



Kingdom of Bahrain Long Term Load Estimation Modeling

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Authors' contributions

This work was carried out in collaboration between all authors. Author ISQ designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors MI, YIK and ARI managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This paper highlights on different models of load estimating and the factors affecting the load. Various methods were discussed on forecasting the minimum and maximum load demand for the Kingdom of Bahrain; these methods are linear, exponential and polynomial. Using the three methods help to find the suitable models. Under the calculation of the load forecast, it has been mentioned some important parameters affecting the estimated loads which are mainly minimum and maximum loads, and their variation with the population. The article is prepared on the basis of data collection in the Kingdom of Bahrain. It concludes that the linear is the most suitable and efficient one in the research.

Keywords: Load; Bahrain; linear; exponential; polynomial.

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ABBREVIATIONS

ANN : Artificial Neural Network
 SES : Simple Exponential Smoothing Method
 GMDH : Group Method of Data Handling
 Min : Minimum
 Max : Maximum
 Exp : Exponential
 MTLF : Mid-Term Load Forecast

1. INTRODUCTION

It is well known that the Load forecasting generally means to predict the future load and then do the necessary precautions for supplying that forecasted load. The Load forecast can help electric industry to have an important decision for upgrading the substations that means to develop and upgrade the parts of these substations, i.e. generators and load switching. Load forecasts are extremely important for energy suppliers, financial institutions, and other participants in electric energy generation, transmission, distribution and markets.

Load forecast can be divided into three types [1]:

- a) Short-term forecasts which are usually from one hour to one week [2]
- b) Medium forecasts which are usually from a week to a year [3], and
- c) Long-term forecasts which are longer than a year [4].

In the present paper we are focusing on long-term load forecast and for that purpose we will discuss various methods that can help to model the long-term load forecasting.

The forecast of different time periods are important for different purposes for a company or authority [1]. The accuracy of these methods is not the same all time. For a specific time periods the accuracy may change. The main reason for this is that for short periods it is predicted the load forecast based on the historical data. The historical data could be for 25-30 years in order to forecast the future load demand. But the supply and demand keeps changing as well as the weather conditions and the energy prices with the time. Therefore, load forecasting is very important for the industries.

The short term load forecast is very useful to prevent the failures of the system and load

shedding. Based on the future loads, accurate decisions can be made to prevent overloading and to maintain reliability. During different times of the year the demand for electricity changes. It is well known that in winter the people use less electricity than in summer. In winter, they do not require as much air conditioning compared with summer. During this time, the load on the power decreases, which shows us the minimum load demand. This information is important as this tells the company when they can start maintenance. Where the electricity needed is much lower compared with winter. Therefore, the companies can maintain their equipment as there is a lower chance of cutting off electricity.

The minimum and maximum load capacity is also affected by different seasons. However, it occurs in the summer. During the summer, where the people consume more electricity as they stay indoors more often and use more air conditioning. Companies must know this information to minimize faults caused by overload. As the electric demand increases, the supply must increase, which sometimes is not possible. Companies must also avoid maintenance in the summer as it cuts off electricity.

Population has an impact on the usage of electricity. Population has more importance in long term forecasting, but it also can impact the load curve for short term load forecasting. As an example, the daily load curve of developed countries shows different patterns as compared to the daily loads curve of under developed countries. Huge peak load is observed in daily bases for Bahrain between 1:00PM till 4:00PM and between 10:00PM till 1:00AM (after Midnight). Thus for load forecasting we must consider the country's population, and also must have glance on the industrial development of the country for long term load forecasting.

To calculate load forecasting, different methods can be used based on the type of load forecast. For example, for short term forecasting we use historical data as mentioned earlier and for long and medium term forecasting artificial intelligence or computer programs are used. The accuracy of load forecasting depends on the method being used and also depends on the weather conditions or the population of some specific area. In this paper, the factor of population is considered as an important tool for calculating the future load forecasting.

2. LITERATURE REVIEW

Many studies were carried out on the Load forecasting. Qamber et al. [5] in his study of the Peak Load modeling deriving some models to estimate the electrical demand for future for the Kingdom of Bahrain which is carried out in the study. The ambient temperature is taken into the account as well as the time factor (Year). The model was developed in away describing the electric power demand during a summer period. The estimated values of the maximum electrical load is obtained and evaluated on actual peak load data of the Kingdom of Bahrain.

Badran et al. [6] carried-out their study entitled "Forecasting Electrical Load using ANN Combined with Multiple Regression Method". In their study, they have taken in consideration the history of loads which is taken from different companies and based on that they predict the future load up to year 2020 using the artificial neural network (ANN) technique with the traditional technique of trend curves. This technique is used to get results from any complex problem using large amount of training data. The data input studied through the Matlab. The results obtained can be used for future planning and operation.

Bon-gil Koo et al. [7] carried-out their study which leads to another technique in comparing three methods and predicting the electric load. The three methods used are ANN, SES, and GMDH. These methods are not used in the present study, because their study based on daily load.

Qamber [8] carried out the study on "Estimation of the Maximum Annual Loads Modeling in Kingdom of Bahrain". According to the review of the air temperature which has direct effect on electricity demand, it shows that the graph fitting technique was used for different loads in four years and three models were made. The results showing that the load increases every year except for one year, which was un-usual case because the temperature dropped down in that year. Therefore, the temperature has direct effect on load. The relation used during the study was linear relation.

Almeshaiei et al. [9] were made their study on "A methodology for Electric Power Load forecasting" which uses models to predict the load based on decomposition and segmentation of the electric load. As a case study, load data

was recorded from Kuwaiti electric network. This method involves average and probability plots. The results illustrated that every electric plant has to have its own special method for forecasting because each country in some cases has different factors that can affect the load demand. For example in developing countries the load demand grows at high rate.

3. FACTORS EFFECTING THE LOAD DEMAND

There are some factors affecting the load demand such as weather, population and some other factors [1]. In electric demand analysis and forecasting, weather is usually considered to be composed of three elements: Temperature, Humidity, and Sunlight. The sunlight element effect is not considered in the present study. The weather in Bahrain is hot in summer and cold in winter. Humidity is high in Bahrain which also affects the electricity. So Bahrain's weather affects the load. Also the population is one of the most important factors that affect the load demand in Bahrain for a long term.

3.1 Temperature

It is well known that the electrical power demand is linked to several weather variables, mainly the air temperature. The high temperature in Bahrain has a great effort on energy consumption. Therefore, it is obvious the relationship between temperature and electric power load is a direct correlation. For example, in summer the people will consume more energy due to high temperatures. Furthermore, a particular network is possible to predict the next year maximum load based on the available data.

3.2 Humidity

Temperature is only one of three weather factors as mentioned earlier, the other two are humidity and solar illumination. The humidity can have an important effect on electric load and if the air is humid it has considerably more mass which means more equipment will be considered like cooling and heating. Humidity can make large difference in electric demand in summer and little in winter. Unfortunately, it is obvious that the humidity in Bahrain is mostly high in all seasons. Therefore, it might affect all year.

3.3 Population

The population of Bahrain is increasing highly every year. This is due to the increased rate of birth and the increasing rate of people travelling from different countries to Bahrain. This leads to the increase of power demand to meet the need of the increasing population. Secondly, the market of Bahrain is open, which means that more companies and manufacturers get the opportunity to setup business in Bahrain. This leads to further increase in power demand. The requirement of power by these companies and manufacturers is huge as compared to the domestic load. Manufacturers use bigger machines which require more power. As well, the companies need all time electricity for purposes like lighting, air conditioning etc. which leads to increase in power demand.

Some people in Bahrain don't have the proper knowledge on how to use the electricity more efficiently as there are no much awareness created among the people on this topic. If people are aware on how to use electricity more efficiently, then the load demand can be reduced up to certain limits.

