TIME-SERIES FORECAST OF NIGERIA'S ELECTRICITY STATISTICS FROM 1991-2028 USING AUTO-REGRESSIVE INTEGRATED MOVING AVERAGE (ARIMA) MODEL

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DEPARTMENT OF MECHANICAL ENGINEERING

FACULTY OF ENGINEERING

AUGUST 2014.

DECLARATION

I, OYETIMEIN Oluwatobi Christopher declare that this work entitled 'TIME-SERIES FORECAST OF NIGERIA'S ELECTRICITY STATISTICS FROM 1991-2028 USING AUTO-REGRESSIVE INTEGRATED MOVING AVERAGE (ARIMA) MODEL' was carried out by me in the Department of Mechanical Engineering, Ahmadu Bello University, Zaria.

The information derived from literature has been duly acknowledged and referenced in the text. No part of this project was previously presented for another degree, diploma or certificate at any university or institution of learning.

	……..……	……...…….
OYETIMEIN Oluwatobi Christopher	Signature	Date

CERTIFICATION

I certify that this work entitled 'TIME-SERIES FORECAST OF NIGERIA'S ELECTRICITY STATISTICS FROM 1991-2028 USING AUTO-REGRESSIVE INTEGRATED MOVING AVERAGE (ARIMA) MODEL' was carried out by Oyetimein Oluwatobi C. in the Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Nigeria. The project meets the regulation governing the award of the degree of Masters in Engineering Management in the School of Post Graduate Studies of Ahmadu Bello University, Zaria.

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DEDICATION

This project is dedicated to the Almighty God, the creator of life and giver of health, wisdom and intellect. If I had been in ill-health or lacked the needed intellect, a Master's degree project would not be among my options. Thank you for giving me both.

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I acknowledge and appreciate my parents, Mr and Mrs Oyetimein, who has supported me and encouraged me to be educated. Your support is beyond words and beyond any appreciation I can ever give but I will simply say, Thank You.

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ABSTRACT

In Nigeria, there is a problem of inadequate electricity supply to the populace. A recognized reason for the energy poverty in the country is the poor handling of the electricity statistics provided by the National Electricity Regulatory Commission (Ajayi, 2006). Absence of good forecast is a dominant reason for the NERC's inability to manage the supply chain of electricity or carry out effective electricity demand and production planning. In this project, specific data has been obtained on electricity production (in kWh), electricity consumption (in kWh), electricity consumption per capita (in kWh), electricity transmission losses (in kWh) and percentage electricity transmission losses from the statistical bulletin of the National Bureau of Statistics between the year 1991 and 2011. This data reflects electricity demand and consumption pattern over the last two decades to help carry out a time-series analysis of the data and plot a time-series graph of the data to show the pattern of electricity demand and consumption using the Data Analysis Package, Time Series Modeller and Sequence Chart Analyser of the IBM SPSS 21 application. A Time series forecast of the data obtained was done using the Auto Regressive Integrated Moving Average model. The forecast predicted that if electricity consumption per capita remains static and unchanged at 145.146 kW per person per annum, the annual electricity consumption in 2016 will stand at 30.319 billion KWh thereby surpassing the total amount of electricity produced, 30.251 billion KWh if all other parameters that affect the production and consumption such as the amount of electricity lost in transmission continues in the same pattern as predicted by the model. Therefore the percentage of Nigerians that have access to electricity supply will also reduce from 48% in 2011 to about 41.83% in 2016. Error tests were carried out to ascertain the efficiency of the forecast and the model used. Forecasts are deemed to be accurate and authoritative enough if the MAPE value is below 10 and a forecast whose MAPE is between 1 and 5 is considered authoritative and accurate (Bozarth, 2011). The forecast was able to achieve a MAPE of 1.207 for the forecasts below the 10^{th} Percentile of all forecasts and a MAPE of 1.714 for the forecasts between the 10^{th} and 25^{th} Percentile of all forecasts, which is the forecast between 2012 and 2017. This value increased to 25.037 as the model generated more forecasts. The results obtained by this forecast is further validated by the actual 2013 value of average annual electricity production which stands at 29.166 billion kWh according to (Nnodim, 2013), a 2.89% error difference from the forecasted 28.321 billion kWh. Hence, the forecasts between 2012 and 2017 are relatively accurate and authoritative.

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CHAPTER ONE

INTRODUCTION

1.1 Background To The Study

The Nigerian power sector is known to not cater for the apparent demand of electrical energy by the country's teeming population of approximately 200 million according to the Nigerian Bureau of Statistics 2013 estimate.

According to the United States Energy Information Administration (EIA), Nigeria has one of the lowest net electricity generation per capita rates in the world. Electricity generation falls short of demand, resulting in load shedding, blackouts, and a reliance on private generators. Demand has consistently outweighed the supply of electricity by the nation's eleven recognised power generation companies under the recent privatisation scheme.

Electricity is an essential ingredient for socio-economic development and economic growth. The objective of the power sector is to provide energy services. Energy is central to sustainable development and poverty reduction efforts (Sambo, 2005). It affects all aspects of development-social, economic, and environmental-including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender related issues.

As the very basis of development, energy use is closely related to the level of productivity in the industry, commerce, agriculture and even in office activities. Energy consumption per capita is one of the indicators or benchmarks for measuring the standard of living of a people or nation (Sambo, 2005). Hence, as long as energy supply cannot meet the energy demand of the people, there will be little hopes of achieving enviable national development and even improving the standard of living of the Nigerian people. The onus lies on the management personnel of the energy regulatory body, National Electricity Regulation Commission, NERC to be able to obtain specific information that denotes the energy demand of the people and be able to collate such information in an easily-understandable format for policy makers and generation companies and other relevant stakeholders. Having obtained the relevant information that shows the numeric energy demand of the nation over a past period of time. Management of the nation's energy regulatory body should be also responsible for collation of such information and analyse it to bring out and accentuate any recognisable patterns in the production and consumption of energy by the Nigerian economy. With this information and the recognised pattern, a forecast can be made using up to date statistical analysis and forecast tools and software that will depict the

expected usage pattern and demand for electrical energy over a given period of time in the short or long term future. With this new information, the management of the nation's power sector can also proffer a means of solving and ensuring that the country plans towards meeting the nation's energy demands at any time in the future as depicted by the forecast.

1.2 Statement of Problem

The Nigerian energy sector has not been able to provide adequately for the demand of electrical energy by the Nigerian public. In actual fact, there is a problem of lack of ability to coordinate data collection to generate a forecast of the actual energy demand of the various sectors of the Nigerian economy (Okafor and Joe-Uzuegbu, 2010). This research project wishes to achieve a thorough analysis of average statistical data that shows the energy demand of the Nigerian economy and achieve the recognition of a known pattern of energy demand with time and hence generate a forecast for the energy demand and energy statistics for subsequent years.

1.3 The Present Research

This research project aims to therefore give a forecast based on previous data supplied by the NERC on electricity production, consumption and demand estimate of the Nigerian economy from 1990 till 2011. The forecast provides expected energy demand statistics by the country from 2012 to 2028 and creates a time-series of the energy demand statistics by the Nigerian economy from 2012 to 2028.

1.4 Aims of the Project

Obtain a statistical time-series forecast of the pattern of energy demand, production and consumption of the Nigerian economy over a specific period of time and therefore predicts the nation's electricity statistics thereby creating a platform for effective demand planning.

1.5 Objectives of the Project

1. Carry out a statistical forecast of the energy data of Nigeria between the year 1991 and 2028 (38 years) using an efficient model.
2. Predict based on the forecast obtained, the projected electricity production, consumption and transmission losses and demand estimate of the nation in the short-term future.

1.6 Scope of the Project

1. Carry out literature review.
2. Survey the demand, production and consumption of energy by the Nigerian economy over the last 21 years.
3. Tabulate the results of the survey.
4. Analyze the results for the survey
5. Using the SPSS ARIMA model, obtain a relationship between the available data and carry out a time-series forecast for the available data.
6. Interpret the information
7. Discuss the results based on the information
8. The results obtained from this forecast or any similar forecast is important information for intending investors in the newly privatized power sector and also for managers involved in policy formulation regarding the power sector especially the energy planning commission as such forecast data will help in demand planning and supply chain management.

1.7 Significance of the Study

Management of the nation's energy regulatory body should be responsible for collation of electricity information and analyse it to bring out and accentuate any recognisable patterns in the usage and demand of energy by various sectors of the Nigerian economy. With this information and the recognised pattern, a forecast can be made using up to date statistical analysis and forecast tools and software that will depict the expected usage pattern and demand for electrical energy over a given period of time in the short or long term future. With this new information, the management of the nation's power sector can also proffer a means of solving and ensuring that the country plans towards meeting the nation's energy demands at any time in the future as depicted by this forecast and similar forecasts.

1.8 Contribution to Knowledge

This work shows through accurate prediction and forecasting that the ARIMA Time-Series Modeller is a good model generator that is capable of carrying out a thorough analysis and forecast of Nigeria's electricity statistics.

The work authoritatively predicts the nation's electricity statistics thereby creating a platform for effective demand planning.

CHAPTER TWO

LITERATURE REVIEW

2.1 Electricity Demand In Nigeria

Demand is an economic term that means the quantity of a product or service that a consumer shows willingness and ability to pay a specific price for at a specific time. Demand can change with time and price. Due to increase in population, increased industrialization and the efforts of nations to reduce the combustion of fossil fuels the world faces a steady rise in demand for alternative energy sources (Madueme, 1979) and specifically electricity as a form of energy to replace the fossil fuels and that includes African nations like Nigeria.

Electricity is a si-ne-qua-non, a necessary requirement for the operation of production processes from design to manufacturing of goods, distribution and services. It plays a very important role in the socio-economic and technological development of every nation (Adebanjo, 2012).

There are indications that the nation is still far away from becoming self-sufficient in electricity, going by revelations by the Minister for Power in Nigeria, Prof Chinedu Nebo that at a time Nigeria has shifted the target date for generating 10,000 mega watts from December 2013 to the first quarter of 2014, about 200,000MW is needed to meet current energy demands.

Electrical energy is demanded in Nigeria mainly by households who serve as the final consumers because of the low level of industrialization in the country. However, the manufacturing industry, educational institutions, health care parastatals and the private and public sector firms also consume a good percentage of the electricity generated (Abatan, 1979).

Globally, electricity finds increased usage as the drive to reduce dependence on fossil fuels increases, automobile manufacturers are producing electric cars, the steel making and metallurgical industry is tending towards adoption of more electric arc furnace systems instead of the traditional blast furnace system which uses mainly carbon-based fuels and coking materials.

Although, Nebo failed to give a timeline on when the power need would be met, he told a group of British businessmen led by the Lord Mayor of the City of London, Roger that the target presents huge investment opportunity for local and foreign firms.

Nigeria currently generates around 4,500mw of electricity, and, according to him, investment particularly in the nation's power generation segment is largely dominated by firms from Asia and the United States of America.

He explained that the Nigerian government is determined to diversify its energy mix by increasing power generated from wind, solar and other bio-mass to reduce dependence on gas and hydro powered plants.

According to the Minister, "we need a robust energy mix, for security purposes, as a nation it is not expedient to have a source or two we need a good mix of power, we now have wind turbines, solar power too are being commissioned, but we are still far considering our potentials. Only recently a South Korean firm has agreed to produce for us 1,000 solar panels every year for the next 10 years".

According to (Ibidapo-Obe and Ajibola, 2011), some rural parts of Nigeria are known to be good for wind and this robust power mix of wind and solar energy will be good for our off-grid rural folks, who will intend to focus under the Rural Electrification Scheme.

2.1.1 Sources and methods of compiling electricity supply and demand statistics in Nigeria

The Power Holding Company of Nigeria (PHCN) is virtually the only source of statistical information on electricity supply and demand in Nigeria.

Each of the Power Stations completes Form 125 titled "Generation Returns". Information supplied includes:

- Name of Power Station.
- Number of generating unit.
- Energy type.
- Turbine set.
- Quantity of electricity generated in gigawatt hours.
- Installed capacity.

Each of the Zonal Offices also completes sales returns on which, among others, information is supplied as summarised for all consumers as follows:

- Consumer category (domestic, commercial, industrial),
- Unit consumed and
- Amount paid.

The processing of these returns consists of aggregation over Power Stations or zonal offices in order to obtain national estimates of the parameters. Other items of data which are produced by the statistics division of the PHCN are derived from the two returns on

'Peak Demand for Electricity' and

'Transmission and Distribution Losses'.

Energy generation and sales returns as obtained from the generating stations and zonal offices respectively are also forwarded to the NBS, CBN and relevant State ministries. These forms are the sources of statistics of electricity supply and consumption as published regularly by the National bureau of Statistics, NBS and the Central Bank of Nigeria, CBN (Oyedepo, 2012).

2.1.2 Statistics involving electricity demand

The Power Holding Company of Nigeria [PHCN] as stated before, being virtually the only source of statistical information on electricity supply and demand in Nigeria. According to category E division 40 of the International Standard Industrial Classification [ISIC], electricity statistics cover the production, collection, and distribution of electricity. Thus, it includes statistics on generation, collection, transmission and distribution of electrical energy for sale to all categories of consumers. Also included will be statistical information on privately-owned electric power plants, which sell a significant amount of electricity to consumers as well as produce electricity for their parent enterprises which can be reported separately from the other units of the relevant organisations.

Although the PHCN has computerised its billing system, it has not done so for the production of its administrative statistics. The PHCN does not have adequate electronic data processing facilities to enable it computerise the production and storage of its administrative statistics.

Most of PHCN administrative statistics are stored in hard copies or flat files. Although statistical information on its activities (generation, transmission and distribution of electricity) are published in its **Annual Reports and Accounts**, regular sources of time-series information on electricity production and consumption are in the **Annual Abstract of Statistics**, published by NBS, and **Economic and Financial Review** published by the CBN. Electricity production and consumption statistics are, therefore, not available in machine-readable form. However the operators of the National Bureau of Statistics have put together a database of 9 items containing a total of 135 details on electricity production and consumption data on which the PHCN should focus its attention in respect of data collection and reports (Oyedepo, 2012).

