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Energy Demand Forecast In Nepal: Issues And Options

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INTRODUCTION

Literally, as well as practically, to forecast is to predict future events or actions. The predictor generally takes past values as the basis of forecasting. Forecasts of the future events are based on certain assumptions for all forecasts involve some kind of uncertainty. Using regression analysis generally makes predictions of future events on the basis of past values. It requires variables of two types: dependent variable that has to be forecasted and independent or explanatory variable which is the basis of forecasting. To forecast the former on the basis of the latter variable, the predictor either uses time series data or cross sectional data. Regression analysis expresses the casual relationship between two or more than two variables under consideration.

Time series data reflects the values in a chronological sequence of observations of a particular variable. In time series models, historical data on the variable to be forecasted is analysed in an attempt to identify a data pattern. The forecaster then may assume this pattern will continue in the future. Extrapolation of data is necessary in order forecast. While modeling time series data, the basic assumption is that the data pattern that has been identified will persist in the future. In casual models, the assumption is that the relationship between the dependent variable will hold. Uncertainty arises in casual model forecasting because assumption must be made on the values of the independent variable before a forecast can be made.

Following are the basic sectors, which have to be considered in choosing a forecasting technique:

— The objective of forecasting.

— The time frame.

— The pattern of data.

— The cost of forecasting.

— The accuracy desired.

— The ease of operation and understanding.

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TREND ANALYSIS

Time series data involves an increasing or decreasing pattern of values over time. The smoothly increasing or decreasing pattern of data is said to contain a trend. Various time series data such as energy consumption, GDP, GNP and other related indicators appear to be in a trend. These trends appear due to increase in population, improvements in technology and increase in wealth or combinations of these effects. One can make use of this trending behavior of data. Trend analysis uses mathematical formulae to fit a past series of values with time. Projections are then made by extrapolation. The data may be first transformed before they are used for curve fitting. Thus, in this light, trend analysis is a time series forecasting method.

The trending behavior of the time series data requires some mathematical formulae to fit a past series of values with time as independent variable. There are some uncertainties to use trend analysis in forecasting.

— It makes no attempt to discover the factors affecting the behaviors of the system.

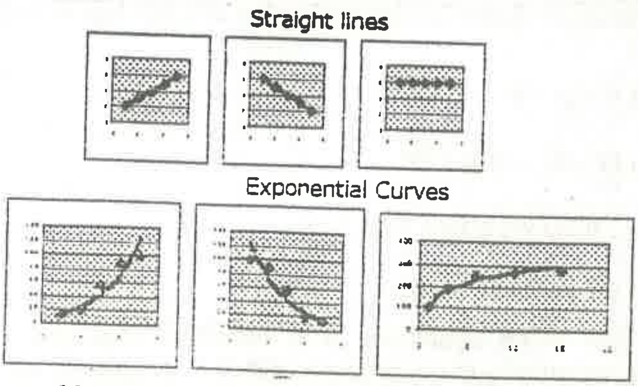
— It may be extremely difficult to measure the relationship.

— The major concern may be only to predict what will happen and not to know why it happens.

ESTIMATING A CURVE

Various growth curves can be used to fit the trending data. However, in common practice simple curves such as a straight-line on an exponential are used to fit the data. For data tending to saturation level, growth curves are normally used. Some of the commonly used trends are shown in the figures below:

Figure 1
Possible Shapes Of the Curves With Time Trend



Source : Prepared by the Author based on the basis of imaginary data.

From the above figures it is seen that in several cases a unique curve is not a possibility. In such a situation, the user can fit all the possible curves under consideration. After fitting the possible curves, the user can examine which curve gives the best fit. The most commonly used curve fitting techinique is the ordinary least square (OLS) method. However, various non-linear curve fitting technique are also available. For these non-linear curve-fitting techniques, it is possible to make them linear by logarithmic transformation. The user can follow this procedure to apply the OLS method.

