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Research Article

Electrical Load Profile Analysis and Investigation of Baghdad City for 2012-2014

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Abstract

Electricity sector in Iraq has confronted many troubles and fences which have a great effect on the development and upgrading of this sector. Such problems involve the increasing of the electrical load demand after 2003 and appearance of peak loads causing the electricity generation deficit. Various factors have led to this situation, such as the international blockade on Iraq, limited investments, consecutive wars, security issues and many others. This study presents electrical load demand analysis of Baghdad city in Iraq during 2012-2014 for all consumption sectors (residential, commercial, industrial,...etc.). Also the electrical supply and load shedding are analyzed because they are related to the load demand. From analysis the electrical load profile, the increment in the loads demand is very low for 2014 when compared with 2012 and concluded that there are two electrical peak load periods, diurnal peak period in which smaller than the second period in which represented by nightly peak. Seasonally, the winter has no diurnal peak load and its nightly peak load is less than of that in the summery months. While, the electrical supply for Baghdad city is significantly increased for 2014 when compared with 2012, and this due to Iraqi ministry of electricity plans in the last years. As a result, the load shedding is noticeably decreased.

Keywords: *Load demand; Analysis; Load profile; Peak load; Load shedding; Baghdad city; Electrical.*

1. Introduction

Load profile or load curve describes the variation of the consumption of electricity demand with time (B.L. Theraja *et al*, 2005), The load demand for electricity differs in each area and therefore depends on numerous factors, such as the price of electricity, the weather conditions, the time of day, the type of activity and the type of the season (A. Batman *et al*, 2012). Load demand or energy use can be divided into base load, intermediate load and peak load. Base load is the load that exists on the grid 24 hours a day. Typically nuclear, hydro and steam thermal, these power plants operate 24 hours a day. Peak load is the maximum electrical load consumed at specific period. It can be met by combustion turbine, renewable energy resources and load management. Intermediate load filling the gap between base and peak load as shown in Fig.1. Sometimes it is supplied by gas-oil power stations and sometimes by steam thermal stations. The base load represents the first 30% of load curve followed by the intermediate load which represents the 45% after the base load. While the peak load demand represents the last 25% of the load duration curve and load curve (M. Diesendorf, 2007, O. Liik *et al*, 2004).

Analysis the general pattern of electricity consumption is the first step in managing electric load demand. Understanding the profile of energy use helps the utilities to predict and forecast possible demand variation which may occur. In some electrical power systems such as Iraq, electrical energy generated do not equal to the delivered and consumed energy by customers. A gap between electricity generation and load demand is called load shedding and it should be identified and analyzed. Distribution sector is the weakest part of whole power system because of the problems in end-use system such as irrational tariffs, lack of awareness and technology obsolescence of industrial equipment that can cause electricity shortage. With study of demand variation using load curves, it is possible to identify and reduce the distribution system losses and hence, the profit of power utilities can be enhanced. Also, additional loading capacities of feeders, distribution transformers and other equipment of distribution system can be known (P. Dabur *et al*, 2012, D. D. Sharma *et al* 2014).

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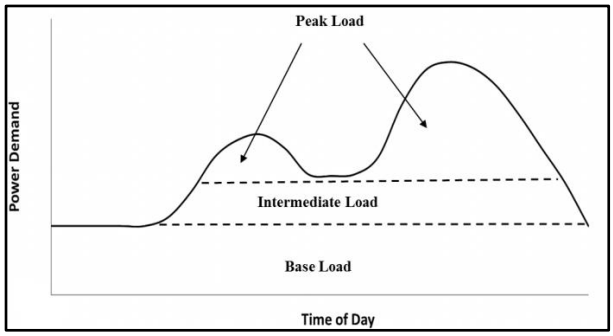


Fig.1 Types of load demand.

From literature, R. Effatnejad , 2010 (R. Effatnejad, 2010) presents the influence of electrical component in load peak and evaluates how we can reduce the peak load. Load profile analysis presented firstly. Yusri Syam Akil1 and Hajime Miyauchi, 2013 (Y. S. Akil *et al*, 2013) presents a seasonal peak demand characteristics investigation for commercial area in Japan by developing hourly demand regression models for each season. This study presents electrical load profile investigation and analysis with electricity supply and load shedding for Baghdad city in Iraq during 2012-2014.

