INVESTIGATING TEMPERATURE EFFECTS ON THE RAINY SEASON DAILY ELECTRIC LOAD

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Abstract

Daily data of load and mean temperature were gathered for Ijebu-Ode electric area in Nigeria during the rainy season from year 2002 to 2004 in order to investigate the relationship between the variables. A power relationship between rainy season-daily electric load and mean daily temperature was established.

Keywords: Daily electric load, mean daily temperature,weather.

Introduction

Without the variability of weather to contend with, forecast of future electricity demand would be an easy task. However, the regular demand pattern observed, to a large extent, is masked by the erratic behaviour of the weather which accounts for practically the whole of the variability in demand (Davies, 1958). The effects of weather on electricity demand vis- a –vis consumption can be quantified and evaluated. This can be performed on a variety of spatial scales ranging from individual residences (micro scale) to large geographic areas encompassing a variety of local 'weather'.

A number of mathematical models are available in technical literature in relation to the role of relevant meteorological variables on electricity consumption. Many authors have used regression to model relationship between load and temperature. Takenawa et al (1980) analyzed the relationship between hourly load and hourly temperature. Bolzern and Fronza (1982) were concerned with examination of daily load and daily mean temperature. Some were concerned with the analysis of weekly load with weekly temperature (Le. Conte and Warren, 1981). Hourly time scaling requires relatively refined stochastic models (Takenawa et al., 1980). Hence the researcher settled for daily time scaling due to the fact that the meteorological variable, temperature, was supplied on daily basis and the load data (though supplied on hourly basis) were converted to daily in order to be compatible with time scale of meteorological variable. According to Quayle and Diaz, 1980, weather projections can yield energy demand projections.

Degree days and other weather variables have been used to estimate electricity loads for areas served by individual utilities (Proctor, 1980).According to Davies (1958), the following meteorological elements were found to affect electricity demand: (a) temperature (b) wind speed (c) Cloud (d) visibility and (e) precipitation. Monforte(2003), discovered that temperature was the primary variable involved in developing a weather-dependent electricity consumption model. However, other secondary variables such as dew point, cloud cover and wind speed have less predicable impact on the consumption model.

The main objectives of the research are:

(a) To detect the role of mean temperature , on raining season daily load.
(b) Generation of historic loads.

Fitting the Model

A basic assumption usually made, for simplicity, is that the daily electricity consumption in an area is linearly related to the weather elements of the place .The electricity consumption in a place can be predicted by first forecasting the weather of the place and then using a regression equation. Usually different regression equations for each year are used. The success of each regression in reducing the variance in the observed load is measured by r_n^2, the square of the multiple – correlation coefficient, also known as the fractional reduction of variance. An overall or an average multiple –correlation coefficient, R or an overall reduction of variance R^2, is presented to measure the success of all the regression equations taken together.

In a situation where electricity supplies is not steady, for instance as in case of Nigeria where power supply is not regular, could linear relationship between electricity load and temperature be established? Hence the researcher, in this work, assumed the Classical Freundich Model in investigating the relationship between daily load and mean daily temperature using the Levenberge-Murquardt iterations.

The model is of the form: $Y = A X^B$ where Y is the dependent variable (load) ,X is the independent variable (mean temperature) ,A and B are constants.

Data

Ijebu-Ode, situated (6°48'N, 3°52'E) is in the tropical rain belt of Nigeria. The station experiences a wet season between April and October, during which there is much rain and intense thunderstorm activities. Ijebu-Ode district office of National Electric Power Authority (NEPA) provided hourly data of Ijebu-Ode area under the district. The daily loads (Y), for the area was calculated from the hourly (01-24) data so as to synchronize with daily data of weather variables. Load data for the rainy season which comes up between April and October were supplied. Load data for April 2002 were not available (due to loss of record). .All data, both for week days and week-end, including holidays were collected for the period under consideration. Black-out problem may arise at any time of the day.

Nigeria Meteorological Agency (NIMET) supplied daily meteorological data for Ijebu-Ode Station for the corresponding season of the years 2002 to 2004. The daily figures of the following weather elements were supplied by the agency- Minimum Temperature and Maximum Temperature for the day (from which the daily average temperature (X) was calculated).