There are numerous mathematical formulae to be used to analyse trending. Some of them are chosen here to represent the theoretical trends. Following formulae contain few parameters, which may be the good candidates :

— The straight line : $y = a + bt$

— The exponential curve : $y = \exp(a + bt)$

— The parabolic curve : $y = a + bt + ct^2$

— The modified exponential curve : y = s + ae x p)bt)

— The Gompertz curve : y = s*exp [a* exp (bt)]

— The logistic curve : y = s/[1 + a*exp (bt)]

Where, y is the time series of interest.

t is the time

s is the saturation level, and

a, b, c are formulae parameters.

The above formulae can be transformed in the semi-logarithmic form in order to apply the OLS method because this process gives linearity to the dependent variable. Some of the examples of semi-log transformation are shown below.

— In y = a + bt

— In (Y - S) = In a + bt

— In [In (s/y)] = In a + bt

— In (s/y-1) = In a + bt

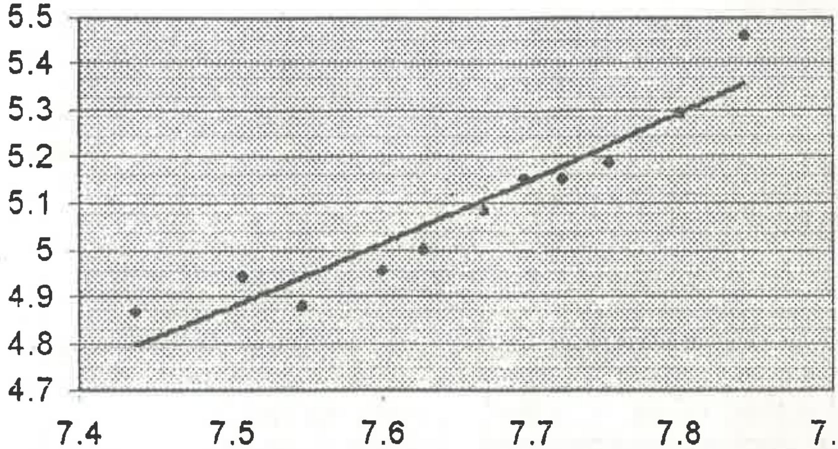
In the last three equations it is assumed that saturation level is known. If the value of s is not known and it is treated as a parmeter to be estimated, non-linear fitting need to be used.

THE APPLICATION OF TREND ANALYSIS IN ENERGY DEMAND

Here, an attempt is made to show the example of trend analysis in the energy demand analysis. In Nepal the consumption of electricity has increased exponentially over the last decade. The exponential growth trend can easily be detected if the consumption is plotted against time. There is a strong correlation between per capita energy consumption and per capita non-agricultural GDP. The time series data of per capita electricity consumptiion and per capita non-agricultural GDP between 1991 and 2001 of Nepalese economy is plotted in logarithmic scale which is shown in the following diagramme.

Figure 2

Per Capita Electricity Consumption And Per Capita Non-agricultural GDP



Source : Prepared by the Author on the basis of secondary data, Economic Survey 2001, MOF.

The 1991 - 2001 data is used to fit the following selected simple models.

Ln (EC) = a + bt .... (1)

Ln (EC) = a + bin (NGDP) .... (2)

Ln (NGDP) = a + bt .... (3)

Where, EC = Electricity consumption in million GJ

T = Time

NGDP = Non - agricultural GDP in million Rupees.

The estimated equations are given below.

Ln (EC) = 4.77 +).059 t .... (4) $r^2 = 0.92$

Ln (NGDP) = 7.43 +).038 t .... (5) $r^2 = 0.99$

Ln (EC) = -5.5 + 1.4 In (NGDP) .... (6) $r^2 = 0.90$

Based on the r^2 values the models give fairly good firts. The estimated electricity consumption and non - agricultural GDP are given in the following table (Table 1).