2. Profile of Energy Use in Baghdad City and Data Acquisition

The data of electricity supply, consumption and shedding are collected for the years 2012 to 2014 from the Iraqi Ministry of Electricity-National Control Center. This data includes all Iraqi cities (such as Bagdad, Basrah, Babil, Najaf, Karbala'a and Naynawa) except Sulaymaniyah, Erbil and Duhok. The load, supply and shedding data are included in excel sheet tables where each day has its data alone separately from other days of the year, also the data of each city is combined with other cities. For this reason, the first step of this work is sorting and separating the data of each city from other cities for the years 2012, 2013 and 2014. After that, the analysis of these data can be done using MATLAB and Microsoft Excel . This analysis of load demand data, supply data and load shedding data will be presented as follows.

2.1. Growth of Electrical Load Demand

Weather, economic activity and load management can potentially affect the growth of electrical loads. Fig.2 shows annual growth rate with 42% from 2009 to 2014 of Baghdad city. The load demand increases due to loss of energy efficiency and load management.

It is obvious that there are two peak load periods, diurnal peak load and nightly peak load. The peak loads are occurred at night higher than daytime. This is due to the lighting loads in the night and commercial loads such as restaurants, cinemas, malls as well as shops. Also, the loads are occurred in summer season higher than loads in the winter as shown in Fig.3. The demand is highest between Jun and September because of high summer temperatures and hence using air conditioning**.**

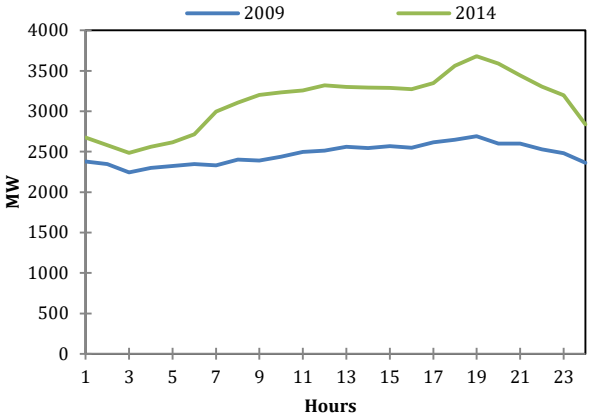


Fig.2 Annually average of hourly load profile of Baghdad.

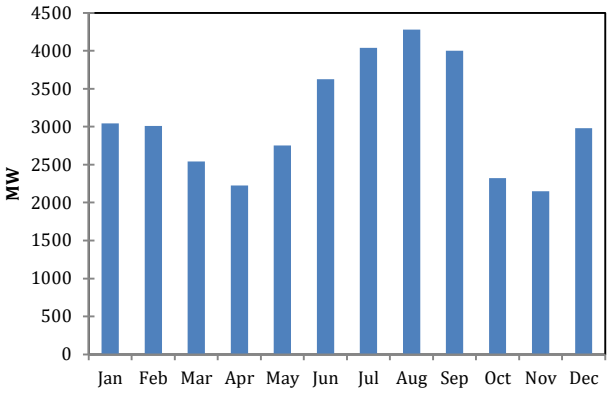


Fig.3 Monthly load profile of Baghdad.

As a result, the high electrical loads is driven by changes in the weather, especially the temperature increase or decrease as well as humidity. As example, in Naynawa city which lies in the north of Iraq, the peak loads in the summer season is the same as in the winter season because of very low temperatures in the winter as shown in Fig.4.

