資料１．“Biobriquetts” A Potential Alternative to Fuelwood

"BIOBRIQUETTES"
A POTENTIAL ALTERNATIVE TO FUELWOOD

A Study Conducted for JICA/RONAST Alternate Energy Development Project

Elite Consultant P. Ltd.
Kathmandu, Nepal

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PREFACE

The purpose of this study was to make an assessment of the alternative energy technologies and their role in the substitution of fuelwood, which is still the prime source of energy in Nepal.

Due to the over exploitation and heavy dependence on fuelwood deforestation coupled with environmental and ecological degradation are serious problems, which the country is facing. Reliance on fossil fuels is not only a heavy burden for the economy but also make the energy system very vulnerable to external influence and control. Given this situation it was deemed essential to make some comparative study and assessment of the prevailing alternative energy technologies (AETs) their cost and benefits.

A series of discussions took place with the National Research and Development Centre for Alternate Energy (NRDC for AE) on Biomass sector team including Dr. T. Maruyama of Hokkaido Industrial Research Institute (HIRI), whereby the Terms of Reference (Annex III) was prepared to undertake the study in light of the projects objective towards fuelwood substitution.

This study was basically conducted using the secondary information sources. Some materials/information, received from the NRDC project was also used for the study.

The ideas/views expressed in the study are mainly derived from the analysis and findings of the study and exclusively our own.

We hope that findings and suggestions will draw the attention of the concerned authorities towards the promotion of biomass briquetting (including Biocoal), which seem to have an enormous potential to substitute fuelwood.

We sincerely thank Mr. K. Yoshida and Dr. T. Maruyama for entrusting us with the task of undertaking this study and providing us information on Biocoal and Japan's energy situation. We very much appreciate the valuable suggestions provided by Dr. R.M. Singh of RONAST and the contributions and guidance of Mr. S. Rimal of WECS for this study.

Elite Consultant P. Ltd.
P. O. 7641, Bhote Bahal,
Kathmandu, Nepal

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BIOBRIQUETTES - A POTENTIAL ALTERNATIVE TO FUELWOOD

1. Energy situation

1.1. General situation

Energy is a vital input for development and hence the per capita energy consumption has been recognised lately as an important development indicator in the assessment of the levels of development of different countries.

The energy situation in Nepal is characterised by a very low per capita energy consumption of 14.06 GJ (WECS 1992/93). Only four other countries in the world have per capita energy consumption lower than Nepal. The total energy demand of the country was estimated to be 248 million GJ in 1990/91. The average increase in the demand has been 2.4 % per annum during the past 10 years. The total energy consumption in the year 1992/93 was estimated to be around 271 million GJ, 91 % of which was consumed by the residential sector and the remaining 9 % by other sectors. About 91 % of the energy demand is met from traditional sources, out of which 68 % is met by fuelwood, 15 % by agricultural residue and 8 % by animal dung. The share of petroleum products, coal, and electricity in the total consumption are estimated to be 7.2, 1, and 0.9 % respectively. (see Figure No. 1). Only about 12 % of the total population have access to electricity and the rural population, which comprises about 90 % of the total population has very limited access to electricity that comes to about 3 % only.

The power deficit in the nation's electricity demand, which is growing at a rate of 14 - 15 %, is a glaring reality which is evidenced by frequent and regular load shedding. This deficit will continue to increase for at least 5 - 7 years until additional supply from proposed projects such as Arun III, Kali Gandaki "A" and Khimti Khola is available. Even then by the time of realization of these projects, some deficits will continue to remain or even increase if additional efforts are not made.

The present energy situation needs to be rectified to achieve development targets and maintain ecological balance. To make energy resources sustainable, there is a greater need to gradually move away from forest based energy sources.

1.2. Fuelwood situation

Fuelwood is the main source of energy for regular household consumption. Its supply is mainly forest based. Considerable supply also comes from farms, and other sources in the rural areas. The supply situation of fuelwood has been characterized by a widening gap between sustainable supply and increasing demand during the past decades.

Nepal has an estimated area of 9.2 million hectares of potentially productive forest, shrub and grassland, of which 3.3 million hectares are considered to be accessible for fuelwood collection in the year 1992/93. Sustainable yield from the accessible forest, farm land, and non cultivated inclusion is estimated to be about 7.5 million tons. Accessible forest land area and sustainable fuelwood supply for the year 1992/93 is given in Table No 1.

Table No 1. Sustainable fuelwood supply, 1992/93

Land description	Accessible forest area		Sustainable yield	
	Hectares	%	Million tons	%
Forest, shrub & grassland	3,320,000	(72 %)	5.042	(67 %)
Non-cultivated inclusions	986,000	(21 %)	0.359	(5 %)
Farm-land	328,000	(7 %)	2.088	(28 %)
Total	4,634,000	(100 %)	7.489	(100 %)

1.3. Forest wastes

One of the by-products of forests is the forest waste or sometimes referred to as forest litter or residue, which has been used by the rural population but has not drawn attention until lately. Forest litter (Chart No.1) has been used by rural people for animal beds, fertilizer preparation (compost preparation) and even substitutes for fuelwood. In addition to the normal forest litter - leaves, herbs, bushes, shrubs, etc. - with the growing deforestation and conversion of previous forest lands to barren or agricultural land, weed encroachments have been encountered in forest management and promotion programmes and afforestation programmes. In the Barun Valley it has been noted that large areas that has turned barren due to deforestation have been covered with Bamara - the "Forest Killer". Sagarnath Forestry Project particularly faced serious fire problems and forestry extension problems with Banmara and Bhanti (another weed). During the dry season Banmara dries up and are extremely fire hazardous. During other times it prohibits the propagation and growth of young saplings. Another forest litter which is of fire hazardous nature is the pine needles which is found in enormous amounts in the pine forests of the Far Western Development Regions.

Exact estimates of these materials are not available in the records or documentation but some figures/estimates of these forest wastes are given below to provide some initial idea of the vast potentials that exists within the country.

Table No.2 Types of forest wastes

No	Forest Area	Forest waste or litter	Yield/ha (tons)	Collection Cost	Remarks
A.	Sagarnath Forestry Project				
1.	11,000 hectares	Banmara	0.80	Rs 40 for 70 kg	Actual cost of collection and yield
2.	11,000 hectares	Bhanti	1.20	-	Also plenty but exact figures not known
		Khar			
		Siru	-	-	
B.	Far Western Development Region		-	-	
1.	Pine forests	Pine needles	0.50	-	Rough estimates of villagers for use in compost preparation

Source : NRDC for AE field visit reports

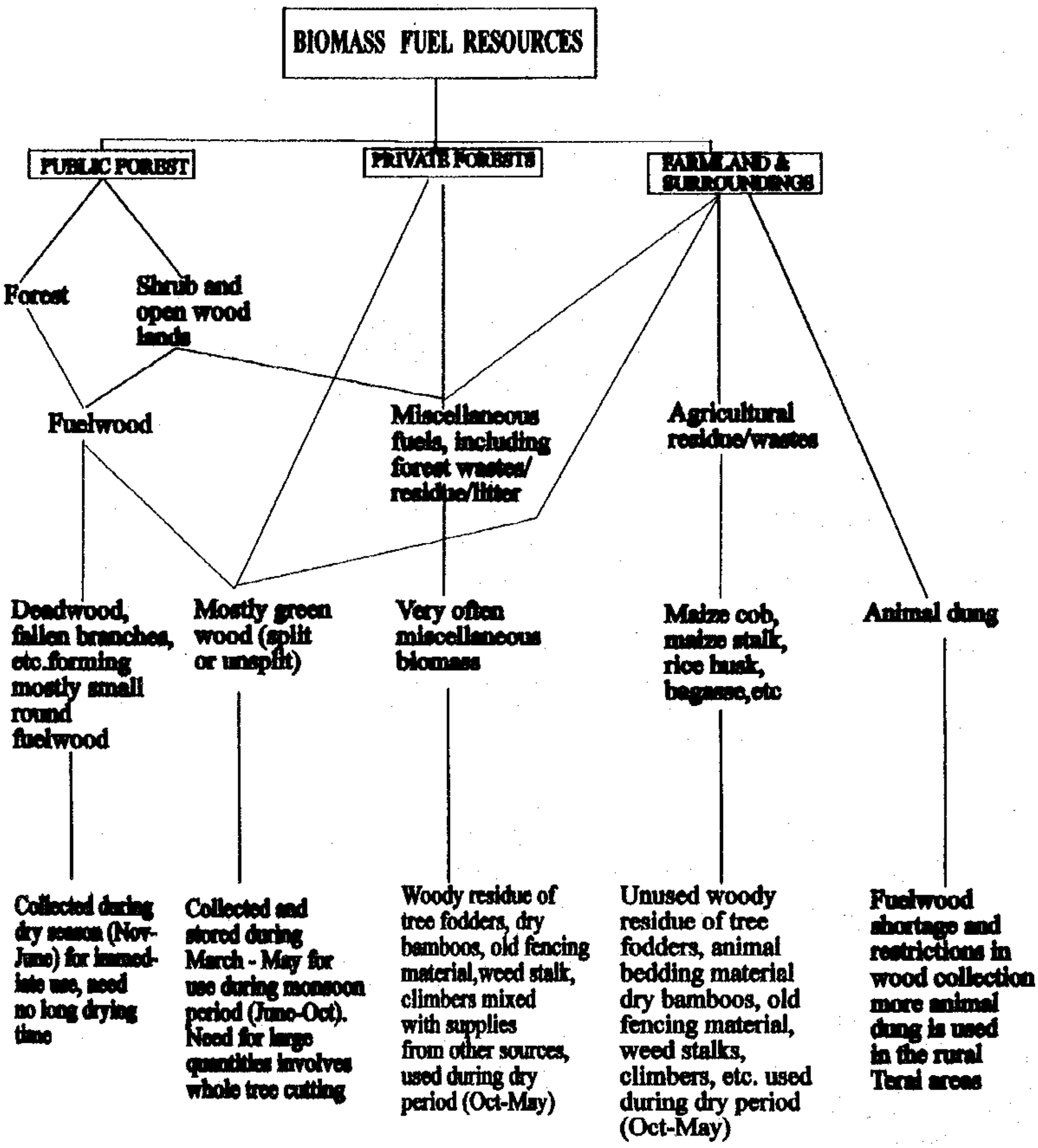
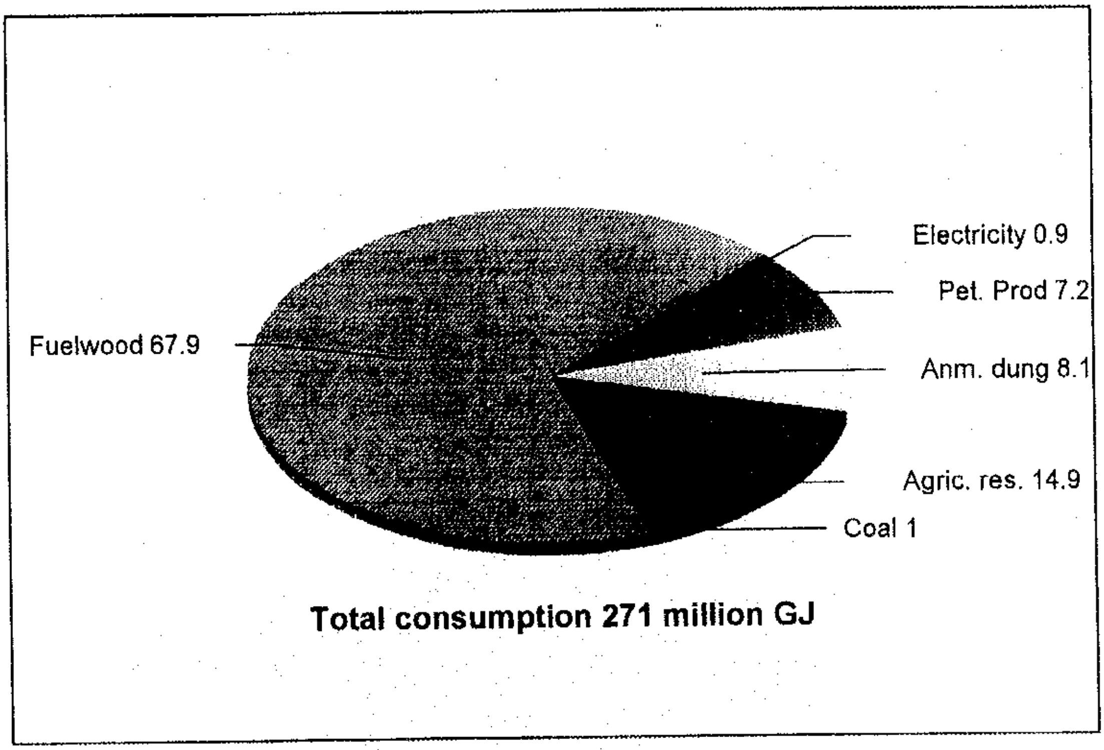


Chart No 1

Source: T.B.S. Mahat 1985 (Ph.D. Thesis)

With this preliminary information the available potential of the forest waste can be projected or rough estimated can be made knowing the forest area. Assuming that only 25 % of the forest area is covered by these different forest weeds/litter, on the basis of Banmara alone about 1.84 million tons of forest residue could be available for different uses. It is in this connection that the Alternate Energy Development Project of JICA/RONAST, in the pursuit of identifying new raw materials suitable for biobriquetting has identified Banmara, Bhanti and pine needles as potential biomass raw materials, analysed them and used them for testing purposes.

Figure No 1. Energy consumption by fuel type in % (1992/93)



1. 4. Consumption pattern of fuelwood and other energy resources

Fuelwood is still the main source of energy in Nepal and will play a dominant role to fulfill the energy needs in the future as well unless some viable alternatives are gradually introduced. It currently represents about 69 % (WECS 1993\94) of the total energy consumption and most of it comes from the natural forests.

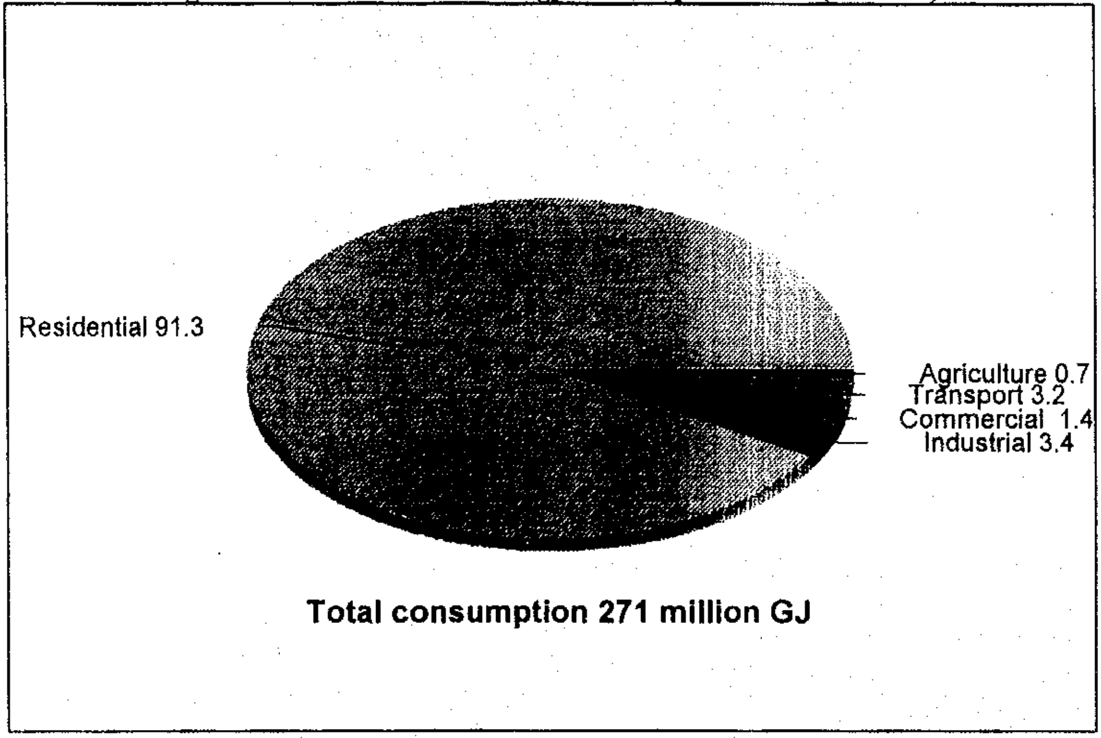
Biomass fuel includes fuelwood prepared from tree stems, branches and twigs, agricultural residue and animal dung. Categorisation, collection and use of biomass fuel is given in Chart No 1. Rural household consume all these types of fuel. Urban households as well as some commercial and other sectors such as army barracks, police force, etc. and industries e.g. food manufacturing, textiles, brick, carpet, rosin and turpentine, tobacco curing, etc. (see Table No 3.) also use mainly fuelwood. The sector wise energy consumption for the year 1992/93 is given in Figure No 2.

Table No 3. Industrial sector energy consumption of some industries (tons)

NSIC	NSIC name	Fuelwood	Coal	Charcoal	Remarks
311	Food manufacturing (A)	10191	231		
312	Food manufacturing (B)	2601	142		
313	Beverage industry	6445	815		
314	Tobacco Manufacturers	483	78	1	Tobacco curing included
321	Manufacture of textiles	16281	1300		Boiler operation
324	Footwear manufacture	54	174		
331	Wood products except furnitures	586	4000		
341	Paper and paper products	442	4000		Boiler operation
352	Other chemical products	7622	383	1	Boiler operation
369	Other non metallic mineral products (structural clay products-bricks, cement, lime and plasters) included	189271	60293	2686	High grade coal is used for cement, low grade for bricks
371	Iron and steel basic products	43	251		
381	Non machinery fabricated metal	698	503	226	
	Total (including others also)	235703	72448	2693	

NSIC - Nepal Standard Industrial Code

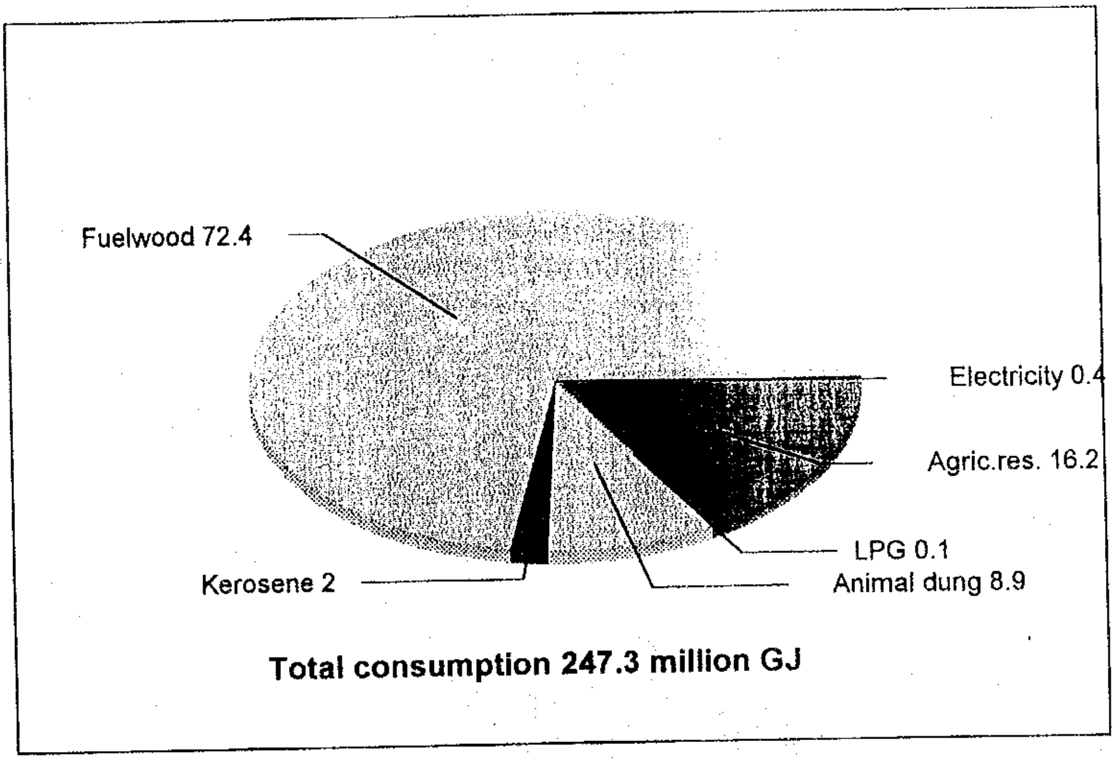
Figure No 2. Sector wise energy consumption in % (1992/93)



From Figure No 2, 91.3 % of total the energy is consumed by the residential sector and the rest by other sectors with only 3.4 % consumed by the industrial sector. As the residential sector consumes the major portion of the energy it is interesting to see types of fuel consumed in this sector on one hand and the end uses of energy fuels on the other hand. The breakdown of the residential energy consumption is given in Figure No 3 and the typical end uses for the rural hills in the Western Development Region is given in Figure No 4. The major portion of the fuel used is still fuelwood - 72.4 % with agricultural residue next -16.2 %. The typical end uses (Figure No 4) show that 42.4 % of the energy is spent on cooking food and 37.7 % is spent on animal feed preparation. Altogether about 80 % of the fuel is associated with cooking purposes alone. This together with the other end uses such as rituals and rites (8.4 %), space heating (4.6 %), agroprocessing (4.9 %) basically also consume fuelwood.