4. METHODS FOR LOAD ESTIMATION AND MODELING

There are number of methods that can be used to estimate the load forecast. Some of these methods are given in the coming sub-sections.

4.1 4th Degree Linear Regression

The 4th degree linear regression demand curve is considered as graphical representation of the relationship between the electric demand and the time. The demand for electricity is always proportional directly to the population using the electric power. This means if the number of population increases the demand for electricity will increase as well and vice versa.

4.2 Exponential

An exponential function is a mathematical function of the following form [10]:

$$f(x) = a^x \quad (1)$$

where x is a variable, and a is a constant called the base of the function. The most commonly used exponential-function base is the

transcendental number e , which is equal to approximately 2.71828. Thus, the above expression becomes:

$$f(x) = e^x \quad (2)$$

When the exponent in this function increases by 1, the value of the function increases by a factor of e . When the exponent decreases by 1, the value of the function decreases by this same factor (it is divided by e).

As an example for exponential function, in electronics and experimental science, base-10 exponential functions are used. The general form is:

$$f(x) = 10^x \quad (3)$$

When the exponent increases by 1, the value of the base-10 function increases by a factor of 10; when the exponent decreases by 1, the value of the function becomes 1/10 as great.

For a given, constant base such as e or 10, the exponential function "undoes" the logarithm function, and the logarithm undoes the exponential. Thus, these functions are inverses of each other.

4.3 Fourth Degree Polynomial

Polynomial comes from poly which means "many" and nomial means "term" so basically polynomial means "many terms" [11].

A fourth degree polynomial can have:

1. constants (like 3, -20, or $\frac{1}{2}$)
2. variables (like x and y)
3. exponents (like the 2 in y^2), but only 0, 1, 2, 3, ... etc. are allowed

That can be combined using addition, subtraction, multiplication and division except not division by a variable (so something like $2/x$ is right out).

4.4 Methods of Load Estimation Modeling

The data given from Um Al-hassam control system is shown in Table (1). The minimum load starts with 353MW and increases further approximately linearly. Until it reaches 2010 there is a big gap increased from 2009-2010 because the weather was a hot year and the temperature rises and it reached 47.3°C which

affecting the load. It has been shown earlier the factors affecting the load. The temperature and population showing the positive relationship with the load. In the data table (Table 1) there is a clear indication shows the relation of the rise in load caused by temperature.

According to the maximum data given, the first year 2003 the load was 1535 MW. Every year further increased by some amount (6% to 10%). In 2010, the increased of the maximum load was high almost 300 MW which was a big difference compared with the increasing in load from 2003-2009. The idea it will be clear with calculating the error in the present study.

The Government always tries to give the best solution to live in Bahrain. The number of people in Bahrain increases by every year as it is shown in Table (1). That means Bahrain attract people from everywhere. Because of that the load increased by every year plus the other factors also.

Back to the old days every house has a few devices or less power consumed by the residents. The average of air conditioners used by house was two air-conditioners. Now a days the increase of financial ability and the Welfare requirements rise. At least four air conditioners

used at a single house rather than the refrigerants and all electrical appliances.

Both Figs. (1) and (2) show the population versus year and peak load versus population in Bahrain, respectively. Also, it has been noticed that in the year 2011 the population decreased, but the maximum load increased. The reason behind this was the economic situation, as some new factories opened that year. Therefore, more power was needed.

Table (1). Actual data of minimum, maximum loads and population

Year	Min Load (MW)	Max Load (MW)	Population
2003	353	1535	764519
2004	397	1632	823744
2005	411	1725	888824
2006	445	1906	960425
2007	494	2136	1039297
2008	570	2314	1103496
2009	607	2438	1178415
2010	663	2708	1228543
2011	669	2812	1195020
2012	644	2880	1208964
2013	699	2917	1253191
2014	758	3152	1316000

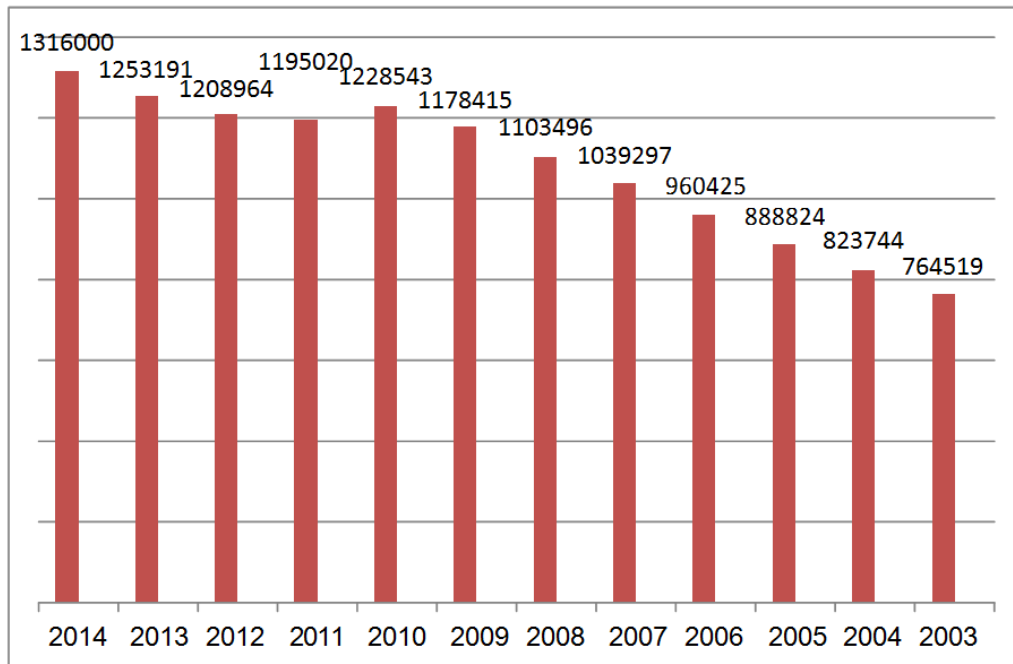


Fig. 1. Population of Bahrain from 2003 to 2014

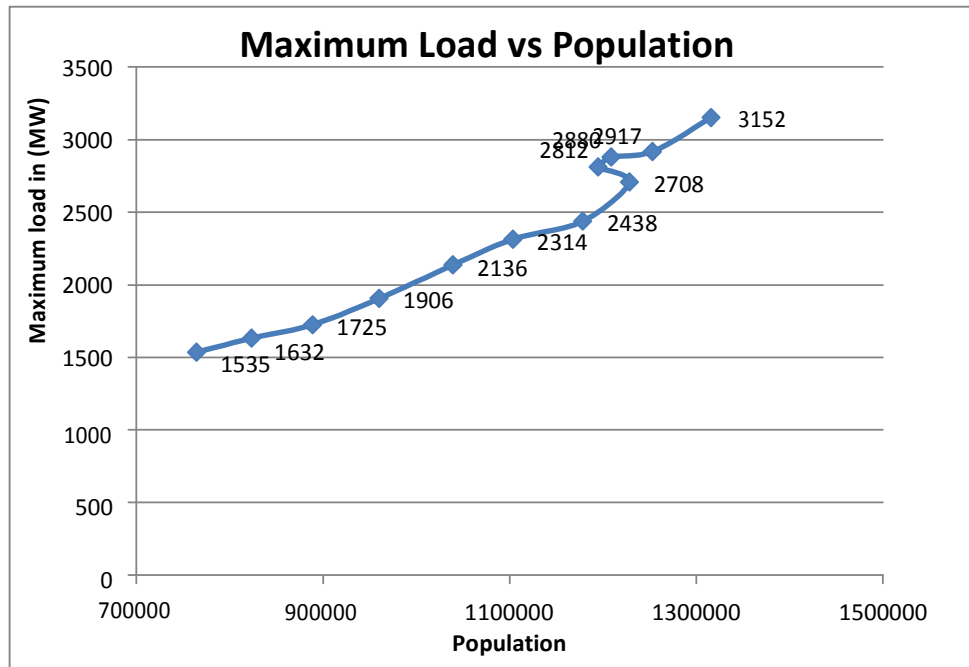


Fig. 2. Maximum load (MW) vs population

Now a days the forecasting getting easier than before, the programmers developed the tools in Microsoft Excel, Matlab and other programs to model any curve by using linear, cubic or any polynomial equations even the exponential. It is showing the forecast curve and the equation of the curve.

