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Annual Maximum Loads Estimation Modeling for Kingdom of Bahrain

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Abstract

The present paper proposes the impact of the air temperature on electricity demand as expected. The annual maximum load is recorded versus the years starting by the year 2009. At present, the graph fitting was applied with some mathematical and computational tools considering the lower values, the higher values and the average values of the annual maximum loads of Kingdom of Bahrain. For the three scenarios, the models are obtained by curve fitting technique. As well, the model of actual loads is obtained finally which has mostly the closest values obtained.

Keywords: Annual Maximum Load, Curve Fitting, Load Scenarios.

1. Introduction

For technical operations and control of Power Systems, the knowledge of the evolution of electric power load is important. The reason behind that is the electric demands must meet secure and reliable operation at all times.

The electric power load scheduling for the next years is related to the operation of the Power Systems. The historical data of the maximum load is needed to estimate the coming future maximum loads. In the present paper, the historical data for the Kingdom of Power was considered and based on that the estimated and expected maximum loads were obtained.

Power System operation, at the moment, faces new challenges associated with non-controlled power independent producers, such as wind farms, photovoltaic plants and small-hydro power plants (SHPPs). At the moment, a large amount of the independent renewable power generation is characterized for being a type of electric power production difficult to control: thus, on one hand, generally there is some kind of intermittency in the power resource, which is not controllable, while on the other hand, there are as many operation strategies as managers of renewable power stations.

Short-term forecasting of power production, for each kind of power plant, is a key matter for the Power System, since such short-term forecasting is an essential tool for ensuring power supply, planning of reserve plants, or inter-power-systems electric energy transactions, or helping to solve power network congestion problems.

A lot of research activity has been carried out, during the last years, in the short-term forecasting of power production. The forecasts of load variables for the next years, has helped in the improvement of short-term forecasting models based on statistical models.

2. Literature Review

As it is well known that finding an appropriate load forecasting model for a specific electrical network is not an easy task. As previous studies carried out for such type of purpose, Almeshaiei and Soltan in their paper [1] they present a pragmatic methodology that can be used to construct a model for electric power load. The methodology they followed is based on decomposition and segmentation of the load time series. The study was carried out on a daily real data from the State of Kuwait, where the electric network was used as a case study. The methodology was followed in the present paper is mainly based on principles of time series segmentation and decomposition. As well, some additional statistical analysis was followed to aid the decision making based on the adopted forecasts such as probability plots.

Emovon et al in their paper [2] are concerned with the optimization of the workforce scheduling for solving maintenance problems. The program they have written was written in Quick Basic. The program software designed to produce a seven day schedule for organization operating a seven day week. Hence organization operating a five day schedule wishing to change to a seven day schedule the researchers found the software very useful. The Quick-Basic computer programme was based on Alfares algorithm for solving schedule problem. Their data collected from Afam power station, Nigeria which was used as input data. The test results show the software is capable of determining workforce size and assigning workers to day-off pattern. The seven-day schedule produced savings of 11% maintenance labour cost when compared with the 5-day schedule currently being practiced by the Power station.

From the data collected by the authors [2], from Afam Power Station Nigeria it's on record that the first major gas turbine station built in Nigeria is the Afam Gas Turbine Power Station. The power station is located in the Niger Delta because of the large reserve of natural gas in the region.

The software used by Emovon et al [2] is capable of determining workforce size and assigning workers to days-off pattern for Afam power station and other organization like airline, police station and restaurant operating a 7 day a week. The software does not require specialized training unlike integer programming software. Also, the software was tested with data from Afam power station Nigeria. The tested results show that the software is capable of generating a seven day schedule. The seven day Schedule is more efficient and cost effective than the five day work schedule. The authors made a comparison and they made the comparison between the existing five-day schedule practiced by Afam power station Nigeria and the seven-day schedule generated by this software. The seven-day schedule is expected to produce savings of 11% maintenance labour cost annually.

