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AN ASSESSMENT OF THE ENERGY SECTOR IN NEPAL

Implication for the Planning and Management of Rural Energy

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International Centre for Integrated Mountain Development

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PREFACE

This paper was prepared for, and presented at, the Seminar on 'Rural Energy and Related Technologies' held in Kathmandu from 26 to 28 March, 1991, in collaboration with the Agricultural Development Bank of Nepal and the Water and Energy Commission Secretariate of His Majesty's Government of Nepal.

This paper assesses the energy sector in Nepal in terms of the existing and projected demand and supply of different energy forms and the use of indigenous energy resources, policies, and programmes in the energy sector, and highlights major issues and options for promoting a sustainable development in future.

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INTRODUCTION

The World Commission on Environment and Development, popularly known as the Bruntland Commission, has noted that "*a safe and sustainable energy pathway is crucial to sustainable development; we have not found it yet*" (WCED 1987). While some countries depend excessively upon fossil fuel to meet their energy needs, others still fall back upon forests and other traditional forms. In either case, the environmental implications are obvious. In developing countries the problem is further exacerbated by high population growth and the consequent increased demand for energy. Obviously, the present energy scene needs to be re-examined in an attempt to examine possibilities for promoting approaches that do not draw so heavily upon the fragile environment. Furthermore, in view of the crucial role that energy plays in economic development, it is apparent that the current low level of per capita consumption will increase as the national economy grows and the modern industrial sector becomes more important. If the additional demand were to be met solely from the existing sources of supply, it would have severe environmental consequences.

The energy sector in Nepal already demonstrates elements of unsustainability. Excessive dependence on forests, a low level of current per capita consumption which is expected to increase in the future, high population growth and its effect on energy demands, inefficient use of energy resources, and negligible conservation efforts are some of the contributing factors. At this point, it should be noted that, in Nepal, the prime reason for unsustainability is not the dependence upon an exhaustible resource base but the indiscriminate and excessive use of one type of renewable resource whereas other types of renewable resource have remained virtually unused. The excessive dependence on the forests when hydropower, biogas, and solar energy could also have been exploited to meet the energy needs illustrates this point. Therefore, energy planning and management in Nepal should attempt to redress the imbalance between energy resource endowment and its current use. An important associated issue, in this context, is that of ensuring that the energy sector positively affects the growth of the overall economy, while imbalances between use and endowment are reduced. Thus, the issue of energy transition not only relates to the substitution of one form of energy by others but also to the growth and development of the economy brought about by such a transition.

About 90 per cent of Nepal's estimated population of 18.8 million lived in rural areas in 1990. In the next 20 years, the population is expected to increase to about 31.2 million. Although the percentage of the rural population is expected to decline, it will still remain at a fairly high level; around 78 per cent of the total (Banskota et al. 1990). In absolute terms the population residing in rural areas will be around 24.4 million, and this is almost one and a half times the current number. The distribution of the population between the mountains (including the hills) and the *Terai* is approximately 53:47 at present, but it is expected to be 47:53 at the end of the next 20 years. The rural *Terai* accounts for about 45 per cent of the total at present and this is expected to increase to about 48 per cent in 2010 A.D. Clearly, development in Nepal cannot take place

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ENERGY DEMAND PATTERN AND END USES

Overview

Nepal's energy sector is dominated by few resources. Traditional resources, such as fuelwood, agricultural waste, and animal dung, are by far the most important sources of energy, providing about 95 per cent of the total energy consumed. Commercial energy, in which petroleum products, coal, and electricity are prominent, accounts for the remaining five per cent.

The dependence on traditional fuel has obvious implications for the forests. For various reasons (of which energy is only one) forests have been "consumed" at a rate that far exceeds their regeneration. *Between 1964 and 1985, the area of natural forests was reduced by about 570,000 ha or 22,800 ha annually. During the same period reforestation has been only 69,200 ha or 3,295 ha annually .... at present, the rate of deforestation and degradation are estimated as 44,166 ha/year and the reforestation rate as 4,000 ha/year* (Banskota et al. 1990). The declining forests have led to use of agricultural residue and dung on an enhanced scale, and the use of agricultural residue and dung for energy rather than for their traditional use as plant nutrients has obvious disadvantages.

Currently, approximately 12 per cent of all energy consumption in Nepal is monetised. Fuelwood is now monetised in the towns and is increasingly becoming so in parts of the *Terai.*

The demand for electricity and imported hydrocarbon sources has grown annually at approximate rates of 14 per cent and 7 per cent respectively over the 1980s. The past fluctuations in growth rates of different types of energy demonstrate a sensitivity to the reliability and availability of supply.

The transport and industry sectors rely on a steady supply of imported hydrocarbons. In the foreseeable future, petroleum products and coal will continue to be imported through India. Petroleum and coal import costs have accounted for about 25 per cent to 30 per cent of merchandise export earnings, accounting for as much as 50 per cent in some years. Kerosene, commonly used for lighting in rural areas, is subject to high distribution costs, especially in remote areas.

Hydropower is Nepal's major resource endowment. However, out of a theoretical potential of 83,000 MW, the current installed capacity is only 230 MW. Numerous run-of-the-river and multipurpose hydro schemes have been identified but remain undeveloped. Small and micro-hydro potential remains virtually unused in the hill and mountain areas.

Despite Nepal's small size, only about nine per cent of the population has access to electricity and about half of all domestic connections are concentrated in the Kathmandu Valley.

The per capita consumption of energy was less than 400kg of oil equivalent (KOE) in 1988/89 which is far lower than that of many other countries in the region. The consumption of energy is highest in the domestic sector; being 95 per cent of the total and 24.4 per cent of the commercial energy consumed in the country.

An improvement in Nepal's energy situation is essential for sustainable economic growth and the alleviation of poverty. Investments to expand energy supply is required to meet growing needs. The 1989 trade and transit impasse with India underlined the importance of promoting a self-reliant energy development programme in the long run. Excessive dependence on imported energy has political and economic implications as is commonly observed not only in Nepal but also in other oil importing countries.

Energy Demand Patterns: Current and Projected Trends

The Current Situation

Table 1 provides data on energy demands in different sectors of the economy. During the 1980s there has been an increased consumption of agricultural and animal waste to meet domestic energy needs. This indicates that people in rural areas are finding it difficult to rely solely on the forests to meet their energy needs. The overall demand for energy grew at an annual rate of 7.5 per cent during the 1980s. The growth rate is seen to be highest for animal waste (48.5%) and lowest for fuelwood (4.8%). Commercial energy consumption during this period increased at an annual rate of approximately 8 per cent.

The data gap precludes an analysis of energy demands by sectors in different geographical regions of the country. Nevertheless, it will not be misleading to say that there has been a substitution of fuelwood by agricultural residue in the hills and by animal dung in the *Terai*.

Population growth is one of the main causes of the increasing energy demand in the domestic sector. Growth in the demand for commercial energy has matched the pace of development of the modern industrial sector, transport sector, and other non-agricultural sectors of the economy. Limited use of commercial energy for lighting, has been made in rural areas. In the urban centres, commercial energy is used in the domestic sector to meet different needs such as lighting, heating/cooling, cooking, etc.

A set of *status quo* energy demand projections has been prepared by the Water and Energy Commission Secretariat (WECS) for the five major sectors of the economy: namely, the domestic, industrial, transportation, agricultural, and commercial sectors. The projections were generated from computer-based, end use models. These models simply serve as a basic tool for energy planning and rely on the use of data available from various field surveys and studies initiated by WECS, supplemented by information obtained from HMG ministries and external agencies. Demand/supply profiles were developed by WECS for the base year of 1985.

In 1985/86, the total consumption of energy was 244.5 million gigajoules (GJ) out of which approximately 231 million GJ were used in the domestic sector. The industrial and commercial sector was estimated to have consumed 5.8 million GJ and 4.9 million GJ respectively. For the remaining sectors, the consumption was almost 3 million GJ. Table 2 provides details of energy demand by sectors.

Table 1: Sectoral Energy Demands 1980/81 and 1988/89

	Energy Demand by Type ^000 Tons of Oil Equivalent (TOE)						
Sector	Fuelwood	Agricultural Waste	Animal Waste	Petroleum	Coal Coke	Electricity	Total
Domestic							
1980/81	3110.2	55.2	21.1	31.3		6.8	3224.5
1988/89	4499.8	652.2	497.7	53.8		15.9	5719.4
Industrial							
1980/81	21.8	-		4.9	22.5	4.3	53.5
1988/89	47.6	5.9		8.7	29.3	15.1	115.1
Commercial							
1980/81	9.3			6.7		2.0	18.0
1988/89	14.4			22.0	17.3	2.6	56.3
Transport							
1980/81				69.3	0.7	0.1	70.0
1988/89				105.8	1.1	0.1	107.0
Agricultural							
1980/81				5.2		0.3	5.5
1988/89				7.3		1.2	8.5
Others							
1980/81						0.6	0.6
1988/89						4.7	4.7
Total							
1980/81	3141.3	55.2	21.1	117.3	23.1	14.1	3372.1
1988/89	4561.7	658.1	497.7	197.7	47.7	39.7	6011.1
Annual Growth Rates (%)	4.8	36.3	48.5	6.7	9.5	13.8	7.5

Source: WECS. Energy Balance Sheet of Nepal. 1990.

Note:

1. Figures rounded up to one decimal place. Total may not exactly tally.
2. Due to the trade impasse in 1989, the last three months of 1988/89 show a lower supply of petroleum and coal corresponding to the same period in 1987/88.

Out of the total of 244.5 million GJ consumed in 1985/86, fuelwood supplied 184.5 million GJ of energy. Further, 47.7 million GJ were from agricultural residue and animal dung. Commercial energy, such as petroleum products, electricity, gases, and coal, supplied only about 12 million GJ that year. Details on the share of different energy sources are provided in Table 2.

Projections for 2000 A.D

Demand projections were made for the year 2000 A.D. In these projections, total energy consumption for all sectors of the economy, including the use of traditional and commercial forms of energy, was estimated to rise from about 244 million GJ in the year 1985/86 to 325 million GJ by the year 2000. This works out at two per cent per annum. Since traditional sources play such a large role in the total energy picture and, given that traditional components, especially fuelwood, are becoming scarce, there will be some changes in the relative importance of each energy type. The projections for the domestic sector are provided in Chart 1.

The projections (Table 2 and Table 3) show that the energy demand will increase most rapidly in the agricultural sector (8.5 % annually), followed by the transport sector (5.2% annually), and the industrial sector (5.1% annually). The annual increase in demand in the commercial sector is expected to be about 4.5 per cent annually. The growth rate in demand in the domestic sector is expected to be about 1.7 per annum; the least of all sectors. However, because of its size, the domestic sector will still be consuming about 91 per cent of the total energy consumed in the country by the turn of this century.

The projections show that by 2000 A.D. there will be a relative shift in demand for various energy sources. Fuelwood, which met 75.5 per cent of the demand for energy in 1985/86, is expected to meet only 54.7 per cent of the demand in 2000/2001 A.D. The projections not only show a decline in the share of fuelwood but also show a decrease in absolute terms. Other energy sources show positive growth rates during the period and they range from 3.3. per cent to 8 per cent per annum. Commercial energy sources are expected to contribute 8.4 per cent of the total energy in 2000/2001 compared to 5 per cent in 1988/86.

The major change over the medium-term will be in traditional energy types with fuelwood being increasingly substituted by dung and agricultural wastes, particularly in the *Terai* where the fuelwood deficit is most pronounced. Estimates giving the percentage of the population, whose energy demands will be satisfied sustainably from the forests (assuming that efforts to implement the Forestry Sector Master Plan are successful) were derived as a separate planning exercise by WECS. The results vary by development and physiographic regions but it is believed that, if fuelwood consumption is kept at a sustainable rate, it will be able to meet 64 per cent of the traditional energy demands by the year 2000; a drop from 71 per cent in 1990. WECS estimates that fuelwood met approximately 79 per cent of the demand in the 1985 base year. With the inclusion of supplies from other traditional energy sources, and given the successful distribution of Improved Cooking-Stoves (ICS) and biogas plant installations, about 92 per cent of the population can be served on a sustainable basis by the year 2000; still leaving a deficit. The deficit will be most critical in the *Terai* regions; particularly in the eastern districts.

The projected deficits indicate that there is a need for effective management of the energy sector in order to meet the expected demand by 2000 AD. Energy management has to be planned and implemented on the basis of domestic resource endowments, barring which recourse to large-scale imports of fossil fuels may be required. The capacity of the nation to follow this course is severely limited. Alternative technologies, thus, assume a far greater significance than they have so far been accorded, as these technologies, if promoted and implemented properly, have the potential to meet the demand for rural energy.