For drawing the actual curve (2003-2014) using Microsoft Excel 2010 it is an easy progress. But, the idea in which curve model you will choose for forecasting. It depends on the historical data given and the goal of engineering view. It means which curve (methods) will help to reach the best performance of the research.

In this paper three different methods are used. These are linear, fourth degree polynomial and exponential equations.

To compare the three different methods, the % error of estimating values are calculated by

$$\frac{\text{Actual Load} - \text{Estimated Load}}{\text{Actual Load}} \times 100 = \% \text{Error} \quad (4)$$

For the minimum load which explained before, the load increases slowly with population. It is clear that the relation is linear. For this reason, the linear method for forecasting is chosen.

After preparing the data (Years and Minimum loads), the following equation is obtained:

$$y = (36.601x) - 73955 \quad (5)$$

Where:

y is a function of (x) which is the minimum load (MW)

x is the year

The linear regression method is attempted to develop a mathematical relationship between demand and factors that cause its behavior. These are the equations used:

$$y = a + bx \quad (6)$$

$$a = \bar{y} - b\bar{x} \quad (7)$$

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} \quad (8)$$

Where,

$$a = \text{intercept, } \bar{x} = \frac{\sum x}{n}$$

$$b = \text{slope of the line, } \bar{y} = \frac{\sum y}{n}$$

In Fig. (3) it is shown the actual minimum load every year from 2003 until 2014 and it is clear the relationship is linear.

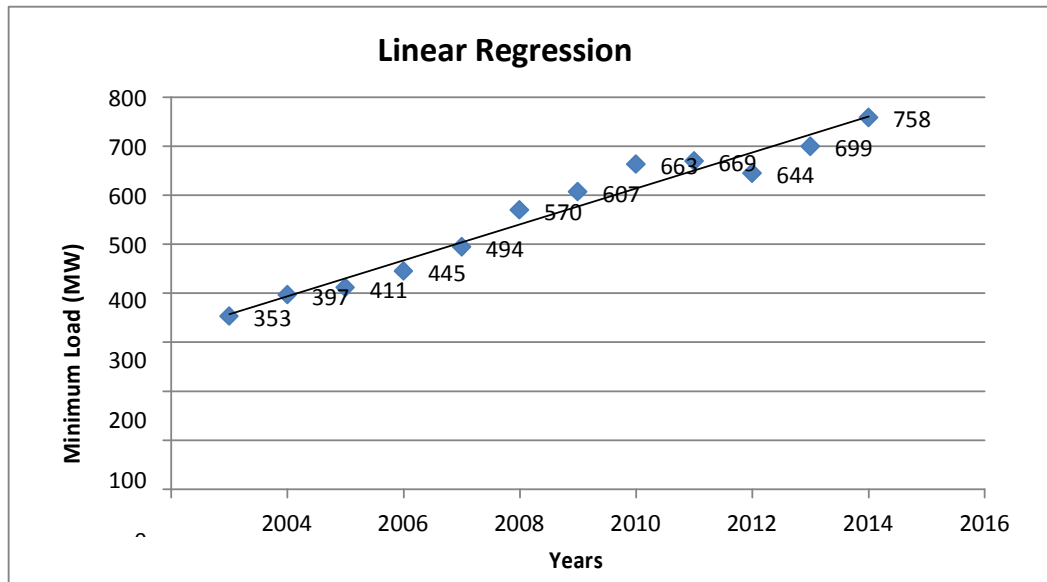


Fig. 3. Actual minimum loads vs years

For the maximum load demand it needs to show the entire digit to give the best results. Using Matlab was fine for the minimum but not for the maximum. Also it has been tried to check using the Microsoft Excel 2010 and it gives wrong equation due to the missing digits in the equation. Therefore, the model was obtained using the linear regression method. The obtained model is:

$$y = (135.1713287x) - 305298.3636 \quad (9)$$

Fig. (4) shows the Actual Maximum load and it also can be as linear relation due to the low value of error.

In the beginning of the research the exponential curve was not bad for the data given and it had a good curve from 2003-2014. It has been explained earlier that the exponential function which leads to the increases in the curve in the next years coming as straight line. However, the estimation for a long time it makes the time fixed at some point and the load will reach a high value. However, the equation of the exponential curve derived for the minimum load (Fig. 5) was formed by Microsoft Excel 2010:

$$y = (8 \times 10^{-58}) \times e^{0.0686x} \quad (10)$$

Similarly for the maximum loads, the exponential model derived and it shows the similar behavior as for the minimum loads curve. The derived equation for the curve is:

$$y = (1 \times 10^{-56})e^{0.068x} \quad (11)$$

This equation is represented and shown in Fig. (6).

The plan was to use the polynomial equations because it gives more accuracy curve which means less error. First, using the cubic equation to plot the curve but it gives a wrong statement after 2020. In the year 2020 the curve starts to decrease and if we go further for more years it will not be stable. So, we tried the fourth degree of polynomial curve to see if there is a difference as compared to the cubic curve. The equation for the minimum load given by Microsoft excel was:

$$y = (0.1681x^4) - (1350.3x^3) + (4 \times 10^6x^2) - (5 \times 10^9x) + (3 \times 10^{12}) \quad (12)$$

The actual minimum load was drawn on a polynomial curve which is shown in Fig. (7). Similarly for the actual maximum loads, the 4th degree polynomial curve was made and it shows us the similar behavior as for the minimum loads curve. It is shown in Fig. (8).

In the present section, all methods used are discussed. In addition, the long term forecast depends on the factors affecting the load mainly is the population. The humidity is almost high in all year due to the high temperature in the Kingdom of Bahrain.

