ON REGRESSION MODELLING OF ELECTRIC–CONSUMPTION IN EASTERN PROVINCE

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ABSTRACT: Statistical techniques are used to facilitate the systematic development of regression models. In the present study, electrical energy consumption in Eastern Province of Saudi Arabia is modeled as a function of weather data, global solar radiation, and population. Five years of data have been used to develop the energy–consumption model. The model adequacy is determined from a residual analysis technique. Model validation aims to determine if the model will function successfully in its intended operating field. In this regard, new energy consumption data is collected and the results predicted by the regression model are compared with the new data set. Finally, the sensitivity of the model is examined. It is found that the model is strongly influenced by the ambient temperature and the present model is suitable for forecasting electric–energy consumption within the tested range.

1. INTRODUCTION

Statistical techniques of regression models are frequently used to study a set of data [1]. This study may be helpful in planning electricity generation and distribution in the region. The objective of the present work is to discuss the influence of weather parameters, total horizontal radiation, and population on the energy consumption in the eastern province of Saudi Arabia. The details of the electric-energy-consumption model are presented by Al-Garni et. al.[2].

2. LOCATION, ENVIRONMENT AND DATA

The Eastern province is located on the Arabian Gulf and its climate is arid but significantly influenced by Gulf waters. Dhahran, Dammam, Al–Khobar, Jubail, Qatif, and Al–Hasa are the main cities. The weather conditions in these cities remain more or less the same. For regression modelling, we have selected Dhahran (26.32°N, 50.13°E) as having representative weather. The monthly average temperature, T (C°), relative humidity, H(%), and solar radiation, S(W h / m^2day) based on the last five years are shown in Figs. 1–2. The data used for population,P, (see Fig.2) are based on References [2-5]. Data for energy *consumption* were obtained from the Saudi Consolidated Electric Company (SCECO–EAST). Figure 3 shows consumption data as a function of time (month) for five years 1407–12 H (1987–92 G).

3. THE MODEL

3.1 On Stepwise Regression Method

The stepwise regression is a procedure adapted to control the entry of variables into the model. The forward selection process begins with the assumption that there are no regressors in the model other than the intercept. The first regressor selected for entry into the model has the largest correlation (R^2) . This is also the variable that will produce the largest value of the F-statistics used in testing the regression significance. This process is continued until the partial F-value at a particular step falls below the pre-selected F-value. The effective regressors recommended by the stepwise regression are introduced to linear modelling procedure to determine the unknown coefficient of the mode.A step–wise regression technique was used and a STATGRAPHICS [6] package was utilized.

3.2 Electric–Energy Consumption Model

The best correlation for consumption data is

$$\hat{E}_p = A \times \hat{P} + B \times \hat{H} + C(\hat{S}, \hat{H}) \times \hat{T}, \tag{1}$$

where A = 0.792015, B = -0.251461, and $C(\hat{S}, \hat{H})$ = 0.044328 $\hat{S}$ + 0.433848 $\hat{H}$. Here A × $\hat{P}$ is the contribution of population, B × $\hat{H}$ of relative humidity, and C × $\hat{T}$ of outside temperature changes. Note that $\hat{E}_p, \hat{P}, \hat{H}, \hat{S}$, and $\hat{T}$ are dimensionless variables with respect to their mean for E_p, P, H, S, and T, respectively.

3.3 Model Adequacy

Evaluating model adequacy is an important part of any model as shown in Figs. 4–6. Fig. 4 shows a normal probability analysis for the residuals. The points lie along a straight line and no obvious model inadequacies are observed. A plot of residuals vs predicted values of energy consumption is shown in Fig. 5. There is no indication of any model defects. Finally, measured and predicted values of the electric power consumption rates are compared in Fig. 6. This figure indicates model suitability for forecasting electric–power consumption within the tested range.

3.4 Model Validation

Model validation is essential for model building, since a model that fits a data well need not necessarily work well for predictions [1]. Figure 7 shows predicted energy consumption and actual energy consumption vs time. It is observed that the predicted energy consumption is in general close to the actual energy consumption. Although the error during the period II (future) i.e., August 1992 to July 1993 (this data was not used in model building) is higher, however the discrepancy is within the acceptable limits (± 10 %). This shows that the model performs reasonably well for predictions. The R^2 value, the F–ratio, and Durbin–Watson Statistics are shown in Table 1.

Table 1: Analysis of variance for the full regression.

