First Libyan international Conference on Engineering Sciences & Applications (FLICESA_LA)
13 – 15 March 2023, Tripoli – Libya

Forecasting of Electrical Energy Demand in Libya using Demand Side Management Measured Data

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Abstract—**The paper provides long-term forecasts of electrical energy demand for the types of electric energy consumers in Libya, where more than twenty years have been estimated to forecast the demand for electric energy (MWh) and power (MW) in the period (2017-2040) for the residential, agricultural, small industry, heavy industry and service sectors based on historical geographical and econometrical data, electrical energy consumption and the GDP of these sectors are estimated in millions of Libyan dinars, using the EVIEWS program.**
The loads are analyzed for samples from the residential sector in the summer and winter season for the DSM project data represented in air conditioners, water pumps, water heaters, refrigerators, lighting, etc., using DSM project measured results to obtain daily load curve of electrical power consumption behavior for residential sample sector in the summer and winter seasons and using this data as a basis data to calculate the forecasted demand for electric energy and power for the target years of the study.

I. INTRODUCTION

The most useful in the world is the electrical energy, that's why we need a technique to tell us about the demand of consumption and the exact load to generate the required power which is required load forecasting techniques.
Load forecasting is the predicting of electrical power required to meet the short term, medium term or long-term demand. The forecasting helps the utility companies in their operation and management of the supply to their customers.
It is used by power companies to anticipate the amount of power needed to supply the demand. It tells about the scenario of present and future load demand. It has many applications including energy purchasing and generation, load switching, contract evaluation, and infrastructure development. The achievement of long-term load forecasting is the foundation of power planning. It supplies reliable basis for network system planning, for the establishment of new power plant and power distribution system. It has great importance to not only the regular development of power industry but also the development of the whole national economy [1].
At present, many systematic studies on short term load forecasting have been carried out. The regression model, the index curve model, the logistic curve model, biological evolution methods and so on have been proposed to forecast. However, long term load forecasting is influenced by many direct or indirect factors, such as the number of population, output value of the primary, secondary and tertiary industries, the industrial regulation factors, the industrial output indexes. The quasi-linear forecasting is mainly based on the historical data and some mathematical model, but the forecasting result may not be coincide with the reality, which is brought by the shortage of information. Thus, Thus, besides the scientific theory, experts' experiences should also be introduced to reduce some uncertain interference. Based on this idea, when forecasting the long term load, this paper adopts a method of forecasting the values of years according to the values of years, and then forecasts the values of years according to the values of years which are forecasted in previous, etc. This rolling annual extrapolation method of long-term load forecasting is not only based on artificial intelligent calculation, but also considering experts' experiences and opinions. Residential sector is the most important sectors consuming of electrical energy, especially after the technological development in recent years in the world. For this reason, in this thesis has been Focused on this sector as it is the most consuming sector of electrical energy in Libya and analyze samples from the residential sector in the summer and winter seasons to study consumer behavior in electrical energy consumption in this sector and Analyze the daily load curve of these samples and record measurements of the loads by using Demand Side Energy Management project meters and the application of the Demand Side Energy Management project, which aims to reduce the demand for electrical energy.

a. *Types of Load Forecasting Techniques Involved*

Load forecasts can be divided into four groups:

1) Ultra/very short-term load forecasting (VSTLF)
2) Short-term forecasting (STLF).
3) Medium-term forecasting (MTLF).
4) Long-term-term forecasting (LTLF).

very short-term load forecasts are ranges from a few minutes to an hour ahead and is used for real-time control.
Short-term forecasts are usually from one hour to one week. They play an important role in the day-to-day operations of a utility such as unit commitment, economic dispatch and load management. A short-term electricity demand forecast is commonly referred to as an hourly load forecast.

Medium-term forecasts are usually from a few weeks to a few months and even up to a few years. They are necessary in planning fuel procurement, scheduling unit maintenance and energy trading and revenue assessment for the utilities. A medium-term forecast is commonly referred to as the monthly load forecast.

Long-term electricity demand forecasting is a crucial part in the electric power system planning, tariff regulation and energy trading. A long-term forecast is required to be valid from 5 to 25 years. This type of forecast is used to deciding on the system generation and transmission expansion plans. A long-term forecast is generally known as an annual peak load [2].

Long-term electric load forecasting used to supply electric utility company management with prediction of future needs for expansion, equipment purchases or staff hiring. This is longer than a year.

Medium-term forecasting, used for the purpose of scheduling fuel supplies and unit maintenance. This is usually from a week to a year.

Short-term forecasting, it is used to supply necessary information for the system management of day-to-day operations and unit commitment [3].

