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A Forecast of Coal Demand in Nigeria

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Abstract: The immediate introduction of coal into the Nigeria energy mix has now assumed a level of urgency occasioned by the perennial scarcity of petroleum products. The study identifies the various variables in coal demand forecast in Nigeria. The empirical findings of the study reveal that coal demand would continue to increase in Nigeria but not in appreciable quantity. The policy implications of the findings include the need to stimulate coal demand in Nigeria by initiating intensive educational campaign to raise public awareness of the benefits of using coal at the industrial and household level.

Key words: Coal demand, energy mix, household level, Nigeria

INTRODUCTION

Energy availability in Nigeria and its supply has been a source of constant friction between the people and the government. This however, should not be so because among the abundant energy resources such as oil, gas, wood, solar, hydropower and coal available in Nigeria, only the oil and gas sector have so far being well developed. The industrial and domestic sectors of the Nigerian economy continue to suffer from perennial shortage of energy. This shortage has led to acute energy crisis at the household level. The bulk of the energy use for cooking at household level in Nigeria is mainly derived from wood-fuel and fossil fuel (kerosene) (Adeoti *et al*., 2000). Although, fossil fuels are depletable fuels, however recent discoveries of more coal and other fossil fuels worldwide indicates that these fuels will be with us for a long time than predicted the various energy experts. In Nigeria, coal was mostly used for power generation and as industrial fuel: until recently in the production of smokeless coal briquettes (Adebimpe *et al*., 2001).

As at 1999, the domestic demand for coal in Nigeria stands at about 20,000 metric tons per annum while the export demand is in excess of 15 million metric tons per annum (Iwu, 1990). However, in Bostwana, the total demand for beneficiated coal is 100,000 tons for use in industry and public institutions. Of this 25-30% is estimated to be for use in public institutions and 2-3% will be available for households (Diphaha, 1994). Mainly because of its low cost, an important consideration in many developing countries, coal can often be a good substitute for other energy sources-for example in industrial heating, power generation, household cooking and space heating (Mao, 1994).

The objective of this study therefore, is to forecast coal demand in Nigeria. Information from this study will assist the government in its energy resources diversification programme and also the investors in decision-making before committing their financial resources to coal/coal briquette production in Nigeria.

Potentials of the Nigeria coal: Available data show that coal (mainly sub-bituminous steam coal except for the Lafia-Obi bituminous coking coal) occurrences in Nigeria have been indicated in more than 22 coal fields spread in over 13 states of the Federation. The proven coal reserves so far in Nigeria total about 639 million metric tons while the inferred reserves sum up to 2.75 billion metric tones (Coal News, 1999). In addition, an estimated 400 million tons of coal lie untapped under the soil of Enugu (Coal News, 1999).

Presently the Nigerian coal industry has four existing mines at Okpara and Onyeama underground mines in Enugu State, Okaba, -Odagbo open cast mine in Kogi State and Onwukpa underground mine in Benue State. Okpara and Okaba mines are operational while Onyeama and Owukpa are slated for reactivation and private sector participation through product sharing joint venture arrangement. Coal and lignite occurrences are widespread in Nigeria and other locations include Delta, Nassarawa,

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Anambra, Ebonyi and Imo States. Others are Gombe, Bauchi, Ondo, Edo, Kwara, Adamawa and Plateau States. Nigerian coal and lignite are environmentally friendly because of their low sulphur (<1%) and generally low ash (< 1%) contents and is therefore acceptable for direct application and usage as domestic and industrial fuel (Coal News, 1999).

World coal demand: Coal is one of the world's major energy sources providing in year 2000, 24.9% of the world primary energy requirements (International Institute for Environment and Development, 2002). Demand for coal is projected to rise by 1.4% per year but coal's share in world primary energy demand will still fall a little, from 20% in 2000 to 24% in 2003 (Coal Industry Advisory Board, 2003). Coal in 2030 is projected to cover 33% of world primary energy demand and 53% of electricity generation (World Energy Congress, 2004). Coal consumption is projected to increase from 1.051 billion tons in 2001 to 1.444 billion tons in 2025 and coal for electricity generation constitutes about 90% of the total coal demand in United States of America (United States Energy Association, 2003).

China and India together account for almost three-quarters of the increase in world coal demand. In all regions coal use becomes increasingly concentrated in power generation, which accounts for almost 90% of the increase in demand between 2000 and 2030 (Coal Industry Advisory Board, 2003). For instance, domestic coal demands in China in 2002 reached 1370Mt, accounting for 66% of the total primary energy consumption in China (Yougou, 2003). Japan total primary energy supply, which was 459 million ton oil equivalent (toe) in 1990 reached 456 million toe in 2001 indicating an increase of 1.6% year for the period (Minuroto and Koizumi, 2003).