Jiang et al [3] in their paper examine a new time series method for very short-term wind speed forecasting. The time series forecasting model is based on Bayesian theory and structural break modeling, which could incorporate domain knowledge about wind speed as a prior. Besides this Bayesian structural break model predicts wind speed as a set of possible values, which is different from classical time series model's single-value prediction This set of predicted values could be used for various applications, such as wind turbine predictive control, wind power scheduling. The proposed model is tested with actual wind speed data collected from utility-scale wind turbines. The authors [3] highlight in their paper that in the recent years, many time series models are developed to deal with nonlinearities in time series that cause problems for traditional linear models. Among these models, structural break models have become increasingly popular and achieved promising computational results in estimation and prediction of economic time series data. To test the efficacy of the proposed approach [3], real wind speed time series are used. The wind speed data used in this paper was collected by the anemometer installed on the top of each wind turbine's nacelle from a wind farm located in the east coast of Jiangsu province, China. Though the data was sampled at a very high frequency by a wind turbine's SCADA system, it was averaged and stored at 10-s or 10-min intervals (referred to the 10-min or the 10-s average data) in wind industry. The 10-s (high frequency) data shows the dynamic nature of the wind turbine, while the 10-min data reflects rather steady state of the turbine. The data used in this research is collected over a period of two weeks. The proposed forecasting method is tested on both 10-s and 10-min average data and compared with a persistent forecasting model. The authors in their paper [3] introduced a new time series model of forecasting very short-term wind speed. The forecasting model integrates the concepts of structural breaks and Bayesian inferences, which allows prior information about the wind speeds to be incorporated into the model and somehow boosts forecasting performance. For very short-term wind speed or power forecasting (e.g. the forecasting time step is 10 s), persistent model is very hard to beat. The proposed method is tested with real-world wind speed time series and its forecasting performance is compared with a benchmark persistent model and other popular forecasting approaches.

Three scenarios have been carried out by Qamber [4] to calculate the predicted maximum annual load for the kingdom of Bahrain with the objective of formulating an expansion plan for a future generating system. The results of the three scenarios were obtained and compared using a comprehensive analysis. The maximum annual load was calculated at average rates of 6.79% in the more reasonable scenarios using the MATLAB package following the curve-fitting polynomial technique.

Hahn, et al. [5] used various models and methods to predict future load demand. These various models and methods help decision-makers in the electricity sectors in facilities planning and an optimal day-to-day operation of power plant. The authors conclude that finding an appropriate approach and model is at core of the decision process and a decision maker in the energy sector has the need of accurate forecasts since most of the decisions are necessarily based on forecasts of future demands, where the selection of an appropriate model is the one of the first decision to be made.

Doege, et al. [6] realized power markets have been restructured since 1990s worldwide with electrical power nowadays being traded as a commodity. The liberalization and with it, uncertainty in gas, fuel and electrical power prices, requires effective management of production facilities and their financial contracts.

3. Results and Discussions

Because of random fluctuations of the obtained data of maximum annual load for Kingdom of Bahrain over the years starting by the year 2009, the curve fitting technique is applied to find out the estimated load values for the coming years in previous study [4] and the best fit equation. Then curve fitting analysis identifies the trend of the data for the individual data points. The main reason behind that is to build a described model. A simple models are obtained to optimize the maximum annual load for the coming years. Table (1) shows the loads under study.

Table (1) The Loads (MW) vs Year

Year	Authority	Scenario1	Scenario2	Average	Actual Peak Load (MW)
2009	2194	2436	2377	**2336**	2437
2010	2325	2601	2508	**2478**	2708
2011	2453	2778	2646	**2626**	2500
2012	2588	2967	2792	**2782**	2948
2013	2731	3168	2945	**2948**	?
2014	2881	3383	3107	**3124**	?
2015	3039	3613	3278	**3310**	?

Fig. (1) shows the lower value of annual maximum load in (Mega Watt) as a function of the years, where the result is a straight line. This type of result has already been observed in the following form:

$$P_L(\chi) = 140.17857\,\chi - 279437.71 \quad (1)$$

where: $P_L(\chi)$ is the lower value load (MW)

χ is the year

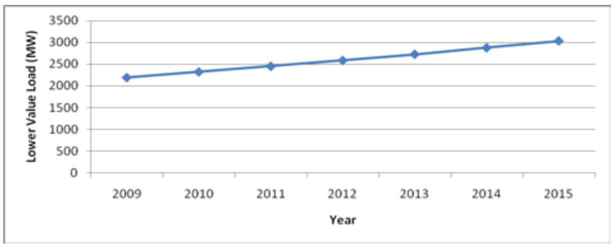

Fig. (1) Lower Value Load vs Year

The straight line corresponds to the data obtained through the calculation made/obtained by the Electricity and Water Authority of Kingdom of Bahrain, as well as done in both scenarios carried out in previous study [4]. The results confirms the validity of equation (1).

Fig. (2) shows the higher value of the annual maximum load in (Mega Watt) as a function of the years, where the result is a straight line. This type of result has already been observed in the following form:

$$P_H(\chi) = 195.89286\,\chi - 391144.14 \quad (2)$$

where: $P_H(\chi)$ is the higher value load (MW)

χ is the year

The straight line corresponds to the data obtained through the calculation made/obtained by the Electricity and Water Authority of Kingdom of Bahrain, as well as done in both scenarios carried out in previous study [4]. The results confirms the validity of equation (2).