Source	Sum of Squares	DF	Mean Sq.	F–Ratio	P–Value
Model	61.0731	4	15.2683	1360.96	0.0000
Error	0.628248	56	0.0112187		

R–Squared = 0.989818 Std. error of est. = 0.105918
R–Squared (Adj. for d.f.) = 0.989272 DurbWat stat. = 0.930944

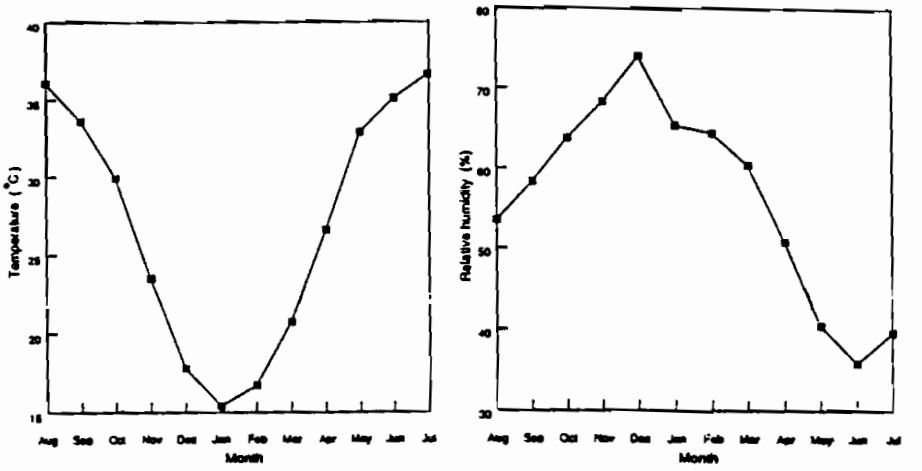

Figure 1: Monthly average temperature and relative humidity vs month for Dhahran.

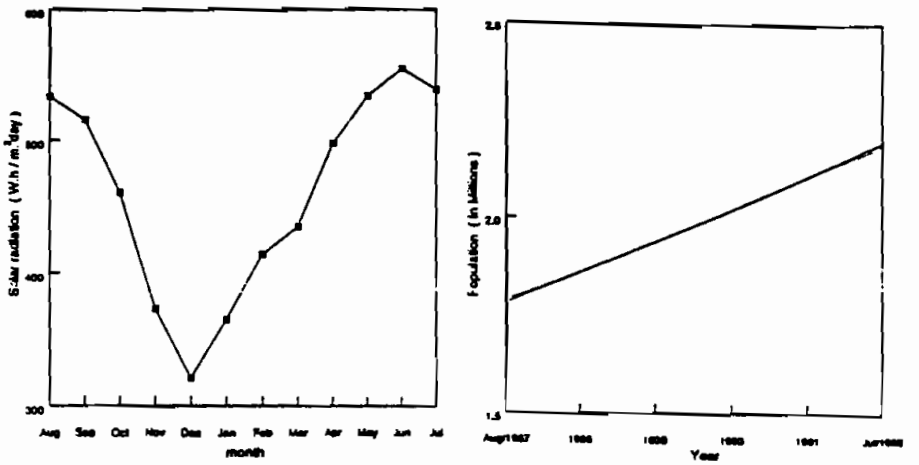

Figure 2: Monthly average solar radiation vs month for Dhahran and the estimated population for eastern province.

