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The Effects Of Load Forecasting As A Planning Tool In Nigerian Power System Industry

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ABSTRACT:*The Nigerian power system is bedeviled with a series of challenges and problems like low voltage, technical faults etc, giving rise to epileptic power supply and consequent power outage. The fundamental problem here, among others, is population explosion. Most of the technical faults ranging from phase failures, transformer break-down etc, stem from over-population, and that is the reason for the so-called load shedding practice which is even none the worse in salvaging the situation. Forecasting is a very important engineering tool in any stage of the planning process. In this paper, exponential curve fitting technique using a method of least squares was employed on some uncovered water levels in a dam to estimate the power generated at the hydro-power station. The results obtained, showed a downwards decrease of 33.86MW, 21.95MW and 14.23MW of the power generated, given uncovered water depth in the dam to be 25m, 35m and 45m respectively. This sends a warning signal of impending danger of draughts to power system engineers who gets prepared to harness power from other sources e.g. thermal, solar, gas turbine, wind turbine, biomass etc, to meet the power demand of the populace.*

Keywords*: Nigerian power system, over-population, low voltage, load forecasting, exponential curve fitting, method of least squares.*

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I. INTRODUCTION

Power system study and planning is not easy to the effect that the establishment of a new power generating station in an area, substation or even expansion of an existing station becomes a hectic job and might be based on a lot of factors.

The factors that determine the size of power and location of plant include[1]:

1. The population of the area and its growth rate.
2. Industrial status of the area and the growth rate of industries.
3. The number of cities the station will service.
4. The atmospheric nature of the area.

Load forecasting has to do with the ability to determine the trend of power demand of an area based on the past data of its load demand[1]. Forecasts may be long term forecasts, medium term forecasts or short term forecasts. As power plant planning and construction require a gestation period of four to eight years or even longer for the present day super power stations, energy and load demand forecasting plays a crucial role in power system studies[3].

Long term forecasts covering a period of 20 years provide a basis for examining the energy supply problems of the country in a broader perspective in relation to various other modes of development, including conversion and substitution of different forms of primary and secondary energy[2]. Construction and installation of equipment in power plants takes 4 to 6 years.

Medium term forecasts of 5 or 6 years are, therefore, very significant for planning the size of power plants. Forecasts of demand and energy are required to estimate the additional installed capacity required to facilitate the plant maintenance programme and to estimate the firm capacity of the restricted hydroplants[2].

Short term forecasts of 1 or 2 years are mainly required for deciding operating procedures and for preparing budget estimates.

Forecasting of load requirements is an essential part of power project design. The forecast is based upon: (i) past development of a power project in the region, (ii) applications received from different types of consumers, (iii) trends towards the development of industries and other potentialities for load development. The methods that are generally used for forecasts or estimates of future demand of electrical energy are[2]:

1. Load survey methods.
2. Methods of extrapolation.
3. Mathematical methods.
4. Mathematical methods using economic parameters.

1.1(1)Load Survey Methods: In this method, the area of interest is visited and the existing and the future load needs are estimated taking into considerations of the communities in the region and factors which are likely to increase the load demand of the region in the near future. Loads are grouped under different categories such as: residential/domestic, commercial, industrial etc.

(2)**Methods of Extrapolation**: These methods are essentially statistical and involve the study of data collected from different records. These methods are used in determining the average rate of increase of energy consumption in the past, and also in the countries with similar economic structure. These data are used in forecasting and estimating the future needs. However, this has a major drawback because it does not consider the unforeseen developments e.g. establishment of large and major industries which may alter the future load requirements altogether.

(3)**Mathematical Methods**: These methods are linear or exponential curve fitting techniques for extrapolation of the curves indicating energy consumption for the past several years. These methods can be applied only when adequate statistical data over a sufficiently long period on the past consumption of electrical energy is available.