1.1 Important Factors for Forecasts

Consideration of various factors is the prerequisite for accurate forecasting of load. Time factor, past weather data, type of consumers, load demanded by the region in past, growth of the region, amount of load increased etc, these are the factors which play pivotal role in calculating the demand load.

For Short-term load forecasting several factors should be considered, such as

[i] Time factors.

[ii] Possible customers' type.

the forecasts of energy demand in the medium and long term take into account

[i] The historical load.

[ii]Weather data.

[iii]The number of customers in different categories.

[iv]The appliances in the area and their characteristics including age.

[v] The economic and demographic data and their forecasts,

[vi]The appliance sales data and other factors.

1.2 Medium and Long-Term Load Forecasting

The end-use modeling, econometric modeling, and their combinations are the most often used methods for medium- and long-term load forecasting. Descriptions of appliances used by customers, the sizes of the houses, the age of equipment, technology changes, customer behaviour, and population dynamics are usually included in the statistical and simulation models based on the so-called end-use approach. In addition, economic factors such as per capita incomes, employment levels, and electricity prices are included in econometric models. These models are often used in combination with the end-use approach. Long-term forecasts include the forecasts on the population changes, economic development, industrial construction, and technology development [4]. Medium and long-term load forecasting methods are:

1.2.1 Trend Analysis

Trend analysis extends past rates of electricity demand in to the future, using techniques that range from hand-drawn straight lines to complex computer produced curves. These extensions constitute the forecast. Trend analysis focuses on past changes or movements in electricity demand and uses them to predict future changes in electricity demand. Usually, there is not much explanation of why demand acts as it does, in the past or in the future. Trending is frequently modified by informed judgment, wherein utility forecasters modify their forecasts based on their knowledge of future developments which might make future electricity demand behave differently than it has in the past.

The advantage of trend analysis is that, it is simple, quick and inexpensive to perform. The disadvantage of a trend forecast is that it produces only one result, future electricity demand. It does not help analyze why electricity demand behaves the way it does, and it provides no means to accurately measure how changes in energy prices or government polities influence electricity demand.

1.2.2 End-Use Models

The end-use approach directly estimates energy consumption by using extensive information on end users, such as applications, the customer use, their age, sizes of houses, and so on. Statistical information about customers along with dynamics of change is the basis for the forecast.

End-use models focus on the various uses of electricity in the residential sector. These models are based on the principle that electricity demand is derived from customer's demand for light, cooling, heating, refrigeration, etc. Thus, end use models explain energy demand as a function of the number of applications in the market. Ideally this approach is very accurate. However, it is sensitive to the amount and quality of end-use data. For example, in this method the distribution of equipment age is important for particular types of appliances. End-use forecast requires less historical data but more information about customers and their equipment [7].

The following relation defines the end use methodology for a sector:

$$E=S*N*P*H \tag{1}$$

E = energy consumption of an appliance in kWh

S = penetration level in terms of number of such appliances per customer

N = number of customers

P = power required by the appliance in kW

H = hours of appliance use.

This, when summed over different end-uses in a sector, gives the aggregate energy demand. This method takes into account improvements in efficiency of energy use, utilization rates, etc. in a sector as these are captured in the power required by an appliance, P. In the process the approach implicitly captures the price, income and other economic and policy effects as well.

This method predicts the energy consumptions, to calculate the load need to have the load factor in each sections and different types of energy consumptions and then by load factor we can calculate the load in each section. The system load factor is defined as follows equation:

$$\text{Load Factor} = \frac{Average-Load\ demand}{Peak-Load\ demand} \tag{2}$$

$$= \frac{Annual\ KWh\ energy}{Peak-Load\ demand*8760\ hours/year} \tag{3}$$

The estimates the energy consumed by utilizing information obtained from its end users. This information might be in terms of consumers' use, size of houses, age of consumers, and applications, among many others. This method is based on the concept that electricity demand will always depend on the end user demand for refrigeration, cooling and lighting.
Mathematically the end-use method is a set of equations designed to disaggregate end user's household's total annual energy consumption generally through Residential Energy Consumption Survey (RECS) and based on these disaggregated values, particular weight has been given to produce population estimates of total and average energy end uses at various levels of geography. A visualization of end-use modes is given in figure (1).

