

Forecasting of Electric Consumption in a Semiconductor Plant using Time Series Methods

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Abstract

This paper presents the method of electric consumption forecasting by using time series in analyzing data. The source of time series data come from the Metropolitan Electricity Authority (MEA) monthly energy consumption (kWh) during 2010 – 2012, 36 months in total. The objective is to select the best forecasting method from least Mean Absolute Present Error (MAPE). The results of this study show that single exponential smoothing was the best method and least MAPE at 5.60 smoothing constant $\alpha = 0.706780$ and also shows the highest significant level compared to the others by using interpolation model in Minitab program. The best forecasting method will be used in forecasting the electricity consumption in the future.

Keywords: time series method, electric consumption forecasting, means absolute present error, energy consumption charge

1. Introduction

1.1 Introduce the Problem

There are many cases in which a business will make use historic data based on customer information to make predictions or forecast future trends. Forecasting is an important planning tool of particular relevance in the business environment. So then, electrical load forecasting is a main to planning due to it have many parameters relevant such as ft, exchange rate, electricity tariff rate, and volume driven. The researcher has an opportunity to work in a semiconductor plant. Found that, it is a difficult in electric load forecasting because it is a dynamic machine running as demand or volume driven. However, electricity planning system must be accurate for the optimal operation process to least unit cost as well.

Electrical load forecasting is an antique issue in the electricity planning in a semiconductor plant because; it is a big cost to consider for maximizes profit or least unit cost. From the earliest times, it has always been a way to enable the physical balance between the supply and the demand, allowing a reliable system operation. Its role is fundamental to support the analysis of the capacity expansion of existing processes. In a short term perspective, it is also valuable to provide an optimized machine running, helping to manage at least unit cost process. It is therefore essential, according to an operational and planning perspective, to make sure that electricity is available for any period of time align with budget. Electrical load forecasting classified into three categories; short term, medium term and long term load forecasting (C. Narumol, 2002). Over the past several decades, researchers have studied a problem to improving load forecast accuracy, and a wide variety of models have been presented. For instance, (D. Srinivasan, C.S. Chang, A.C. Liew, 1995) presented linear regression models for electricity consumption forecasting, (Bianco V, Manca O, Nardini S., 2009) applied grey prediction model for energy consumption, (Zhou P, Ang BW, Poh KL., 2006) presented an improved singular spectral analysis method for short-term load forecasting in Iran electricity market, (Kumar and Jain, 2010) applied three time series models, namely, Grey-Markov model, Grey-Model with rolling mechanism, and singular spectrum analysis to forecast the consumption of conventional energy in India (6 Afshar K, Bigdeli N., 2011).

Forecasting models merely identify patterns in the data being analyzed and using these patterns, forecast what the variable will do in the future. They are relatively simple to build and use. It is does not depend on some underlying theory, they were based on mathematical relationships designed to capture patterns in the data and this paper using electricity in the past totally 36 months to forecasting and facilitated using Minitab program. In section II literature reviews each time series forecasting method is presented and discussed. The methodology is performing in section 2. In section 3 presented and evaluated the results each time series forecasting method. Conclusions and discussion follow in section 4.

1.2 Literature reviews

Discuss Electric load forecasting method has many methods and interested in study, however, the constraint of

time which is researcher decision selected time series method to apply to semiconductor plant who has the six methods detail as following;

- Trend analysis method (Bianco V, Manca O, Nardini S., 2009)

This method makes use of statistical technique known as the time series. The time series is an ordered sequence of events over a period of time relating to a certain variety. It shows a series of values of a dependent variable as it changes from one point of time to another by using time series it is possible to project the trend of scales in the future. These are one method used for trend projection was the least square method. It uses data in the part to future projections by using fit linear equation. Equation (1) is used to compute the average and to forecast the next period.

$$Y_{(t+1)} = \sum_{t=1}^n Y_t \quad (1)$$

Where Y= Forecasting data, t = Time, Y_t = Value of times, n = total data

The first n data points are used as the initialization part and the rest as a test part.

- Decomposition method (Benaoudaa D, Murtaghb F, Starckc JL, 2006)

Decomposition method is a generic term for solutions of various problems and design of algorithms in which the basic idea is to decompose the problem into sub problems. It can be an effective procedure for the analytical solution of a wide class of dynamical systems without linearization or weak nonlinearity assumptions, closure approximations, perturbation theory, or restrictive assumptions on stochasticity and used data in the part to fours portions and each portion is trending, season, cycle, uncertain variation. The equation as (2)

$$Y_t = T_t * S_t * C_t * I_t; t = 1, 2, \dots \quad (2)$$

- Moving average (Pappas SS, Ekonomou L, Karamousantas DC, 2008)

A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles. The threshold between short-term and long-term depends on the application, and the parameters of the moving average will be set accordingly. It uses data in the part to future projections by using averages from starting point to periods to desire, who is this paper used three months average for analysis. The equation (3) is used to compute the moving average and to forecast the next period.

$$Y_t = \sum_{t=1}^n Y_{t-i} / n \quad (3)$$

Where n is the number of periods in the moving average.