Table 2: Sectoral Energy Demand Projections

(in 10^6 GJ)

Sector	1985/86	%	2000/01	%	Average Growth % Over Period
Domestic	230.8	94.4	296.0	91.1	1.7
Industrial	5.8	2.4	12.3	3.8	5.1
Commercial	2.6	1.1	5.0	1.5	4.5
Agricultural	0.3	0.1	1.1	0.3	8.5
Transportation	4.9	2.0	10.5	3.2	5.2
Total	244.5	100.0	324.9	100.0	1.9

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

Table 3: Total Energy Demand Projected by Source of Energy

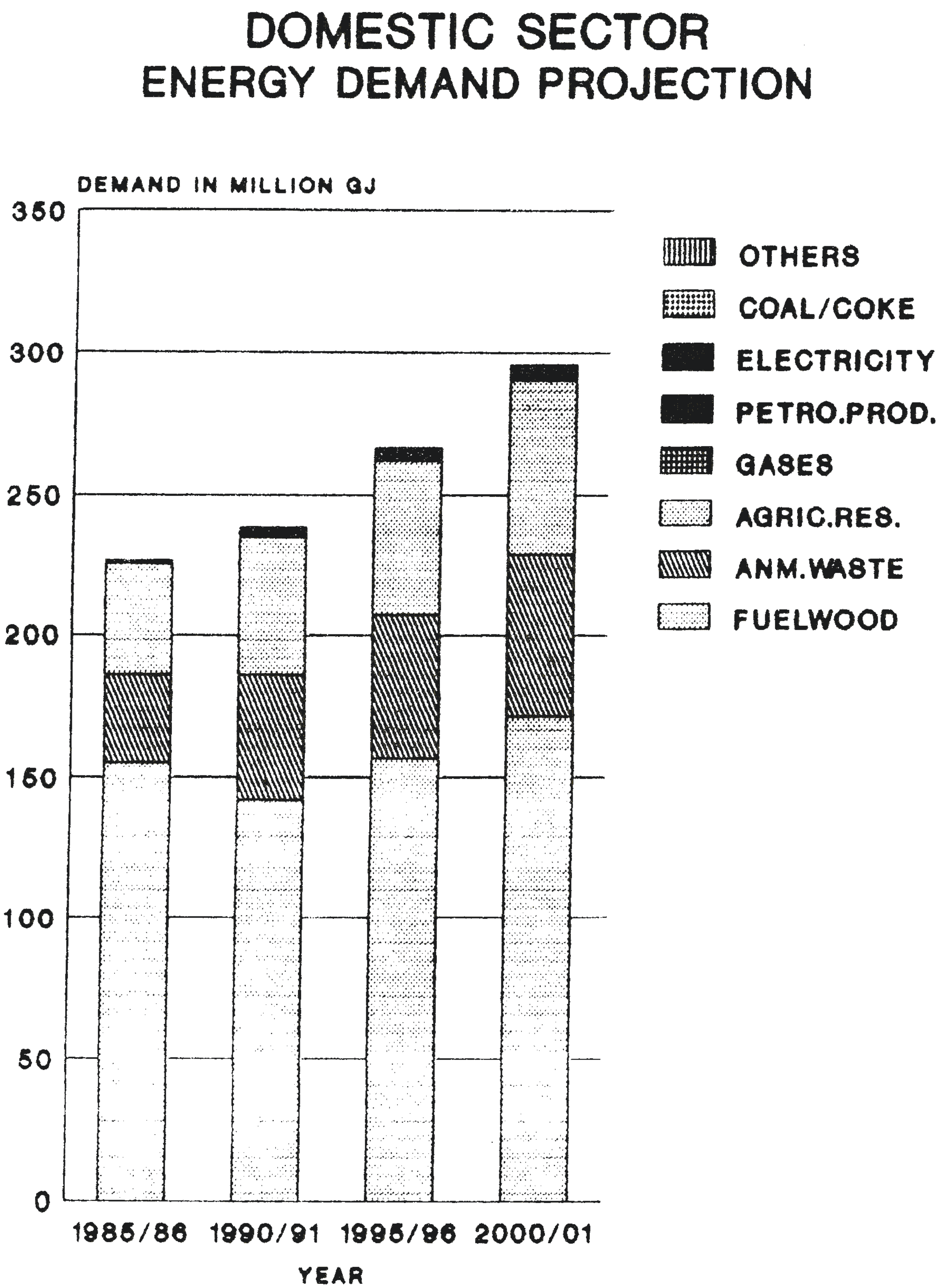
(in 10^6 GJ)

Fuel Type	1985/86	%	2000/01	%	Average Growth % Over Period
Fuelwood	184.5	75.5	177.8	54.7	-0.25
Agric. Residue	26.9	11.0	57.3	17.6	5.17
Animal Waste	20.8	8.5	62.3	19.2	7.61
Gases	0.1	0.0	0.2	0.1	4.03
Petroleum Product	8.6	3.5	17.3	5.3	4.75
Electricity	1.7	0.7	5.2	1.6	7.74
Coal/Coke	1.1	0.5	3.5	1.1	7.98
Others	0.7	0.3	1.1	0.3	3.31
Total	244.5	100.0	324.9	100.0	1.91

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

Note: Total may not add up due to rounding.

CHART 1



Source: Nepal Oil Corporation, 1988.

Over the longer term, and assuming that the Forestry Sector Master Plan Programmes are implemented and begin to yield satisfactory results, the proportional share of fuelwood will increase again (HMG/N, FINNIDA, and ADB 1988). The share of commercial energy in the total national energy demand profile will grow marginally, although the significance of commercial energy use in terms of foreign exchange expenditure will remain high. If the measures to launch afforestation programmes, outlined in the Forestry Master Plan, are not implemented immediately, a much higher level of commercial energy consumption can be expected. The domestic sector, which now accounts for about 94 per cent of the total energy consumption, will be reduced to about 91 per cent of the total consumption while the industrial, transport, commercial, and agricultural sectors will grow at a faster rate and account for the balance.

Sectoral End Uses and Projections

It is important to know the end-use specificity of various energy types as well as end use specificity by sector. This information indicates to what extent one form of energy can substitute another in use in various sectors of the economy. A relatively high end use specificity indicates difficulties in substituting one form of energy by another. Planning implications in such cases are that the relative importance of each form remains more or less at the same level over a certain period of time. The energy sector in Nepal gives the following picture.

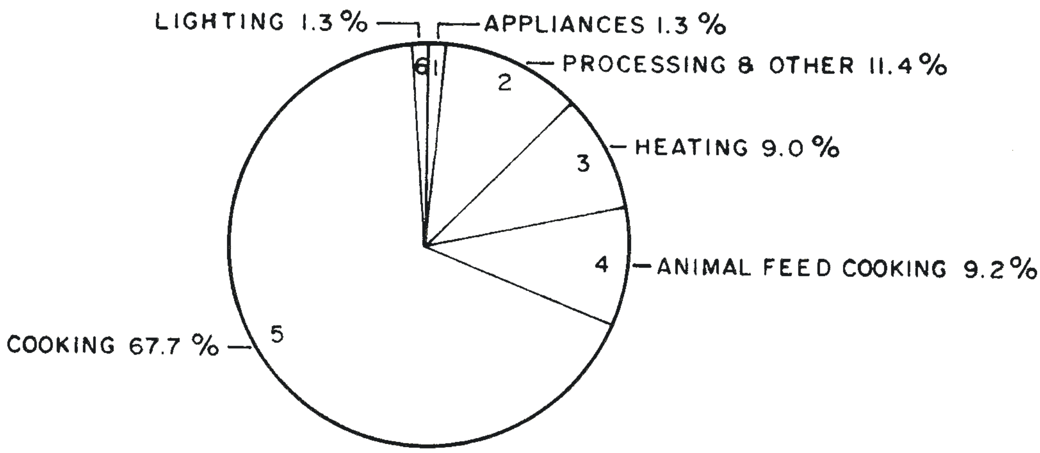
Domestic Sector

The domestic sector, which consumes nearly 95 per cent of the energy, relies mainly on traditional energy sources. This is mostly non-monetised consumption. Commercial energy use includes petroleum products, electricity, and fuelwood that is purchased for cash. Commercial energy use accounts for about five per cent of the total domestic energy use and, perhaps more significantly, for about 26 per cent of the consumption of petroleum products, mostly kerosene, for cooking and rural lighting.

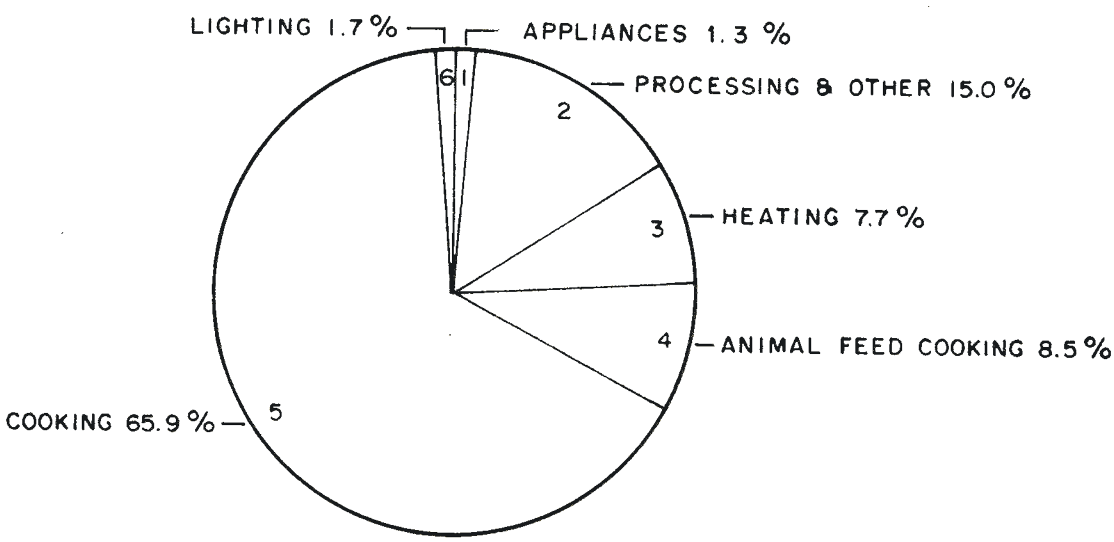
Cooking needs account for a high proportion of the total energy demand in the rural sector. Traditional sources have been meeting this demand. Projections show that, while energy for cooking will continue to be important, energy needs for processing and other income-generating activities will increase at a faster rate during 1985 to 2000 (WECS 1988). Chart 2 shows end use energy demand by domestic sector. The end use of commercial energy in the domestic sector is shown in Tables 4 and 5. It should be noted here that fuelwood is treated as commercial energy for urban Kathmandu. The statistics highlight a few main points. Firstly, lighting accounts for almost all of the use of commercial energy in the rural areas, whereas, in the urban areas, lighting and cooking use commercial energy. Commercial energy use in space heating/cooking, water heating, and use of other appliances are only observed in urban areas. Apart from the WECS Study, other studies too show that rural households meet their energy needs through a variety of sources. In fact, they are seen to employ various energy mixes to meet their needs. For example, in one rural area where electricity was available, 42.7 per cent of consumers used fuelwood and kerosene and 27 per cent used fuelwood, kerosene, and other biomass resources. The rest of the consumers used electricity in combination with fuelwood, kerosene, and other biomass resources (Sharma 1988). The same study reports the use of commercial energy to be at a very low level. In the urban context also, the study conducted in urban Kathmandu indicates that domestic energy needs are satisfied by a combination of traditional and commercial energy mixes. There are very

CHART 2

DOMESTIC SECTOR
END USE ENERGY DEMAND
1985



END USE ENERGY DEMAND
2000



Source: Nepal Oil Corporation, 1988

Source: Nepal Oil Corporation, 1988

In the rural areas, *the cost of using fuelwood (measured by a proxy variable-time taken) has clearly increased in the last 5 years. Almost two-thirds of the sample households reported more than 6 hours as [a] fuelwood collection time per day* (Sharma 1988). Almost 75 per cent of the households reported an increase in fuelwood collection time.

Other Sectoral Demands

The industrial sector (1.9%), the transport sector (2%), the commercial sector (1.1%), and the agricultural sector (0.1%) are the other principal consumers of energy. The industrial sector uses about eight per cent of all petroleum products consumed in Nepal. The industrial energy demand increased by 41 per cent between 1974/75 and 1984/85 and is expected to grow at a rate of around five per cent annually until 2000 A.D. (WECS 1989). In the industrial sector, fuelwood still accounts for the highest share of the energy demand (about 51%), followed by coal/coke (20%), furnace oil (9 %), electricity (7 %), charcoal (6 %), agricultural residue (3 %), diesel (3 %), biogas (1 %), and kerosene (0.7%). The energy intensity of the sector is increasing (UNDP-ESCAP 1987) and is likely to continue to do so in the future (Banskota et al. 1990).

The transport sector uses about 53 per cent of imported petroleum energy and the demand is expected to increase at a rate of 5.2 per cent during the 1990s (WECS 1984).

The agricultural sector at the moment consumes very little of commercial energy but the demand in this sector is expected to increase at a rate of 8.5 per cent annually. Shallow tubewells, estimated to number about 17,000 in 1988, lift irrigation units, and tractors account for the use of energy in the agricultural sector.

Details of energy consumption in all these sectors are provided in the Annexes.

Table 4: Commercial Use of Energy in the Domestic Sector By End Use

(Estimates for 1988)

	Energy GJ (000s)		As % of Total Commercial Energy Use in Domestic	
	Rural[2]	Urban[1]	Rural	Urban
End Use				
Cooking		948	-	31.8
Lighting	1,260	552	42	18.4
Others				
- Space Heating/Cooling	-	77		2.6
- Appliances	-	156		5.2
- Water heating	-	3		-
Total	1,260	1,736	42	58

Source: WECS, June 1989.

Table 5: Distribution of Commercial Energy Demand in the Domestic Sector by Fuel Type

	% Kathmandu	% All Urban
Fuelwood	42	74.0
Kerosene	33	15.4
Electricity	14	7.6
LPG	5	1.5
Others	6	1.5
Total	100	100

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

Note: Assumes that 65% of fuelwood consumed in urban areas, other than in Kathmandu, is monetised consumption.

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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.