This is because PHCN has the monopoly of public distribution of electricity in Nigeria. Electricity purchased by the PHCN from Nigeria Electric Supply Company (NESCO), Shell Company and African Timber and Plywood Company (AT & P) is usually reported as such by PHCN. Also some agencies, notably the National Bureau of Statistics (NBS) and Central Bank of Nigeria (CBN), publish statistical information on electricity supply and consumption, as obtained from PHCN. All the statistical information on electricity supply and demand are produced in the course of day-to-day administration and as reported to the headquarters by PHCN's Power Stations, Zonal offices, and the private generating plants which sell electricity to PHCN.

Four categories of administrative statistics are produced by PHCN. These are:

1. Energy generation statistics.
2. Energy transmission statistics.
3. Energy distribution statistics.
4. Energy sales statistics.

But the organization does not compile administrative data that shows the expected changes in energy demand in the country with time. Hence, Nigeria could be aiming to produce a certain quantity of energy which they know is the current demand for electricity but may increase in the next two years or more. This also implies a total inability to manage the supply chain of electric power with the current amount produced by the available power plants in the present day and definitely in the future. In other words, the energy generating companies that have taken over the power generation aspect of the industry may be working blindly as regards knowing what their consumers will need in the short term future. If they don't know what their customers will need in the future, they will not be able to provide adequately and generate enough energy for these customers. Hence, the vicious cycle of low volume of production will continue as supply will continually remain non commensurate with the demand (Goshwe and Kureve, 2012).

2.2 Electrical Energy Review in Nigeria since 1960

Nigeria with a population of over 160 million people is endowed with enormous energy resources, such as, petroleum, natural gas, coal, nuclear, tar sand. Others include solar, wind, biomass and hydro. However, development and exploitation of such energy sources have been skewed in favour of the hydro, petroleum and natural gas. At independence in 1960,

agriculture was the dominant sector of the economy contributing about 70%. This trend changed with the discovery of oil in 1970.

Between 1970 and 1980, petroleum products were cheap and readily available as premium motor spirit (PMS) otherwise known as petrol assumed the role of main source of energy in Nigeria. As a result, all other energy sources were neglected (Oji, Idusuyi, and Kareem, 2012).

Also, the country's natural gas reserves account for 5.2 trillion cubic metres, making it the world's seventh biggest natural gas reserve. Although, natural gas occurs in associated form with crude oil, Nigeria's gas reserves are three times greater than its oil reserves. The country provides 10% of the world's LNG. Despite this potential, gas flaring has continued unabated over the years (Eboh, 1998). Currently, the Nigerian energy crisis has stymied the socio economic activities of the country which has brought untold hardship on the people of the country. At the moment, the electricity supply in the country does not meet national demand. While the estimated daily power generation was about 3,700MW as at December 2009, the peak load forecast for the same period was 5,103MW. This is based on the existing connections to the grid which does not take into account the suppressed demand. While the government owned monopoly company (Power Holding Company of Nigeria) has been unbundled, in its stead, three hydro and seven thermal generating, a radial transmission grid (330kV and 132kV); and eleven distribution companies (33kV and below) that undertake the wires, sales, billing, collection and customer care functions within their area of geographical monopoly have been set up. Except for the transmission function, the others have been privatized.

The epileptic nature of electricity has led to scarcity of petrol and kerosene because the citizens have resulted to using generators and kerosene powered equipment to provide energy for use at homes. Other alternative energy sources including solar, wind, wave are largely underdeveloped in the country. Furthermore, as a result of domestic fuel prices that has gone up several times with attendant upsurge in transport fare and prices of goods and services. (Bamikole, 2012) reports that industrial capacity utilization has plummeted from 78.7% in 1977 to 30.1% in 1987 before resurgence to 53.3% in 2007 and 53% in 2010. National electricity generation capacity in 1990 was 5958 megawatts to meet a load of 4000 megawatts. Subsequent increase in capacity was less than proportionate to load growth, hence the start of electricity shortage in the country. As a matter of fact, since the generating system was upgraded in 1990, no new units have been added. Today, less than 3000 megawatts are being generated to meet a demand load of almost 6000 megawatts (Anaekwe, 2010).

2.2.1 Sources of energy

As stated previously, Nigeria is blessed with abundant energy resources from various sources that include:

- Petroleum,
- Natural gas,
- Coal,
- Tar sand.

Others include

- Solar,
- Wind,
- Biomass and
- Hydro.

In this section, I have provided brief reviews of the various available sources of electrical energy in Nigeria, giving statistical details about them.

Table 2.1: Nigeria's Energy reserves/capacity as at December 2005

Resource type	**Reserves**	**Reserves (BTOE)c**	**Reserves (× 10^7) TJ**
Crude oil	36.2 billion barrels	4.896	20.499
Natural gas	166 trillion SCF[a]	4.465	18.694
Coal and lignite	2.7 billion tonnes	1.882	7.879
Tar sands	31 billion barrels of oil equivalent	4.216	17.652
Subtotal Fossil		15.459	64.724

Resource type	Reserves	Reserves (BTOE)c	Reserves (× 10^7) TJ
Hydropower, large Scale	11,000 MW		0.0341/year
Hydropower, small Scale	3,250 MW		0.0101/year
Fuel wood	13,071,464 ha[b]		
Animal waste	61 million tonnes/year		
Crop residue	83 million tonnes/year		
Solar radiation	3.5 to 7.0 kW h/m^2/day		
Wind	2 to4 m/s (annual average) at 10 m in height		
[a]SCF, standard cubic feet; [b]forest land estimate for 1981; [c]BTOE, billion tonnes of oil equivalent.			

(Source: ECN Bulletin 2007)

Petroleum

With proven oil reserves exceeding 9 billion tons, Nigeria is one of the largest hydrocarbon feedstock producers in Africa, and ranks twelfth place worldwide. The country relies heavily on its petroleum industry for economic growth, the sector accounts for about 80% of government revenues and provides 95% of foreign exchange (Morvay and Gvozdenac, 2008). Nigeria is a member of the Organisation of Petroleum Exporting Countries (OPEC) and total

crude oil production, including condensates, stood at 855.736 million barrels or an average of 2.344 million barrels per day in 1997.

Table 2.2: Nigerian Crude Oil Production and Exports 1961 – 1997 (Barrels)

	Production		Exports	
Year	Total Production	Daily Average	Total Exports	Daily Average
1961	16,801,896	46,033	16,505,985	45,222
1962	24,623,691	67,462	24,697,969	67,666
1963	27,913,479	76,475	27,701,320	75,894
1964	43,996,895	120,210	43,431,563	118,665
1965	99,353,794	272,202	96,984,975	265,712
1966	152,428,168	417,611	139,549,969	382,329
1967	116,553,292	319,324	109,274,902	299,383
1968	51,907,304	141,823	52,129,858	142,431
1969	197,204,486	540,286	197,245,641	540,399
1970	395,835,825	1,084,482	383,446,359	1,050,538
1971	558,878,882	1,531,175	542,545,131	1,486,425
1972	665,283,111	1,817,713	650,640,779	1,777,707
1973	750,452,286	2,056,034	725,017,584	1,986,350
1974	823,320,724	2,255,673	795,710,044	2,180,028
1975	651,509,039	1,784,956	627,638,981	1,719,559
1976	758,058,376	2,071,198	736,822,998	2,013,178
1977	766,053,944	2,098,778	744,413,355	2,039,489
1978	692,269,111	1,896,628	667,357,065	1,828,376
1979	841,226,770	2,304,731	818,726,943	2,243,088
1980	752,223,285	2,055,255	700,138,614	1,912,947
1981	525,500,562	1,439,728	447,814,027	1,226,888
1982	470,687,221	1,289,554	366,410,179	1,003,864
1983	450,974,545	1,235,547	341,360,910	935,235
1984	507,998,997	1,387,975	400,428,085	1,094,066
1985	547,089,595	1,498,876	453,758,591	1,243,174

1986	535,296,671	1,466,566	445,673,729	1,221,024
1987	482,886,071	1,322,976	388,815,449	1,065,248
1988	490,440,000	1,340,000	406,443,000	1,110,500
1989	626,449,500	1,716,300	556,953,500	1,525,900
1990	630,245,500	1,726,700	565,750,000	1,550,000
1991	690,981,500	1,893,100	587,650,000	1,610,000
1992	716,262,000	1,957,000	580,110,000	1,585,000
1993	695,398,000	1,905,200	568,305,000	1,557,000
1994	664,628,500	1,820,900	580,350,000	1,590,000
1995	672,549,000	1,842,600	607,725,000	1,665,000
1996	681,894,600	1,863,100	620,135,000	1,694,358
1997	855,736,287	2,344,483	767,949,757	2,103,972
Grand Total	18,630,912,907	51,008,654	16,785,612,262	45,956,612

(Source: OPEC Bulletin 1999)

Natural Gas

Nigeria has an estimated 159 trillion cubic feet (Tcf) of proven natural gas reserves, giving the country one of the top ten natural gas endowments in the world. Due to a lack of utilization infrastructure, Nigeria still flares about 40% of the natural gas it produces and re-injects 12% to enhance oil recovery. The World Bank estimates that Nigeria accounts for 12.5% of the world's total gas flaring. Shell BP estimates that about half of the 2 Billion cubic feet per day (Bcf/d) of associated gas -- gaseous by-products of oil extraction -- is flared in Nigeria annually. The new industry strategy is to collect the associated gas and process it into liquefied natural gas (LNG), greatly enhancing Nigerian natural gas revenues while simultaneously reducing carbon dioxide emissions (Goshwe and Kurewe, 2012).

Table 2.3: Nigerian Natural Gas Production and Disposal

1961 – 1997			(Million Cubic Metres)
Year	Gas Produced	Gas Utilised	Gas Flared
1961	310	N/A	N/A
1962	486	N/A	N/A
1963	626	N/A	N/A
1964	1,029	N/A	N/A
1965	2,849	116	2,733
1966	2,908	216	2,692
1967	2,634	102	2,532
1968	1,462	151	1,311
1969	4,126	64	4,062
1970	8,068	111	7,957
1971	12,996	206	12,790
1972	17,122	274	16,848
1973	21,882	395	21,487
1974	27,170	394	26,776
1975	18,656	323	18,333
1976	21,274	657	20,617
1977	21,815	863	20,952
1978	20,486	1,046	19,440
1979	27,450	1,378	26,073
1980	24,551	2,337	22,214
1981	17,113	3,643	13,470
1982	15,382	3,442	11,940
1983	15,192	3,244	11,948
1984	16,251	3,438	12,813
1985	18,569	4,647	13,922
1986	18,738	4,821	13,917
1987	17,170	4,976	12,194

1988	20,250	5,510	14,740
1989	25,129	6,303	18,784
1990	28,430	6,020	22,410
1991	31,460	6,800	24,660
1992	32,084	7,508	24,575
1993	33,680	7,910	25,770
1994	33,680	6,770	26,910
1995	35,100	8,114	26,986
1996	35,450	8,860	26,590
1997	37,150	10,383	24,234
Grand Total	668,728	111,022	552,680

(Source: OPEC Bulletin, 1999)

Coal

The exploitation of the Nigerian energy resources began with coal in 1916 (Mudashir, 1979). There are nearly three billion tonnes of indicated reserves in seventeen identified coalfields and over 600 million tonnes of proven reserves in Nigeria (Anaekwe, 2010). Following the Nigerian civil war, many coal mines were abandoned and coal production never completely recovered. This is evident by coal production levels becoming erratic as both the resuscitation and maintenance of imported mining equipment proved troublesome (Godwin, 1980). As a result, coal production dropped significantly from 50% in 1960 to less than 1% in 1990. This decline in coal production was hastened by the discovery of crude oil in commercial quantities in Otuabagi / Otuogadi, Oloibiri district in Bayelsa state by Shell Darcy on 15 January, 1956.

Solar

The Sun releases an amazing amount of energy due to the nuclear fusion of hydrogen taking place within its core. Solar panels, which consist of photovoltaic cells, are used to convert the Sunʻs energy into electricity. The Sun can also be used to heat water passing through special solar collectors.

(Okafor and Joe-Uzuegbu, 2010) indicates that Nigeria is endowed with an annual Average daily sunshine of 6.25 hours, ranging between about 3.5 hours at the coastal areas and 9.0 hours at the far northern boundary. Similarly, it has an annual average daily solar radiation of about 5.25 KW/m^2/day, varying between about 3.5 kW/m^2/day at the coastal Area and 7.0kW/m^2/day at the northern boundary.

Nigeria receives about 4.851x 10^{12} KWh of energy per day from the sun. This is equivalent to about 1.082 million tons of oil Equivalent (mtoe) per day, and is about 4 thousand times the current daily crude oil reduction, and about 13 thousand times that of natural gas daily production based on energy unit. This huge energy resource from the sun is available for about 26% only of the day (Garba and Bashir, 2002).

According to (Fagbenle et al, 2010), the country also experiences some cold and dusty atmosphere during the harmattan, in its northern part, for a period of about four months (November-February) annually (13). The dust has an attenuating effect on the solar radiation intensity. Based on the land area of 924 x 10^3 km^2 for the country and an average of 5.535 kWh/m^2/day, Nigeria has an average of 1.804 x 10^{15} kWh of incident solar energy annually. This annual solar energy insolation value is about 27 times the nation total conventional energy resources in energy units and is over 117,000 times the amount of electric power generated in the country In other words, about 3.7% only of the national land area is needed to be utilized in order to annual collect from the sun an amount of energy equal to the nation's conventional energy reserve.

Director General of the ECN, Professor Abubakar Sambo, who spoke recently, said that one percent of Nigeria's land mass could be utilised for the generation of over 600000 MegaWatts of electricity using solar energy. Nigeria currently generates less than 6000 megawatts using fuel products.