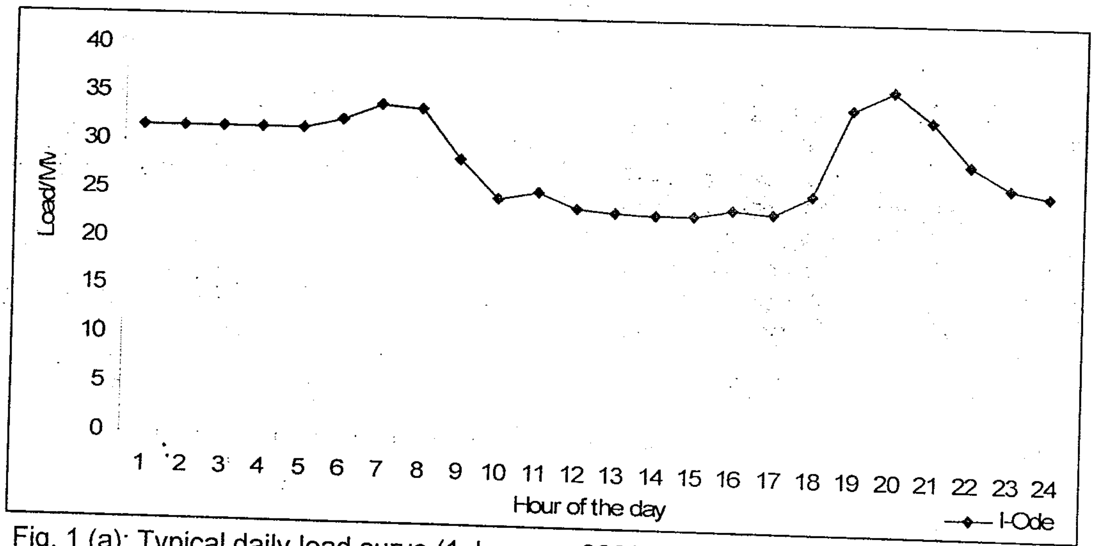

Fig. 1 (a): Typical daily load curve (1 January, 2003)

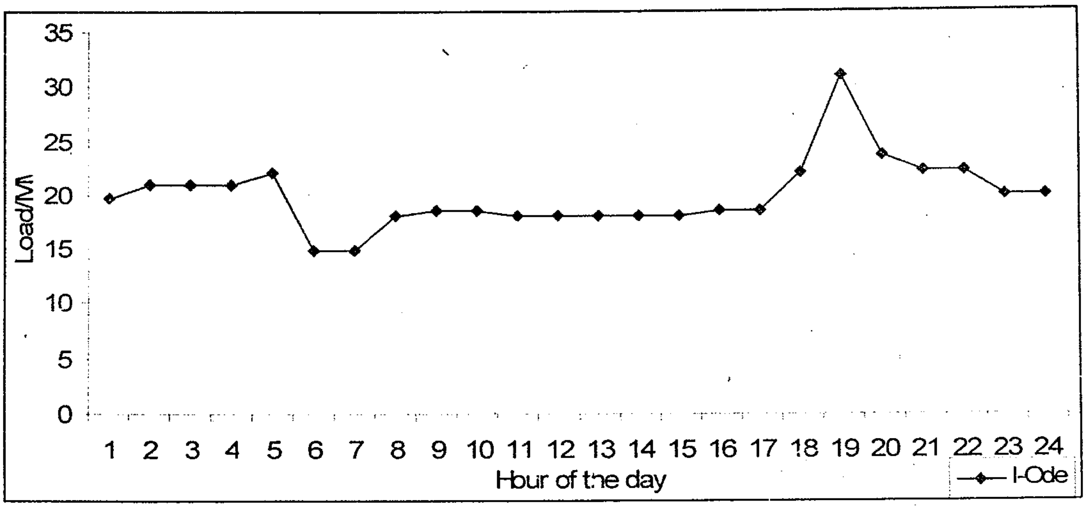

Fig. 1 (b) : Typical daily load curve (7 July, 2003)

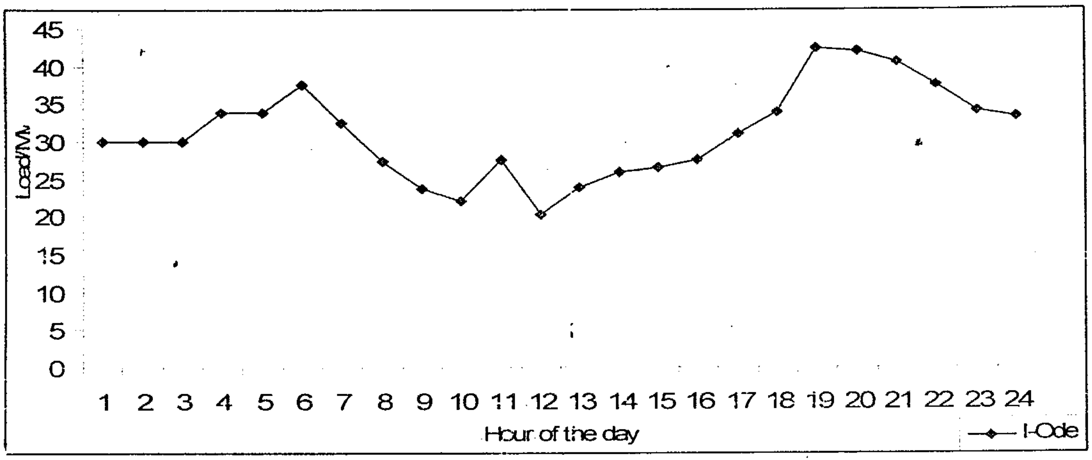

Fig. 1 (c): Typical daily load curve (15 October, 2003)

Analysis and Results

Data were analysis with the aid of the computer using ORIGIN 5 package.