Table 1
Projected Electricity Consumption In GJ And NGDP
(In Nepalese Rupees)

Year	Using Equation 4	Using Equation 5	Using Equation 6
2002	239	240	2643
2003	254	253	2744
2004	269	267	2849
2005	286	281	2958
2006	303	296	3071
2007	322	312	3189
2008	341	329	3311
2009	362	347	3438
2010	384	366	3570
Av. Annual growth rates	5.5	5.4	3.8

Source : As of the Figure 1.

Observing the projected electricity consumption there is no much variations in the forecasted values using equation 4 and 5. Therefore, the trend analysis is fairly good to use energy demand projection for the short period of time. However, in the long run trend analysis will not show fairly good or approximates projected values to theat of observed values. The second and third columns show projected per capita electricity consumption and last column represents the projected per capita non-agricultural GDP.

ENERGY CONSUMPTION AND ECONOMIC GROWTH

Nepal's energy consumption is characterised by a low level of per capita consumption. WECS estimated it at about 14GJ. In terms of commercial energy consumption, Nepal has high growth rate. The table 2 shows that during the period 1990-93, approximately 27 percent increase in commercial energy consumption has been observed. When comparing to the growth rates of energy consumption the growth rate of total energy consumption is less than the GDP growth rate.

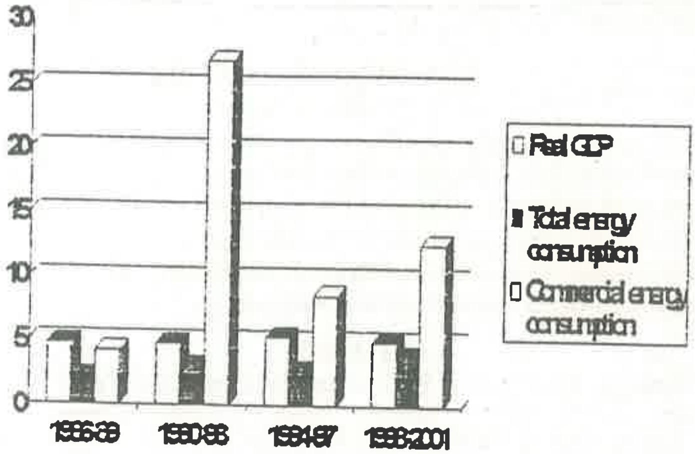
When the growth rate of energy consumption is viewed to that of the growth rate of GDP in Nepal during 1985-2001 the growth rate of CEC has the greater growth rate than the GDP growth. During the period, 1986-89, the growth rate of commercial energy consumption is slightly lesser than the growth of GDP, However, it is a surprising fact that during the period 1990-93, commercial energy consumption increased at 5.6 times the growth rate of GDP and followed 1.5 times and 2.5 times the growth GDP during the period 1994-97, and 1998-2001 respectively.

Table 2
The Growth Rate Of Energy Consumption And GDP

Particulars	1986-89	1990-93	1994-97	1998-2001
Real GDP	4.8	4.8	5.3	5.0
Total energy consumption	2.2	3.0	2.7	3.9
Commercial energy consumption	4.3	26.9	8.6	12.6

Source : As of the Figure one

It can be Illustrated Through Bar Diagramme as follows :



Source : Economic Survey, 2001.

RELATIONSHIP BETWEEN ELECTRICITY CONSUMPTION AND NON-AGRICULTURAL GDP

A standard of measuring economic activity is essential for examining the relation between national fuel use and the production of material goods. To examine between energy, electricity, consumption and national output here, an attempt is made to show the relationship between energy, electricity, consumption and non-agricultural GDP as the output. The performance of an economy is primarily based on the availability of commercial energy. Electricity is only the indigenous source of Nepal.

Nepal is second richest country after Brazil with respect to water resources. Owning to such vast hydropower potential, 83000 MW, less than one percent of it is utilized. Accessibility of electricity is limited to 14 percent of the population of Nepal. However, the accessibility of electricity is again limited to the urban population of the country. Electricity contributes 1.4 percent and 9.9 percent to the total energy consumption and total commercial energy consumption in the fiscal year 2000/01 respectively.

