

DEMAND ANALYSIS AND FORECASTING FOR ELECTRICITY IN TURKEY FOR THE YEARS 2000-2020

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Abstract: We conducted a study, which aims to analyze the demand for electricity and forecast the consumption of Turkey in a 20 years time period. We assumed demand for electricity as a function of population, economic factors and net income; and environmental and psychological factors. We used the following tools and techniques in the study: pattern analysis, trend models, quadratic models, adaptive smoothing models, seasonal models, growth models, exponential models, test of hypothesis, validity, and accuracy. The research attempted to define and analyze electricity consumption as an equation in conjunction with: gross national product (GNP), gross domestic product (GDP), population growth, as well as the GDP-portions of various sectors such as: heavy industry, manufacturing, construction and trade. In the analysis we were concerned with the problem of finding the “best-fitting” curve or line describing the relation between Electricity Consumption, a random variable over time horizon of 23 years and experimental effecting variables, GNP, GDP etc. In conclusion, we can say that, in addition to regression model, S-Curve Trend Model is the best fit to the obtained data. Demand for electricity for the year 2020 is estimated as 436638 GW/h. For the same year quadratic estimation is 327965 GW/h. Finally, our results are compared with alternative forecasts such as TEAŞ, Cambridge Energy Research Associates (CERA) and Energy Information Administration (EIA).

Keywords: *Forecasting, Demand, Electricity, Turkey*

1. Introduction

Forecasting demand for customer service begins with having the right product or service, in the right quantity, at the right time, in the right location. This forecasting is only achievable through excellence in operational forecasting systems but not forecasting methods. This study, briefly deals with forecasting systems including forecasting methods in it. Throughout the study, statistical analyses were performed by using Minitab Release 13.20.

2. Electricity Demand Forecast

2.1. Variables used in Demand Analysis

In order to develop a realistic generation plan for Turkey, one of the more challenging tasks is to derive a demand forecast for the complete Turkish power system. For this purpose, an extensive analysis with various tools and techniques was performed to develop such a forecast. The results of three modeling methods, which seem to reflect possible demand growths in the future, have been chosen for our high, medium and, low forecast scenarios.

Demand for electricity may be determined as:

$$D_{et} = f(P_t, I_t, S_t, E_t)$$

Where: D_{et} is defined as demand for electricity at time t , P_t is defined as population at time t , I_t is defined as economic factors, net income at time t , S_t is defined as savings at time t , E_t is defined as environmental and psychological factor at time t .

Within the context of this study, we attempted to define and analyze electricity consumption as an equation in conjunction with: gross national product (GNP), gross domestic product (GDP), population growth, as well as the GDP-portions of various sectors such as: heavy industry, manufacturing, construction and trade.

Gross generation during the last 10 years indicates an average growth rate of about 8 to 9 %. The losses have steadily increased over the last two decades to a level of 22 % of the gross generation in 1999. The losses can be separated into power station auxiliary consumption, transmission losses and distribution losses.

The level of non-technical losses in Turkey including domestic and non-domestic, are exceptionally high when compared to the losses in other European countries. This is especially true for the South-East Anatolian provinces. In order to decide whether to include non-technical losses in demand growth analysis, the following key points are decisive in this decision making process:

- Due to the low per capita consumption (1,725 kWh per capita compared with Greece's 4,500 kWh per capita for year 2000), domestic non-technical losses seem essential for daily usage and it appears that these will be almost completely shown as "billed" after privatization of the distribution system.
- Over 50 % of electricity consumption is from industry. When the electricity sector is privatized, all consumed energy by the industry will be "billed".

Consumption of electricity by the year 2004 shall increase by homeowners due to increase in sales of air conditioners, electric ovens, water pumps etc. in apartment buildings and private homes. Electrical operated loan-movers, Internet, computers, electrical telephones, etc. will increase the consumption of electricity ever before on the average 5 to 7% more than before under similar conditions. This additional increase in electricity consumption may not be explained in the statistical analysis as causal effect. Annual population growth of 1.5% is included in the aggregate demand prediction for electricity consumption.

Examining the underlying trend for electricity consumption in the years 1977-1999; clearly indicates that there exists a long-term pattern of growth.

Comparing the annual growth values indicate that GDP growth has been erratic from year to year, from a high of 10 % in 1987 to a low of minus 6 % in 1994. The breakdown of GDP by sector indicates that the main change in terms of contribution has been an increase in share from the industrial sector at the expense of the agricultural sector.

The general growth pattern in population indicates a declining growth rate of about 1.5 % per annum. The decline in population growth is mainly due to the fall in the fertility. The data for electrification indicate that, since 1988 over 99 % of villages have been electrified. In 1996, the percentage was 99.97 %. We can conclude that an insignificant amount of electricity growth can be associated with rural electrification in the last decade and that the whole country can now be considered as electrified with no further growth potential from rural electrification.