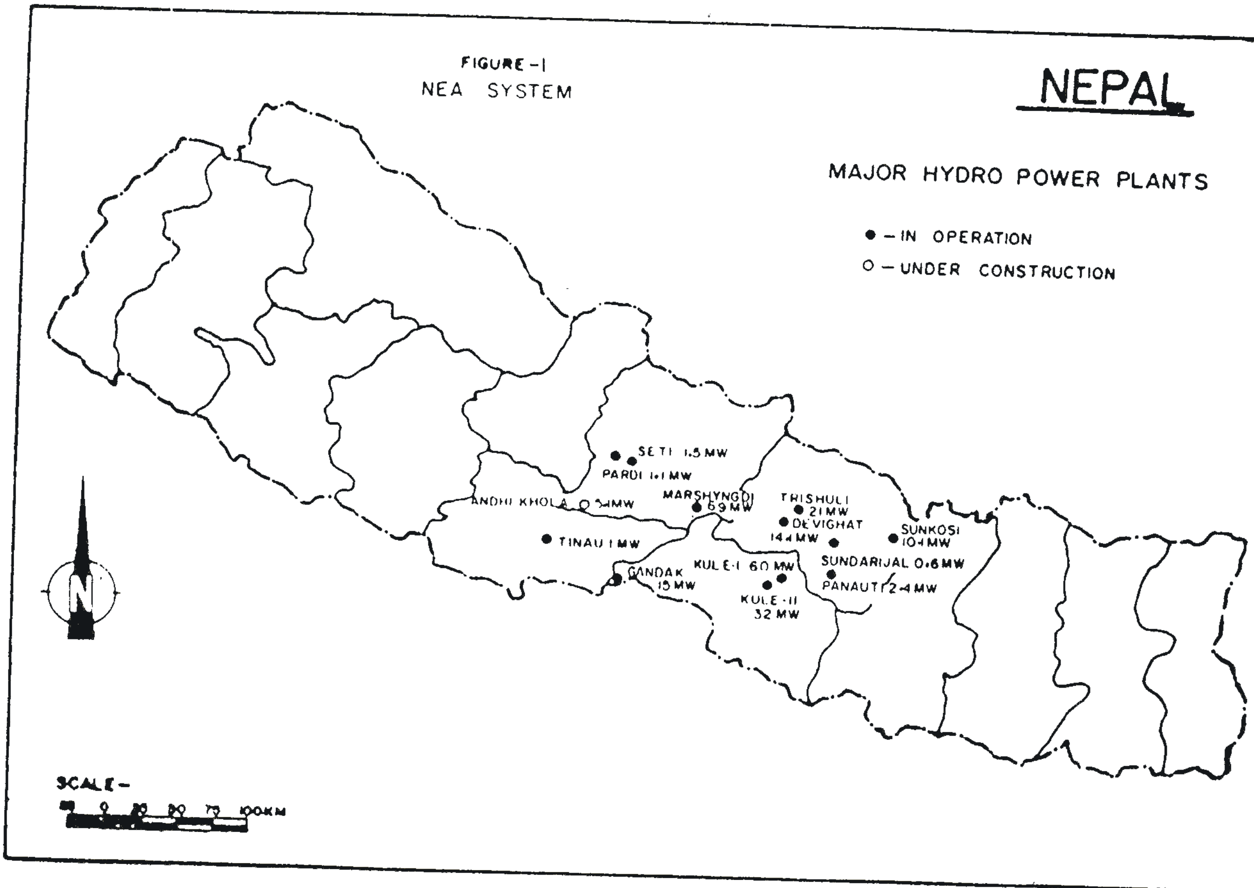
Electricity generation in Nepal consists of hydroelectricity generation - both from the interconnected system and remote, isolated plants - and some thermal generation based on fuel imports. Legislation permits private ownership of micro-hydro plants with a capacity of less than 100kW. Figure 1 shows 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.

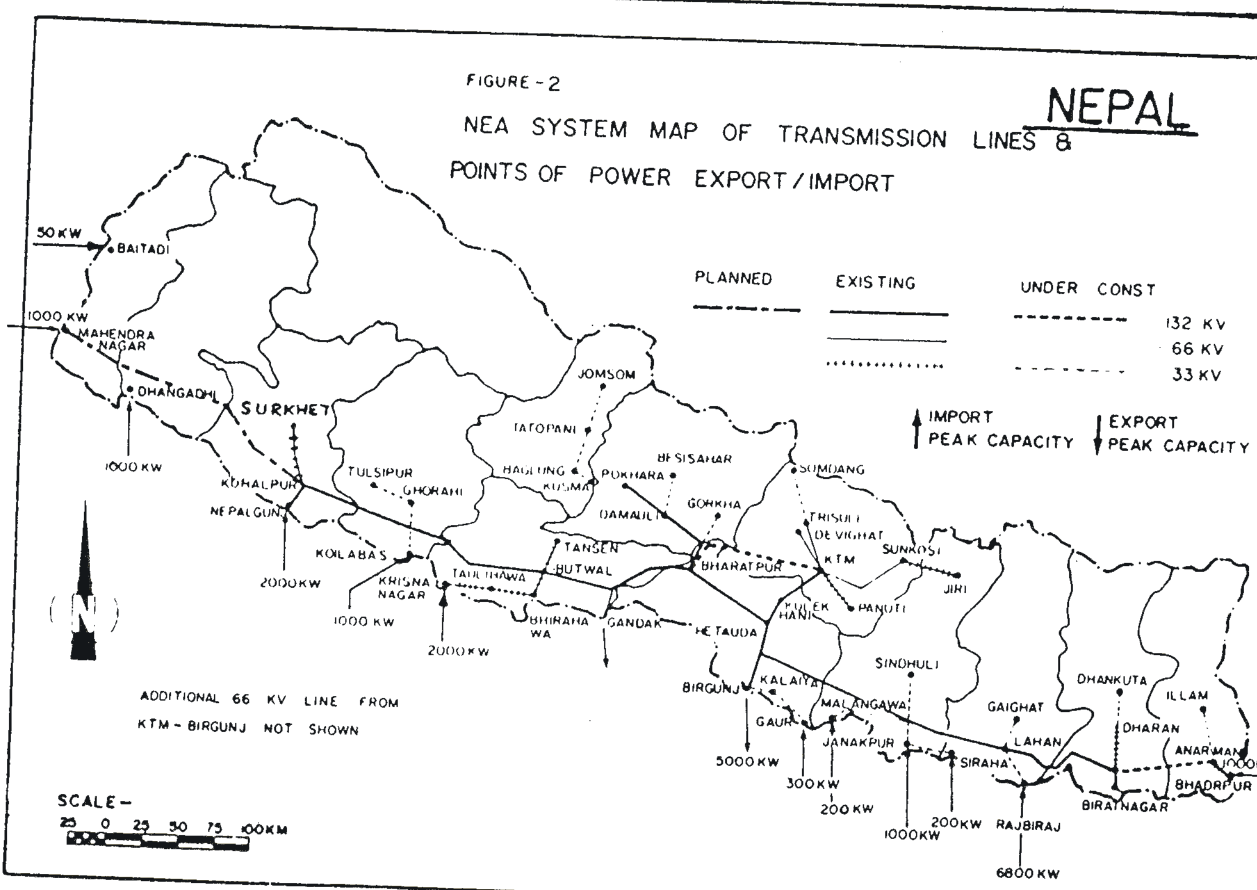
NEA Interconnected Grid. In early 1990, the total installed hydroelectricity-generating capacity on the interconnected system was 230MW. Total electricity generation from the interconnected system was 556GWh in 1989/90. The 1991 peak load requirement on the interconnected system was experienced at 190MW.

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.

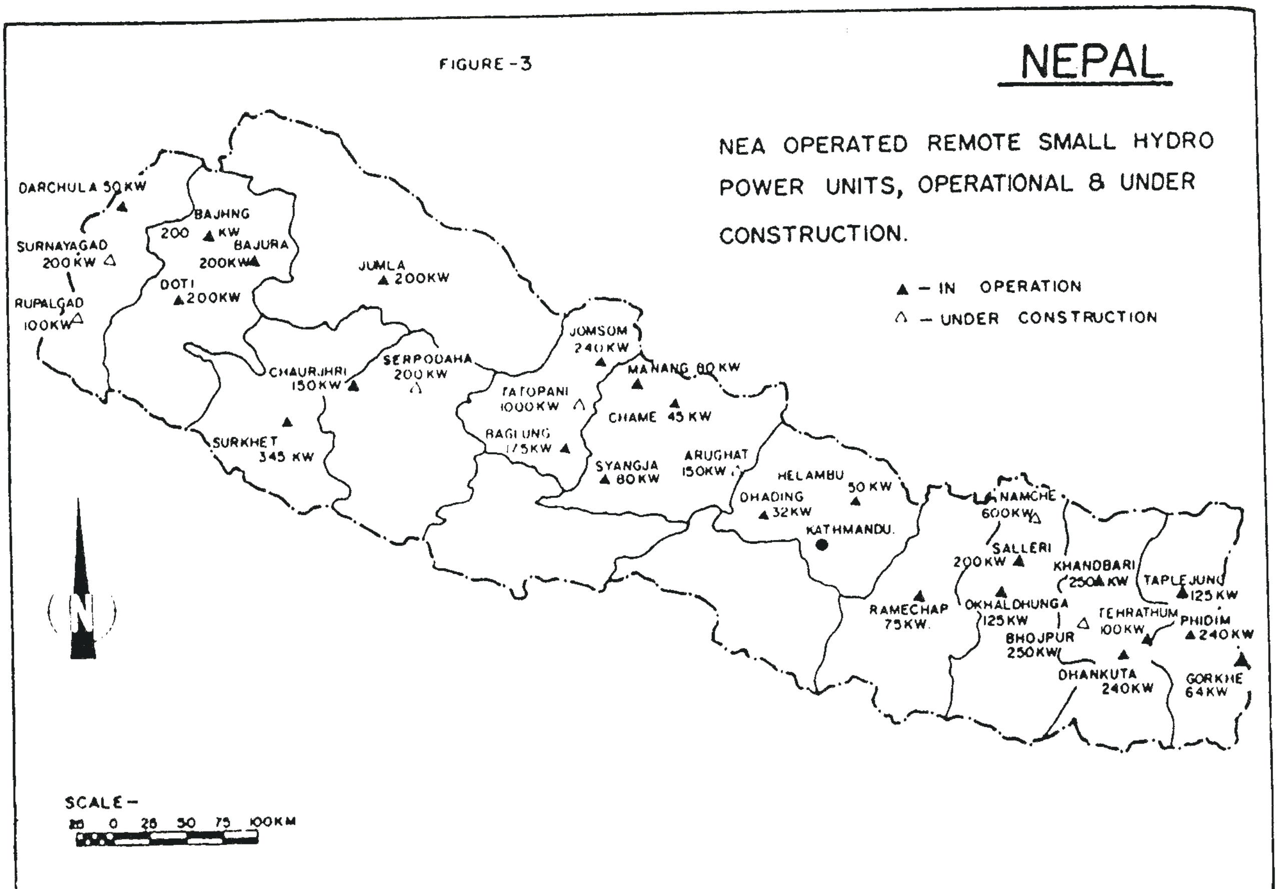
Solar and Wind Energy

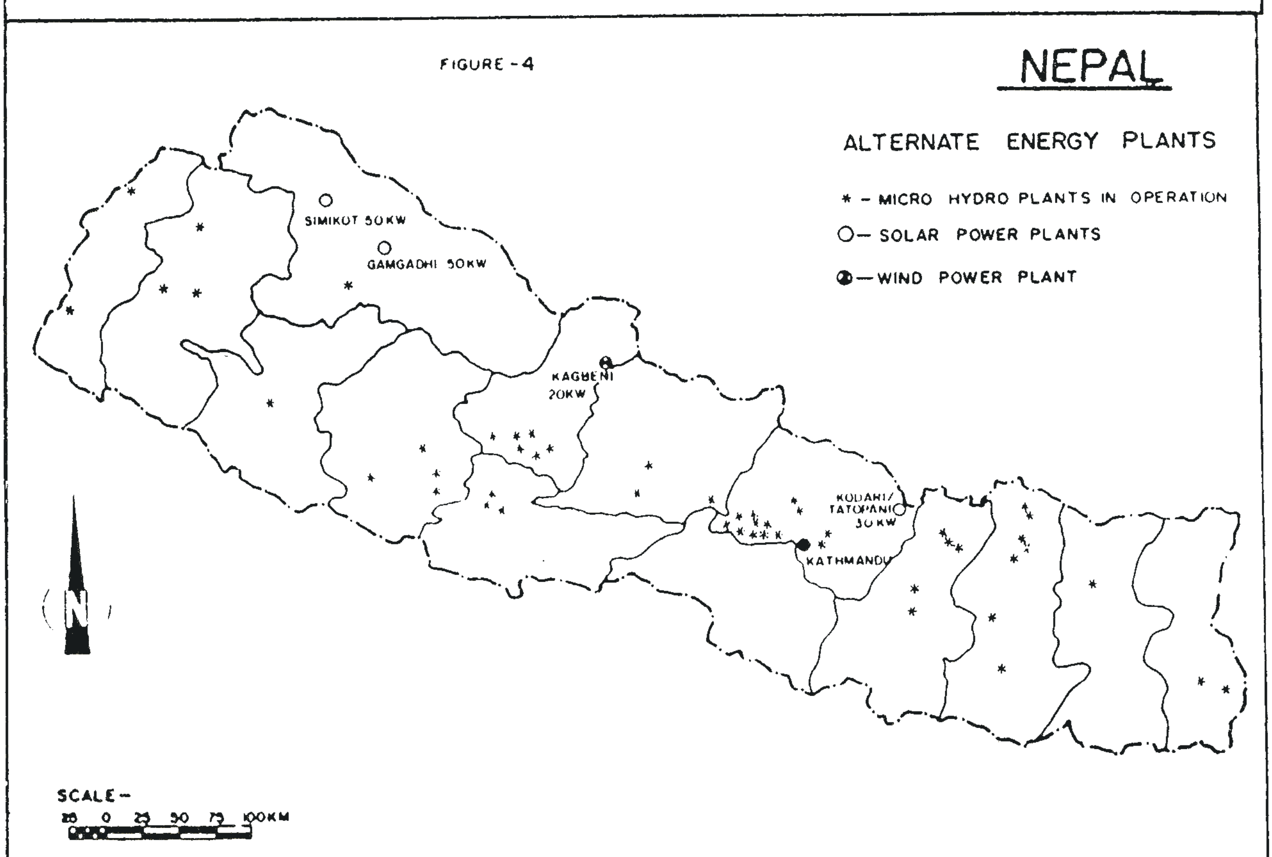
Direct solar energy accounts for a negligible proportion of the energy consumed (excluding sun-drying for which there are no estimates) and under one per cent of the long-term, theoretical indigenous energy potential on a raw GJ basis. Conversion of sunlight to electricity is a simple but high technology 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.





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

ource: Nepal Oil Corporation.

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

tricity Exchanges. Under a power-exchange provision, Nepal imports power from and ts power to India along the border. Currently, Nepal exchanges electricity at 12 points. ver, interconnection with the national grid has led to a reduction in dependency on ted electricity in the *Terai*. Although the present arrangement allows for an exchange of up MW of power, owing to transmission line and sub-station capacity limitations, the exchange 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.

