and, in most cases, this results in distortion since energy markets do not exist in most mountain communities. Given this situation, two policy options are available: either to create countervailing subsidies for renewable energy technology or to minimise subsidies for fossil fuels. At the same time, energy subsidies should be provided to targeted poor populations in order to increase their access to renewable energy resources and technologies.

10.2.3 Revamp the Energy Decision-making Process

The existing mechanism of a centralized decision-making process tends to favour large-scale energy investments. Equity concerns, or the social obligation to provide energy to the poor mountain population, are assumed to be taken care of by providing grid-connected electricity to villages without assessing the physical limitations of such extensions, understanding the local need for energy services, investigating possibilities of developing suitable small-scale renewable energy technology options, or understanding the long-term economic and institutional implications of such development. Nowadays, various renewable energy technologies are available to meet the energy needs of the mountain population within the HKH Region and beyond. In this context, the involvement of beneficiaries and entrepreneurs in developing RETs, after energy choices to fulfill a particular energy demand have been made, should be made mandatory. This would not only ensure the economic but also the institutional sustainability of the programme.

10.2.4 Change Energy Users' Investment Incentives

Entrepreneurs should be given incentives to manufacture and market renewable energy technologies in order to reduce the cost of production and generate awareness among energy users about the benefits of RETs. Energy price signals should favour renewables and improve investment incentives for RETs by way of, for example, below market loans, grants, rebates, tax incentives and tax credits, exemptions, and deduction. Substantial improvements in policy implementation should be facilitated by integrating policy approaches, developing marketing strategies, providing technical support services and information, conducting training programmes, evaluating cost-effectiveness, and monitoring and evaluating the performance of RETs systematically. In this context, appropriate institutional arrangements need to be established to promote RETs. Care must be taken not to duplicate institutions at the local level but to involve existing indigenous institutions, NGOs, or entrepreneurs as vehicles for technology transfer that maximise the participation of beneficiaries. However, what is more important is for decision-makers and planners to encourage private entrepreneurs to develop RETs by reducing financial risks and costs, making tangible the benefits of modular RETs, reducing unforeseen risks, and relaxing resource rights.

10.2.5 Accelerate Investment in Renewable Energy Commercialisation

There has been no concerted effort to commercialise RETs in the past; most programmes have been subsidy-driven, having been considered as energy options for the poor. This approach needs to be reversed if meaningful development of RETs is envisaged. The investment in RET promotion is comparatively meagre. To derive the full advantages from RETs, investment in renewable energy commercialisation should be increased as quickly as possible. This could be achieved by providing enough support for RD&D. Public investment in RD&D should to be improved by allocating public funding, integrating RD&D into the broader context of economic gains for mountain communities, and improving the effectiveness of RD&D institutions. Investments in RETs can be increased by attracting private investment, for which targetted incentives packages need to be devised. These incentives should be designed as a part of the commercialisation plan in order to reduce investment risks.

10.2.6 Develop a Commercialisation Plan

A commercialisation plan should be developed for each of the renewable energy technologies. The efforts required may differ depending on the level of development that each technology has attained in a specific country. Appropriate participation of each stakeholder in the development of RETs and consensus among them become crucial for the successful implementation of the commercialisation plan. In this context, the role of the government is to create the right kind of policy atmosphere, as mentioned above, so that hesitant entrepreneurs are attracted to investing in renewable energy technologies. Further, broad guidelines should be made available to various donor agencies in order to avoid duplication of their efforts. Some donors may be interested in capacity building, some in marketing technologies, others in research and development, while yet others may be interested in promoting these technologies in specific areas or among specific ethnic groups. Each of them should be allowed to function with clear mandates and objectives. The lessons learned and the successful strategies employed in disseminating RETs must be taken into consideration in designing programmes related to the dissemination of RETs. The role of donor agencies has been found effective in capacity building and research activities. The implementation of various renewable programmes should not be handled directly by the donors since this does not help to build local capability. The implementation of the programme should be carried out in partnership with local institutions, be they government or non-governmental organizations or local traditional institutions.

10.3 Policy and Institutional Recommendations

Energy policies in Nepal must emphasise renewable resources and technologies. Primarily three options are available, namely, biomass, hydropower, and solar. At the same time, the promotion of energy efficiency (both technical and allocative) should receive priority in energy policy. Distorted pricing-making regulations are always detrimental to the promotion of efficient energy use since they cause faulty, inefficient fuel use and send wrong signals to consumers in regard to the choice of energy use devices. Not only an integrated energy policy and programme is required, but also an effective institutional framework from the national to the grassroots levels.

