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Trends and Patterns of Energy Consumption in Nepal

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Abstract

There has been growing concern recently about energy consumption, energy security and energy conservation. Oil shock of 1970s hits world today and many of the developed and underdeveloped countries have been trying to innovate alternative permanent source of energy. Nepal is no exception of the event although it consumes an insignificant amount of petroleum products. However, Nepal is paying one-third merchandise export earnings to import hydrocarbons per annum. High population growth rate of Nepal demands more farmland for which forest land of Nepal is being converted into agricultural land. In addition, People depend on firewood to meet their primary energy requirement for which the forest of Nepal is dwindling overtime. Past trend shows that the growth of GDP is closely related to growth rate of energy consumption in Nepal. The energy GDP elasticity is found highly elastic. Taking historical growth rate of GDP and population, the energy demand forecast has been made. Nepal has low level of per capita commercial energy consumption. Imported hydrocarbons contributes major share in the commercial energy consumption in Nepal. Electric energy does not have significant impact in the total commercial energy consumption although electric energy elasticity is found to be significant. The high economic growth rate can be achieved when the economy is endowed with adequate energy. The growth rate of economy, among other things primarily depends on the availability of energy in an economy. Nepal is rich in water resources and hydroelectricity is the only indigenous source of commercial energy. Its development and generation has remained stagnant since last two decades because of the long debating proposals of Arun III to Mahakali Package Program.

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1. The Context

Globally, people have been hearing about energy crisis through the information media since the last three decades. In general, governments of the world have been searching for alternative energy technologies after the OPEC supply shock of Petroleum, Oil and Lubricants (POL) products in 1973. In particular, a great agitation has occurred in the developed countries of the world by the oil embargo because they have been consuming a major share of world oil products. After the oil shock of 1973, both developed and underdeveloped countries have been giving emphasis on the energy crisis because it is considered that all economic activities are guided by the availability of energy.

Energy is a commodity, which like other commodities, serves to fulfill people's basic needs. Energy is not only needed to fulfill the basic needs of the households where it is used for cooking, heating and lighting but also in transportation, industries, service, agriculture and commercial sectors. Unavailability of adequate energy to fulfill the needs of these sectors will paralyze our economy and it will cease to function properly. Given such a context, it will be appropriate to quote Hall et al. (1986: 21):

> *"If we were to remove the dollars from our economy, it could continue to function in very different ways. If we were to remove any of the principle commodities say iron ore, fertilizers or trees the economy would continue to function, although again very differently. If energy were removed from the economy, however it would cease to exist once storage were used up."*

The fact that energy is a commodity has already been stated before. Energy is important not only to consumers, but to producers as well. It acts as a factor of production like land, labour and capital, which is a fact that has been ignored by the neo-classical economists. If we were to remove energy from the production process, labour would be unable to function properly. This can be attributed to the fact that energy is used by the labour in his daily means of subsistence. Land, as a factor of production, will not be fertile (to grow trees, crops, etc.) without energy. Land absorbs heat from the sun, which is sufficient to become fertile. Capital, another important factor of production, cannot be manufactured without availability of energy. Therefore, so important is energy and its intensity so great that it determines the efficiency of the labour and capital involved in the production process.

The main focus of this article is on the consumption of commercial energy. An attempt is made to fit an exponential trend, taking time as independent variable and energy consumption in GJ as the dependent variable. However, this attempt is limited to the consumption of commercial energy. It is because of the availability of the data concerning the consumption of biomass fuel being either inadequate or inappropriate. The method of least squares will be used to estimate the energy consumption from historical data. The semi log linear regression equation would be:

$$\ln TDEC = \alpha_0 + \alpha_1 t$$

$$\ln CEC = \alpha_0 + \alpha_1 t$$

$$\ln CC = \alpha_0 + \alpha_1 t$$

$$\ln PPC = \alpha_0 + \alpha_1 t$$

$$\ln EC = \alpha_0 + \alpha_1 t$$

Where, TDEC = Traditional Energy Consumption (fuelwood, agricultural waste, animal dung)

CEC = Commercial energy Consumption

CC = Coal consumption

PPC = Petroleum Products Consumption

EC = Electricity Consumption.