(i) The daily consumption curves

Fig.1(a) is an example of daily consumption curve for Ijebu –Ode area. The day in question, 1st January 2003, was a rear typical public holiday when load shedding and faults recorded by the National Electric Power Authority were minimized to 14.8MW. Consumption was low during the early hours of the morning reaching its morning peak around 7:00 to 9:00 hours when domestic activities such as using electricity for lighting, ironing, cooking, etc normally go on. Thereafter, consumption dropped until around 10:00 hour. Consumption was fairly steady until around17:00 when consumption continued to rise again reaching an evening peak around 20:00 to 21:00. There after, consumption dropped again from around 12:00 when activities in industries and commercial centers would be gaining momentum until the evening peak would be reached around 19:00 hour to 21:00 hour. Thereafter, consumption dropped again

Whenever there is load shedding or fault in operating system, there is a drop in consumption. For instance, the consumption on 7th July 2003 Fig. 1(b) recorded minimum around 6:00 to 7:00 hour contrary to the morning maximum peak expected.
Almost the same pattern of consumption with that of a public holiday was maintained on a typical working day as recorded in Fig. 1(c) on 15th October 2003 (coincidentally, there was a no shedding that day) except for the

fact that the mid morning peak occurred around 5:00 hour to 7:00 hour.

(ii) **Iterations result**

Levenberge-Murquardt iterations were used in the analysis of the Classical Freundich Model for the three rainy seasons under consideration. The results of iterations were shown in table 1

Table 1: Results of Levenberge-Murquardt iterations based on three rainy seasons in Ijebu-Ode area

Year	A	B	χ^2
2002	7.2558 ± 10.4178	1.2782 ± 0.43790	15081.74969
2003	12.666 ± 18.6985	1.1228 ± 0.4479	32410.6679
2004	7.8653 ± 7.1340	1.2935 ± 0.2760	13902.54916
Combination	9.12636 ± 6.7611	1.22872 ± 0.2253	21676.36076

