3

NEPAL'S ENERGY RESOURCE BASE AND ITS USE

Nepal's energy resources consist of traditional and commercial sources; including fuelwood, agricultural residue, animal wastes, solar and hydro-electricity. Petroleum fuels are imported and electricity is exchanged with India.

Hydro resources represent a large proportion of the total theoretical potential. Nepal is estimated to possess 1,857.7 million GJ of raw energy. Hydropower alone is estimated to have a theoretical potential of 1,461 million GJ or 78.6 per cent of the total. Yet, at present, hydropower provides less than one per cent of the energy being consumed in the country. Forest resources are next in order of importance to hydropower, followed by agricultural residue. Table 6 provides further details. It may be noted that the table shows estimated energy that is theoretically available in the country. Not all of the theoretical potential can be economically exploited.

Indigenous Energy Resources

The following is a brief description of the main indigenous energy resources.

Fuelwood

Currently, wood accounts for 75 per cent of all energy and over 16 per cent of the long-term theoretical, indigenous energy potential of Nepal on a raw GJ basis. Fuelwood comes from public forests, shrub and grasslands, and private holdings.

Nepal has an estimated total of 8.85 million hectares of potentially productive forests, shrubs, and grasslands; of which 6.73 million hectares are estimated to be forests and shrublands only. About 50 per cent of the 6.73 million hectares or around 3.34 million hectares are used for fuelwood collection.

In the absence of the adequate development of alternative energy sources, and due to Nepal's population growth, the demand for fuelwood in the country is rapidly expanding and has resulted in tremendous pressure on the existing forests. Over-exploitation of the forests has resulted in the loss of forest areas and crown cover.

Table 6: Theoretical Indigenous Energy Resources

Annual	Natural Units: Annual Supply	Raw Energy Available: (GJ*10^6)	(%)
Sustainable Forest Yield (3)	17.5 MM-Tons	293	15.8
Agriculture Residue	6 MM-Tons	76	4.1
Animal Wastes	2.3 MM-Tons	25	1.3
Hydropower (1)	405800 GWh	1461	78.6
Direct Solar (2)			
- Insulation	26000 M-kW	3	0.2
- Wind	?	?	0.0
Fossil Fuel	Unknown	?	0.0
	Sub Total	1,857.7	100.0

Source: WECS. Energy Issues and Options and the Eighth Five Year Plan. 1989.

Notes:

1. Based on average flow.
2. Assumes maximum 0.001% of land area coverage for solar infrastructure.
3. Based on Forestry Sector Master Plan projections of sustainable supply for 2010/2011 only. Competition for land is assumed to be a limiting factor.

Agricultural Residue

Currently, agricultural residue constitutes 11 per cent of the energy consumption and about four per cent of the long-term, theoretical indigenous energy potential of Nepal on a raw GJ basis. The total production of crop residue in Nepal for 1985/86 was estimated to be 12.5 million metric tons. Rice straw accounts for 67.4 per cent of the total agricultural residue supply. Most agricultural wastes are burned in open fires.

Animal Waste

Dung constitutes 8.5 per cent of the energy consumption and a little over one per cent of the long-term, theoretical indigenous energy potential on a raw GJ basis. Using the assumptions presented in the "Energy Sector Synopsis Report, 1985/86", WECS estimated the supply of dung

available for energy conversion in 1985/86 to be 2,274 thousand metric tons. Dung has considerable value as a fertiliser and this competes with its use as a fuel. Dung is mostly dried and burned directly. Alternatively dung is used for biogas plants, in which case it produces both energy and organic fertilisers.

Hydroelectricity

Electricity currently constitutes about 0.85 per cent of all energy consumption, compared to about 78 per cent of the long-term, theoretical indigenous energy potential on a GJ basis. It is also the most expensive, indigenous resource to develop and requires considerable capital and external inputs, given the small, local manufacturing capability to produce the hardware, equipment, and services.