A decentralized approach to energy planning and its distribution is a viable alternative to centralized energy systems. RET intervention can be successfully implemented in a variety of institutional settings. NGO- and CBO-based programmes may be more flexible, committed and friendly to users. Sustainable institutional settings in the long run, however, should come through participatory institutions at the grassroots' level. Therefore, greater reliance on user group-based systems may prove to be more sustainable.

The following policy and institutional recommendations are made on the basis of the study.

- ***Define Ownership Rights***: Craft clearly-defined legislation on ownership rights over various natural resources such as forest, water, wind, and solar, in order to reduce conflict over resource use.

- ***Protect Intellectual Property Rights***: Pass legislation to protect intellectual property rights in order to promote R&D under private and public sector partnership and to increase the level of funding for R&D activities related to RETs.

- ***Strong Political Commitment***: Seek commitment at higher levels for the promotion of RETs (most decision-makers find it easier to supervise, evaluate, and monitor large-scale energy interventions).

- ***Develop an Equitable and Rational Subsidy Framework***: Develop a framework for subsidies with respect to each RET based on an analysis of their economic and social equity according to the energy services they provide.

- ***Ensure Womens' Participation***: Involve women, who manage, use, and procure energy, in all aspects of renewable energy development programmes so that sociocultural dimensions are properly reflected in the programmes.

- ***Promote Private Entrepreneurs***: Promote private entrepreneurs for the development of RETs by reducing financial risks and costs, providing for unforeseen set backs through insurance, and improving investment incentives, e. g., below market loans, grants, rebates, tax incentives and tax credits, exemptions, and deductions.

- ***Simplify Banking Procedures***: Develop simplified banking procedures and make interest rates and other conditions on loans uniform for all RETs.

- ***Enforce Technical Standards and Quality Control***: Develop standards for the manufacture and construction of RETs that incorporate safety guidelines. Also, strict enforcement of standards should be made mandatory. Product warranties should be made obligatory for manufacturers and service providers so that the quality of products and services is assured.

- ***AEPC must Function as a Task-manager***: The AEPC, a recently established institution, must function as a task-manager for promoting of RETs. Care must be taken not to duplicate institutions at the local level but to involve existing indigenous institutions, NGOs, or entrepreneurs as a vehicle for technology transfer and thus maximise the participation of beneficiaries. Coordination, monitoring, evaluation, and technical backstopping functions become crucial for the commercialisation of RETs. the AEPC should take on this responsibility.

10.4 Technology-Specific Recommendations

It is observed that knowledge about the state of development, the level of technological interventions, and the rate of success among various renewable energy technologies vary widely. For example, a good manufacturing base exists in Nepal with regard to micro-hydro and biogas technologies, while very little experience has been gained in solar photovoltaic technology in terms of programme dissemination. At the same time, the improved cooking stove programme initiated in the early 1980s failed miserably, although recent programmes on improved cooking stoves (the locally-built mud-chimney type) are gaining popularity in the hills, since this stove primarily uses local materials and is constructed by women entrepreneurs. Based on these factors, the level of effort needed for the promotion of each renewable energy technology varies. Subsequently, the technology-specific measures should be adopted.

Besides general policy and institutional recommendations, which are applicable to all RETs, the following technology-specific recommendations are made.

10.4.1 Micro-Hydro Power

Adopt an Integrated Approach: An integrated approach to promoting microhydropower development should be adopted. An important measure in this context would be to integrate the irrigation requirements of a particular community with the installation of micro-hydropower plants.

Promote Community Management: Promote community-owned and managed micro-hydropower plants. Care must be taken that strong community organization and cohesiveness, democratic leadership, good technical and managerial capabilities, and strong technical back-up either exist or are built up.

Ensure Women's Participation: The participation of women in planning and implementation of micro-hydro plants should be ensured, which is not the case at present. However, women have been instrumental in convincing male members of households to install micro-hydro plants, since they reduce drudgery.

Evaluate Socioeconomic Conditions: A proper evaluation of the socioeconomic setting, technical and managerial capabilities, and surveys and designs must be ensured while carrying out feasibility studies. Accountability, on the part of surveyors and manufacturers, is essential.

Choose Suitable Technology: Promotion of smaller units, such as the improved *ghatta,* to replace traditional ones should be given priority, since this will ensure the participation of low-income groups.

Diversify End Use: Promote diversification of end uses for productive purposes such as agro-processing, cold storage, ice factories, power looms, carpet weaving, wood carving, and food processing.