According to him, Nigeria could generate about 600000 megawatts of electricity by deploying solar photovoltaic panels of only about 5% efficiency from just one percent of her land mass.

Hydro

(Sambo, 2005) identified that essentially, hydropower systems rely on the potential energy difference between the levels of water in reservoirs, Nigeria has a capacity of 11,500 MW for

large hydropower and only 1972 MW has being exploited while for small hydro power, the country has about 3,500 MW and only about 64.2 MW has being exploited.

Nigeria is endowed with hydropower potential of about 15,000 megawatts unit of which 23 per cent is small hydropower according to the Director General, Energy Commission of Nigeria (ECN), Prof. Eli Jidere Bala.

Bala who spoke at Abuja during the five-day training course on conducting feasibility studies on Small Hydro Plants by renewable academy (RENAC), Germany.

According to him, "small hydropower schemes of capacities of less than 30mw are known to be environmentally friendly and contribute less to Green House emissions, a major cause of climate change. Small Hydropower potentials are also available in many parts of rural communities, where majority of the population reside."

The Director General, who attributed the training to this situation, noted that the training will focus on small hydropower plants feasibility studies to enable the country have personnel that will identify potentials in suitable sites that can be used to set up the Small Hydropower Power (SHP) plants in virtually any part of Nigeria.

The value for Electricity production from hydroelectric sources (kWh) in Nigeria was 6,374,000,000 as of 2010. Over the past 39 years this indicator reached a maximum value of 8,234,000,000 in 2002 and a minimum value of 1,447,000,000 in 1972 as shown in the table below:

Table 2.4: Hydroelectricity Production in Nigeria 1971 - 2010

YEAR	VALUE (kWh)	% of Electricity production from Hydroelectric sources
1971	1,574,000,000	83.41
1972	1,447,000,000	64.68
1973	1,858,000,000	70.78
1974	1,989,000,000	86.97
1975	2,393,000,000	69.08

1976	2,907,000,000	70.80
1977	2,889,000,000	61.30
1978	2,324,000,000	50.75
1979	3,305,000,000	52.64
1980	2,783,000,000	38.82
1981	2,390,000,000	30.74
1982	2473000000	28.99
1983	1989000000	22.83
1984	2668000000	29.70
1985	3091000000	30.24
1986	3630000000	33.72
1987	3284000000	29.15
1988	4008000000	34.39
1989	4140000000	32.31
1990	4387000000	32.59
1991	5931000000	41.86
1992	6059000000	40.85
1993	5572000000	38.41
1994	5562000000	35.81
1995	5500000000	34.69
1996	5500000000	33.86
1997	5593000000	34.70
1998	5775000000	38.22

1999	6148000000	38.21
2000	5628000000	38.22
2001	5909000000	38.21
2002	8234000000	38.22
2003	7448000000	36.90
2004	8108000000	33.40
2005	7768000000	33.00
2006	6263000000	27.10
2007	6227000000	27.10
2008	5721000000	27.10
2009	4529000000	22.90
2010	6374000000	24.40

(Source: IEA Statistics 2011)

Wind

Wind is made when the Sun heats the Earth and the area above land gets hotter than the area above water. The hot air above land rises upwards leaving an area of low pressure. Cooler air moves into this area of low pressure making wind which we use to turn wind turbines and make electricity. Wind used to be used to turn windmills to grind wheat into flour.

Wind is a natural phenomenon related to the movement of air masses caused primarily by the differential solar heating of the earth's surface. (Sambo, 2005) stated that seasonal variations in the energy received from the sun affects the strength and direction of the wind. The ease with which aero turbines transform energy in moving air to rotary mechanical energy suggests the use of electrical devices to convert wind energy to electricity. Wind energy has also been utilized, for decades, for water pumping as well as for the milling of grains. A study on the wind energy potentials for a number of Nigerian cities shows that the annual wind speed ranges from 2.32 m/s for Port Harcourt to a figure of 3.89 m/s for Sokoto (Sambo, 1987). The maximum extractable power per unit area, for the same two sites was

estimated at 4.51 and 21.97 watts per square metre of blade area, respectively and when the duration of wind speeds greater than 3 m/s is considered than the energy per unit area works out as 168.63 and 1,556.35 kWh per square metre of blade area, again for Port Harcourt and Sokoto.

Although use of wind energy for water supply has been known and used for hundreds of years, in recent times efforts have been directed largely towards the use of wind power for the generation of electricity and in the past twenty years or so rapid changes in technology have occurred and major wind powered electricity generating plants have been installed, especially in the rural areas of the developed countries (Fagbenle et al, 2010).

Biomass

Biomass uses the energy from plants and waste materials to make electricity. For example, wood or animal droppings can be burnt to make steam that turns turbines to make electricity. Even though Biomass is a form of renewable energy, Biomass combustion emits CO_2 and other pollutants.

(Okafor and Uzuegbu, 2010) identify that the biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal as waste arising from forestry, agricultural, municipal and industrial activities, as well as, Aquatic biomass.

(Garba and Bashir, 2002) indicate that the biomass resources of the nation have been estimated to be about 8×10^2 MJ. Plant biomass can be utilized as fuel for small-scale industries. It could also be fermented by anaerobic bacteria to produce a very versatile and cheap Fuel Gas. i.e. biogas

2.2.2 Relationship between energy consumption and standard of living

(Dantama, Umar, Abdullahi and Nasiru, 2012) examined the impact of energy consumption on economic growth in Nigeria over the period 1980-2010 using the autoregressive distributed lag (ARDL) approach to co-integration analysis. The results indicate a long-run relationship between economic growth and energy consumption variables exist. Both petroleum consumption and electricity consumption are statistically significant on economic growth but coal consumption is statistically insignificant.

The investigation of the relationship between the consumption of crude oil, electricity and coal in the Nigerian economy (1970 to 2005) was conducted by (Odularu and Okonkwo,

2009). Their result obtained after applying the co-integration technique, showed that there exists a positive relationship between period energy consumption and economic growth.

However, with the exception of coal, the lagged values of these energy components were negatively related to economic growth.

Using a vector error correction based Granger causality test, the examination of the relationship between energy consumption and economic growth in Nigeria (1970 - 2005), (Orhewere and Machame, 2011) reports a unidirectional causality from electricity consumption to GDP both in the short-run and long-run. Unidirectional causality from gas consumption to GDP in the short-run and bi-directional causality between the variable in the long-run was also reported. A unidirectional causality from oil consumption to GDP is found in the long-run. However, in the short run, no causality was found in either direction between oil consumption and GDP.

The results of the various tests conducted by (Yu and Chai, 1985) in Philippines found causality from economic growth to energy consumption and from energy consumption to employment without feedback. The major findings of their study infer that economic growth have impact on total energy consumption. Further investigation indicates that economic growth also leads to growth in petroleum consumption. In the case of the gas sector, neither economic growth nor gas sector effect each other. However, in the power sector, it has been found that electricity consumption leads to economic growth without feedback. Finally, that energy consumption also directly causes employment.

(Cheng and Lai, 1997) applies the Hsiao'a version of the co-integration and Granger causality method, in examining the causality between energy and GNP, and energy and employment to Taiwanese data for the 1955–1993 periods.

The Phillips-Perron tests reveal that the series with the exception of GNP are not stationary and therefore differencing is performed to secure stationarity. The study finds causality running from GDP to energy consumption without feedback in Taiwan. It is also found that causality runs from GDP to energy but not vice versa.

(Ebohon, 1996) examines the impact and causal directions between energy consumption and economic growth (proxied by GDP) and reports a simultaneous causal relationship between energy and economic growth for Tanzania.

(Soytas and Sari, 2003) studied the time series properties of energy consumption and GDP and re-examined the causality relationship between the two series in the top 10 emerging markets (excluding China) and G-7 countries. They discover bi-directional causality in Argentina, causality running from GDP to energy consumption in Italy and Korea, and from

energy consumption to GDP in Turkey, France, Germany and Japan. Hence, energy conservation may harm economic growth in the last four countries mentioned. (Wolde-Rufael, 2005) investigates the long run relationship between energy use per capita and per capita real gross domestic product (GDP) for 19 African countries for the period 1971–2001 using Bounds co-integration and the vector auto regressions tests. The results show that there was a long run relationship between the two series for only eight countries and causality for only 10 countries.

The quest for rapid industrialization in the opinion of (Hall and Reynolds, 2007) cannot be achieved without a strong and well developed energy resource base. Energy is a crucial element in the process of achieving sustainable economic development.

(Akinlo, 2008) in a study of the relationship between energy consumption and economic growth for eleven countries in sub-Saharan Africa used the autoregressive distributed lag (ARDL) bounds test. The study finds that energy consumption is co-integrated with economic growth in Cameroon, Cote d'Ivoire, Gambia, Ghana, Senegal, Sudan and Zimbabwe. Moreover, this test suggests that energy consumption has a significant positive long run impact on economic growth in Ghana, Kenya, Senegal and Sudan. Granger causality test based on vector error correction model (VECM) shows bi-directional relationship between energy consumption and economic growth for Gambia, Ghana and Senegal. However, Granger causality test shows that economic growth Granger causes energy consumption in Sudan and Zimbabwe. The neutrality hypothesis is confirmed in respect of Cameroon and Cote d'Ivoire, Nigeria, Kenya and Togo.

(Esso, 2010) investigates the long-run and the causality relationship between energy consumption and economic growth for seven Sub-Saharan African countries during the period 1970–2007. Using the Gregory and Hansen testing approach to threshold co-integration, the study indicate that energy consumption is co-integrated with economic growth in Cameroon, Cote d'Ivoire, Ghana, Nigeria and South Africa. The test suggests that economic growth has a significant positive long-run impact on energy consumption in these countries before 1988; and this effect becomes negative after 1988 in Ghana and South Africa. Furthermore, causality tests suggest bi-directional causality between energy consumption and real GDP in Cote d'Ivoire and unidirectional causality running from real GDP to energy usage in the case of Congo and Ghana.

Also, the speed of adjustment in the estimated model is relatively high and contains the expected significant and negative sign. This survey of the literature has shown diverse results,

but the consensus is that the impact of energy on social, economic and welfare development in the country is manifest.

It has been observed that Nigeria's per capita electricity consumption is very low as the country lags behind other African countries in providing energy access to its citizens. Electricity generation is put at about 20 watts per person. Indeed Nigeria's per capita energy consumption is 4 times less than the African average and about 19 times less than the world average.

2.3 Statistical Forecasting Techniques

Forecasting is the process of making statements about events whose actual outcomes (typically) have not yet been observed (Bozarth, 1998). Forecasting involves formal statistical methods employing time series, cross-sectional or longitudinal data, or alternative less formal judgemental methods. Risk and uncertainty are central parameters and properties of any forecasting process. In any case, the data must be up-to-date in order for the forecast to be as accurate as possible.

2.3.1 Forecast methods

There are several categories of forecasting methods and they are listed and explained briefly in this section:

Qualitative Methods and Quantitative Methods: Qualitative forecasting techniques are subjective, based on the opinion and judgement of consumers, experts; they are appropriate when past data are not available. They are usually applied to intermediate or long-range decisions. Quantitative forecasting models are used to forecast future data as a function of past data; they are appropriate when past data are available. These methods are usually applied to short-or-intermediate range decisions.

Naive Approach: Naive forecasts are the most cost-effective objective forecasting model, and provide a benchmark against which more sophisticated models can be compared. For stationary time series data, this approach says that the forecast for any period equals the historical average. For time series data that are stationary in terms of first differences, the naive forecast equals the previous period's actual value.

Time-Series Methods: Time series methods use historical data as the basis of estimating future outcomes. Examples of Time-series methods includes moving average, weighted

moving average, Kalman filtering, exponential smoothing, autoregressive moving average (ARMA), autoregressive integrated moving average (ARIMA), extrapolation, linear prediction, trend estimation, growth curve.

Causal/Econometric Forecasting Methods: Some forecasting methods try to identify the underlying factors that might influence the variable that is being forecast. For example, including information about climate patterns might improve the ability of a model to predict umbrella sales. Several information methods used in causal forecasting do not employ strict algorithms, but instead use the judgement of the forecaster. Some forecasts take account of past relationships between variables: if one variable has been approximately linearly related to another for a long period of time, it may be appropriate to extrapolate such a relationship into the future, without necessarily understanding the reasons for the relationship. Causal methods include regression analysis and autoregressive moving average with exogenous inputs (ARMAX).

Judgemental Methods: Judgemental forecasting methods incorporate intuitive judgements, opinions and subjective probability estimates. Judgemental Methods include Delphi Method, Composite forecasts, Forecast by analogy, Scenario building, Statistical surveys, Technology forecasting.

Artificial Intelligence Methods: This includes artificial neural networks, group method of data handling, support vector machines and these are usually carried out by specialized programs loosely labelled data mining, machine learning, and pattern recognition.

Other Methods include:

Simulation

Prediction Market

Probabilistic Forecasting

Ensemble Forecasting

2.3.1.1 Types of ARIMA Model

In an ARIMA model, we do not have a priori for forecasting model before model identification takes place. ARIMA helps us to choose a “right model” to best fit the time

series. This is the major reason why an ARIMA model is the model of choice for most forecasting exercises. Put in a simple flowchart:

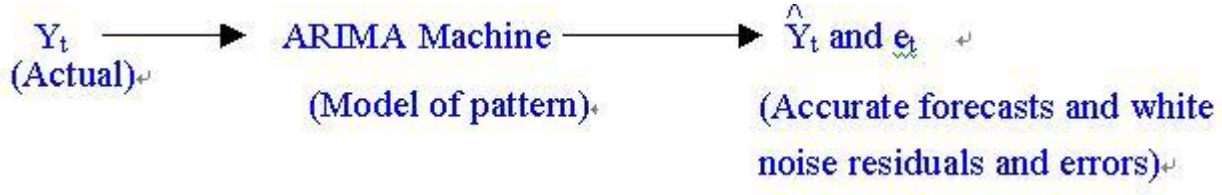


Figure 2.1: Simple Flowchart of the ARIMA Model (Source: Clements, 1998)

Given a time series of data X_t where t is an integer index and the X_t are real numbers, then an ARIMA(p' ,q) model is given by:

$$\left(1 - \sum_{i=1}^{p'} \alpha_i L^i\right) X_t = \left(1 + \sum_{i=1}^{q} \theta_i L^i\right) \varepsilon_t$$

Figure 2.2: General formulae of the ARIMA (Source: Clements, 1998)

Where L is the lag operator,

the α_i are the parameters of the autoregressive part of the model,

the θ_i are the parameters of the moving average part and

the ε_t are error terms. The error terms ε_t are generally assumed to be independent, identically distributed variables sampled from a normal distribution with zero mean.

