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,

1 Mr Shrestha worked as Renewable Energy Specialist for CRT for the study sponsored by ICIMOD.

2 Ms Bajracharya worked as the Women's Development Specialist for CRT for the study sponsored by ICIMOD.

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.

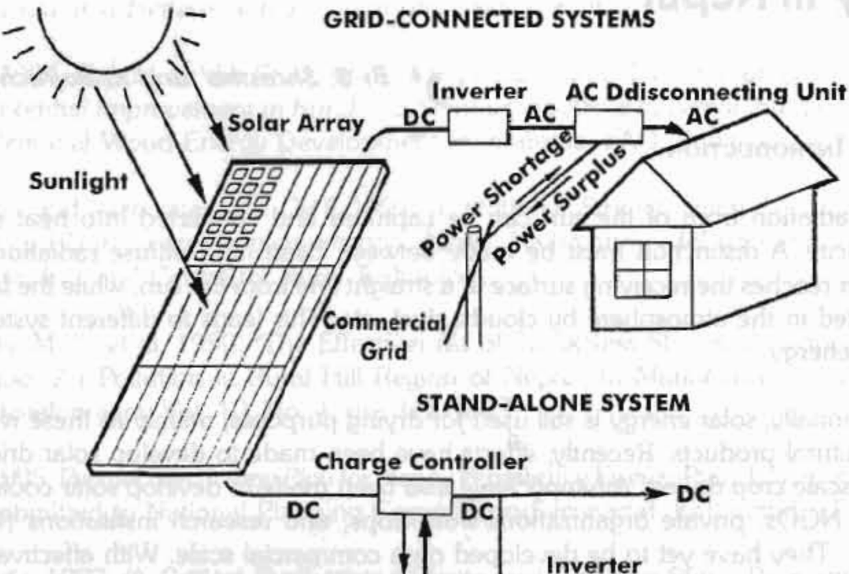

Figure 9.1: Solar Photovoltaic System

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 grass-roots 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 grass-roots' 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 micro-hydropower 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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