4

STRATEGY, POLICIES, AND PROGRAMMES IN THE ENERGY SECTOR

Energy Development Strategies and Policies

Principally it is the Government that manages the energy sector in Nepal. The institutions involved, at various levels for different tasks, operate under general government guidelines. The energy development strategies for general and rural energy (the latter in particular) are not explicitly articulated even though elements of strategies appear in periodic plans. Hydropower development is a major element in government strategies. Consequently, the hydropower sector has received high priority. The Seventh Plan document notes *Development of the power sector has consistently received high priority in the periodic plans as this sector occupies a prominent place amongst the infrastructures essential for the overall development of the country* (NPC, Seventh Plan, 1985). However, the progress to date has not been satisfactory and this has been noted in the Seventh Plan document as well. *Thus though power generation, especially [the] hydroelectric power generation capacity of the country has increased substantially, it has to be admitted that achievement in this area has always lagged far behind the power generation targets specified by the periodic plans .... both external and internal factors have been identified as being responsible for big gap between specified targets and actual achievements.*

An evaluation of the energy development approach shows a lack of clear and articulated strategies for the energy sector. Plan documents that are supposed to expound on strategies are silent on this subject. Consequently, one has to fall back on stated policies to see whether they form the basis for a strategy. A close examination of the basic features of energy policies in Nepal shows a concentration of policies in the following areas.

(a) The promotion of water resource development projects which, in addition to providing hydropower, also provide benefits such as irrigation, drinking water, and flood control.

(b) The investment in the expansion of transmission lines, electrification, and systems' improvement.

(c) The investment in small hydropower projects and district level projects under decentralisation schemes.

(d) Exploration for and propagation of alternative energy technologies such as 'biogas', improved cooking-stoves (ICS), turbines, improved water mills, and solar and wind energy, as well as R and D and training.

The forestry sector, which has a predominant energy implication, has so far not been considered explicitly within the energy policy framework. Nevertheless there are programmes, such as afforestation and community forestry, which include energy as a part of their focus.

Policies for fossil fuel import are basically seen as import management rather than energy planning and management.

The above policies are pursued through various institutions that are not yet well integrated. Because multiple institutions are involved, a coordinating agency called the Water and Energy Commission was established with a mandate to coordinate energy development and policy planning. The commission has a secretariat called the Water and Energy Commission Secretariat (WECS) as its executing body. It is linked with the Ministry of Water Resources.

Table 7 gives the percentage distribution of investments in the energy sector from the Fifth to the Seventh Plan; i.e., from 1975-80 to 1985-90.

Table 7: Percentage Distribution of Investment Planned for Different Activities in the Plan Periods

	Fifth Plan Period (1975-80)	Sixth Plan Period (1980-85)	Seventh Plan Period (1985-90)
1. Large hydropower projects	88.7	69.2	56.8
2. Small hydropower projects	1.5	4.2	5.3
3. Transmission lines	2.4	13.2	10.1
4. Electrification and systems' improvement	1.7	9.7	9.5
5. Survey and feasibility studies	2.7	2.1	4.9
6. District level projects under decentralisation	-	-	13.5
7. 'Others' not specified above	2.8	1.6	
8. Total amount allocated (million Rs)	737.2	3800	4757.1
9. Amount allocated for alternative energy (million Rs)			50.0
10. (9) as % of (8)			1.1

Source: HMG/Nepal, The Fifth Plan (1975), The Sixth Plan (1980), and The Seventh Plan (1985), NPC. Ram Shah Path. Kathmandu.

Table 7 shows that large power projects (they are large in the Nepalese context and not in an absolute sense) account for a sizeable proportion of the money allocated for this sector. A comparison of the allocations made in this sector with those made for alternative energy development shows the latter to be only about one per cent of the former. It is thus apparent that in spite of what is written in the plan document, the development of alternative technology receives least priority in the energy development scheme.

The policy of promoting large power projects has its positive and negative aspects. On the positive side, the multiple benefits of power exports, irrigation, drinking water, flood control, and river navigation are attractive. So are the savings made on fuelwood as a result of the expanded use of electricity in areas where currently fuelwood is being used, for example, domestic use in urban areas and industrial use in industries that have a natural resource base such as cement, bricks, and bakeries. The ecological and environmental costs that necessarily accompany such projects are also evident and this issue has received insufficient focus in policy planning. Furthermore, given the huge resource and capital intensive technologies needed for such projects, an evaluation in terms of the impact of this investment in income generation, employment, and equity must be made. Investment may be attractive, in terms of its benefits vis-a-vis the cost, but if it increases social inequality then it is no longer sustainable. This question assumes a great deal of importance in Nepal, as investment decisions , based on 'trickle-down' theories, have totally failed to increase the well-being of a majority of the people. This is attested by indications that income inequalities have increased over time.

Energy Pricing Policy

The policy of promoting alternative energy, although absolutely necessary, has not produced tangible results. Has there been a problem in implementation? Or is it not seriously pursued at all? When only 30 per cent of distributed ICS in urban areas and 10 per cent in rural areas are in operation, the programme is far from achieving its goal of reduction in fuel consumption through increased end use efficiency. Similarly, the biogas programme has hardly made any progress. Is the lack of demand for biogas plants an indication of social resistance due to cultural practices or does it rather reflect insufficient attention given to design sensitivities and operational problems arising out of local resource conditions? Further enquiry concerning these aspects should be undertaken in future.

The institutional arrangements of the central coordinating body, however attractive on paper, still fail to address the crux of the problem, that is, that 'energy' is not an exclusive sectoral concern. However, present practices are purely sectoral in reality. Petroleum pricing comes under the authority of the Ministry of Supply, fuelwood pricing under the Ministry of Forests, and electricity pricing under the NEA. The revenue considerations of the Ministry of Finance are reflected in the tax and duty structure for petroleum products.

The market prices of important energy forms - such as fuelwood, petroleum products, and electricity - are not indicative of their true economic costs. Neither are their relative prices reflective of their scarcity/abundance. For example, during 1975 to 1985, percentage increases (per Kcal) indicated that fuelwood prices increased the least (38%) when the forests were depleting at a high rate. The price increases were mostly in diesel, followed by kerosene, electricity, and petrol, and they were 275 per cent, 195 per cent, 125 per cent, and 90 per cent respectively. During this period, the relative prices, in fact, moved in the opposite direction from that warranted by the resource endowment. Also, the domestic prices of petroleum products did not reflect the decrease in international prices during the 1980s. The conclusion was that *energy pricing policy at present is basically form-specific and does not take into account the total effect of the pricing of the individual forms. Consequently the relative price structure does not reflect true scarcity value. Non-economic considerations are somewhat narrowly defined and have a bias towards short-run perspective. The net effect has been implicit encouragement for the use of scarce resources* (Sharma 1988). There has been no real change in relative prices since then (WECS 1989). However, in the last two years, petroleum prices have increased significantly. Petroleum products in general, and motor spirit, in particular, show a high margin between the actual cost of imports and their selling prices.

The real price of <u>fuelwood</u> shows a significant divergence from nominal prices. So do the real prices of most other energy forms. The short-run, real economic cost of fuelwood ranged between NR 459/m^3 to NR 903/m^3 for 1987 (Devkota 1987). The real cost showed an increasing trend during 1977 to 1987, as indicated by the estimated figure of NR 148/m^3 in 1977 compared to the above-mentioned figure (Devkota 1987). The long-run, real cost, on the other hand, was lower than the short-run cost and was estimated at NR 325/m^3. The price of fuelwood prevailing then was about NR 0.55/kg (public corporation price) or NR 385/m^3;while the long-run, real cost was lower than the market price of fuelwood, the short-run, real cost (more relevant to fuelwood pricing) was at a much higher level.

Similarly, the real, economic cost of electricity ranged widely between seasons and between peak hours and off-peak hours. The average systems' cost for the rural and the urban sector varied as well. While recent figures on such costs are not available, a tariff study made during 1982 indicated that the annual average systems' cost per kWh ranged between NR 2.09 to NR 2.61 (Nepal Electricity Corporation 1982). The lowest cost per unit was NR 0.57 for off-peak hours for wet seasons in the urban system and the highest was NR 6.54 during peak hours for dry seasons in the rural electricity supply system. This indicates that there is scope for promoting electricity consumption during low load periods, i.e., wet season off-peak hours. For 1984, the Long-range Marginal Cost (LRMC) of electricity generation in Nepal was estimated to range between NR 0.76 to NR 1.22 per kWh in the case of firm energy and to be stable at NR 0.21 per kWh in the case of incremental secondary energy. The LRMP figures are for generation (i.e., at high voltage level) and have to be complemented with distribution (at low voltage) cost. The unit cost of electricity from micro-hydro plants was estimated at NR 3.6.

The real cost of fossil fuel estimated by using a shadow exchange rate for 1983, indicates that the economic cost is lower than the market price for diesel and petrol and higher for kerosene and LPG (Devkota 1987). There was a bigger discrepancy in the case of petrol (NR 5.93 economic cost, NR 9.3 market price) than in the case of other fuels.

The above real costs, although for the earlier 1980s, sufficiently indicate a persistent issue for energy planning - to what extent should prices reflect the economic cost? An intimately related issue, regarding electricity pricing, is that the real cost reflects part of the inefficiency cost arising out of a low load factor and that increases in the load factor will significantly reduce the costs.

Discrepancies between costs and prices will lead to misallocation of resources and encourage inefficient resource use, and this is an element of unsustainability. Suitable policy responses in the form of price and non-price variables are, therefore, required to correct this distortion.

The distributional impact of failure on the allocative front should be the next consideration. Because misallocation leads to an overall welfare loss, its incidence across various strata needs to be properly understood. A scenario analysis of the impact on consumer welfare, due to price changes in fuelwood, electricity, and kerosene, shows that low income households are affected most by fuelwood price increases and upper income households most by electricity price changes (Sharma 1988). Any pricing policy attempting to correct the price distortions by a change in administered prices, should also look for ways to safeguard the interest of the weaker members of society. The safeguards could range from outright grants (or subsidies) to the concentration of conservation efforts with the poor as a target group.

The above discussion, digressing somewhat from rural energy policy, is nevertheless important to highlight policy gaps/failures because these policies do have an indirect but powerful impact on the rural energy situation. Take, for instance, the fuelwood pricing policy. By keeping it below its social cost, there is not only an implicit encouragement of its consumption but it is also diverted to an area where its substitutes are available. Furthermore, such diversions take it away from areas where it is needed most, i.e., rural areas. It is indeed ironic to note that the urban hills are supplied with fuelwood from the *Terai*; which itself is facing a deficit (APROSC 1983 and Shaik, et al. 1989). Similarly, the pre-occupation with large-sized hydropower projects has drained the energy away from the crucial issue at hand. This is that in spite of a somewhat higher estimated cost per unit of smaller hydroprojects they have more potential for substituting fuelwood; at least in commercial activities in the rural townships. Even more important, they exhibit the ability to encourage economic activities in rural areas. When micro/mini-hydroprojects are integrated with economic activities, they are seen to be profitable (Cromwell and Wishart 1989).

The kerosene distribution cost is high in rural areas but there has been no systematic attempt to examine whether kerosene could still be competitive if the social cost of energy use is considered.

While pricing and related policies are important they have limited applicability in the rural sectors. Here the emphasis has to be on energy generation and conservation programmes. A look at the government programmes shows a strong emphasis on management of the commercial energy sector. Details of such policies and programmes are provided in the Annexes.

The Energy Conservation Policy

Energy conservation, especially in the context of rural energy demand management, assumes added significance because the scope of other policy tools is fairly limited. Since fuelwood is the major energy source, emphasis on sustainable fuelwood use is the prime requirement. Propagation of, and programmes on, distribution of improved cooking-stoves (ICS) have been launched in an attempt to facilitate fuelwood conservation.

Estimates of the number of ICS distributed, and in actual use, vary considerably according to different sources. WECS reports that out of a total of 40,000 ICS distributed, only 20 per cent or 8,000 are in operation. MPFS reports 16,000 units distributed, out of which 70 per cent or 11,200 are in use. The latter estimate most likely includes only those distributed through Community Forestry Development Programmes (CFDPs) and Integrated Rural Development Projects (IRDPs). There are other institutions involved in this programme such as UNICEF, Agricultural Development Bank/Nepal (ADB/N), and other bilateral donors.

The exact number of ICS distributed and in actual use, apart, it is beyond debate that this programme has failed to fulfill its potential. The reasons are many and are within the ambit of social and technical considerations. Enough attention has also not been given to the differences in adoption rates across different ecological regions.

In spite of poor performance, the technology in itself has potential. Estimates show that, if the ICS programme fulfills its potential, it could result in a saving of as much as six per cent in fuelwood demand in the middle mountains, Siwaliks, and the *Terai* by 2010 (HMG/N, FINNIDA, and ADB 1988). This would require a significant increase in the programme and implementation capabilities of concerned institutions. There will hardly be any ground for optimism if the existing arrangement continues. Therefore, this indicates the need to articulate the expected role of ICS and institutions involved in their distribution under an overall strategy for rural energy planning and management. Only then can one expect a meaningful realisation of the theoretical potential of ICS technology.

Conservation policies that directly affect other sectors, the effects of which would also be felt by the rural domestic sector, are provided in the Annexes.

Biogas Development Programme

A total of 4,351 biogas units were estimated to have been installed by 1988/89 (WECS). The installation rate has increased since 1985/86 and 2,462 of the total units have been installed since then. The Seventh Plan target was for the installation of 4,000 units during the plan period. Two main designs, the fixed dome type and the floating gas holder type, are in vogue; the former being greater in number. Private and community biogas units are in operation. *The community biogas plants are used mostly to run agro-processing and other small-scale industries, while the family type plants are used mainly for household cooking and lighting* (Shrestha and Bajracharya 1989).