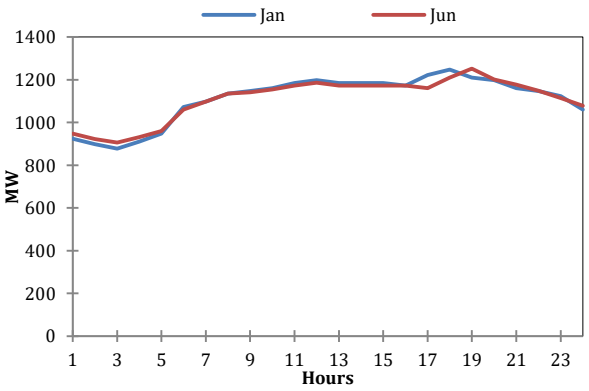


Fig.4 Load profile of Naynawa for two different months

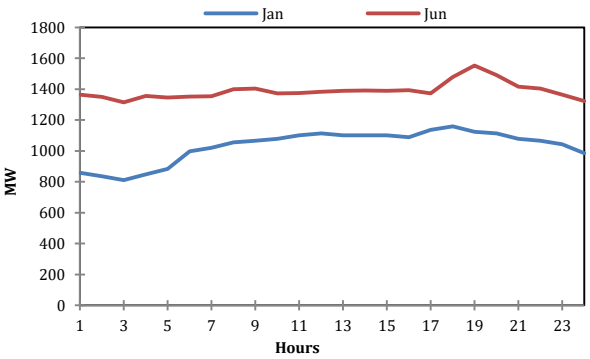
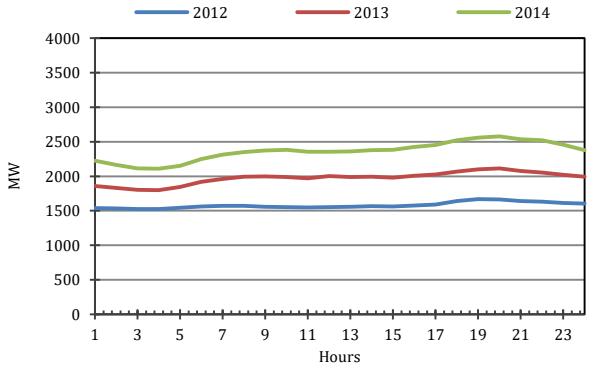


Fig.5 Load profile of Basrah for two different months.

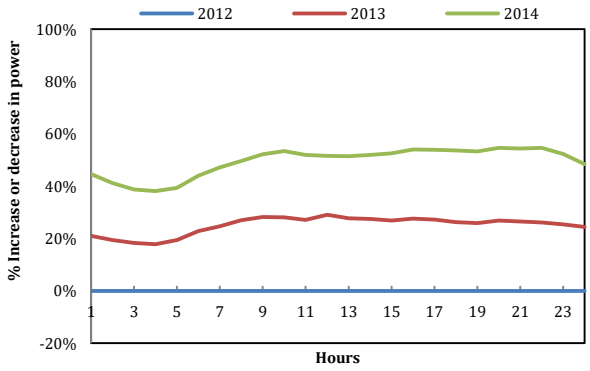
While in Basrah city, which lies in the south of Iraq, because of high temperatures in the summer and high humidity, the air conditioning does not turned off by consumer as well as the air chillers are not effective for cooling and the load profile is shown in Fig.5. It is obvious that there are high different between the summer loads and winter loads as well as the peak load in the summer is higher than of that in the winter, also there are no diurnal peak load in the winter.

2.2. Supply and Load Demand Analysis

Fig.6.a shows the supplied loads of Baghdad for last three years. This figure indicates that the supply power was increased significantly. The increasing of 2013 and 2014 is about 25% and 49% respectively as a proportion from 2012 and as shown in Fig.6.b. This is due to Iraqi ministry of electricity new plans that achieved in the last two years.



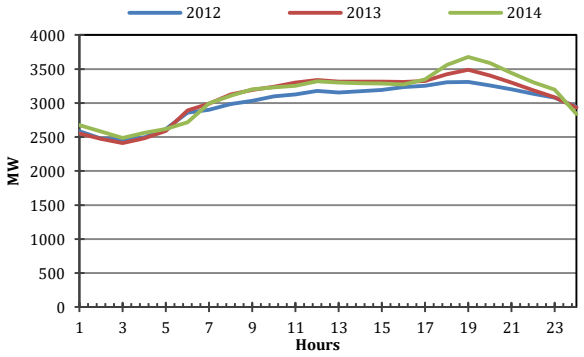
(a)



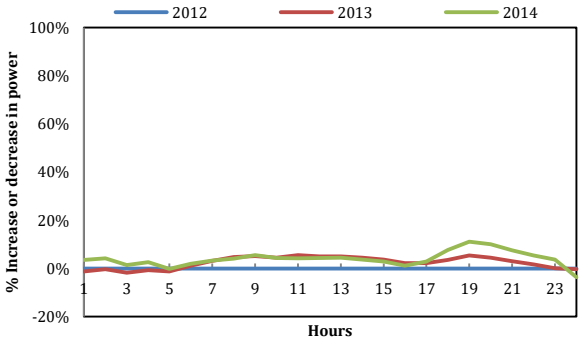
(b)

Fig.6 (a) Annually Average of hourly supply profile of Baghdad, (b) Increasing in supply.