T = time period at origin 1984/85 = 1

2. Energy situation of Nepal

Water and Energy Commission (WECS) 1996 has estimated that Nepal's per capita final energy consumption of 15GJ (Giga Joules). It reflects that the energy consumption per capita is low. The level of economic development is largely determined by per capita energy consumption and hence this indicator shows the living standard of people. The World Bank (2000/01) estimates that Nepal's per capita GNP equivalent to US dollar 220 and that 51 percent of the total population lives under absolute poverty with an income less than one dollar a day (World Bank: 2000/01; UNDP 2000). This is the scenario now Nepal is facing. The main source of energy in Nepal is biomass that accounts for over 90 percent of the total energy consumption. The historical trend of energy consumption by fuel type is presented in Annex.

To relate our society to energy use it is necessary to analyse different strata of the people in the society. Over 86 percent of the population lives in the rural areas and their livelihood is based on agriculture. Recently, it is partly diverted to other sectors; also there is high labour mobility outside the country. The rural people earn some money as a remittance derived from other countries of the world. There is a wide variation between the distribution of income, consumption patterns, attitudes, aspirations and life styles of the people in Nepal. The above variables separate the elites of Nepal from the masses. There is a great disparity in the energy consumption pattern of the people as there is a disparity in the income, consumption, attitudes, aspirations and life style of Nepali people.

Fuelwood has always been the dominant source of energy in Nepal. It fulfils over 80 percent of the primary energy requirement of the people. The major sources of fuel wood are public forests, shrub lands, grasslands and private holdings. The annual growth rate of fuelwood consumption during 1984/85-1994/95 was 2 percent. Fuelwood is likely to remain the principal sources of energy in the foreseeable future. However, it is important to

note that the depletion of forest is the major concern of the recent times. The growing demand of firewood coupled with the mismanagement of its sources is exhausting the forest cover and resulting in (a) increased usage of agricultural waste and the same of animal dung. (These increased with a growth rate of 4.5 percent and 1.3 percent per annum during 1984/85-1994/95 respectively). Increased usage of animal dung as primary source of energy directly imposes adverse effect in agricultural productivity because it is used as a source of energy rather than a supplement to crop as fertilizer. (b) Environmental degradation through soil erosion and (c) increased wastage of manpower in gathering firewood.

Forest resource, a major source of energy, has dwindled over time due to continuous extraction for domestic and commercial use. WECS (1994/95) has estimated a total forest and shrub land of 4520.94 thousand hectares of which 2127.81 thousand hectare are accessed for fuel wood collection. While making this estimation, it has been assumed that the rate of depletion is 2 percent per annum.

As for the availability of commercial energy source Nepal has no proven deposits of fossil fuel. The use of fossil fuel as energy is growing substantially at present and it is expected that it will grow at a faster rate in the near future. The imported hydrocarbons are used as energy not only for transportation, industrial and other requirements but also for domestic cooking and lighting. Hydrocarbon imports contribute to a significant proportion of the country's import bill. The total amount of hydrocarbon imports is about 226 thousand tonnes per annum (Ramani, et al.: 1993).

While dealing with the situation of energy consumption in Nepal, it is necessary to analyze various factors, which are economic in nature. Energy consumption is affected by many factors, the main ones are population size, GDP per capita, prices charged for energy (particularly for POL products), the structure of the economy including the energy intensity of different sectors and particularly the average temperature of winter season (Gamba, et al.1986). However, this article does not attempt to take all these factors under consideration. Energy consumption in Nepal is presented in the following table on the basis of energy sources.

Table 1: Annual growth rate of energy consumption (in percent) in different periods.

Energy sources	1984/85-1989/90	1989/90-1995/96	1995/96-2000/01
Fuel wood	1.2	2.2	2.7
Agriculture waste	2.8	2.2	2.7
Animal dung	2.6	2.2	2.5
Coal	-14.2	6.9	27.2
Petroleum	7.8	12.6	12.7
Electricity	17.5	8.7	10.4
Total	2.7	2.8	3.9

Source: Economic Survey, MOF/HMG, 2001.