Compared to the present situation, biogas use can be significantly increased in Nepal. The livestock population is quite large and is expected to increase to 11.6 million livestock units (LSU) by 2000 AD. This offers a lot of potential for the use of dung to produce energy. At present dried dung is directly burned, but using it to produce biogas would leave its fertiliser value intact after providing energy. A rough calculation shows that, theoretically, almost 500,000 biogas plants can be in place by the turn of the century if the full potential is exploited; financial and technical impediments are unlikely to allow for such a massive increase in capacity.

Because of its favourable conditions, the *Terai* is the ideal place for the expansion of biogas technology. To facilitate this, R & D for cost reduction, managerial efficiency in programme expansion, and an explicit policy of financial incentives/subsidies are required. Again, this points to the need for incorporating biogas development programmes as an essential component of the energy development strategy.

Solar and Wind Power Development Programmes

Although relatively unimportant from the current rural energy supply point of view, these technologies cannot be left out of the overall energy strategy. They exhibit potential, they are renewable, and are seen to flourish under the right conditions. For example, solar energy, in spite of its high cost is being used in urban areas for water-heating. Water-heating is the main energy consuming activity in cooking activities, and cooking activities account for almost 80 per cent of all energy used. Thus the right conditions seem to be there for this technology, provided it can compete with the other options that may be available to a rural household. Clearly, the need is for a reduction in cost in the use of solar energy, and this can only be made possible by an increased R & D programme for solar energy use.

Similarly, wind energy is largely untapped. Isolated instances of use are reported, but efforts are inadequate and need to be strengthened. The database is weak and needs to be improved.

Integrated Approach to Energy Planning and Management

As discussed earlier, a clear strategy on rural energy is missing. Components of the rural energy sector have been dealt with in an isolated and perfunctory manner. They will continue to be treated in the same fashion unless the objective of rural energy planning and management is established.

Evaluation of the approach to energy planning in Nepal shows that it is still to be integrated into the overall socioeconomic planning strategies. The practice of looking only at a particular energy form in the planning process has been the basic problem. There have been no systematic attempts to look at energy in terms of a sector, let alone in terms of integrating that sector with other sectors of the economy.

The first step in the move towards integrated planning is to define the goals of energy planning. These goals have to be consistent with the overall socioeconomic goals of development planning, i.e., improvement in the quality of the life of the people. In pursuing this goal, energy planning must be within the framework of the overall economic and policy analysis to meet interrelated and often conflicting national objectives.

If the goal of rural development planning in Nepal is to improve the socioeconomic standards of rural people, then energy planning too must contribute towards this goal. This is possible only when the energy sector has strong links with the production structures of the rural economy. In other words, the primary requirement of this integrated approach is that energy in the rural area should not be seen as an item of final consumption, e.g., lighting or cooking, but as an input into the rural economy which will lead to the attainment of a higher level of output. The rural economy in Nepal is predominantly agricultural and improvements in living standards are inconceivable without a growing agricultural sector. Energy can play a vital role in this respect. Enhanced energy supply, for example, for irrigation-lift or surface, could go a long way to improving rural agriculture. This in turn could lead to a higher demand for energy by the agro-processing and small-scale industrial sector. Choice of appropriate energy technology becomes important in the promotion of such an approach.

Planning must ensure that scarce resources are used in the best possible manner. Rural energy planning must also be guided by the same consideration even though some of the resources may not be commanding a market price. Fuelwood, for instance, falls outside the scope of pricing intervention in most of rural Nepal but is a scarce resource. The need, therefore, is to conserve it. The potential of ICS in biomass conservation is attractive and it should be exploited fully. Side by side promotion of energy sources which have the same end use, such as that of fuelwood, is essential to reduce pressure on fuelwood. In Nepal this means promoting biogas. Electric power and other non-conventional energy sources, where such technologies are feasible, will also contribute to saving fuelwood even though the savings may not be as great as those brought about by an increased use of biogas. Planning at this stage must address the issue of social as well as financial costs and benefits of various energy options and technologies.

Coordinated energy planning and pricing require detailed analysis of the interrelationships among the various economic sectors and their potential energy requirements, on the one hand, and of the capabilities and advantages and disadvantages of the various forms of energy used to satisfy these requirements on the other. Non-conventional sources, which could play an especially effective role in remote areas where they turn out to be viable alternatives, must also be fitted into this framework (Kumar 1987).

Such a coordinated approach requires investment policies that are not only based on energy sector investment priorities but which also take into account investments to be made in other interrelated sectors. For instance, transport sector investments, in the form of road construction, resulting in the linking of rural area to the widemarket, may bring about additional demand for local agricultural produce and cottage industry products, and this in turn will lead to an increased demand for energy for intermediate use. The degree of such demands depends of course on the energy intensity of these sectors. Similarly, tracing the effects of other policy decisions, such as the pricing of a particular energy form, is necessary to promote an integrated approach.

The next level of integration is intra- and sub-sectoral. A detailed analysis of each sector is required to assess the extent of interaction among different energy sub-sectors, substitution possibilities, and for the resolution of resulting policy conflicts. For instance, it may seem attractive to promote hydropower in a particular rural region but one may encounter conflicts of different types once the scale of plant is taken into consideration. Similarly, it may be necessary to make judgments and trade-offs on equity vs. efficiency basis.

Organisational and institutional requirements for the promotion of integrated energy planning for rural Nepal assumes as much significance as matching aggregate demand and supply or intra-sectoral integration of different energy sub-sectors.

On a macro-scale, specialised energy planning agencies can make technical decisions but, once planning reaches micro-level, then these institutions are seen to be inadequate to the task on hand. The insensitivity of macro-level institutions to micro-level conditions has strongly emerged as one of the key lessons from past development experiences.

It is becoming more and more evident that poverty eradication and resource conservation measures are location-specific activities. Pressures on natural resources are strongly interlinked with local production systems; poverty eradication requires a clear understanding of local environment and socioeconomic characteristics and of opportunities and constraints in order to identify appropriate programme interventions. Obviously there are serious limitations in the technical capacities of local organisations; also many so-called local institutions are only agents of central level institutions. The important point being emphasised is that programmes designed at the Centre and implemented by the Centre have not succeeded in the fields of poverty eradication and resource conservation. What is needed is to provide greater opportunities for local people to organise their own management systems (ADB 1990).

Thus, to base rural energy planning on realities, efforts have to be initiated to follow a decentralised approach, and this should be based on two major factors. Firstly, population settlements in rural Nepal are scattered. This makes it extremely costly to execute any strategy that aims at covering a fairly large geographical area for supply of abundant domestic energy; hydropower. Secondly, because of spatial diversity, no single energy technology can possibly be viable across the whole country. Climatic conditions, resource endowments, and resource potentials vary across three major ecological belts. It is therefore obvious that energy technology choices have to vary as well.

For example, take the case of the hills and mountains. The Forestry Sector Master Plan estimates that the high hills and high mountains are fuelwood sufficiency areas whereas the middle mountains are not. The deficit of fuelwood is estimated to reach 23 per cent of the sustainable fuelwood supply in the area in 2000/01 and 19 per cent in 2010/11. But this is an area where other forms of energy are also not available. Because of the physical features as well as the difficulty in management, large-scale importation of POL products to meet energy needs may not be feasible. But the natural conditions here are suitable for the exploitation of numerous rivers and streams. Traditionally, these rivers have been used to generate mechanical power through *ghattas*.

Can the rivers be exploited to produce electric energy for domestic use as well? ADB/N's experience has shown that this can indeed be done if planned and executed properly. The demand for micro-hydro technology in the private sector points to its viability in hill conditions. This technology has integrated energy and economy in the sense that the demands for electric and mechanical power form the basis of the demand for this technology. Yet this experience has remained largely within the confines of ADB/N and no real efforts are being made to make it a part of the rural energy development strategy. This is not to say that micro-hydro technology does not face any problems; it does, but the problems can be better addressed if the 'technology' becomes a component of overall strategy. It is only then that sufficient resources and technical skills can be channelled so as to take advantage of this technology.

In the case of the *Terai* there is already a fuelwood deficit in some areas, and the deficit can be expected to grow in the future. The *Terai* abounds with livestock and agricultural residue. If livestock waste and the residue can be turned into energy, without detracting from their traditional uses as manure, then energy and economy will be integrated. The apparent attractiveness of biogas technology in such a situation cannot be ignored. Again this calls for a strategy that internalises the issues involved and identifies programmes and investment options commensurate to the need.

The Chinese have demonstrated that energy technologies can be combined within a certain spatial unit to provide energy to the rural population. This is achieved in what is called an Energy Village. Such villages are being promoted by the Chinese Academy of Science. The basis element of the strategy was to reach a higher consumption of energy through a series of demand and supply management activities. They are:

- o reforestation of fast growing species for fuelwood supply,
- o conservation of fuelwood by adoption of energy-saving stoves,
- o extensive application of biogass and other appropriate technologies such an ICS, and
- o a change in animal husbandry practices.

A brief description of the Chinese Energy Village is provided below.

Illustration of the Chinese Energy Village Experiences

During 1982, six villages in Sichuan Province in China were included in a rural energy experimentation project. These villages were characterised by acute shortages of energy. Increasing population pressure encouraged conversion of forests into agricultural land. Forest-based energy sources were in short supply. There was a heavy dependence on the use of agricultural residue in meeting the energy needs. However, the situation was such that even if farmers were to burn all the available crop residues they would still not have sufficient fuel; they would face a deficit for three months. Also the environmental consequences of the practice of burning straw and other biomass, instead of recycling it into the land, affected the agro-ecological balance. It also reduced the fertility of the land.

One of the villages included in the programme was Changle. This village lies to the south of Chengdu. It had 71 households with 301 persons in all. The cultivated land consisted of little more than 20 hectares and the main crops were rice, wheat, and rape seeds. The climate in the area is relatively mild with an annual mean temperate of above 15 °C. The annual precipitation is more than 1,000m.

When the programme was initiated, there were 124 biogas digesters in the village with many households having two units. All of them were wet fermentation types and were round, small, and shallow. The annual mean biogas yield rate was about $0.1 m^3/m^3$ diameter. The total production was $21,000 m^3$ which was only enough to cook three meals a day for 6 months in a year.

Crop straws were used as kitchen fuel with traditional stoves having a 10% calorific efficiency. About 82,000kg of straw were burned annually. Further, approximately 25,000kg of coal was brought into the village annually for use mainly in cooking pigs' feed.

An initial enquiry revealed the energy flow pattern in the village to be as depicted in Figure 5.

In Changle village, one person on an average owned 1.2 pigs. There was enough manure for biogas fermentation. The favourable climatic situation of the area also conductive to biogas production. Therefore, special attention was given by the Chengdu Institute of Biology of the Chinese Academy of Sciences to popularising innovative designs of biogas digesters.

Biogas units with dry and wet fermentation digesters were built. The dry digesters were fed with crop straws only with a total solid concentration of 25 per cent. The wet ones were fed with animal manure and night soil. Fermentation processes in the old type of digesters improved. These improved digesters were fed with manure without the addition of straw. Mixed with water, this helped to maintain the proper concentration and fertility of the fermentative materials. Low-pressure biogas stoves, developed by the Chinese University of Science and Technology, were widely disseminated in the village. The calorific efficiency obtained was as high as 64 per cent under rated pressure conditions. Apart from biogas fermentation, improved stoves, designed by the Chinese University of Science and Technology, was widely popularised in the village. The stove provided a calorific efficiency as high as 35 per cent.

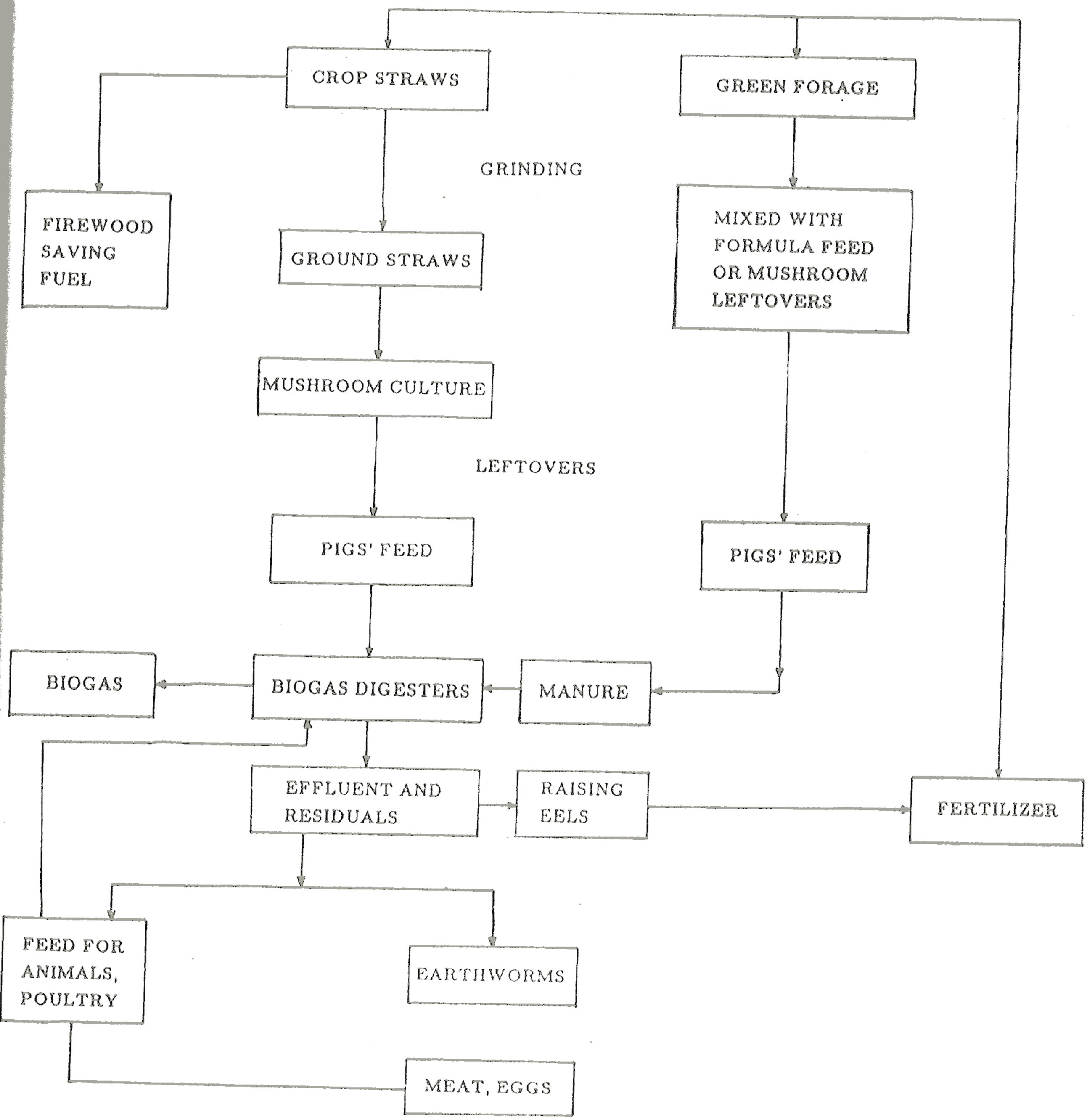
Fuel was saved in preparing pigs' feed. The energy consumption for cooking the feed used to account for about 50 per cent of the total domestic energy requirement. A new method of preparing feed was used by mixing green feed with formula feed. Left over mushrooms, mixed with crop straw and other agricultural waste, was used for this purpose.