The different fuels used in the industrial sector are shown in Figure No 5. and in the commercial sector the breakdown of different energy used by type is shown in Figure No 6. Figure No 5 shows that the industrial sector is also mainly based on fuelwood, which contributes 42.8 %. Next coal contributes 26.5 % and petroleum products 17.1 %. The commercial sector energy consumption pattern (Figure No 6) show fuelwood to be contributing 22.5 % and other forms of energy 77.5 % including 49.2 % kerosene.

Figure No 3. Residential sector energy consumption in % (1992/93)



Since Agriculture and transport sector do not consume much fuelwood or kerosene for the purpose of this study the energy consumption pattern of these sectors have not been considered and discussed here.

The amount and percentage of fuelwood used in different sectors of the economy are given in Table No 4. In all of the given sectors - residential, industrial and commercial - substantial amount of fuelwood is used and the amount comes up to 10,690,000; 235,224 and 51,343.2 tons respectively. The total amount comes up to 10,985,671 tons . (The conversion to weight was done on the basis that 1 ton of fuelwood = 16.75 GJ of energy). The total amount of fuelwood consumed as per WECS report is 10,979,000 tons for 1992/93.

Figure No 4. Typical residential energy end uses in % (1992/93)

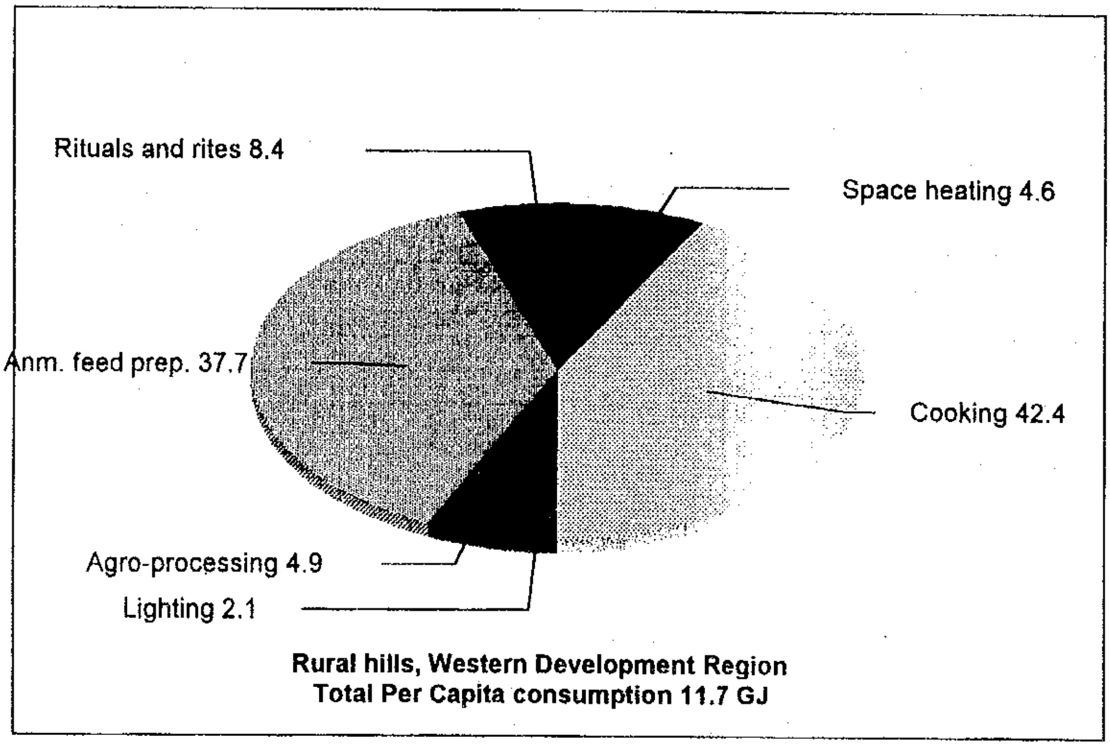


Figure No 5. Industrial sector fuel consumption in % (1992/93)

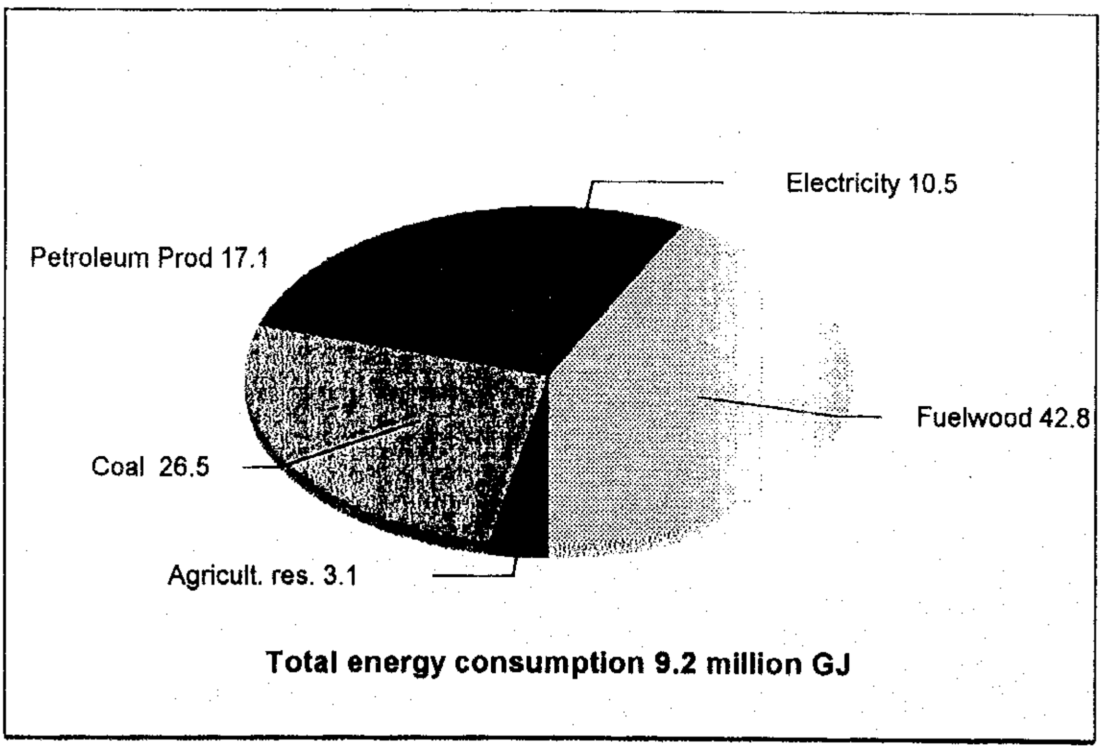


Figure No 6. Commercial sector energy consumption in % (1992/93

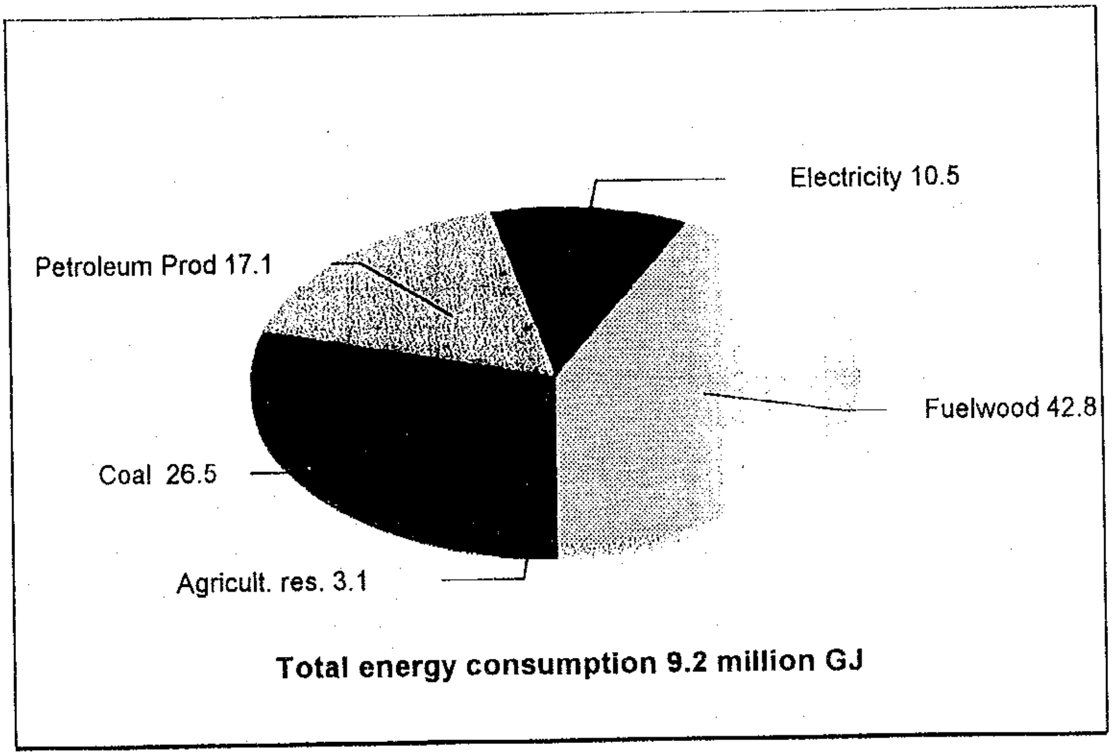


Table No 4. Share of fuelwood in different sectors (1992/93)

No	Sector	Energy consumed, million GJ	Fuelwood, amount, million GJ	Fuelwood (%)	Fuelwood amount, tons	Remarks WECS figure
1.	Residential	247.3	179.05	72.4	10,690,000	
2.	Industrial	9.2	3.94	42.8	235,224	
3.	Commercial	3.8	0.86	22.5	51,343.2	
4.	Total	271	184.01	67.9	10,985,671	10,979,000

1.5. <u>Historical trend of fuelwood and other energy consumption</u>

The trend of use of fuelwood in the country for the past 10 years or so is given in Figure No 7 and Figure No 8. Figure No 7 shows the absolute quantities whereas Figure No 8 shows the % share.

The total quantity of different fuels used in the country during the above mentioned period (1980/81 - 1992/93) shows an increasing trend in all the different forms of energy used, whereas the % share of the different fuels show a different picture. The percentage (%) shares of fuelwood and animal dung are in the decreasing trend, whereas for the other fuels such as agricultural residue, coal and petroleum products show an increasing trend. This slow but gradual increasing and decreasing trends in use of different fuels is factual evidence of the gradual shifting from fuelwood to other fuels.

Figure No 7. Quantity of different type of fuels consumed

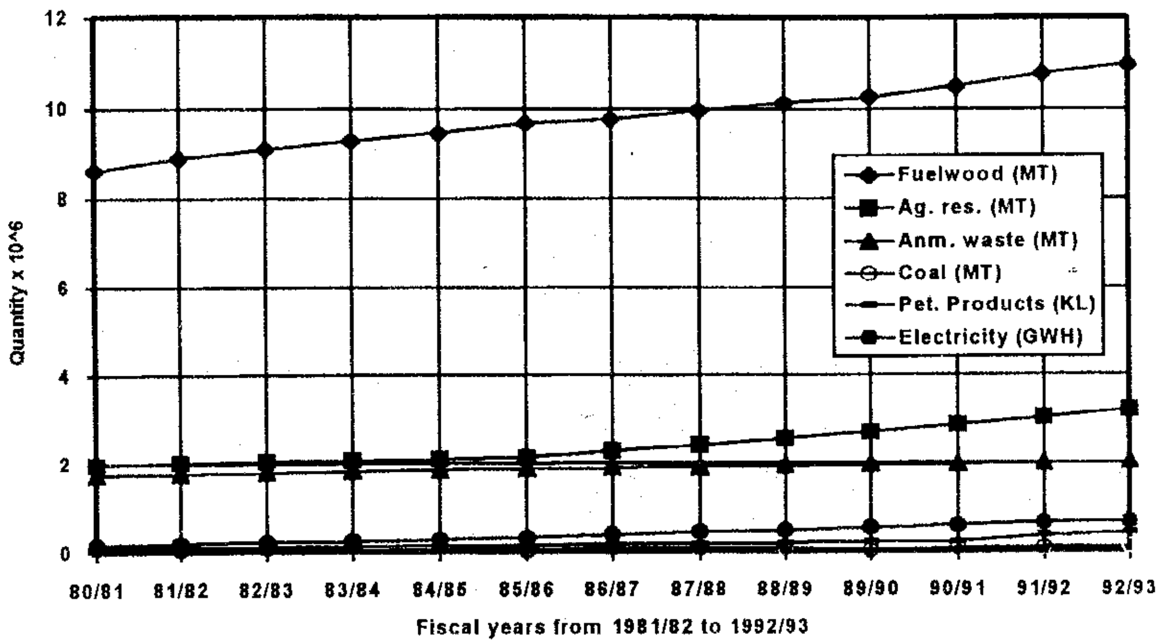
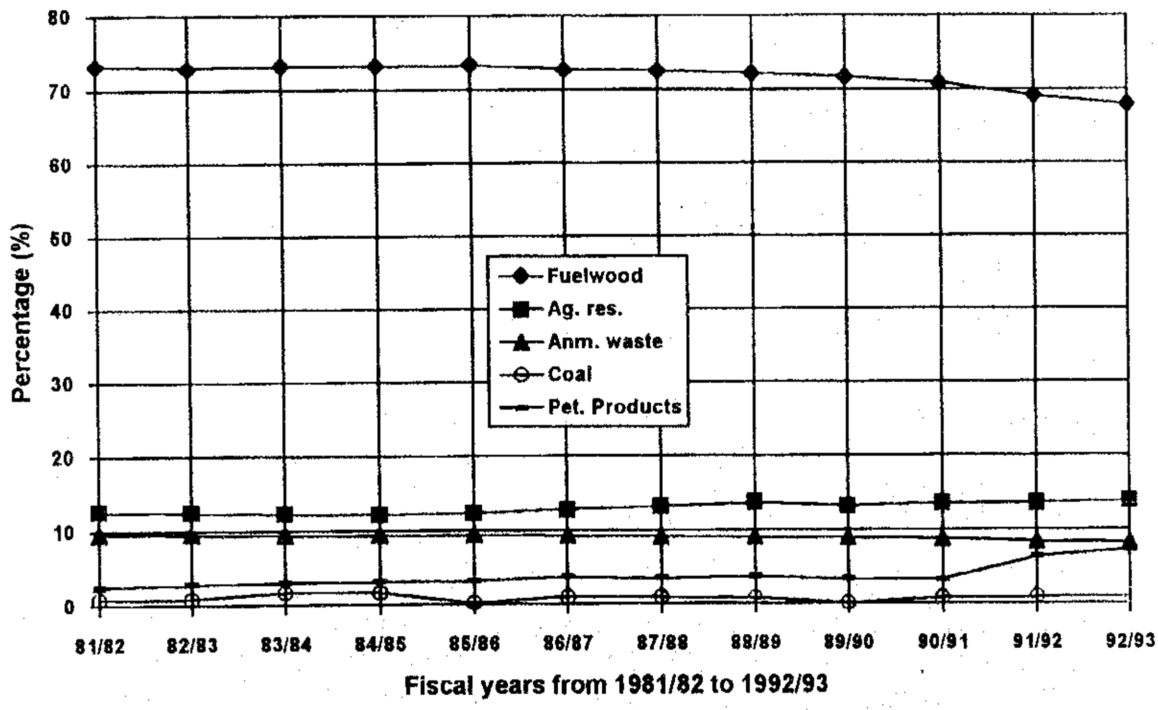


Figure No 8. Percentage (%) of different types of fuels



The energy consumption trend in the different sectors of economy - residential, industrial and commercial sectors are given in Figures Nos 9, 10 and 11.

Figure No 9. Energy Consumption trend in the residential sector

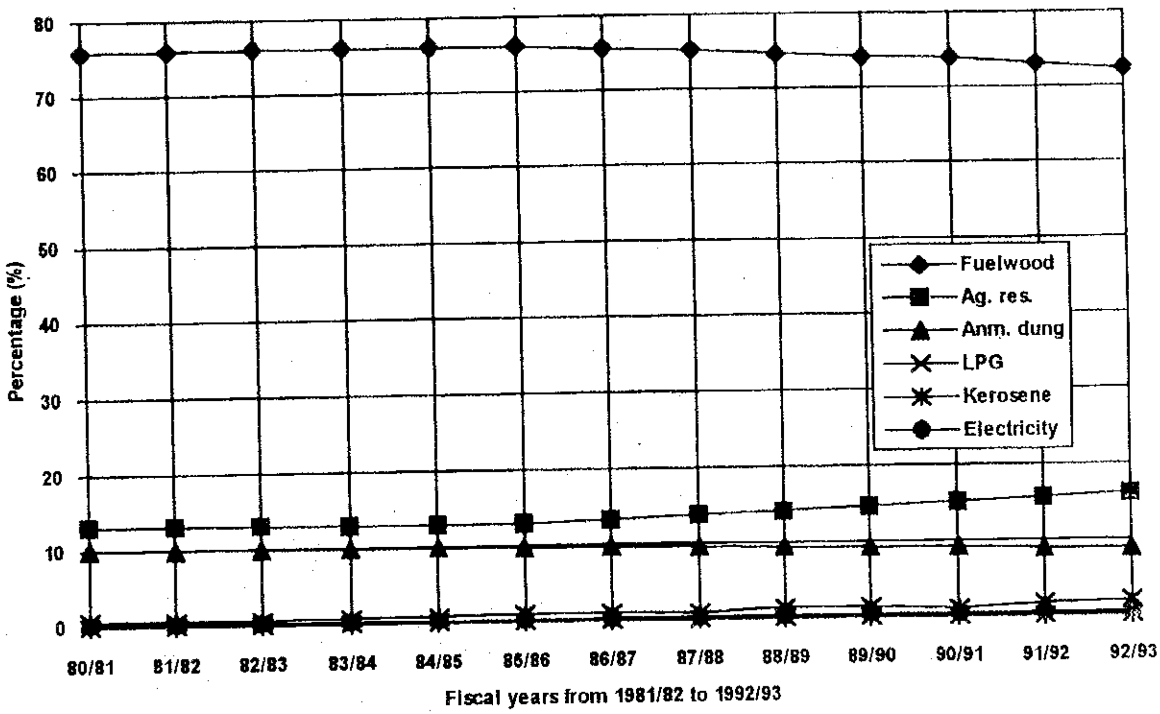
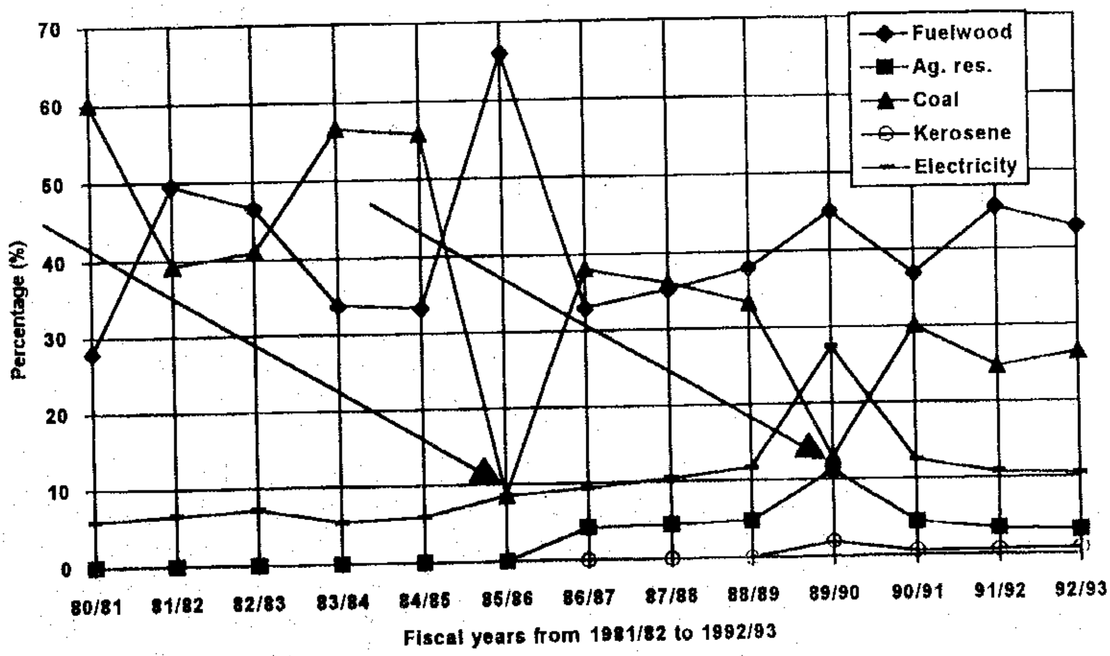


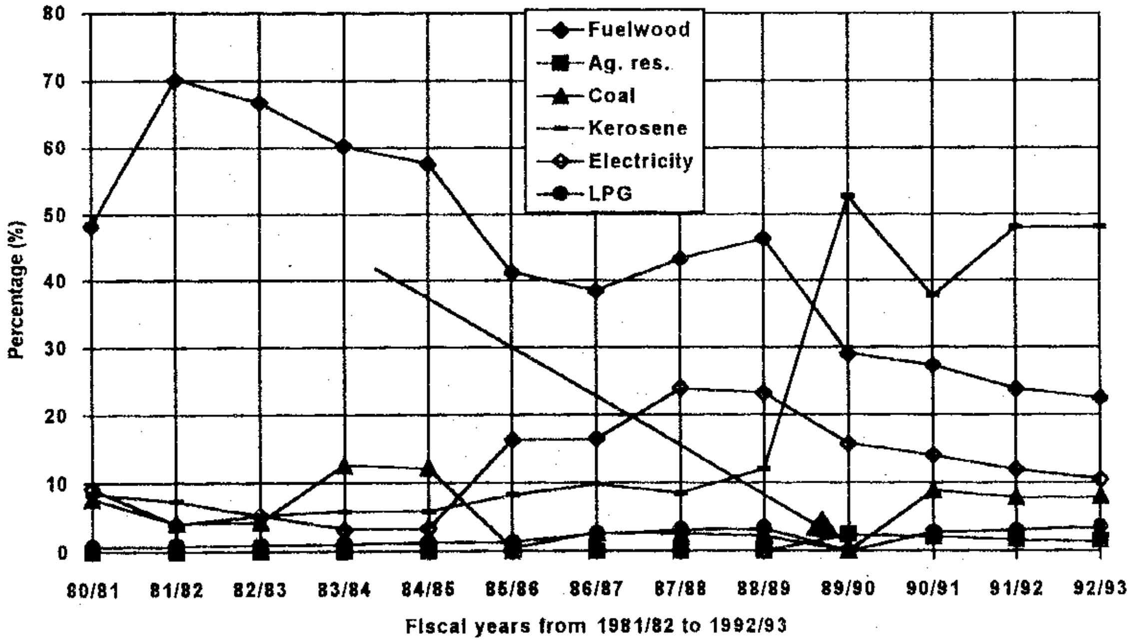
Figure No 9. shows the heavy reliance of the residential sector on fuelwood. A gradual decrease in the use of fuelwood and animal dung is observed while an increasing trend in the use of agricultural residue is observed.