(4)**Mathematical Method using Economic Parameters**: These methods are based on the assumption that per capita consumption of electrical energy in a country depends upon economic factors, such as specific gross investments, industrial production, specific GNP, steel consumption, housing and transport etc. Indices of these parameters are found and suitably used for extrapolation by linear or exponential approximations[3].

II. DEVELOPMENT OF THE MATHEMATICAL MODEL

In this paper, the mathematical method described in subsection 1.1(3) was employed in this research work. These are linear or exponential curve fitting techniques for extrapolation of curves indicating energy consumption for the past several years[2].

2.1 Exponential Curve Fitting (Models)

Given a function of the form $Y = \alpha\beta^X$ … - - - - - 2.1

First, the function is linearized by converting it to equation of a straight line, using logarithmic function thus[1]:

$\text{Log } Y = \log\alpha + X\log\beta$ - - - - - - - 2.2

Where X and Y are variables and α and β are constant quantities.

Using equation of the least square line[1], which stated that $Y = a_0 + a_1X$ - - 2.3[1]

Where the constants a_0, a_1 are to be determined.

$$\left.\begin{aligned} \Sigma Y &= a_0N + a_1\Sigma X \quad \text{(i)} \\ \Sigma XY &= a_0\Sigma X + a_1\Sigma X^2 \quad \text{(ii)} \end{aligned}\right\} \quad - \; - \; - \; - \quad 2.4$$

NB: The above equations (2.4) can be remembered by observing that the first equation can be obtained by summing both sides of equation 2.3 and multiplied by 1, while the second is obtained by multiplying both sides of the equation by X and summing up. This is not a derivation of normal equations but a simple means of remembering them.

III. DATA COLLECTION

The following are data collected at Shiroro Hydro-power station; the depth of the dam (meters) uncovered by water is obtained against the generated power (MW) as shown below:

Table 3.1: Showing the uncovered depth of dam and power generated.

X(meters)	Y(MW)
1.0	98.2
2.0	91.7
5.0	81.3
10.0	64.0
20.0	36.4
30.0	32.6
40.0	17.1
50.0	11.3

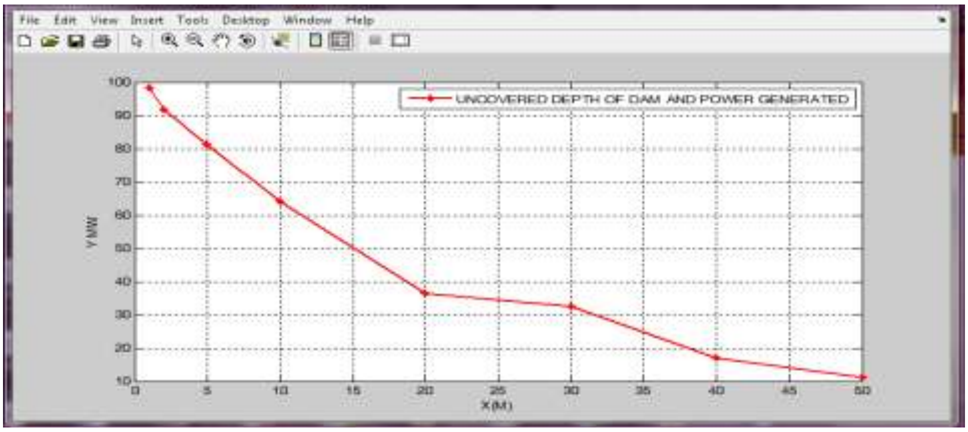

Fig 3.1 showing the plot of uncovered depth of dam against the power generated

What is required, is to estimate the generated powers when the uncovered level of the dam are 25m, 35m and 45m respectively, using the exponential curve fitting techniques by method of least square or regression curve.