- Single Exponential smoothing method (Christiaanse W., 1971)

Exponential smoothing is a technique that can be applied to time series data, either to produce smoothed data for presentation, or to make forecasts. The time series data themselves are a sequence of observations. The observed phenomenon may be an essentially random process, or it may be an orderly, but noisy, process. Whereas in the simple moving average the past observations are weighted equally, exponential smoothing assigns exponentially decreasing weights over time. It is a forecasting method that is easy to use and is handled efficiently by computer program. The formula can be shown as equation (4)

$$Y_t = Y_{(t-1)} + \alpha(A_{(t-1)} - Y_{(t-1)}) \quad (4)$$

Where Y_t is new forecast, $Y_{(t-1)}$ is previous forecast, α is smoothing constant ($0 \leq \alpha \leq 1$), $A_{(t-1)}$ is previous period actual demand.

- Double exponential method (Gelper, S., Fried, R., Croux, C., 2010)

Like the regression forecast, the double exponential smoothing forecast is based on the assumption of a model consisting of a constant plus a linear trend. It is used for forecasting technique to smooth the trend and slope directly by using different smoothing constants for each and gives more flexibility in selecting the rates at which the trend and slope are tracked. The formula can be shown as equation (5)

$$Y_{(t+k)} = X_t + kT_t \quad (5)$$

$$X_t = \alpha Y_t + (1-\alpha)(X_{(t-1)} + T_{(t-1)}), T_t = \beta(X_t - X_{(t-1)}) + (1-\beta)T_{(t-1)}$$

Where T_t is estimated of trend, α , β are smoothing parameters, in the range 0 to 1, for the constant and the trend.

- Winter's method (Gelper, S., Fried, R., Croux, C., 2010)

This method can be extended to deal with time series which contain both trend and seasonal variations. The Holt-Winters method has two versions, additive and multiplicative, the use of which depends on the characteristics of the particular time series. The latter will be considered first. It is similar to Holt's method with

an additional element included to account for seasonality. The formula can be shown as equation (6)

$$Y_{(t+k)} = (X_t + kT_t) * S_{(t-L+k)} \tag{6}$$

$$S_t = \gamma [Y_t / X_t] + (1-\gamma) * S_{(t-L+k)}$$

γ is smoothing parameters, in the range 0 to 1, L is the length of seasonality.

2. Method

The population of this research is historical power consumption data available in the period from year 2010 to 2012 total sixty-six months as shown in figure. 1 and compared by annually in figure.2. The data collected from a semiconductor plant in Thailand by using primary data is electric load consumption and secondary is literature reviews of each method. Modeling in Minitab program application to analyze by using time series method after that testing forecasting methodology by trend analysis method, decomposition method, moving averages method, single exponential method, double exponential method, winter's method. The results from Minitab program is electric load forecasting six months ahead compared actual with forecast value and considered mean absolute percent error. If also what method has at least MAPE. It will be significant at six and slightly down to one as MAPE values. Selecting the best forecasting method for use to electric load consumption in a semiconductor plant in the future.

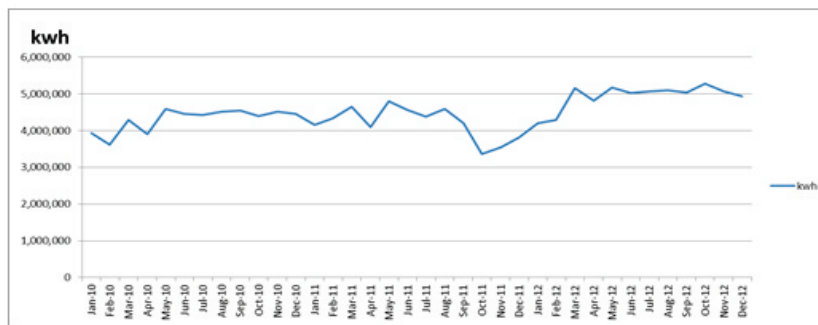


Figure 1. Monthly historical data of the time series from 2010 to 2012.