Figure No 10. Energy consumption trend in the industrial sector



Heavy dependence of the industrial sector on fuelwood and coal is seen from Figure No 10. Further, from the graph (Figure No 10) it is noticeable that whenever there is a shortage of coal, fuelwood consumption rises. This is more glaring for the years 1985/86 and 1989/90. Another interesting point to note is the increasing use of agricultural residue during these periods and especially during the 1989/90 Trade and Transit conflict with India.

Figure No 11. Energy consumption trend in the commercial sector



The commercial sector (Figure No 11) also depend mainly on fuelwood; but lately the trend shows a substantial decrease in fuelwood with kerosene and electricity slowly substituting it. Again the period 1989/90 shows conspicuously the instability in the supplies of different fuels including electricity, even though it is based on indigenous hydropower resources.

1.6. Fuelwood consumption trend and some conclusions

The declining figures for fuelwood consumption trend would have been indeed encouraging, in the context of the problems of deforestation and environmental degradation, had it been due to rational use of fuels and the use of substitutes on a selective basis or from the Government policies and programmes on energy, its conservation and utilization.

From the above graphs we can see clearly how irregular is the supply of fuelwood in all the sectors especially the industrial and the commercial sectors. It can be clearly seen that there is a direct relationship between the decrease in the fuelwood supply and consequently the consumption and the increase in the consumption of electricity, coal and other petroleum products in both of these sectors. For the industrial sector during the years 1980/81, 1985/86, and 1989/90 we can see the direct relationship between coal and fuelwood. This is even more glaringly illustrated in the year 1989/90 during the time of the trade and transit impasse with India, when coal and petroleum products were in minimum use and the use of electricity and fuelwood increased substantially. A closer examination of the situation show many reasons for this trend. Some of them seem to be :

1. Widening gap between the demand and supply of fuelwood, which leads to the search for alternatives.

2. Restrictions in the collection and supply of fuelwood from the natural forests.

3. Due to deforestation the collection time and the distance to the forests have increased considerably.

4. Increased use of agricultural residue to fulfill the gap between supply and demand.

5. Introduction of various alternative energy technologies and partial substitution of energy through alternative fuels such as biogas, coal, kerosene, LPG, briquettes, etc.

Nevertheless, the prime reason seems to be the unavailability of fuelwood which compels resorting to other fuels substitutes, which too are not reliable for stable and constant supply. Coal and petroleum products are imported and any political (bad neighbourly relations, artificial (shortage of stocks, administrative and management problems, price fluctuations, etc.) or natural (floods, landslides, and road blocks, etc.) reasons lead to the disrupt in their supply. Similarly, electricity, although it is produced indigenously, also faces problems in its supply due to frequent loadshedding and repair and maintenance works.

1.7. Demand projection of fuelwood and other energy resources

The total energy demand of the country in the year 2000/01 will be in the tune of 324.9 million GJ on the basis of the demand projection. The breakdown of the shares and quantities of the different type of fuels required are given in Table No.5 and the sector wise demand is given in Table No. 6.

Table No 5. Total energy demand projection in 10^-6 GJ

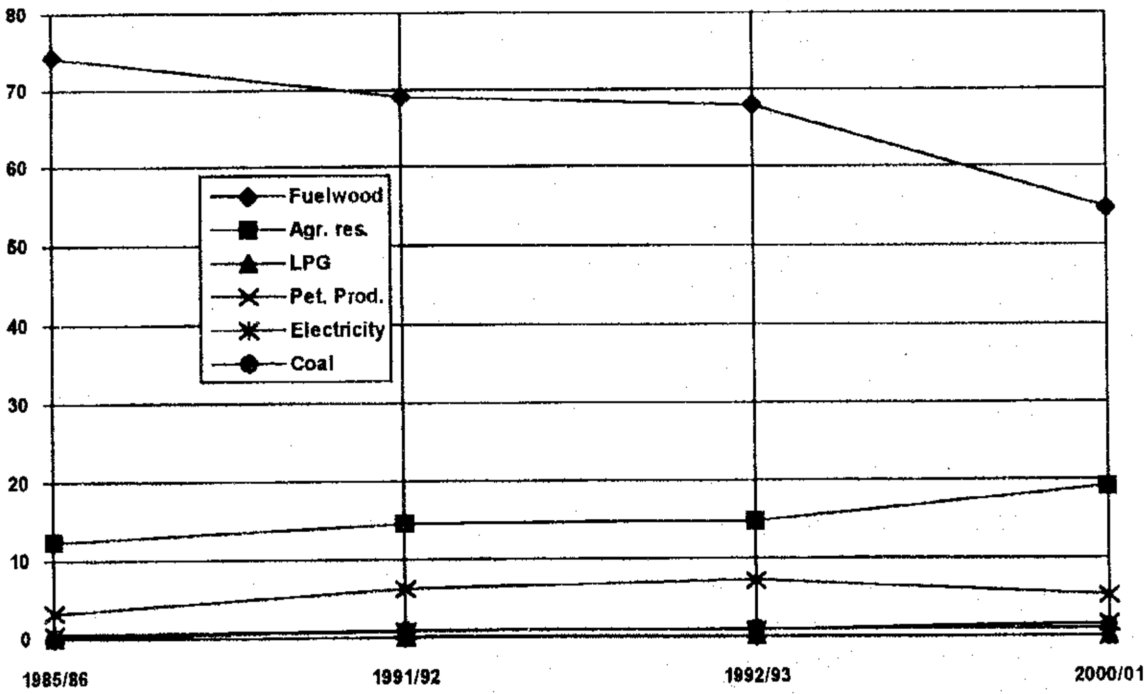
No	Fuel type	1985/85	%	1992/93	%	2000/01	%	Av. growth
1.	Fuelwood	162.0	74.4	184.0	67.9	177.8	54.7	- 0.25
2.	Animal dung	20.5	9.39	22.0	8.1	57.3	17.6	5.17
3.	Agricultural residue	26.8	12.3	40.3	14.9	62.3	19.2	7.61
4.	LPG	0.05	0.02	0.38	0.14	0.2	0.1	4.03
5.	Petroleum products	7.0	3.2	19.5	7.2	17.3	5.3	4.75
6.	Electricity	1.15	0.53	2.43	0.9	5.2	1.6	7.74
7.	Coal	0.42	0.2	2.71	1.0	3.5	1.1	7.98
8.	Others					1.1	0.3	3.31
9.	Total	217.8	100	271	100	324.9	100	1.91

The trend in the energy consumption along with the demand projection can be seen from Figure No 12., whereas the trend in the sector wise consumption can be seen in Figure No. 13.

Table No 6. Sectoral energy demand projection, 10^-6 GJ

No.	Sector	1985/86	%	1992/93	%	2000/01	%	Av. growth
1.	Domestic	208.2	95.5	247.3	91.3	296	91.1	1.7
2.	Industrial	4.7	2.2	9.23	3.4	12.3	3.8	5.1
3.	Agriculture	0.5	0.23	1.80	0.7	5.0	1.5	4.5
4.	Commercial	1.3	0.6	3.84	1.4	1.1 ?	0.3	8.5
5.	Transportation	3.0	1.4	8.67	3.2	10.5	3.2	5.2
6.	Total	27.8	100	271.0	100	324.9	100	1.95

Figure No 12. Energy Consumption and demand projection in %



Although there is a decreasing trend in the fuelwood from 75.5% in 1985/86 to 54.7% in the year 2000/01, the decrease in terms of quantity is not much = 6.7 million GJ or about 382089 tons of fuelwood. In the domestic sector the energy demand will increase to 296 million GJ from 208.2 million GJ in 1985/86 and 247.3 million GJ in 1992/93.

The demand projection of fuelwood and the population projection (medium variant) is shown in Table No 7 and graphically this is represented in Figure No 14. There seems to be a direct linear correlation between the increase of population and fuelwood consumption and this relation seems to be in direct proportions.

Table No 7. Demand projection of fuelwood and population projection

No	Subject	1985/86	1990/91	1995/96	2000/01	2005/06	2010/11
1.	Population ('000)	16909	19108	21285	23386	25302	26951
2.	Household Fuelwood consumption('000 tons)	11170	12256	13904	15172	16290	17199
3.	Industrial fuelwood consumption ('000 tons)	160	189	228	262	248	236

Figure No 13. Energy consumption and demand projection (%) in different sectors

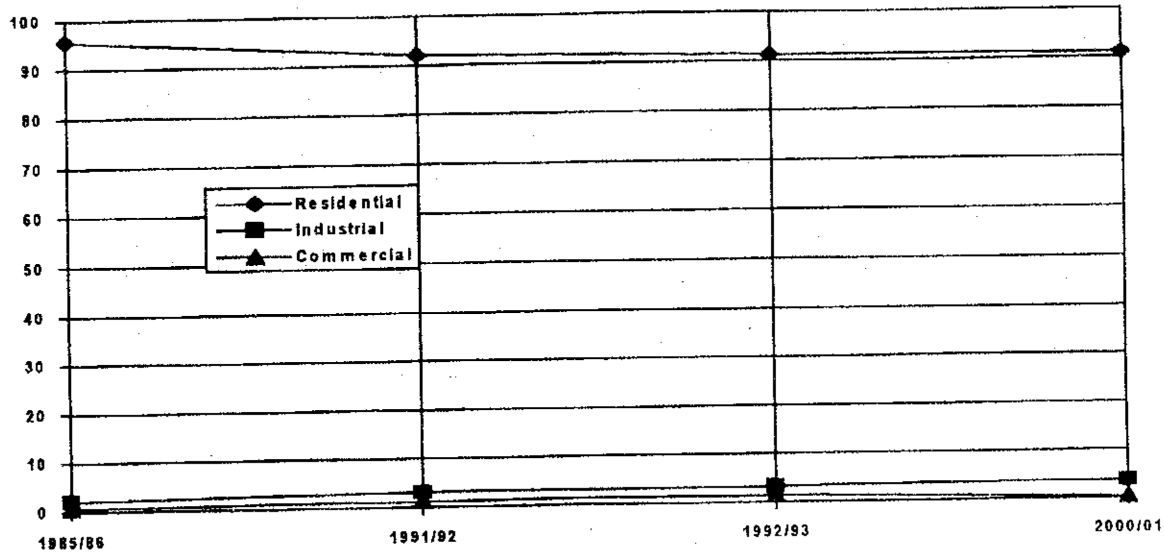
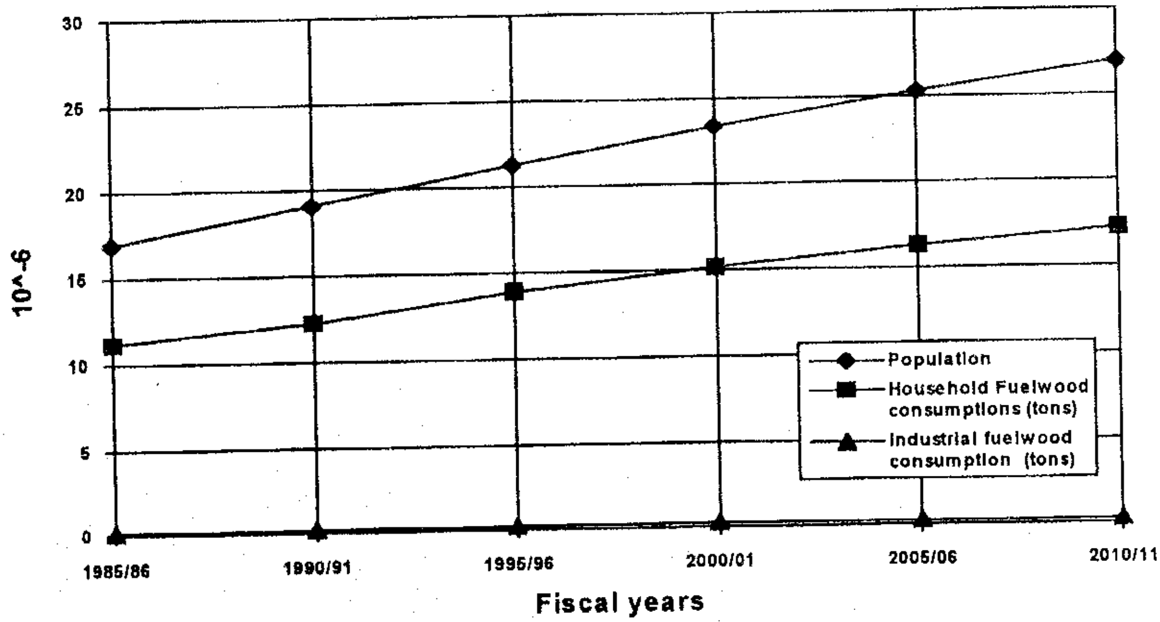


Figure No 14. Demand projection of fuelwood and population projection



Summary and Conclusions

1. The energy situation in Nepal is characterised by a very low per capita energy consumption (14.06 GJ) and there is still a heavy dependence for energy on the traditional sectors (over 90 %) such as fuelwood, agricultural residue, animal dung.

2. The gaps in the fuelwood supply and demand is more often met by the mining of forest resources, which has been wide scale deforestation. For the fiscal year 1992/93 the sustainable supply was 7.5 million tons and the demand was 10.9 million tons.

3. So far forest residue/litter has not been considered as a resource and no estimates of their existence is available. But their problem, especially of Banmara in forestry expansion and propagation has been felt in many areas of Nepal.

4. All of the economic sectors - industrial, commercial, residential- depend heavily on fuelwood and imported fuels-coal and petroleum products. The residential sector alone which consumes 91.3 % of the total energy requires 10.7 million tons of fuelwood.

5. A general decreasing trend in the use of fuelwood is observed while on the other hand, the increase in the use of agricultural residue and other on traditional fuels - coal, petroleum products is observed. The decrease in the use of fuelwood is more due to reasons of its unavailability and inaccessibility rather than due to policy and other measures of the government.

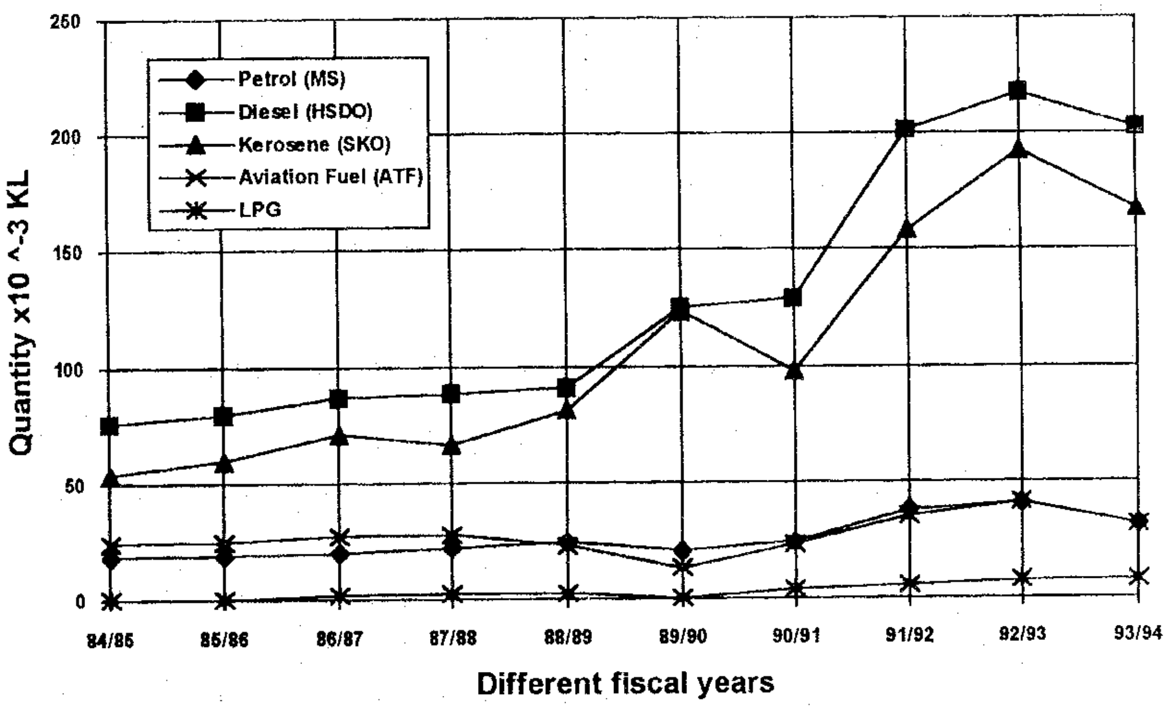
6. Possibilities of increasing use of electricity instead of fuelwood in the next decade is still unrealistic. The demand projections of fuelwood shows a requirement of 17.2 million tons of fuelwood. Condidering sustainable yeild as 4-5 tons/ha then it will require 4.3 million ha of sustainable forest area to meet the growing requirement of the population in the year 2000 A.D.

2. Fossil fuel consumption

2. 1. Petroleum products consumption

Nepal imports petroleum products and coal to meet almost all of its demand. The Nepal Oil Corporation (NOC) is solely responsible for import and distribution of all the petroleum products. It purchases the petroleum products from the international markets and is transported and exchanged with India. The quantity of oil imported under the Open General License (OGL) system is not known. The import of petroleum products for the past 10 years is given in Figure No.15, whereas the consumption is shown in Figure No 16. The expenses for the import of the petroleum products in relation to the export earnings is shown in Figure No 17.

Figure No 15. Import of petroleum products in different fiscal years



A closer observation of the data between import and consumption (sales) show some lagged correlation, which most probably is met from its previous storage. The storage is roughly for 45 days but in reality the reserves are maintained for only about 17 days.

Nepal spent about 32 % of its merchandise export in 1991/92 for the import of petroleum products and this figure came down to 22.6 % in 1992/93. Sometimes the expenditures go up to 53 % (1982/83), 39.9 (1989/90) and 41 % (1990/91), which is a heavy burden on the country's economy. The substitution of fuelwood by petroleum products specially kerosene is limited mostly to urban areas and its peripheries only. Such substitution in the rural hill and mountain areas is difficult because of the lack of transport facilities. Even if there is a possibility despite the transportation difficulty, the prices go up and the cost may be beyond the capacity of the rural population to afford.