After three years of experimentation in the integration of energy, agriculture, and animal husbandry, supported by the propagation of improved and innovative technologies, the village has undergone remarkable changes. These changes, are reflected in the following statistics.

- The annual net income per capita was raised by 94.1 per cent.
- Grain production increased by 25,000kg.
- Chemical fertiliser purchases decreased by 35,000kg.
- Use of coal was reduced by 22,000kg.
- Bio-energy accounted for 96.3 per cent of the total domestic energy (including 64 % from biogas).

The transformation brought about in the village by implementation of the Energy Village Concept is worthy of detailed examination. The attractiveness of the experiment is seen in terms of not only an increased energy consumption concomitant with increase in income but also in terms of the shift in the source of energy supply; from fossil fuel to biomass energy.

Figure 5: Ecological Circulation of Energy in the Village



Source: Chengdu Institute of Biology, Chinese Academy of Sciences.

Can such an approach work in Nepal? Afterall, the resource conditions are not radically different; a deficit of biomass fuel and pressure on marginal land for cultivation. There is also a need to increase energy consumption from its current low base. A pilot programme with cooperation from the Chinese Academy of Science, ICIMOD, and the active participation of R & D organisations as well as financial institutions in Nepal can be visualised in this context.

The approach adopted in the Chinese Energy Village experiment is guided by decentralised planning and implimentation as all such approaches should be. The decentralised approach demands the active participation of different agencies involved in the field of energy planning and management, again a fact attested by the Chinese village experiment. Research and Development Agencies, technology producers, financial institutions, and technology users need to come together in an integrated fashion. A lead in this regard can be taken by local development authorities by way of coordinating and facilitating the process of interaction between these agencies.

The main features of the decentralised approach are as follows.

- Need Assessment: Assessment of energy needs for domestic as well as economic use on an appropriate spatial basis.

- Resource Potential: Assessment of energy resource endowments within the same geographical unit.

- Technology Package: Identification of technological options and prioritisation of the same. Match needs with exploitation of potential.

- Organisational Form: Identification of roles of relevant organisations; including those in the public and private sector with respect to planning, implementation, monitoring, and evaluation aspects.

- Financial Support: Assessment of financial support needed in terms of investment funds and credit lines.

- Project Planning and Implementation: Planning and implementation of projects within the technological and financial options available.

- Evaluation: Evaluation in terms of intended benefits relating to final consumption of energy in the domestic sector as well as its use as an intermediate input in the production sectors.

The above approach has the following advantages.

- It draws upon the strengths of local people and organisations.

- It is based upon the exact condition of local resources.

- It interlinks promotional institutions with consumer groups.

- It incorporates the elements of 'integration'.

- It clarifies the expected role of each organisation /institution.

- It allows sufficient flexibility for the mid-stream correction of courses if the need arises.

5

MAJOR ISSUES AND OPTIONS

Major Issues in the Energy Sector

The assessment of the energy sector in the preceding sections of this paper has underlined some important issues which demand careful consideration.

Nepal's energy sector is on the road to long-term unsustainability. This situation arises because of the overuse of certain renewable resources while other renewable resources remain unused. Plans are supposedly being prepared, and in some cases have been partially implemented, to rectify the situation. Even accepting that these plans can bring about desired changes in the future, what can be done in the interim until the expected changes begin to materialise?

The supply gap in the provision of traditional energy is leading to a diversion of organic plant nutrients into domestic energy use. This can only continue at the cost of agricultural productivity. How can this conflict be resolved?

The exploitation of water resources for energy can be conceptualised in terms of meso-or micro projects and a range in between. Each has positive and negative aspects. What should be the guiding considerations in decisions concerning investment in hydropower development?

Energy in rural Nepal is basically a consumption item and does not form a part of the rural economy. How can the existing situation be changed to make energy a prime mover in the rural economy?

Energy-led demands on the rural environment may continue to put further stress on the already fragile, natural ecosystem. How can such stress be reduced?

Government policy responses seem primarily geared towards the monetised component of the energy sector. This is inadequate to meet the overall challenge. This inadequacy is due to the absence of an overall strategy on energy development. How can this gap be closed?

Institutional arrangements in the energy sector still fail to promote an integrated approach to energy development. The sector therefore shows the syndrome of the 'tragedy of the commons'; especially in respect of the cost to society in consuming various energy forms. How can this problem be adequately addressed?

Energy conservation efforts are grossly inadequate. Programme implementation does not provide scope for optimism. What can be done to remedy the situation?

Alternative energy technologies are largely ornamental in an overall policy context. They, however, exhibit potential for far-reaching changes. How can this potential be realised?

Continued external assistance will be required for energy development programmes. How can they become a part of the overall national development policy?

Options in the Energy Sector

The options for sustainable development emerge from an explicit recognition of the fact that Nepal's energy problems do not arise out of an excessive reliance on non-renewable energy sources. They rather arise because one form of renewable energy is being consumed at an unsustainable rate while others remain virtually unused. Thus, the energy transition for sustainable development does not entail a shift away from fossil fuel to other forms; as is commonly observed in most other countries.

The feature of energy transition within renewable forms should be such that it not only generates growth in the economy but also does it in a manner that integrates sectors by way of stronger linkages. In other words, the energy transition should be a contributing factor to the sustainable development of the economy. The importance of this linkage is also underlined by Nepal's painful experiences caused by external shocks. The vulnerability of the economy to such external shocks underscores the need to follow strategies that minimise the chances of the recurrence of such situations.

There is little doubt that the long-term path to sustainability lies in exploiting the abundant hydropower for energy. Clean energy is a major goal; hydroelectricity can provide it. It can also become a major export commodity. On the domestic front, an electricity-based transport system could go a long way to reducing dependence on fossil fuel and thus contribute to the conservation of non-renewable resources.

The basic options available rest on a choice between following a mega-project approach in water resource development or a decentralised approach with emphasis on appropriate plant sizes. One fundamental question here is how investment in either of these will lead to (a) wider participation of the population in sharing the benefits of the investment, (b) a stimulus to agricultural and agro-processing industries, (c) an overall impetus to rural industrialisation, and (d) minimisation of negative environmental consequences.

The next set of action relates to the use of the forests to meet energy needs. The forests will continue to be an important energy source for the majority of Nepalese. Therefore, in addition to using a pricing policy to affect consumer behaviour (at least in places where alternative energy sources are available; for example, in the major urban centres), there should also be efforts towards conservation and enhanced efficiency in use. Increased prices affect the weaker sector of the community disproportionately. Therefore, conservation efforts, such as distribution of ICS, must place strong emphasis on the poor. Similarly, management of the forests for better productivity should be an equally important consideration. The option here is whether to attempt to reduce indiscriminate use through a central management system or to attempt the same through decentralised management and user group participation. Of course, the latter is easier said than done, but the ability of the actual users to manage community resources has been well and truly demonstrated. Also user group participation is a process that becomes stronger with time; a condition compatible to sustainability.

The long-term option in the forestry sector is certainly reforestation on an enhanced scale. Here too, the question of central vs. local capability to effectively implement such programmes by involving the actual users, especially women, must be given proper consideration.

Energy conservation programmes are important and should be seen as programmes that compete, with the funds being provided for capacity generation and expansion. Conservation efforts should cover all energy forms and not only fuelwood. Electricity conservation could be achieved through the promotion of better end use devices. Encouragement to domestic industries to produce such devices may be contemplated.

Conservation education aimed at providing information and hints for efficient use of end use devices must be undertaken. Such a conservation education programme should have actual users as its focus. Transport users, housewives, agriculturalists, and industrialists are some of the target groups.

The option of using a pricing tool to regulate consumption behaviour should always be exercised. However, the effect of such policies is seen to fall more often on the weaker section of the society. The pricing tool can always be effective in setting more reasonable, relative prices for various energy forms in an environment, when energy is a traded commodity. It is necessary to look at fuelwood pricing policies to make them competitive with kerosene prices, in order to reduce the pressure of accelerated deforestation arising out of the increased demand for fuelwood in the future. There is a wide divergence between the market and social cost in the fuelwood sector.

ADB/N's experience in the promotion of micro-hydro technology deserves a closer look for replicability on a wider scale. The agricultural development bank, private sector producers, and technology consumers are seen to have worked out an arrangement beneficial to all. Besides, this technology has demonstrated that energy as an intermediate input and as a final consumption item can be promoted simultaneously. Wider application of this approach in hill agriculture, especially in lifting water for irrigation, could open up unlimited possibilities.

Biogas, in spite of its enormous potential, is not being widely adopted in Nepal. The reasons for this lie within technical, economic, and social variables. What are they? An in depth study to identify the exact reasons and possible remedial actions should be undertaken immediately. This form of energy should not go untapped. At the same time, better use of agricultural residue and dung could be facilitated as the slurry from the gas pits could go back to the fields as manure.

Wind energy for electrification and water pumping in a few mountain areas might be a feasible proposition as shown by the Jomosom experience. Additional efforts to promote wind energy are, therefore, required.

Effective use of location-specific resources can only be possible under conditions of decentralised planning and management of resources. Rural energy planning and management must also be seen in this light. This is possible when an overall strategy for energy development is formulated, and rural energy made a part of such a strategy. This has not been the case and rural energy is not, for all senses and purposes, part of a well thought out strategy.

The role of women in the energy sector is very prominent. Their role is not only important in the domestic sector (cooking and lighting) but also in the agricultural sector. Therefore, women should be fully involved in extension education, training, and R and D. Similarly, women, in recognition of their productive role, must be directly approached in the context of the planning and implementation of projects. For example, for projects such as social forestry it should be made compulsory to include women.

The above are the main issues and options in the energy sector. Some of the options are short-term in nature, e.g., the pricing of energy, compared to others that are essentially long-term.

Sustainable development should follow all those options leading to a transition from inefficient use to efficient use, from non-renewable energy to renewable energy, and from current consumption to investments for the future. After all, if one plans for the future then such planning must begin now and actions must follow immediately.

Unfortunately, quite often in the past, programmes have been proposed and discussed, commitments made, funding assured, institutions identified, and a plan of action formulated within the confines of a seminar hall; only to be ignored or discarded when actual programming begins in the relevant ministries. It would help if everyone reflected upon the number of such seminars one has attended and in which recommendations have been made that were hardly or ever translated into concrete action.

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ANNEXES

ANNEX 1

ENERGY CONSUMPTION IN THE NON-DOMESTIC SECTOR

The Industrial Sector

The industrial sector uses about 1.9 per cent of the total energy requirement and approximately 8.0 per cent of the imported petroleum products. Nepal initiated planned industrial development, in the mid-fifties, with the first of its five year plans. Encouragement has been given to the industrial sector in an effort to move the national economy away from total dependency on agriculture, thereby increasing job opportunities, reducing import requirements, and providing export earning opportunities. While Nepal's industrial base remains small, the continuing efforts to build an industrial infrastructure have led to a growth rate of 18.7 per cent in 1985/86 and 29.2 per cent in 1986/87.

With the increasing use of modern processing and technology, however, the industrial demand for energy increased by 41 per cent between 1974/75 and 1984/85, or faster than the output growth rate. Demand by fuel type for industrial needs has also been changing and will continue to do so as fuels are substituted to meet changing end use requirements. Among all categories of industry, fuelwood still provides the highest share of the total energy requirement, being about 51 per cent of the total, coal/coke has the second highest share, being about 20 per cent, followed by furnace oil (9%), electricity (7%), charcoal (6%), agricultural residue (3%), diesel (3%), biogas (about 1%), and kerosene (about 0.7%).

Investment rates in modern industrial infrastructure, capacity utilisation rates, energy supply constraints, changes in the energy efficiency of production processes, and the energy pricing environment are some of the factors that will have an impact on future end use energy requirements in this sector.

The Transport Sector

The transport sector uses about 2.0 per cent of the total energy requirement and 53 per cent of the imported petroleum energy. Under WECS's BNP scenario, transportation energy requirements are projected to increase to 5.2 per cent of the total energy requirement by the year 2000. Most transportation in the informal sector is on foot or by cart or bicycle. The modern transportation infrastructure consists of one international airport, 41 domestic airports, 6,306 km of roads of all types, 42km of electric ropeway, a 13km electric trolley bus network, gas/diesel buses and cargo carriers; taxies and vehicles serving the tourist industry, private vehicles and bicycles, a railway connection, and some unmotorised river traffic.

