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# Demand Function of Electricity in Industrial Sector of Pakistan

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**Abstract:** Electricity is one of the basic inputs in the progress of industry, for its productivity and its potential contribution to GDP. Keeping in view the immense importance of electricity in the industrial sector, the objective of the study revolved around the growth trends of electricity consumption in the industrial sector of Pakistan and its demand function. For this purpose, the time series data from secondary sources were used. The stationarity of the data was checked with ADF test and variables were integrated of order two. Therefore, the model was estimated with ordinary least square method. Results showed that with an increase in price of electricity and oil, the demand for electricity tends to decrease. Moreover, the industrial share in GDP was positively related with electricity demand in the country.

**Key words:** Electricity Demand · Energy Supply · Energy Prices and Industrial Sector of Pakistan

## INTRODUCTION

Electricity is one of the basic inputs for industrial growth of the country. Consumption of electricity is among the critical indicators for the development of the developing countries like Pakistan. It is common observation that developed countries use more energy as compare to the developing countries because the use of energy declines over time in the more advance stages of industrialization. The increasing demand for energy results in the scarcity and increasing cost of energy for the growth rate of GDP. This ever increasing role of energy underlines the need to increase the supply of energy and to find some new alternate energy sources.

The use of energy in Pakistan is intensively growing and as in most other non-petroleum producing countries, its energy requirements are met by large quantities through imports. The consumption of oil in 1975-76 was 194569 tonnes, which has increased to 1542398 tonnes in 2004-05 and 28.4 percent of the energy need of Pakistan, is met by domestic and imported oil. Similarly, 50.4 percent of energy need of Pakistan is met by indigenous gas. The consumption of gas in 1975-76 was 41507 mmcft that has increased to 226116 mmcft in 2004-05. Electricity contribution in energy use is 12.7 percent. In 1975-76, the electricity consumption was 3113 Gwh, which has increased to 18591 Gwh in 2004-05. The industrial sector of Pakistan plays a major role for the economy having a share of 25.8 percent in the GDP [1].

The increase in the electricity consumption was only 0.7 percent during July-March 2008-09 as compare to the same period in the last year in the different sectors of the economy. The average rate of increase in consumption of electricity was 6.1 percent per annum since 1999-00 to 2007-08. This trend of the decelerating growth of electricity consumption started in 2006-07. Reduction in consumption of electricity by different sectors was due to a shortage of electricity, its higher cost due to gradual phasing out of a subsidy on electricity and the circular debt problem. The primary energy supply has increased by 12.9 percent since 1998-99. After remaining positive until 2007-08, primary energy supply and per capita availability of energy witnessed a negative growth during 2008-09, due to lower than normal economic growth experienced during this period [2].

Paul, A., *et al*. [3] identified electricity demand factors in the continental United States and used these for the projections of electricity consumption.

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The partial adjustment model of electricity demand was used for estimation in a fixed-effects OLS framework. It was found that demand for electricity was highly price inelastic in the short run as compared to the long run. The price elasticities were also found varied by customer class, region and season. The national, annual average short-run price elasticity across all customer classes was –0.13 and a long-run elasticity were –0.36. Abosedra S. *et al*. [4] estimated electricity demand in Lebanon using OLS, ARIMA and exponential smoothing techniques of estimation from time period 1995 to 2005. Electricity demand forecasted by ARIMA (0,1,3) (1,0,0)12 was preferred as compared to exponential smoothing and OLS techniques on the basis of lowest RMSE, MSE and MAPE.

Pakistan's economy is working on supply side economy formula. If we look at the latest trends in energy sector we must focus on demand side economies and formulate policies accordingly. Keeping in view the demand side economies, the objective of present study is to estimate the demand function of electricity in industrial sector of Pakistan. The industrial sector in Pakistan is expanding over the time and needs more use of electricity. Keeping in view the consumption needs of electricity in the industrial sector, the demand function of electricity in industrial sector of Pakistan is estimated in the study.

**Data and Methodology:** For the sake of estimating the demand function of electricity, the time series data was used from the period 1976 to 2008. The included variables in the model were the demand for electricity, price of electricity, price of oil and industrial share in GDP. Data was derived from various secondary sources like Pakistan Economics Survey, FAO statistical database and Pakistan Energy Yearbooks.