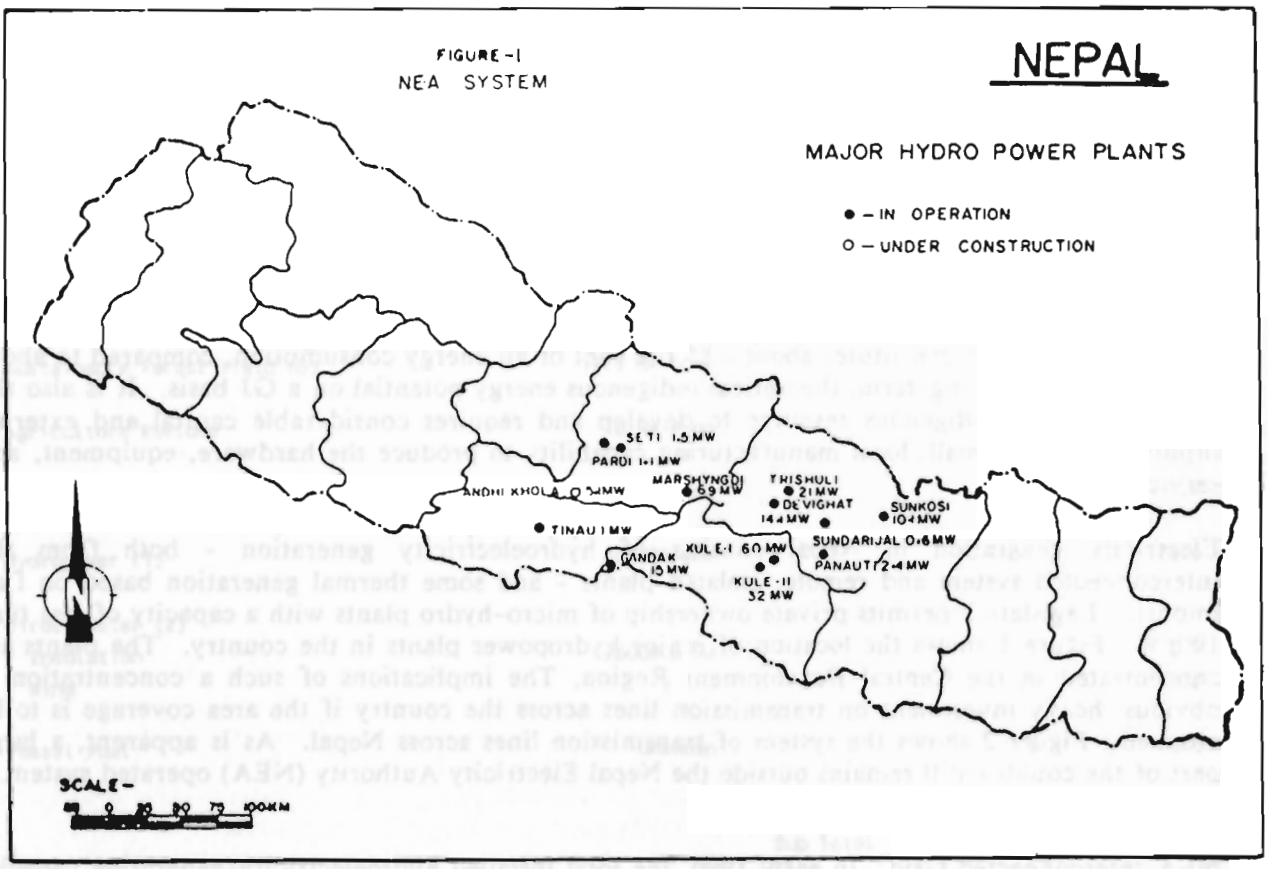
Electricity generation in Nepal consists of hydroelectricity generation - both from the interconnected system and remote, isolated plants - and some thermal generation based on fuel imports. Legislation permits private ownership of micro-hydro plants with a capacity of less than 100kW. Figure 1 shows the location of major hydropower plants in the country. The plants are concentrated in the Central Development Region. The implications of such a concentration is obvious; heavy investment on transmission lines across the country if the area coverage is to be attained. Figure 2 shows the system of transmission lines across Nepal. As is apparent, a large part of the country still remains outside the Nepal Electricity Authority (NEA) operated system.