Seasonal Models

Non-seasonal models

Types of non-seasonal ARIMA models

ARIMA(0,1,0) = random walk
ARIMA(1,1,0) = differenced first-order autoregressive model
ARIMA(0,1,1) without constant = simple exponential smoothing
ARIMA(0,1,1) with constant = simple exponential smoothing with growth
ARIMA(0,2,1) or (0,2,2) without constant = linear exponential smoothing

2.3.2 Measurement of forecasting accuracy

Of course, a good forecast is an accurate forecast. However, a forecast is never completely accurate; forecasts will always deviate from the actual demand. The objective of forecasting is that it be as slight as possible. There are many measures of forecast error; the more popular ones are;

- Mean Percentage Error, or MPE
- Mean Absolute Deviation (MAD)
- Mean Absolute Percent Deviation (MAPD)
- Cumulative Error
- Average Error or bias (E)
- Mean Absolute Percentage Error, or MAPE

Mean Percentage Error: Retailers use a simple calculation to measure forecast accuracy. It's formally referred to as "Mean Percentage Error", or MPE but most people know it by its formal. It is calculated as follows:

MPE = ((Actual – Forecast) / Actual) x 100

Mean Absolute Deviation: This is the most popular and simplest to use measure of forecasting. MAD is an average of the difference between the forecast and the actual demand

$$\text{Formula: } MAD = \frac{\text{Sum } |D_t - F_t|}{n}$$

Where: t = the period number

D_t = the demand in period t

F_t = the forecast for period t

n = the total number of periods

| | = the absolute value

· The smaller/lower the value of MAD, the more accurate the forecast

· One benefit of MAD is to compare the accuracy of several different forecasting techiniques.

Mean Absolute Percent Deviation: Measures the absolute error as a percentage of demand rather than per period. This results in elimination of the problem of interpreting the measure of accuracy relative to the magnitude of the demand and forecast values, as MAD does.

$$\text{Formula: MAPD} = \frac{(\text{Sum } |D_t - F_t|)}{\text{Sum}(D_t)}$$

Mean Absolute Percentage Error: Fortunately, there is another way to fix problems of MPE by using "Mean Absolute Percentage Error", or MAPE, which is calculated as:

1. MAPE = (Absolute Value(Actual – Forecast) / Actual) x 100

MAPE is remarkably similar to MPE with one big exception. The exception is that you take the absolute value of the difference between the actual and forecast. The benefit of MPE is that it is easy to calculate and the results are easily understood. Statisticians and math-heads like to throw around complex ways of calculating forecast accuracy which are intimidating by name and produce results which are not intuitively understood.

The problem is that when you start to summarize MPE for multiple forecasts, the aggregate value doesn't represent the error rate of the individual MPEs (Clements, 2010).

The forecast error needs to be calculated using actual sales as a base. There are several forms of forecast error calculation methods used, namely Mean Percent Error, Root Mean Squared Error, Tracking Signal and Forecast Bias. They are explained below, according to (Bozarth, 2011):

Error: Error = Actual demand – Forecast OR $E_t = A_t - F_t$

Mean Forecast Error (MFE)

For n time periods where we have actual demand and forecast values:

$$MFE = \frac{\sum_{i=1}^{n} (e_i)}{n}$$

Ideal value = 0;

MFE > 0, model tends to under-forecast

MFE < 0, model tends to over-forecast

Figure 2.3: Formulae of the Mean Forecast Error (Source: Bozarth, 2011)

Mean Absolute Deviation (MAD)

For n time periods where we have actual demand and forecast values:

$$MAD = \frac{\sum_{i=1}^{n} |e_i|}{n}$$

Figure 2.4: Formulae of the Mean Absolute Deviation (Source: Bozarth, 2011)

While MFE is a measure of forecast model bias, MAD indicates the absolute size of the errors

Tracking Signal

Used to pinpoint forecasting models that need adjustment

$$TS = \frac{\sum_{i=1}^{n} e_i}{\text{MAD}}$$

Figure 2.5: Formulae of the Tracking Signal (Source: Bozarth, 2011)

$$\text{Forecast Error} = \left(\frac{|Actual - Forecast|}{Actual}\right) * 100\%$$

$$\text{Forecast Accuracy} = \text{Maximum}\,(0,\ 100\% - \text{Forecast Error})$$

Forecast accuracy in the supply chain is typically measured using the Mean Absolute Percent Error or MAPE. Statistically MAPE is defined as the average of percentage errors. Most practitioners, however, define and use the MAPE as the Mean Absolute Deviation divided by Average Sales. This is in effect a volume weighted MAPE. This is also referred to as the MAD/Mean ratio.

A simpler and more elegant method to calculate MAPE across all the products forecasted is to divide the sum of the absolute deviations by the total sales of all products. All of the mathematical formulae above are supplied by (Bozarth, 2011) in his paper, Measuring Forecast Accuracy: Approaches to Forecasting.

2.3.3 **Types of statistical data analysis tools**

Microsoft Excel

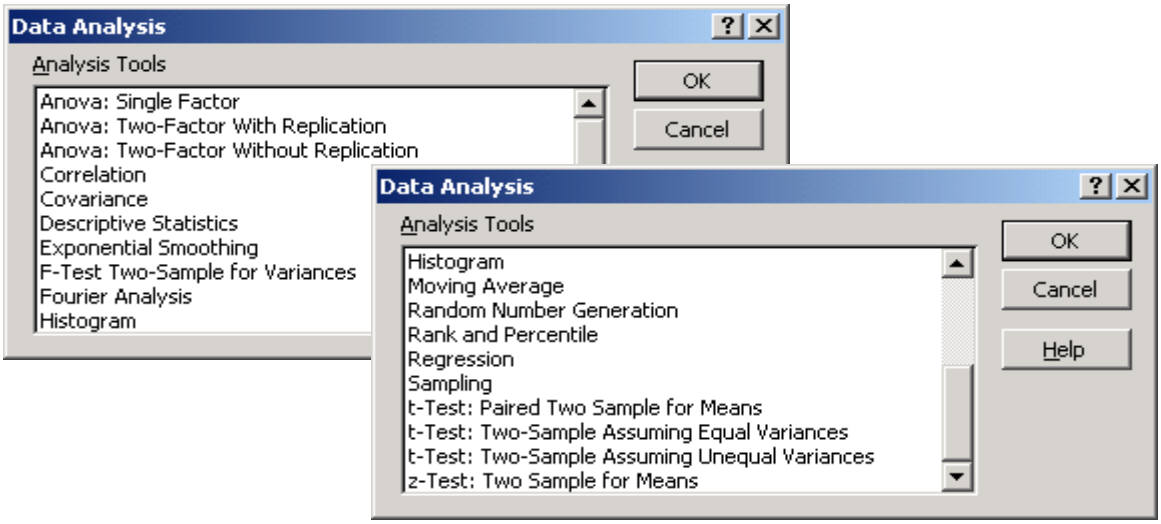


Figure 2.5: Microsoft Excel Data Analysis User Interface (Source: Clements, 2010)

Excel has several data analysis tools included through an Analysis ToolPak add-in. These tools can quickly produce complex engineering or statistical analyses of your data. Each tool is a little different, but all require you to input what data you wish Excel to analyze.

Data Analysis is located under the Tools menu. If the option is not there, you will need to install the Analysis ToolPak.

1. On the **Tools** menu, click **Add-Ins…**.
2. Select the **Analysis ToolPak** check box.
3. On the Tools menu, click Data Analysis.

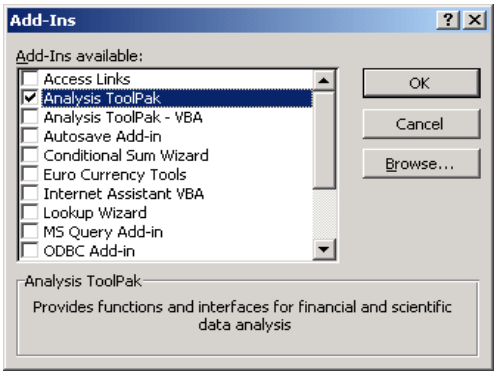
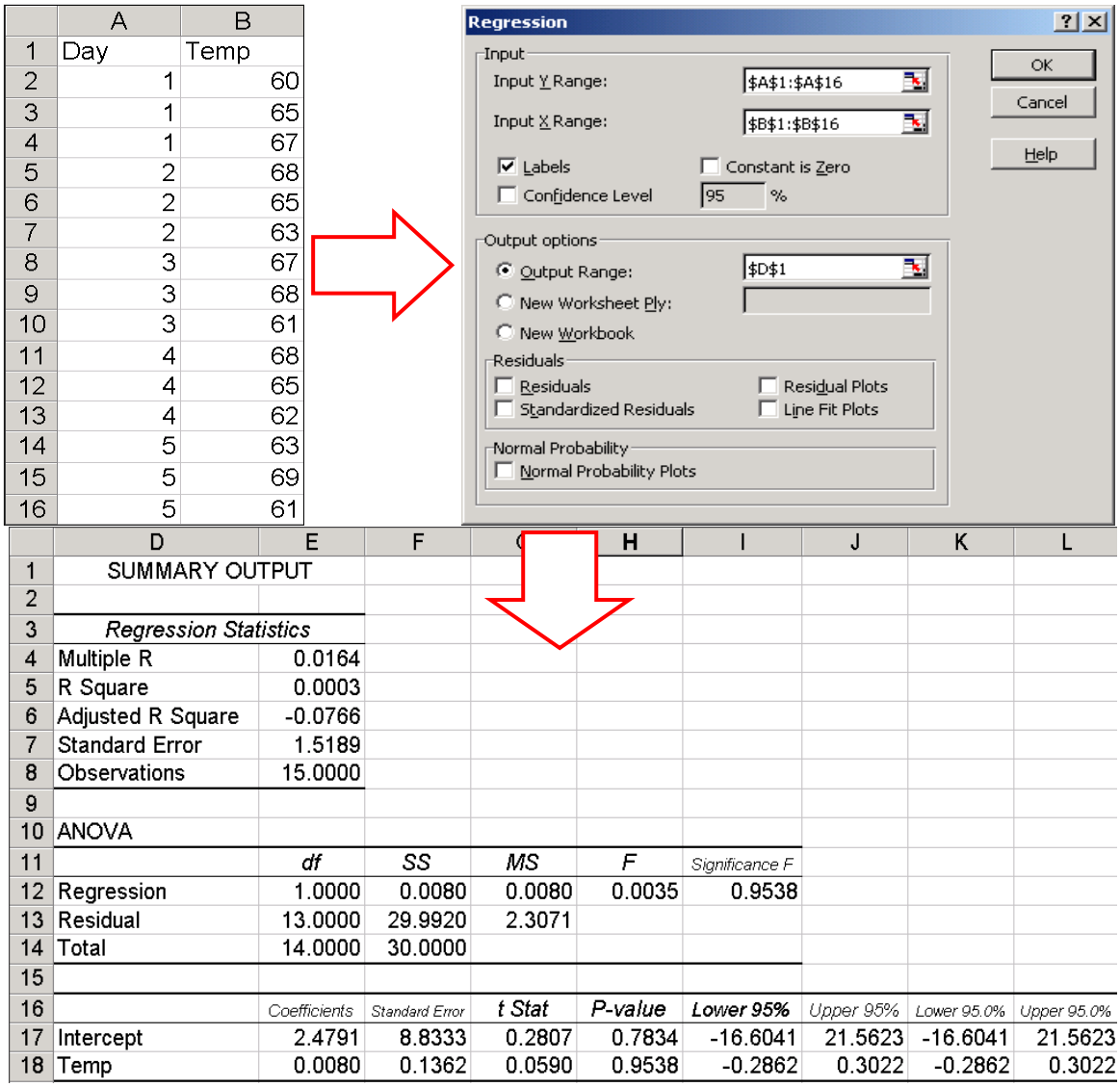


Figure 2.6: Microsoft Excel Data Analysis Add-In Interface (Source: Clements, 2010)

Note: If Analysis ToolPak is not listed in the Add-Ins dialog box, click **Browse…** and locate the drive, folder name, and file name for the Analysis ToolPak add-in, Analys32.xll — usually located in the Microsoft Office\Office\Library\Analysis folder — or run the Setup program if it isn't installed.

Sample Regression



	A	B
1	Day	Temp
2	1	60
3	1	65
4	1	67
5	2	68
6	2	65
7	2	63
8	3	67
9	3	68
10	3	61
11	4	68
12	4	65
13	4	62
14	5	63
15	5	69
16	5	61

	D	E	F	G	H	I	J	K	L
1	SUMMARY OUTPUT								
2									
3	*Regression Statistics*								
4	Multiple R	0.0164							
5	R Square	0.0003							
6	Adjusted R Square	-0.0766							
7	Standard Error	1.5189							
8	Observations	15.0000							
9									
10	ANOVA								
11		*df*	*SS*	*MS*	*F*	*Significance F*			
12	Regression	1.0000	0.0080	0.0080	0.0035	0.9538			
13	Residual	13.0000	29.9920	2.3071					
14	Total	14.0000	30.0000						
15									
16		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
17	Intercept	2.4791	8.8333	0.2807	0.7834	-16.6041	21.5623	-16.6041	21.5623
18	Temp	0.0080	0.1362	0.0590	0.9538	-0.2862	0.3022	-0.2862	0.3022

Figure 2.7: Microsoft Excel Sample Regression Interface (Source: Clements, 2010)

SPSS

An example of using SPSS Time series Analysis and Forecasting is shown below for the quarterly sales of a departmental store. The sales figures in this example are seasonal.