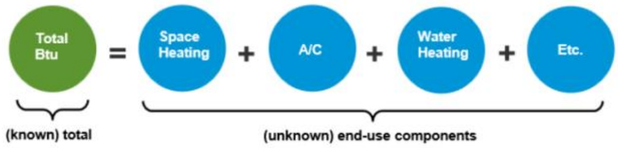


Figure (1) Total energy consumption for End-use Models

The method is extremely accurate as the models explain electricity demanded by putting it as a function of its various applications. Nevertheless, the accuracy of this model relies entirely on the quality and amount of information obtained from end users. For instance, in some circumstances, information obtained on consumer age will be more relevant as compared to the size of houses. This is because there are definite areas that contain many youths who tend to overuse electricity through their various electronics such as heaters, fridges, video games, and computers, among many others. This implies that the size of a house occupied by an individual might be small, but he or she might be consuming a lot of electricity [5].
The end-use analysis is that most end-use models assume a constant relationship between electricity and end-use (electricity per appliance). This might hold for over a few years, but over 10 or 20-year period, energy saving technology or energy prices will undoubtedly change, and the relationships will not remain constant.

1.2.3 Econometric Models

The econometric approach combines economic theory and statistical techniques for forecasting electricity demand. The approach estimates the relationship between energy consumption (dependent variables) and factors influencing consumption. The relationships are estimated by the least-square method or time series methods. One of the options in this framework is to aggregate the econometric approach, when consumption in different sectors (residential, commercial, industrial, etc. is calculated as a function of weather, economic and other variables, and then estimates are assembled using recent historical data. Integration of the econometric approach in to the end use approach introduces behavioral components in to the end-use equations.
The advantage of econometrics are that it provides detailed information on future levels of electricity demand, why future electricity demand increases, and how electricity demand is affected by all the various factors.
A disadvantage of econometric forecasting is that in order for an econometric forecast to be accurate, the changes in electricity remain the same in the forecast period as in the past. This assumption, which is called constant elasticity, may be hard to justify especially where very large electricity prices changes, make customers more sensitive to electricity prices.

1.2.4 Neural Network Technique

It is similar as to the neural network technique used for the short-term load forecasting except in this technique with train the network with the large data and forecast the load for the whole or for long term [3].

1.2.5 Multiple Linear Regressions

Regression is the one of most widely used statistical techniques. Since, the load is totally dependent on the temperature, humidity, wind speed and day type parameters hence regression is used to obtain the relationship between load and these parameters. Firstly, using the past data the values of regression parameters a, b, c is calculated and using these parameters and the load is forecasted for long term [3].

II. Demand side management

This module covers "demand-side management" or DSM, as applied to energy efficiency measures that modify or reduce end-users' energy demand. This has traditionally been applied to electricity loads but is also used for changes that can be made to demands for all types of energy. The benefits for the energy user are reduced energy costs for a given output (production level or other measure of activity). For the energy provider, the benefit is a better use of its supply capacity.
In November 2009, the Navigant Consulting (Navigant), and Global Energy and Technology Consulting (GETCON) were contracted by the General Electric Company of Libya (GECOL) to provide an assessment of the demand side management (DSM) potential in Libya. These services was started from 2010 and include winter and summer load research (end-use metering), estimating DSM potential, and designing appropriate pilot programs. the provides summer and winter load research results are the first phase of the (DSM) project.
The summer peak period, occurring between June and September, is characterized by an overall peaking trend occurring in August with daily peaks occurring in the evening (8pm – 9pm).
The winter peak period, occurring between December and February, is characterized by an overall peaking trend occurring in January with daily peaks occurring in the evening time (7pm), the composition of this peak hour is the focus of this project.
End-use and load metering was conducted between July and September 2010 for the following six sectors: residential, commercial, government, agriculture, small industrial and heavy industry sector, based on the results of this effort, sector level load curves have been constructed that will help GECOL develop programs to decrease energy use in Libya.
The residential sector is the most important sector of the consumer and the largest consumption of electric power, especially after the technological development witnessed by the world in recent years.
All household appliances are turned on by electrical energy, so that is why it has increased in the consumption of electrical energy in this sector, the DSM project focused on analysis of too many samples of the residential sector in the summer and

winter seasons in the years (2010-2016) and recording real measurements by using DSM meters such as voltage, current, power factor, temperature and lighting intensity of the loads to obtain the daily curve of the measured samples, and use the results of the analysis in the study of forecasting the demand for electrical energy in the residential sector

In the residential samples, before installing metering equipment at each participating facility, GECOL engineers conducted a detailed site audit. For each site, full power draw was metered as well as multiple end-uses specific to the sector and sub-sector for the given site. Meters were left in place for a minimum of two weeks.

Once the meter data were collected, results were examined by the Cadmus engineering team to ensure that all relevant end-use information was collected. Where necessary, engineers calculated additional end-use loads based on nameplate information collected during the site audits. These results were then aggregated and normalized to produce sector and end-use level results.