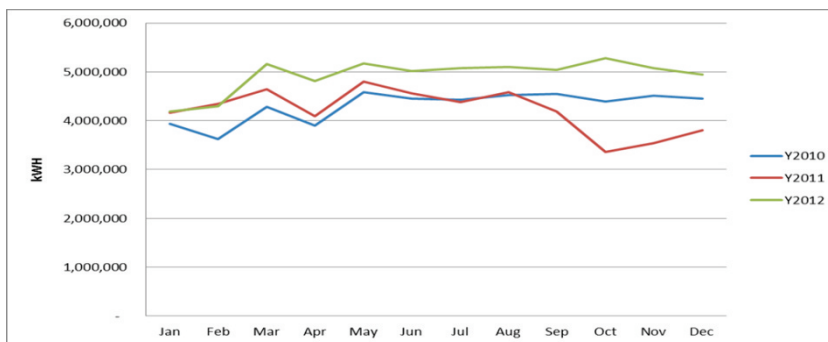


Figure 2. Historical data on power consumption from 2010 to 2012 annually.

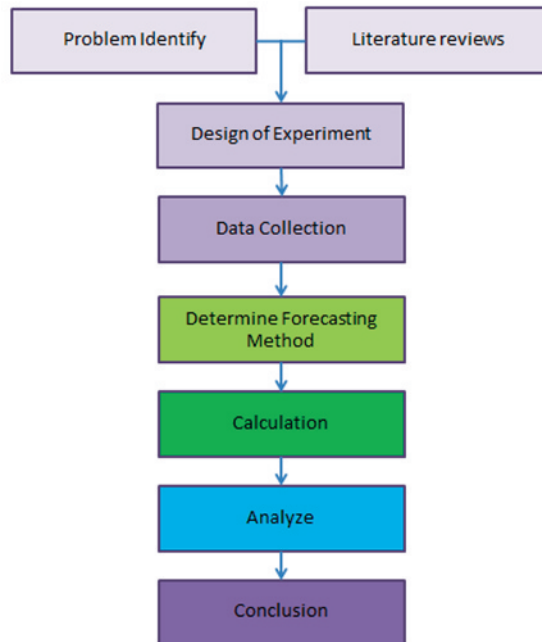


Figure 3. Research Methodology

From figure 3 show the research methodology diagram by starting from problem identification with literature review to confirm and finding the problem solving. After that make a design experiment to confirm the process go to the right way and possible. The third step will get the data from 2010 – 2012 by monthly electric consumption total thirty six months. Determine forecasting method by using time series method for testing and calculation for projection electric consumption six months ahead compared as of 2013 with actual of each method. Finally, conclusion by using the MAPE to justification of each method for the best method selected to use in a semiconductor plant in the future.

3. Results

The time series forecasting method by using trend analysis. This technique fits a trend line to a series of electric consumption totally sixty months and then projects the line into the future. The results show in the figure. 4

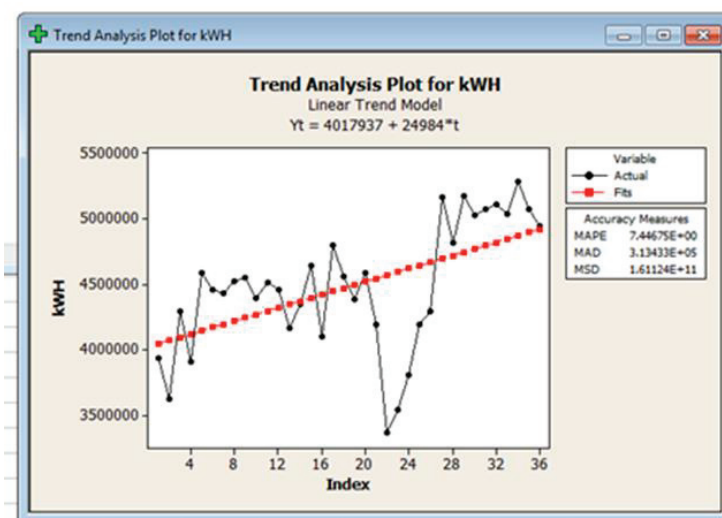


Figure.4 Forecasting by using trend analysis

Decomposition method is forecasting time series in the midterm by decomposition time series data in on electric consumption totally sixty months and split in four parts are trending, seasonality, cycles, random variations. The results show in the figure. 5