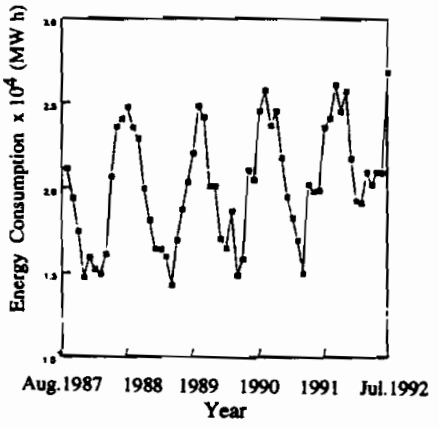

Figure 3: Electric-energy-consumption in eastern province of Saudi Arabia

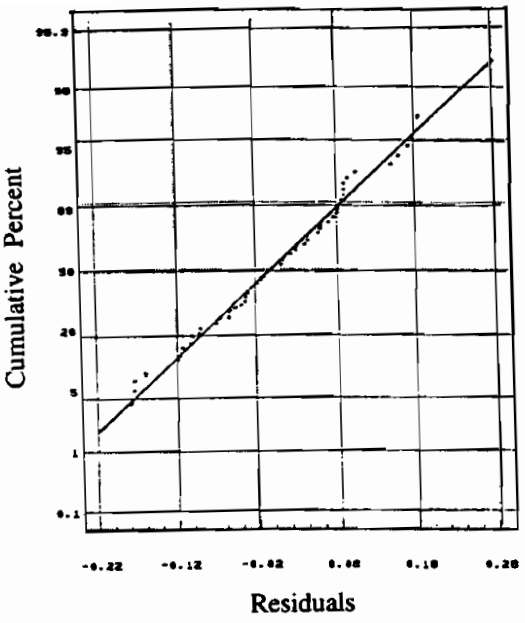

Figure 4: Normal probability plot of residuals.

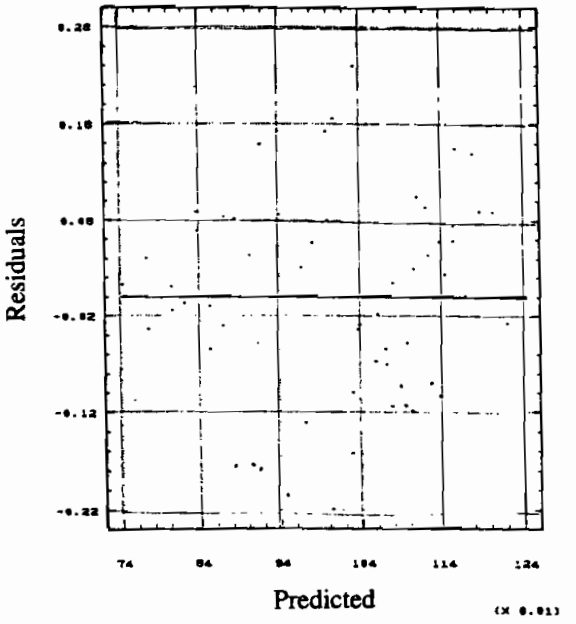

Figure 5: Residuals vs the electric–energy consumption.

3.5 Model Sensitivity

The sensitivity of the model is examined with respect to weather data, global solar radiation, and population. In this regard, the developed model is presented in a graphical form as a function of regressor variable. It is found that the model is strongly influenced by the ambient temperature, (see Fig. 8).

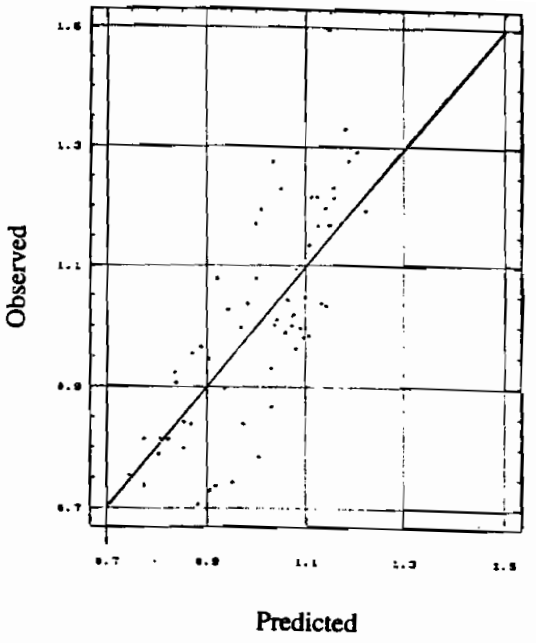

Figure 6: The observed vs the predicted electric–energy consumption in eastern province of Saudi Arabia.

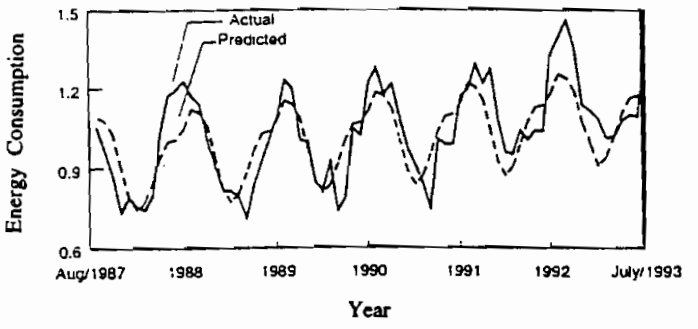

Figure 7: The observed and predicted electric–energy consumption vs time for the two periods.