On other hand, the load demand growth is very low as shown in Fig.7.a. The percentage increase of 2013 and 2014 is about 3% and 4% respectively as a proportion from 2012 as shown in Fig.7.b.



(a)



(b)

Fig.7 (a) Annually Average of hourly load profile of Baghdad, (b) Increasing in loads.

As discussed in the previous section, it is obvious from load curve that there are two peaks, diurnal peak and nightly peak which is greater than the diurnal peak.

Furthermore, the load profile for each month is shown in Fig.8. It is noted that the loads in the winter is less than the summer loads as well as the winter has no diurnal peak (very small comparing to summery diurnal peak). The previous figures are drawn using Microsoft Excel based on Average function.

The Gaussian distribution curve of load demand gives an idea about how the loads were cumulated and increased. It can be plotted based on the following function in Microsoft Excel,

No. of needed hours =
Frequency(data array; bins array) (1)

Where,

Data array is the electricity data, and bins array is the range of power.

This function provides the number of hours needed for a specific value of power. The resultant load distribution curve for 2012-2014 is as shown in Fig. 9.

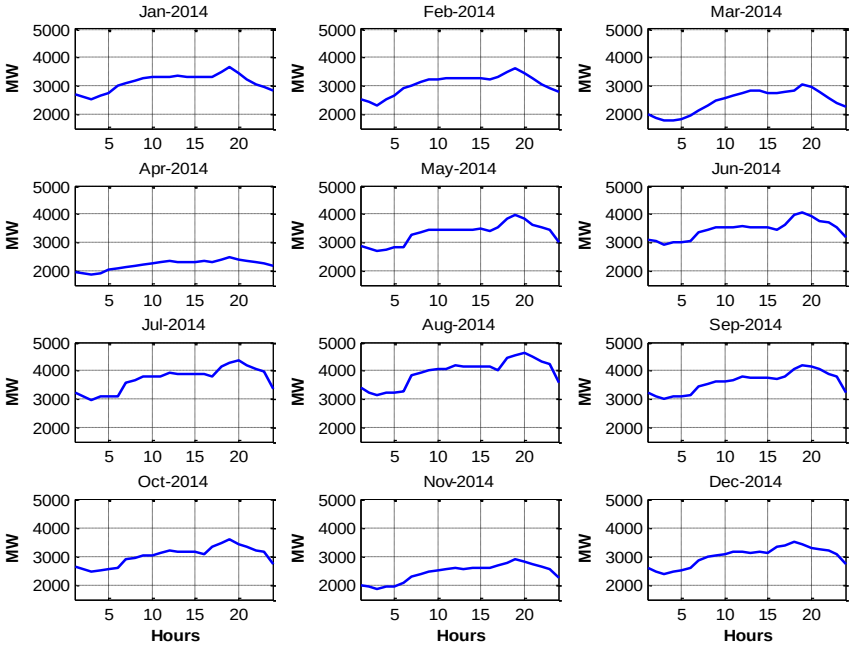


Fig.8 Load profile of Baghdad for each month during 2014.

It is obvious that the load growth is very small and the loads are more spread for 2013 and 2014 and shifted to the right side of the curve. This means that the loads with high values are appeared causing peak loads and no high values of hours needed for a specific range of power.

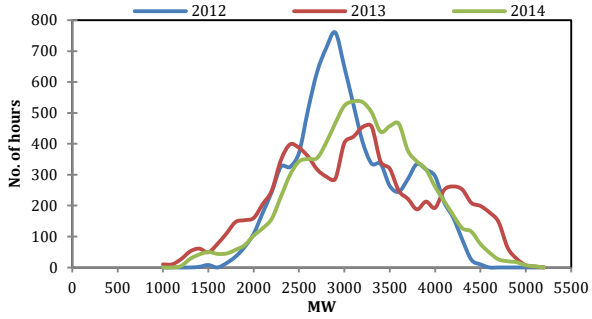


Fig.9 Gaussian distribution of Baghdad load demand for last three years.

Fig.10 which represents the load duration curve for last three years can be derived from previous figure and according to the following equation,

$$\text{Needed hours} = 8760 - \text{Cumulative Frequency} \quad (2)$$

Where,

8760 represents the hours of the year, and cumulative frequency is obtained from,

$$\text{Cumulative Frequency} = \sum \text{Frequency} \quad (3)$$

The load duration curve shows that how the loads are cumulated for last three years. It is obvious that the cumulative loads are very low. Also, this curve gives a view that how many the hours needed for a specific power. As example, the power which equal to 3000MW is needed 5000 hours during 2014.