Figure No 16. Consumption of petroleum products

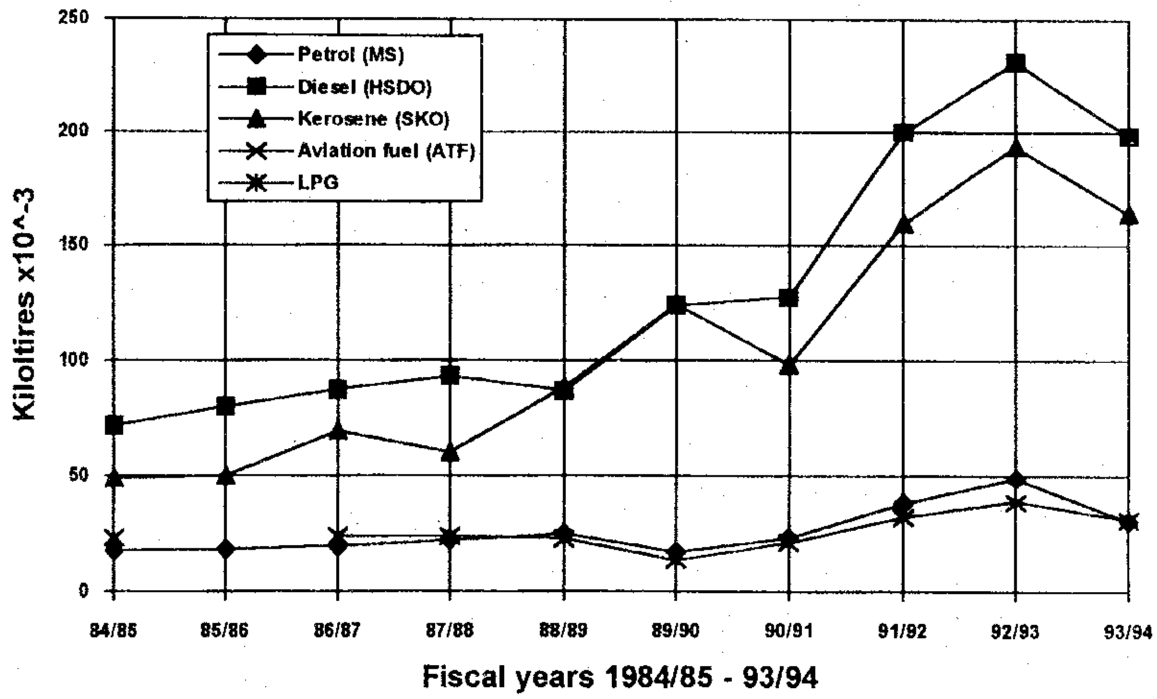
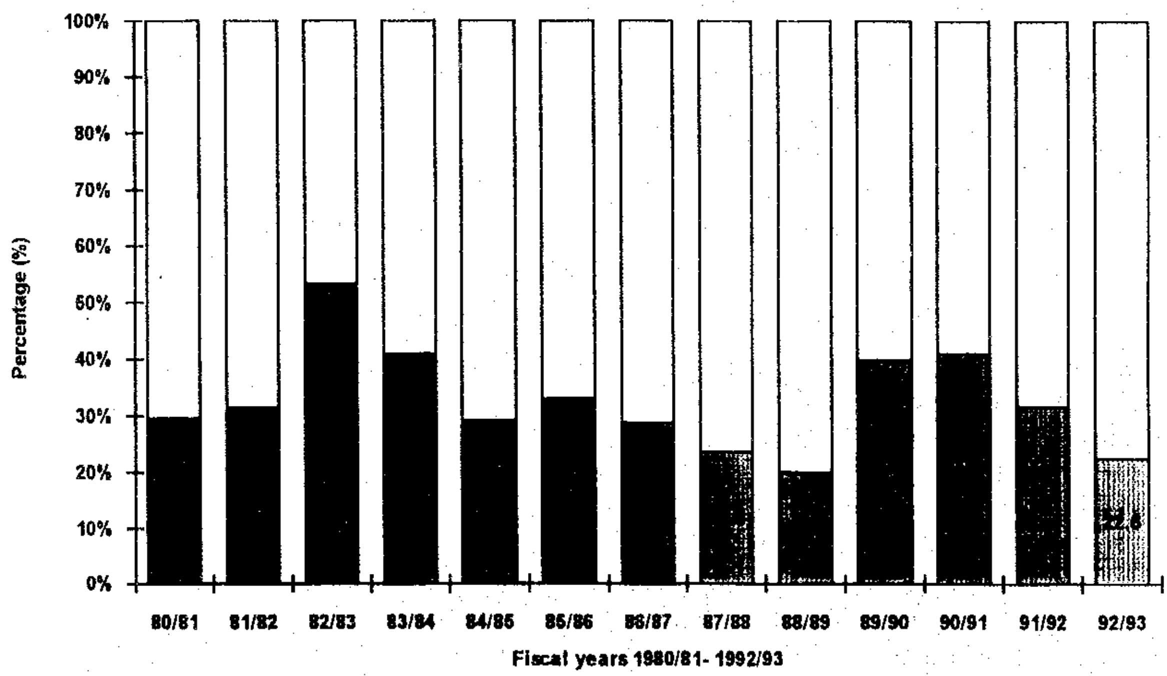


Figure No 17. Percentage of export earnings spent on import of petroleum products



Nepals total petroleum product sale during the fiscal year 1993/94 was about 450,699 Kl. Out of this diesel (HSDO) comprised 44.1 %, Kerosene (SKO) 36.4 %, petrol or motor spirit (MS), 6.7 %, Aviation fuel (ATF) - 6.83 %, Furnace oil (FO) - 5.9 %. Liquefied petroleum gas sales was in the tune of 7700 (1992/93) MT. The cost breakdown and the different prices of the petroleum products are given in Table No 8.

Table No 8. Cost break down of major petroleum fuels
(as of October 1993 for Amlekhgunj depot and Kathmandu)

No	Cost item	Petrol (MS)	Diesel (HSD)	Kerosene (SKO)	LDO	Furnace oil (FO)	Aviation fuel ATF	Remarks
1.	Ex-depot price (IRs/KL),Raxaul)[1]	4808.50	5537.36	4905.50	5563.11	3757.96	5485.31	
2.	Ex-depot price (NRs/KL)	7700.81	8868.08	7856.16	8909.32	6018.37	8784.72	
3.	Custom duty	5880.00	1155.00	300.00	24.00	160.00	955.00	High for MS & low for SKO
4.	Sales tax	1396.59	523.33	0.00	959.48	647.93	1017.90	0 for SKO
5.	Transportation (Raxaul-Amlekhgunj)	151.92	151.92	151.92	169.11	949.90	657.38	
6.	Adm. expenses	200.00	200.00	200.00	200.00	200.00	200.00	
7.	Sub total	15329.32	10898.33	8508.08	10477.91	7976.20	11615.00	
8.	Stock loss 1% of [1] above	77.01	88.68	78.56	89.09	60.18	87.85	
9.	Interest on inventory	150.00	150.00	150.00	150.00	150.00	150.00	
10.	Demurrage 3 % of [1] above	231.02	266.04	235.68	267.28	180.55	263.54	
11.	Ocean loss 0.5 % of [1] above	38.50	44.34	39.28	44.55	30.09	43.92	
12.	PEF 2 % of sales	230.00	0.00	0.00	0.00	0.00	230.00	
13.	Sub total	16055.86	11447.39	9011.61	11028.83	8397.03	12390.31	
14.	Recovery (+)/Loss (-)	11108.30	-996.79	-288.92	266.46	192.80	2954.21	
15.	Price ex-depot distribution	27164.15	10450.61	8722.68	11295.29	8589.83	15344.52	
16.	Municipality tax	271.09	145.58	86.96	167.11	68.26	107.58	
17.	Transportation (Amlekhgunj-Kathmandu)	524.38	524.38	524.38	567.82	567.82	653.38	
18.	Sub total	27959.62	1120.57	9334.02	12039.22	9234.91	16105.48	
19.	Shrinkage (0.7 %-0.4 %)	195.72	44.48	37.34	48.16	36.94	64.42	
20.	Drum depreciation (%)	0.00	0.00	94.66	0.00	0.00	0.00	
21.	Sub total	28155.34	11165.05	9466.02	12087.38	9271.84	16169.90	
22.	Dealers commission (3%)	844.66	334.95	283.98	362.62	278.16	485.10	
23.	Selling price Rs/KL	29000.00	11500.00	9750.00	12450.00	9550.00	16655.00	Selling price of SKO is Rs 8.75

The basis of petroleum product pricing is cost plus. The other costs in addition to border costs are taxes and NOC cost recovery components such as administrative expenses, transport costs, dealers commissions and stock losses. The prices of the three main products - MS, HSD and SKO are fixed by HMG. The NOC can fix the prices of the other unregulated products.

The Historical prices of selected petroleum fuels such as Kerosene (SKO), Diesel oil (HSDO) and Petrol (MS) for different years starting from 1983 to 1991 are given in Table No 9.

Table No 9. Historical prices of petroleum fuels

Year	CPI*	Kerosene (SKO)			Diesel (HSDO)			Petrol (MS)		
		Retail Price	Constant '83 price	CPI adj. price	Retail price	Constant '83 price	CPI adj price	Retail price	Constant '83 Price	CPI adj price
1983	100	5.9	5.9	5.9	7.5	7.5	7.5	10.9	10.9	10.9
1984	116.5	5.9	5.1	6.9	8	6.9	8.7	10.9	9.4	12.7
1985	126.5	7.5	5.9	7.5	8	6.3	9.5	10.9	8.6	13.8
1986	130.8	7.5	5.7	7.7	10	7.6	9.8	12.9	9.9	14.3
1987	143.1	7.5	5.2	8.4	10	7	10.7	12.9	9	15.6
1988	173.1	7.5	4.3	10.2	10	5.8	13	20	11.6	18.9
1989	200.3	8.5	4.2	11.8	10	5	15	20	10	21.8
1990	229.1	8	3.5	13.5	10	4.4	17.2	20	8.7	25
1991	245.1	8	3.3	14.5	10	4.1	18.4	25	10.2	26.7

N.B. * Fuel, light and water component of urban Consumer's Price Index (CPI)
Source - The equitable and efficient energy pricing study

From the table it is clearly seen that the Urban Consumer's Price Index (CPI), which is related to fuel, light and water component, has more than doubled 245.1 since 1983, whereas the prices of kerosene and diesel have increased by only 36 (from Rs 5.9 to Rs 8) and 33 (from Rs 7.5 to Rs10) percents respectively over the same period. The price of petrol or motor spirit, however seems in the tune with the CPI (Rs 25 and Rs 26.7). The price of kerosene in 1983 was Rs 5.90 per litre and in 1991 in terms of 1983 price is only Rs 3.3 . The price of kerosene if it were to be comparable with CPI, calculates at about Rs 14.5 per litre, disregarding the real price increase in kerosene. The actual retail selling prices of petrol, diesel and kerosene are given in Table No 10.

Table No 10. Retail selling prices of some selected petroleum products.

Year	Petrol (MS)	Diesel (HSDO)	Kerosene (SKO)
1989/90 (2045/46)	12.90	7.50	5.75
1990/91 (2046/47)	19.00	9.10	6.90
1991/92 (2047/48)	20.00	10.00	8.00
1992/93 (2048/49)	25.00	10.00	8.00
1993/94 (2049/50)	29.00	11.50	9.75
1994/95 (2050/51)	29.00	12.00	8.50
Av annual increase	10.47 %	4.81 %	4.31 %

Source - NOC

From these tables it is clearly seen that the prices of diesel and kerosene are indirectly subsidized and is compensated by the price of petrol.

The sales projection of the major petroleum products are given in Table No 11. It is estimated that by the year 2000 the sales of kerosene alone will be in the tune of 418,212 KL. If we assume the price of kerosene to be constant and the difference between CPI adjustment price and the selling price as the subsidy then for the year 2000 A.D. based on this assumption and 1990 prices (Table No 9), the subsidy willbe in the tune of 2.3 billion Rs. In reality the total subsidy on petroleum products will be even higher.

Table No. 11 Sales projection of major petroleum products (KL)

Year	MS	HSDO	SKO	ATF	FO	Total
1995	35,110	250,250	217,206	39,150	31,815	541,716
1996	37,567	280,280	247,614	41,890	33,406	607,353
1997	40,197	313,914	282,281	44,824	35,076	681,215
1998	43,011	351,583	321,801	47,960	36,830	764,355
1999	46,022	393,773	366,853	51,318	38,671	857,965
2000	49,243	441,026	418,212	54,910	40,605	963,391

Kerosene is a product which is used as a daily commodity by the urban population and its peripheries alone. The huge amount of subsidy is defintely a burden to the country's economy and it is enjoyed by less than 10 % of the country's population.

Table No 12. Kerosene subsidy

Requirement for 2000 A.D.	Selling price Rs/litre (1990)	CPI adj. price Rs/litre	Price diff. (subsidy)	Total subsidy
418212 KL	8.00	13.5	Rs 5.5/litre	Rs 2.3 billion

N.B. These calculations are just to get some idea of the magnitude of the subsidy and not for any other purposes.

2.2 Coal consumption

Coal is mainly used by the industrial sector in Nepal and most of it, with the exception of the locally supplied lignite and coal, is imported. The major coal consuming industries of the country as shown in Table No.3 are textiles, paper products, wood products, cement, brick manufacturing.

Until lately Nepal Coal Limited was the sole authority to import coal. The amount and type of coal imported by the NCL for the last few years are given in Table No.13. High grade coal - coke is mainly used by the cement industries whereas other types of coal are used by other industries.

Table No.13 Amount (ton) and types of coal imported by NCL

No.	Coal/coke	1990/91	1991/92	1992/93	Remarks
1.	Steam coal	24682	31131	18374	
2.	Slack coal	20164	23338	27030	
3.	Assam coal	13814	19340	4230	
4.	ROM coal				
5.	Indonesian coal	2262			Cement industry
6.	B. Hard coke				"
7.	BP Hard coke	33		70	"
8.	Soft coke	9			"
9.	Breeze coke	6364	4687	6323	"
10.	Coal Briquette	55			
11.	S.L.V. coal	38			
12.	Steam coal Gr4		2276		
13.	Total	67420	80771	56027	

Except for the high grade coal, most of the Indian coal have high sulphur and high volatile matter content which have harmful impact in the degradation of the environment.

Besides the import of coal, the local coal and lignite mines are also active in the supplementing the coal demand of the country. Lignite come mainly from the mines of Kathmandu, whereas, coal come from several mines from Dang, Barachettra and Chitwan. So far the lignite deposits of Kathmandu and coal deposits of Dang area are believed to be of economic importance according to the Department of Mines and Geology. The tentative estimated amounts of coal and lignite are shown in Table No.14.

Table No.14 Coal/Lignite deposits of Nepal

No	Type of Coal	Estimated deposit (tons)	Exploitation rate per annum	Price NRs per ton	Remarks
1.	Lignite of Kathmandu Valley	0.3 million	8,500 - 12,700 tons (~when 29 mines were operating)	375 - 1,600/-	Recently cannot compete with Indian coal and production is 2000-3000 ton/yr
2.	Coal of Dang area	2.8 million	2000 tons/year	Rs. 2,500/- Rs. 8000/- (Ktm)	Nos of mines increased. Prod 8000 ton/year (1995)

2.3. Impacts of coal combustion on the environment

Combustion of coal produces, mainly CO_2 a major greenhouse gas , high concentrations of which cause global warming. But if coal is used instead of fuelwood to save forest, then the trees can absorb CO_2 from the atmosphere for photosynthesis and the position may not be as bad as it is than in using fuelwood alone. And it is the question of using clean coal technologies to burn coal products, which produce less pollutants that has attracted many African (Zimbawe, Botswana, Rwanda) and Asian (China, Indonesia) countries to substitute fuelwood by coal products.

Summary and Conclusions

1. All the fossil fuel requirement of the country (coal and petroleum products) is met through import with only small amounts of coal and lignite met through domestic resources, which are scattered along the country and their exact amounts have yet to be detrmined. Except for the coke, the coal imported from India has high sulphur content.

2. The country has to spend even up to over 50 % of its export earnings on the importation of pertorleum products and this is a heavy burden to the economy of the country.

3. The price structures and analysis of the prices of different petroleum products show that there is a subsidy in the prices of kerosene and diesel, which is probably met or adjusted from the earnings on petrol.

4. The industrial and the commercial sectors oif the country depends heavily on coal and petroleum products in the absence of which fuelwood demand increases and consequently this leads to increase in deforestation.

5. Although the subsidy on some petroleum products seems to be indirect (namely for kerosene), the magnitude of the subsidy in reality must be very high. This subsidy on a daily commodity is a burden to the country's economy which is enjopyed by urban population and its peripheries.

3. Deforestation and consequences

The heavy reliance on fuelwood has caused not only grave and irreversible consequences to the country, but also has increased the social burden in the 78 % of the rural women and a large number of children, who have to allot 20 % of their work for fuel collection only (Joshi 1991). The insufficient supplies of fuelwood have also forced the people to burn increasing quantities of animal dung and agricultural wastes, thereby depriving the soil of valuable nutrients and organic conditioning materials resulting in the declining of the fertility of land and decrease in agricultural production.

Nepal has 5.5 million ha of natural forest, which is 37 % of its total land area (14.7 million ha). The natural forest area was reduced by about 570,000 ha in the period between 1964 and 1985. Reforestation has taken place on a relatively small scale; during the same period there were only 47,300 ha of new government plantations and 21,900 ha of community plantation.

Over exploitation of the accessible forest has resulted in loss of about 382 thousand hectares of forest land between 1964/65 and 1978/79, a rate of 2.1% per annum which is equivalent to 27,000 hectares of forest land per annum. (Table No.15)

Table No 15 Changes in area of forested lands shrublands

No.	Area/Place	WECS 1964/65 ('000 hectares)	LRMP 1978/79 ('000 hectares)	Difference ('000 hectares)
1.	Siwaliks	1739	1476	-263
2.	Terai	784	593	-191
3.	Nepal	6689	6307	-382

The depletion rate in the Terai appears to have decreased from 3.1 percent per year during the period 1964/65-78/79 to 1.3 percent per year during 1978/79-1990/91. The reduced population growth rate during 80s, people's awareness, substitution of fuelwood by other traditional and commercial energy, reduced accessibility to forests, and increase effectiveness of forestry programs could be the possible reasons for the decrease in the forest depletion rate. In 1992/93 estimates of on-farm fuelwood supply accounted for about 2.09 million tons. This is based upon the assumption that on-farm fuelwood supply has remained unchanged since 1978/79 due to lack of updated data.

Although the fuelwood supply significantly contributes to the deforestation, but it is not the only cause. Rehabilitation programs, extension of farm lands, cutting trees for timber and other industrial uses have also contributed significantly to the deforestation and environmental degradation process.

As mentioned earlier about 70% of the energy consumed is still met by fuelwood which is met from the natural forests. The fuelwood demand is 11 million tons, whereas the sustainable supply is 7.5 million tons. This leaves a shortfall of 4 million tons which leads to excessive and illegal exploitation of the existing forests. The MPFS 1988 estimates that 1.5 million ha of forest area will be degraded to meet the deficit of fuelwood, timber and fodder demand by the year 2011.

Although fuelwood and fodder supply is not the only reason for deforestation, it is now a widely accepted fact that destruction of rain forests leads to irreversible consequences which was once again highlighted and given top priority by the World Summit on Biodiversity and Climate Change organized by the United Nations in Rio De Janeiro Brazil in 1992.

It is relevant to note and highlight here the grave consequences of destruction of natural forests.

i.	Ecological imbalance and loss of valuable flora and fauna.
ii.	Soil erosion and desertication
iii.	Floods and landslides
iv.	Decrease in ground water table.
v.	Global climate change and CO_2 - Greenhouse effect
vi.	Problems of health and sanitation and increase in social burden to collect fuelwood

3.1. Ecological imbalance and loss of biodiversity

Deforestation leads to the change in the fragile ecosystems and consequently to the change and loss of biological diversity of the area. The biodiversity (flora, fauna and genetic species) that was prevalent even centuries back has been significantly altered and reduced due to the activities of man. Particularly in the case of Nepal, which has unique and varied climatic zones, the biodiversity especially of the mountainous area have been affected due to deforestation and energy related project including big hydropower projects.

A typical example will be the case of the Barun Valley. In many parts of the valley, deforestation for agriculture and intensive grazing of animals on pastureland has resulted in increased weed encroachment leading often to permanent replacement of forest cover and grassland by weed biomass such as Banmara (Eupatorium adenophorum). These weed species are both exotic as well as native. Such weed invasions have adversely altered the biodiversity in vast areas of the region.