However, exponential smoothing and curve fitting can be carried out quite easily for non-seasonal data (like the electricity statistics to be forecasted in this research work) in SPSS by following the instructions in the Help menu.

The quarterly sales of a departmental store have been monitored for the past five years with the following information being produced:

	Total quarterly sales (£0000s)			
Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4
2001	48	58	57	65
2002	50	61	59	68
2003	52	62	59	69
2004	52	64	60	73
2005	53	65	60	75

1 Type all the sales figures in chronological order in one column heading it Sales.
Then *Data / Define dates*, Select *Years, quarters / First case in Year 2001 quarter 1*.
Look at the new variables in both Data Editor grids. They describe the year, the quarter and their combination for use in time series diagrams. Save this file as Sales.

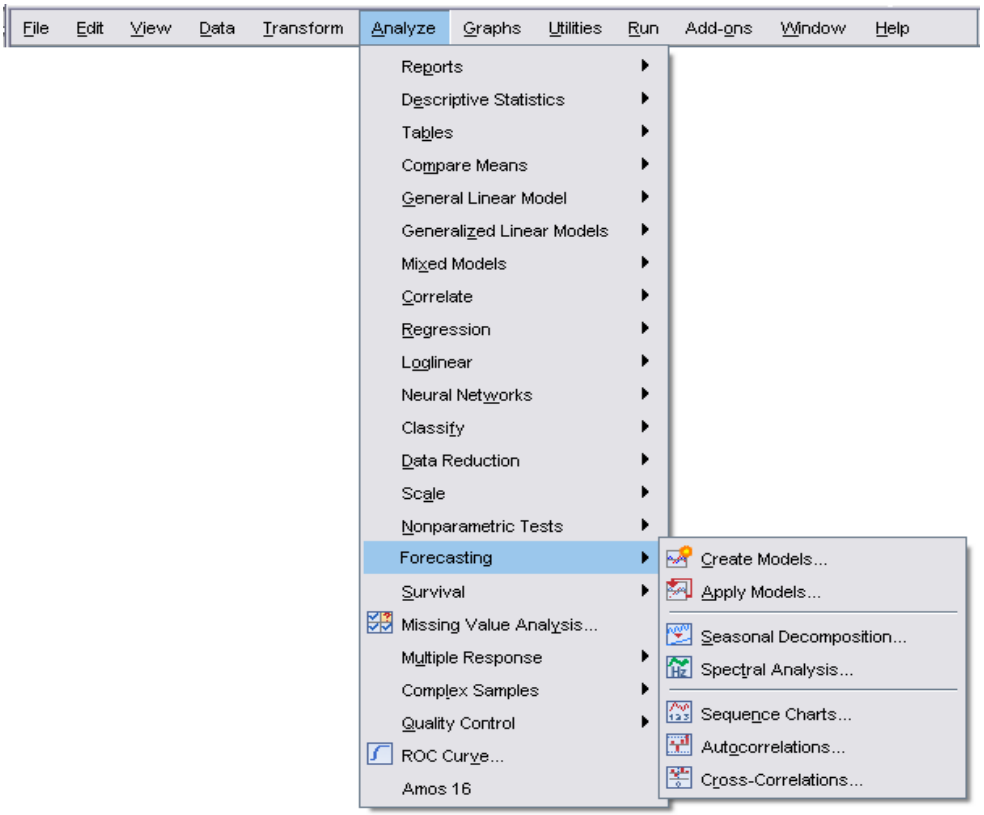
2 Plot a sequence graph of sales with dates to see if an additive model is appropriate.
Graphs / Sequence / Variables: Sales / Time axis labels: Date

IBM SPSS 21

SPSS is an acronym for Statistical Programming for Social Sciences and it is a programme developed by the software development team of the International Business Machine Corporation, popularly known as IBM. The programme contains a data analysis and forecasting package known as the Time-Series Modeller. The time-series modeller recognizes several forecast models and methods of forecasting but some of these models can be customized to accommodate curve smoothing options that are peculiar to any kind of data. Formulas like the Least Square Method of Forecasting and the Averaging Method of forecasting are recognized. In this project, I will be using a moving average model called the Auto-Regressive Integrated Moving Average Model. This model is peculiar for its unique smoothing and fitting techniques which changes as the pattern of the forecast data changes,

thereby creating a relatively accurate forecast that automatically considers un-mentioned data peculiarities. The procedure involved is shown by the pictures below:

1. Click on “Analyze” and then “Forecast” on the drop-down menu.
2. Then click on “Sequence charts” and.....



3. Modify the settings that form the peculiarities of the model you intend to use and generate the forecast from the interface shown in the picture below.

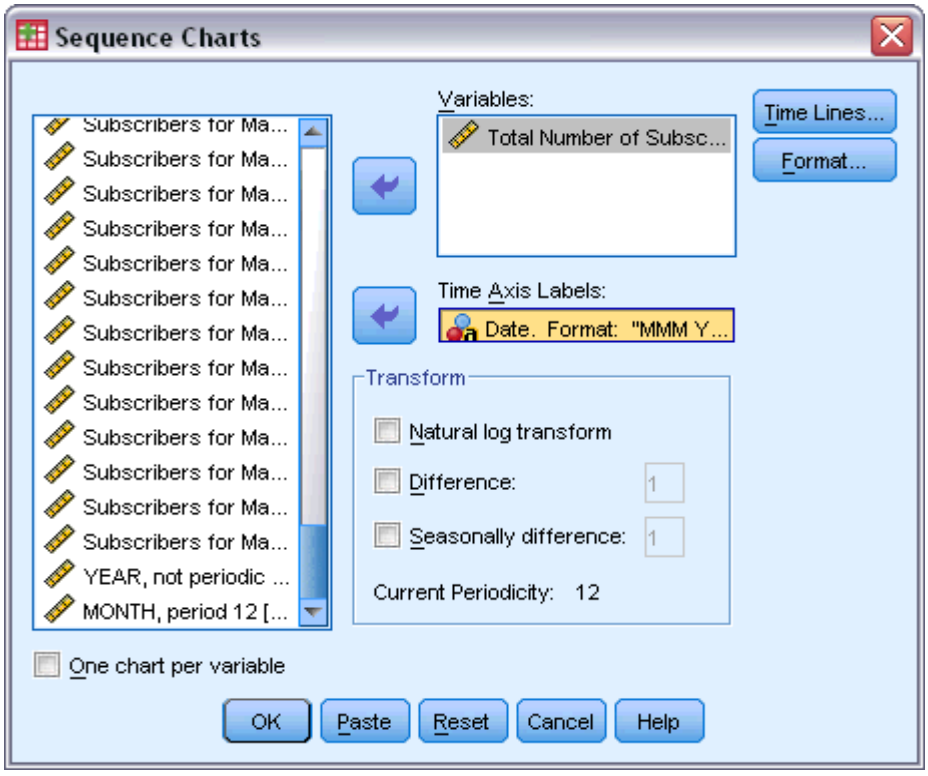


Figure 2.8: IBM SPSS Sequence Chart Analyser Interface (Source: Clements, 2010)

2.4 Data Forecasting: Importance And Its Application In The Energy Industry

Climate change and increasing energy prices have led to the use of Egain Forecasting for buildings. This attempt to reduce the energy needed to heat the building, thus reducing the emission of greenhouse gases.

Forecasting is used in customer demand planning in everyday business for manufacturing and distribution companies.

Forecasters perform research that uses empirical results to gauge effectiveness of certain forecasting models. However, research has shown that there is little difference between the accuracy of the forecasts of experts knowledgeable in the observed situation and those by individuals who know much less. Similarly, experts in some studies argue that role thinking does not contribute to the accuracy of the forecast (Clements, 2010).

The discipline of demand planning, also sometimes referred to as supply chain forecasting, embraces both statistical forecasting and a consensus process. An important, albeit often ignored aspect of forecasting, is the relationship it holds with planning. Forecasting can be described as predicting what the future will look like. There is no single right forecasting method to use. Selection of a method should be based on your objectives and your conditions

(data etc.) a good place to find a method is by visiting a selection tree. Forecasting has application in many situations (Clements, 2010).

Supply chain management – forecasting can be used in supply chain management to ensure that the right product is at the right place at the right time. Accurate forecasting will help retailers reduce excess inventory and thus increase profit margin. Accurate forecasting will also help meet consumer demand (Bozarth, 1998).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Statement and Research Questions

The Nigerian energy sector has not been able to provide adequately for the demand of electrical energy by the Nigerian public. In actual fact, there is a problem of lack of ability to coordinate data collection to generate a forecast of the actual energy statistics of the country. This paper wishes to achieve a thorough analysis of statistical data that shows the energy demand of the Nigerian economy and through a process of statistical forecasting, achieve the recognition of a known pattern of energy demand with time and hence generate a time-series forecast for the energy demand for subsequent years.

As long as energy supply cannot meet the energy demand of the people, there will be little hopes of achieving enviable national development and even improving the standard of living of the Nigerian people. The onus lies on the management personnel of the energy regulatory body, NERC to be able to obtain specific information that denotes the energy demand of the people and be able to collate such information for energy demand planning by policy makers and generation companies and other relevant stakeholders.

3.2 Materials Used

The materials used in the study included

- Microsoft Word Processing Application (Microsoft Word),
- Statistical Models; ARIMA – Auto Regressive Integrated Moving Average.
- IBM SPSS Data Analysis package

3.3 Data Collection and Gathering Techniques

Statistical and numerical data was collected mainly by extensive survey of previous literature available about the subject. The survey method predominantly involves reading of such literature as books, journals, articles and bulletins of organizations with interests relevant to the topic. Some of the relevant organizations whose bulletins and reports were used in this research as primary sources include:

- World Bank's World Development Indicator Bulletin, 2012.
- Energy Commission of Nigeria

- Central Bank of Nigeria.

Time series data for the period 1980-1999 on electricity production, electricity consumption, electricity consumption per capita, transmission and distribution losses in Nigeria were used for the forecast. These data were obtained from the Central Bank of Nigeria (CBN) Statistical Bulletins for the year 1999 and 2011 and World Bank Bulletin, 2012.

3.4 Data Processing, Analysis and Forecasting Methods to be Used

The computation and forecasting of electricity data obtained was done using Time-Series Modeller on the IBM SPSS Data Analysis Application. The quantities of electricity produced, consumed, lost in transmission and consumed per person is tabulated, analyzed and shown graphically using the IBM SPSS Data Analysis and Chart-Builder Application. The model used by the Time-series modeller is the Auto Regressive Integrated Moving Average (ARIMA) model. The bias of the model used is evaluated using the MFE, Mean Forecast Error. The level of forecast error is measured using MAPE and MaxAPE.

The ARIMA model is used because in an ARIMA model, we do not have a priori for forecasting model before model identification takes place. ARIMA helps us to choose a "right model" to best fit the time series. It carries out an autoregressive fit of the data to be forecasted. It also has a good usage in similar types of data as the one used for this research. Data that is randomly produced and randomly patterned like in the FOREX and stock trading market.

CHAPTER FOUR

DATA PRESENTATION

4.1 Data Presentation

The following datum needed for complete analysis and forecasting were obtained from relevant agencies and sources stated below:

Statistical Bulletin of the Energy Commission of Nigeria (2006).

National Development Indicators Data of Nigerian Bureau of Statistics, 2012.

1999 Statistical Bulletin of the Central Bank of Nigeria.

2012 Statistical Bulletin of the Central Bank of Nigeria.

2012 World Development Indicator Bulletin of World Bank.

TABLE 4.1: Electricity Statistics of Nigeria

YEAR	ELECTRICIY PRODUCTION (kWh)	ELECTRICITY CONSUMPTION (kWh)	ELECTRIC CONSUMPTION (Per Capita)	[1]ACCESS TO ELECTRICITY (% of Population)	[2]ELECTRICITY DEMAND ESTIMATE (kWh)	ELECTRICITY TRANSMISSION LOSSES (kWh)	PERCENTAGE OF ELECTRICITY TRANSMISSION LOSSES
1991	14167000000	8751000000	89.2	-	-	5324000000	37.6
1992	14834000000	9020000000	89.7	-	-	5722000000	38.6
1993	14505000000	10361000000	100.5	-	-	4040000000	27.9
1994	15531000000	10062000000	95.1	-	-	5331000000	34.3
1995	15857000000	9876000000	91.1	-	-	5981000000	37.7
1996	16243000000	9507000000	85.5	-	-	6736000000	41.5
1997	16117000000	9304000000	81.6	-	-	6813000000	42.3
1998	15110000000	8953000000	76.6	-	-	6157000000	40.7

1999	16089000000	9036000000	75.4	-	-	7053000000	43.8
2000	14727000000	9109000000	74.1	-	-	5618000000	38.1
2001	15463000000	9476000000	75.2	-	-	5987000000	38.7
2002	21544000000	13459000000	104.2	-	-	8085000000	37.5
2003	20183000000	13444000000	101.4	-	-	6739000000	33.4
2004	24275000000	16730000000	123.0	-	-	7545000000	31.1
2005	23539000000	17959000000	128.7	-	-	5580000000	23.7
2006	23110000000	15929000000	111.1	-	-	7181000000	31.1
2007	22978000000	20328000000	138.1	-	-	2650000000	11.53
2008	21110000000	19121000000	126.5	-	-	1989000000	9.42
2009	19777000000	18617000000	119.8	50.6	36792490118.577	1160000000	5.87
2010	26121000000	21624000000	135.4	50.3	42990059642.147	4497000000	17.22
2011	27034000000	24453000000	148.0	48.0	50943750000	2581000000	9.5

[1]Access to Electricity as a percentage of Total Population is a parameter whose absolute values were not statistically recognized by the Nigerian Bureau of Statistics and Energy Regulatory bodies in Nigeria until 2009 (World Development Indicators of the World Bank, 2011).