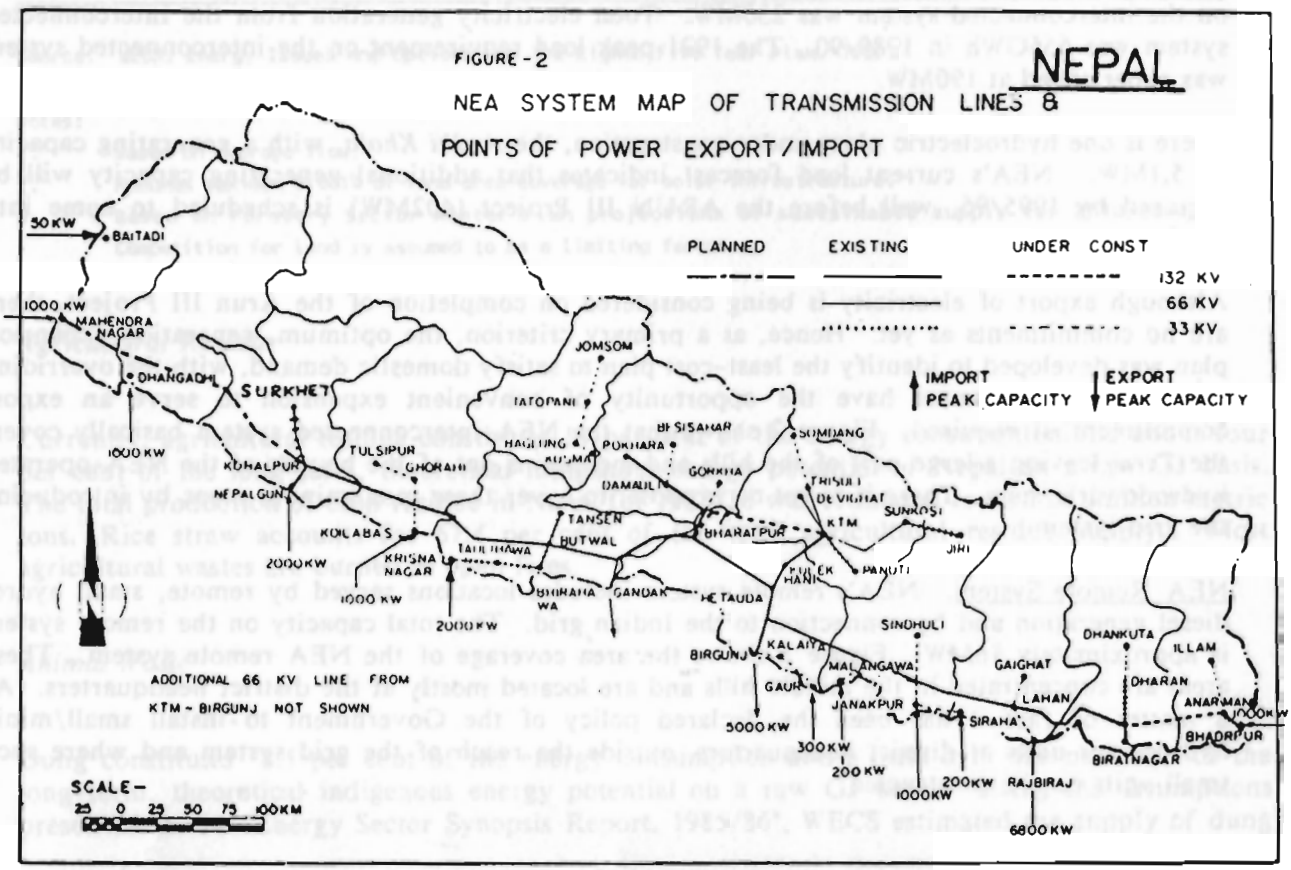
NEA Interconnected Grid. In early 1990, the total installed hydroelectricity-generating capacity on the interconnected system was 230MW. Total electricity generation from the interconnected system was 556GWh in 1989/90. The 1991 peak load requirement on the interconnected system was experienced at 190MW.

There is one hydroelectric plant under construction, the *Andhi Khola*, with a generating capacity of 5.1MW. NEA's current load forecast indicates that additional generating capacity will be required by 1995/96, well before the ARUN III Project (402MW) is scheduled to come into service.

Although export of electricity is being considered on completion of the Arun III Project, there are no commitments as yet. Hence, as a primary criterion, the optimum, generation expansion plan was developed to identify the least-cost plan to satisfy domestic demand, with the overriding constraint that it must have the opportunity of convenient expansion to serve an export commitment, if required. Figure 2 shows that the NEA-interconnected system basically covers the *Terai* leaving a large part of the hills and mountains out of the bounds of the NEA-operated hydropower system. There is as yet no proposal to cover these mountainous areas by introducing the grid system.

NEA Remote System. NEA's remote system includes locations served by remote, small hydro, diesel generation and by connection to the Indian grid. The total capacity on the remote system is approximately 16MW. Figure 3 shows the area coverage of the NEA remote system. These areas are concentrated in the middle hills and are located mostly at the district headquarters. As a matter of fact it has been the declared policy of the Government to install small/mini-hydropower units at district headquarters, outside the reach of the grid system and where such small units can be constructed.