2.2. Methods Used for the Demand Forecast

The tools and techniques utilized for forecasting the demand growth for this study were: Pattern analysis, Trend models, Adaptive smoothing models, Seasonal models, Growth models, and Exponential models.

Although it has been possible to define electricity consumption with various regression equations using a vast variety of driving variables, three modeling methods which show the consumption as an equation of time, seem to express the best possible demand growth scenarios in Turkey for a 20 year time horizon:

- S - Curve Trend Model: $GWh(t) = 10^3 / (0,949952 + 58,6932 \times 0,913943^{t-1})$
- Quadratic Trend Model: $GWh(t) = 18,7672 - 0,239391 \times t + 0,165480 \times t^2$
- Double Exponential Smoothing

Table 1. Demand forecast modeling for net consumption

Modeling Method	Net Consumption incl. Non-technical Losses (GWh) Year 2010	Net Consumption incl. Non-technical Losses (GWh) Year 2020
S-curve Trend Model	235,512	436,638
Quadratic Trend Model	201,922	328,603
Double Exponential Smoothing	160,467	216,054

The aforementioned results were derived from historical data pertaining to a 22-year period (1977-1999).

3. Alternative Forecasts

In January 2001, TEAŞ had published a generation plan designed for internal distribution. It estimates 286,586 GWh for year 2010 and 566,512 GWh for year 2020. The Demand Forecast stated in the *VIII. Five Year Development Plan* published by SPO (State Planning Organization) in year 2001 indicates very similar figures:

294,530 GWh for year 2010 and 555,690 GWh for year 2020, respectively. The forecast was developed by the Ministry of Energy & Natural Resources (MENR) utilizing the MAED model (Model for Analyses of Energy Demand). The key assumptions utilized in the MAED model to arrive at the load forecast are as follows:

- A decrease in population growth from 1.5 % to 1.0 %
- GDP growth rate of 4.7 / 5.0 / 5.7 % in year 2005 / 2010 / 2020, respectively.
- Employment of 81 / 97 % in year 2010 / 2020, respectively.

By 2010 and 2020, per capita consumption is estimated to be 3,974 kWh and 6,794 kWh respectively. Comparing these figures with the present values for Greece which an average of 4,700 kWh, and over 6,000 kWh on average for European OECD countries indicates that as Turkey continues to develop, the consumption trend towards that of developed countries coincides.

The Cambridge Energy Research Associates (CERA) has provided a high and low forecast for growth in electricity demand of 6.2 % and 4.9 % respectively over the period 1997 to 2010. The latter assumes a growth in GDP of 3.5 %, while the former assumes a growth in GDP of 5 %. This figure is based on the assumption that inflation is brought under control to enable faster economic expansion.

In December 2000, the Energy Information Administration (EIA), an administration established by the US Department of Energy, has published the International Energy Outlook 2001, which includes a World Net Electricity Consumption Forecast by Region. The forecast includes Turkey and states 150,000 GWh and 166,000 GWh for year 2010 in reference case and in high growth case, respectively. For year 2020, it states 205,000 GWh and 248,000 GWh in reference case and in high growth case, respectively.

In 1999, per capita consumption was estimated to be 1,642 kWh. By comparison, the average per capita consumption for European OECD countries is over 6,000 kWh. Greece, a better comparator due to similar climate and geography, has an average per capita consumption of 4,073 kWh. At the present rate of growth per capita consumption in Turkey, this level could only be possibly reached by 2012.

When we compare our demand growth forecast with the alternative forecasts, the following can be inferred:

- During the recession experienced in 1994, demand growth was about 6 %, which makes us optimistic about the rapid recovery of the Turkish economy with a high demand growth of 6.7 % and 6.1 % in year 2010 and 2020.
- Our medium demand forecast is near to that of CERA's high demand forecast. With a rapid recovery, but with a slightly negated effect resulting from privatization, we think that Turkey can experience demand growth of 5.5 % and 5.0 % in year 2010 and 2020.
- Our low demand forecast is as pessimistic as the EIA's, considering that the possibility of a world-wide economical recession will continue in the future, which will cause the Turkish economy not to recover as quickly as estimated.

4. Conclusions

In the analysis we were concerned with the problem of finding a "best-fitting" curve or line describing the relationship between Electricity Consumption, a random variable over time horizon of 23 years and experimental effecting variables, GNP, GDP etc. In conclusion, we can say that, S-curve Trend Model known as Pearly-Reed Logistics Function, is the best fit to the obtained data. Demand for electricity for the year 2020 is estimated as 436638 GWh. For the same year quadratic estimation is 327965 GWh. Using our hunches and guesses 2020 electricity consumption for Turkey will be 350000GWh with a standard deviation 10000 GWh.

References

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