[2] ELECTRICITY DEMAND ESTIMATE (kWh) is a parameter whose absolute values are not statistically computed by the Nigerian Bureau of Statistics and Energy Regulatory bodies in Nigeria (World Development Indicators of the World Bank, 2011). Estimate was obtained by the percentage calculation of percentage access to electricity and electricity consumption (in kWh).

(Source: National Development Indicators Data published by The Nigerian Bureau of Statistics, 2012.)

4.1.1 Electricity production: Electricity production is measured at the terminals of all alternator sets in a station. In addition to hydropower, coal, oil, gas and other renewable or non-renewable sources. Production includes the output of electricity plants that are designed to produce electricity only, as well as that of combined heat and power plants.

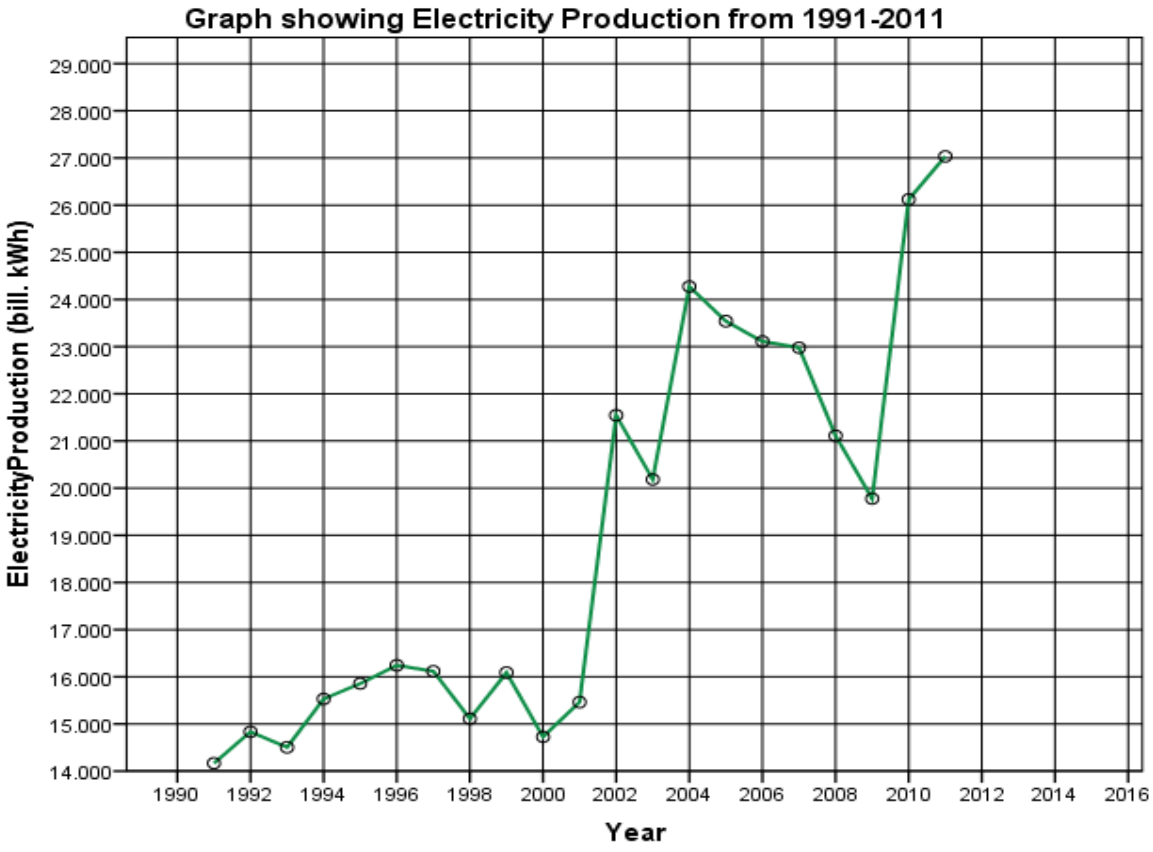


Figure 4.1: Time-Series Graph showing Nigeria's Electricity Production from 1991-2011

4.1.2 Electricity consumption: Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution and transformation losses and own use by heat and power plants.

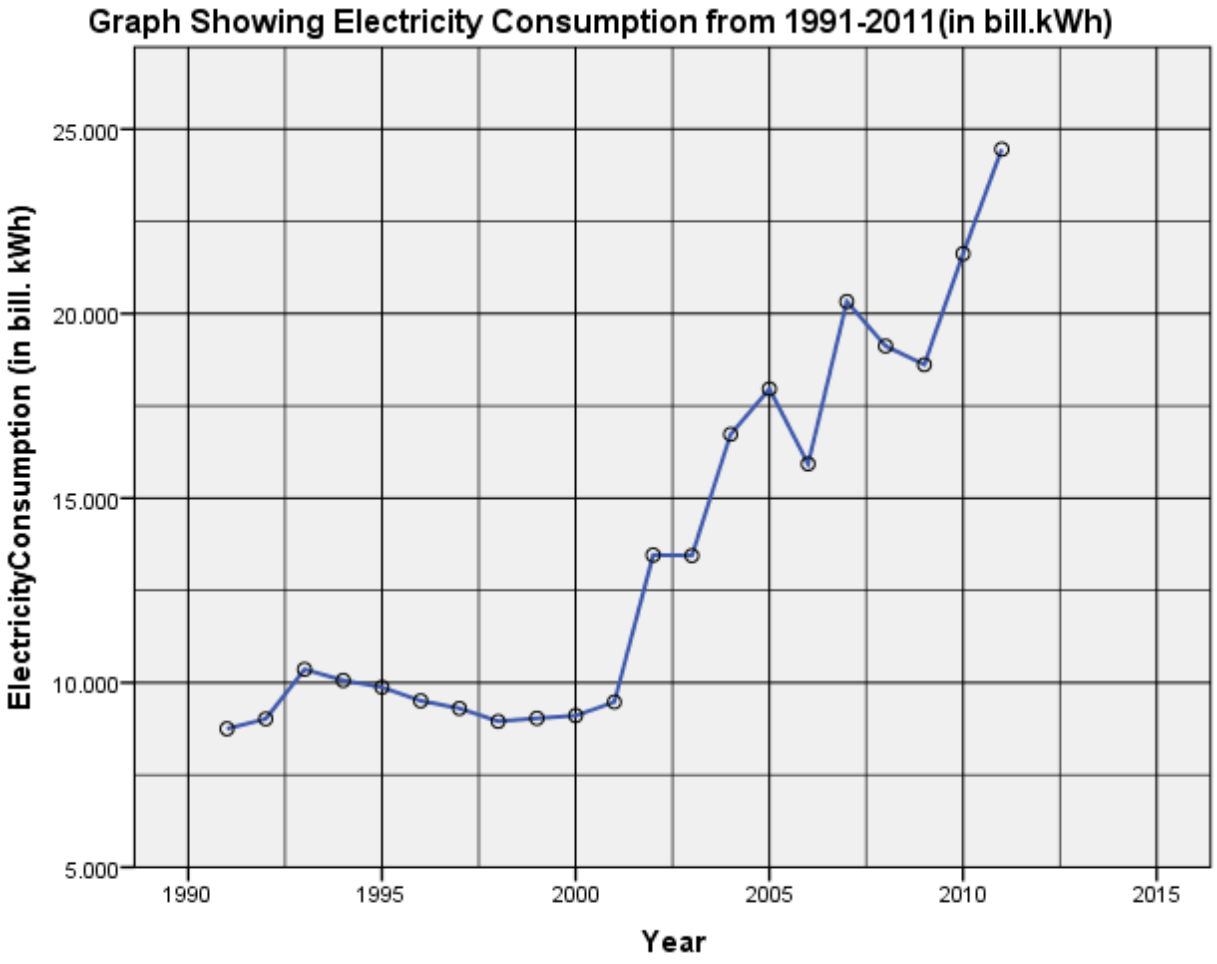


Figure 4.2: Time-Series Graph showing Nigeria's Electricity Consumption from 1991-2011

4.1.3 Electricity consumption per capita: This entry calculates the amount of electricity available per individual in the country. It is a division of total amount of electricity consumed by the total population of the country.

4.1.4 Electricity transmission losses: This entry calculates the electric power transmission and distribution losses include losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage and vandalization of transmission equipment and facilities.

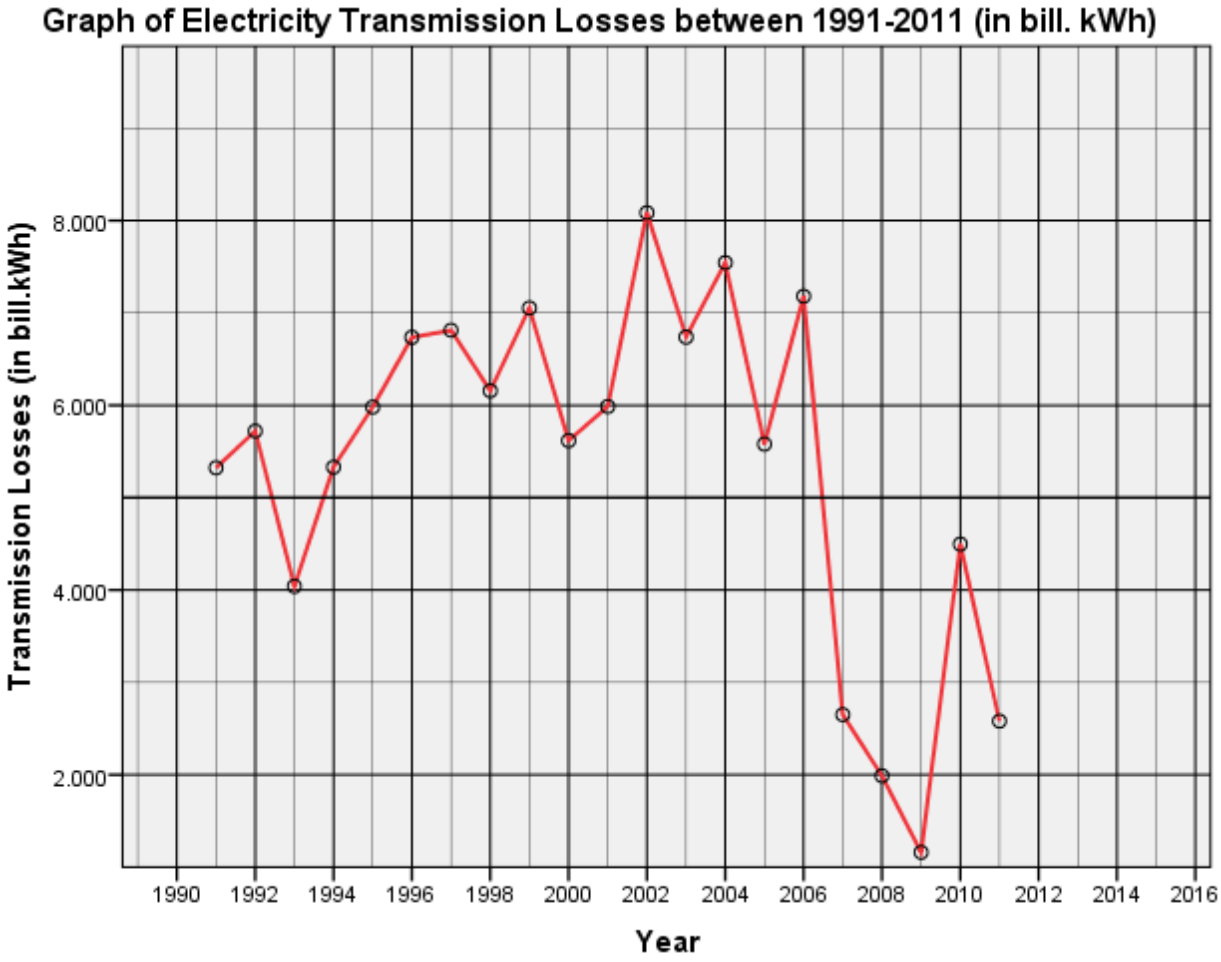


Figure 4.3: Time-Series Graph showing Nigeria's Electricity Transmission and Distribution Losses from 1991-2011

4.1.5 Percentage electricity transmission losses: This entry calculates and expresses the electricity transmission losses as a percentage of total electricity production.