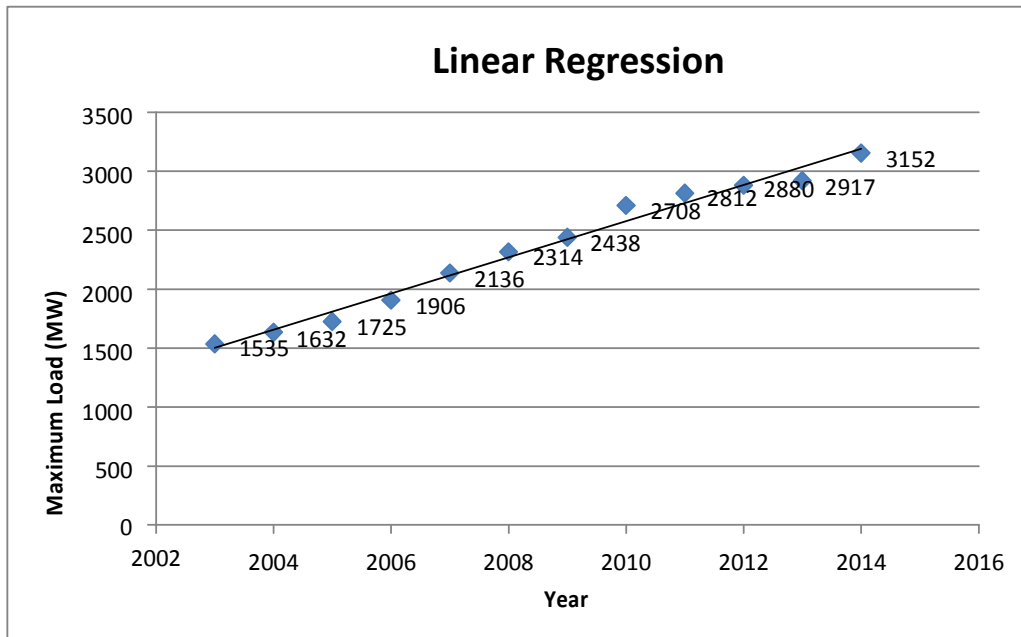


Fig. 4. Actual maximum loads vs years

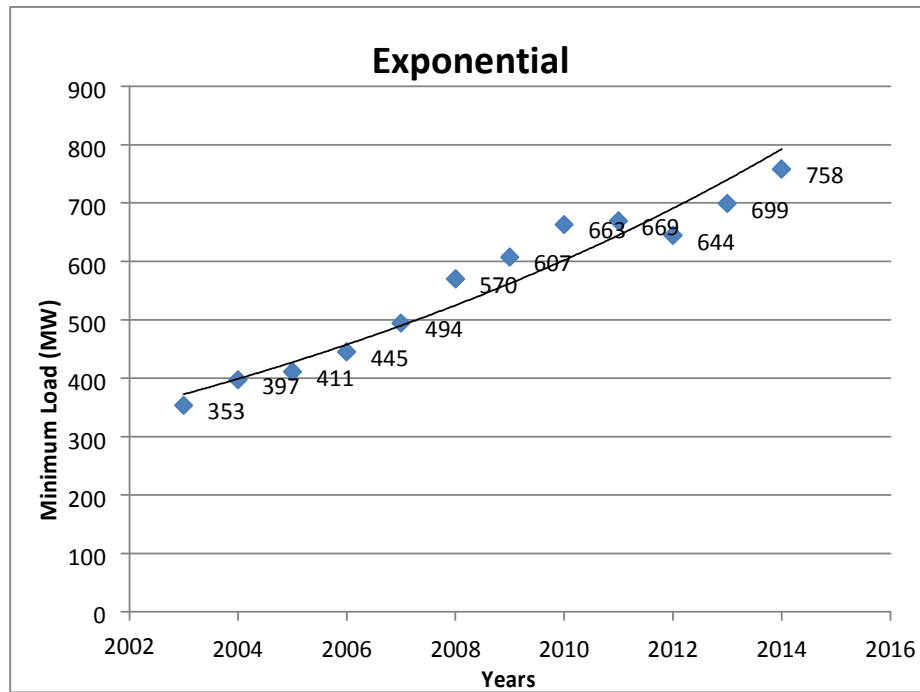


Fig. 5. Actual minimum loads in exponential model

Economically we have to plan for future demand and we need to have stand- by generators [12]. Some commitment has to be made in advance to keep the generators ready all the time for future demand which increases and we can use the method of load forecasting to keep our

generators committed. The decision to commit means that the generator will cost some fixed revenue in order to supply the future demand. This is the main application of load forecasting as an economic dispatch.

The future load demand is calculated using the load demand forecasting method and then we use economic dispatch methods to know the best combination of the stand-by generators which will give us the minimum cost when they are needed in the future.