A time series data is usually non-stationary and posses a trend over time. A time series data is said to be stationary if it's mean, variance and covariance remain constant over time. A time series is non-stationary if it fails to satisfy any part of the above definition. There are number of approaches to test the unit root hypothesis but the Dickey-Fuller (DF) test [5, 6] is most commonly used. The DF-test requires estimating the following equation by OLS:

$$\Delta y_t = \alpha + \beta\tau_t + (\Phi - 1)\, Y_{t-1} + \mu_t$$

$Y_t$ series has both stochastic and deterministic trends and can be used as DF-equation for testing the unit root hypothesis i.e. $H_0$: $(\Phi - 1) = 0$. The DF-test is based on the assumption that $\mu_t$ is white-noise. But if the error term is not white-noise, there is auto-correlation in the residuals of the OLS regression in the above equation. To solve this problem Augmented Dickey Fuller (ADF) test [6] is adopted by adding lagged values of dependent variables as

$$\Delta Y_t = \alpha + \beta\tau_t + (\Phi - 1)\, Y_{t-1} + \sum_{i=1}^{K} \theta_1 \Delta Y_1 + \mu_t$$

The DF/ADF- tests are based on the assumption that there is only one unit root in the process. However, if there is more than one unit root, the standard testing procedure is to test first for a unit root in the levels of the series $Y_t$. If the hypothesis of the presence of a unit root is not rejected, we test the first difference (i.e. $\Delta Y_t$) for the presence of a second unit root and so on. This testing procedure from lower to higher of integration continues until the null of a unit root is rejected [6]. The study in hand followed the model used by Ghaderi *et al*. [7] with a few alterations e.g. the whole industrial sector was selected and number of industrial consumers were dropped from the model and inclusion of price of oil due to its significant contribution in electricity generation. The general form of demand function, specified in log form is as follows.

$$\ln DE = \alpha + \beta_1 \ln Y_i + \beta_2 \ln PE + \beta_3 \ln PO + \mu_e$$

where

- lnDE = Natural logarithm of demand for electricity in Giga Watt per hour for industrial sector of Pakistan.
- lnPE = Natural logarithm of price of electricity in Rs per Giga Watt hour for industrial sector of Pakistan.
- lnPO = Natural logarithm of price of oil in Rs per tonne for industrial sector of Pakistan.
- $\ln Y_i$ = Natural logarithm of industrial share in GDP in million rupees of industrial sector of Pakistan.
- $\mu_e$ = Stochastic error term for electricity. It is assumed to be independently and normally distributed with zero mean and constant variance.

## RESULTS AND DISCUSSIONS

The estimation of all desired tests necessary for drawing any results about estimation of demand function of electricity in industrial sector of Pakistan were presented below:

**Unit Root Results:** In the first step all the data series were tested for the presence of unit root. All the variables which were used for the estimation of demand function of electricity in industrial sector of Pakistan including demand for electricity, price of electricity, price of oil and industrial share in GDP were tested for unit root. All series under observation were used for the period 1975-76 to 2007-08.

It was noted that all the variables were non-stationary at first difference. Further these variables were tested separately for second difference where they were stationary. The results were presented in appendix table 1 through 3. The results in the table 3 declared that ADF test statistics of all variables was less than critical value on second difference. Therefore, it was concluded that all these variables were stationary at second difference.

**Co Integration:** It was found that all the variables were stationary at second difference. It meant that order of co integration was I(2). The long run relationship of the variables included in the electricity demand model was confirmed with co integration techniques based upon Johansen [8].

The results of the co integration with unrestricted intercepts and no trends in the VAR based on Trace Value of the Stochastic were presented in table 1. One co integrating vector was selected on the basis of the Trace Value Test. Therefore, it was concluded that the included variables in the electricity demand model were co integrated. It meant that these variables established a long run relationship.

**Regression Model:** The variables of the electricity demand model established the long run relationship. Therefore, a regression model was run by keeping the demand for electricity as dependent variable and price of electricity, oil and industrial share in GDP as independent variables to check the effect and changes into demand for electricity due to these independent variables.

The estimated coefficients in the regression model were elasticities because the model was specified in the double logarithmic form. As shown in table 2 that, the coefficient of price of electricity is -0.28 which was highly significant. It showed that increase in price of electricity by 1 percent will decrease the demand for electricity by 0.28 percent. Similarly the coefficient of price of oil was -0.27 and showed that 1 percent increase in price of oil will decrease the demand for electricity by 0.27 percent.

Table 1: Johansen Co integration Results for Electricity Demand Model

| | Hypotheses | | | |
|---|---|---|---|---|
| Relationship | $H_0$: r | $H_a$: r | Trace Values | Critical values |
| LDE, LY, | 0 | 1 | 42.23 | 39.81 |
| LPO, LPE | 1 | 2 | 20.50 | 24.05 |
| | 2 | 3 | 8.29 | 12.36 |
| | 3 | 4 | 0.49 | 4.16 |

The critical values were given (p = 0.05 per cent) levels for co integration.