Source: WECS. *Energy Issues and Options and the Eighth Five Year Plan.* 1989.

Small Hydro Units. In mid-1989, NEA had 23 small hydro units in operation with capacities ranging from 32kW to 345kW (total capacity 3,591kW). In addition, there are currently seven small hydro units under construction under the supervision of NEA, with capacities ranging up to 1,000kW.

Hydraulic Mechanical Power. During the past ten years, small-scale water turbines used primarily for agro-processing and rural village electrification have become popular in the hill and mountain regions. The most popular types are traditional mills, multipurpose power units, and crossflow turbines.

Private Micro-hydro. The estimated capacity of all micro plants currently operating is 920kW from 91 sites, for an average of 10kW per site. The largest plant is 40kW, with the remaining plants being 27kW or less. Figure 4 shows the location of alternative energy plants in the country. Micro-hydros are the main types of generating plant used in this context and are concentrated in the Bagmati and Lumbini zones.

Fossil Fuels. There are no known commercial resources of fossil fuel in Nepal. Seismic and other explorations are continuing in cooperation with international agencies and companies.

Solar and Wind Energy

Direct solar energy accounts for a negligible proportion of the energy consumed (excluding sun-drying for which there are no estimates) and under one per cent of the long-term, theoretical indigenous energy potential on a raw GJ basis. Conversion of sunlight to electricity is a simple but high technology option, although a number of developing countries, including India, have solar cell manufacturing capability. Solar Photovoltaic (PV) technology is only cost-effective today for very remote and small but vital power loads. All materials are imported. With further cost reduction in PV technology and the development of storage systems, solar electricity does hold some promise for future application as a village-level power source. In Karnali Zone, two solar power plants have been installed but they have not performed satisfactorily. Similarly, solar water heating has the limited but useful potential for replacing wood and electricity for low temperature water heating.

Wind energy is not used to any practical extent in Nepal. Agencies such as the Royal Nepal Academy of Science and Technology (RONAST) and the Research Centre for Applied Science and Technology (RECAST) are working on the development of windmills and wind turbines to be used in the remote regions. NEA has constructed a pilot plant with a 20kW capacity situated at Kagbeni in Mustang. Wind remains a site-specific consideration whether for mechanical or electrical applications.

Commercial Energy Imports

Petroleum accounts for approximately 5.4 per cent of the current energy consumption in Nepal on a GJ basis. Petroleum products play an obvious role in all sectors of the economy, especially transport, and coal in industry. Demands for petroleum products and coal are met entirely through imports and electricity is exchanged with India along some border points under a power exchange agreement.