Socio-economic profile of Nigerian households: Nigeria has a land area of 923,300 km^2 and a population of 140 million by the 2006 population census figures. Nigeria's per capita income which plunged from $1000 in the early 1980's to $320 and further down to about $250 in the 1990's, gives an indication of the pervasiveness of her citizens poverty and also 45% of the population of the poor are extremely poor (Oladunni, 1999). Data from the Federal Office of Statistics (FOS) on poverty profile in Nigeria showed that the incidence of poverty rose from 28.1% in 1980 to 46.3% in 1985 but dropped slightly to 42.7% in 1992 from where it rose sharply to 65.6% in 1996 (Awoseyila, 1999). However, household sizes are generally higher in the rural areas than in the urban areas. In 1990 it was 5.6 in rural areas and 4.8 in urban centers while the average is 4.75 (FOS, 1996).

Information on average rural household income put at about 4,820 naira as of 1998 becomes relevant in the computation of coal demand (FOS, 1998). Approximately 20.5, 27.3 and 33.0% of households in Nigeria had electricity in 1981/82, 1990 and 1993/94, respectively and also there are significant state variation in the percentage of households with electricity. For instance in Taraba State, the percentage of household with electricity was 5.11, while in Lagos State the percentage was 97.32 (FOS, 1996).

Model description

Energy demand model: In the study of energy demand, energy demand models are usually used. These models are used for quantitative analysis of energy demand and its timely variation. Energy demand model MADE II (Model for Analysis of Demand for energy) has been developed on the basis of statistical, econometric and engineering process techniques (Saboohi, 1989). The model is used to project into future energy demand based on the assumption that economic determinants such as price of substitute fuel and income are very important factors of energy demand.

Energy demand is a function of prices of fuels (preferred fuel and substitute fuel) and income can be described using the following equation (Saboohi, 1989):

$$E_j = a\, P_i^{\alpha} P_j^{\beta} I^{\delta} \quad (1)$$

Where,

E_j : The demand for coal.
P_i : The price of kerosine.
P_j : The price of substitute fuel.
I : The minimum income.

The coefficient α, β, δ represent the respective elasticities of the independent variables P_i, P_j and I. the natural logarithm transform of Eq. (1) gives:

$$\text{Log } E_j = \log a + \alpha \log P_i + \beta \log P_j + \delta \log I \quad (2)$$

Applying ordinary least square method, the following equation is obtained.

$$\text{Log } E_j = -1.69158307 \log P_i + 1.6057713 \log P_j + 0.13207904 \log I \quad (3)$$

(0.2200) (0.4896) (0.1321)

The values in parenthesis are the standard errors
Correlation coefficient R = 0.9955
Coefficient of determination, R^2 = 0.9910
F_{stat} = 5118.8 (Table 1).

Table 1: Anova

	Df	SS	MS	F	Significant F
Regression	3	1493278235	4977594116	5118	971459E-14
Residual	14	1361527645	0972519747		
Total	17	1506893511			

Input data for coal demand and price of coal for this study was collected from Nigerian Coal Corporation Enugu, while price of kerosene was obtained from retail outlets in Ado-Ekiti. In addition the income used for this study is the minimum monthly income as applicable in the Federal Civil Service of Nigeria.

RESULTS AND DISCUSSION

Analysis of regression result: The multiple regression was run for the model by transformation in Eq. (2). The variables explain the demand for coal reasonably well, as indicated by the high coefficient of determination (R^2) which is 0.99 (Table 2). This implies that 99% of the variation in the dependent variable can be explained by the regression on the independent variable. A multiple R value of 0.9955 shows high definition of relationship between price of fuel (kerosene), the prices of substitute fuel (coal), income and coal demand. The lower the standard error, the better the acceptability of the estimates. Therefore, standard error of 0.9861 for the regression indicates that the estimate is acceptable.

Table 3 shows that coal demand from 1988 continue to decline from 83,806.79 tons reaching a lower limit of 1,058.33 tons in 2003 as the price of substitute fuel (coal) increased from N45 ton^{-1} in 1988 to N2500 ton^{-1} in 2003 and the price of kerosene also within a period of 13 years increased to N32 L^{-1}, the demand for coal continues to decrease. This is curious because in this scenario, the demand for coal is supposed to increase. This may not be so, because of the contributory factors such as; Unavailability of the coal briquettes in other parts of the country aside from the coal fields environs and lack of public awareness on coal utilization. However, the coal demand forecast indicates that coal will be in high demand in the next 15 years provided that the price of kerosene does not exceed N111.33 L^{-1}. From the above model equation was obtained. Table 4 however, indicates that coal demand would continue to increase but the increase would not be substantial.