The overall annual growth rate of energy consumption during 1984/85-1989/90 was 2.7 percent (Table 1). The annual growth rate of fuelwood, agriculture waste, animal dung, coal, petroleum and electricity were 1.2, 2.8, 2.6, -14.2, 7.8, and 17.5 respectively. The annual growth rate of coal remained negative meaning that the coal consumption as energy during this period of time had decreased. However, the annual growth rate of coal consumption increased and reached 6.9 and 27.2 percent during 1989/90-1995/96 and 1995/96-2000/01 respectively. The annual growth rate of petroleum product was 7.8 percent during (1984/85-1989/90). However, it increased alarmingly during the periods of 1989/90-1995/96 and 1995/96-2000/01. During these periods the annual growth rates remained 12.6 and 12.7 percent respectively. The annual growth rate of electricity was 17.5 percent during the period of 1984/85-1989/90. During 1989/90-1995/96 the growth rate of electricity dwindled to 8.7 percent. However, the annual growth rate of electricity increased and reached 10.4 percent during the period 1995/96-2001/01.

Table 2: Energy Consumption (in thousand Tons of Oil Equivalent; TOE)

Energy sources	1984/85	%	1989/90	%	1995/96	%	2000/01	%
Fuelwood	4269	84.8	4753	84.8	5408	81.9	6165	77.2
Ag. Waste	191	3.8	213	3.8	243	3.7	278	3.5
Anm. Dung	320	6.4	355	6.3	404	6.1	457	5.7
Coal	83	1.6	45	0.8	67	1.0	223	2.7
POL	151	3.0	204	3.6	416	6.3	756	9.5
Electricity	21	0.4	40	0.7	66	1.0	108	1.4
Total	5035	100	5610	100	6604	100	7987	100

Source: Economic Survey, MOF/HMG, 2001.

Energy consumption in Nepal is dominated by traditional sources. Traditional sources of energy accounted for 95, 94.9, 91.7 and 86.4 percent of which fuel wood alone contributed 84.5, 84.8, 81.9 and 77.2 percent in 1984/85, 1989/90, and 1995/96 and 2000/01 respectively. The share of commercial energy consumption was 5, 5.1, 8.3 and 13.6 during these periods. The per capita commercial energy consumption is very low revealing the low level of economic development.

3. Analysis of Energy Consumption Over Time

The trend line equation has been estimated using time series data. (Annex 3). The regression equations are estimated for each type of energy used. For traditional sources total energy consumption is considered whereas for commercial sources various sources are treated separately. The following table shows the results of the regression equations:

Table 3: Fuel-wise Estimation of Regression Equations

Equation	α_0	t-stat	α_1	t-stat	F	R^2
1	12.2	2331.3	0.02	31.98	1022.9	0.99
2	9.0	103.2	0.094	7.36	54.21	0.85
3	7.08	13.39	0.06	0.79	0.63	0.06
4	8.6	158.41	0.11	13.54	183.33	0.95
5	6.91	180.7	0.09	17.64	311.4	0.97

3.1 Biomass Fuel

It includes the consumption of fuelwood, agricultural waste and animal dung. The annual growth rate of biomass consumption in Nepal during 1984/85-1994/95 was 2 percent. The result of the first regression equation is obtained by taking time as an independent variable and consumption of biomass in Nepal as the dependent variable. From the result, the growth rate is inelastic meaning any change in the time will have less than unitary (proportionate) change on the consumption of biomass. It is because there is no fuel substitution (for cooking, heating etc). The value of R^2 is very high meaning that 99 percent change in the biomass consumption is explained by the equation. The overall fit of the exponential trend of the historical energy consumption data over time is highly significant for the reason that the F- ratio as we have seen in the table is very high.

3.2 Commercial Energy Consumption

Coming to the consumption of commercial energy, Nepal has no proven source of hydrocarbons. Electricity is only the indigenous source of commercial energy in Nepal. This high growth rate of commercial energy consumption in Nepal can be attributed to the increased number of vehicles, urbanization and promotion of industrial activities. The growth rate is inelastic meaning any change in time will have less than unitary (proportionate) change on the consumption of commercial energy. It is because there is no fuel substitution for transport. R^2 is 0.85 meaning that the model explains 85 percent change in the commercial energy consumption in Nepal.