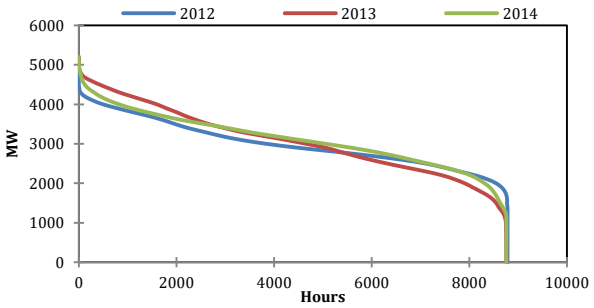


Fig.10 Baghdad load duration curve for 2012-2014.

As explained in the introduction, the base load represents the first 30% of load duration curve followed by the intermediate load which represents the 45% after the base load. While the peak demand represents the last 25% of the load duration curve and load curve. These percentages can be calculated from,

$$\%\text{ of load from total consumption} = \frac{\text{Load power demand}}{\text{Max.load demand}} \quad (4)$$

The load duration curve for 2014 with the mentioned percentages is as shown in Fig. 11.

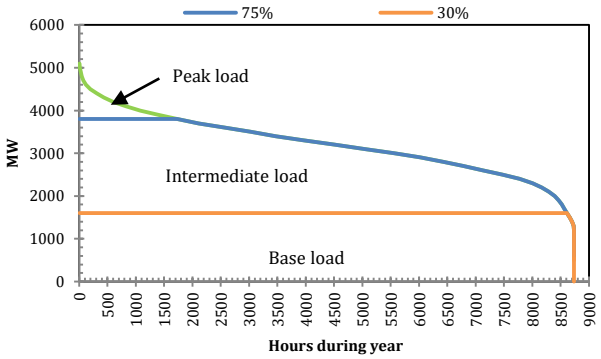


Fig.11 Analysis of load duration curve of Baghdad during 2014.

For more analysis of peak loads, the yearly peak load can be calculated from the following equation,

$$\% \text{ of yearly peak load} = \frac{\sum \text{Frequency}}{8760} \quad (5)$$

Table 1 illustrates the obtained results from analysis of peak loads. We note that the percentage of peak loads is 16% from the load demand during 2014.

Table 1 Analysis of peak load for 2014.

Range of power (MW)	No. of needed hours (Freq.)	Percentage from demand	Total percentage of peak	Total hours needed
3900 to 4400	1196	13.7%	16%	1394
4500 to 5100	198	2.3%		

Therefore, if we reduce the load demand by 20%, the load duration curve before and after load reduction can be seen in Fig.12. It is obvious that the range of powers (4900 – 5100)MW which causes the peak loads has been diminished after load reduction.

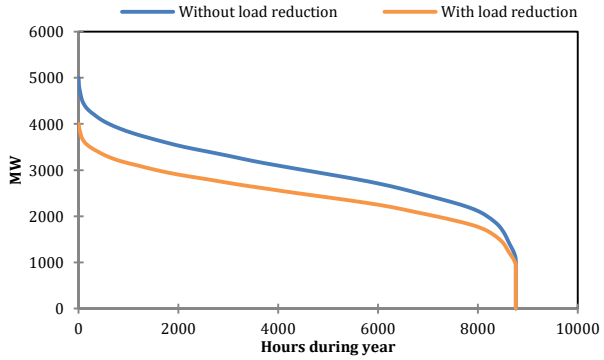


Fig.12 Load duration curve with and without load reduction.

2.3. Load Shedding Analysis

At any time, there should be enough supply to meet demand, but it is difficult because of peak load periods and continuous growth in the consumers with their requirements, therefore needing more electricity generation to cover the electricity shortage. Some of countries such as Iraq suffer from this shortage because of weakness in the distribution sector. This shortage is called load shedding**.**

Load shedding can be defined as the gap between the supply and the load (i.e. it is the power needed to make supply sufficient to cover the load). As example, if we have a load equal 2kW and the supply is 1.5kW, hence the shedding of the load is 0.5kW. Some of electrical power systems suffer from load shedding such as Iraq. Fig.13 shows the annually load shedding profile of Baghdad for last three years.