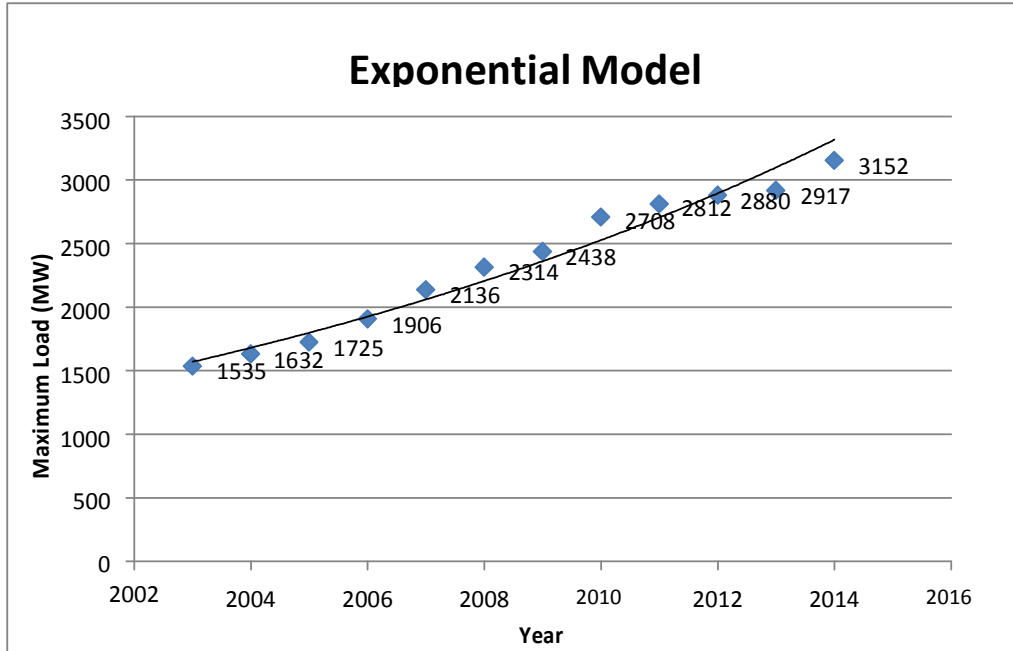


Fig. 6. Maximum loads (MW) vs year in exponential model

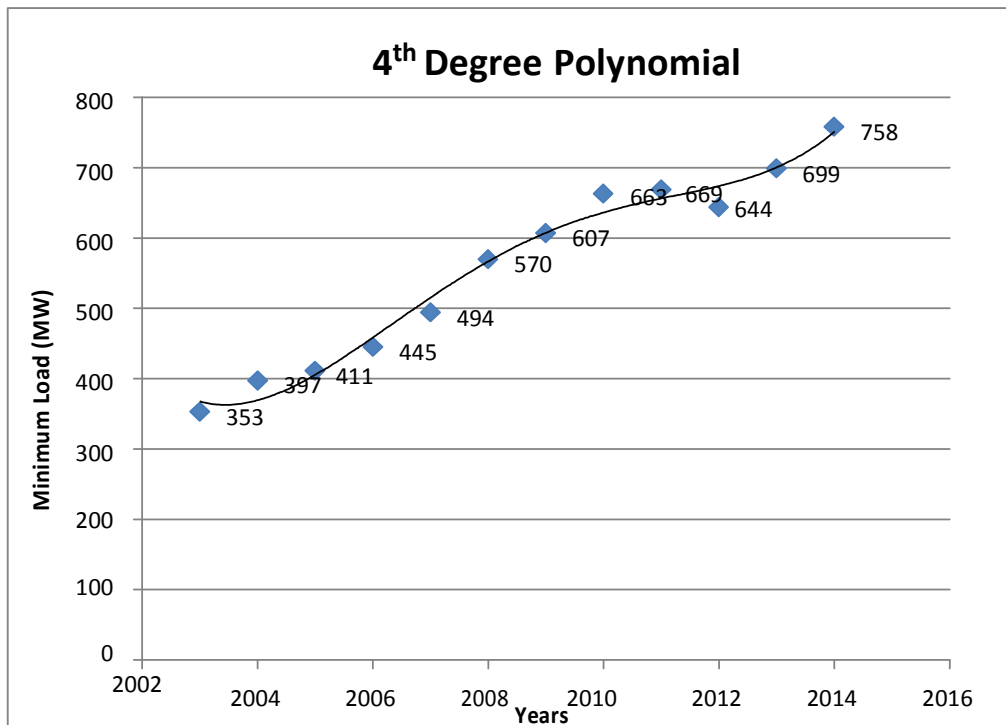


Fig. 7. Actual minimum loads (MW) vs year

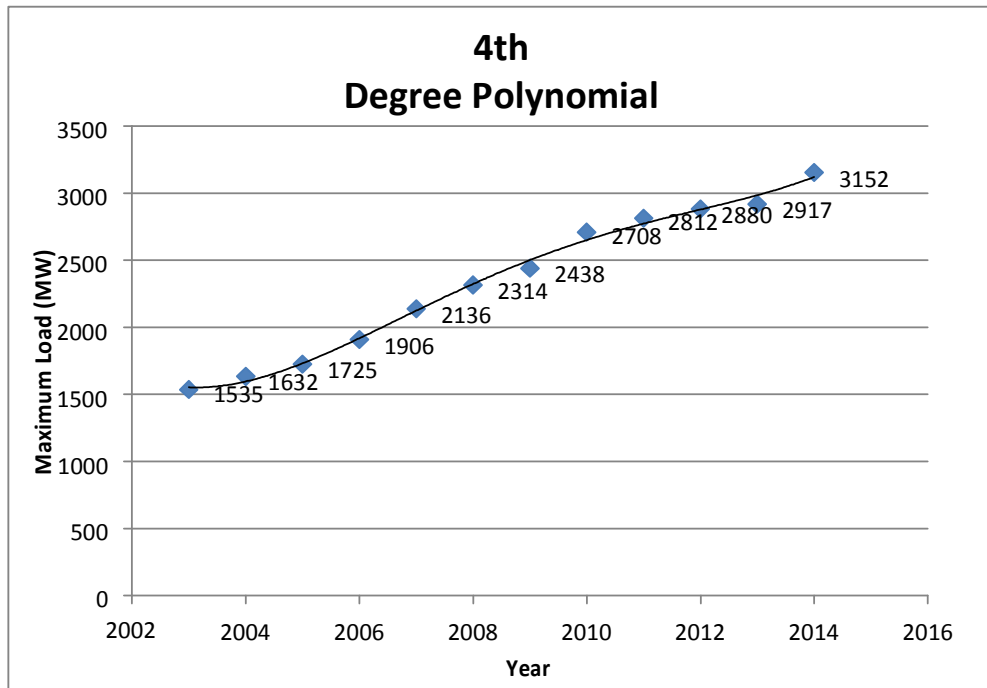


Fig. 8. 4th degree polynomial of actual maximum loads vs year

As it mentioned before the forecasting of the linear curve shows the best performance of expecting load in the future. However, the increases in population for the next ten years might be guaranteed so the linear curve is the best method to use.

The average increase of the actual load was almost 33MW from 2003 to 2014. The constant increase of minimum load was equal 36.6MW. In 2025, the load is equal to 1162.0250 MW and the actual load power was equal to 758MW in 2014 so the difference between the actual load and the estimating value was 404MW. Comparing the loads from 2003 to 2014 of the same period is the difference which is 405MW. So, the differences should be equal to each other but there is an error which considered as a very low error when compared with other methods. Due to this reason, this method is considered as the best method for the load forecasting.

Here we found that the maximum error is 7.5% which is high error found for the exponential and the Minimum Error was 0.18% which is a really good accuracy for a minimum load Fig. (9) and Table (2). So, the average error is almost 3.68%. We calculate the error by equation (4).

Table (2). Estimated of minimum load in (MW) from 2015 to 2025

Year	Estimation of Minimum load in (MW)
2015	796.0150
2016	832.6160
2017	869.2170
2018	905.8180
2019	942.4190
2020	979.0200
2021	1015.6210
2022	1052.2220
2023	1088.8320
2024	1125.4240
2025	1162.0250

In Table (2) the minimum load estimated using the equation for the minimum load. The average increase of the actual load was 147 MW from 2003 to 2014, the constant increase of maximum load was almost 153MW. In 2025 the load is equal to 4873.58 MW and the actual load which was in 2014 is equal to 3152 MW so the difference of an actual load and the estimating value was 1721 MW. Comparing the load from 2003 to 2014 the difference was 1617 MW. So, the differences should be equal to each other but they are not equal because in the year 2010 the population increased and in the year 2011 the

population decreased. Therefore, due to this annual population changes there is an error in the estimation of the future load but this error is very low as compared to other methods. In Fig. (10) it shows the linear forecast until 2025. Table (3) shows the estimation maximum load calculated from the given equation.

The average of actual load was 147 MW from 2003 to 2014, the constant increase of minimum load was almost 6.6% in each year. In 2025 the load equals to 1540.4756 MW and the actual load which was 3152 MW in 2014. Therefore, the difference of an actual load and the estimating value was 1721 MW.