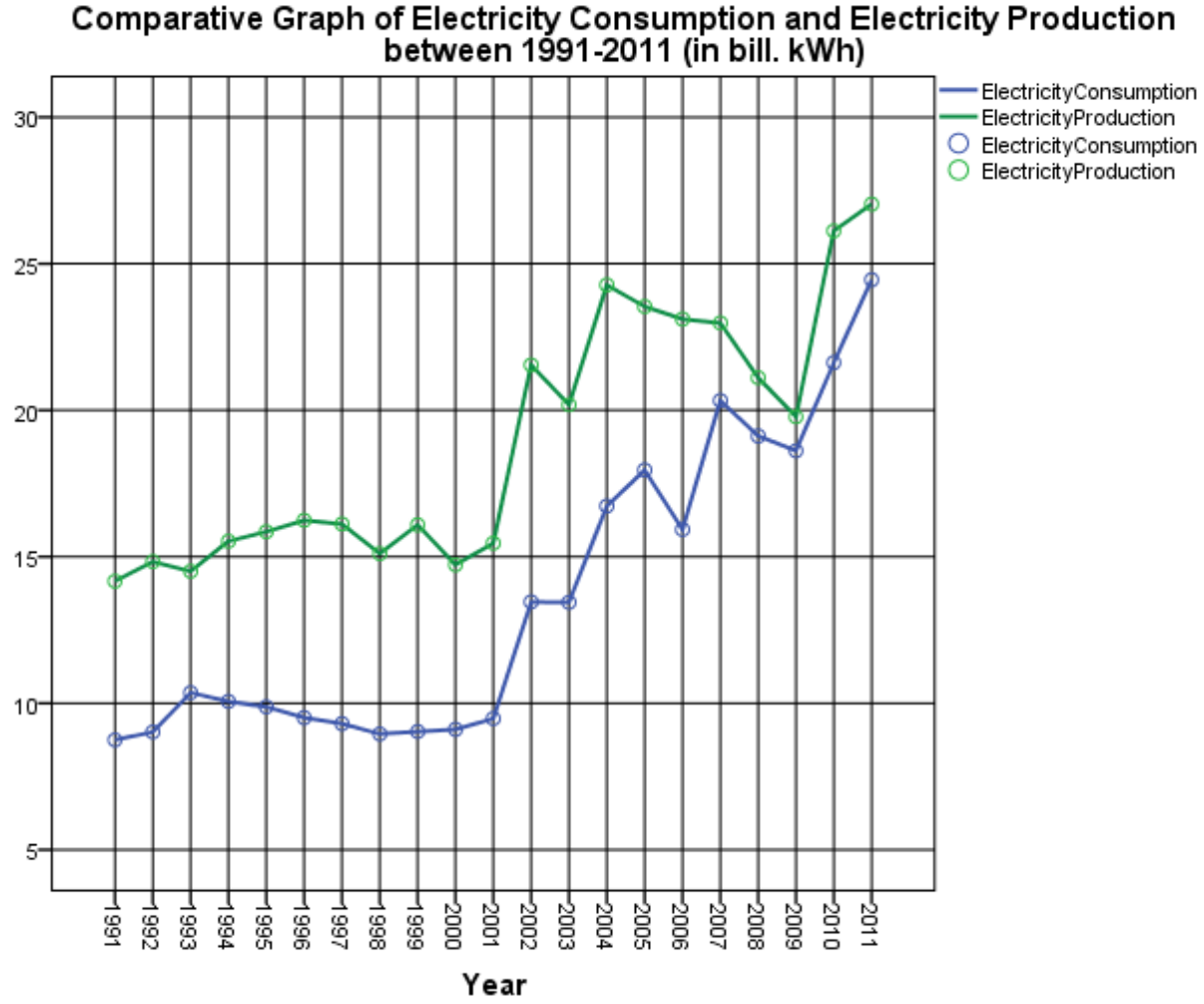


Figure 4.4: Time-Series Graph showing Relationship between Electricity Production and Consumption from 1991-2011

4.3 Forecast

The forecast was carried out using the Time Series Modeller package of the IBM SPSS Statistics Application Version 21.

Table 4.2 : Final Forecast generated

	Model													
	ElectricityProduction-Model_1			ElectricityConsumption-Model_2			ElectricityConsumptionpercapita-Model_3			PercentageTransmissionLosses-Model_4			Electricitydemandestima	
Year	Forecast	UCL	LCL	Forecast	UCL	LCL	Forecast	UCL	LCL	Forecast	UCL	LCL	Forecast	UCL
2012	27.677	32.494	22.860	24.939	28.590	21.288	145.146	171.023	119.268	6.780	20.518	-6.959	58.020	73.797
2013	28.321	35.133	21.509	26.284	30.995	21.573	145.146	178.491	111.800	4.485	21.134	-12.164	65.096	87.408
2014	28.964	37.307	20.621	27.629	33.548	21.710	145.146	184.569	105.722	2.191	22.153	-17.771	72.172	99.499
2015	29.607	39.241	19.974	28.974	36.226	21.722	145.146	189.828	100.463	-.104	23.515	-23.722	79.248	110.80
2016	30.251	41.022	19.480	30.319	39.015	21.624	145.146	194.530	95.761	-2.398	25.177	-29.974	86.324	121.60
2017	30.894	42.693	19.095	31.665	41.902	21.427	145.146	198.822	91.470	-4.693	27.110	-36.495	93.400	132.04
2018	31.537	44.282	18.793	33.010	44.881	21.138	145.146	202.795	87.497	-6.987	29.289	-43.263	100.476	142.21
2019	32.181	45.805	18.557	34.355	47.946	20.763	145.146	206.511	83.780	-9.282	31.698	-50.261	107.552	152.17
2020	32.824	47.275	18.373	35.700	51.092	20.308	145.146	210.015	80.277	-11.576	34.321	-57.473	114.628	161.9
2021	33.467	48.700	18.235	37.045	54.315	19.775	145.146	213.339	76.953	-13.871	37.149	-64.890	121.704	171.59
2022	34.111	50.087	18.135	38.390	57.611	19.169	145.146	216.508	73.783	-16.165	40.171	-72.500	128.780	181.10
2023	34.754	51.440	18.068	39.735	60.978	18.493	145.146	219.543	70.749	-18.459	43.378	-80.297	135.856	190.5(
2024	35.398	52.765	18.030	41.081	64.413	17.748	145.146	222.458	67.834	-20.754	46.765	-88.273	142.932	199.8
2025	36.041	54.064	18.018	42.426	67.914	16.938	145.146	225.267	65.024	-23.048	50.324	-96.421	150.008	209.0
2026	36.684	55.340	18.028	43.771	71.478	16.064	145.146	227.982	62.310	-25.343	54.050	-104.736	157.084	218.1
2027	37.328	56.595	18.060	45.116	75.104	15.128	145.146	230.610	59.682	-27.637	57.939	-113.213	164.160	227.2
2028	37.971	57.832	18.110	46.461	78.791	14.132	145.146	233.159	57.132	-29.932	61.985	-121.848	171.236	236.2

Model											
sumptionpercapita-Model_3			PercentageTransmissionLosses-Model_4			Electricitydemandestimate-Model_5			AccesstoElectricityaspercentageofpopulation-Model_6		
	UCL	LCL	Forecast	UCL	LCL	Forecast	UCL	LCL	Forecast	UCL	LCL
	171.023	119.268	6.780	20.518	-6.959	58.020	73.797	42.243	47.053	60.312	33.794
	178.491	111.800	4.485	21.134	-12.164	65.096	87.408	42.784	45.753	60.030	31.475
	184.569	105.722	2.191	22.153	-17.771	72.172	99.499	44.845	44.453	59.681	29.225
	189.828	100.463	-.104	23.515	-23.722	79.248	110.802	47.694	43.153	59.276	27.030
	194.530	95.761	-2.398	25.177	-29.974	86.324	121.603	51.045	41.853	58.824	24.882
	198.822	91.470	-4.693	27.110	-36.495	93.400	132.046	54.754	40.553	58.331	22.775
	202.795	87.497	-6.987	29.289	-43.263	100.476	142.218	58.734	39.253	57.803	20.703
	206.511	83.780	-9.282	31.698	-50.261	107.552	152.176	62.928	37.953	57.244	18.661
	210.015	80.277	-11.576	34.321	-57.473	114.628	161.959	67.297	36.653	56.658	16.647
	213.339	76.953	-13.871	37.149	-64.890	121.704	171.595	71.813	35.353	56.048	14.658
	216.508	73.783	-16.165	40.171	-72.500	128.780	181.107	76.453	34.053	55.415	12.691
	219.543	70.749	-18.459	43.378	-80.297	135.856	190.509	81.203	32.753	54.761	10.744
	222.458	67.834	-20.754	46.765	-88.273	142.932	199.817	86.047	31.453	54.090	8.816
	225.267	65.024	-23.048	50.324	-96.421	150.008	209.040	90.976	30.153	53.401	6.904
	227.982	62.310	-25.343	54.050	-104.736	157.084	218.188	95.980	28.853	52.697	5.009
	230.610	59.682	-27.637	57.939	-113.213	164.160	227.268	101.052	27.553	51.978	3.128
	233.159	57.132	-29.932	61.985	-121.848	171.236	236.286	106.186	26.253	51.246	1.260

4.3.1 Model used for the forecast

The model used for the forecast is an Auto Regressive Integrated Moving Average (ARIMA) model whose properties are shown below.

Table 4.3: Model Description

Model Description

			Model Type
Model ID	ElectricityProduction	Model_1	ARIMA(0,1,0)
	ElectricityConsumption	Model_2	Brown
	ElectricityConsumptionpercapita	Model_3	Simple
	PercentageTransmissionLosses	Model_4	Brown
	Electricitydemandestimate	Model_5	ARIMA(0,1,0)
	AccesstoElectricityaspercentageofpopulation	Model_6	Holt

Table 4.4: Model Fit

Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.243	.341	-.015	.650	-.015	-.015	-.007	1.006E-013	.615	.650	.650
R-squared	.781	.107	.702	.951	.702	.702	.708	.721	.898	.951	.951
RMSE	4.221	4.502	1.043	12.405	1.043	1.043	1.192	2.026	8.041	12.405	12.405
MAPE	8.750	8.614	1.207	25.037	1.207	1.207	1.714	7.852	12.761	25.037	25.037
MaxAPE	37.016	49.546	1.366	134.594	1.366	1.366	1.873	26.605	56.811	134.594	134.594
MAE	3.061	3.339	.599	9.052	.599	.599	.808	1.431	5.996	9.052	9.052
MaxAE	9.348	11.109	.687	29.145	.687	.687	.830	4.929	18.925	29.145	29.145
Normalized BIC	2.296	1.829	.780	5.181	.780	.780	.808	1.541	4.231	5.181	5.181

Table 4.5: Model Statistics

Model Statistics

Model	Number of Predictors	Model Fit statistics	Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	Statistics	DF	Sig.	
ElectricityProduction-Model_1	0	1.006E-013	12.357	17	.828	0
ElectricityConsumption-Model_2	0	.581	11.593	17	.824	0
ElectricityConsumptionpercapita-Model_3	0	-.015	10.543	17	.879	0
PercentageTransmissionLosses-Model_4	0	.650	17.843	17	.399	0
Electricitydemandestimate-Model_5	0	1.000E-013	.	17	.	0
AccesstoElectricityaspercentageofpopulation-Model_6	0	.	.	17	.	0

Table 4.6: Model Equations Used to Generate Each Forecast

For Electricity Production Model

$$\left(1-\sum_{i=1}^{17}\alpha_i \mathrm{L}^i\right) Electricity_Prod = \left(1+\sum_{i=1}^{17}\theta_i \mathrm{L}^i\right)\in_t$$

Where

α_i = number of years;

θ_i = electricity production data from 1991-2011;

ϵ_t =Error terms;

L = lag operator;

i = order of differencing = 1- 17; t = time = 38

For Electricity Consumption Model

$$\left(1-\sum_{i=1}^{17}\alpha_i \mathrm{L}^i\right) Electricity_Consumption = \left(1+\sum_{i=1}^{17}\theta_i \mathrm{L}^i\right)\in_t$$

Where

α_i = number of years;

θ_i = electricity consumption data from 1991-2011;

ϵ_t =Error terms;

L = lag operator;

i = order of differencing = 1- 17;

t = time = 38

For Electricity Consumption per Capita Model

$$\left(1-\sum_{i=1}^{17}\alpha_i \mathrm{L}^i\right) Electricity_Consumption_per_capita = \left(1+\sum_{i=1}^{17}\theta_i \mathrm{L}^i\right)\in_t$$

Where

α_i = number of years;

θ_i = electricity consumption per capita data from 1991-2011;

ϵ_t =Error terms;

L = lag operator;

i = order of differencing = 1- 17;

t = time = 38

For Percentage Transmission Losses Model

$$\left(1-\sum_{i=1}^{17}\alpha_i L^i\right) PercentageTransmission_Losses = \left(1+\sum_{i=1}^{17}\theta_i L^i\right)\in_t$$

Where

α_i = number of years;

θ_i = percentage transmission losses data from 1991-2011;

ϵ_t =Error terms;

L = lag operator;

i = order of differencing = 1- 17;

t = time = 38

For Electricity Demand Estimate Model

$$\left(1-\sum_{i=1}^{17}\alpha_i L^i\right) Electricity_Demand_Estimate = \left(1+\sum_{i=1}^{17}\theta_i L^i\right)\in_t$$

Where

α_i = number of years;

θ_i = electricity demand estimate data from 2009-2011;

ϵ_t = Error terms;

L = lag operator;

i = order of differencing = 1- 17;

t = time = 38

For Access to Electricity as Percentage of Population Model

$$\left(1-\sum_{i=1}^{17}\alpha_i L^i\right) Access_to_Electricity = \left(1+\sum_{i=1}^{17}\theta_i L^i\right)\in_t$$

Where

α_i = number of years;

θ_i = access to electricity as percentage of population data from 2009-2011;

ϵ_t = Error terms;

L = lag operator;

i = order of differencing ;

t = time = 38

4.2.2 Discussion and analysis based on the forecast

Based on the forecast generated by the ARIMA model, we can easily deduce that if electricity consumption per capita remains static and unchanged at 145.146 kW per person per annum, the annual electricity consumption will increase steadily and in 2016, electricity consumption will stand at 30.319 billion KWh thereby surpassing the total amount of electricity produced, 30.251 billion KWh if all other parameters that affect the production and consumption such as the amount of electricity lost in transmission continues in the same pattern as predicted by the model. Therefore, the percentage of Nigerians that have access to electricity supply will also reduce steadily from 48% in 2011to about 41.83% in 2016 and predicted electricity demand estimate will stand at 86.324 billion KWh. However, the forecast generated gives several allowances which are depicted by the UCL (Upper chart Limit) and LCL (Lower Chart Limit). These limits are generated based on the measure of accuracy and pattern obtained from the supplied data and they signify a situation of “best case scenarios” and “worst case scenarios” which can be an effect of several unmeasured circumstances or situations that are unaccounted for like policy changes, changes in capacity of available facilities or even the recent extensive privatisation schemes.