The Energy Efficiency

Energy efficiency is a concept used differently by different users. It has a variety of meanings depending on the perspectives of the observer. Economists define efficiency in relation to *pereto optimality*, which is the pattern of allocation of scarce resource so that no one can be made better off without making someone else worse off. Accordingly, efficiency is defined in terms of the quantity of fuel is used to provide a unit of economic output. Thus, the most commonly used index of an economic system's energy efficiency is the ratio of fuel used by that system in a given period to the real GNP produced during that pariod.

$$\text{Thus, Energy efficiency} = \frac{\text{Total fuel used in period t}}{\text{GDP produced in period t}}$$

To keep this concept into practice, an attempt is made to calculate electricity consumption efficiency in Neplaese economy. The electricity consumption and non-agricultural GDP during 1984/85-2000/01 has been taken to calculate the energy, electricity, efficiency.

The time series data are used to find the energy, electricity, efficiency. The data are taken from the secondary sources.

Table 3
Energy, Electricity, Efficiency In Nepalese Economy

Year	Efficiency	Year	Efficiency	Year	Efficiency
1985	0.014	1991	0.021	1997	0.022
1986	0.015	1992	0.021	1998	0.021
1987	0.017	1993	0.021	1999	0.022
1988	0.018	1994	0.020	2000	0.023
1989	0.018	1995	0.020	2001	0.026
1990	0.019	1996	0.021		

Note : Electricity Intensity of KWh per 1 million rupees.

Source : As of the Table 2.

The average energy, electricity, intensity in Nepalese economy has been only two percent per annum during 1985-2001. This low energy, electricity, intensity has been attributed to following reasons :

The tariff of electricity in Nepal is very low compared to the cost of electricity production. Due to the low level of price per unit the producers as well as consumers do not care about its consumption efficiently. The producers use obsolete machineries in their factories that consume huge unit of electricity when they are in the operation. Similarly, the consumers are also using electricity inefficiently due to the low tariff, which does not give burden feelings to them.

There is the loss of one-fourth of total electric power every year in Nepal. Loss of power is mainly due to the inefficiency in the transmission and distribution of line.

Energy Income Elasticity

Now, I am turning to estimate the energy income elasticity in Nepalese economy. Despite of the lack of adequate data, attempt is made to fit the following type of models taking time series data of the period of 1985-99.

$$\text{Ln TEC} = \alpha_0 + \alpha_1 \text{ InrGD} \quad (1)$$

$$\text{Ln TEC} = \alpha_0 + \alpha_1 \text{ InrGDP} + \alpha_2 \text{InN} \quad (2)$$

$$\text{Ln CEC} = \alpha_0 + \alpha_1 \text{ InrNGD} \quad (3)$$

$$\text{Ln CEC} = \alpha_0 + \alpha_1 \text{ InrNGDP} + \alpha_2 \text{InN} \quad (4)$$

$$\text{Ln EC} = \alpha_0 + \alpha_1 \text{ InrNGDP} \quad (5)$$

$$\text{Ln EC} = \alpha_0 + \alpha_1 \text{ InrNGDP} + \alpha_2 \text{InN} \quad (6)$$

Where, TEC = Per capita total energy consumption in GJ

CEC = Per capita commercial energy consumption in GJ

EC = per capita commercial energy consumption in KW

RGDP = Per capita real GDP

RNGDP = Per capita non-agricultural real GDP

N = Population

α_0, a_1 and α_2 are the parameters and

α_1 signifies the energy income elasticity.

Empirical Results

The estimated values of each of the models is presented in the following table (Table 4).

Table 4
The Estimation Results Of The Equations 1, 2, 3, 4, 5 and 6

Model	α_0	t-stat	α_1	t-stat	F	R^2
1	2.41	37.08	0.023	3.08	9.98	0.42
2	1.45	5.42	-0.11	- 2.99	15.75	0.72
3	-13.7	-9.2	1.82	9.13	83.4	0.87
4	-11.8	-2.96	0.90	0.57	39.5	0.87
5	-11.23	-5.58	1.21	4.49	20.12	0.61
6	-14.5	-2.12	1.35	0.56	9.92	0.61

Source : Calculated by the Author based on the data as of the Table 1.