A sketch of each residential sample was created to assist the data analysis effort. This sketch would include location of the light sensor and its associated energy density to help separate energy consumption of lights. Window area and building orientation along with building characteristics may be used to determine heating load on the building and to establish a BTU/m² heating requirement baseline for each sector. Additionally, a sketch is used in an audit to help the auditor determine any systems that might not have been recorded. These sketches would be especially helpful when returning to the participating facility [6].

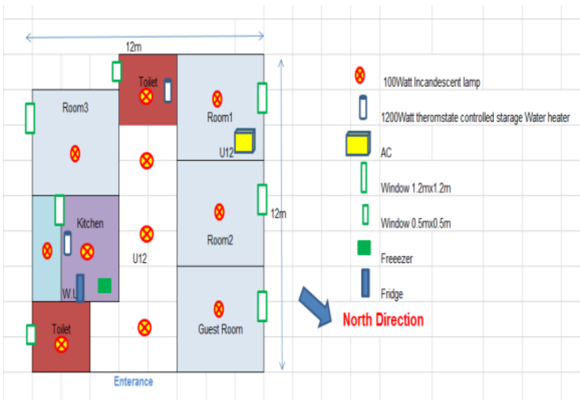


Figure (2) Example of Site Map

2.1 Why Promote DSM?

Various reasons are put forward for promoting or undertaking DSM. For example, DSM may be aimed at addressing the following issues:

- Cost reduction many DSM and energy efficiency efforts have been introduced in the context of integrated resource planning and aimed at reducing total costs of meeting energy demand.
- Environmental and social improvement energy efficiency and DSM may be pursued to achieve environmental and/or social goals by reducing energy use, leading to reduced greenhouse gas emissions.
- Reliability and network issues—ameliorating and/or averting problems in the electricity network through reducing demand in ways which maintain system reliability in the immediate term and over the longer term defer the need for network augmentation.
- Improved markets short-term responses to electricity market conditions ("demand response"), particularly by reducing load during periods of high market prices caused by reduced generation or network capacity.
- An energy customer may have many reasons for selecting a certain DSM activity. Generally, these would be economic, environmental, marketing or regulatory. The above points are expressed in a slightly different way, where it is argued that the benefits of DSM to consumers, enterprises, utilities and society can be realized through:
  1) Reductions in customer energy bills.
  2) Reductions in the need for new power plant, transmission and distribution networks.
  3) Stimulation of economic development.
  4) Creation of long-term jobs due to new innovations and technologies.
  5) Increases in the competitiveness of local enterprises.
  6) Reduction in air pollution.
  7) Reduced dependency on foreign energy sources.
  8) Reductions in peak power prices for electricity [7].

III. Case study analysis

3.1 Forecasting electrical energy for residential Sector

The forecasts for the residential sector were entirely based on demographic data, the use of energy will be affected by a number of factors related to the economy. A booming economy produced more disposable income which results in an increase in the number of households, the number of appliances in a household, and an increase in the electrification rate.

An analysis of the available data showed that a simple application of demo-graphic data to develop the load forecast would sufficiently capture the effects of increasing energy consumption and population growth.

Accurate knowledge of household consumer loads is important when small scale distributed energy technologies are optimally planned in a local grid or local demand side management (DSM) measures to reduce energy consumption in the residential sector.

This knowledge is also useful in planning medium and low voltage networks in residential areas [8].

the fluctuations in electricity consumption for individual households are revealed as well as the division of consumption among different types of household appliances. By using the recording of real measurements of electrical energy consumption in many samples of the residential sector and analyzing these measurements and their results to obtain the daily curve of energy consumption for most samples in the project period from 2010 to 2016 and using them as a basis for calculating the expectations of energy demand in the target years of the study.

The DSM measurements included recording measurements of major appliances, such as heating, ventilation and air conditioning (HVAC) systems, refrigerators, lighting, and freezers

The residential model for used in developing the forecast had the following general form:

Residential Consumption = Households * Electrification rate * Unit consumption 5

Where

Households is derived from the population forecast, assuming a slowly decreasing number of people per household.

Electrification rate was assumed to grow asymptotically from the current 98 % estimated level to 100 %, by the end of the forecasting period.

Unit consumption: consumption per household.