4.2.3 Accuracy of the forecast, error calculations and reliability of the forecast model

It is important to know how reliable the forecast is and the model that generated it. The forecasts reliability is measured by the MAPE whose graph is shown below. The smaller the MAPE the greater the accuracy of the forecast. Forecasts are deemed to be accurate and authoritative enough if the MAPE value is below 10 and a forecast whose MAPE is between 1 and 5 is considered authoritative and accurate. In this forecast, I was able to achieve a MAPE of 1.207 for the forecasts below the 10^{th} Percentile of all forecasts and a MAPE of 1.714 for the forecasts between the 10^{th} and 25^{th} Percentile of all forecasts, which is the forecast between 2012 and 2017. This value increased to 25.037 as the model generated more forecasts. Hence, the forecasts between 2012 and 2017 are very accurate and authoritative. Forecast accuracy generally diminishes as the number of forecasts generated increases and the farther away the forecasts get from the observations and these accounts for the increase in MAPE value. Averagely, the MAPE for the complete forecast stands at 8.750.

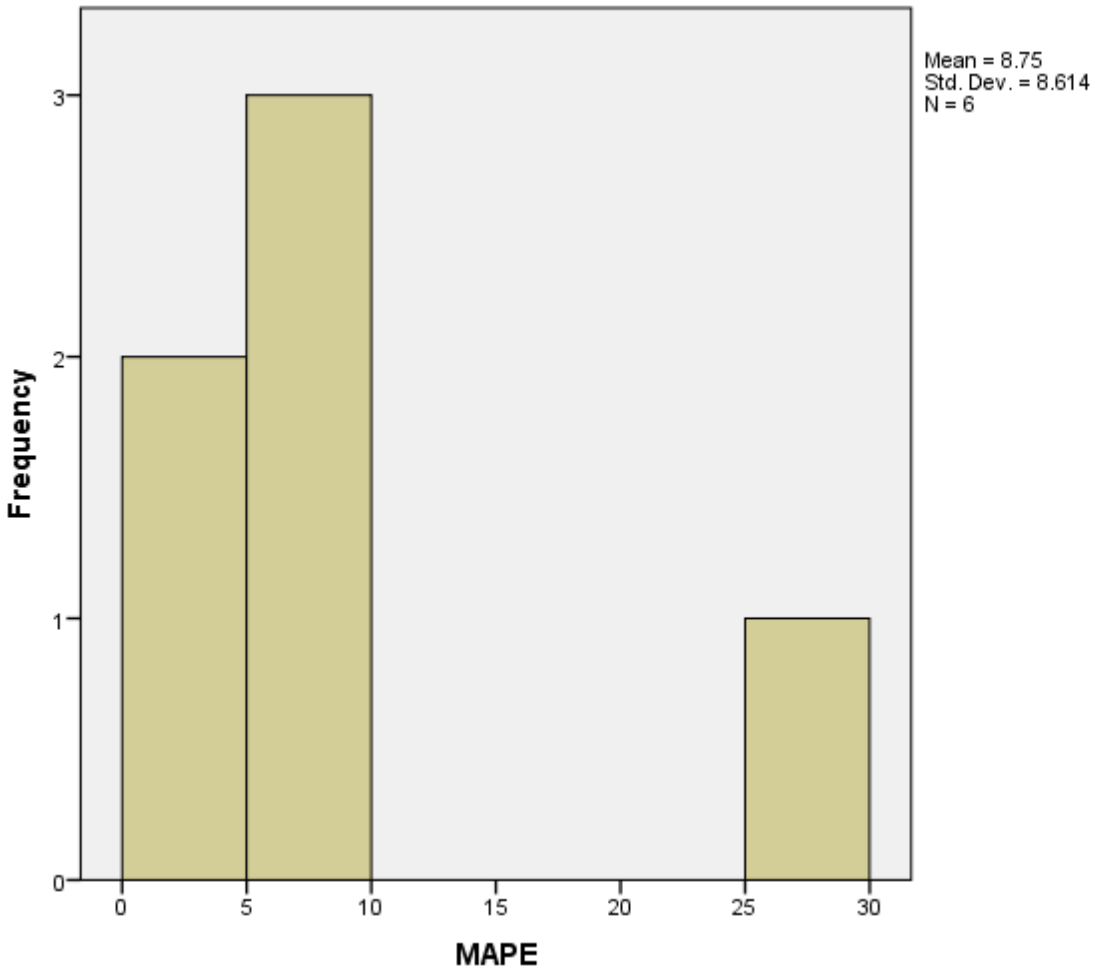


Figure 4.5: Frequency distribution of the forecast MAPE

MPE, also known as MFE or Bias is a measure of forecast model bias:

Ideal value = 0

MFE > 0, model tends to under-forecast

MFE < 0, model tends to over-forecast

In this research, the model used returned a MFE value of 0.243 below the 10^{th} Percentile (between 2012 and 2016) and showed general fluctuations between 0.94 and -0.015. Hence, the ARIMA model shows a great level of unbias in its calculations, though it tends more towards under-forecasting the values and its values can be deemed reliable.

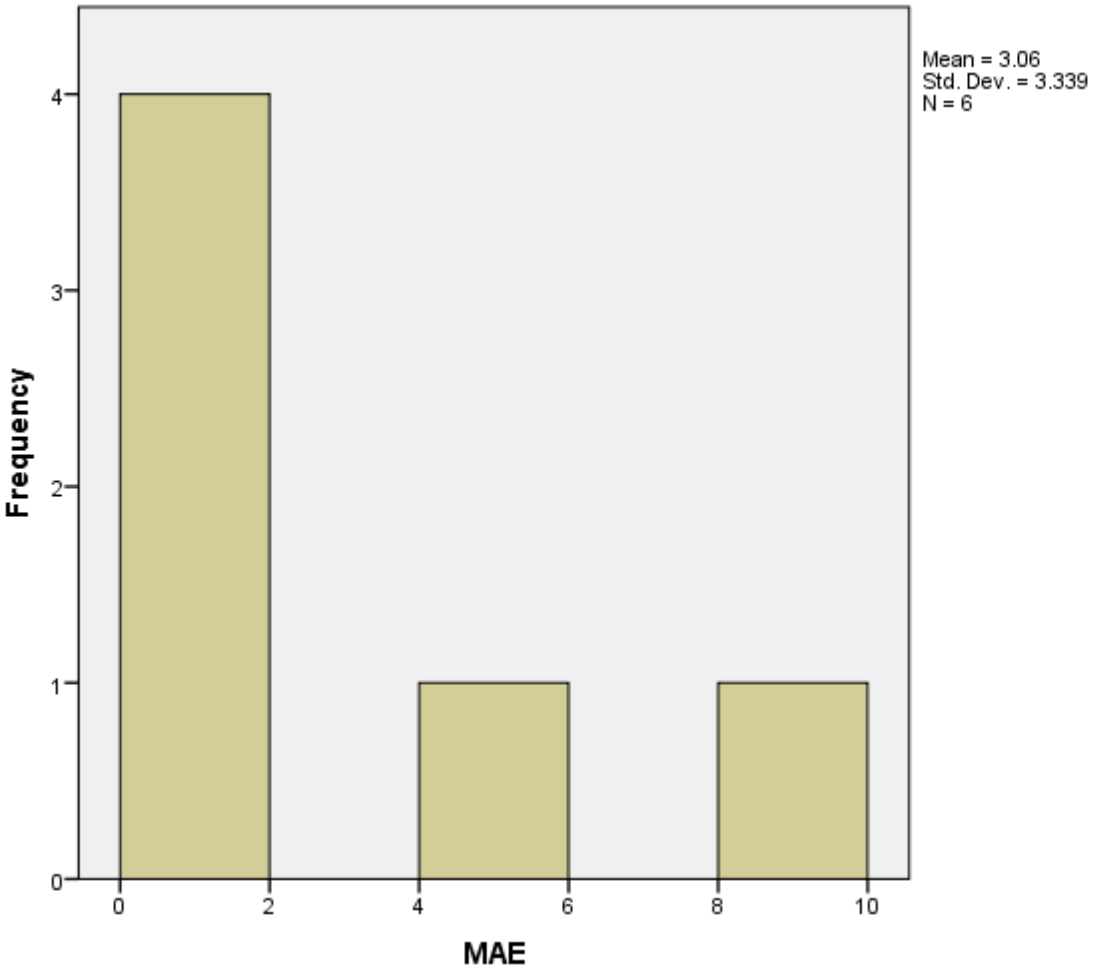


Figure 4.6: Frequency distribution of the forecast MAE

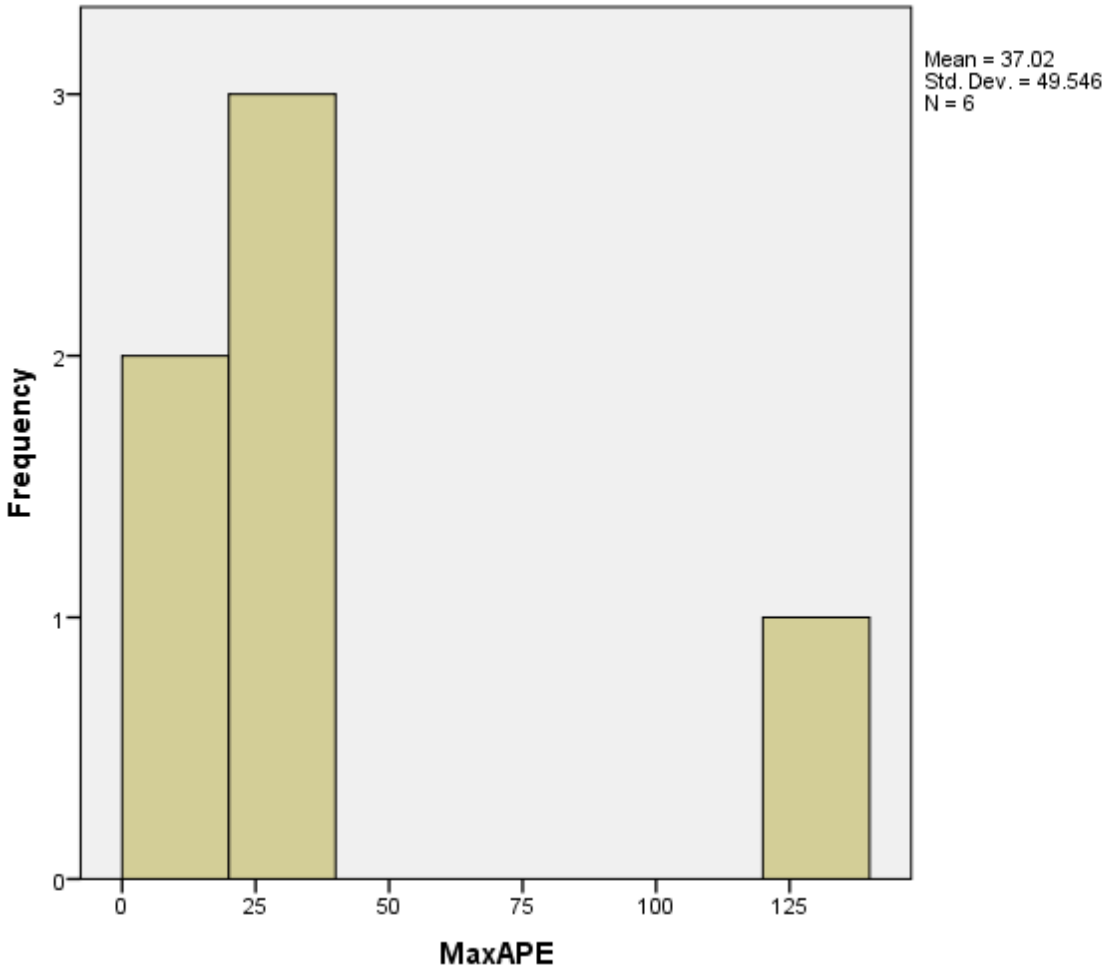


Figure 4.7: Frequency distribution of the forecast MaxAPE

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this research work, I have been able to work with the IBM SPSS application and several packages under it like the ChartBuilder and the Time Series Modeller to create a statistical Time-series forecast of the electricity production, consumption, demand estimate and transmission and distribution losses in Nigeria having obtained the absolute figures of these parameters between the year 1991 and 2012 from the relevant agencies within and outside the country. I have subjected my forecasts to the approved tests of accuracy signified by the MAPE, RMSE and other error estimates. Forecasts are deemed to be accurate and authoritative enough if the MAPE value is below 10 and a forecast whose MAPE is between 1 and 5 is considered authoritative and accurate. In this forecast, I was able to achieve a MAPE of 1.207 for the forecasts below the 10^{th} Percentile of all forecasts and a MAPE of 1.714 for the forecasts between the 10^{th} and 25^{th} Percentile of all forecasts, which is the forecast between 2012 and 2017. This value increased to 25.037 as the model generated more forecasts. Hence, the forecasts between 2012 and 2017 are very accurate and authoritative. Forecast accuracy generally diminishes as the number of forecasts generated increases and the farther away the forecasts get from the observations and these accounts for the increase in MAPE value. Averagely, the MAPE for the complete forecast stands at 8.750. Also, the RMSE value at forecasts below the 10^{th} Percentile is 1.043 and for values at the 25^{th} and 50^{th} Percentile are 1.192 and 2.026 respectively. This value increased to 12.405 as the model generated more forecasts. The mean RMSE is placed at 4.221. Based on this error estimates obtained, the forecast can be adjudged to be fairly accurate and the model used has proved to be acutely capable of carrying out these forecasts if we consider the prospects of its usability in helping our electricity regulatory commission and other relevant statistical agencies in determining how to manage data that gives a good picture of the electricity demand, production and consumption patterns that help in determination of management processes of the supply chain of electricity.

5.2 Recommendation

I will recommend that the results of these forecasts be considered by the NERC as a possible indicator of the direction in which the Nation's energy statistics are tending to. Also, I will recommend that the model used to carry out this forecast be considered for use in the nation's regulatory organisations because if it can create a forecast with the level of accuracy it has done, then a trained statistician in the Nigerian Bureau of Statistics, for instance, may have an idea about how to customize it's working formulas to create a customised model that can work more accurately for the intricacies that form our national statistics. This has been done by the United Nations Environment Programme and the model used is now called the Egain Forecasting Model.

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