FIGURE -3

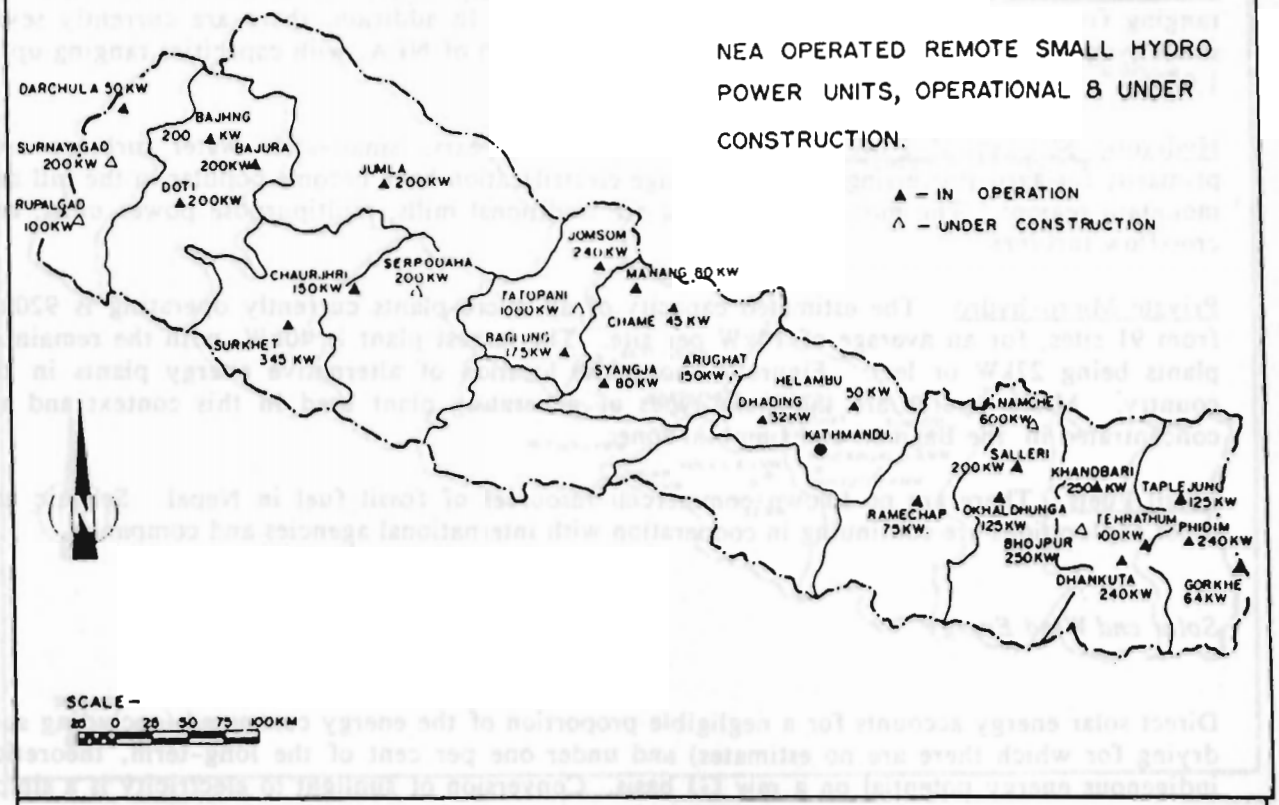
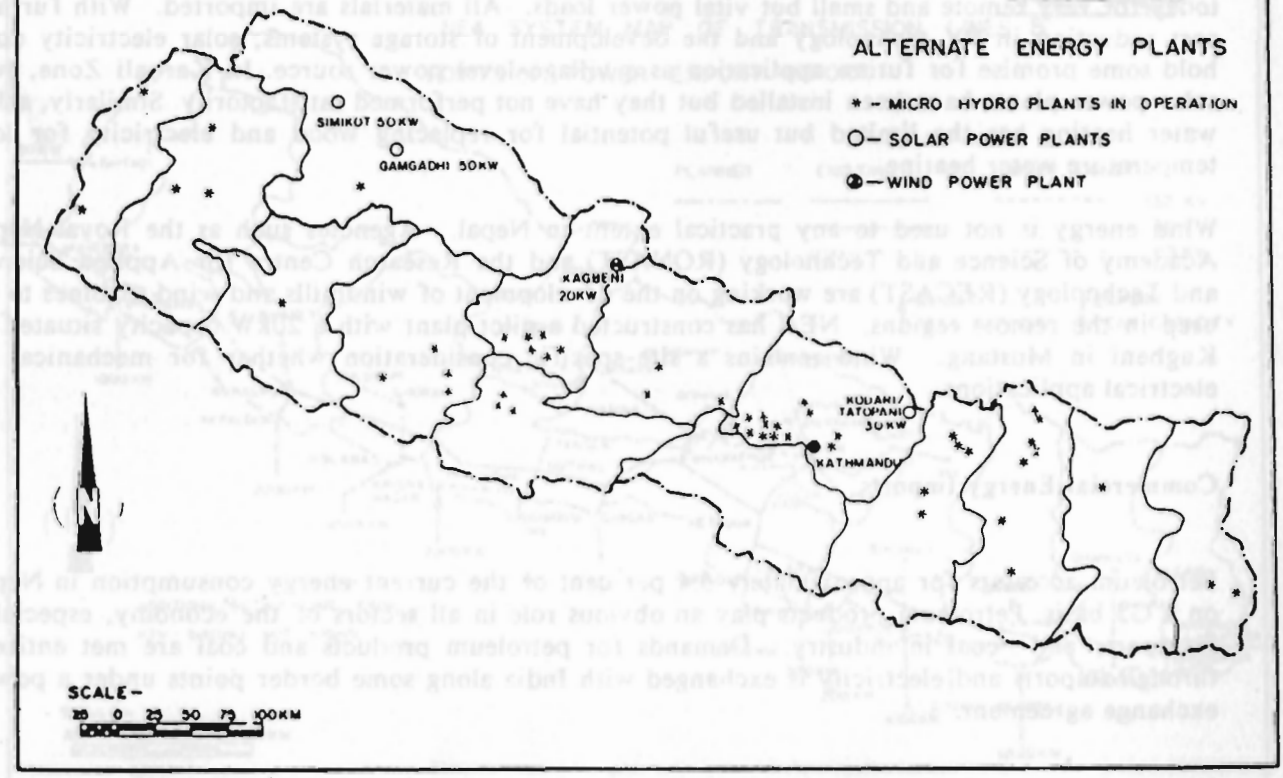


FIGURE -4



Source: WECS. *Energy Issues and Options and the Eighth Five Year Plan.* 1989.