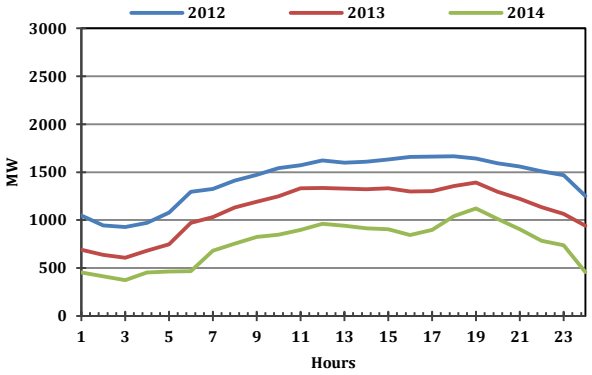


Fig.13 Annually average of hourly load shedding profile of Baghdad.

It is clear that the shedding for 2013 and 2014 is decreased about 23% and 48% respectively as a proportion from 2012. We can also observe the percentage reduction for each hour of load shedding profile in Fig.14, where the blue line is a reference line which represents 2012.

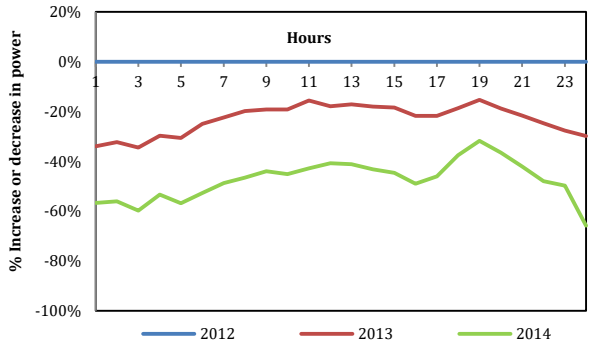


Fig.14 Hourly percentage decrease in load shedding

As discussed in previous section, because of the cumulative loads are very low and the rise in the supply is high compared to 2012, so the shedding of loads will reduce. Furthermore, this conclusion can be significantly seen in colored Figs. (15, 16, and 17). Each figure has 8760 squares and each square filled with a specific color where each color indicates to a limit of power (white represents less than or equal 500 MW, the yellow 501-1000 MW, the orange 1001-1500, the red 1501-2000, and the blue is more than 2001) as illustrated in Table 2.

Table 2 Range of powers and their colors

Range of power (MW)	Color of square
Less than or equal 500	
501 – 1000	
1001 – 1500	
1501 – 2000	
More than 2001	

Fig.16 shows the load shedding for 2012. We notice that the blue and red colors are spread in the middle of the figure (summer months) because of high load demand. While in the winter, the yellow and orange colors as well as red are spread much greater than the

other colors because the shedding is reduced in these months due to reduction in the loads demand. However the white color is very slight because the load shedding in this year is extremely greater than 500MW.

Fig.17 shows Baghdad load shedding for 2013. In this year, the blue color reduced due to increasing the supply. Consequently, the red color is the most significant as well as the white color is more spread from previous year.

This mean that the load shedding is reduced.At last, Fig.18 shows the load shedding of Baghdad for 2014. In this year, the blue color almost disappeared and the red reduced significantly as well as the white is increased and more spread. The Predominant colors are yellow and orange. This indicates that the load shedding starting to be fading due to rising the supply and very low growing in the loads demand.

