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 energies, 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 photo-voltaic 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	2,300,000m²	326,000m²	125-150kg ce	279
Passive solar houses	5,000,000m²	N.A.	30-40kg ce	150
Solar cookers	140,000m²	N.A.	500-700kg ce	84
Solar greenhouses	225,000ha			
Solar driers	1,314m²			
Solar photovoltaic cells	3.3MW	4.5 MW		
Small-scale wind	130,000 units	17 MW		
Turbines (100W-5 kW)	14.6MW			
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	1,305,000m²			
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 renew-

able 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 know-how 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