

STATISTICAL ANALYSIS OF ELECTRICAL AND FUEL ENERGY CONSUMPTION IN NIGERIA SPANISH ENGINEERING COMPANY, KANO

¹A. Ahmed, ¹M. S Dambatta, ²A.B. Aliyu and ²J.S. Enaburekhan

¹Department of Mechanical Engineering, Kano University of Science and Technology, Wudil, Kano, NIGERIA

²Department of Mechanical Engineering, Bayero University, Kano, NIGERIA
abdula2k2@yahoo.com

ABSTRACT

The electrical and fuel energy consumption for the period (2000 - 2006) in Nigeria Spanish Engineering Company, Kano was studied. Monthly energy consumption data were gathered and analyzed. The average electrical energy and thermal energy consumption per tonne of product for the period considered are 34.04GJ/Tonne and 99.74GJ/Tonne respectively. The energy end users were identified as electric furnace, DC main motor, Compressor machine, Air-conditioning, Lightning and Electrical equipment. Regression techniques were used to correlate the monthly energy consumption with product weights in Tons. The Coefficient of determinant (R^2) for electrical energy consumption was 0.8458 while R^2 for fuel oil energy consumption was 0.7773 indicating strong correlation for electrical and fuel oil energy consumption. This research generates a data base that can be used for the following, rapid response learning process, improving reliability of retrofits and comparing energy consumption patterns between periods. Analysis performed on data identified energy conserving measures (ECMs), which when implemented will make the energy more efficient and less expensive.

KEYWORDS: *Electrical energy, Fuel energy, Regression, Correlation, Equipment.*

INTRODUCTION

Energy is a primary input for almost all economic activities and is, therefore vital for the improvement in quality of life. The International Energy Agency (IEA) has gathered data from various sectors on energy consumption trends. During the last two decades (1984 - 2004) primary energy has grown by 49% with an average annual increase of 2% (Capehart et al., 2005).

The industrial sector consumes over one third of any nations primary energy but government and private enterprises have kept watchful eyes in their use of energy by ensuring efficient utilization of their energy resources (Chan et al, 2005), but traditionally energy conservation and energy efficiency has not been given high priority for many industries and private sectors in Nigeria, this was because of low energy price which was sustained by government subsidy on various forms of energy especially fossil fuel and electricity.

Presently, energy supply in Nigeria is a major problem for both large and small scale purposes. Highly centralized production and distribution units have not been equally distributed thus becomes inadequate in meeting the economic needs of both urban and rural populace in Nigeria. With respect to this problem, this calls for efficient energy conservation measure in which energy audit is a key method.

In this context, over the years researchers have carried out a number of studies in order to evaluate how much energy could be saved without affecting productivity.

(Omorogiuwa, 2006) in their study considered 5 years (1997- 2001) electrical energy consumption in cement company, Ewekoro, Nigeria. In the study, it was found that the energy intensity was found to be between 120 - 349kWh/Tonne of cement, also an increase of 82% was recorded in 1998 in a bag of cement when compared with the previous records. Electrical energy consumption at the raw mill sector machinery was 41% while the dispatch sector was 10% in electrical energy consumption.

In this presentation, 7 years (2000 - 2006) data for product weight, electrical and fuel oil energy consumption were obtained from the steel rolling mill company and Power Holding Company Nigeria (PHCN), regression techniques was used in the analysis. The aim of this present work, is to study how energy is been used, data acquisition and formulating energy equations using linear regression for effective growth of the Company.

Data Collection and Analysis

In this study, data for product weight (iron rods), electrical and fuel energy consumption in a rolling mill company, Kano, Nigeria are investigated. Seven years monthly and yearly data (2000 - 2006) from the Nigeria Spanish Engineering Company, Kano and PHCN were used. In collecting data for energy consumption and identification of energy carriers and consumers, one can construct various types of energy use profiles, comparison tables and corresponding correlation plots.

In examining further the measured energy consumption data for the company, different energy characteristics and patterns can be established. In investigating and evaluating the company energy use, different category of loads was considered. The first category are equipment used in the company; examples are

electric arc furnace, electric motor, compressor machine, air conditioning plants and systems, office equipment and other electrical appliances. The second category is the product energy consumption, which is defined as the quantity of energy used by each equipment within a stipulated production time.