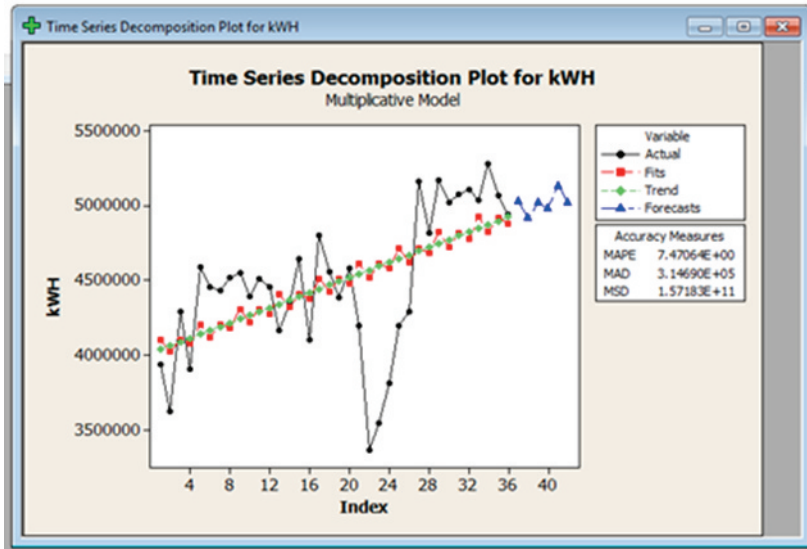


Figure.5 Forecasting by using decomposition method

Moving averages are a method to reduce the side effect impact such as season, business cycle, and random variation from time series forecasting. It is appropriate for short term load forecasting and trend calculating will be stretched a line and constant as the horizon. This paper used 3 months averages. The results show in the figure. 6

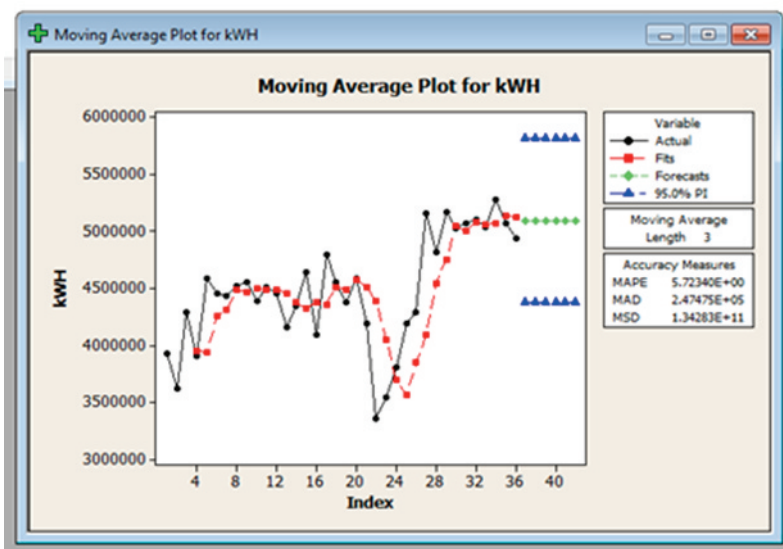


Figure.6 Forecasting by using moving averages three months method

Single exponential method is a relatively simple but very useful forecasting technique. Part data is used to generate the forecast with the more recent observations getting a greater weight than older data. The results show

in the figure. 7

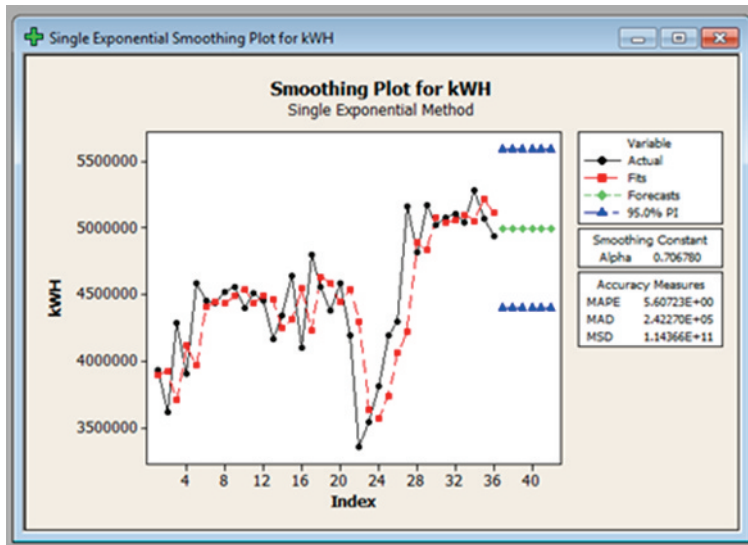


Figure.7 Forecasting by using the single exponential method

The double exponential method is used for forecasting time series data with a linear trend. This technique smoothes the trend and slope directly by using different smoothing constants for each. The results show in the figure. 8

