Abstract - A sustainable supply of electric power is a prerequisite to foster all sorts of development in a country. Development of electricity infrastructure is undoubtedly a capital intensive project that needs a careful planning especially when taken future expansion into consideration. To keep Nigeria abreast with other developing countries which have exhibited a substantial growth in economic development, the existing gap between the electric power demand and supply scenario of the country must be bridged. Till now, the country is still entrenched in constricted opportunity for development due to frequent power outages resulting from a shortage in generation. As well, insufficient transmission and distribution facilities have been another recounted setback in the electric power sector of the country. Within the ambient of socio-economic development and increase in human population, electric load demand will tend to increase from time to time over the years to come. Thus, this paper studies a load demand forecasting using least squares technique in four different regional power supplies scenarios in Nigeria. Summarily, the overall result indicated a continuous growth in load demand in the selected regions.

Index Terms-Forecasting, Electric load, Power sector, Nigeria.

I. INTRODUCTION

One of the fundamental challenges of an electric utility company is to forecast load requirements at various times. The foremost reason behind this task is that power demand in a given place does vary with growth in population and economic activities [1]. Outcomes obtained from load forecasting progressions are used in different endeavors in power sector such as planning, system expansion, maintenance and operational schedule. For example, long-term load forecasting for at least a period of ten years ahead based on monthly and yearly values can be applied for resolution of some basic power sector challenges. Some of the problems can be expansion planning, inter-tie-tariff setting and long-term modeling of capital investment. Short-term load forecasting domino effect of few days to months ahead are considered necessary in unit commitment analysis, maintenance schedule and diagnosis of economic dispatch [2]. Load forecasting is an essential and integrated process in planning and operation of electric power utilities. It involves the accurate forecast of both the magnitudes and geographical location of electric load over the different periods of planning horizon. The basic quantity of interest in load forecasting is typically the time period in relation to load demand studied. However, load forecasting is also concerned with the prediction of hourly, daily, weekly, monthly and yearly values of the system load, peak system load and system energy demand [3]. A system network or grid is that part of power system which consists of the sub-stations and transmission lines of various voltage levels. The Nigerian electricity sub-sector is called Power Holding Company of Nigeria (PHCN). PHCN has a system comprising twenty six buses, forty transmission lines and fourteen generating stations which make up the Nigerian National Grid System [4]. The system is developed upon 330kV and 132kV transmission infrastructural network. At various point of time, power demand in the country has been constantly out-weighing the available capacity. Power demand developed from 3233 MW in 2002 to 3479 MW in 2003 and 3403 MW in 2004 [5]. The maximum power demand in 2003 exceeded the available capacity of 3477 MW [5]. A national target for electricity production has been advocated at different time from one regime of government to another. The more recent is the 10,000MW defined by the National Economic Empowerment and Development Strategy (NEEDS) in 2007. Incontrovertibly, some technical constraints needed to be resolved to strike this target. This includes upgrading of generation, transmission and distribution capacities. A well identified situation of insufficient maintenance, regression of new investments as well as high rate of auto-generation [6] has result in several catastrophic system failures, and eventually frequent power outages. Considering a point of fact, the demand of electricity in the country shall continue to increase due to continuous growth in population and increase quest for development. Consequently, this paper addresses an issue of electric load forecasting in four different regions of Nigeria using a least square technique.