The energy requirement for the transport sector was approximately 131,000 tons of oil equivalent (toe) in 1988/89, virtually all of which was for petroleum products. Indeed, the transport sector uses 53 per cent of all petroleum imports which is equivalent to 13 per cent of the total export earnings, in Nepal, at 1988 prices. By end use, trucks use 36 per cent of the transport sector's fuel requirements, followed by aviation (32%), buses (17%), and cars (11%). However, if current trends continue, the share of trucks in the total requirement will increase to 44 per cent by the year 2000 with the annual requirement for trucks growing at nearly 6 per cent. Excluding aviation, diesel fuel accounts for 75 per cent of the transport sector's energy requirement and this is expected to grow at the rate of over 6 per cent during the next decade. Finally, if current trends persist, the overall demand in the transport sector will grow at the rate of over 4.2 per cent during the next decade.

The Agricultural Sector

Commercial energy use in the agricultural sector accounts for about 0.1 per cent of the total energy requirement and 4.0 per cent of the imported petroleum products.

Energy consumption in the agricultural sector can be classified as either direct or indirect. The major end uses of direct energy include draft power for tilling and threshing and pumping for irrigation. Indirect energy consumption includes human and animal labour, and imbedded energy in manure and chemical fertiliser inputs. A detailed presentation of both direct and indirect energy consumption in the agricultural sector is included in the WECS Report "Energy Demand Analysis for the Transport and Agricultural Sectors of Nepal".

The Commercial Sector

The commercial sector accounts for about 1.1 per cent of the total energy requirement and 9.0 per cent of the imported petroleum products. The commercial sector refers to commercial activities or services undertaken by private, public, or government institutions, excluding transportation services.

Energy demand in the commercial sector was approximately 72,000 toe in 1988/89. Power consumption accounted for over a quarter of this demand and the commercial sector accounted for approximately 21 per cent of all power consumption and 25 per cent of the demand for petroleum products. Hotels/lodges and restaurants account for over 80 per cent of the sector's energy requirements, with cooking accounting for approximately 69 per cent and lighting 14 per cent. Thus, to the extent that improved cooking-stoves in urban areas can also be used in restaurants, the scope for energy savings in this sector could be significant. With respect to power demand, lighting in hotels accounts for 22 per cent of the commercial sector's power requirements, and contributes significantly to peak-load requirements. Energy demand in the commercial sector will grow at the rate of 4 to 5 per cent per year over the next decade, and growth rates by fuel type are not expected to vary significantly.

EXISTING POLICIES AND PLANNING ACTIVITIES

The Energy Pricing Policy

Energy pricing is an important government policy tool. Pricing structures can have a significant influence on the mix and pattern of energy use that will occur over time in all those sectors of the economy where energy consumption is monetised. Indirectly, pricing policies help to shape future government investment requirements for energy supply development, including the level of future recurrent costs for energy imports.

Decisions on the absolute and relative prices of energy forms have direct impacts on concerns such as:

- o promoting or reducing the use of selected fuels by influencing the consumer's selection of competing fuels where substitution is possible;
- o ensuring the profitability and financial viability of energy suppliers;
- o meeting government revenue requirements and achieving government social welfare objectives such as minimising the adverse impacts of price increases through cross-subsidy, especially on lower income households.

The overwhelming dependence of rural families and the rural economy on fuelwood, agricultural waste, and animal wastes in meeting household energy requirements, relying on free collection where the cost is the individual's time, means that there is little short-term direct scope for using pricing policy as a tool for influencing the pattern of energy use in the rural sector. For rural requirements, emphasis on conservation/efficiency measures and the development of new energy supplies to meet growing demands is required.

All energy sources which are bought and sold to end users are controlled by government agencies and corporations. The Nepal Oil Corporation (NOC) handles import, distribution, and pricing of petroleum products. The Nepal Electricity Authority (NEA) is responsible for electricity generation, transmission, and distribution. The Ministry of Water Resources, in conjunction with NEA, is responsible for electricity tariffs. The Nepal Coal Corporation is responsible for the importation, distribution, and pricing of coal. The distribution and pricing of commercial fuelwood sources is carried out by both private dealers and the Fuelwood Corporation.

While the various implementing agencies prepare their own pricing schedules, largely based on financial costs and profit requirements, the proposals must be approved by the Cabinet to ensure that public welfare and all other concerns are addressed. The factors and trade-offs considered in pricing decisions include the following.

- o Economic supply costs faced by the country.
- o Financial costs faced by suppliers and licence dealers to obtain and market the energy form, either indigenous or imported.

- o Government revenue requirements in the form of central and local taxes.
- o The impact of absolute energy prices on the end users and consumers and, in the case of domestic energy sources, the impact on lower income families especially .
- o Adjustment mechanisms to reflect changes in exchange rates and to minimise exchange rate losses for imported fuels.

The energy pricing environment thus, typically, has both market and socioeconomic aspects.

Energy Pricing Issues in Selected Sectors

Domestic - Urban

Energy consumption by urban households accounts for approximately 5 per cent of the total consumption in the domestic sector, reflecting mainly the national split between urban and rural population. Domestic cooking requirements are met by an assortment of fuels, depending upon the household income bracket. Cooking requirements generally account for 70 to 90 per cent of the household's energy budget, and on average about 11 per cent of urban household income. Higher income households have the ability to use the more convenient, cleaner fuel forms such as electricity and gas.

Table 2.1 illustrates the financial costs of cooking by different fuels, including the cost of the cooking device. Observations made regarding the pricing of urban cooking fuels are as follows.

- o Fuelwood supplied from private depots and electricity are priced at about half the long-run marginal supply cost or the true economic cost of supply (LRMC), thereby encouraging greater use of wood and electricity than would otherwise be justified under strict economic efficiency objectives.
- o Clearly, there is greater justification for continuing to encourage the use of electricity rather than encouraging greater wood consumption, in view of the diminishing forest stock.
- o The Timber Corporation's prices are about one-third of the LRMC cost of wood. This assumes that transport costs involved in bringing wood to Kathmandu represent on an average 65 per cent of the market price of wood.
- o Prices for imported LPG and kerosene are set for cost recovery and reflect the import costs to government. Prices, nevertheless, do remain susceptible to any future change in world oil price and to supply constraints.
- o Relative to kerosene and wood tax structures, taxes and duties on LPG cooking gas are low. It is assumed that LPG is mainly used in higher income households.

Table 2.1 RELATIVE FINANCIAL ATTRACTIVENESS OF COOKING OPTIONS

ENERGY SOURCE	COOKING DEVICE					ENERGY COST					TOTAL	RANKING
	Type of Cooker	Unit Cost	Expected Life	Annual Maintenance	Simple Annualise Cost	End-use Demand	Efficiency of Device	Energy Required	Energy Price	Annual Energy Cost	Total Annual Cost	
		(Rs)	(Yrs)	(Rs)	(Rs)	(GJ/HH/yr)		(GJ/yr)	(Rs/GJ)	(Rs)	(Rs)	
Fuelwood-Kathmandu												
- TCN	Traditional	0	2	0	0	5.9	0.12	49	33.5	1,646	1,646	1
- Private Depots	Traditional	0	2	0	0	5.9	0.12	49	69.5	3,416	3,416	6
- Private Depo with ICS	Improved Stove	200	2	10	100	5.9	0.25	24	93.5	2,201	2,311	2
Kerosene	Wick Stove	150	2	10	85	5.9	0.40	15	198.9	2,934	3,019	4
	Pressure	200	5	25	65	5.9	0.50	12	198.9	2,347	2,412	3
LPG	Stove	3,000	10	50	350	5.9	0.65	9	470.6	4,272	4,622	8
Electricity (400 V Supply)	Modern Stove	1,500	10	10	160	5.9	0.60	7	444.8	3,280	3,440	5
	Clay Stove	75	2	25	63	5.9	0.50	12	333.5	3,935	3,998	7
Ag. Waste	Traditional	Non-Monitized										
Animal Waste	Traditional	Non-Monitized										

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

The greatest scope for pricing adjustments from strict economic efficiency objectives appear to be with wood followed by electricity. Consumption of electricity for cooking needs, nevertheless, is relatively minor and largely restricted to higher income families except under circumstances of kerosene supply interruptions. Electricity is mainly for lighting. About 60 per cent of the urban households rely on wood for cooking and any major revision of pricing structure would have to be developed in stages while ensuring adequate supplies of substitute fuels; it is kerosene that is mainly available and households can afford the replacement of cooking stoves.

The most significant factor to assess, in energy pricing strategy, is the relative pricing of kerosene and wood, and in the case of electricity, if the policy objective is to gradually reduce kerosene use, to overcome vulnerability to supply shocks. At present, kerosene and wood together represent over 80 per cent of the urban domestic cooking requirements and can be substituted. Kerosene, under the current pricing structure, is slightly less economical than wood. Before the supply shock, kerosene prices were slightly more economical than wood prices for cooking needs. The previous pricing structure, combined with convenience of use, would have gradually reduced the share of wood use in relation to kerosene for urban needs, assuming that there are no supply constraints in the case of either fuel.

Domestic - Rural

Energy consumption in the rural domestic sector on a GJ basis accounts roughly for 89 per cent of the total energy consumption in the Kingdom. The bulk of consumption is for cooking and is based on non-monetised use of traditional fuels, including wood, agricultural waste, and animal waste. Electricity is available in only a few former *Panchayats* and kerosene is mainly used to supplement lighting requirements to the extent that households can afford the fuel and that the supply is available. Pricing policy will thus have little direct influence in the short-term, on patterns of rural energy use, apart from in the case of kerosene.

Overwhelmingly, this means that rural energy policy has to focus on the options which are:

a) development and management of new supplies and
b) conservation/efficiency improvements.

In districts where there are already acute pressures on the the available supply of traditional energy sources through the felling of trees or land clearanes, the most immediate option is the introduction of improved cooking-stoves. Improved cooking-stoves have the potential to double the conversion efficiency of traditional fuel use and thus, theoretically, offer the opportunity to reduce half the requirement of fuelwood and agricultural waste. The development of new energy supplies is expected to occur over a longer time-frame. It should include community-based forest management and plantation schemes and, where appropriate, extension of the hydroelectricity grid, micro and small hydro-based energy plants, biogas, and other options.

In terms of the extent to which pricing policies have an impact on rural energy uses, areas of ongoing or further consideration include:

o updating the policies on cost-recovery, life-line rates, and cross-subsidy requirements for rural electrification, small hydro-schemes, and other commercial energy supply projects;

o examination of the role that locally-derived energy pricing structures can play as an incentive to encourage community-based forest management and afforestation schemes;

- examination of opportunities for extending credit schemes, to communities having lower income-generating and landholding households, for implementing biogas schemes where technically feasible (i.e., dung availability and climate);

- examination of the extent to which pricing policy in urban centres can reduce depletion of forest stocks in adjacent rural areas; and

- examination of the extent to which kerosene is required as a rural domestic fuel if forestry programmes are not fully implemented, the extent of subsidy required, and the pricing and rationing options.

The Transport Sector

The transport sector accounts for about 53 per cent of the imported petroleum products. Regarding the scope for adjusting the pricing policy for transportation fuels, the main considerations are as follows.

- Current petroleum product, pricing policies reflect cost recovery objectives and economic efficiency. Retail prices primarily reflect the border costs and government revenue requirements.

- Adjustments in relative prices of petroleum fuels used in transportation offer limited scope in the short-term for changing the transportation fuel mix, for example, towards more economical use of diesel, given the vehicle types in the existing transportation fleet. Fuel costs are a minor component in the purchase decision for the impact of new vehicles.

- The establishment of absolute price levels for transportation fuels remains a trade-off between government revenue requirements and the socioeconomic impact of increased transportation costs. It is significant to note that private vehicle ownership represents about 50 per cent of all light vehicle registrations.

- Apart from private vehicle use, the technical and non-technical measures to improve energy efficiency in the transportation system are discussed in Section 6. These offer greater opportunities for cost reduction and energy savings than the use of pricing mechanisms.

Industrial Energy Sector

Industry accounts for about 25 per cent of the monetised energy consumption and about 8 per cent of the imported energy requirements. The share of industries in energy consumption is growing. Electricity is required for motors and lights. Process heating and boilers account for approximately 60 per cent of energy requirements in modern industry. Fuelwood, coal, and oil are the main fuels used for process-heating (WECS 1990).

The relative prices of fuelwood, coal, and oil will have an impact on an industry's choice of fuel. This assumes that over the longer term the capital is available to make the necessary equipment conversions to facilitate a switch over from fuels currently used in industry and assumes that both capital costs and annual fuel costs will be accounted for the choice of fuel for a new plant.

Considering energy prices alone, the relative costs of using different fuels for process-heating requirements in industry are shown in Table 2.2. An average conversion efficiency for each energy type is taken into account. The pricing structure in Table 2.2 is for Kathmandu. Absolute prices of these energy sources vary slightly in different regions reflecting the difference in cost of the transportation of supplies.

Regarding energy pricing for industrial process-heating requirements, for both air-heating and water-heating applications, the following observations are made from Table 2.2.

- Wood supplied from the FCN is currently the cheapest energy source for industry, on an efficiency-corrected basis. This is reflected in the fact that wood still meets over 40 per cent of the process-heating energy used in industries.

- Coal and wood supplied from private depots are roughly competitive at current prices.

- Coal is less expensive to use than oil by a factor of 65 per cent. However, this does not include the cost of storage and the handling of coal on the plant site or the relative cost of coal-burning equipment.

- LPG and electricity are considerably more expensive for the low temperature process-heating that is most common in industry and their use is limited to special process applications, motors, and lighting.

The main considerations for energy pricing in the industrial sector should be based on the basic policy of reducing reliance on imported fuels. There is added scope for using coal to displace wood in industry through a relative adjustment in the pricing of wood, although the trade-off is for imported coal. This will require examination of the conversion costs faced by industries and of whether it is technically feasible for small cottage type industries to convert to coal. Wood used by the industrial sector represents approximately 21 per cent of the current wood use for all domestic requirements in urban centres and under 2 per cent of the total national wood consumption.

The other aspect of energy pricing for industry is the consideration of using electricity tariffs to stimulate energy- intensive industrial development. There appears to be limited scope for this in the short-term, and its use would necessitate a separate investigation by WECS in the form of a power absorption study.