3.3 Coal

The third regression equation is related to the consumption of coal in Nepal. There was a declining trend of coal consumption during 1984/85-1994/95 (–2.2 percent). For this reason the value of r^2 is insignificant. However, the regression coefficients are positive indicating that there is a positive relationship between coal consumption and time. The overall significance of the fit of the regression equation seems very thin.

3.4 Petroleum Products

The overriding increase in the use of petroleum products has been conceived from the viewpoint of increased number of vehicles, rapid urbanization, expansion of road facilities and the changes in the lifestyle of the people. The annual growth rate of consumption of petroleum products during 1984/85-1994/95 was 9.5 percent. If this growth rate of petroleum products continues in the future, Nepal has to pay substantial amount of foreign currency it earns to meet the demand of POL products. The fourth regression equation has been established to show the trend of consumption of petroleum product over time. R^2 is highly significant that 95 percent change in petroleum product consumption has been explained by the change in time. The coefficient is 0.11 meaning that the changes in time say, by one year; the petroleum products will be changed by 11 percent. F-ratio is high enough to justify overall significance of the estimated regression equation. It shows that in Nepal, the petroleum products import will increase substantially causing an unfavorable trade balance as well as a similar balance of payments.

3.5 Electricity

The only indigenous commercial source of energy in Nepal, electricity, at present contributes less than one percent of the total energy consumption. The hydropower potential in Nepal is about 83 thousand MW of which 25 thousand MW is economically feasible. However, the production of hydropower is less than one percent of the total hydropower potential. The annual growth rate of electricity consumption during 1984/85-1994/95 was 9.1 percent At present, about 14 percent of the population has access to electricity (Ninth plan).

The fifth regression equation establishes a relationship between electricity consumption and time. The estimated slope coefficient is found to be 0.09. Changes in time are positively related to electricity consumption. The annual growth rate of electricity demand is about 9 percent. This highlights the importance of electricity consumption over the change in time. R^2 is high enough to justify that 97 percent change in electricity consumption has been associated with the time. The overall significance of the estimated trend is appreciable for the reason that F-ratio is seemed very high.

4. Energy and National Output

Economic production has been defined as the process in which fuel, capital and labour are combined to transform natural resources into goods and services produced. the quality of these products ultimately depends on the quantity of economic energy available and the efficiency with which that energy is used (Hall et al. 1986). However, the principal concern of this article is not to establish such relationship between energy use and GDP. But it is certainly true that the principal concern here is to relate energy use to total economic output

that may effect income elasticity. In this context, focus will be given to calculate income elasticity with the help of following models:

(a) $\ln TCEC = \alpha_0 + \alpha_1 \ln GDP$

(b) $\ln PPC = \alpha_0 + \alpha_1 \ln GDP$

(c) $\ln EC = \alpha_0 + \alpha_1 \ln GDP$

Where, TCEC = Total commercial energy consumption in thousand TOE.
PPC = Petroleum product consumption in thousand TOE.
EC = Electricity consumption in thousand TOE.
GDP = Gross Domestic Product at real prices (1984/85 = 100)

The estimation technique of the above regression equations is the method of least square. The values of the variables are expressed in per capita terms. Following diagrams shows the relationship between energy used and GDP in Nepal during 1991-2001.

The GDP in real prices and energy consumption are measured in x and y axes respectively in the diagrams 1,2 and 3.

Diagram 1: Relation Between Commercial Energy and GDP.