Evaluation of forecasting performance of the model: Using the inequality coefficient.

$$U = + \sqrt{\frac{\frac{\Sigma(P_i - A_i)2}{n}}{\frac{\Sigma A_i^2}{n}}} \quad (4)$$

Table 2: Regression statistics

Multiple R	0.995472085
R Square	0.990964672
Adjusted R^2	0.91824534
Standard error	0.986164158

Table 3: Input data for forecasting

Year	Demand E_i	Price of fuel (kerosene, N/lt)P_i	Price of substitute fuel N ton^{-1} (P_j)	Income l. (N)
1988	83806.79	0.08	45	1.319
1989	82268.57	0.05	80	1.319
1990	78742.03	0.37	80	1.319
1991	101675.2	0.4	150	1.319
1992	56748.68	0.4	185	1.319
1993	28128.98	3.27	475	1.319
1994	13363.48	6.76	1500	1.463
1995	19817.08	7	1500	2.118
1996	18667.98	7	1500	2.118
1997	18081.75	7	1500	2.736
1998	12124.94	7	1500	4.195
1999	13838.94	7	1500	6.432
2000	12135.67	17	2000	6.776
2001	3400.34	17	2500	7.266
2002	1715.48	24	2500	7.569
2003	1058.33	32	2500	7.764
2004	1058.33	59	2500	8.734
2005	1058.33	59	2500	8.734

Table 4: Coal demand forecast (tons)

Year	Forecast E_i demand
2006	751.71
2007	1110.63
2008	1140.04
2009	1170.12
2010	1197.34
2011	1248.33
2012	1272.57
2013	1291.31
2014	1310.93
2015	1401.98
2016	1350.32
2017	1369.40
2018	1368.40
2019	1385.68
2020	1401.02

Where,

P_i : Predicted value.
A_i : Actual value.
n : Sample size.

The smaller the value of the inequality coefficient, the better is the forecasting performance of the model. Test of significance of the difference between a single prediction and the actual observation.

Using the test statistic

$$t^x = Su \frac{Y_A - Y_F}{\sqrt{1 + \frac{1}{n} + \frac{(X_F - X)}{\Sigma(X - X)^2}}} \quad (5)$$

Where,

t^x = Observed value of t statistic.
S_n = Estimate of the variance u.

Table 5: Actual and forecasted values of coal demand (tons)

Year	Actual value	Forecasted value
1988	83806.79	83809.36
1989	82268.57	464600.9
1990	78742.03	15731.18
1991	101675.2	37913.82
1992	56748.68	53118.25
1993	28128.98	6873.88
1994	13363.48	12941.36
1995	19817.08	12810.45
1996	18667.98	12810.45
1997	18081.75	13240.51
1998	12124.94	14014.26
1999	13838.94	14833.2
2000	12135.67	5302.59
2001	3400.34	7623.03
2002	1715.48	4275.89
2003	1058.33	2726.3
2004	1058.33	750.71
2005	1058.33	951.71

Table 6: Forecast performance

Year	Predicted value (tons)	Actual value (tons)	T
2000	7623.03	12135.67	0.0389
2001	4275.89	3400.34	-0.0074
2002	2726.3	1715.48	-0.0085
2003	950.71	1058.33	0.0008
2004	961.71	1058.33	0.0008
2005	751.71	1058.33	0.0008

X_F = Actual (observed) value of X in the period of forecast

Y_A = Actual (observed) value of Y

Y_F = Predicted (forecast) value of Y from the regression.

The inequality coefficient, U = 0.6587

$$T^{(13)}\ 0.025 = 2.16$$

The model performance evaluation coefficient, u = 0.6587. Given that the inequality coefficient is (U<I), we conclude that the forecast performance of the estimated coal demand function from which the prediction was derived is good (Table 5). From Table 6 $t^x < t$ we conclude that the difference between the predicted values and the observed values are not significant. Therefore, the forecast power of the coal demand model is good.

CONCLUSION

The empirical findings, of the study revealed, that coal demand would continue to increase and by 2020 would increase so 1410.02 tons. However, this did not show an appreciable increase. The result indicates that for coal to be utilized adequately both at urban and rural households, its price must be reduced to make it affordable. In this regard, government should encourage the use of coal briquette by initiating intensive educational campaign to raise public awareness of the benefits of using coal at the industrial and household level.

RECOMMENDATIONS AND POLICY IMPLICATION

The inability of coal to play a vital role within the energy sector can be viewed as very dangerous from the point of view of resource constrained electricity generation and distribution which is prevailing in Nigeria. Due to the high reliance of the household sector on fossil fuels for domestic cooking and water heating, it is important to have a good knowledge of coal demand in order to be able to establish the level of usage. Also, the Nigerian coal sector of the mineral industry is resources constrained and effort should be made to control to an appreciable extent both the supply and demand. To strengthen the supply side, the Federal Ministry of Solid Minerals Development had already commenced the deregulation of the coal industry. This would enable more coal mines to be in operation thereby enhancing coal supply. The decrease in coal demand in the next twenty years signifies the inability of government to project coal briquette usage at the household level and also guarantee its supply. Although there are some environmental/socio-economic barriers against coal briquette usage at the household level, in order to overcome this, the government needs to mount an intensive educational campaign to raise public awareness of the advantages of using coal briquette. Also, efforts should be made to reduce unnecessary bottlenecks in the collection of mining license.

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