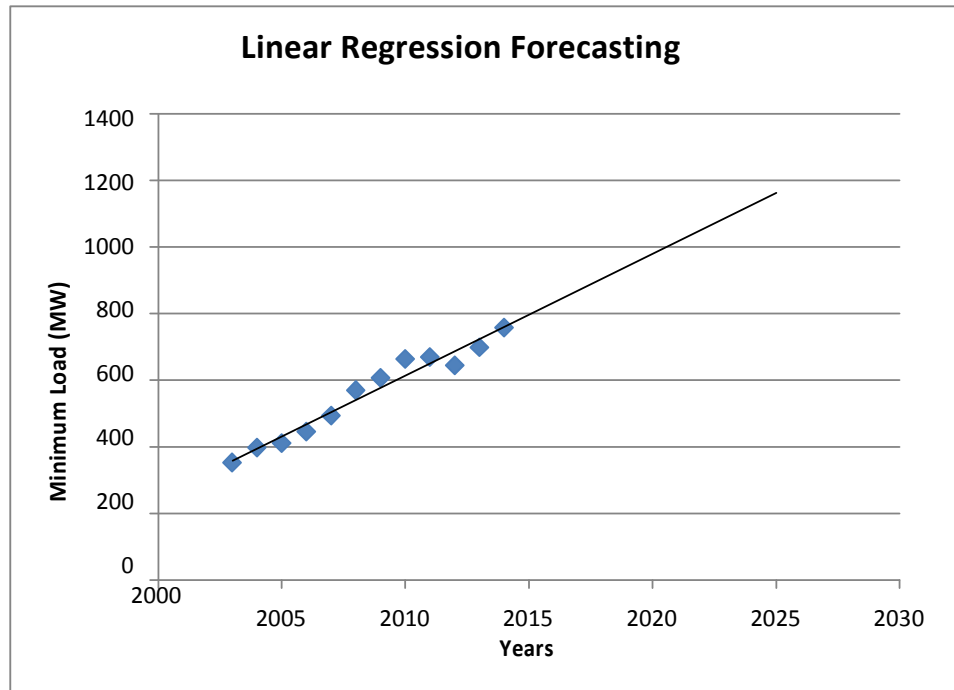


Fig. 9. Minimum estimated loads vs years

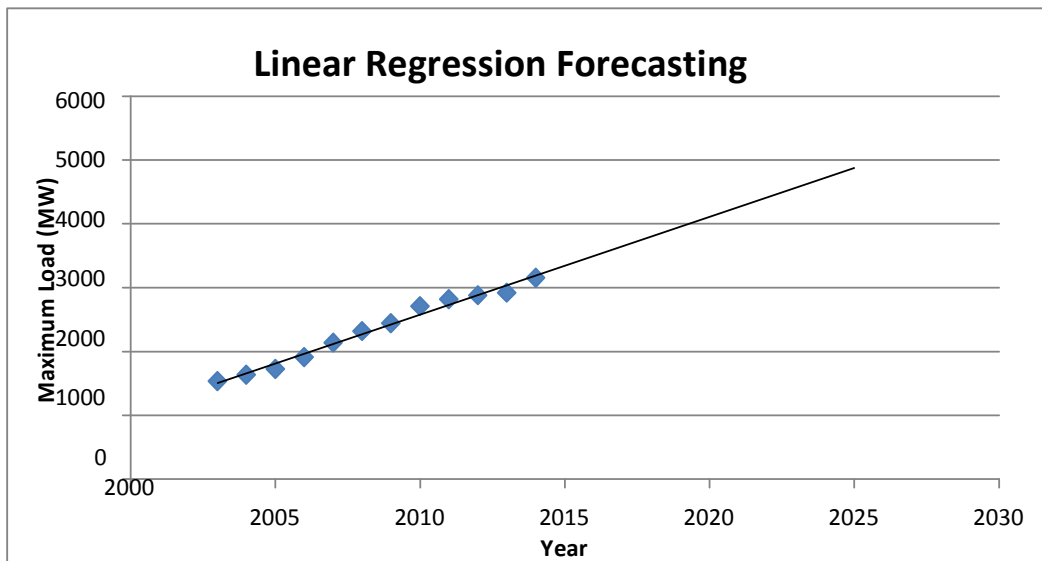


Fig. 10. Estimating of maximum load vs year

Comparing the load from 2003 to 2014 the difference was 1617MW. So, the differences should be equal to each other but they are not equal because in the year 2010 the population increased and in the year 2011 the population decreased and due to this annual population changes with an error in the estimated future load but this error is very low when compared to other methods so due to this reason, this method is considered as the best method for load forecasting.

It is found that the maximum error was 8.9% which is high error using the exponential and the minimum error was 0.72% which is a good accuracy given from exponential curve for a minimum load and the average error is 5.39%. The estimated minimum load using the exponential modeling is shown in Fig. (11) and Table (4).

Similarly, for maximum load using the Exponential method is estimated and shown in Fig. (12) and the estimation value calculated by the given equation in Table (5).

From the curves illustrated in Figs. (7) and (8), the curves passing through almost the same points of minimum and maximum loads, respectively. Then, based on the obtained model the load forecast is obtained for the years 2015 till 2025.

For the load estimation from the years 2015 to 2019 the differences of the minimum load was logical. For example, the different in minimum load for 2015-2016 was 159 MW. But after 2019 the curve will increase like exponential and the average of increasing almost 1500MW per year from 2020 to 2025 which is not logic. As another example, from 2021 to 2022 the different of the power load was 1263 MW. The minimum load shouldn't increase by this big amount as here. In addition, it will be hard to forecast the population in the next years, because there is a number of factors will affect the number of population.

Table (3). The Estimated values of maximum load in (MW)

Year	Estimation Max Load (MW)
2015	3341.86
2016	3459.04
2017	3648.21
2018	3801.38
2019	3954.55
2020	4107.72
2021	4260.89
2022	4414.06
2023	4567.23
2024	4720.40
2025	4873.57

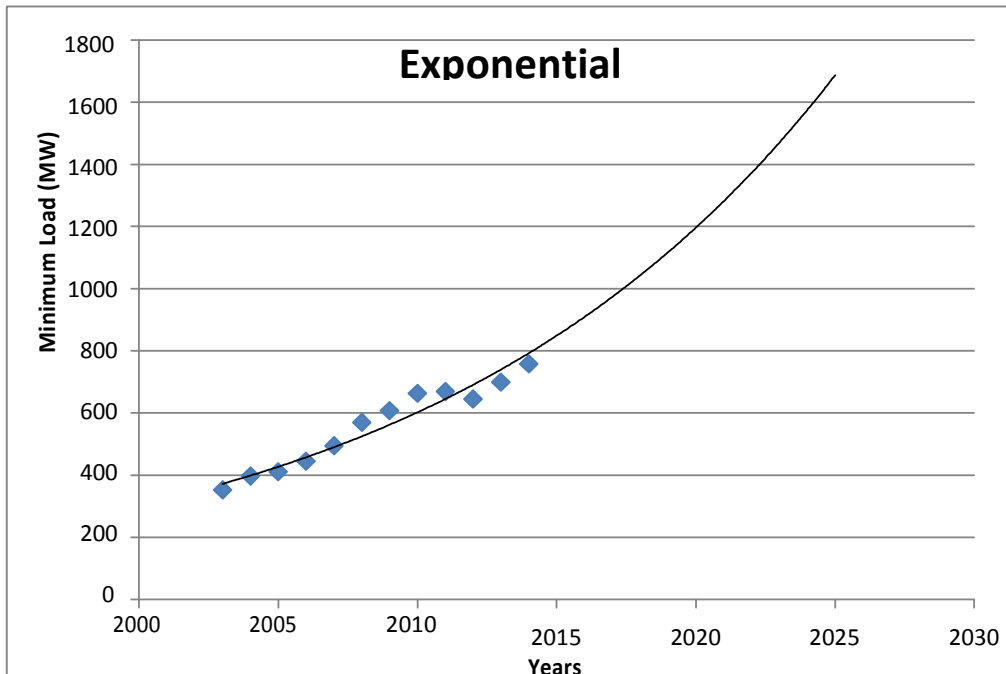


Fig. 11. Estimation curve by exponential for minimum load in (MW)

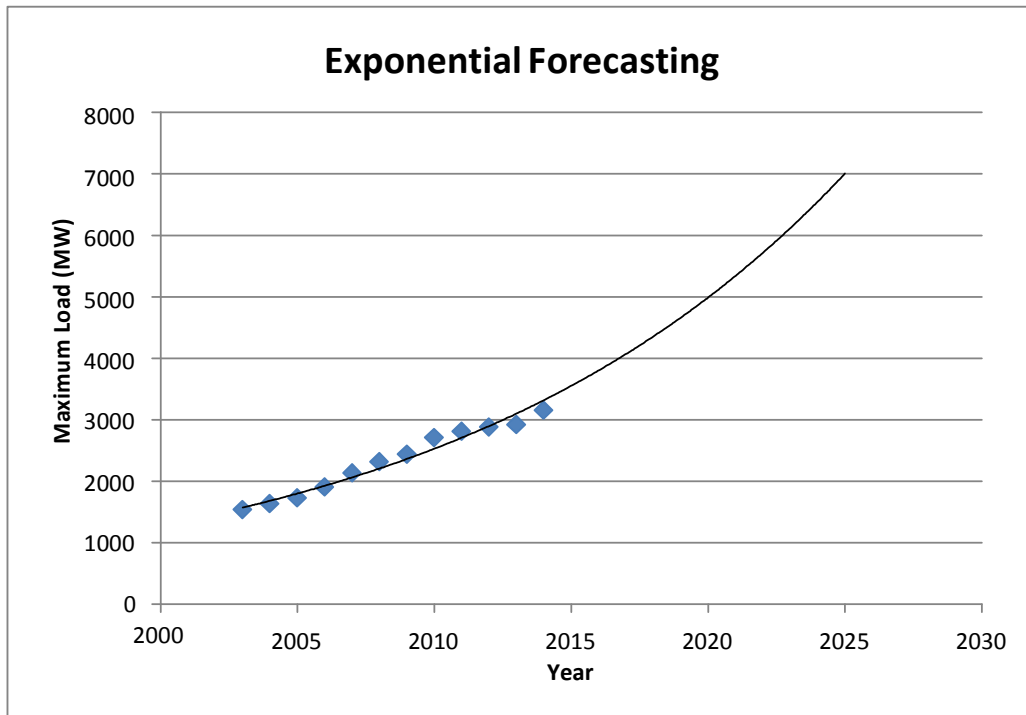


Fig. 12. Estimation curve of maximum load in (MW) using exponential modeling

As a result, the equation from the curve fitting tool in Matlab, if the year 2015 is substituted ($x=2015$) in the equation the result will not give the same result. The polynomial written as

$$P = Ax^4 - Bx^3 + Cx^2 - Dx + F \quad (13)$$

Where:

$$A = 0.1681, B = 1350.3, C = 4 \times 10^6, D = 5 \times 10^9, F = 3 \times 10^{12}$$

The coefficient C, D and F are not showing the exact number in digits. So, the result will not be exactly due to the high power equation. The polynomial forecasting of a long term will not give the best solution for Bahrain demand in the next ten years.