Regression Analysis

The electrical power and fuel oil consumption can be obtained from the equation (1) and (2) below (Murray et al, 2000);

$$y_1 = a + b_1x_1 + b_2x_2 \text{ ----- (1)}$$

$$y_2 = a + b_1x_1 + b_2x_2 \text{ ----- (2)}$$

y_1 & y_2 = dependent variables

a = constant

b_1 & b_2 = independent variable coefficient

x_1 & x_2 = independent variables

Alternatively, the t-statistics for variables coefficient x_1 and x_2 are computed using equation (3) below;

$$t - \text{statistics} = \frac{\text{variable} - \text{Coefficient}}{\text{variable} - \text{s tan dard} - \text{error}} \text{ ----- (3)}$$

The Mean Bias Error provides information on the long term performance of the regression equation model. Below shows relation for Mean Bias Error (MBE).

$$\text{Mean Bias Error (MBE)} = \sum_i^{12} \frac{(x_i - y_i)}{12} \text{ ----- (4)}$$

Energy Use Index

The amount of energy used per tonne of product is computed using the relation below;

$$EUI = \frac{\text{Annual Energy Consumption}}{\text{Annual Product Weight}} \text{ ----- (5)}$$

Power Factor Analysis

Irrespective of the nature of voltage and current, the power factor may be define as the ratio of true power consumed (kW) to apparent power (kVA) which is the product of voltage and current.

$$\text{Power factor} = \frac{\text{True Power(kW)}}{\text{Apparent Power}} \text{ ----- (6)}$$

To obtain an accurate assessment of the power factors of the equipment, kilowatt hour (kWh) reading of the equipment were taken within a specified production time.

Energy Usage & Cost Analysis

The cost of energy consumed were computed , also cost analysis was made in using energy efficient motors instead of the standard motor used by the company, the amount of kW saved is stated in the conclusion (Capehart et al,2005).

$$\text{Cost of power consumed in kWh} = \frac{\text{Power(W)} * t * \text{Cost / kWh}}{1000} \text{ ----- (7)}$$

$$kW_{\text{saved}} = h.p * 0.746 * \left[\frac{100}{E_{STD}} - \frac{100}{E_{EE}} \right] \text{ ----- (8)}$$

E_{STD} = Efficiency of standard motor

E_{EE} = Efficiency of energy efficient motor

Annual savings in Naira due to differnce in efficiency ;

$$h.p * 0.746 * L * C * N * \left[\frac{100}{E_{STD}} - \frac{100}{E_{EE}} \right] \text{----- (9)}$$

L = Load
 C = Cost of energy per kWh
 N = Number of poles
 h.p = Horse power

RESULTS AND DISCUSSION

Data for energy consumption and product weights for the period considered were gathered and analyzed. Table 1 shows the annual product weight in tonnes, electrical energy (kWh) and fuel oil consumption in (litres) for the period (2000 – 2006). Table 2 presents the results of regression analysis of the electrical energy and fuel oil energy. From the table it can be seen that R² values are high and ranges from 0.703487 to

0.886193 indicating strong correlation for electrical and fuel energy consumption. The equation $y_1 = -245801.75 - 686.31x_1 + 4517.69x_2$ and are used in computing the predicted electrical and fuel energy consumption for year 2000 respectively, equations for the remaining years are also generated from the regression results as presented in Table 2.

$$y_2 = 17161.96 - 134.87x_1 + 606.80x_2$$

Table 1: Annual electricity consumption, fuel oil consumption and product weight.

Year	Product Weight (Ton)	Electrical Consumption (kWh)	Power	Fuel Oil Consumption (Litres)
2000	2330	3292721		1005554
2001	2320	3575729		1028841
2002	2515	3404432		985524
2003	2675	3861645		1026671
2004	2595	3788078		988978
2005	2530	3794938		1036112
2006	2130	3449738		1016490

Table 2: Coefficient of determinant (R²), intercept(a), 1st and 2nd independent variable coefficient (b₁ & b₂).

Year (Elect.)	a	b ₁	b ₂	R ²
2000	-245801.75	-686.31	4517.69	0.886193
2001	-262523.86	-962.56	4855.07	0.843666
2002	-361125.77	818.94	4435.70	0.844015
2003	-328720.50	1481.64	4009.87	0.870102
2004	-337452.10	924.56	4586.70	0.822295
2005	-283264.63	53.84	4666.85	0.885091
2006	-151373.79	-748.12	3840.32	0.769356
Year (Fuel)	a	b ₁	b ₂	R ²
2000	17161.96	-134.87	606.80	0.832420
2001	10835.35	-143.98	656.57	0.872699
2002	-14740.51	63.43	702.21	0.794225
2003	-25000.15	272.77	665.54	0.758983
2004	-43761.07	112.26	935.70	0.753590
2005	-22777.39	260.72	737.73	0.703487
2006	1062.46	-625.78	954.59	0.725632

Figure 1 shows the amount of energy consumed per tonne of product which is expressed in GJ. It can be seen from the figure that electrical energy is more consumed than the thermal energy in producing the products throughout the seven years considered in the research work. Figure 2 shows bar chart for actual and predicted fuel energy consumption and figure 3 shows the actual and predicted electrical energy consumption, the predicted fuel energy consumption is obtained from the regression

equation. It can be seen from both charts that the differences in energy consumption for both actual and predicted consumption is quite minimal. While figure 4 shows residuals for both electrical and fuel energy consumption. A positive residual indicates that the actual consumption is greater than the predicted consumption and a negative residual indicates that the predicted consumption is greater than the actual consumption.