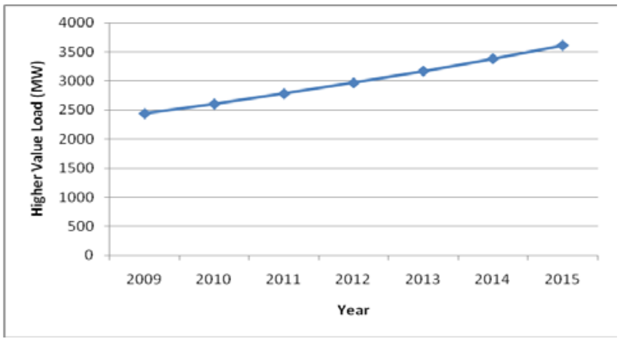

Fig. (2) Higher Value Load vs Year

Fig. (3) shows the average peak value load (annual maximum load) in (Mega Watt) as a function of the years, where the result is a straight line. This type of result has already been observed in the following form:

$$P_{APV}(\chi) = 162\,\chi - 323143.43 \quad (3)$$

where: $P_{APV}(\chi)$ is the average peak value load (MW)

χ is the year

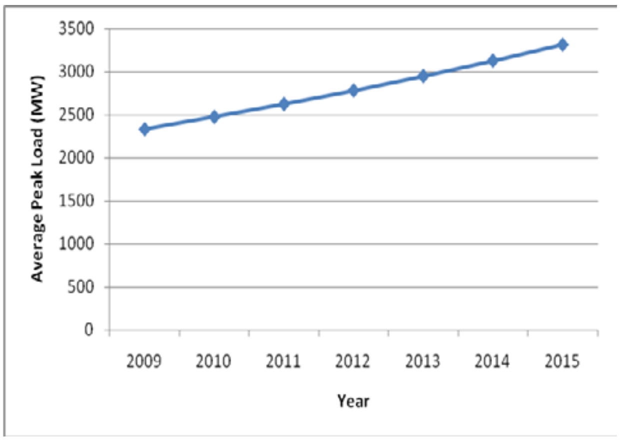

Fig. (3) Average Value Load vs Year

The straight line corresponds to the data obtained through the calculation made/obtained by the Electricity and Water Authority of Kingdom of Bahrain, as well as done in both scenarios carried out in previous study [4]. The results confirms the validity of equation (3).

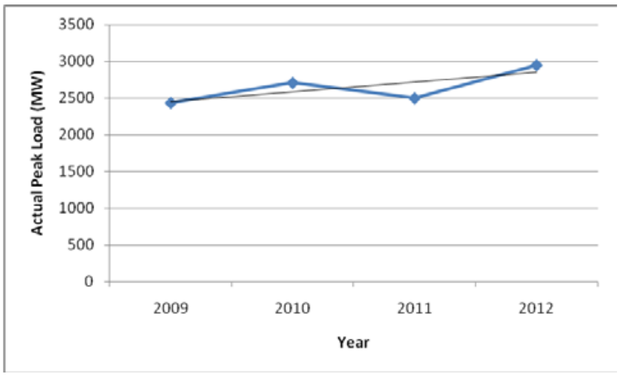

Fig. (4) Actual Peak Load vs Year

From the three figures (1), (2) and (3) it is interesting to note that these types of maximum annual loads are raising against increasing of the years for a reasons. These reasons are the increasing of populations and the increasing of the industrial companies (factories), except for a conditions such as temperatures in some cases (un-expected) it might be decreases during summer (as it happened during the year 2011 in Bahrain). This cause less demand of electricity which is un-expected as shown in Fig. (4). The best straight line that fits the points of figure (4) is:

$$P_{APL}(\chi) = 132.5\,\chi - 263743 \qquad (4)$$

where: $P_{APL}(\chi)$ is the actual peak load (MW)

χ is the year

4. Conclusions

Through the curve fitting technique, the algorithms have been found by feeding the data for each case using the computer simulation. The used simulation is highly efficient. It was shown that the annual maximum load increases every year except for exceptional case when during summer the temperature is decreases as un-usual case (Year 2011 in Kingdom of Bahrain). The relationships found during the carried study has the following shape:

$$f(\chi) = a\,\chi - b$$

where this reveals that summer has the fastest annual maximum temperature rate at growth (except some unusual cases, e.g. the year 2011 where the temperature dropped down). It will known that the temperature has impact on electricity demand.

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