Petroleum Products

Nepal Oil Corporation (NOC) purchases kerosene and diesel on the international market. A percentage of these products is handed over to India in return for the supply of a full petroleum product mix; including motor spirits, aviation fuel, and Liquified Petroleum Gas (LPG). As such, the oil supply in Nepal is dependent on the world oil market and upon a mutual arrangement with India. By purchasing kerosene and diesel directly on the open market, Nepal can ensure the most favourable price for these products under long-term contracts and/or spot market conditions. However, Nepal remains susceptible to variations in refiner's costs, profit margins, administration, and transportation and storage costs in India as well as potential supply interruptions; as witnessed by recent events.

Currently NOC has a total storage capacity of 27,750 kl in Kathmandu, Amlekhgunj, Biratnagar, Bhairawa, Nepalgunj, and Dhangari and has plans to build an additional 7,934 kl of storage facilities by the end of the Seventh Plan period.

In 1987/88, NOC imported the following mix of petroleum products.

	MT	Percentage
Motor spirit	15,609	9.0
Kerosene	51,835	29.3
Diesel	72,098	41.4
Light Diesel Oil (LDO)	5,719	3.3
Aviation fuel	19,345	11.1
Furnace oil	7,435	4.0
LPG	2,304	1.3
Total	174,345	100.0

Source: Nepal Oil Corporation.

Coal. The supply of coal is now the responsibility of Nepal Coal Limited (NCL). This organisation was established in June 1985 with a mandate to import and distribute coal, in an organised manner and at a reasonable price, to all Nepalese industries and other sectors according to their need. NCL has depot offices in Birgunj, Biratnagar, and Bhairawa. The supply of coal comes from five collieries in Northern India and the different types of coal imported are steam, slack, hard coke, and beehive, hard and soft.

Electricity Exchanges. Under a power-exchange provision, Nepal imports power from and exports power to India along the border. Currently, Nepal exchanges electricity at 12 points. However, interconnection with the national grid has led to a reduction in dependency on imported electricity in the *Terai*. Although the present arrangement allows for an exchange of up to 50MW of power, owing to transmission line and sub-station capacity limitations, the exchange is only around 10 to 15MW.

Major Issues for Consideration

The preceding discussion on aggregate and sectoral energy demands and supplies together with the examination of indigenous energy resources underline some major issues in the energy sector. These issues are:

1. The consumption of fuelwood from the forests is beyond their long-term sustainable yield potential. Continuation of this trend will have serious environmental effects. The Master Plan for Forestry Development has already been prepared. Even assuming that all the proposed programmes are implemented, there will still be a time lag before increased sustainable yield from the forests materialises. In the interim what is to be done?

2. The use of agricultural residue and dung for energy at present exceeds their theoretical potential. Removing them as a source of energy further increases the energy supply gap but a continued use of these energy forms will be at the expense of agricultural productivity. What steps can be taken to reconcile this conflict?

3. A tiny portion of the theoretical potential of hydropower is currently exploited. Clearly it is the energy of the future. Yet, given the time and cost involved in exploiting this resource through big power projectors, it is extremely unlikely that hydropower can be supplied to rural Nepal in a significant way. What steps can be taken so that, at least, a beginning can be made to make hydroelectricity available in the rural areas?

4. Energy forms show a high degree of end use specificities. In the rural areas, when available, electricity is used for lighting. If it is not available, kerosene is used. Fuelwood is used for all other activities. In such a situation, to what extent is inter-fuel substitution possible?

5. Even if electricity could be supplied to the rural areas, will the present load factor permit its promotion as an alternative to a fuelwood-based energy system?

6. Matching resource endowment with use indicates a more prominent role for alternative energy such as micro-hydro, biogas, solar, and wind-power. To what extent have these technologies been internalised in Nepal's energy development strategy?

These major issues indicate a need to review Nepal's energy development strategy and policies as it is within this framework that answers should be sought.