Table 2: Regression Model Results

| Regressor | Co efficient | Standard Error | T Ratio | P-value |
|---|---|---|---|---|
| Inpt | 3.04 | 0.15 | 20.92 | 0.00 |
| LYi | 0.96 | 0.05 | 17.85 | 0.00 |
| LPE | -0.28 | 0.04 | -6.99 | 0.00 |
| LPO | -0.27 | 0.03 | -8.16 | 0.00 |
| $R^2$ = 0.98 | | DW = 1.76 | | |

Coefficient of Industrial share in GDP is 0.96, which was also significant at less than 1 percent, showed that 1 percent increase in industrial share in GDP will increase the demand for electricity by 0.96 percent.

The above results were showing a positive relationship between industrial share of GDP and energy (electricity) demand i.e. as the economy particularly the share of industrial sector will grow it will enhance the demand for energy (electricity). While the inverse relationship between energy demand and prices of energy (electricity) itself and oil will decrease the demand as it should be. These results were similar to Ghaderi *et al*. [7], Siddiqui, [9], Aqeel and Butt, [10] and a little different to Christopoulos, [11];

**Policy Recommendations:** The following recommendations are provided to overcome the energy crises in Pakistan.

- The industrial developments are related with the power inputs. Pakistan faces power shortage and high price of oil makes it more difficult to overcome the problem of power shortages. Therefore, the shift from consumption of energy such coal and firewood to wind power, tidal power, bio-gas, solar and geothermal energy is recommended.
- Gas is a cheaper source of energy but in many industries electricity is required for appliances and machinery operations. Thus for industrial growth and more industrial share in GDP policies should be designed which compensate the shortage of electricity and control the prices for future demand of electricity.

- The total energy consumption may still remain at present level or may even continue to grow but the gap should be filled by other sources like nuclear power and renewable sources of energy like hydro, biomass, solar and wind energy.
- Solar power is an environment friendly source of energy because it produces no pollution. Therefore, the use of solar power is recommended to fill the gap between demand and supply of energy.
- The high capital cost of renewable energy technologies and long gestation are not attractive for private sector financing, which has many other competing uses for money. This is difficult under the new regime of liberalization and privatization. The initiative in investment on renewable energy technologies ought to come from public sector but it will be difficult under the new scenario of liberalization and privatization. One therefore suggests that Government of Pakistan needs to adopt two approaches to promote investment in renewable energy sector. First it needs to offer subsidies to green energy producers. Second GOP must promote public private partnerships to promote green energy investments.
- Pakistan and other developing countries should themselves take the necessary steps. In this connection, the industrial sector in Pakistan should devise a policy for appropriate energy technologies and its proper adoption in the country.

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## APPENDIX

Appendix Table1: Unit Root tests using Augmented Dickey-Fuller Method

| Variables | Intercept | Intercept and Trend |
|---|---|---|
| DE | -0.40 | -2.64 |
| PE | 4.32 | 1.43 |
| PO | 10.14 | 9.27 |
| Y | 5.27 | 4.37 |

- Critical value for the augmented Dickey-Fuller statistic with intercept and without trend was –2.96 (p = 0.05 per cent)
- Critical value for the augmented Dickey-Fuller statistic with intercept and trend was –3.56 (p = 0.05 per cent)

Appendix Table2: Unit Root tests using Augmented Dickey-Fuller Method

| Variables | Intercept | Intercept and Trend |
|---|---|---|
| DDE | -2.28 | -2.11 |
| DPE | -1.45 | -3.52 |
| DPO | 2.92 | 1.19 |
| DY | 1.79 | -0.14 |

- Critical value for the augmented Dickey-Fuller statistic with intercept and without trend was –2.96 (p = 0.05 per cent)
- Critical value for the augmented Dickey-Fuller statistic with intercept and trend was –3.56 (p = 0.05 per cent)

Appendix Table3: Unit Root tests using Augmented Dickey-Fuller Method

| Variables | Intercept | Intercept and Trend |
|---|---|---|
| $D^2DE$ | -3.53 | -3.45 |
| $D^2PE$ | -6.85 | -6.91 |
| $D^2PO$ | -4.22 | -5.90 |
| $D^2Y$ | -4.39 | -5.49 |

- Critical value for the augmented Dickey-Fuller statistic with intercept and without trend was –2.96 (p = 0.05 per cent)
- Critical value for the augmented Dickey-Fuller statistic with intercept and trend was –3.56 (p = 0.05 per cent)

Where:
D denotes the first difference of the variables.
$D^2$ denotes the second difference of the variables.
DE is demand for electricity.
PE is price of electricity.
PO is price of oil.
$Y_i$ is industrial share in GDP.