Ensure Compensation: Water rights were among the critical issues identified. Prevailing laws do not ensure the right of prior use for agro-processing and electricity production. Appropriate compensation should be provided to owners if a conflict arises.

Standardise Quality Control: The quality of raw material used, safety codes to be followed during installation, and the rated power of turbines and generators, should be standardised.

Carry out Training Programmes: The preparation of construction manuals and codes and the enforcement of standards are essential. Also, training manuals on operation and maintenance as well as on bookkeeping are required, and programmes must be initiated to provide training to micro-hydropower operators and owners.

10.4.2 Biogas Technology

Initiate Integrated Programmes: BSP activities should be integrated with the livestock development programme and with other rural development initiatives.

Continue Subsidy Schemes: The subsidy policy for biogas plants should continue with the same level of management support. However, low-cost biogas plants should be promoted with easy access to credit facilities for low-income households through community loan schemes for landless and women's groups.

Promote Low-cost Biogas Plants: The dissemination strategy adopted for and the performance of the *Deen Bundhu* biogas model were found to be encouraging. Similar action research programmes should be replicated in other areas to cater to the needs of low-income farmers. The initial cost of biogas plants is very high; therefore, R&D should focus on reducing this cost.

Initiate Demonstration Programmes: Demonstration biogas units should encourage adoption of the technology by being identified with a progressive farmer willing to install a biogas plant.

Enforce Standardisation and Quality Control: Strict enforcement of quality control and standardisation is needed. But care must be taken not to go to extremes, since this inhabits innovation.

Conduct Awareness Programmes: Plant owners should be made aware of how to apply slurry on their fields and how to develop appropriate tools/equipment (such as trolleys) for handling slurry.

10.4.3 Improved Cooking Stoves

Develop Long-term Vision: A long-term vision of what a healthy kitchen environment implies should be developed, along with how to reduce fuelwood consumption. The programme should focus on factors fundamental to kitchen improvement.

Develop Technology to Match Users' Needs: The various types of models suitable for different locations and ethnic groups should be developed and demonstrated. For this, a strong programme of research and development endowed with adequate financial support is required.

Provide a Subsidy for Promotional Activities: Promotional activities related to ICS dissemination should be subsidised. The cost incurred during the dissemination of ICSs is primarily for training ICS technicians and for promotional materials.

Build Women's Capabilities at Village Level: The capabilities at village level should be augmented. For this to happen, a person to be trained as an ICS technician should selected. This could be someone who is unemployed, local, innovative, with good motivations skills, preferably a woman. Users should also be oriented so that they understand the importance of each component of an ICS, and they should be involved in their placement and construction.

Promote Use of Local Materials and Indigenous Skills: Promote the use of local materials and indigenous skills and impart training to women for the construction of ICSs.

Institutionalise Technical Back-up and Monitoring: An institution with the responsibility for providing technical back-up and programme monitoring is needed.

10.4.4 Solar PV Technology

Area Identification for SPV Home Systems: Areas suitable for the dissemination of SPV technology should be identified.

Continue the Subsidy: The subsidy for SPV technology is justified because of the effect demonstrations in remote areas have in popularising it in the initial phase.

Remove Technical Constraints through R&D: Various technical constraints (low power conversion efficiency, the storage problem, and climatic uncertainty) need to be resolved for the smooth functioning of SPV systems, namely, by promoting suitable research and development activities.

Promote Stand-alone SPV Systems: Stand-alone SPV systems should be promoted rather than centralized systems. Stand-alone SPV systems are more appropriate in remote areas due to there being less difficulty with transmission and fewer managerial constraints.

Promote Institutional Linkages and Coordination: Institutional linkages and coordination must be promoted among the various institutions involved in the development and promotion of SPV. A newly established organization, AEPC, should play the lead role in facilitating the efforts of these various organizations to promote SPV technology.

Design Innovative Funding Mechanisms: Innovative funding mechanisms should be designed so that the equity concerns of the poor can be met. In this regard, the formation of village-level cooperatives could be an important beginning; and for this the government may have to provide seed money. This approach needs to be tested prior to its replication.

Promote Integration with Income-generating Activities: SPV technology dissemination should be integrated with income generation and social development activities so as to justify the subsidy scheme.

Promote Women's Participation: Women's active participation in the SPV programme should be sought since availability of light provides the opportunity for women to participate in various income-generating and social development activities.

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Indexes of keywords and phrases

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Myanmar
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Pakistan

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