3.2. Soil erosion and desertification

When livestock members increase rapidly the problems of grazing cause serious damage. By eating and trampling young shoots and saplings, animals also prevent the natural regeneration of forest vegetation. Furthermore, slope exposure can have serious consequences for run-off under torrential monsoon rain, when there is little ground cover after the long dry season and are very prone to soil erosion.

Deforestation coupled with overgrazing grassland and conversion of forest land to agricultural land, particularly in the hill areas cause systematic denudation of soil causing not only erosion of the fertile top soil leading to desertification but also to formation of islands in the Bay of Bengal.

3.3. Floods and landslides

Forested watersheds have the ability to withhold substantial amounts of rainfall precipitation and plays a positive role in the checking of floods and landslides. Hilly slopes with little ground coverage or forest areas do not have the ability to check the run-off from monsoon rain to that extent. Hence hill topography and overgrazing of grassland along with deforestation during monsoon rains cause floods and landslides. The increase in the frequency of landslides and floods, and particularly the recent flood and landslides of 1993, bear testimony of these facts.

3.4. Decrease in the water table and hydrological changes

Similarly, as mentioned above barren land do not have the ability to hold and conserve water to that much extent as forested watersheds, shrublands and grasslands. Fuelwood harvesting, accompanied by burning and grazing followed by conversion of forest area and grassland into barren land have not only erosional effects but also hydrological effects leading to reduced ground water level, drying of rivers and streams in the dry seasons.

3.5. Global climate change and carbon dioxide - Greenhouse effect

The combustion of all fossil fuels and biomass fuels generates carbon dioxide. Carbon dioxide plays a role in maintaining the earth's heat balance by absorbing heat radiation from the earth's surface, the past trapping it, and preventing it from dissipating into space (greenhouse effect). Over the past century, CO_2 atmospheric concentrations have increased about 15 % mostly as a result of burning fossil fuels and deforestation. Depending on the growth rated in the burning of fossil fuels and deforestation processes, global atmospheric CO_2 concentrations could double around the middle or latter part of the next century. Such a doubling of CO_2 according to estimates could increase the average annual global surface temperatures by 3^{o} C ± 1.5^{o}C with the greater effect near the poles.

Temperature increases of this magnitude could produce changes in rainfall patterns; geographical shifts in areas for food production and areas sensitive to desertification; higher sea levels due to melting of polar ice; and changes in fish stocks, forests and water supplies.

Carbon dioxide build-up in the atmosphere is a lesser issue for coal than for petroleum products as the global consumption of hydrocarbon fuels are more dominant.

Photosynthesis is a process that take place in plants, whereby the CO_2 in the atmosphere is consumed by the plant to produce oxygen. On one hand the lesser the plant vegetation the lesser CO_2 is used up. On the other hand the greater the use of fuelwood (from deforestation) and other biomass fuels for energy resources the greater the concentration of CO_2 in the atmosphere and the greater the greenhouse effect leading to increased global warming.

3.5.1 Carbon dioxide emissions from fuelwood combustion

A rough estimate by ESCAP put Nepal's yearly emission of carbon at 200,000 tons for the year 1986. By the year 2000, the carbon emission would be doubled to 400,000 tons and by 2010, it will be tripled. However, with an energy efficiency strategy, this could be reduced to 500,000 tons and further, with fuel switching strategies this could be brought down to 400,000 tons ,which would be constant with that of the 2000. These figures represent emissions from fossil fuel utilization alone.

Preliminary attempts were made by ESCAP to calculate CO_2 emissions due to fuelwood combustion in the Asia Pacific regions. Sedjo (1989) gives figure of) 0.26 tons of carbon emissions for 1 cubic meter of wood. The Forestry Sector Master Plan has estimated the annual consumption of fuelwood at approximately 12.5 millions tons, which, converted to cubic meters, turns out to be roughly 19 million cubic meters, Hence, Nepals yearly emission of carbon in the atmosphere could be estimated to be roughly 5 million tons. This shows the extend of fuelwood burning in Nepal and the resulting CO_2 emissions in comparison to 200,000 tons of carbon emitted from fossil fuel consumption. In addition if agricultural residue and animal dung uses are considered, this figure would increase significantly.

3.6. <u>Problems of health/sanitation and increase in social burden</u>

The Mrigendra Medical Trust (1984) had initiated some research studies on the impact of smoke and smoky environment on respiratory diseases in some specific rural areas where traditional cooking methods were practiced. These studies had indicated that acute respiratory diseases were a major health problem and significant reason for infant mortality and there was a significant reduction of these diseases with the introduction of Improved Cooking Stoves (ICS).

Furthermore, Bhadra (1990) had pointed out that chronic bronchitis and obstructive lung diseases such as asthma and emphysema are very common health problems in Nepal.

Substitution of fuelwood by biogas also have shown reduction in eye and lung diseases, more clean and hygienic domestic conditions along with clean kitchen utensils in the rural house holds. There is an increasing awareness in health and sanitation among rural and sub-urban population as 75 % of biogas plants are attached with latrines.

With the deforestation, forest areas are fast receding and with the introduction of strict rule and regulations on fuelwood collection and the amount of time spent on fuelwood collection by the rural population has greatly increased. This has greatly increased the social burden of the rural women and girl children as fuelwood collection is mostly done by the female population.

3.7. Remedies to the problems of deforestation

There are many possible ways to solve these problems to meet the deficit supply of fuelwood. They can be classified as

i. Proper management of forest resources for sustainability or managing existing forest to the required extent
ii. Launching of afforestation programmes or increasing new managed forest
iii. Reduction in the consumption of fuelwood, timber, etc. through alternatives or fuelwood substitution

The first two measures are being implemented by the government, many donor and other agencies. The prime concern and purpose of this study lies in finding through analysis and assessment of alternatives to fuelwood and its substitution in both industrial and domestic sectors.

Summary and Conclusions

1. Deforestation during the past few decades has led to reduction of forest area by about 570,000 ha (between 1964-1985). The average rate of deforestation is about 27,000 has per annum.

2. Deforestation leads to grave irreversible consequences and natural disasters such as floods landslides, environmental and ecological degradation, increase in CO_2 build up, etc., which adversely effect the climate, biodiversity and the ecosystem.

3. Excessive dependence on fuelwood for cooking adversely effect the health of the rural population and contribute heavily to emissions of CO_2 gas which is a major greenhouse gas.

4. Fuelwood substitution.

Since evolution and the initial stages of development, early man used fuelwood as the prime source of energy. As economic development progressed with the development and application of science and technology due to various reasons and factors such as availability of alternative fuels, ecological and environmental conservation, issues of health and sanitation, etc. people gradually resorted to alternative sources of energy with the foresight into the future to avoid irreversible consequences form the heavy dependence on traditional energy resources.

If we take the starting point as fuelwood and the ultimate goal as high quality fuels such as electricity. LPG or Solar energy, each country in its course of development experiences shift from fuelwood, through its substitution by various intermediates, to high quality fuels. The choice of various intermediates depends mostly upon:

1. The available indigenous resources
2. The levels of technological capability and technological development
3. The economic status of the country
4. The policies and strategies of the country relating to energy and indigenous resources

The different routes of shifts from fuelwood to the ultimate goal for some selective countries are given in Chart No 2 and Chart No 3.

Japan

In Japan the shift from fuelwood to Electricity and LPG in the domestic sector took place rapidly after the reconstruction of the economy after World War II, when it emerged as an economic power. The intermediate period used charcoal, coal and coal briquettes mainly because it did have coal deposits. As exports grew enormously, imports became necessary to keep the trade balance in one hand and environment and hygienic conditions received due importance within the country. Hence the shift to electricity and LPG became easily affordable for the country due to trade surplus although huge amounts of petroleum products and coal have to be imported.

Thailand

Similarly, Thailand has quickly shifted to electricity and LPG in the last decade, even at the rural level for domestic use because of the big deposits of natural gas, the establishment of the power distribution network, strong policies and implementation strategies. Before this deforestation was severe and charcoal was a very popular cooking fuel. During these periods the army used mainly Green Fuel, a composite fuel produced, from a mixture of sawdust, water hyacinth and other biomass, by low pressure extrusion method. For industrial purposes agricultural residue, which is available in abundance, is still commonly used with the back up from R&D institutions.

An attempt to introduce Biocoal briquettes in 1986-87 by producing it with a bench scale plant from the available lignite and biomass with the assistance of JICA was made for substitution of charcoal for cooking purposes. This product was not acceptable because, firstly, LPG and electricity became easily available and, secondly, the product itself was not acceptable for domestic cooking purposes as it gave an unpleasant smell (mainly from lignite and combustion gases), required special type of stove and was more difficult to handle than charcoal.

Indonesia

Indonesia poses a different picture. Due to the abundance of coal resources and the increasing deforestation, the government has lately started implementing policies and programmes to use the coal deposits through improved method of coal use - carbonized and uncarbonized coal briquettes, with low pollution emissions of CO, SO_2 and other pollutants. Kerosene, which was widely used instead of fuelwood is exported to earn foreign currency for the country.

Botswana and Zimbawe

In Africa, namely Botswana and Zimbawe, fuelwood was still the major fuel for the domestic sector, Massive deforestation and high cost of fuelwood not only pressurized the government but also the people to use other alternatives. Huge coal deposits and introduction of clean coal technologies has helped the smooth transition from using fuelwood to the use of coal and coal briquettes. Introduction of coal products was simple because *COAL PRODUCTS WERE CHEAPER THAN FUELWOOD AND NO SUBSIDY WAS REQUIRED.*

Nepal

In Nepal the substitution of fuelwood has started in many different routes and alternative resources depending upon the area, place, available resources and many other factors. The main resources of the country is water resources, which has been tapped and used to a very little extent (less than 1 % of the economical potential). Due to the economic status of the country and the people, the exploitation of the water resources through large hydropower projects is still not a reality in the near future (at least a decade). In the rural areas microhydro installations are getting popular, event then the economic status of the rural population does not allow its extensive use, although the government is providing some subsidy.

Kerosene and LPG is increasingly used in the urban areas and its peripheries to substitute fuelwood but the cost the country pays is high because all of the petroleum products and most of the coal is all imported.

Rural population use mainly agricultural residue and animal dung (in the rural Terai area). Biogas has gained popularity and support (substantial subsidy) from the governments as well as donor agencies, but it has its own limitations, which does not permit its use in areas of cold climate.

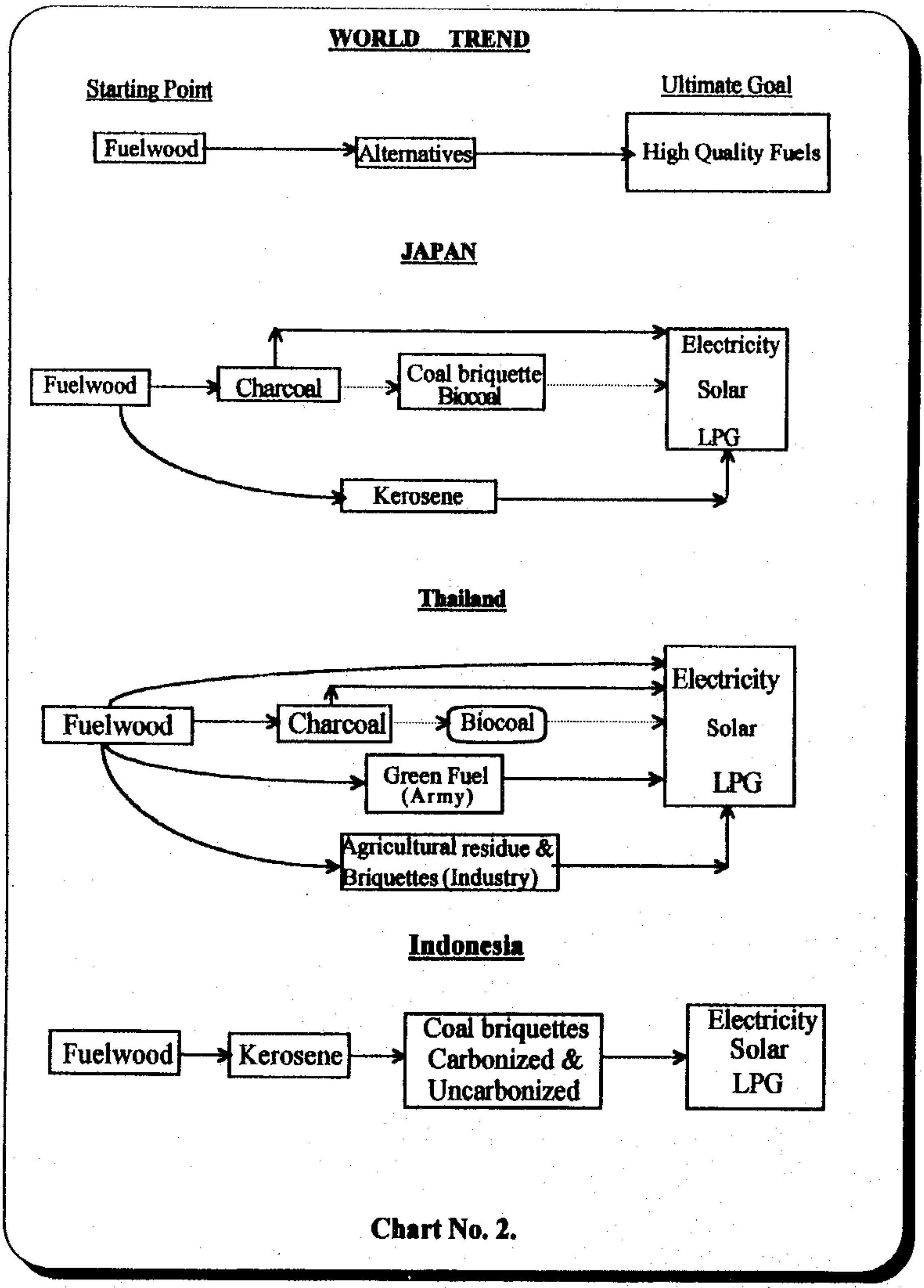

WORLD TREND
Starting Point
Ultimate Goal
Fuelwood
Alternatives
High Quality Fuels
JAPAN
Fuelwood
Charcoal
Coal briquette
Biocoal
Electricity
Solar
LPG
Kerosene
Thailand
Fuelwood
Charcoal
Biocoal
Electricity
Solar
LPG
Green Fuel
(Army)
Agricultural residue &
Briquettes (Industry)
Indonesia
Fuelwood
Kerosene
Coal briquettes
Carbonized &
Uncarbonized
Electricity
Solar
LPG

Chart No. 2.

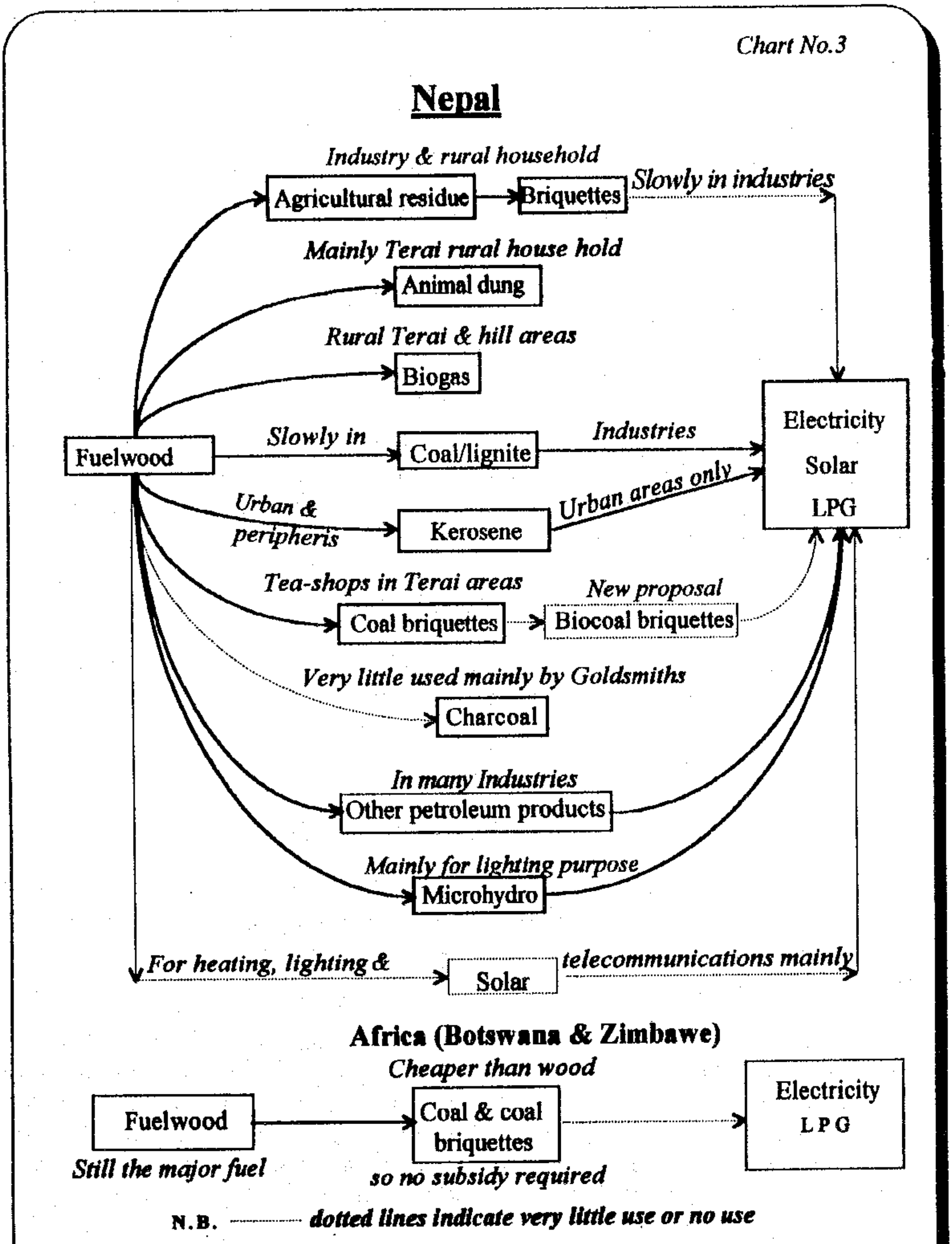


Chart No.3
Nepal
Industry & rural household
Agricultural residue
Briquettes
Slowly in industries
Mainly Terai rural house hold
Animal dung
Rural Terai & hill areas
Biogas
Fuelwood
Slowly in
Coal/lignite
Industries
Electricity
Solar
LPG
Urban & peripheris
Kerosene
Urban areas only
Tea-shops in Terai areas
Coal briquettes
New proposal
Biocoal briquettes
Very little used mainly by Goldsmiths
Charcoal
In many Industries
Other petroleum products
Mainly for lighting purpose
Microhydro
For heating, lighting &
Solar
telecommunications mainly
Africa (Botswana & Zimbawe)
Cheaper than wood
Fuelwood
Coal & coal briquettes
Electricity
LPG
Still the major fuel
so no subsidy required
N.B. ----------- dotted lines indicate very little use or no use

Chart No. 3

So far in terms of quantity and percentage, agricultural residue is the largest substitute for fuelwood and Nepal, being an agricultural country has enormous potentials to use this alternative in a more efficient and extensive manner to substitute fuelwood.(Oosterveen 1989).

4.1. Mathematical evaluation of substitution of fuelwood by coal

Some studies conducted regarding the substitution of fuelwood by coal products have shown some direct simplified relationship between the life span of trees, its annual growth rate and the carbon content in coal.

If Q_W = the heating value of wood, Joules/ kg and
Q_C = the heating value of coal, Joules/kg
C_W = carbon content of wood and
C_C = carbon content of coal, then

to produce 1 Joule of heat, $1/Q_C$ kg of coal has to be burnt and C_C/Q_C kg of carbon will be released in to the atmosphere. But if this coal is used to replace wood, $1/Q_W$ kg of wood can be saved. Suppose the remaining life of the wood is **n** years and its annual growth is **r**, in the coming **n** years this wood will increase its weight to:

$$(1+r)^n / Q_W \text{ kg}$$

The carbon sequestered is the difference between the carbon contained in the wood at the beginning and at the end of this time period. The substitute of wood by coal is desirable if this amount of carbon is greater than the carbon released into the atmosphere by coal combustion or

$$[(1+r)^n - 1] C_W/Q_W > C_C/Q_C.$$

If we expand this expression $(1+r)^n$ into Taylor series, ignoring the high order of small number **r**, and assume that the ratio carbon content to heating value for wood equals that of coal (or that the ratio of carbon to hydrogen, the major elements proving heat, for these fuels are equal), or $C_W/Q_W = C_C/Q_C$, we have the simplified condition $rn > 1$.