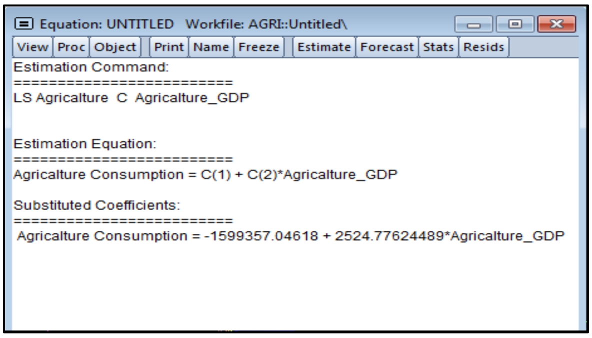


Figure (3) Forecasting equation analysis of the agriculture sector

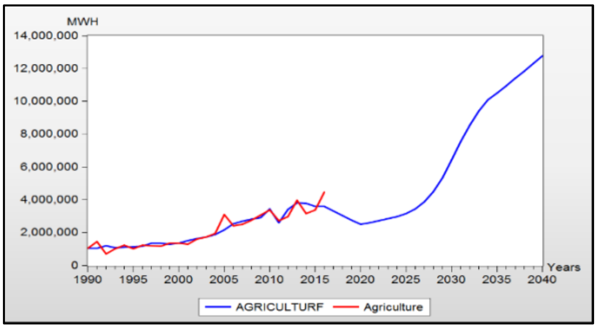


Figure (4) Comparisons of actual and forecasting electrical energy results for agriculture sector

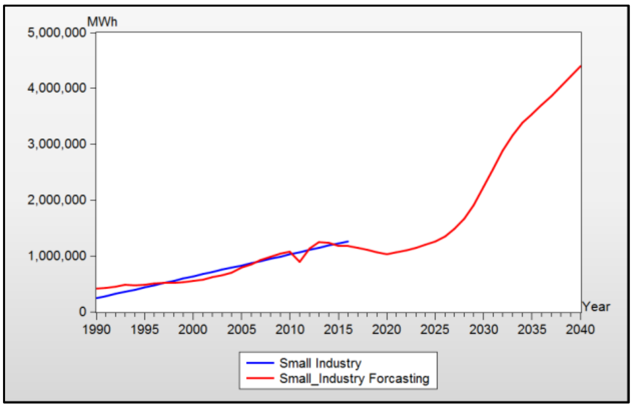


Figure (5) Comparisons of actual and forecasting electrical energy results for small industry sector

3.2 Forecasting electrical energy for agriculture sector and other sectors

Energy consumption in all its forms is the most important obstacle to economic and social development in Libya. Although Algeria is an oil exporter, its energy consumption has increased in recent years, particularly electricity. Adoption of the growth of the agricultural sector on energy is inevitable. And an increase in the price of kilowatt-hours in the future. The most important challenge for the advancement of the agricultural sector will be to forecasting electrical energy of the agricultural sector in the future to provide affordable food products, to guarantee a decent standard of living for the Libyan citizen, self for future generations.

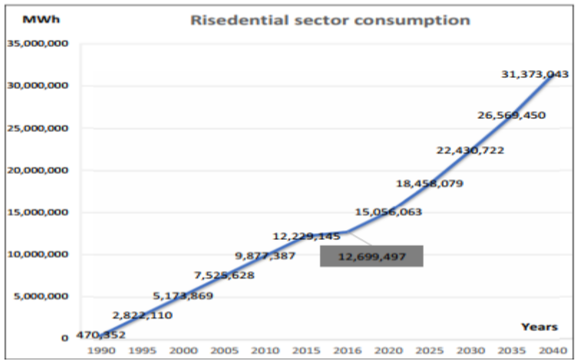


Figure (5.1) Electrical energy requirement for a period of (2017 - 2040) for residential sector

Thus, the general equation used to forecast the load for the Agriculture sector are as shown below:

Agriculture consumption = $\alpha + \beta$ * GDP Agriculture

The results of the regression analysis produced the following equation:

Agriculture consumption = 1599357.04618+2524.77624489 * GDP Agriculture

The application of various tests to determine the best correlation between various indicators showed that the strongest relationship to energy sales was to be the non-oil GDP. Since previous analysis showed that the non-oil GDP also reflects growth from economic factors, this relationship was retained for forecasting purposes.

The general equation used to forecast the load for the Small Industry sector is as shown below:

Small Industry consumption = $\alpha+\beta$ *GDP small industry

Small Industry consumption = 37.6317951401* GDP small industry

The analysis of various options showed that best correlation using historic data occurred using the manufacturing domestic product as key indicator. Thus, the general equation used to establish the load forecasts for the Heavy Industry sector are as shown below:

Heavy Industry consumption = $\alpha+\beta$ *GDP heavy Industry

Heavy Industry consumption = 1934281.17004+1840480955908*GDP Agriculture

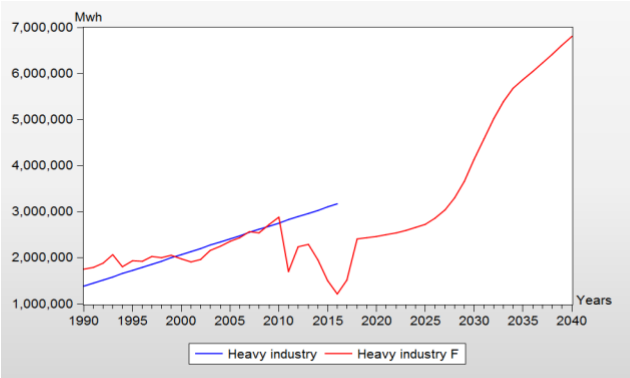


Figure (6) Comparisons of actual and forecasting electrical energy results for heavy industry sector

Service sector divided into commercial (local shop, shopping mall, admin office, etc), public amenities (mosque, health center, school, hospital, police station, etc), utilities (sewerage treatment, plant, desalination, park, etc), and street lightening. Thus, the general equation used to establish the load forecasts for the Heavy Industry sector are as shown below:

Service consumption = $\alpha+\beta$ *GDP $_{\text{heavy Industry}}$

Service consumption = -814734.610016 + 395.486804772*GDP $_{\text{Service}}$

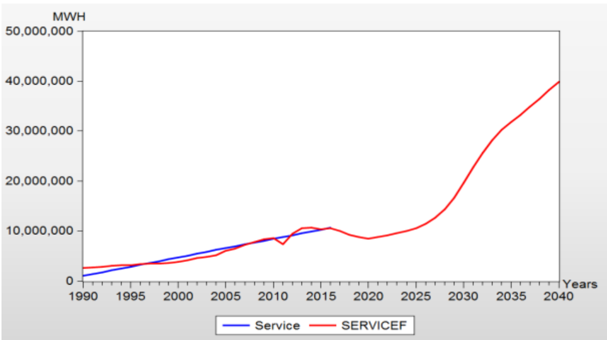


Figure (7) Comparisons of actual and forecasting electrical energy results for service sector

The overall forecast was carried out in terms of energy consumption or demand. A complete forecast also requires an estimate of the peak demand and system losses. This section summarizes the approach used to estimate future peak load and demand.

System Losses

System losses were incorporated into the load forecast and take into the following factors:

- transmission losses
- distribution losses

The general relationships used to calculate the losses were:

Net Generation = Total Energy consumption + Losses

% Losses = 1 - (Total Sales/Net Generation)

Losses as a percentage of generated energy or sold energy are well known from the historic data.

Once the annual electricity consumption is estimated for each sector, the total national electricity consumption is easily obtained by the sum of all sectors' consumptions.

$$\text{Net Generation}=\frac{Total\ energy\ consumption}{(1-Technical\ losses)} \quad (5)$$

Where the technical losses is 17%

$$\text{Gross generation}=\frac{Net\ Generation}{(1-Auxiliary\ Consumption)} \quad (6)$$

Where the auxiliary consumption is equal to 2%

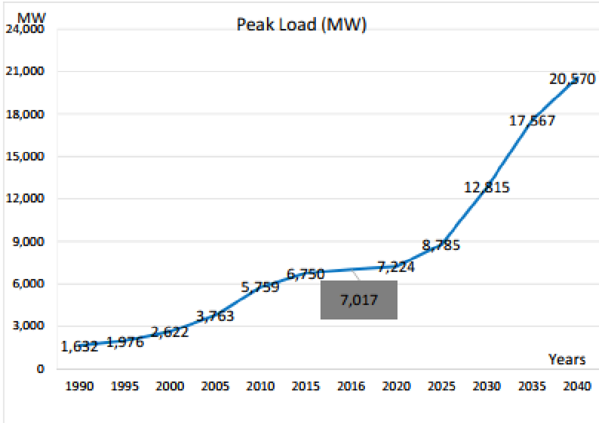


Figure (8) results of the peak load regression analysis

3.3 Samples analysis of Demand Side Management Project

This study aims to identify the consumption pattern of one of the most important sectors consuming the electric power, the domestic sector, and also to determine the consumption of household equipment most consumed by electric power. It also aims to determine the nature of the consumption of household equipment most consumed by electric power in an attempt to study the possibility of rationalizing the consumption of electric power and reducing peak loads without affecting the level of energy consumption for Libyan families.

By collecting information related to all electrical household equipment for different samples of homes, and then it can be analyzed and studied to identify the behavior of that equipment inside the house in the summer season.