In model 1, total energy consumption, including traditional and commercial, is considered. From the model it is found that the income elasticity coefficient is 0.0023. It implies that for a one percent increase in the per capita GDP the total pre capita energy consumption on average increases by about 0.0023 percent. Since the imcome elasticity of per capita income elasticity is less than one, we can say that per capita total energy consumption is income inelastic. The value of r^2 shows the fit of the model implying that only about 42 percent of the variation of the per capita total energy consumption is explained by per capita real GDP.

Model 1 shows inelastic value of income elasticity. Model 2 incorporates population as an explanatory variable. It captures the effect on income elasticity via a population. However there is no improvement in the income elasticity. R^2 is 0.72, which shows the fit of the model. However, the elasticity coefficient is negative. It reveals that there is no improvement in the income elasticity.

Model 3 incorporates the per capita commercial energy consumption as dependent variable and per capita real GDP as an explanatory variable. From the table it is found that elasticity coefficient is 1.83. It implies that for a one percent increase in the per capita real non-agricultural GDP total per capita energy consumption on average increase by about 1.83 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 the r^2 shows the fit of the model implying that about 87 percent of the variation of the per capita commercial energy consumption is explained by per capita non-agricultural GDP.

Using model 4 to the same with population as an additional explanatory variable, it is found that the coefficient of income elasticity is less than one. There is no improvement in the value of income elasticity. However, the value of coefficient of determination remains the same.

Model 5 incorporates the per capita electricity consumption as a dependent variable and per capita real non-agricultural GDP as an explanatory variable. From the table it is seen that the estimated coefficient is low as compare to the per capita consumption of total commercial energy consumption. It is an amazing fact that despite Nepal's high potential of hydropower generation electricity could not contribute a significant amount to total commercial energy consumption.

However, the income elasticity of the consumption of electricity is positive as well as greater than one. The coefficient of income elasticity of the per capita electricity consumption is 1.21. It implies that for a one percent increase in the per capita real non-agricultural GDP, the per capita electricity consumption, in an average increases by about 1.21 percent. In this model, it is found that the value of coefficient of determination is moderate. It is found only 0.61 and suggesting that 61 percent of the variation of per capita electricity consumption is explained by per capita non-agricultural GDP. However, the coefficient shows that the income elasticity of the per capita electricity consumption is income elastic.

Now turning to last model, there is an additional explanatory variable i.e. population. Three variables under consideration are correlated. There is an improvement in the value of income elasticity compared to the value of model 5. In this model, the coefficient of income elasticity is 1.35 while the value of coefficient of income elasticity is 1.21 while the value of coefficient of determination remains the sme.

CONCLUSION

The low level of per capita commercial energy consumption characterises developing countries like Nepal. Developing countries are facing a great challenge of environmental degradation, deforestation, desertification, poverty alleviation, poor health of the people, unfavorable balance of payment and low economic growth. These issues are directly or indirectly related to energy use, availability and pattern of its consumption. Today developing countries make various efforts to overcome these issues. The income of a country has the close and positive relationship with energy consumption. Energy security, and conservation for achieving high economy growth is one of the most important function of developing countries. How much energy is needed to achieve specified economic growth and what is the role of energy in changing lifestyle of people are the major concerns in modern era. To answer these questions, quantitative forecasting of energy requirement is needed. Some of the widely used model of energy demand forecasting are presented and taking time series data of Nepalese economy also makes possible application of these models, fuelwise income elasticity revealed that there is the high responsiveness of energy demand in Nepalese economy.