The greater the remaining life of a tree and its growth, the better or more preferable it is to substitute this wood by coal. Thus the effect to switching fuels form wood to coal is very obvious. Chinese experience showed that barren hills turned green within two years after coal briquettes were brought to substitute wood. At the same time, the yield of farm products per hectare gradually grew because their residues remained in the field instead of being burnt, thus increasing the organic material and fertility of soil.

The above formula express the obvious fact of fuelwood substitution by coal in mathematical way in the simplest form. In addition, besides the comparison of heat content and other factors involved in the substitution the positive aspect of aborption of CO2 in photosysnthesis that takes place in plants and trees, thereby diminishing the CO2 content in the atmosphere, is hard to quantify.

Summary and Conclusions

1. In all the countries of the world fuelwood was the starting point and the initial source of energy for human beings.

2. The general trend of switching from fuelwood to cleaner forms of energy depends on many factors such as availability of energy resources, levels of technology and economic status of the country. Some can afford to switch by importing almost all the forms of energy (Japan), others (African countries and Indonesia) can switch to coal use with application of improved coal technologies and indigenous coal resources.

3. Nepal's situation is different. With the under exploitation of hydropower resources and the over exploitation of forest resources, it has to fill the energy gaps by adapting and promoting various AETs such as biogas, microhydro, ICS and biomass briquettes.

5. Alternate Energy Situation

Alternative Energy Technologies (AETs) is another name for new, renewable and non-conventional forms of energy, i.e., the technologies which use local energy resources other than commercial fuels (petroleum products, gas, coal, etc.) and biomass fuels (fuelwood, agricultural residues, animal wastes) in traditional forms. The use of AETS has been gradually increasing for the last two decades all over the world. The main sources of these alternatives are sun, air, water, and biomass energy.

Some by-products and solids wastes with technical interventions, e.g., agricultural residues and animal wastes, are also included as alternative resources. When exploited on an appropriate scale, these can provide cleaner energy and are comparatively benign as regards their effects on the environment. Moreover, Nepal's rural economy does not provide enough basis for large-scale investment for the exploitation of vast hydro-potentials. In this context, alternate energy can play the role of a catalyst in rural development by providing a modern form of energy (WECS,1993).

It can effectively

a) Help in reducing the drudgery of the rural population by cutting down the time required to collect and use traditional forms of energy such as fuelwood, animal dung

b) Provide a cleaner cooking environment to rural women;

c) Combat the environmental effects of CO_2 emission, forest depletion, etc., by reducing and replacing the use of the traditional as well as commercial forms of energy;

d) Save convertible currency resources by substituting imported fuels;

e) Be exploited at different scales and sizes to suit locals needs, which is not necessarily possible in the case of existing energy systems. It can also provide modern forms of energy like electricity even in remote location; and

f) Has the potential to create rural employment and increase productivity

The most important AETs in the context of Nepal are related to micro-hydropower, biomass energy (biogas, briquettes, improved cook stoves), solar energy (solar water-heaters, dryers, cookers, generators and pumps), wind energy (wind turbines, wind mills), etc.

Since Nepal has a vast potential for alternative energy resources development , and the infrastructure needed to exploit them already exists to some extent, it can be reasonably expected that they will contribute towards the sustainable economic development of the country.

There has been a series of efforts going on in the development of AETs, particularly from the private sector. A number of donor agencies have been supporting various AET projects. Also, a sizable infrastructure for R&D, fabrication, promotion and dissemination has been developed. The agencies involved with alternate energy are given in Annex I. and the situation along with the alternate energy technologies prevalent in Nepal are discussed below. Some line agencies which are responsible for energy development and promotion are given in Annex II.

HMG/N policy regarding the development of these technologies in the past has been very widely criticized for its inconsistent and irregular nature. Only lately, has the importance of alternate energy has been strongly felt at the policy and decision-making level, and this is reflected in the Eighth Five Year Plan document. It envisages the government effort in developing alternative and decentralized energy resources and has provided detailed policy and programmes including provision for an institutional set-up for the development of alternate energy in Nepal. *The objectives is to gradually replace imported fuels by indigenous energy sources that can be locally-exploited.*

5.1. Micro-hydro electric power plants

Micro-hydro power plants (< 100 kW) or often simply referred as micro-hydro has a great potential for fulfilling the energy requirements of rural Nepal to a great extent because of the country's topography and high hills along with its enormous streams, rivers and rivulets. The total number of micro-hydropower turbines manufactured and installed in Nepal stands at 924 units (ITECO, 1994). The total installed capacity for electricity generation so far is about 2,651 KW, which corresponds to 1.14 % of the total hydroelectric power output in the country. Micro-hydropower has been seen as an important potential contributor towards a reduction in the demand for traditional fuels.

The installation of micro-hydropower units for generating electricity began with small add-on plants dominated by 1 KW plants. The popularity of these plant is primarily due to the ease of raising the capital and the possibility of quick commissioning. The use of this category of plant is limited primarily to lighting purposes.

Micro-hydropower projects usually cause very little change in the landscape, environment and ecology and has a potential for substituting traditional fuels by electricity in areas where such fuels are no longer available and where commercial activities are prevalent and activities related to tourism development has good scope to generate financial return capabilities.

5.2. Biogas

One of the alternative sources of energy for cooking and lighting in the rural areas is biogas. Application of the biogas technology in Nepal was initiated in the mid 50's with the development of micro model digester. However, genuine interest in biogas development came only after the energy crisis in the mid 70's. Between 1973 and 1978, a total of 708 "Drum type" biogas plants were established in different parts of the country.

Due to the successful implementation of biogas development programmes, availability of government subsidy, interest of INGOs and donor agencies as well as the government's privatisation policy, many private biogas companies started mushrooming after 1990. At present there about 15 such companies.

About 20,000 biogas plants of different sizes have already been constructed. The potential number of biogas plants in Nepal has been estimated at about 1.3 million. Total dry dung produces in Nepal is about 11 million tons and if the total available dung is used in biogas production, the amount of gas will be around 1200 million cubic meters per year. This is equivalent to 29 million GJ or about 10 % of the present energy consumption, without affecting the agricultural productivity. Due to favorable climatic conditions biogas is popular in the Terai region followed by the hills. The cold climate of the mountain region does permit biogas production.

5.3. Solar energy

The uses of solar energy is still at an early stage of development. Attempt has been made to develop solar cookers and some NGOs, private organizations and research institutions are currently engaged in R&D design, construction and promotion of solar cookers. Though photovoltaic technology is still at a research and demonstration stage in Nepal, its use was introduced as early as 1962 when the first PV system was set up in Bhadrapur. Solar PV system has been extensively used in telecommunications. Few projects for water pumping too have been installed within the country.

300 sunny days and global radiation is favourable in many location for the exploration of this energy. The total solar radiation in Nepal is estimated to be equivalent to 260000000 MW. Solar water heater is one technology which has been successfully adapted and popularised by the private sector. Popularity gained by this technology can be observed through the increasing numbers of locally manufactured flat plate solar collectors in the roof tops of the houses, hotels, etc. But exact data is not available regarding the number of solar water heaters installed by the individuals. In recent years, Nepal Electricity Authority has installed PV stations of 30-50 KW capacity in some remote parts of the country. However, their performance has not been very satisfactory mainly because of their overly elaborate and expensive centralized design and lack of proper maintenance support.

5.4. Wind Power

Wind power development in Nepal is in experimental stage and so far no contribution has been made by wind energy in meeting the energy needs of the country. A 30 MW wind power plant was installed by Nepal Electricity Authority in Kagbeni, Mustang. But it was damaged by high wind after only a few months of installation. At present, a wind power project is being implemented by NEA and some private workshops fabricating wind mills for pump irrigation purposes. The main difficulty in harnessing and utilizing wind energy in Nepal is the absence of reliable wind data for proper assessment of wind energy.

5.5. Improved Cooking Stove (ICS)

This technology does not provide or utilize new form of energy but it has potential to save fuelwood used for household cooking in Nepal. Annually, about 11 million tons of fuelwood is burnt in cooking alone. Theoretically it is possible to reduce the fuelwood consumption for cooking by 50%. It is estimated that about 65% of the total number of 88,000 ICS distributed so far are still in operation while the rest are either dismantled permanently or abandoned.

5.6. **Biomass briquetting**

One of the basic strategies of the 8th five year plan is to gradually replace imported fuels and fuelwood with the utilization of indigenous resources through development and utilization of AETS. Most of the AETS have been highlighted above. For the purpose of this study it is relevant to review the status of the biomass briquetting technology within the country.

Briquette is the product of densification of suitable raw materials into a more compact form for easier handling and end use. And densification is the general process of compressing the raw materials to a certain shape using some mould and pressure with or without the use of a binder.

So far two types of briquetting techniques have been commonly used.

i. Pyrolyzing technology to produced charred products.

ii. Non-pyrolyzing technology to produce non charred products.

When biomass alone is used for briquetting as in the non-pyrolyzing technology no binding agents are required, since the cellulose content of the biomass itself acts as the binder. In such case of pyrolyzing technology some binders such as molasses, starch, clay, cowdung, etc. are commonly used.

Since time immemorable, Nepal too has been using traditional types of briquette prepared from cowdung and biomass such as rice straw, jute stick.

The first briquetting plant in Nepal was established in 1982 to produce charred briquettes using pyrolyzing technology. Since then a lot of briquetting plants have been established. Some are still in operation, others have closed down. The total list of briquetting industries is given in Table No.14.

Among the total list of briquetting plants including the pyrolyzing type of briquetting plants that were registered for establishment are given in Table No.14. At present all of the pyrolying planta are not operational at all because of several problems which are given below.

A. Pyrolyzing type of plants

* Low quality of steel used for pyrolyzer
* Frequent repair because of corrosion
* Problems of drying (raw material & product)
* Wearing of the screw/worm feeder
* Availability of raw material - seasonal
* Coat of raw material - high cost
* Pollution and Environmental degradation

The industries using direct extrusion type technology are given in Table No.15. All of them are still operational except for Himalayan Briquette Factory. The problems of these factories are given below.

Table No. 14 Briquetting industries in Nepal

No	Name of industry	Status	Remark
1.	Jwala Industry Pvt. Ltd.	Trial production	
2.	Nepal Bio-Extruder Industry Thapathali, Kathmandu	Currently closed for site relocation	
3.	Sarita Huskcoal Engg. Pvt. Ltd. Jawalakhel	Not established (applied only for reg.)	
4.	Chitwan Briquette Coal Industry Bharatpur, Chitwan	Trial Production	Non-pyrolizing
5.	Koshi Briquetted Fuel Industry Dharan	In operation	
6.	Jyoti Coal Industry Sangam Chowk, Narayangadh	Not established	
7.	Palistha Briquette Industry Kathmandu	"	
8.	Pashupati Ketan Industry	"	
9.	Banwarilal Ketan Industry	L.C. opened	
10.	Alka Briquette Fuel Pvt. Ltd.	"	
11.	Nepal Nava Urja Udhyog Dilli Bazaar, Kathmandu	"	
12.	Trishakti Husk Coal, Narayan Garh, Chitwan (Not established)	Plan to use locally Produced machinery	
13.	Burn Well Fuel Pvt. Ltd. Hetauda	Not established	
14.	National Briquette Manufacturing Co. Kathmandu	Under construction	
15.	Sai Baba Briquette Industry Janakpur Dham	Not established	
16.	Nepcoal Pvt. Ltd., Butwal	Operating	
17.	Narayani Briquette Industry, Birgunj, Parsa	Not established	
18.	Quality Wood and Fuel Industry, Hetauda	Trail production	Non-pyrolizing
19.	Shanti Briquette Industry, Kathmandu	Not established	
20.	Roop Shri Coal Industry , Chitwan	"	

<u>B. Non-pyrolyzing type of plants (Direct extrusion type)</u>

* Wearing if the screw/worm feeder & muff
* Availability of raw material - seasonal
* Cost of the raw material - high cost
* Acceptability - slow burning & smell
* Marketing problems
* Ignition problems - difficult to ignite
* Pollution and environmental degradation

It is estimated that about 150,000 metric tons of rice husk is produced annually in the Terai. Its use has been on the increase for industrial heating and process heating purposes. To reduce the transportation/handling cost to improve heating value, rice husk is made into briquettes which can be used for space heating and cooking activities in domestic and commercial sectors and for heating and process heating purposes in industries. Briquettes have the potential to substitute kerosene, fuelwood and coal in domestic and industrial sectors. All of the industries, ones producing pyrolyzed briquettes are not functioning where as the non-pyrolyzing briquetting industries are still functioning with few problems that were mentioned above. The list of the non-pyrolizing type of briquetting industries with their production details are given in Table No.15.

5.7. <u>Biocoal</u>

Biocoal is a composite fuel prepared from the 70 -80 percent coal and 20 -30 percent of biomass by weight. The technology for mass production of biocoal briquettes has already been developed by adoption of high pressure briquetting method with compression only in the roll press technique, and the practical plant annually producing 6,000 tons of almonds shaped biocoal briquettes was constructed in November 1985 at Obira in Hokkaido, Japan. Besides, coal or lignite a wide variety of biomass ranging from agricultural residue (bagasse, straw, rice husk, etc.) to forest wastes (tree barks, saw dusts, woods chips, weeds, leaves, etc.) can be used as the other important component which acts as the binder.

RONAST and JICA have been collaborating in a joint research project on Alternate Energy Development since 1992. One of the areas of research has been the Biocoal technology, its transfer and adaptation in the Nepalese context. Prior to initiating, this research in Nepal, it has been learnt that similar projects on Biocoal have been successfully implemented in China, Thailand and Pakistan.

In the process of research, laboratory tests and field tests using locally available coal and lignites as well as different biomass - bagasse, tree barks, saw dusts, pine needles, Banmara, etc. they seem to have come up with a possible solution for the substitution of fuelwood which could be used in the residential, industrial and commercial sectors, provided that there will be sufficient amount of charcoal and lignite deposits and that there will be due attention from the side of the government and donor agencies to this composite fuel. Moreover, even if small amounts of coal exist, biocoal can be prepared from a wide range of mixing ratio or from biomass alone. The technical details can be referred to the project report. Some of the advantages and positive attributes of biocoal can be highlighted here:

i) <u>Versatile fuel.</u>

Biocoal can be used for cooking as well as heating purposes in the residential sector. It can be used very well for industrial purposes in boiler operation of industries and other heating purposes. Biocoal has the ability to replace coal wherever it is used except in places where coke or very high grade coal is required.

Table No. 15 Data of existing rice husk briquetting factories

Name of Factory (Location)	Chitwan Briquette Factory (Narayanghat)	Himalayan Briquette Factory (Narayanghat)	Simra Briquette Factory (Simra)	Quality Woods & Fuel Industry (Hetauda)	Bageswori Briquette Udyog (Nepalgunj)	Mhaypi Briquette Industry Pvt. Ltd. (Nawalparasi)
Owner	Mr. Prabhat Joshi Mr.K.K. Maskey (Partner)	Mr. Ram Pd. Nepal Kamal Nagar, Narayanghat	Mr. Jeevan Basnet, Simra	Mr. C. B.Karjeet Hetauda	Nepalgunj	Mr. S. Gorkhali Shivabasti, Shiva Mandir Kawasoti
Act. Production capacity	4 ton/day. 4 machines	500 kg/day 2 machines	4 ton/day	4.8 ton/day		Max. 6 tons/day Average. 3 tons/day
Working hours	3 shift (8 hours shift)	11 hour/day		8 hours/day		12 hrs (3 hrs - break)
To C of muff/heating	720°C	117°C		Electric heating		Heating by Briquette
Selling price of briquette	Rs. 4.00/kg. (no transportation)	Rs. 3.50/kg. (no transportation)		Rice husk-Rs.6.00/kg Saw dust-Rs.6.15/kg	Rs. 2.40/kg.	Rs. 4.00/kg. in KTM Rs.3.25/kg - Factory
Purpose	Cooking in army Brick, & carpet dying	Cooking in army Brick, & carpet dying		Cooking by army Heating in hotels		Army Quarter
Cost and origin of Machinery	Made in Taiwan US$60,000	Self made NRs.125,000 each		Taiwan, $47,000 CIF Calcutta 1987, full set	Self made NRs.125,000 each	Nepalese-NRs. 1,25,000 Taiwan - NRs. 3,75,000
Market	Kathmandu	Kathmandu		Kathmandu		Kathmandu - Army, Carpet industry
Problems	Every 2½ to 3 hrs. Screw & Muff damage	Every 7-11 hrs. Screw & Muff damage	Screw & muff need change after 100 truck production	Muff damaged (muff & screw made by local mechanical w/s)		Muff damaged (muff screw made by local mechanical w/s)
Raw material used	Rice husk Rs.1/kg	Rice husk Rs.1/kg Rs.12/17kg.		Rice husk-Rs0.80/kg. Saw dust-Rs. 1.10~1.25/kg	Rice husk - free	Rice husk - Rs. 1.15/kg
Necessary equipment for maintenance	Lathe machine, grinding, drilling, welding machine, hand tools etc.	Table grinding, drilling, welding, hand tools etc.				
Manpower	Skill labour - 3 Non skill labour - 16 Administration - 3	Skill labour - 1 Non skill labour - 4		Welder, operator, technician- 5 persons Others-temporary		Welder-1, Welder Grinder, Non. skill. Total 13 persons
Data collected date	May 1994	May 1994		December 1994	January 1994	January 1995

ii) Easy packing, transportation and handling

The composite fuel is produced in the form of almond shaped briquettes with high breaking strength. Hence, it can be easily packed in any desired quantities and transported to any destination. Since it is a processed product compressed under high pressure handling and use of biocoal does not pose much problem regarding cleanliness as in the case of coal.

iii) Possibility to have product with desired heating value.

Depending upon the quality of coal and biomass used, the calorific value and ash content of the biocoal can be regulated as desired. If coal of high quality is used the calorific value of the product will be higher. If biomass such as bagasse is used the ash content of the product will be low.

vi) Control over emission gases

The emission of gases CO, CO_2, SO_2 and NO_x can be controlled by using different additives and different types of stoves. Adding desulphurising agents such as limestone , slaked lime or quicklime, in the biocoal the SO_2 emissions can be well checked. Stoves with different structures, designs and air suppliers can control CO emissions.

v) Comparatively Superior performance in cooking

As per the project research findings in comparison to other biomass cooking fuels - fuelwood, rice husk, briquettes, cowdung - Biocoal BC-17 (75% coal and 25% bagasse) gave the best performance. To cook the same amount of food (500gm potatoes, 250gm rahar, 1000gm rice) the following parameters were received.

Table No. 16 Comparison of fuel for Cooking

Parameter	Fuelwood	Rice husk briquettes	Rice husk 58% Coal 40% lime 2%	Cowdung	Biocoal (75%+25% bagasse)
Time required to cook food in minutes	85	112	83	144	64
Quantity of fuel consumed kg	2.992	3.035	2.643	4.0	1.535

Source: NRDC for AE.

Furthermore, the experiment results show low emissions of CO, SO_2, NO_x and less smoke generation. Tests for industrial application had not been performed due to limitation in the production capacity as these tests require large amounts of Biocoal.

Some of the disadvantages are:
i) High cost of the Biocoal briquette and plant machinery.

Coal itself is a costly commodity and the product biocoal too is also a costly fuel in comparison to rice husk briquette, fuelwood, etc. The plant for its production is also comparatively more expensive than the rice husk briquetting plant. The cost of the plant can be reduced by using local materials and technology for secondary items. Only the primary items could be imported. Next, in the preliminary phase the machinery could come in the Grant Assistance package, which later could be dissemination through local adaptation. If subsidies are already existing on kerosene, biogas, ICS, microhydro, it could also be arranged for this technology.

ii) The raw material availability

Scattered deposits of coal and lignite are being exploited in Nepal but their estimates have to be reconfirmed through specific site exploration and export service. But as per the information available these deposits may be exploited successfully for biocoal in view of the growing expansion of the coal mines in recent years. Biomass as the second raw material seems to be available in abundance.

iii) Requirement of special devices- Stoves and adaptors

Special cooking devices - stoves and adaptors - may be required in the residential sector for cooking purposes, which will be additional economic burden on the rural population . In industry the switching to Biocoal may not be so much of a problem as coal use is similar to Biocoal.

5.8. Analysis of alternatives

In the search for alternatives to fuelwood, the country has introduced several AETS , which have been given in the alternative energy situation. The analysis of alternatives are given in the following Table No 17.

5.9. Comparison of different energy forms with respect to briquettes

The comparison of different forms of energy in terms of prices of different quantities of various energy and their respective conversion to gigajoule, gigajoule per rupee and effectiveness of the energy is presented in Table No.17 and the graphical representation is given in Figure No 18.

Gigajoules of energy per rupees is the highest for briquettes, while kerosene ranks second followed by fuelwood. Similarly, electricity is the most expensive. Effectiveness of the energy depends on the type of energy used. Efficiency is the highest for electricity (76 %) followed by gas (70) %. Firewood is found to give the lowest efficiency.