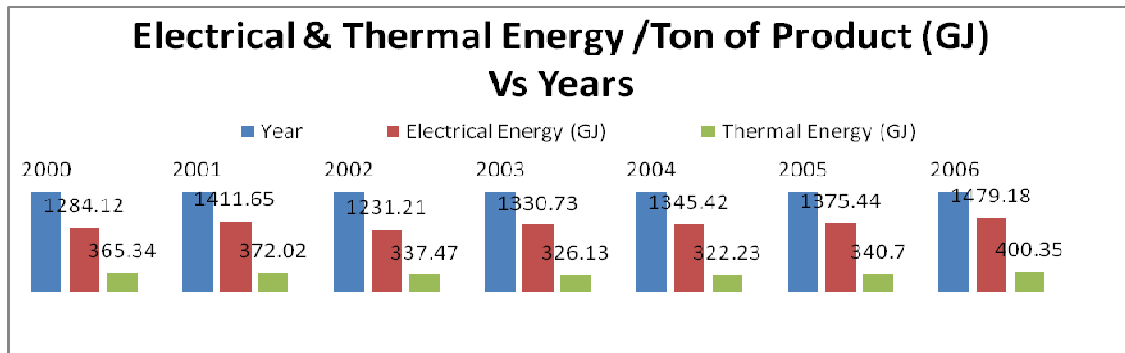


FIGURE 1: Electrical and Thermal Energy/Ton of Product (GJ) Vs Years

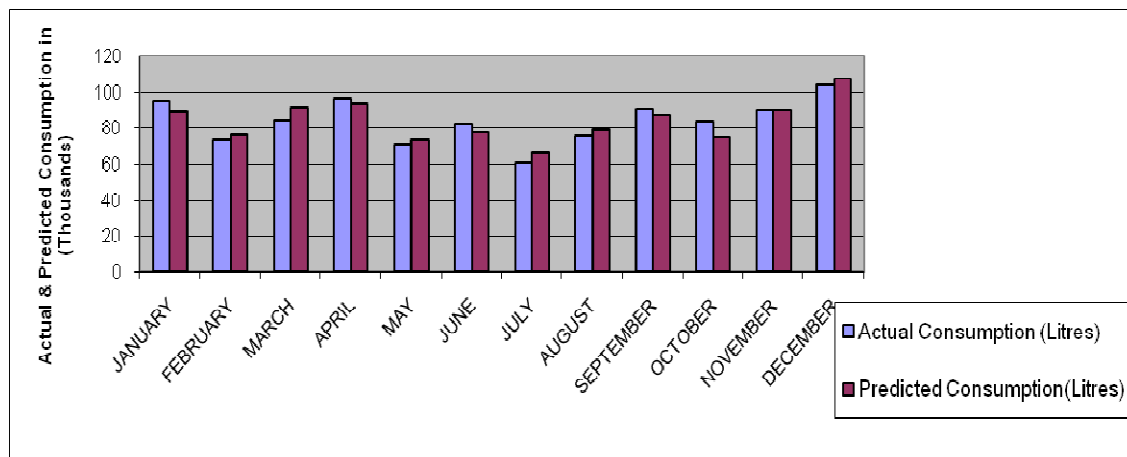


FIGURE 2: Actual and Predicted Fuel Energy Consumption (Litres) Vs Months

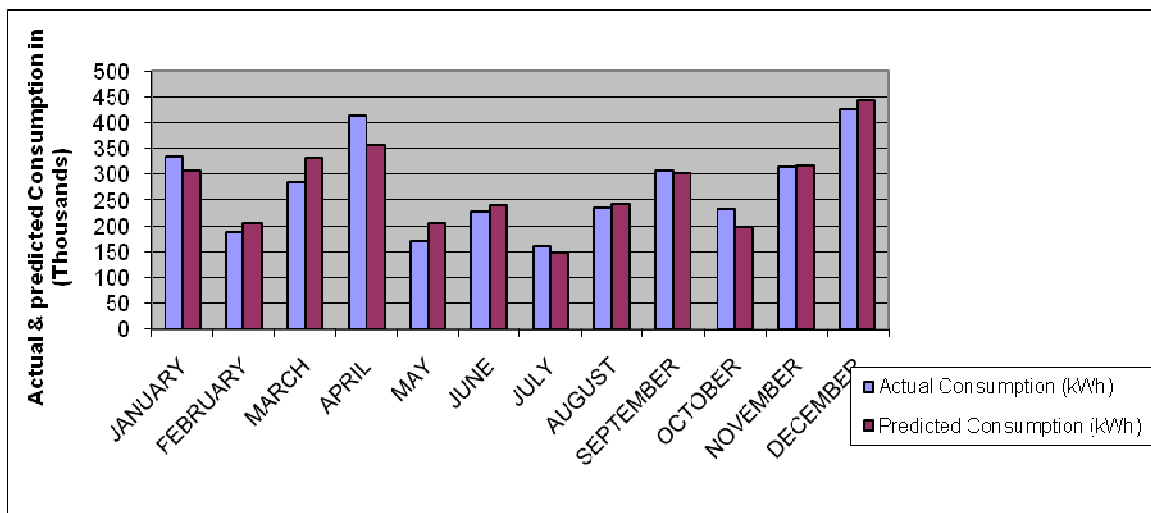


FIGURE 3: Actual and Predicted Electrical Energy Consumption (kWh) Vs Months

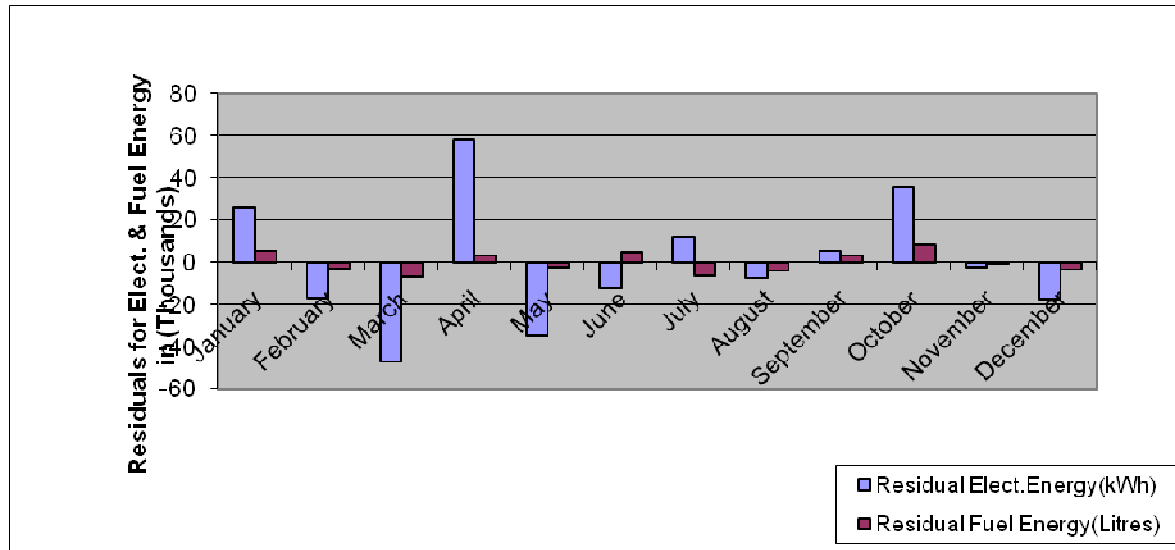


FIGURE 4: Residuals for Electrical and Fuel Energy Vs Months

CONCLUSION

In this study, regression equation model was developed for the electrical and fuel oil energy consumption for the period considered. The coefficient of determinant (R^2) ranges from 0.703487 - 0.886193 indicating strong correlation in energy consumption. The average percentage increase of electrical energy and fuel oil consumption for the period considered are 19.4% and 6.17% respectively while the average energy consumption per product tonne are 7.79GJ/Tonne for electrical energy and 22.73GJ/Tonne for fuel oil energy, this indicates that more energy is consumed in using fuel oil.

Power factors were computed for the main electrical equipment (D.C main motors, electric furnace and compressor machine) the results of the power factors are 0.66, 0.216 and 0.303 respectively, from the results it shows that there is wastage of energy in electric furnace and compressor machine since the power factors are very low.

Finally, in calculating the savings in using an energy efficient motor of 95.0% as against a standard motor of 91.7% the amount in kilowatt that will be saved for the company was calculated to be 2.83kW annually.

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