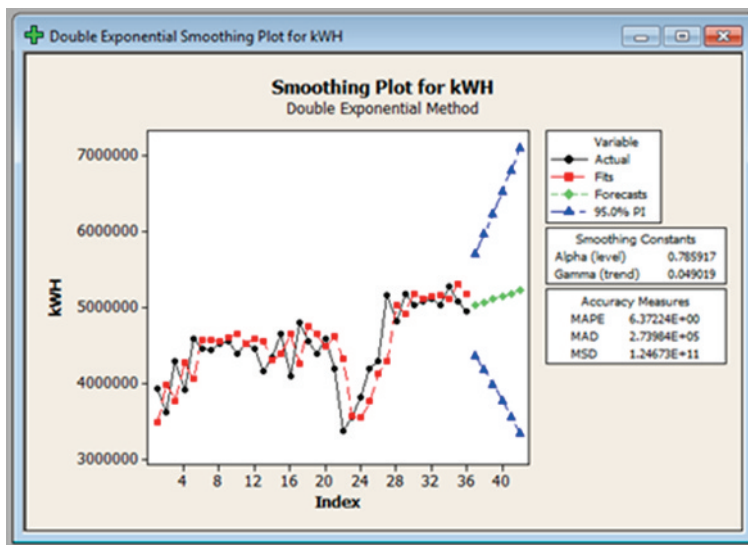


Figure.8 Forecasting by using a double exponential method

Winter's method is similar to double exponential method with an additional element included to account for seasonality. The results show in the figure. 9

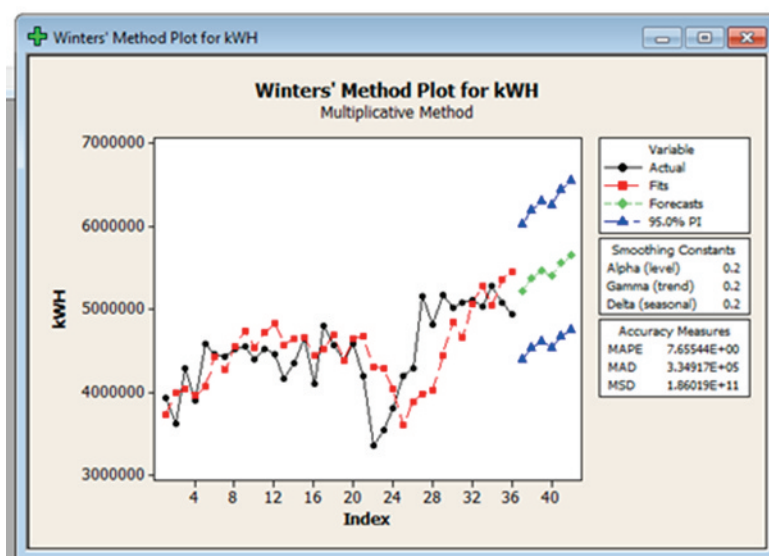


Figure.9 Forecasting by using Winter’s method

There are other measures of the accuracy of historical errors in forecasting. In this paper used the performance of the model will be evaluated according to mean absolute percentage error (MAPE), calculated according to;

$$MAPE = 1/n * (\sum_{i=1}^n (|Y_t - Y_i|) / Y_i) * 100\% \quad (7)$$

Where n is the number of existing samples, Y_t is the real historical value and Y_i is the estimated value.

As a result, comparing time series forecasting method for finding out the optimal model in a semiconductor plant by using monthly historical data of the time series from 2010 to 2012 and used MAPE found that as following;

Table 1. Comparison of forecasting methods

Forecasting methods	MAPE (%)	Scores
Single exponential smooth	5.60	6
Moving averages	5.72	5
Double exponential smooth	6.37	4
Trend analysis	7.44	3
Decomposition	7.47	2
Winter’s	7.65	1

4. Discussion

This paper presented a study and the comparison of electric forecasting methods by using monthly historical data of the time series from 2010 to 2012. The MAPE value sequence from high to low of each method were Single exponential smooth, Moving averages, Double exponential smooth, Trend analysis, Decomposition, Winter’s and 5.60, 5.72, 6.37, 7.44, 7.47, 7.65 respectively. As a result, a single exponential smoothing method was the best electric load forecast for semiconductor plant at smoothing constant $\alpha = 0.706780$ and highest significant level scores. It can reduce avoidance cost of electricity spending and a tool for management team decision making in order to minimize the unit cost or maximize the profit from operational management. The model in

this research, can be applied to others time series.

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