The above figures in terms of effective gigajoule per rupees of various energy forms and use shows briquette to be the cheapest followed by kerosene and gas. Electricity and Fuelwood are the most expensive. These figures indicate that fuel briquette prices are competitive as compared to prices of other energy. As fuelwood and kerosene are considered as the main products for substitution by briquette, briquette technology is considered to be viable from the economic and financial perspective.

Table No.17 Analysis of Alternatives

No.	AET or Alt. Fuel	Cost	Beneficiary Group	Advantages	Disadvantages	Conclusion/ Remarks
1.	Biogas technology	Rs. 12627/- to 34570/- depending upon the plant capacity	One or few household	* Can be used for both cooking and lighting. * Good health and sanitary conditions * Clean fuel & no environmental pollution. * Increased agricultural productivity through enrichment of soil from slurry. * Easy and fast cooking. * More time for school (children) and household activity (women) * Direct substitute for fuelwood so reduction in fuelwood consumption.	* Lower income groups cannot afford. * If subsidy lifted, even middle class farmers cannot afford. * Benefit to only limited people or household. * Only domestic application so far. * If no support from HMG & donor agencies, promotion of biogas technology not possible. * No cash returns/no income generation form dung cakes. * Suitable climate required, suitable for limited areas * Stall feeding of cattle for easy dung collection. * Water collection may be difficult, substantial amount of it required * Subsidy should be present till 9th five year plan.	*Major decisive factor for success is presence of heavy subsidy whereas benefit to only small group *Some reduction in fuelwood consumption
2.	Microhydro installation	Rs. 31,000-99,000 (cost varies from place to place)	Community groups	* Utilization of Indigenous water resources. * Used for lighting & agroprocessing, but not cooking. * Environmental pollution very little. * Benefits are shared/used by community. * Income/cash generation possible. * Local technological capability already exists in the country.	* Not used for cooking so no reduction in fuelwood consumption. * High cost, cannot be afforded by rural people with low income. * Operation and maintenance costs high. * Difficult to control electricity leakage. * Requires technical and trained skills for operation & maintenance * Electricity distribution costs are extra. * Frequent breakdown and problems of spare parts.	*High cost means economically and financially difficult to afford by low income group of rural people. *No reduction in fuelwood consumption.

No.	AET or Alt. Fuel	Cost	Beneficiary Group	Advantages	Disadvantages	Remarks/ Conclusion
3.	Rice husk or saw dust briquettes	Cost of plant is high Rs 33.45 lakh, (local plant Rs 70-80,000) cost of briq-uette also expen-sive	Wide circle of population including industry, commercial and domestic groups.	* Utilization of indigenous waste resources. * Direct substitute for fuelwood. * Can be used for domestic and industrial use. * Wide beneficiary group. * Easy to handle and transport. * Technology and capability already available in the country. * Wide variety of agro- and forest wastes can be used as raw material * Less pollution than from coal and oil and petroleum products * Huge potentials of agricultural and forest wastes as raw material exists. * Improvement of product through mixtures/ blends exists to improve combustion properties	* Cost of plant is high but local plant is bit cheaper * Briquette is comparatively expensive. * Wearing of screw and muff and delays production. * Price of rice husk (raw material) is increasing so profit margin low * No moral, technical and financial support form HMG or donor agencies. * Repair and maintenance cost are high. * Production and use of briquette still release CO and CO_2 gases and smoke causing environmental pollution * Combustion properties not satisfactory * Too much use of agricultural residue may effect agricultural productivity * No line agency to take care or solve problems	* Wide use in domestic and industrial sectors * Direct substitute of fuelwood . * With subsidy and support from HMG/donor agencies cost can be reduced. * Blends with coal can produce briquettes of desired heat content.
4.	Kerosene and LPG	Rs. 8.75 per liter, Rs 300/-per 15kg	Urban and peripheral groups only.	*High heat content. *Used for cooking and lighting, space heating. *Easy to transport but transportation cost adds up. *Cooking time is shorter and easy to handle. *Good health and sanitary conditions *Direct substitute for fuelwood *Pollution from combustion less *Heavy financial subsidy	* Cannot be afforded by rural people due to high cost. * Transportation costs are high. * Requires additional investments in stoves, heaters, lamps, etc. * Imported fuel, consumes high amounts of foreign currency. * Fire hazardous and prone to accidents * Beneficiary groups limited to urban and peripheral population. * Heavy dependence on foreign sources for stable & continuos supply.	* Due to high cost rural population cannot afford it * No indigenous resources base or very little in case of gas. *Limited industrial use at present * Heavy burden on country's economy.

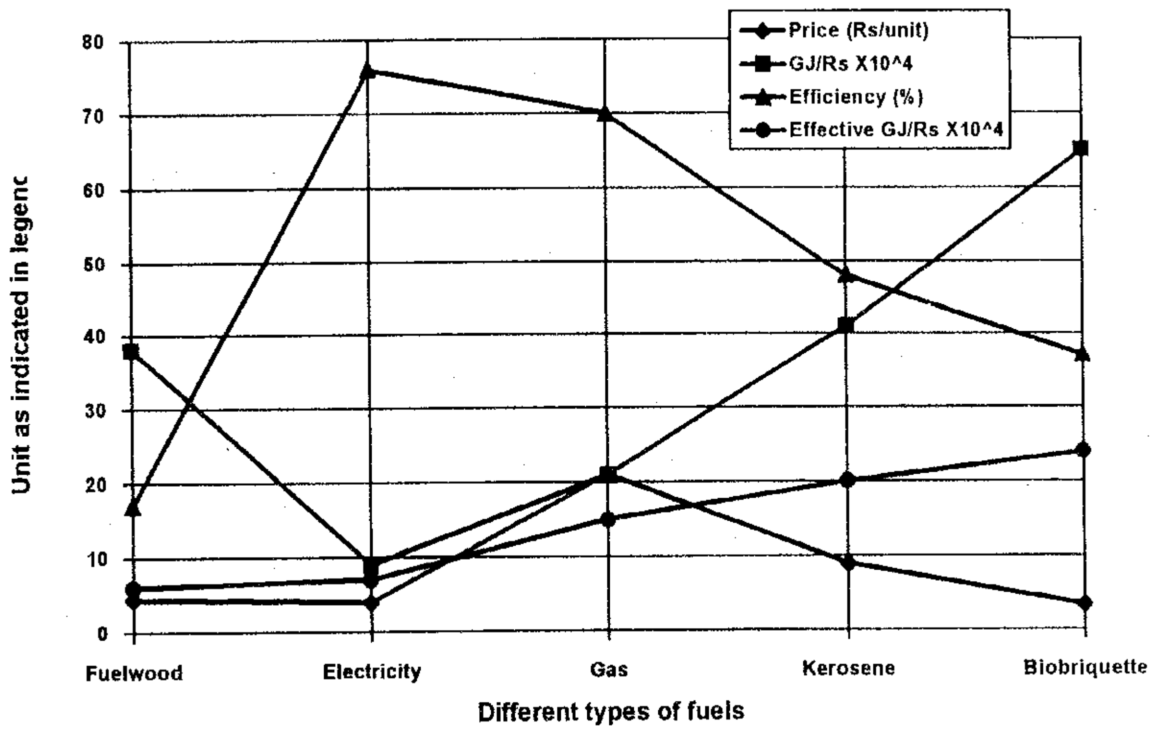
No.	AET or Alt. Fuel	Cost	Beneficiary Group	Advantages	Disadvantages	Conclusion/ Remarks
5.	Improved Cooking Stoves (ICS)	Low cost Rs. 200- 275/- (cost of small ICS, big ones cost more)	Rural population at large	* Used for cooking and heating * Cuts down fuelwood consumption * Comparatively low costs (only small ICS) * Improved health, sanitation, environment conditions and other social benefits. * Support form HMG/N and donor agencies exist for subsidy and free of cost distribution.	* Provides only 30-50% fuelwood saving and no direct substitute of fuelwood. * Limited only for domestic cooking purposes * Not applicable for industrial use. * Many small technical constraints. * Required big institutional and promotional and dissemination support and network * No responsible line agency exists * If subsidy and free distribution withdrawn promotion is difficult	* Not a direct substitute for fuelwood and use is limited to domestic cooking * If subsidy lifted program may fail
6.	Solar application - cookers, heater, dryers, PV, etc.	Cost varies - SWH- Rs 20-50,000/ SD~ Rs 34,000/ SC- Rs 500-10,000/ PV lighting- Rs 2.5 to 4 lakh	Individual household or small community	* Use of indigenous resource * Cleanest form of energy * Domestic and some industrial use * Cuts down fuelwood consumption in some areas * Used for cooking, heating, lighting , telecommunication purposes	* Costs of are comparatively high * Requires additional investments in lights, cookers, batteries, storage means, etc. * Requires sufficient technical knowledge and back up as well as spare parts * Not a direct substitute for fuelwood, only reduces fuelwood consumption to some extent * R&D still inadequate	* Can't be afforded by rural people due to high cost * Not a direct substitute for fuel wood * Mostly Limited people are benefited

7.	Biocoal briquette	Cost of plant is high	Industrial, commercial domestic sectors	*Can be used for cooking, heating heating in domestic & commercial sectors *Can be used industries *No additional binders required *SO2 emissions can be checked by DSA and other emission gases can be controlled *Indigenous biomass(forest & agrowaste) can be used in different proportions *Easy to transport and easy to ignite *Biocoal of different blends and heat characteristics (CV) can be produced *Lab & field test show its supremacy over prevalent fuels	*Cost of plant & equipment is high *Cost of biocoal is high *Limited coal and lignite resources *R&D still in initial stage	*Could be a direct substitute in residential, commercial and industrial sectors *High cost of product means subsidy will be required

Table No.18 Comparison of different energy form with respective briquettes

No.	Type of energy	Unit quantity	Price (Rs/ unit Q	GJ/unit Q	GJ/Rs	Efficiency (%)	Effective GJ/Rs
1.	Fuelwood	1 kg	4.42	0.0167	0.0038	17	0.0006
2.	Electricity	kwh	4.00	0.0036	0.0009	76	0.0007
3.	Gas	1 kg	21.13	0.0452	0.0021	70	0.0015
4.	Kerosene	1 liter	9.00	0.0365	0.0041	48	0.0020
5.	Briquette	1 kg	3.40	0.0223	0.0065	37	0.0024

Figure No. 18 Comparison of different energy forms



In order to encourage fuel switching from fuelwood to briquettes, the price of briquettes will have to be low. The strategy to achieve this will depend upon energy pricing policies and other socio-economic aspects.

From the above analysis direct firewood substitution is provided by biogas, kerosene, LPG, Briquettes. Kerosene and LPG are imported materials and they have a heavy burden on the country's economy consuming large amounts of foreign currency. Furthermore, their use are limited to the urban population and its periphery and to domestic application. Biogas provides a direct substitute to fuelwood but its climatic limitations and cost, although heavily subsidized, provides benefits to smaller group of selected rural population. In addition their industrial use is limited.

Biomass briquettes are a little expensive and the plant establishment costs are high, nevertheless, they provide a direct substitute of fuelwood in the domestic and industrial sectors. Furthermore, without much support from the government and donor agencies the private sector has developed the technological capability to produce plants and briquettes. With the introduction of some institutional arrangements, change in pricing policy, technical and financial support these briquetting industries could utilize the indigenous resource base - agricultural residue, forest wastes, coal/lignite - to produce biomass briquettes or biocoal that can be used as direct substitutes for fuelwood.

Summary and Conclusions

1. Nepal has introduced several alternative fuels and alternative energy technologies such as kerosene, LPG, biogas, microhydro, ICS, biomass (rice husk, saw dust) briquettes, solar, etc. in the pursuit of fuelwood substitution and experienced mixed feelings and impacts.

2. Microhydro and biogas have been popular and successful mainly because of the financial support in the form of subsidies from Government and Donor agencies. Nevertheless, their promotion and disseminations have not reached large scale due to the comparatively high costs for the common rural mass. The benefits are enjoyed by small households or community only. Industrial and commercial sector applications are still limited or not possible. Fuelwood substitution for cooking in wide scale is not yet possible.

3. Kerosene and LPG are costly and additional costs are required for devices and utensils so the common rural population cannot afford it although they have the potentiality to directly substitute fuelwood for cooking and a subsidy for kerosene already exists. The uses are confined to urban areas and its peripheries. Industrial and commercial displacement of fuelwood by these fuels are limited and they consume big amounts of export earnings of the country for their importation.

4. Improved cooking stoves are comparatively cheaper and may be affordable by the rural population at large, but they do not provide a direct substitute for fuelwood. The application of ICS are limited to the rural household alone. If the subsidy and support from donor agencies are lifted the programmes may not survive long

5. Solar technologies are at present too expensive for the rural people at large and except for solar water heaters and driers other solar technologies are still at an experimental stage with R&D at its initial stage. Further they do not provide a direct substitute for fuelwood.

6. Biomass (rice husk, saw dust) briquettes are comparatively more cost effective and fuel efficient (refer to Table No.18). Biomass briquette is a more versatile fuel, which can be used in industrial, commercial and residential sectors for cooking and space heating. Nepal, being predominantly an agricultural country, has large amounts of agricultural residue along with forests wastes as well, for the production of biobriquettes. Due to the initiative of the private sector alone the technological capability of briquetting already has been established with the ability to produce briquetting machines locally. Since the benefits from the investments in briquetting can be shared by all the important sectors of the economy, with due financial (subsidy and investments) and organisational (creation of responsible line agency) supports from the government and other agencies, they could substitute fuelwood in a large scale.

7. Biocoal as a composite fuel of biomass and coal shares almost all the positive aspects of biomass plus some other unique superior qualities - desired increase in the calorific values through different blends and mixing ratios, improved ignitability, control over emission gases SO_2, NO_x, CO, improved heat efficiency, ease of transportation and packing. If similar attention and support, as in the case of biomass briquettes, could be extended to this composite fuel, it could gain wide scale application in industrial, commercial and residential sectors.

8. With due financial and organisational support biomass briquettes and biocoal will be able to substitute fuelwood on a country wise basis.

6. Energy and environment

6.1. Environmental cost and subsidy

One of the major reasons for switching domestic fuel from woodfuel to coal is to save trees and avoid land degradation. If the objective is to reduce pressure of the woody biomass, then environmental cost considerations must also enter the equation. That is, the real cost of woodfuel or its social cost, must be the sum of private cost and environmental cost. Let C_s be the social cost of woodfuel, a_1 and a_2 be the private cost and environmental cost respectively; all are in terms of Pula per ton. Then we have:

$$C_s = a_1 + a_2 \quad (1)$$

Let **b** be the cost of briquettes, also in Pula per ton, and **h** the co-efficient of heat equivalent of briquettes to coal, considering the difference of heating value, the heat efficiency, and the methods of operating of these two fuels. The following inequality then gives the required condition for replacing woodfuel with briquettes:

$$b < h\,(a_1 + a_2) \quad (2)$$

If **b** exceeds $h\,(a_1 + a_2)$, there may be no point in a switch away from woodfuel with briquette coal on the basis of social cost. If (2) is valid, and at the same time $b > ha_1$ - that is, the private cost of briquettes is greater than the private cost of woodfuel - then a subsidy S in Pula per ton would be required to support coal in preference to woodfuel. That subsidy is given by:

$$S = b - ha_1 \quad (3)$$

When a subsidy S is in effect, the price of briquettes would be reduced to **(b - S)**, at which point choosing woodfuel or briquettes will make no financial difference to consumers. Combing (2) and (3), we have

$$S < ha_2 \quad (4)$$

Equations (3) and (4) state that the subsidy should equal the difference between the private costs of briquette and woodfuel in terms of equal heat effectiveness, as far as it does not exceed the environmental cost of woodfuel, also in terms of equal heat effectiveness. In order to identify the maximum value of subsidy, the co-efficient of heat equivalent and the environmental cost of woodfuel should be determined. An approach adopted in a paper published in January 1990 (Diphaha, 1990) addressed this issue in some detail, considering woodfuel per capita consumption, the number of people using woodfuel, the regrowth rate of fuelwood trees, the price of woodfuel and its dynamic changes over time. There has been some criticism of this methodology, based on the argument that since woodfuel users do not harvest live trees, but use dead wood, they are not necessarily the cause of deforestation. Although there is evidence in Botswana that live wood is being used, more data are necessary to obtain a clear picture of forest balance. In this paper, fortunately, we show that the private cost of coal briquettes does not exceed woodfuel, so subsidy of briquettes is not necessary and the problem of the environmental cost of woodfuel does not come into the question.

The above case ws the case of substitution of woodfuel with coal briquettes. A similar approach could be adopted in fuelwood substitution by biobriquettes in the case if Nepal to evaluate the costs and the required subsidy for the promotion of briquettes.

6.2 Environmental issues of energy utilization

There are three broad and distinct environmental issues related to energy.

i) Pollution related to energy mining and transportation

Pollutants like methane, sulphur dioxides are emitted from energy mining, whereas oil spills are caused mainly by the transportation of crude material and products. In case of Nepal crude products are not transported and only ready other products are transported.

ii) The problem of clean air

Combustion of fossil fuels generate a variety of pollutants - CO, CO_2, SO_2. NO_x. Combustion of biomass, which is the main fuel for cooking and heating in Nepal, produces smoke containing particulate matters, polycyclic organic materials. CO. CO_2. The health hazards are significantly greater at the house hold level and effect women and children more.

iii) The problem of greenhouse gases

The main greenhouse gases CO_2, CO, methane, NO_x are emitted from the combustion of fossil fuels and biomass. 50 % of the global greenhouse gas comes from the combustion of fossil fuels. Furthermore, with the diminishing amount of forest resources, which absorb carbon dioxide in the process of photosynthesis to produce oxygen, the issue becomes more critical in places where fuelwood is still the main source of energy.

Thus the production, consumption and distribution of energy, especially fossil fuels (petroleum products and coal) and biomass fuel (fuelwood, agricultural residue, animal dung) adversely effect the environment. Combustion of fossil fuels particularly generated pollutants like sulphur dioxide, carbon monoxide, carbon dioxide, methane and other greenhouse gases that are the major cause of local air pollution, regional problems like acid and global climate change.

6.3. Greenhouse gases and Nepal

The greenhouse gases comprises of CO_2, methane, Chlorofluorocarbons, nitrous oxide and ozone. Among them generated by human activities CO_2 ranks the highest.

In Nepal methane is emitted mainly from rice cultivation and cattle and its contribution to greenhouse gas is about 56 %. Land use change (deforestation) account for 43 %, The contribution of fossil fuels is only 1 % of the total emission.

Another important factor, which seems to have been neglected or not considered is the solid municipal wastes. This waste not only poses a threat to the hygienic conditions of the city and the people but also contributes considerably to the generation of methane gas in due course of time through its decomposition. Many countries have tackled this problem through projects of sanitary landfill which not only creates a clean environment but also helps in power generation through the utilization of the generated gases.

Although the energy related emission of greenhouse gases is small (400 kg of carbon equivalent compound in comparison to 4200 kg in the USA), it is rising at a rate faster than that of other developing countries due to growing contribution of energy in the total greenhouse gas emissions. However one of the special characteristics of the country, which is of major national and International concern is deforestation and CO_2 generation from fuelwood combustion.

6.4. Energy - Environment outlook

With the given energy situation and the present trend which has been highlighted in the previous chapters, the energy sector strategy in Nepal should relate to three main factors regarding energy and environment

i) Fuelwood will remain dominant as the source of energy in the still immediate future, but its share will be lower. Deforestation could be a major problem, if the present trend continues.

ii) The demand for fossil fuels is rising at an accelerated rate. This trend is expected to continue in the future. as a result, the severity of a number of environmental problems including greenhouse gases will increase. Although, Nepal will remain the lowest per capita emitter of CO_2, the emissions of pollutants such as SO_2, NO_x, CO, etc. would create problems in the urban areas and at the household levels.

iii) The development of hydropower is also expected to play a major role in future in the energy consumption mix because of the enormous hydropower potentials. Hydropower is the cleanest source of energy in terms of pollution, but storage type of scheme will have extensive environmental impacts.

6.5. Reduction of greenhouse gases

From a longer perspective there are a number of options available to reduce the concentration of CO_2.

1. Improving efficiency in energy production and use
2. Shifting to more cleaner of fuels - from traditional to cleaner fuels
3. Reducing carbon dioxide concentrations

Improving efficiency in energy production and utilization

Improvement in energy efficiency is the most promising policy perspective for minimising greenhouse gases and other energy related pollutants. Various studies confirm that 20-25 % savings in energy can be achieved within a pay back period of two years or less.

All sectors of the economy can make significant improvements in their energy use with the major areas being rural households, industrial sectors, transportation, etc.