Table 4. The Estimation minimum loads (MW) using exponential modeling

Year	Estimation minimum load in (MW)
2015	812.2811
2016	856.9667
2017	923.2006
2018	984.2171
2019	1049.2663
2020	1118.6149
2021	1192.5468
2022	1271.3651
2023	1355.3927
2024	1444.9738
2025	1540.4756

Table 5. Estimated Maximum Load (MW) from 2015 to 2025 using exponential modeling

Year	Estimation maximum load (MW)
2015	3213.882
2016	3440.028
2017	3682.086
2018	3941.177
2019	4218.5
2020	4515.336
2021	4833.059
2022	5173.138
2023	5537.148
2024	5926.771
2025	6343.81

After founding the results of minimum load forecast, the forecasting load will be the same as the minimum load forecast. Using the model obtained for the minimum load applying the polynomial modeling will show results as shown in Fig. (13).

More results are shown in Fig. (14) and Table (6) using the linear regression method for the minimum load. For the maximum load using the Linear Regression are illustrated in Fig. (15) and Table (7), where the percentage error results are

shown in Fig. (16) and Table (8) using Exponential modeling for the minimum load. Fig. (17) illustrates the percentage error of the maximum load using the Exponential modeling and shown in Table (9).

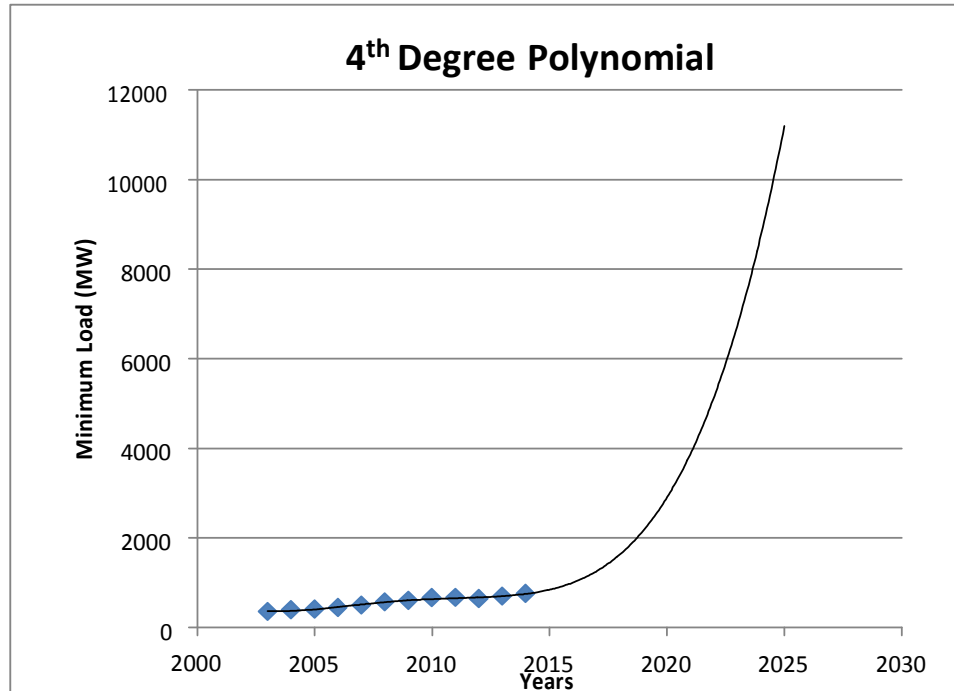


Fig. 13. Polynomial forecasting of minimum load

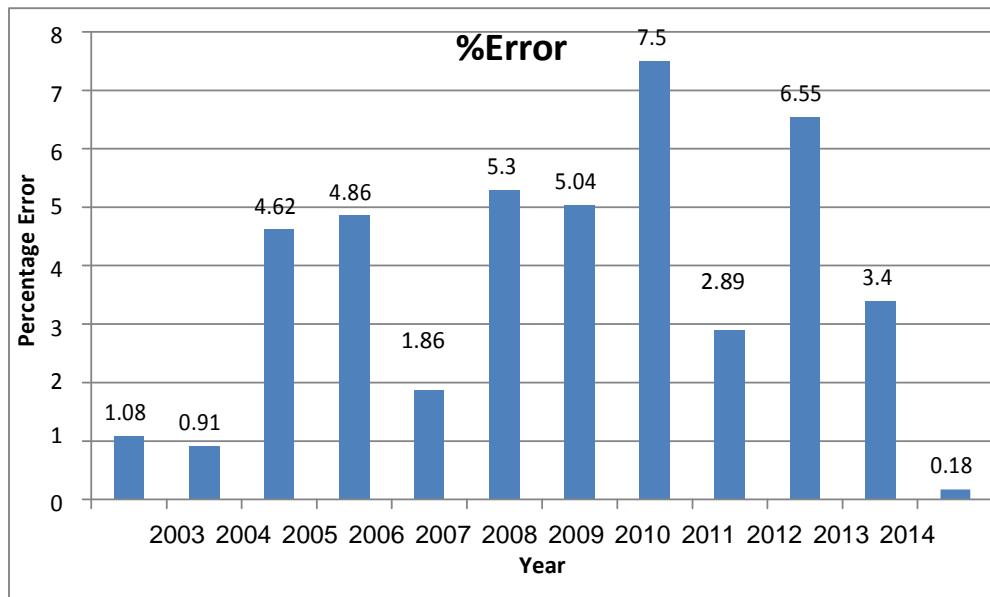


Fig. 14. The % error of minimum load using linear regression method

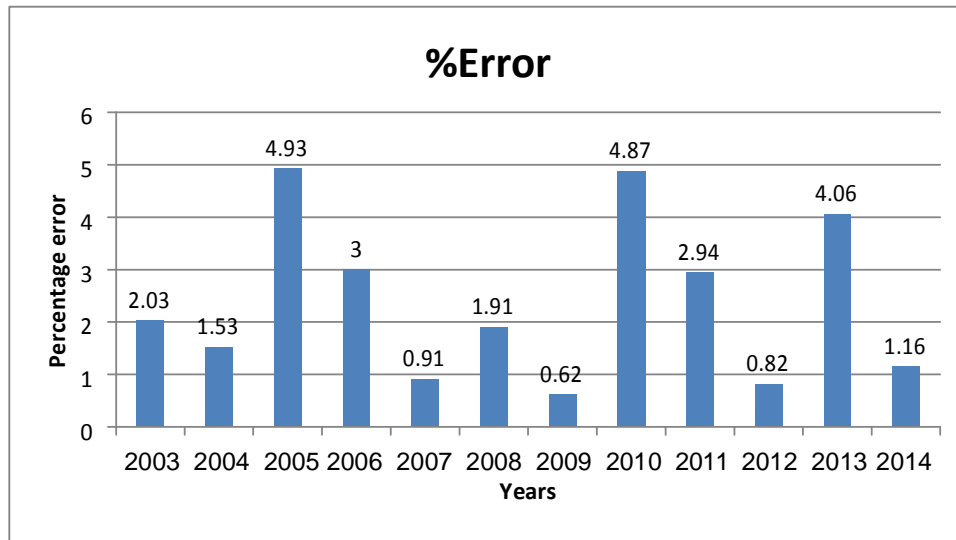


Fig. 15. The % Error of maximum load using linear regression method

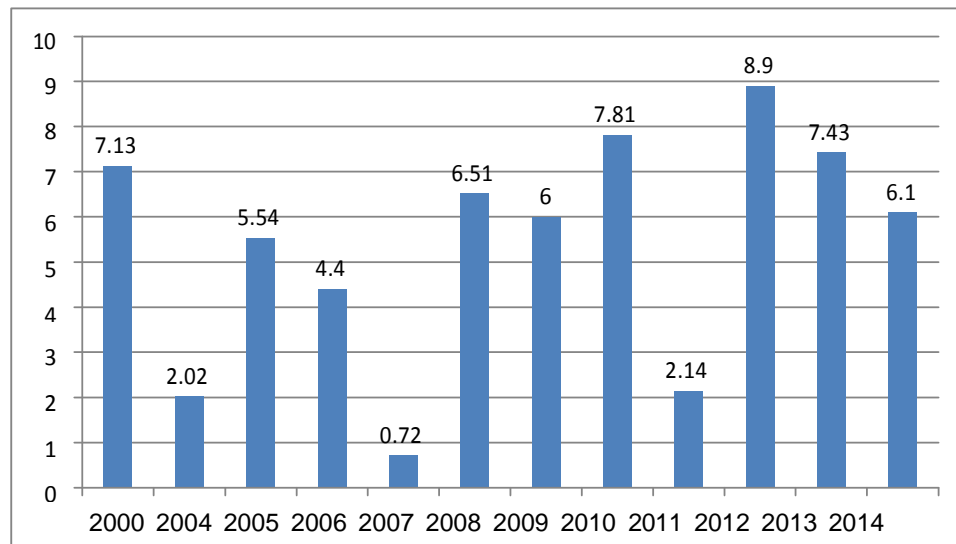


Fig. 16. The % error of minimum load using exponential method

Table 6. The actual and calculated values minimum load (MW) using linear regression

Year	Actual min load (MW)	Linear min load (MW)	Accuracy
2003	353	356.8030	1.08%
2004	397	393.4040	0.91%
2005	411	430.0050	4.62%
2006	445	466.6060	4.86%
2007	494	503.2070	1.86%
2008	570	539.8080	5.3%
2009	607	576.4090	5.04%
2010	663	613.0100	7.5%
2011	669	649.6110	2.89%
2012	644	686.2120	6.55%
2013	699	722.8130	3.4%
2014	758	759.4140	0.18%

Table 7. The actual and calculated values of maximum load (MW) using linear regression

Year	Actual max load (MW)	Linear max load (MW)	Accuracy
2003	1535	1503.81	2.03%
2004	1632	1656.98	1.53%
2005	1725	1810.15	4.93%
2006	1906	1963.32	3.00%
2007	2136	2116.49	0.91%
2008	2314	2269.66	1.91%
2009	2438	2422.84	0.62%
2010	2708	2576.01	4.87%
2011	2812	2729.18	2.94%
2012	2880	2882.35	0.82%
2013	2917	3035.52	4.06%
2014	3152	3188.69	1.16%

Table 8. The actual and calculated values of minimum load (MW) using exponential method

Year	Actual min load (MW)	Exp. min load (MW)	Accuracy
2003	353	378.155	7.13%
2004	397	405.01	2.02%
2005	411	433.77	5.54%
2006	445	464.57	4.40%
2007	494	497.55	0.72%
2008	570	532.88	6.51%