II. REVIEW OF LITERATURE

A prediction scenario of future events and situations are called forecasts, and the act of making such predictions is called forecasting [7]. Forecasting is the basic facet of decision making [8] in different areas of life. The purpose of forecasting is to minimize the risk in decision making and reduce unanticipated cost. One of the most important works of an electric power utility is to correctly predict load requirements. In broad terms, power system load forecasting can be categorized into long-term and short-term functions. Long-term load forecasting usually covers from one to ten years based on monthly, yearly values. Explicitly, it is intended for applications in capacity expansion, and long-term capital investment return studies. In simplicity, forecasting is a system for quantitatively determining future load demand [9]. On one hand, long range planners consider a period of 20-30 years forecasts to ascertain sufficient generation and transmission as well as distribution plans of actions. On the
second hand, the system operator is concerned with the load requirements for hours ahead so that it may commit equipment or schedule an energy interchange with a neighboring area. Daily forecasts are required to schedule generating units for optimum cost-cutting measure. Weekly or monthly forecasts are required for maintenance scheduling [9]. Judging on the time period of interest, forecasting are generally classified as long term, medium term, short term forecast and very short term. According to [9], medium term forecast of 4-10 years are highly essential for planning the size of Power plants, construction and installation of the equipment in power plants and for the addition of new transmission and distribution facilities. In the past few years, several research literatures have emerged with respect to load forecast of any kind. Ye et al., [10] study long term load forecasting and recommendations for China based on support vector regression. In the framework, support vector regression (SVR) is used to develop an algorithm for establishing a non-linear relationship between load requirement and economic factor for growth in GDP. Further, in a study conducted by Mohammed [11], the author focus interest on the estimation and projection of electric power in Nigeria based on a linear regression using corn residues. Recently, other evolving methods such as multiple linear regression, autoregressive and moving average need assumed parameters estimated from historical data [12-14] were also reported. Fuzzy logic [15-16] and artificial neural networks (ANNs) also have been employed to implement load forecasting scenarios [17-21]. In addition, particle-swarm optimization (PSO) [22], dynamic simulation theory [23], hybrid methods [15, 16, 19, 21, 24] and immune algorithm [25-26] have been used to confirm the parameters of a SVR model for load forecasting. Other growing number of literatures such as ARIMA (autoregressive integrated moving average) providing an electricity demand forecasting for Turkish electricity is explored by Erdogan [27] and multivariate linear regression of time series [28]. Several energy models have been utilized to forecast energy demand in different countries such as time series model (TSM) studied by [29-31], expert system and artificial neural network model [32-36], grey prediction approach [37-39] and regression model [40-44]. A least square regression (LSR) method is used for the analysis in this paper. The main advantage of the technique over other methods is that it can be used to fit model that are both linear and non-linear in nature. Therefore, the model uses accuracy trend analysis for extrapolating future load demand. The least squares error estimation results are easy to calculate with a number of remarkable properties. The least squares are the unsurpassed estimates (maximum likelihood) especially when the measurement errors follow a normal distribution.

III. METHODOLOGY

As earlier mentioned, advances in different fields such as artifical intelligence (expert systems) have brought the uses of different techniques for load forecasting. This method is one of the numerous methods which can be used for both long and medium term load forecasting. A raw data regarding load demand covering a period of six years is used for this study. In this work, peak loads for four (4) regions in Nigeria are used spreading from year 2004 through the year 2009. Two of the region (Shiroro and Kaduna) is from the northern zone of the country while the remaining two (Port Harcourt and Osogbo) from the southern part. Data for each region is tabulated and a Matlab script is drafted to compute the power demand in years to come (from 2010 to 2020). Matlab made the realization of power forecasting with least square method (exponential) very simplified in the sense that it gives researcher the freedom to determine the growth of power demand over a range of years using the peak power demand. The various regions as analyzed and the results are presented. The Base year, \(x_0 = 2006\), Base MW = 10^7 are selected mutually for the four regions. The least square method is an extrapolation technique expressed by the analytical function as expressed:

\[
PD_i = \exp\{a + b(x_i - x_O)\} \tag{1}
\]

\(PD_i\) = Normalized power demand with the base MW.

\(x_i\) = the \(i\)th (mark-up) year in which the normalized power demand is considered.

\(x_O\) = the base year.

Constant \(a = \frac{1}{n} \sum_{i=1}^{n} Y_i\) ; \(n=1, 2 \ldots 6\) \tag{2}

\[
\sum_{i=1}^{n} Y_i X_i
\]

Constant \(b = \frac{1}{n} \sum_{i=1}^{n} (X_i)^2\) ; \(n=1,2 \ldots 6\) \tag{3}

Where \(Y_i = InPD_i\)

IV. BRIEF OUTLOOK OF ELECTRICITY GENERATION IN NIGERIA AND PLANNED SCENARIOS

The first electricity generation in Nigeria happened during the pre-colonial era in the then Lagos colony. Low capacity generating sets were used to supply electric power to the premises of the then colonial masters. Later, Electricity Corporation of Nigeria (ECN) was established through an act of parliament in 1951. Subsequently, intention to exploit hydropower potential of the country brought about the establishment of Niger Dams Authority (NDA). In 1972, NDA and ECN were amalgamated to form the National Electric power Authority (NEPA). Electric power sector reform of 2005 brought a change of name to the utility company, Power Holding Company of Nigeria (PHCN). The
sole objective being that the government intends to revamp the already dying sector for improved efficiency, then privatization of the sector was then considered a viable way-out in the reform agenda. This goal is to be realized through the participation of independent power producers (IPPs). Through this IPPs projects more plan of actions towards increasing electricity generation in the country is expected to be sustained. For example, Agip has planned a 450MW power plant capacity in Kwale in the Niger delta region. On the same track under the IPPs are 276MW by Siemens, 700MW Afam power plant, ABBs plant (450MW), Sapele plant (451MW) and China's EXIM Bank Su Zhong and Sino Hydro planning for the development of Mambilla (3,900MW) and Zungeru (950MW). Currently, Chevron is entrusting fund for the development of 780MW, Egbema (338MW), Omoku (230MW) and Caliber (561MW). Many other planned and ongoing means of expanding power supply in the country are still being discussed for sustainability. Today, more IPPs are being granted license for generating power in the country. With all these accomplishments, there is likelihood that future energy demand in the country could be met.