Environmental degradation, deforestation, desertification, poverty alleviation and health hazards of the people are the major concern of developing countries of the world today. These issues are directly or indirectly related to energy use and pattern of its consumption. In order to save our common earth now is depleting from one form to another desertification, ecological imbalance etc., protecting health hazards of people, reducing poverty, correcting balance of payment and providing better and efficient form of energy, energy development programmes, its security and conservation has become major concern to daveloping countries. These issues can be addressed by achieving high economic growth for which energy is one of the major ingradient or component to be developed. An essential factor of examining energy consumption pattern in developing countries, lifestyle of people, relationship between income and energy consumption, analysis of energy efficiency etc. is to forecast the energy demand in an economy. Wide research, comprehensive analysis of energy use, energy resource base etc. will provide the basis of energy demand forecasting. Here, an attempt is made to provide some basic tools to use when analyising energy demand forecasting in developing countries. Trend analysis will provide the basis of energy demand forecasting. However, the developing countries are characterised by the lack of adequate and cormprehensive data. So, the researchers should be aware of using this method to estimate energy demand.

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APPENDIX

Table A
Population, GDP and Energy Consumption

Year	Population in million	GDP in million Rs.	Agri. GDP in mRs	Nagri. GDP inmRs.	Petroleum in OOOtoe	Elrct. In OOOtoe	Total comm. energy in OOOtoe	Total energy cons. In OOOtoe
1985	15.9	44441	22761	21680	151	51	255	5035
1986	16.3	46512	23376	23136	158	24	267	5149
1987	16.8	47427	23213	24214	164	27	201	5189
1988	17.2	50761	24735	26026	193	32	279	5377
1989	17.6	53518	26260	27258	186	38	274	5482
1990	18.1	56151	27774	28377	204	40	289	5610
1991	18.49	59768	28372	31396	242	44	293	5688
1992	18.94	62531	28070	34461	248	50	346	5901
1993	19.39	64586	27896	36690	384	55	493	6168
1994	19.86	69686	30017	39669	374	56	495	6294
1995	20.34	71685	29917	41768	390	60	511	6436
1996	20.83	75773	31239	44534	416	66	549	6604
1997	21.33	79386	32529	46859	533	72	677	6862
1998	21.84	82116	32867	49249	554	77	791	7112
1999	22.36	85789	33761	52028	635	83	892	7350

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

Table B
Basic Energy Conversions

Unit	Gigajoules (GJ)	Tonnes of coal equivalent	Tonnes of oil equivalent
Tonnes of coal equivalent	29.307600	1.000000	0.680272
Tonnes of oil equivalent	43.082200	1.470000	1.000000

Table C
Energy Content of Traditional Fuels

	Physical Unit	GJ	tce	toe	Other
Fuel wood	Ton	16.7	0.57	0.39	1.43 m^3
	Cu.m.	11.7	0.4	0.27	700 kg
Charcoal	Ton	28.9	0.99	0.67	2.86 m^3
	Cu.m.	10.1	0.35	0.23	350 kg
Animal dung	Ton	10.9	0.37	0.25	-
Biogas	000 cu.m.	24.2	0.83	0.56	-
Agric. Waste	Ton	12.6	0.43	0.29	-

Table D
Energy Content of Commercial Fuels

	Natural Unit	GJ	Tce	toe	Other
Diesel	K litre	37.8	1.29	0.88	0.826 ton
	Ton	46.0	1.57	1.07	12101
LDO	K litre	39.3	1.34	0.91	0.853 ton
	Ton	46.0	1.57	1.07	11721
Petrol	K litre	33.4	1.14	0.78	0.709 ton
	Ton	47.2	1.61	1.10	14111
Kerosene	K litre	36.3	1.24	0.84	0.778 ton
	Ton	46.6	1.59	1.08	12851
Av. Tur.	K litre	36.3	1.23	0.84	0.776 ton
	Ton	46.6	1.59	1.08	12881
F. Oil	K litre	41.3	1.41	0.08	12881
	Ton	44.3	1.51	1.03	10711
LPG	Ton	49.2	1.68	1.14	-
Coel	Ton	25.2	0.86	0.59	-
Electricity	MWH	3.6	0.12286	-	-
	Ton	46.6	1.57	1.07	1210
Natural Gas	1000 m3	36	1.56	1.09	-

Source : ADB, 1992, WECS 1994, PEP 1995