2009	607	570.72	6.00%
2010	663	611.25	7.81%
2011	669	654.65	2.14%
2012	644	701.14	8.90%
2013	699	750.93	7.43%
2014	758	804.24	6.10%

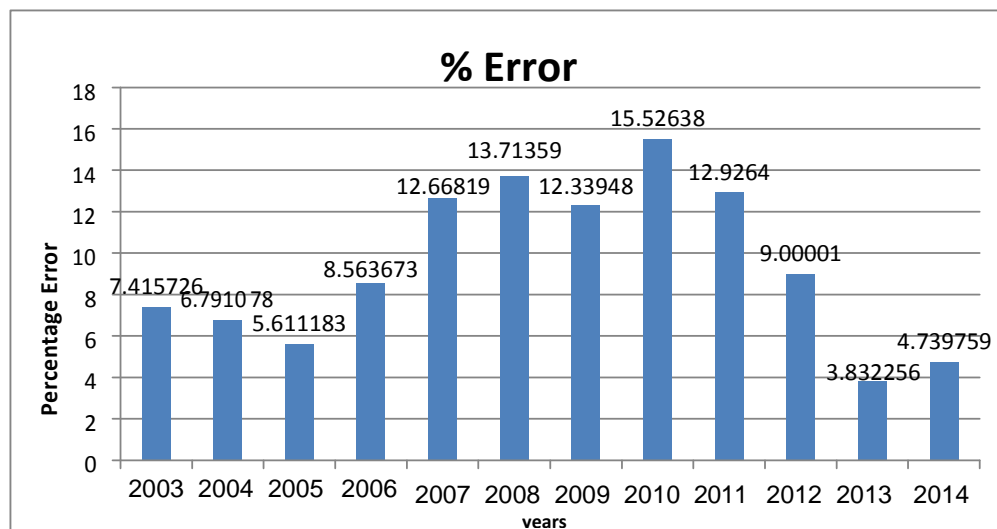
**Fig. 17. The % error of maximum load using exponential method**

Table 9. The actual and calculated values of Maximum Load (MW) using exponential method

Year	Actual max load (MW)	Exp max load (MW)	Accuracy
2003	1535	1421.1690	7.41%
2004	1632	1521.1700	6.79%
2005	1725	1628.2070	5.61%
2006	1906	1742.7760	8.56%
2007	2136	1865.407	12.67%
2008	2314	1996.6670	13.71%
2009	2438	2137.1640	12.34%
2010	2708	2287.5460	15.53%
2011	2812	2448.5100	12.93%
2012	2880	2620.8000	9.00%
2013	2917	2805.213	3.83%
2014	3152	3002.603	4.74%

5. CONCLUSION

Following the estimating load for future as derived in the present research will always help the suppliers even if there is sudden increase in demand to be ready for the purpose. Finding the estimated load for future will help in the future plan for the generators to be ready on commitment. This will help for no load shedding or any shortage of power interruption and thus preventing the loss of revenue.

The most suitable model is the linear model for all derived models compared with the other models (Exponentials and Regression). Thus it is recommended to use as much data as possible to get an accurate reading.

As dis-advantages of the model of the exponential is very sensitive to multiplication. Any abnormal value will derive the equation which can cause high error.

The present research is very useful in the coming future planning period for a power plant of the Kingdom of Bahrain, because planning depends on estimating the minimum and maximum loads. Therefore, the main idea is to obtain the best model of the forecast load until the year 2025 to avoid the cut off of the electricity. This will help to know the capacity of generation needed to satisfy the maximum load calculated by the models obtained in this study. The difference between the present capacity and the estimated maximum load will investigate the shortage in the present capacity. The peak load in 2014 was 3152 MW and this is the highest load achieved on 23th of August. Therefore, the rest of the year 2014 was less than this amount of load. This means the usage of electricity will not go above 3152 MW. The maximum capacity

in Bahrain is 3934 MW at present. This is clear based on our estimation that this capacity will cover our estimating values until the year 2019. Also, it is clear from our estimation that the government of Bahrain might have more generators in 2019 than now, because in 2019 the population expected to increase and will not cover all the load demand.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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