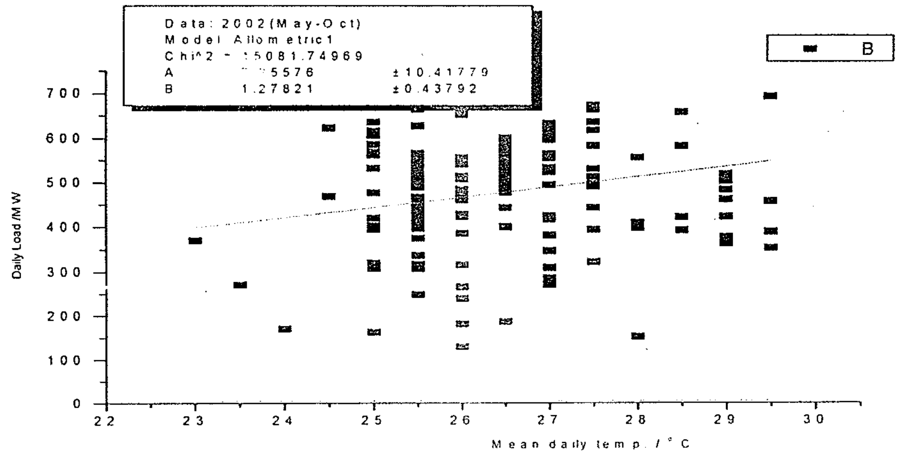

Fig.2 (a): Daily load versus mean daily temperature for year 2002 rainy season

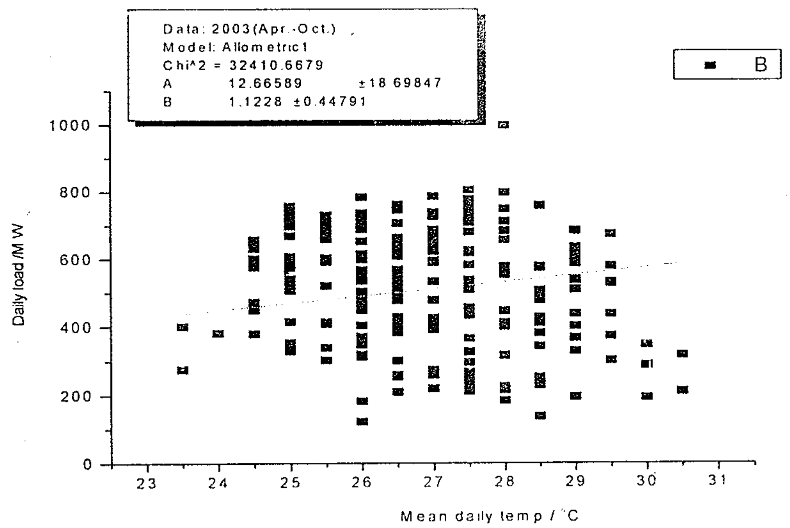

Fig.2 (b): Daily load versus mean daily temperature for year 2003 rainy season

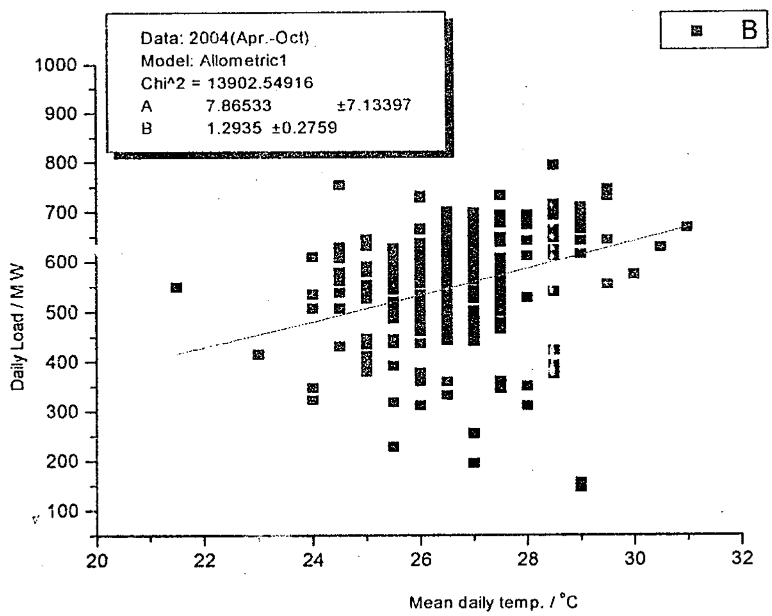

Fig.2(c): Daily load versus mean daily temperature for year 2004 rainy season

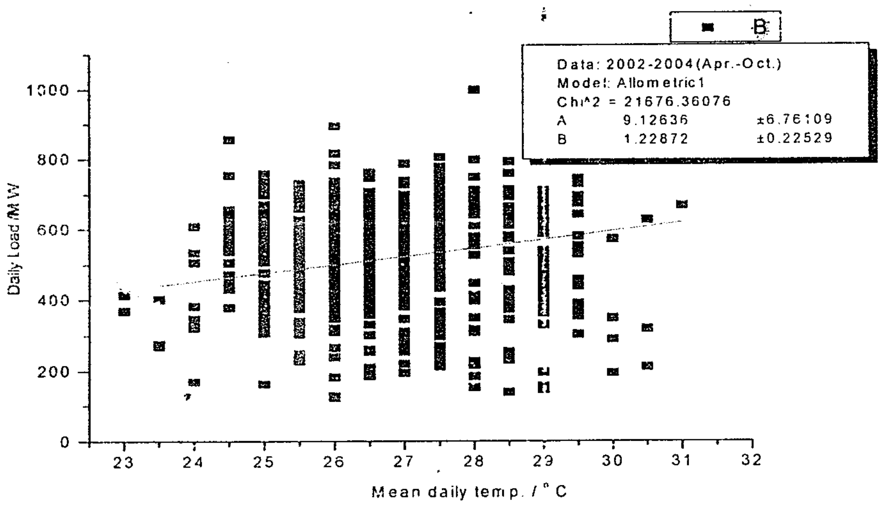

Fig.2 (d): Daily load versus mean daily temperature for combination of years 2002- 2004 rainy seasons

(iii) Figs.2(a)-(d)show the graphs of the plotting of daily load against daily mean temperature with the 'best' model fitted for each season of the three years under consideration as well as for the combination.

The conclusions that can be drawn from the analysis of the Table 1 are the following:

(a) The relationship between daily load and daily mean temperature is not perfectly linear as most models have proved. A power relationship exists between daily load and daily mean temperature, that is, there is a slight deviation from linear relationship. The result is in agreement with the finding of Monforte(2003) who found that the plotting of hourly load against hourly temperature followed a curved path that increased with temperature.

(b) The large error recorded in the value of the constant term,A,may be due to the inconsistency of electricity with time

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