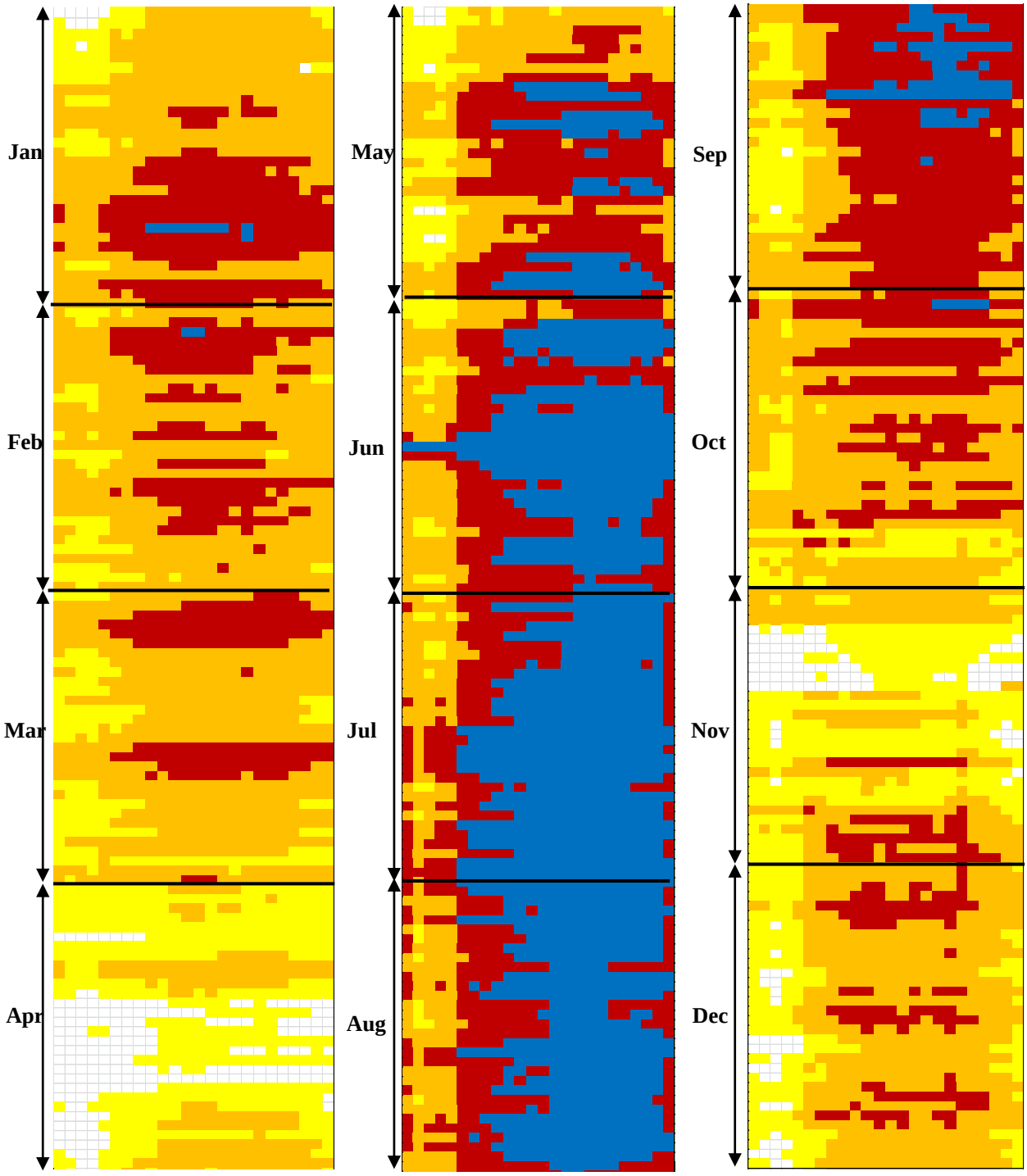


Fig.15 Baghdad load shedding for 2012.