3.1 Data Preparation

The data in table 3.1 are prepared as set down below:

Table 3.2: Showing the prepared data

N	X	LogY	X^2	XlogY
1	1	1.9921	1	1.9921
2	2	1.9624	4	3.9248
3	5	1.9101	25	9.5505
4	10	1.8062	100	18.062
5	20	1.5611	400	31.222
6	30	1.5232	900	45.396
7	40	1.2330	1600	49.320
8	50	1.0531	2500	52.655
Σ	**ΣX=158**	**ΣlogY =13.0412**	**ΣX^2 = 5530**	**ΣXlogY= 212.1224**

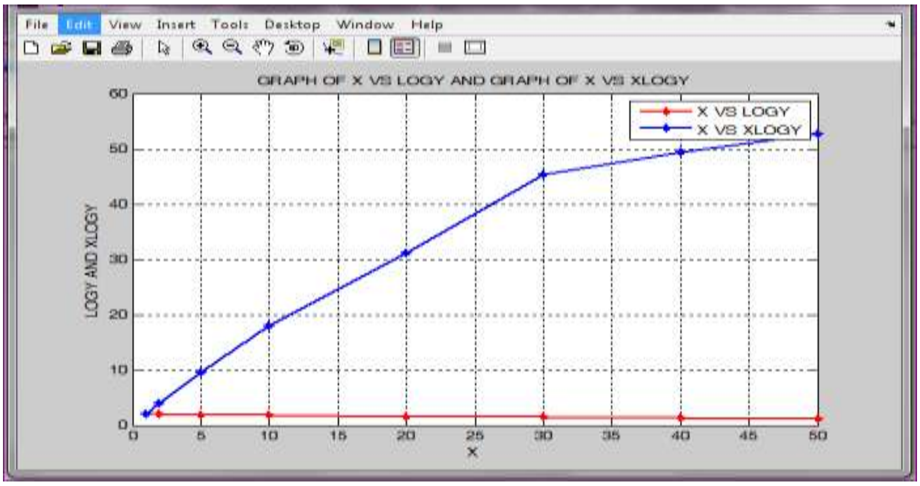

Fig 3.2 Showing the plots of logY and XlogY against X

Looking at equation 2.4, equation (2.2) can be written as:

$$\left.\begin{array}{l}\Sigma \log Y = \log\alpha N + \log\beta \Sigma X \\ \Sigma X \log Y = \log\alpha \Sigma X + \log\beta \Sigma X^2\end{array}\right\} \quad - \quad - \quad - \quad - \qquad 3.1$$

3.2(a) To Fix An Exponential Curve by Applying the Method of Least Squares

The exponential curve was fixed by applying the method of least squares to the data points. Using equations 3.1 and looking at table 3.2, we have:

$\Sigma \log Y = \log\alpha N + \log\beta \Sigma X$

$\Rightarrow \quad 13.0312 = 8\log\alpha + 158\log\beta \quad - \quad - \quad - \quad - \quad (1)$

$\Sigma X \log Y = \log\alpha \Sigma X + \log\beta \Sigma X^2$

$\Rightarrow \quad 212.1224 = 158\log\alpha + 5530\log\beta \quad - \quad - \quad - \quad - \quad (2)$

Solve equations (1) and (2) simultaneously:

$13.0312 = 8\log\alpha + 158\log\beta \quad - \quad - \quad - \quad (1) \times 79$

$212.1224 = 158\log\alpha + 5530\log\beta \quad - \quad - \quad - \quad (2) \times 4$

$= 1029.46 \quad = \quad 632\log\alpha + 12482\log\beta \quad - \quad (1)$

$-848.48 \quad = \quad -632\log\alpha - 22120\log\beta \quad - \quad (2)$

$180.97 = \quad -9638\log\beta$

$$\therefore \log\beta = \frac{180.97}{-9638} \quad = \quad -0.01877 \cong -0.0188$$

$$\log\beta = -0.0188$$

For the value of $\log\alpha$, substitute the value of $\log\beta$ into equation (1) above:

Hence, $13.0312 = 8\log\alpha + 158(-0.0188)$

$13.0312 = 8\log\alpha - 2.9667$

$13.0312 - 8\log\alpha + 2.9667 = 0$

$15.998 - 8\log\alpha = 0$

$15.988 = 8\log\alpha$

$$\therefore \log\alpha = \frac{15.988}{8} \quad = \quad 1.9997$$

$$\log\alpha \cong 2.000$$

Hence, the exponential curve equations:

$\log y = 2.00 - 0.0188X$ (in log form) $\quad - \quad - \quad (3.2)$

or $\quad Y = \alpha\beta^x$ (use antilog)

$= 100(0.9576)^X \quad - \quad - \quad - \quad - \quad (3.3)$

3.2(b) Generated Power at the Uncovered Water Level of Dam

Having extrapolated the linear or exponential curve showing energy consumption from the data (table covering a given period), the generated power can now be estimated when the uncovered level of dam is either 25m, 35m, or 45m respectively using equation (3.3).

Given that the uncovered level of water X in the dam = 25m, the generated power is given as:

$Y = 100(0.9576)^X$

$= 100(0.9576)^{25} \quad = \quad 33.86\text{MW}$

For uncovered level of water X in the dam = 35m,

$Y = 100(0.9576)^{35} \quad = \quad 21.95\text{MW}$

and for uncovered level of water X in the dam = 45m,

$Y = 100(0.9576)^{45} \quad = \quad 14.23\text{MW}$

Hence, the table of results:

Table 3.3: Showing the uncovered depth of dam and power generated

Uncovered depth of dam (m)	Power generated (MW)
25	33.86
35	21.95
45	14.23

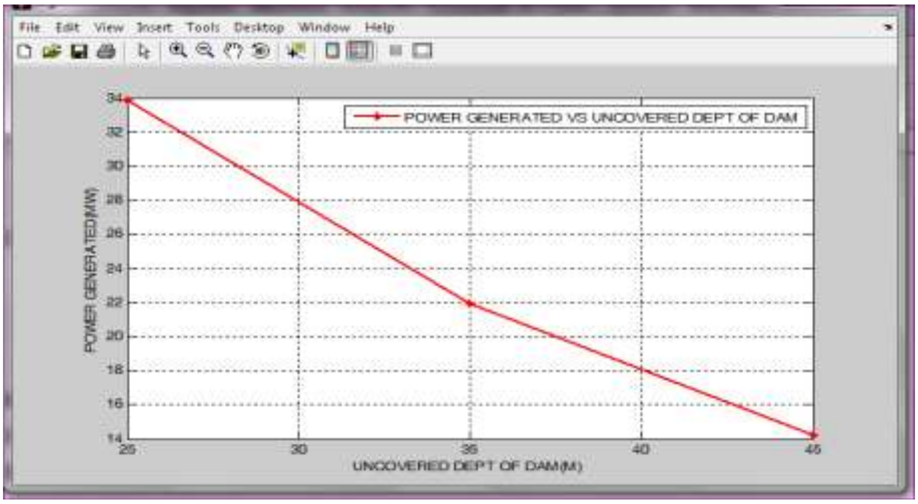

Fig. 3 Plot of uncovered depth of dam against power generated

IV. ANALYSIS RESULT

From table 3.1 and its plots in fig. 3.1 showing the raw data as obtained from the Shiroro dam, it is clear that the greater the uncovered depth (Xm) of the dam, the more the decrease in the generated power, showing drier periods. Again, from the plots of the results in fig. 3.3 showing the uncovered depth of the dam plotted against the generated power, it can be observed that the generated power decreases with increase in the uncovered depth of the dam. This sends a warning signal to the power system engineers especially in the period of draught to prepare to harness power from other sources like thermal, solar, biomass etc to meet the power demands of the teeming population.

V. CONCLUSION

The Nigeria seasons and weather conditions are no more steady but are changing up and down because of the global warming. Flood and draughts set in indiscriminately; this is very worrisome. The power system engineers should be more proactive in their duties by bracing up other sources of power generation like thermal, solar, gas turbine, wind turbine, biomass etc in order not to be caught unawares.

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