SAARC Training Workshop Program
“Identification, Comparison and Scenario Based Application of Power Demand/Load Forecasting Tools”

Long Term Power Demand Forecasting using Regression Model
Contents

• Growth rate
• Intensity
• Elasticity
• Methods of power demand forecasting
Electric power demand is proportional to GDP and population growth rate; we usually use ‘Growth Rate’ for analyzing the relation between power demand and GDP or population.

- When GDP growth rate is 8% in a country, Power demand growth rate is 10%.
- When population growth rate is 1% per year in a country, power demand growth rate is 4%.
Intensity

• ‘Intensity’ is the ratio between energy consumption and economic data.

• Intensity to GDP, Population and Industrial output are used for energy demand forecast models.

• Example 1: Energy Intensity to Population

  = Primary Energy Supply / Population
Intensity

- Example 2: Energy Intensity to GDP
  
  \[ \text{Energy Intensity to GDP} = \frac{\text{Primary Energy Supply}}{\text{GDP}} \]

- Example 3: Energy Intensity to Industrial Output
  
  \[ \text{Energy Intensity to Industrial Output} = \frac{\text{Primary Energy Supply}}{\text{Industrial Output}} \]
‘Elasticity’ is useful to analyze the relation between economic growth and power consumption.

Power Consumption Elasticity to GDP

\[\text{Power Consumption Elasticity to GDP} = \frac{\text{Power Consumption Growth Rate}}{\text{GDP Growth Rate}}\]
Elasticity

- <Example>

- Power generation (+self) of Pakistan
  
  56,739 GWh in 2000  135,381 GWh in 2012
  
  Growth rate  7.5%

- Real GDP (2005 constant)
  
  5,765 Bill Rs. in 2000  9,522 bill Rs. in 2012
  
  Growth rate  4.3%
Elasticity

Energy Consumption Elasticity to GDP = 7.5 % / 4.3 %

= 1.7
Approach for Long Term Power Demand Forecasting

• Intensity approach

➢ Intensity approach is frequently used for power demand forecasting for all kind of sectors.

➢ Power demand = intensity * Denominator
## Approach for Long Term Power Demand Forecasting

<table>
<thead>
<tr>
<th>Sector</th>
<th>Denominator Selected</th>
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</thead>
<tbody>
<tr>
<td>Agriculture Sector</td>
<td>GDP of Agriculture Sector</td>
</tr>
<tr>
<td>Industry Sector</td>
<td>GDP of Industry Sector</td>
</tr>
<tr>
<td>Commercial &amp; Service Sector</td>
<td>GDP of Commercial &amp; Service Sector Floor Area of Buildings</td>
</tr>
<tr>
<td>Residential Sector</td>
<td>Population Number of Households</td>
</tr>
</tbody>
</table>
• Elasticity approach

➢ It is the popular approach in energy demand modelling.

➢ It is based on the following formula:

\[ E_T = E_{T-1} \times (1 + \text{G.R of } G)^a \times (1 + \text{G.R of } P)^b \]
Where,

**E** is the Electricity Demand (Sales GWh)

**G** and **P** are the Independent Variables (GDP, Population)

**T** is the Current Year,

**T-1** is the Previous year,

**a, b** are the elasticities of independent variables. (GDP, Population respectively)

**G.R.** is Growth rate
For the forecasting, the following procedures are studied by the analysts in preparation stage:

- Social & Economic Forecasting
- Energy Demand Forecasting
- Peak Demand Forecasting
The social and economic indicators are forecasted for energy demand forecasting model.

<table>
<thead>
<tr>
<th>Indicators</th>
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<tbody>
<tr>
<td>Population</td>
</tr>
<tr>
<td>Population (by area)</td>
</tr>
<tr>
<td>No. of Households</td>
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<tr>
<td>GDP</td>
</tr>
<tr>
<td>GDP (by sector)</td>
</tr>
<tr>
<td>Income (per capita)</td>
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<tr>
<td>GDP (per capita)</td>
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</tbody>
</table>
Regression Analysis

- Regression is a procedure that produces a line of best-fit for data.
- Must have an explanatory (x) and a response variable (y).
- Use regression line to predict values of y corresponding to unmeasured values of x.
Regression Analysis
Regression line is the best straight line description of the plotted points.
Regressions focuses on direct association, not the causes of association.

The independent variable must preceded the dependent variable in time.

The two variables must be plausibly lined by a theory.
The regression coefficient is the slope of the regression line.

\[ \beta_1 > 0 \implies \text{Positive Association} \]

\[ \beta_1 < 0 \implies \text{Negative Association} \]

\[ \beta_1 = 0 \implies \text{No Association} \]
Regression Analysis

- Simple Regression Equation

\[ Y = \beta_1 x + \beta_2 \]

Where

- \( Y \) = Demand of Electricity (GWh)
- \( X \) = Price of Electricity
Multiple regression is a practical extension of simple regression model.

It allows one to build model with several independent variables.

The multiple regression equation is:

\[ \hat{Y} = a + b_1X_1 + b_2X_2 + \ldots + b_pX_p \]
Multiple Regression Analysis

Where,

\[ a = \text{Y-axis intercept}. \]

\[ b_i = \text{slope of regression for } i^{th} \text{ independent variable } (X_i). \]

\[ p = \text{number of independent variables in model}. \]
R: R-Square $(0 < R^2 < 1)$. Better close to 1

AR: Adjusted R. $(0 < R^2 < 1)$ Better close to 1, if the samples are small.

DW: Durbin Watson Stat. $(0 < DW < 4)$. Good condition $1 < DW < 3$

DF: Deg. of Freedom ($> 1$).

t-value $\text{ABS}(t\text{-value}) > 2$