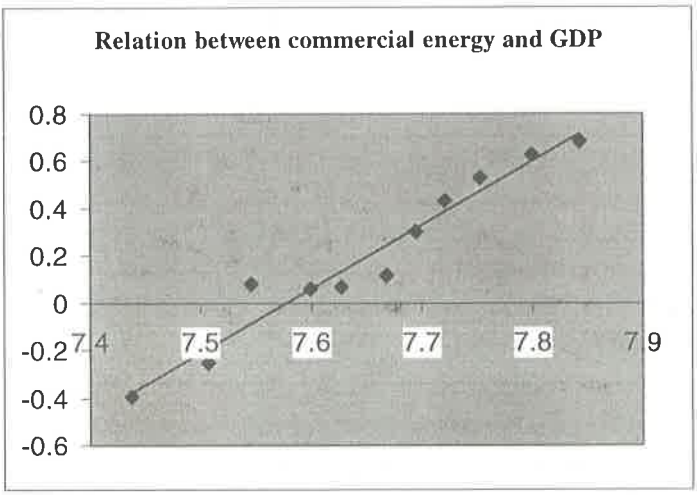


Diagram 2: The relationship between POL products and GDP

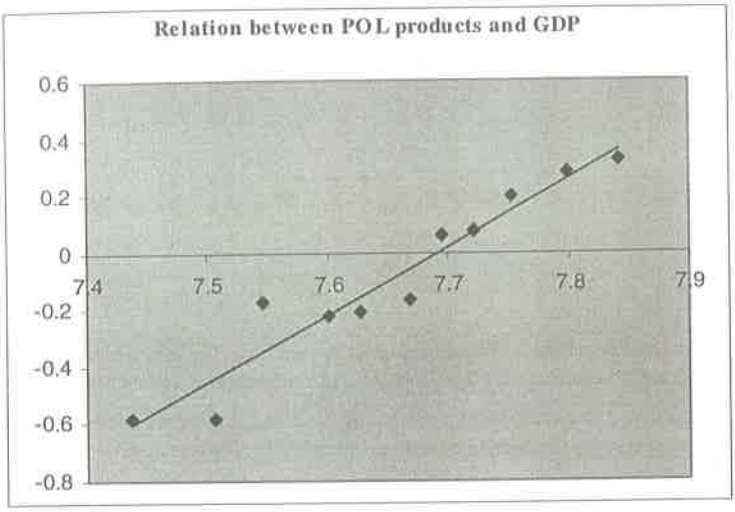
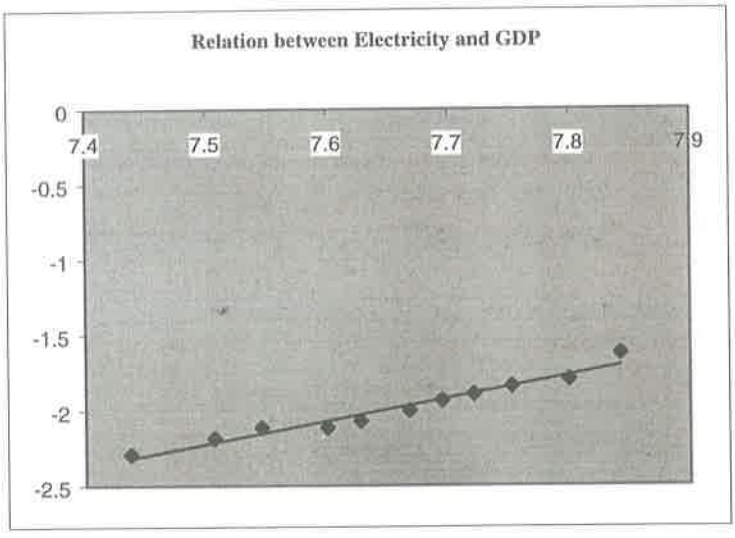


Diagram 3: Relationship between Electricity consumption and GDP



The regression coefficients of the above models are presented in the table below:

Table 4: Income elasticity of per capita energy consumption.

Energy sources	Estimated slope coefficients	R^2	t-values
Total commercial energy	2.69	0.95	13.13
Petroleum product	1.74	0.92	10.44
Electricity	1.49	0.95	14.63

First of all let us deal with the income elasticity of total commercial energy consumption in Nepal. From these regression results (table 4) we know that the income elasticity coefficient is 2.69. It implies that for a one percent increase in the per capita real non-agricultural GDP the total per capita commercial energy consumption on average increases by about 2.69 percent. Since the income elasticity of per capita energy consumption is greater than one, we can say that per capita commercial energy consumption is income elastic. The value of R^2 shows the fit of the regression line implying that about 95 percent of the variation of the per capita commercial energy consumption is explained by per capita non-agricultural GDP.