Planning Activities

In WECS, work focussing on the national-level energy planning includes detailed analyses of the energy sector, its relationship and linkages to the rest of the economy, and the main interactions within the energy sub-sectors themselves. As is the case in all planning disciplines, the energy planner is expected to provide recommendations that explicitly identify or recognise a number of planning trade-offs. As part of the orientation to policy analysis, energy planners and other concerned agency representatives must consider the relative merits, inconsistencies, and trade-offs among the various policy objectives for the energy sector.

HMG has conducted a number of studies and programmes intended to address water and energy development concerns. The three main thrusts of government-wide planning in the past included implementation of the Basic Needs' Programme; planning and implementation of the Decentralisation Policy, and the development of the Government's Eighth Five Year Plan.

An illustration of planning activities included within this policy framework, geared to address the main concerns in the water and energy sectors, are discussed below.

Planning Programmes

- o Interim Government Guidelines. HMG issued a set of policy and planning guidelines for overall economic development after the new government was formed. This occurred after the last PSC meeting. Stress has been placed on indigenous resource development, poverty alleviation, and the maximum use of existing management and technical resources available in the country.

- o The Eighth Five Year Plan. The National Planning Commission (NPC) previously established task groups consisting of officials from HMG line agencies to prepare inputs for the Eighth Five Year Plan. Multi-sector investment priorities are to be outlined. The approach NPC adopted for investment planning in the energy sector was to outline energy supply and demand management programmes for each energy type and the consuming sector. The Irrigation Master Plan formed the main input of the Eighth Plan for that sector. The Eighth Plan has been deferred until after the elections.

- o The Forestry Sector Master Plan. HMG is still in the process of securing finances for the implementation of the Forestry Sector Master Plan. This overall programme includes plans for afforestation, forest management, village woodlot, and other fuelwood supply measures. It incorporates a dissemination programme for improved cooking-stoves (programmes which have met with limited success in the past). Programmes are also planned for soil conservation and stabilisation. The Irrigation Master Plan will form the major input of irrigation programmes.

- o The Power Sector Efficiency Programme. Discussions are continuing between HMG and the IBRD for a 'Power Sector Efficiency' programme which incorporates further funding for equipment to support NEA's loss reduction programme as well as for hydro-plant rehabilitation and distribution system strengthening activities. An industrial energy management programme, focussing on reduction of imported energy, is also included.

- o Least Cost Generation Plan. NEA completed the updating of the generation plan for grid supply. The current load forecasts indicate shortages by the mid 1990's and a 150 MW deficit (hydro only) before the planned commissioning of Arun III.

- o Proposal on Equitable and Efficient Pricing of Fuelwood and Commercial Fuels. HMG and ADB finalised the terms of reference of a study to recommend policy options for pricing and inter-fuel substitution, focussing on the rural and urban domestic sectors. The study proposes to examine local fuelwood market costs and pricing structures, to review and recommend measures to improve programmes promoting the use of efficient stoves, to assess factors that affect traditional and commercial energy inter-fuel substitution, and to recommend pricing and supply strategies in that light. HMG has designated WECS to be the implementing agency to coordinate work done by local and expatriate consultants. The study is scheduled to start by early 1991 and is due for completion after eight months.

o NEA Marginal Cost and Tariff Study. NEA, with World Bank financing, is undertaking a marginal cost and tariff study for the electricity sector. The study will also consider, to a limited extent, inter-fuel pricing factors which affect electricity demand and substitution in all sectors. The report is due by November.

o Rural Electrification Master Plan. NEA, with World Bank financing, completed a rural electrification master plan. The work covers tariff, electrification, and inter-fuel substitution measures in the rural economy for domestic, irrigation, and cottage industry loads and examines electrification strategies and costs. The study is completed in draft form.

o Master Plan for the Karnali and Mahakali River Basins. HMG initiated a programme, with Japanese funding, to provide site investigation work for promising sites in the above basins.

o Hydrometric Network Assessment. HMG initiated a study programme to assess the DHM hydrometric capabilities in Nepal.

o Natural Resource Management for Sustainable Development: ODA funded a natural resource management study which mainly focussed on hill communities. It considers feasible policies, institutions, and investment activities to promote sustainable natural resource use. The study emphasis is on resource use interactions for agricultural development, forest development, and population growth and livestock use. Substitution and trade-offs in the use of different traditional energy forms were considered. The second phase considered policy dimensions and implementation strategies, focussing on community-based initiatives.

o Project Specific Studies. NEA and DOI (with donor support in some cases) are continuing to undertake project-specific reconnaissance, pre-feasibility, and feasibility studies for irrigation and power projects. A detailed design of Arun III is nearing completion. An updated feasibility study of the Kali Gandaki has been planned. Investigation work on the Pancheswor Site is nearing completion. The Chisapani feasibility study was also completed and work on the Upper Arun Feasibility Study was initiated. DOI is also starting studies on a number of major irrigation schemes.

The above represent a few of the main overall planning activities in the water and energy sectors, currently being undertaken by HMG independently or with donor support. In addition, there are numerous project-specific studies that are in process, associated with the ongoing management and implementation of projects. Policy measures that support the objectives of efficient water and energy resource utilisation and facilitate conditions for future development, involving private entrepreneur and local community participation, are also being studied and acted upon by HMG in a number of fields. Over the past few years these have included:

o recent study and subsequent adoption of revisions in forest use legislation and

o recent revisions and improvements in rural credit schemes such as ADB/N subsidies to assist local participation in energy schemes for biogas and micro-hydropower.

ANNEX 3

ENERGY CONSERVATION POLICIES IN THE NON-DOMESTIC SECTOR

Increasing Energy Efficiency

There is currently no comprehensive strategy in the field of energy efficiency in Nepal. There is, however, a significant amount of effort to bring about better energy efficiency in some sub-sectors, particularly in the supply side of the power sub-sector and the forestry sector, and in the use of traditional energy sources. Efforts are being made to design an appropriate energy pricing policy at WECS and to realise the appropriate pricing of electricity.

Regarding energy efficiency, it is currently envisaged that WECS will provide the framework of a comprehensive energy efficiency strategy and will provide advice to the ministries, the public and private suppliers, and users of energy. The implementation and the enforcement of policies and technical measures will be carried out by each of the relevant institutions.

The barriers and constraints encountered in Nepal are very similar to those encountered in other developing countries and to some extent in the developed countries. The main barriers and constraints are the following.

- Lack of information about energy-efficient technologies and about possible savings.
- Lack of technical expertise in those areas.
- The relatively low priority given to the improvement of energy efficiency; importance of access to raw materials, spare parts, etc.
- Front-end investment costs.
- Inadequate pricing of energy, very often below the economic costs.
- Dispersion of the energy users and therefore problems of reaching-out.

The Industrial Sector

By the end of 1990/91, industries in Nepal will have to spend about U.S. $ 12.5 million for energy inputs and future growth is likely to be substantial. Experience from Nepal and other developing countries indicates that no-cost/low-cost energy efficiency measures could provide savings of about 10 to 15 per cent, - i.e., annual savings between US$ 1.2 to 1.8 million.

While there is undoubtedly cost-effective measures that could be taken to improve the energy efficiency of the industrial plants and of the large commercial concerns of Nepal, relatively little has been done except for workshops conducted by the Ministry of Industry (MOI) and ESCAP/UNIDO in 1985 and 1986 and very limited auditing.

As in most of the developing countries, numerous barriers and constraints will have to be overcome. In Nepal, the following barriers and constraints should be addressed.

- o Inadequate energy pricing and supply. As an illustration, there is no time-of-day pricing of electricity and no sanctions (no-metre) or adequate penalties to induce power factor corrections. Because of a lack of storage facilities for furnace oil, many medium and small industries are forced to use higher priced fuel.
- o Lack of knowlege on energy information, on the part of the plant managers and of the technical personnel, on basic energy-management concepts.
- o Lack of skilled technical personnel in the plants or as consultants to identify and implement energy-efficient measures.
- o Lack of an adequate supply of energy-efficient equipment.
- o Inadequate financing and incentives.

To improve the energy efficiency of the industrial and large commercial sectors, MOI and WECS have designed the Nepal Industrial Energy Management Programme (NIEMP) which includes an energy management information programme, an energy management training programme, an energy auditing programme, a financial and capital assistance programme, and an energy services and procurement programme.

Broad principles to explore energy demand management in the industrial sector include the following.

- o Energy Efficiency - to reduce waste and the level of energy inputs required for given production levels, potential actions range from conducting in-plant energy audits to establishing simple no-cost and low-cost 'house-keeping' measures to the specification of modern, energy-efficient equipment for new plants.
- o Energy Substitution - concerns the type of process-heating fuels used in industries (process-heating accounts for 80% of the industrial energy use) and the direction of substitution (e.g. coal and wood vs petroleum).
- o Electrification - concerns defining the role of electricity in industrial development and identification of further substitution possibilities to use electricity to the maximum extent for non-process-heating industrial applications.
- o Energy Pricing - concerns the role of energy pricing as a stimulus for promoting investment in efficiency and substitution measures.
- o The Long-term Industrial Structure - concerns seeking ways to ensure industrial development programmes, giving priority to energy supply issues e.g. the comparative advantage of electricity-intensive industries, opportunities to create local industries which will reduce the import of products with significant imbedded electricity.

The Transport Sector

For the purpose of this paper, a few general approaches are outlined to help reduce reliance on imported energy, recognising that some measures would only be practical or feasible in the longer term and would require investment. Categories of measures to reduce the reliance of the transport sector on petroleum fuels include the following.

a. Efficiency Improvement Measures for Vehicles.

- Technical efficiency - relating to the improvement of the fuel economy of transport vehicles which is a function of engine type, size, state of maintenance, and vehicle weight.

- Operational Efficiency - relating to the management of vehicle fleets and usage patterns which affect total mileage and fuel consumption.

b. Substitution Measures.

- Switching Mode of Travel - includes changing patterns of travel from vehicle to mass public transport, greater use of bicycles, etc.

- Energy Substitution - implying greater use of electricity for transport, for example, by encouraging ropeways-trolley buses instead of diesel buses, and rail electrification to the extent feasible to replace the long-distance haulage of goods by truck on higher traffic density routes.

c. Demand Restraint Measures.

- Rationing Activities - involving restrictions, where appropriate, on the amount of fuel allocated for different uses with the objective of reducing unnecessary or wasteful consumption but not hindering social or economic activity.

- Fuel Pricing - involving the restructuring of fuel prices to reduce or minimise unnecessary travel.

d. Design and Maintenance of Transportation Facilities.

- Road Maintenance - As fuel efficiency depends on road conditions, proper and timely maintenance of roads would contribute to energy savings.

- Urban Design - concerns long-term aspects of urban design to the extent that use of non-energy intensive transportation systems are provided for in planning; for e.g. expansion of public transit, safe use of bicycles in urban areas, etc.

- Land Use Planning - concerns planning the location of industries and commercial enterprises to minimise transportation energy needs and costs over the long- term.

In Nepal, numerous measures can be devised to improve the energy efficiency of the transportation sector. The following have been considered.

- Extension and electrification of the railways. Studies have been conducted but funding has not been secured.

- Extension of the electric trolley system in the Kathmandu Valley. Feasibility studies have been conducted but financing has not been secured.

- Rehabilitation and improved maintenance of the major roads could contribute a lot to savings.

- Extension and improvement of the ropeways. Studies have been conducted and the Hetauda-Kathmandu ropeway may be improved. This will have only a limited impact on road transportation.

- Improvement of traffic management, particularly in the Kathmandu Valley. Financing for this activity will be provided by the ADB.

- Improved maintenance of vehicles through improved training of mechanics, law enforcement, and drivers'/owners' information services.

- Fiscal measures to induce the import of energy efficient vehicles and eliminate inefficient vehicles.

The Agricultural Sector

Since Nepal is dominated by subsistence agriculture, many of the energy-demand management options, in practical terms, are the same as discussed for the rural domestic sector and refer to traditional energy sources.

The use of commercial energy in the agricultural sector is nominal. The amount of time over which tractors and pumps are used is limited. The use of electric pumps is higher than the use of diesel. There is lack of an integrated and coordinated approach for farm mechanisation.

- It is necessary to strengthen the integrated and coordinated efforts to provide modern farm inputs, especially at farm level. It may, therefore, be necessary to devise incentive mechanisms for ensuring the timely delivery of the integrated package (optimum quantities of water, fertiliser, improved seeds, and appropriate and efficient farm machinery and tools) to reach the farmers, rather than providing such components separately.

- There is a need to provide appropriate incentives and training to manufacturers for producing efficient farm machinery.

- The creation of regional training centres for local entrepreneurs, such as blacksmiths, carpenters, etc, to facilitate the repair and maintenance of agricultural implements as required.

- An appropriate environment (proper incentives, academic atmosphere, etc) needs to be provided for researchers, conducive to the development of high yielding varieties of seeds, related farm technology, and organic manure.

The Commercial Sector

The majority of business for hotels and lodges is generated by tourism and business travellers. Hence, increased operating costs are typically passed on directly to the consumer in the form of increased rates and/or itemised costs. Since all foreigners are required by law to exchange convertible currencies into Nepalese rupees (and pay their hotel bills in convertible currency to hotels using substantial amounts of commercial energy) the majority of the commercial energy consumed is effectively being paid for directly by end users with foreign exchange. Consequently, the impact on balance of payments is minimised. Nevertheless, reduction in energy costs will improve the profitability of commercial enterprises.

Some of the measures to be evaluated for demand management in the commercial sector include the following.

o <u>Energy Substitution</u>.

- Consideration of means to encourage greater use of electricity for end uses currently relying on imported fuels, especially for larger establishments.

- Consideration of greater use of simple solar systems for hot water needs in hotels and associated kitchen needs; however, in many cases solar would be marginally more attractive than electricity.

o <u>Energy Efficiency</u>.

- Consideration of the use of improved technologies for lighting and energy management for water heating needs, especially in profitable enterprises with investment capital.

For service institutions, such as hospitals and schools, and for government buildings, energy efficiency opportunities in a practical sense may be limited but, nevertheless, can contribute to reduced operating costs. Before meaningful steps can be identified it will be necessary to establish responsibility for setting in place a group to look at energy management opportunities in these facilities and buildings.