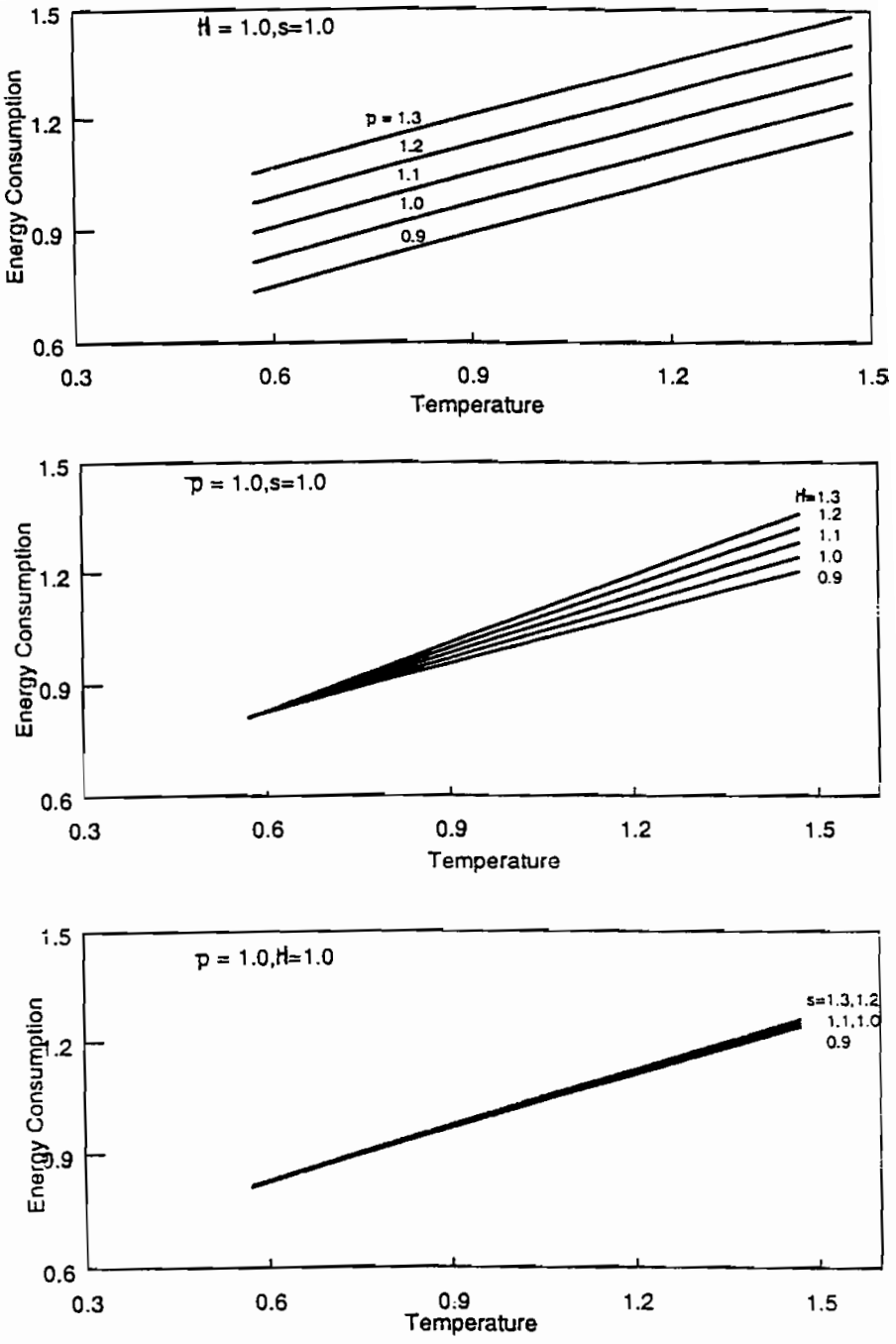

Figure 8.The sensitivity of model with respect to ambient temperature.

4. CONCLUDING REMARKS

A regression model building technique has been used to present an electric-energy consumption model for the eastern province of Saudi Arabia. The four variables for electric-energy forecasting selected in this study are seen to satisfy all the criteria of statistical adequacy. It is expect that the local electric utility will make use of this study for the purpose of forecasting the energy consumption in the eastern province of Saudi Arabia.

ACKNOWLEDGEMENTS

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