Similarly, the income elasticity of the consumption of petroleum products is 1.74. It implies that for a one percent increase in the per capita real non-agricultural GDP the consumption of per capita petroleum product on average increases by about 1.74 percent. The income elasticity of per capita petroleum product consumption is greater than one meaning that one that per capita consumption of petroleum products is income elastic. The value of R^2 is 0.92 meaning that about 92 percent of the variation of the per capita consumption of petroleum product is explained by per capita non-agricultural GDP. It also suggests that the regression line fits the data very well.

Coming to per capita electricity consumption, the estimated coefficient is low as compared to the per capita consumption of petroleum product. It is an amazing fact that despite Nepal's high potential of hydropower generation, electricity could not contribute a significant amount to total energy consumption. However, the income elasticity of the consumption of electricity is positive as well as greater than one. The value of the income elasticity of the per capita electricity consumption is 1.49. It implies that for a one percent increase in the per capita real non-agricultural GDP the per capita electricity consumption, on average increases by about 1.49 percent. The value of R^2 is 0.95 suggesting that the regression line fits the data very well. It implies that, about 95 percent of the variation of per capita electricity consumption is explained by per capita non-agricultural GDP. The income elasticity of the per capita consumption of electricity is income elastic.

5. Forecast of Energy Consumption

The estimated relationship between energy consumption and time can be used to forecast energy consumption. Of course, one needs to estimate future levels of real GDP and population prior to use the estimated equations to forecast energy consumption. However,

assuming the present constant growth rate of real GDP as well as population makes the energy forecasting for future. It is assumed that the annual growth rate of population will remain 2.24 percent per annum and the real GDP growth rate will be around 4 percent per annum. Given this constant growth rate of population and real GDP, the future energy is estimated with the base of the energy consumption data of 1994/95.

Table 5: Estimated Energy Consumption (in million Gj)

Energy Type	1994/95	2004/05	2014/15	Growth Rate (1994/95- 2014/15)
Biomass	262.3	302.5	369.5	1.7
Commercial	23.1	58.3	149.3	9.8
Coal	2.8	4.2	7.6	5.1
POL products	17.5	54.7	164.4	11.9
Electricity	2.8	6.6	16.3	9.1
Total	308.5	426.3	707.1	4.2

The energy estimated results already show an increasing trend of consumption of energy in Nepal. Biomass fuel energy will increase at an annual growth rate of 1.7 percent during 1994/95-2014/15. The consumption of biomass fuel was 262.3 million GJ in 1994/95 and estimated value shows it will reach 369.5 million GJ in 2014/15. There will remain a high annual growth rate of the consumption of commercial energy during the same period of time. It increases at 9.8 percent per annum. The consumption of commercial energy was 23.1 million GJ in1994/95. It will reach 149.3 million GJ in 2014/15. There is six-fold increase in the consumption of commercial energy during 1984/85 to 2014/15. The past trend shows that there is a declining trend in the consumption of coal. However, in the coming years the coal consumption in Nepal will increase by an annual growth rate of 5.1 percent. It is observed that there is a higher annual growth rate of the consumption of imported hydrocarbons in Nepal. It is expected that the continuation of imported hydrocarbons at this rate of growth per annum, Nepal will face acute problem in its balance of payments that will occur from the high degree of trade deficit. There is only one option to keep the consumption of imported hydrocarbons intact, Nepal should generate substantial amount of hydroelectricity from its abundant water resources and sell to other countries that can generate foreign currency in order to solve the acute problems of balance of payment. If this step is not taken seriously under consideration Nepal should reduce the consumption of imported hydrocarbons to minimum level. There will be nine-fold increase in the consumption of hydrocarbons during 1994/95-2014/15. Similarly, the historical fact shows that there is an increasing trend in the consumption of electricity in Nepal that need to generate additional elasticity by investing huge amount of money in this sector.

It is observed from Table 5 that the total energy consumption will increase at an annual growth rate of 4.2 percent. There will be more than double in the consumption of energy in 2014/15 to that of the consumption of energy in 1994/95.