Wattages for each equipment were then found on the site collection forms, as seen below

Address	Tripoli	Area	170 M²	Date	25/8/2015	
Activity type	Residential			Time	12:00 AM	
Appliance						Meters and devices
Eq No	Appliance Type	Mune	Number	W	hp	
1	Main meter		1			Pulse HPBO: 2420912
2	Lighting C.F.L			1400		U12: 2407400 / U12: 2407351
3	AC		1	2400		U10 :2365865
4	Water Pump		1	746	1	
5	Refrigerator	Beko	1	350		Watts app pro

Figure (9) Residential Site Form

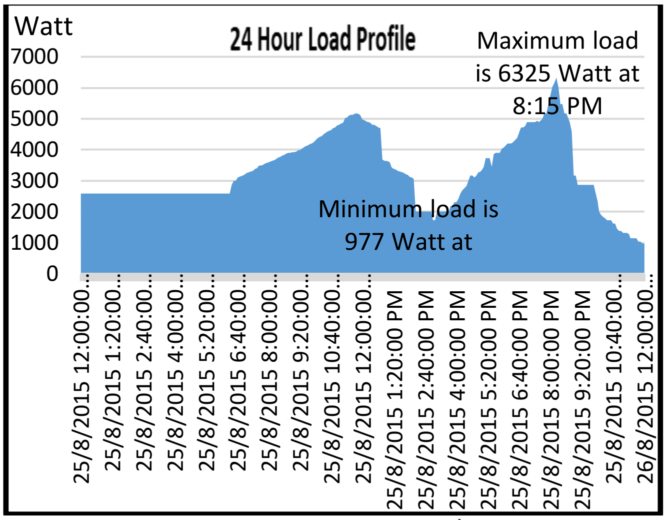


Figure (10) A 24 hours load curve 0n 25th August 2015

In Figure (10) hourly load curves is shown for 24 hours of a day in summer season. The interval length is one hour, so there are 24 intervals in the figure. It can be seen in figure that the load is low and stable from 12 am to 6:25 am, the load start rising after 6:25 am till 11:45 am and after that it descends till 3:05 pm and after 3:05 pm it starts rising till 8:15 pm, after 8:15 pm load gradually decrease again until the end of the day. It can be seen in Figure (10), the curve there arises two peaks, First peak at 11:45 am and the 2nd peak at 8:15 pm.
that maximum demand occurs at 8:15 pm, and minimum load demand occurs after mid night at 11: 55 pm. So closely observe this load curve it can be seen that load demand
At midnight there is no need for lighting or cooling the house and the air conditioner is turned off.
Figures (11) and (12) show the daily load shape for the air conditioner and lightning.

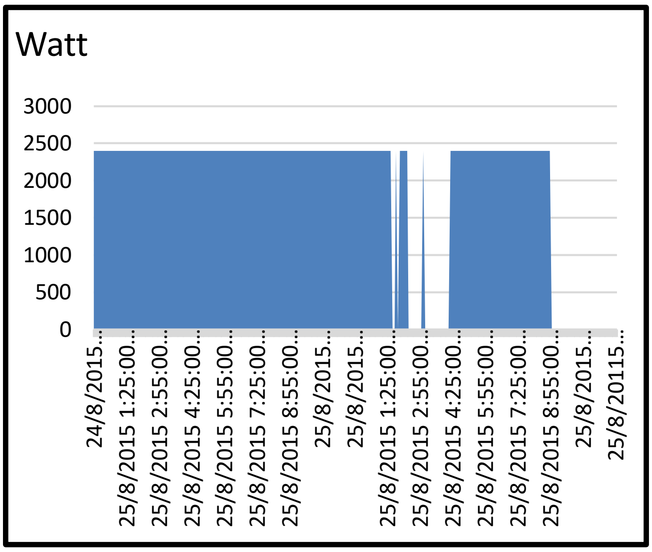
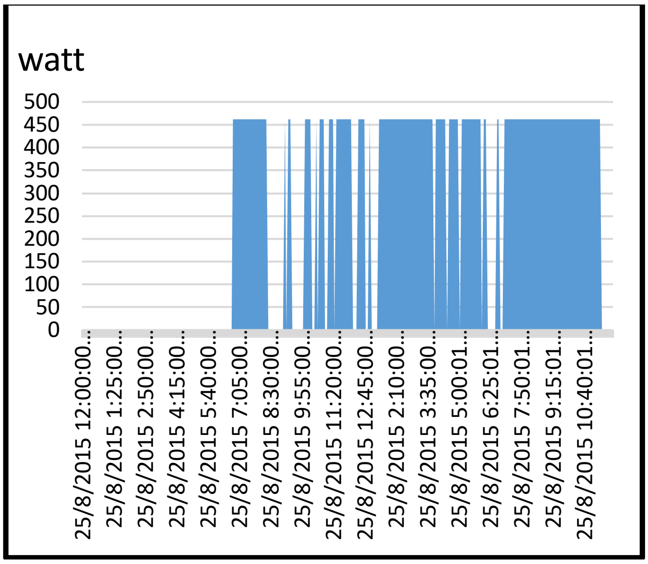


Figure (11) Air conditioner daily load shape



Figures (12) Lightning daily load shape

In Figure (13) hourly load curves is shown for 24 hours of a day in the winter season on 6th February 2015. The interval length is one hour, so there are 24 intervals in the figure. It can be seen in figure (12), In the curve there is one peak at 7:50 PM and the minimum load demand occurs at 2:55 PM.