Shifting to more cleaner of fuels

From the environmental perspective, switching fuel from fuelwood and fossil fuel to hydroelectricity is appealing. However the feasibility of replacing fuelwood and fossil fuels with electricity significantly in the near future is bleak, especially in the transportation sector. Hence the options of substituting fuelwood and fossil fuels with other alternative energy resources, particularly for cooking and heating purposes is more realistic.

Reducing carbon dioxide concentrations

One of the practical ways to control and reduce the concentration of carbon dioxide is by reducing deforestation and accelerating afforestation. However, since deforestation is caused by

i) rising demand for agricultural land for the increasing food needs
ii) increasing energy needs (fuelwood and fodder) in the rural areas and
iii) rising demand for wood for different residential, industrial and export purposes

reducing CO_2 concentrations by preserving the forest to protect against climate may be of little interest to those people, whose main problem is poverty and basic needs fulfillment. Thus management of forests is a challenging task that requires gradual and concentrated efforts together with provisions of viable alternatives to fuelwood and timber.

Summary and Conclusions

1. Exploitation of energy resources leads to changes in the environment and ecological systems. Further, mining of energy resources leads to degradation of the ecosystems and irreversible consequences.

2. Pollution of the atmosphere and the increasing Greenhouse effect are major problems, which follow from the combustion of fossil fuels and biomass fuels. In case of Nepal particularly, the combustion of biomass fuels is a major contributor of emissions of CO_2 - the main greenhouse gas.

3. The checking and control of emissions of CO_2 will be a major concern in our context and hence shifting from traditional fuels to more cleaner fuels is a major issue in the reduction of CO_2. Till the development and exploitation of country's hydropower resources to a fuller extent, AETs to substitute fuelwood will have to be promoted intensively.

7. Policy analysis

7.1. Energy development Policy and analysis

The energy development policies in Nepal was formally introduced only from the Sixth Five Year Plan (1980-1985). The sixth Plan adopted a policy of developing energy resources in relation to the overall objectives of economic growth while preserving an ecological balance. The broad aim of this policy was to minimize reliance on simple sources of energy in the replacement of fuelwood and imported fossil fuel with indigenously produced electricity and to conserve energy through efficient utilization.

The Seventh Five Year Plan (1985-1990) attached greater importance to increased opportunities for production, employment and fulfillment of the minimum basic needs of the people. Fuelwood was recognized as on of the basic needs of the people as a cooking energy in the rural areas and thus emphasized massive tree plantation by involving local people. The rural electrification programme was conceived to assist the growth of farm output and development of cottage and small industries. Similarly, special programmes were designed to promote alternate energy resources like biogas, microhydro, improved cook stoves, solar collectors, etc.

In the past the implementation of AETs has not been very encouraging. Despite their attractive economic and financial performance, potential in the overall energy scenario is still unrealised. A number of issues have emerged related to their development and promotion. These issues can be broadly classified as

* Social issues - acceptability of technologies
* Planning and Policy issues - commitment and willingness at the policy level
* Institutional issues - coordinating bodies and their existence/establishment
* Financial issues - financial investments and subsidies
* Technical issues - technological capability and infrastructure
* Managerial issues - product promotion and marketing

While considering the problems relating to alternate energy and their promotion, these issues have to be carefully examined and addressed for the successful implementation of programmes. The Alternate Energy Policy of the Eight Five Year Plan has tried to address these issues.

7.2. Alternate Energy policy of the government

In the Eight five year plan of the government alternate energy has been recognized as a potential area which can contribute to environmental protection and check deforestation to a substantial extent. The policies of the government relating to alternate energy technologies is given below and the plans are reflected in the Table No.19.

7.2.1. Policies of the Eight Five Year Plan (1992 - 1997)

i) Development of necessary technical manpower and collection of basic data will be carried out for the development and promotion of biogas, solar energy, wind power and others. Besides appropriate places will be identified for the implementation of the programmes of such nature.

ii) The import of equipment related to the alternate energy technology and raw materials will be encouraged by providing incentives on tax, custom etc. Financial grants will be provided to the users of devices related to the alternate energy, if found necessary. Besides technical and financial support will be extended to the non-governmental institutions and private sector towards the promotion of AETs.

iii) With the promotion of biogas plants, concrete steps will be taken to extend their use in order to minimize the destruction of forest for fuelwood. Effective arrangements will also be made for the extensive use of improved stoves in order to reduce consumption of fuelwood in the rural areas. The extension of solar cooker based equipment such as solar cooker, solar water heater, solar drier etc. will be emphasized.

iv) The governmental and non-governmental organization, private sector and educational institutions will be mobilized to create public awareness about the usefulness and uses of AETs.

v) A long term perspective plan will be formulated for the development of alternate energy.

Table No.19 Budget for Alternate Energy Development in the 8th Five Year Plan.

No	Development Programs	Details	Investment	in Lakhs	Rs.
1.	Micro-hydro electricity	Installation - 5,000 KW	500 Govt	2500 Pvt Sector	3000 Total
2.	Biogas Energy	Installation - 30,000 Biogas plants	2500	8000	10500
3.	Solar Energy	Solar water heater - 5,000 nos. Solar cooker 5,000 nos. Solar drier 2,500 nos.	100	1900	2000
4.	Wind Energy	Preliminary study and a master plan for wind energy implemented accordingly.	50	250	300
5.	Biomass Energy	ICS stoves distribution - 250,000 nos.	200	500	700
	Total		3350	13150	16500

Till the Sixth Five Year Development Plan the government did not have any energy development policy. Only the Sixth Plan introduced the Energy policy in the simple form so as to replace fuelwood and fossil fuel by electricity. Today in 1995 we are in the middle of the Eight Development Plan and even with the comparatively heavy investments in the hydropower sector the government has not been able to exploit 1 % of the economical hydropower potential of the country.

Substitution of fuelwood and energy as a whole with electricity even in the next decade would seem very ambitious and unrealistic. Moreover substitution of fossil fuel, the demand of which is increasing in an accelerated rate would also be impossible.

Corrective measures in the Seventh Plan such as emphasis on massive afforestation programmes and switching to alternative energy technologies such as microhydro, small hydro, biogas, ICS, etc. has improved the energy situation to some extent.

Subsidies in the supply of energy in the form of kerosene, ICS, biogas, etc. may not have a positive contribution/impact in the long term perspective as these do not generate any or much income, which leads to sustainabilty. Rather they may have a negative impact and collapse after the withdrawal of subsidy or support from donor agencies.

On the other hand investments and subsidies in research and development, building of technological capability and development of industry to utilize the country's indigenous resources lead to sustainability and have a positive impact in the long term perspective. The Eight Plan has accorded priority to the AETS by bringing out a separate policy for the AETS and allocating financial resources. (see Table No.19). The policy and the programme have tried to provide some solutions to the pertinent issues raised earlier in a comprehensive manner through the proposal of establishment of a line agency for AET promotion, creation of public awareness, extension of financial and technical support, etc. However, in certain aspects the policy document seems silent.

Shortcomings and gaps

1. The R&D component which was much stressed in all the AETS (WECS Alternative Energy Technology Assessment 1995) has not been reflected or specified. Rather the policy has highlighted more the quantitative aspects or numbers to installed during the plan period.

2. The responsible agency for alternative energy, the long time missing element, has been proposed for establishment. But its establishment and functioning may not take place soon. Firstly, the proposal to set it up under NPC, basically a planning body, seems somewhat misplaced. Secondly, its establishment during the Eight Plan period may not be realised soon due to the prevailing unstable political situation. This will be a big set back to the ambitious implementation of the plans and programmes in alternate energy.

3. Identification of leading agencies/organisation like Biogas company Ltd for biogas for other AETS is missing and technical and financial inputs for R&D has not been specified in each of the AETs.

4. Although the Alternative Energy Technology Assessment document of WECS and the Perspective Energy Plan of the NPC have highlighted the potentials of the briquetting technology to substitute fuelwood, the biomass section of the alternative energy development programme of the Eight Plan remains silent as regards the biomass briquetting. There is no leading agency identified for this AET and investments (financial plus technical) have not been specified to solve the problems of this industry.

Summary and conclusions

1. The government has introduced an Energy Policy form the Sixth Five Year Development Plan and taken a basic needs fulfillment approach in the Seventh Five Year development Plan regarding energy and fuelwood. The Eight Five Year Plan has come up with a more comprehensive energy Policy. It has also introduced a Policies and programmes on Alternate Energy Development and promotion for the first time. Nevertheless, corrective measures have to be introduced in the policies and programmes regarding biomass sector and Briquetting technologies.

2. Responsible and coordinating bodies/organisations have to be identified for each potential AET so as to attend to their technical, financial and managerial problems/issues.

3. Research and Development activities should be specified in the programmes with allocation of sufficient financial and technical resources, rather than stressing on the quantity of AETs to be disseminated.

4. Pricing policy and subsidy should be based on wider beneficiary groups, versatility of the fuels and development of the energy related industries in the long terms perspective taken in consideration the environmental costs as well.

CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

1. Almost four decades have passed since the implementation of the series of Five Year Development Plans, but not much achievement has been reached in the area of energy development. On the contrary, if on one hand, the green forests, which the country could boast off as wealth of the nation at one time is in a critical state due to over exploitation and deforestation; on the other hand, the enormous hydropower potentials has not been able to contribute much due to its under exploitation.

2. Fuelwood consumption coupled with the increasing demand of fossil fuels and coal both of which has to be imported, is a heavy burden not only to the country's economy, consuming huge amounts of export earnings, but also the ecosystem and the environment. Fuelwood combustion not only contributes to the enormous emissions of CO_2 but also reduces the CO_2 absorption by trees through deforestation.

3. Only the Sixth Plan was able to introduce the country's Energy Development Policy in its simplest form but not in the realistic and perspective form. The Seventh Plan introduced corrective measures in the energy development concept with a more perspective and realistic approach, launching massive afforestation programmes and adapting AETs mainly through subsidies with the prime objectives of fulfilling the basic needs of the people.

4. However, subsidy in the commodities of daily consumption including energy may definitely promote popularity in the political game and may not necessarily lead to positive impacts on the economy of the country and the financial status of the population at large. Rather, it could have a negative impact in the long term perspective once the subsidy is lifted. While subsidizing different energy forms (coal, biogas, kerosene, briquette, etc.) to substitute fuelwood, the environmental cost, heat efficiency and the versatility of the fuels should be taken into consideration. Similarly, the substitution should be aimed towards serving a larger beneficiary groups including important economic sectors of the country.

5. Subsidy in the development of industry, income generating activity and technological capability development, namely in R&D definitely has a positive impact in the economical development, since this is the age of technology, which is the key to economic development.

6. Industry and technology capability development related to energy and alternative energy should be the focus area of the government investments rather than the easy investments in the promotion, dissemination (subsidized) and commercialization, which normally comes afterwards for proven technologies.

7. The biomass briquetting industry of the country has been promoted and developed till today exclusively through the efforts of the private sector and has not so far received any technical and financial support from the government nor donor agencies. The NRDC for AE project seems to be the first institute to make an attempt to provide some technical support to this industry.

8. Despite the importance attached by both WECS document and the Perspective Energy Plan document the briquetting industry has not been given much attention by the Plans and Programmes of the Eight Plan.

9. Nepal being predominantly an agricultural country with plenty of agricultural residue supplemented by forest wastes, has enormous potentials to develop and promote biomasss briquetting industry to substitute fuelwood with some due technical and financial support to this AET. Similarly, the biocoal technology supplemented by biomass briquetting seems to be a promising fuelwood substitute even with the scattered deposits of coal and lignite of the country, if some support will be received towards their promotion, since these forms of fuel are very versatile and can be used in the industrial, commercial and residential sectors for cooking and heating.

SUGGESTIONS

1. Corrective measures should be introduced in the policy and programmes of the Eight Five Year Plan to incorporate the biomass briquetting technology and biocoal technology in the biomass section of the alternative technologies.

2.Corrective measures should be introduced in the planning document incorporate the financial (with provisions of loans and subsidies) and technical support for the development and promotion of biomass briquettes and biocoal.

3. A responsible agency or organisation (like that for biogas) to assist in the activities of the private sector briquette industries for the coordination, development and promotion of these technologies should identified in the country.

4. Investments in the R&D of these technologies should be incorporated and quantified n the biomass energy section as in the case of ICS.

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ANNEX I - LIST INSTITUTIONS WITH ALTERNATE ENERGY RESOURCES

No	ORGANIZATION	AREA	TYPE OF ORGANIZATION	REMARKS
1	Royal Nepal Academy of Science & Technology (RONAST)	Solar, Wind	R & D Organization	Planning for basic R & D facility
2	Water & Energy Commission, HMG	All Energy resources	Advisory body	No R&D facility
3	Research Center for Applied Science & Technology (RECAST), Tribhuvan University.	Small Hydro (Electrical), Solar Photovoltaic, Wind Electricity	Executing agency	Limited R&D activities
4	Small Hydel Development Board (Nepal Electricity Authority)	Small hydro (Electrical), Solar Photovoltaic, Wind Electricity	Executing agency	No R&D facility
5	Gobar Gas Tatha Krishi Yantra Bikas Company (Pvt.) Ltd	Biogas	Executing agency	Limited R&D
6	Department of Agriculture	Biogas	R & D Organisation	Facility for manure
7	Institute of Agriculture and Animal Science, Rampur	Biogas	R & D	
8	Nepal Fuel Corporation	Charcoal/Briquetting	Executing agency	No R&D facility
9	Agriculture Development Bank Appropriate Technology Unit,	Biogas, Solar Water Heater, etc.	Executing agency with an R&D unit	Basically dealing with low Technology, Limited R&D facility
10	Balaju Yantra Shala	Water Turbine, Solar Water heater, etc.	Manufacturing agency	Limited R&D activities
11	Butwal Technical Institute/DCS/Butwal Engineering	Water Turbine, Electric Cooker, etc.	Consulting/Manufacturing agencies	Limited R&D activities
12	Over a dozen Private Sector Agencies	Water Turbine, Generator, Solar Water heater, Briquetting of Agrowastes, Metallic stove, biogas, etc	Manufacturing agencies	Most of them have no R&D facilities

Annex II. LIST INSTITUTIONS DEALING WITH ENERGY DEVELOPMENT & SUPPLY

No	ORGANIZATION	AREA	TYPE OF ORGANIZATION
1	Ministry of Water Resources	Water Resource	Planning Project Execution
2	Nepal Electricity Authority (NEA)	Hydroelectric Plants (Large & Medium Scale)	Executing Agency
3	Ministry of Forestry	Forest Resources	Planning and Project Execution
4	Department of Forestry		Executing Agency
5	Forest Resource Survey		Resource Inventory
6	Department of Remote Sensing	All Resources	Remote Agency
7	Community Afforestation	Afforestation	Executing Agency
8	Ministry of Local Development	Local Development	Planning & project Execution
9	Department of Local Development		Executing Agency
10	Ministry of Supplies	Supplies Including Fossil Fuels	Planning & Project Execution
11	Nepal Oil Corporation	Oil Products	Executing Agency
12	Nepal Coal Limited	Coal	"
13	Department of Mines & Geology	All Mineral Resources including Geothermal Energy	Exploration, Resource Inventory, etc.

Annex III

Terms of reference of the study

A. **Fuelwood**

i) To study the current fuelwood situation and the consumption pattern in the past and the trend in the future with a demand supply approach and prices structures as far as possible

ii) To discuss the consequences of over exploitation of forests on the degradation of ecology and environment (global warming and greenhouse effect acid rains) in general and the impact on health when used in residential sector for cooking with a quantitative as well as illustrative approach as far as possible

iii) To draw conclusions from the analysis and study on the impact and possibilities of substitution of fuelwood in at least some specific consumer areas from fuel resources of indigenous origin like densified agricultural residue, biocoal (blend of coal/lignite with biomass)

B. **Petroleum products in general with some specific reference to kerosene**

i) To study the current situation of petroleum products and the consumption pattern in the past and the trend in the future with a demand supply approach and prices structures as far as possible

ii) To discuss the consequences of excessive use of petroleum products not only on the degradation of environment (global warming and greenhouse effect acid rains) in general but also its impact on the country's economy as a major consumer of hard earned foreign currency and dependency with a quantitative as well as illustrative approach as far as possible and also to reveal through price analysis the fact that it is a non-profitable commodity

iii) To conduct an analysis of investment alternatives of the expenditures on kerosene on different indigenous energy resources in the long term perspective

iv) To draw conclusions from the analysis and the study on substitution in the long term perspective and the economy of the country

C. **Policy analysis on environment protection and use of alternate energy technologies**

i) To analyze the existing policies on energy utilization and in environmental protection with special reference to pollution from energy consumption

ii) To analyze the government policies on the development and utilization of indigenous energy resources and the administrative, technical and financial support in it.

iii) To analyze directions, trends and policies in relation to the substitution of fuelwood identify problems and shortcomings in the programmes and policies and suggest policy measures in the development and promotion of technologies using indigenous resources in light of saving foreign currency, environmental protection, etc.

Annex IV - Health effects of pollutants

Pollutant	Health effects
Carbon Monoxide gas (CO)	Interferes with absorption of oxygen by hemoglobin (red blood cells); impairs perception and thinking, slows reflexes, causes drowsiness, brings on angina, and can cause unconsciousness and death; it affects fetal growth in pregnant women and tissue development of young children. It has a synergistic action with other pollutants to promote morbidity in people with respiratory or circulatory problems; it is associated with less worker productivity and general discomfort.
Nitrogen oxides gases (NOx)	Can increase susceptibility to viral infections such as influenza; irritate the lungs and cause oedema, bronchitis and pneumonia; and result in increased sensitivity to dust and pollen in asthmatics. Most serious health effects are in combination with other pollutants.
Sulphur dioxide gas (SO2)	A harsh irritant, exacerbates asthma, bronchitis and emphysema; causes coughing and impaired lung functions.
Hydrocarbons and other volatile organic compounds	Low-molecular weight compounds cause unpleasant effects such as eye irritation, coughing and sneezing, drowsiness and symptoms akin to drunkenness; heavy-molecular weight compounds may have carcinogenic or mutagenic effects. Some hydrocarbons have a close affinity for diesel particulates and may contribute to lung disease.
Particulate matter (mostly suspended matter)	Irritates mucous membranes and may initiate a variety of respiratory diseases; fine particles may cause cancer and exacerbate morbidity and mortality from respiratory dysfunction's. A strong correlation exists between suspended particulates and infant mortality in urban areas. Suspended particulates have the ability to adhere to carcinogens emitted by motor vehicles.

資料2． NEDOが実施しているブリケット事業の概要

NEDOが実施しているブリケット事業の概要

中国では、民生用エネルギーとして石炭が1.5億t以上使用されており、インドネシアにおいても石油資源の保護等の観点から民生用エネルギーとしての石炭の導入促進を大きな政策テーマとしている。民生用エネルギーとして、また小型工業用ボイラ用として、ブリケットは脱硫剤（消石灰）やバイオマスを混合させることにより、①硫黄分を固定（脱硫）し、②煤塵、煤煙の発生を抑制し、③燃焼効率を向上させる、等の特長を有するブリケット製造設備に係る実証事業を中国山東省臨江鉱務局湯圧炭鉱及びインドネシアPTBAタンジュンエニム炭鉱において平成5年度から3ヶ年の予定で実施している。

中国の高圧バイオブリケットは石炭（瀝青炭～褐炭）にバイオマス（トウモロコシの茎等）を15％程度混合し、高圧（2～4 t／m²）で成型したもので、燃焼時に石炭から低温域（200～400℃）で発生する揮発分を燃焼させ煤煙の発生を防ぐものである。一方、インドネシアでは揮発分を乾留して除去し、低温（200～300kg／m²）で成型し、乾燥するものである。

両方とも消石炭を混合し、硫黄分を固定する。

実施国及び実施機関	中国臨江鉱務局（山東省）	インドネシア　ＰＴＢＡ（タンジュンエニム）
タイプ	高圧バイオブリケット	乾留ブリケット
ブリケットの概要	能　力：5t／h 圧壊強度：100kg以上 石灰　バイオ　消石灰 （85　：　15）：　10	能　力：5t／h 圧壊強度：40kg以上 石灰　バイオ　バインダー （98　：　2）：　4
基本協定書協定付属書の締結	'94.4.27　ＮＥＤＯ－国計委 '94.7.15　ＣＣＵＪ－臨江鉱務局	'94.3. 1　ＮＥＤＯ－ＤＯＥ '94.8.15　ＣＣＵＪ－ＰＴＢＡ

[中国高圧バイオブリケットの工程表]

1993年度		1994年度(2年目)				1995年度(3年目)				'96
3/四	4/四	1/四	2/四	3/四	4/四	1/四	2/四	3/四	4/四	1/四
	←	— 設計 —	—	→						
		← 製作・輸送	—	→						
				← 基礎工事	→					
						← 現地工事	→			
							← 試運転	→		
								← 実証運転	—	- - -

JICA