V. DISCUSSION OF RESULTS

The raw data used for the analysis is presented in Table 1 [45]. Conventionally, power demand in a country is expected to change in a positive sequence from time to time over the years. This is usually an expected condition when there is an occurrence of growth in economy and human population. From the Table 1 presented, a general increment is observed for all the regions under study for the period of six years. The result of the forecasting as synthesize using a Matlab graphical script is presented in Figure 1 for Kaduna, Figure 2 for Port-Harcourt, Figure 3 for Osogbo and Figure 4 for Shiroro. It is obvious that from the graphical system generated for the forecasted results, an approximately linear trend is observed covering a period from 2010-2020. This in essence shows that a pattern of conventional increase in load demand will be encountered in the nearest future. However, current generation is highly constraint in the face of numerous energy resources.

<table>
<thead>
<tr>
<th>Year</th>
<th>Shiroro</th>
<th>Kaduna</th>
<th>Port-Harcourt</th>
<th>Osogbo</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>272.35</td>
<td>185.00</td>
<td>204.42</td>
<td>198.03</td>
</tr>
<tr>
<td>2005</td>
<td>288.33</td>
<td>206.70</td>
<td>223.07</td>
<td>219.84</td>
</tr>
<tr>
<td>2006</td>
<td>299.61</td>
<td>219.30</td>
<td>243.67</td>
<td>233.60</td>
</tr>
<tr>
<td>2007</td>
<td>321.61</td>
<td>239.20</td>
<td>264.67</td>
<td>243.90</td>
</tr>
<tr>
<td>2008</td>
<td>338.70</td>
<td>242.70</td>
<td>295.70</td>
<td>256.59</td>
</tr>
<tr>
<td>2009</td>
<td>341.40</td>
<td>257.20</td>
<td>322.54</td>
<td>269.21</td>
</tr>
</tbody>
</table>

The Kaduna region has no single generating station, the region may not have natural gas, but it has other resource potential for power generation. A potential large-scale hydro station (DadinKowa) has been identified within the region. Also, available in this region is vast solar radiation for solar energy exploitation though has not been harnessed. Power generation in this region could also be improved when the planned gas pipeline project in the country is completed. Besides, research studies have also pinpointed a potential for wind electricity in the region. The region is associated with vast socio-economic potential. Opportunities presented by the energy potentials need to be developed to meet the regional future power demand for socio-economic growth.

**Fig 1: Power Demand for Kaduna Region**

The Port Harcourt zone is one of the oil rich regions in the Niger Delta. It is well endowed with natural gas and the demand for electric power supply is not very high compare to some densely populated part of the country. More thermal power station can be established in this region since natural gas is within the reach. The power produced can be linked to the national grid for use even in other regions. Also available in this region is a 730MW hydropower potential at Ikom and many other identifiable but yet to be harnessed sites for hydroelectricity.

**Fig 2: Power Demand for Port Harcourt Region**

Osogbo is in the southwest zonal part of the country. This region is presently without a power generating station. A strong potential for bioenergy and hydro energy resources exist within the region. Though the resources are also yet to be exploited but aggressive investment in the power sector could enable such advantage presented by the resources to be utilized.
VI. CONCLUSION

The Nigerian power sector has been confronted with problems like delay in maintenance of power facilities, poor technical knowledge of maintenance crew, obsolete equipment, insufficient energy supply mix and inadequate funding mechanism. The performance of the sector has been unimpressive over the years. A number of the generation units in the power plants across the country have been operating lower than their installed capacity due to several years of neglect and poor funding. At various instances, the Nigerian government has made some useful efforts towards revamping the situation in the sector. Moreover, if all the resource potentials for power generation in all the regions or rather a greater portion utilized, the nation’s electricity sector will wear a new look. In India, China, Thailand, Malaysia and some other emerging economies including the advanced countries, economic growth is directly related to electricity consumption which has been unveiled as a dependable factor. Characteristically, this has compelled so many developing countries across the world to set electricity generation target for economic growth. Nigeria was reported to have made a declaration to achieve over 50,000MW by year 2015. To maintain this increment, vision 2020 has been set on course. Realistically, to achieve this target enough investment has to be made in funding of all the regional power systems to develop the available resource potential for power generation including renewable energies. This will eventually cater for the growing needs for electricity demand as observed in this study.

REFERENCES