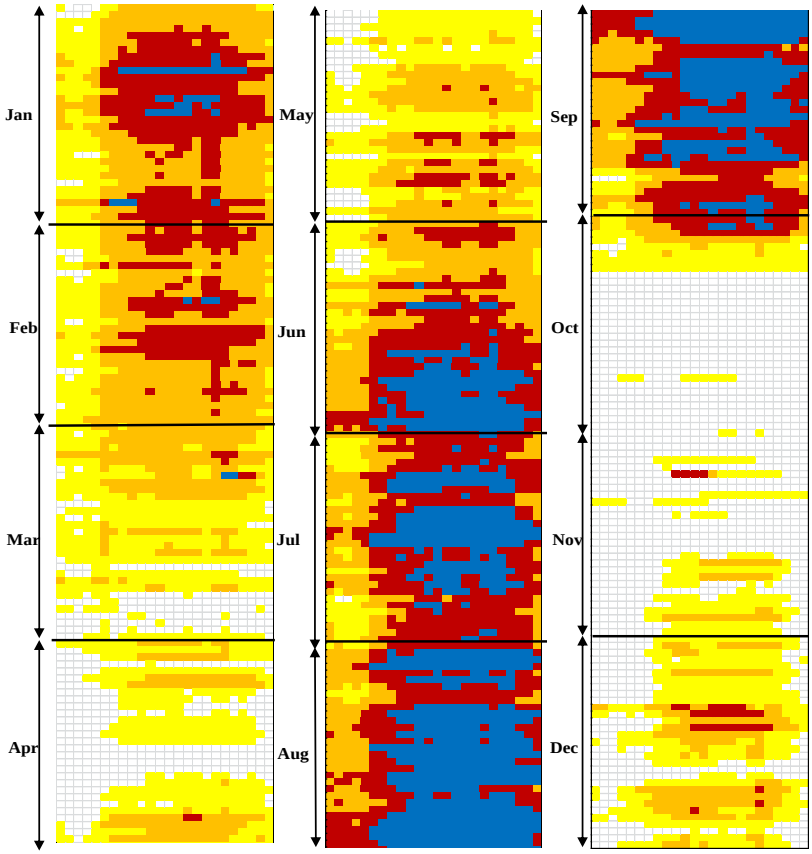


Fig.16 Baghdad load shedding for 2013.

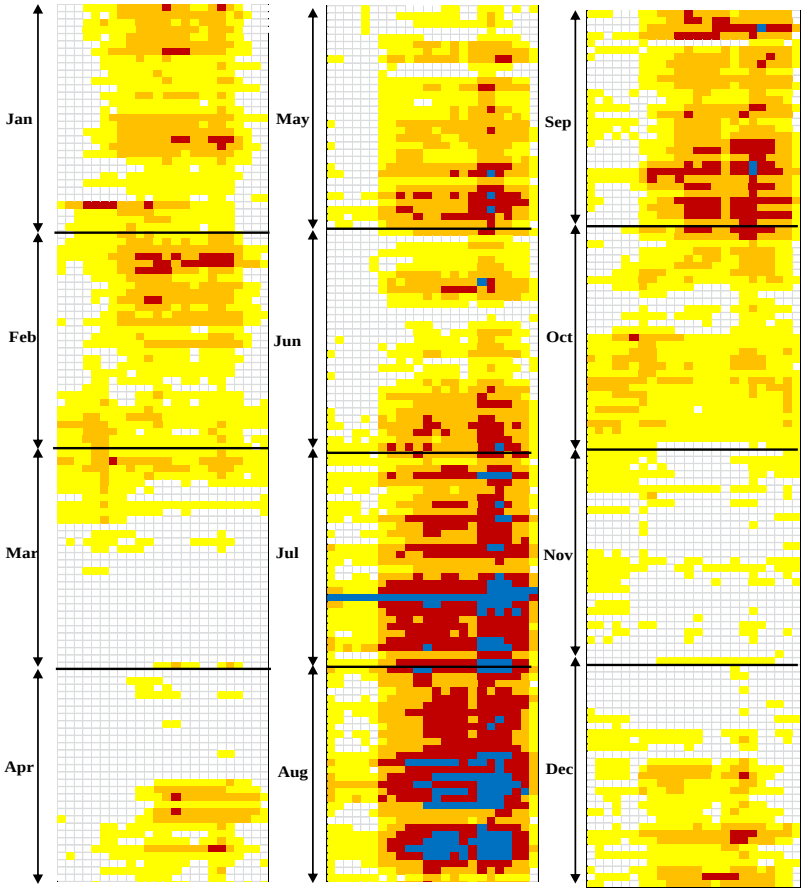


Fig.17 Baghdad load shedding for 2014.

Conclusions

In this study, electrical load profile analysis is presented for Baghdad city in Iraq during 2012-2014. Load shedding and electricity supply analyzed as well. The electricity data are collected from Iraqi ministry of electricity-National Control Center. It is concluded that the electrical loads arise and grow depending on the climate conditions such as high temperatures and humidity. From analysis the load profile, there are two peak load periods, diurnal peak load in which smaller than the second period in which represented by nightly peak load. Seasonally, the winter has no diurnal peak and its nightly peak is less than of that in the summery months. The electrical supply is significantly increased with a percent of 49% for 2014 when compared with 2012, and this due to Iraqi ministry of electricity plans in the last years. While the increment in the loads demand is very low (4% for 2014 when compared with 2012). Therefore, the load shedding is noticeably decreased. Also, the percentage of peak load is rather small, which represents 16% of load demand for 2014, and 1394 hours needed to cover this peak.

This study can be a starting point for a future work for researchers such as management of electricity load, designing the proposed systems to cover load demand by building a new power plants and calculating the load forecasting. Also, this study present to Iraqi ministry of electricity defining the forecasted objectives and the future plans of the ministry.

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