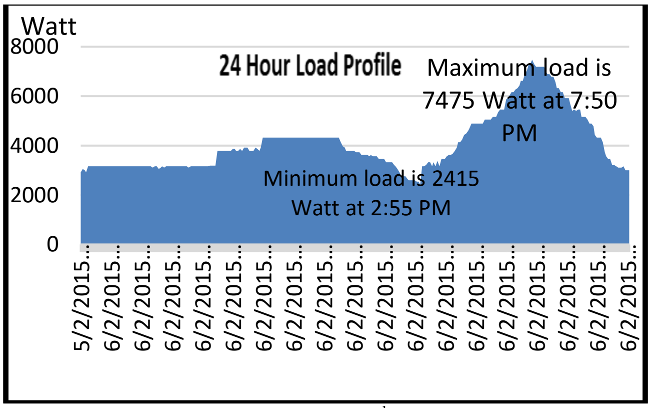


Figure (13) A 24 hours load curve on 6th February 2015

IV. Results and discussion

The residential sector considered the most important consumer sectors and the largest consuming of electrical energy, the growth of the demand for electrical energy in 2040 is 31,373,043 MWh and geographical factors such as population growth, number of households and average annual household consumption of electrical energy are the most important factors causing the growth of demand for electric energy in This sector
For the other sectors, the study based on historical data of electrical energy consumption and the value of the gross domestic product for each sector in the period 1990-2016 and the estimated data of the gross domestic product in the period 2017-2040, the forecasting demand for of electrical energy increase by increasing the annual gross domestic product, the big drop forecasting electrical energy results for heavy industry sector was observed due to the irregular values of the annual gross domestic product in the period 2011-2018 in Figure (6),and the peak load demand in 2040 is 20570MW.
The accuracy of the results of this study increases with the increase in the historical data series for the time period.

V. Conclusion

The load forecasting study was conducted in order to accurately forecast the demand for electric power capacity and in Libya during the period from 2017 to 2040 for the main sectors, which are the residential, agricultural, heavy industrial, light industrial and service sectors. This analysis was done using the end use of the residential sector and the econometric of the rest of the sectors.

The demand analysis indicates a trend that the electricity supply in Libya is expected to increase from 7017 MW in 2016 to 20570 MW in 2040, and total consumption will reach about 95,270,804 MWh in 2040.

Moreover, by analyzing the real measurements samples of the load management project for the residential sector in the year 2015 in the summer season, the highest load was recorded 6325 watts at 8:15 pm and the air conditioner was the highest equipment consumption of 2,400 watts, but in the winter season it was The highest load was recorded at 7475 watts and the heater space was the highest power consumption of 1800watts, The summer peak period, occurring between June and September, is characterized by an overall peaking trend occurring in August with daily peaks occurring in the evening (8pm – 9pm).

The main aim of the Demand Side Management project is to reduce the demand of electrical power consumption, especially in the residential sector, which is the largest sector consumption of electric power in the sectors mentioned.

VI. Recommendations and future work

After conducting the load forecasting study until 2040, it is important to complete the study of generation expansion to cover the expected loads results in the mentioned period, noting any new additions in the mega projects construction such as factories and building new residential cities.

To reduce the electrical energy consumption that the demand management project aims to, especially in the residential sector, there are many methods that must be followed to reduce the consumption of electrical energy in this sector as it is the most energy-consuming sector, including the following:

- Change all Lamps with LED lights
- Increase the cost and tariff price Specially at the peak load
- Application of Energy Efficiency Programme
- Using high efficiency of household appliances

For future work, testing the forecasting models should be recommended taken consideration the relevant parameters affecting electricity demand. The methodology developed in this study can be used to investigate the incentives currently available to consumers to see if it would be possible to shift some of the load from peak hours at residential sector level. Furthermore, the possibility of using renewable energy (e.g PV system) at residential sector could be also studied and investigated. Using the forecasting model developed for residential sector. The evaluation of the cost-effectiveness of the building integrated photovoltaic system when connected to the utility grid could be taken as an example.

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