6. **Conclusion**

While dealing with the energy consumption in Nepal, the second set of regression equation shows that there is a strong relationship between energy consumption and economic development. The elasticity coefficients are greater than one. This fact reveals that an increase in per capita real GDP will increase the amount of per capita energy consumption. The future energy consumption is made with the help of first set of regression equations, which reveals that energy consumption in Nepal will increase over time.

Annex

Annex Table 1: Conversion factor

Fuel wood:	1 ton	=	16.75 GJ
Agricultural residue:	1 ton	=	12.56 GJ
Animal waste:	1 ton	=	10.89
Coal:	1 ton	=	25.12 GJ
Petroleum:	1 KL	=	45.75 GJ
Electricity:	1 MWh	=	3.6 GJ

Annex Table 2: Energy consumption

Year	Energy Consumption					
	Fuel wood (MT)	Ag.Res (MT)	Anm.Waste (MT)	Coal (MT)	Petroleum (KL)	Elect (MWh)
1984/85	9,465	2,105	1,850	145	147	287
1985/86	9,669	2,137	1,878	17	139	320
1986/87	9,769	2,281	1,898	91	177	382
1987/88	9,953	2,414	1,981	84	171	449
1988/89	10,142	2,554	1,938	76	185	479
1989/90	10,256	2,707	1,959	12	223	525
1990/91	10,503	2,864	1,979	81	230	589
1991/92	10,780	3,031	2,000	92	293	652
1992/93	10,979	3,207	2,021	110	359	694
1993/94	11,460	3,288	2,094	104	353	706
1994/95	11,715	3,418	2,124	113	382	787
Growth rate	2.0%	4.5%	1.3%	-2.2%	9.1%	9.6%

Source: WECS, 1996.

AnnexTable 3: Consumption of Energy in '000GJ

Year	Fuel wood	Ag.waste	Ani waste	Total	Coal	POL	Elect	Total	Gtotal
1984/85	158539	26439	20146	205124	3642	6725	1033	11400	216524
1985/86	161956	26841	20451	209248	427	6359	1152	7938	217186
1986/87	163631	28649	20669	212949	2286	8098	1375	11759	224708
1987/88	166713	30320	20887	217920	2110	7823	1616	11549	229469
1988/89	169879	32078	21105	223062	1909	8464	1724	12097	235159
1989/90	171788	34000	21334	227122	301	10202	1890	12393	239515
1990/91	175925	35972	21551	233448	2035	10523	2120	14678	248126
1991/92	180565	38069	21780	240414	2311	13405	2347	18063	258477
1992/93	183898	40280	22009	246187	2763	16424	2498	21685	267872
1993/94	191955	41297	22804	256056	2612	16150	2541	21303	277359
1994/95	196226	42930	23130	262286	2839	17477	2833	23149	285435

Source: Calculated from Annex II.

Annex Table 4: Population, GDP and Energy

Year	Population*	GDP**	NGDP**	Commercial**	POL prod**	Electricity**
1991	18.49	59768	31396	12.49	10.31	1.87
1992	18.94	62537	34461	14.70	10.57	2.13
1993	19.34	64586	36690	21.01	16.37	2.34
1994	19.86	69686	39669	21.10	15.49	2.39
1995	20.34	71685	41768	21.78	16.62	2.56
1996	20.83	75773	44534	23.40	17.73	2.81
1997	21.33	79388	46859	28.90	22.72	3.07
1998	21.84	82116	49249	33.70	23.61	3.28
1999	22.36	85789	52028	38.00	27.06	3.54
2000	22.9	91317	55878	42.75	30.22	3.79
2001	23.45	96612	59759	46.33	32.22	4.60

Source: ** Economic Survey, MOF/HMG, 2001. * Statistical Pocket Book, 2000.

Note: GDP = Gross Domestic Product in million rupees, Com=commercial energy (in millionGJ), POL = petroleum product consumption(in million GJ), Elect = electricity consumption (in million GJ), pop = population in million and NGDP = non-agricultural GDP in million rupees.

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