NIPES Journal of Science and Technology Research 5(2) 2023 pp. 68-76 ISSN-2682-5821

NIPES

Journal of Science and Technology Research

Journal homepage: www.nipesjournals.org.ng

Time Series Analysis of Electricity Generation in Nigeria from 1985 – 2014

Aideyan Donald Osaro
Dept. of Mathematical Sciences, Kogi State University, Anyigba, Kogi State, Nigeria

Article Info

***Keywords*:**
Autoregressive, Average, Generation, Moving, Model.

Received 09 April 2023
Revised 26 April 2023
Accepted 27 April 2023
Available online 06 June 2023

https://doi.org/10.5281/zenodo.8010065

Abstract

This research work analyses power generation in Nigeria from 1985 to 2014. It is glaring that electricity plays a very important role in the social-economic and technological development of every Nation. The electricity demand in Nigeria far outstrips the supply and the supply is epileptic in nature. The country is faced with acute electricity problem which is hindering her development notwithstanding the availability of vast natural resources in the country. In order to analyse this decay, a time series analysis was executed using the ARIMA Model (1, 2, 1) which was one hundred percent significant, and statistically proves that the power sector deteriorated a great deal with low power generation with very high demand. Furthermore, a three year forecast was generated using the Model for the year 2015, 2016, and 2017 with values 3315.48, 3370.03, and 3420.60 respectively in Megawatts which shows that there is serious cause for alarm. Finally, since the decay has been proven scientifically, it is paramount that necessary precautionary measures should be taken in other to fix the decay, that is, the government should try and repair, expand and maintain obsolete power generating equipment and stations as most of these stations have not been checked since they were constructed decades ago. Explore other means of generation such as coal, gas, solar power e.t.c

1.0. Introduction

This research work analyses power generation in Nigeria from 1985 to 2014. It is glaring that electricity plays a very important role in the social-economic and technological development of every Nation. The electricity demand in Nigeria far outstrips the supply and the supply is epileptic in nature. The country is faced with acute electricity problem which is hindering her development notwithstanding the availability of vast natural resources in the country.

Electrical energy is a key driver in the development of every nation [1]. In the case of Nigeria, the electricity supply to her teaming population is inadequate, translating to an energy poor society[2-3]. Electricity generation in Nigeria began in Lagos in 1886 with the use of generators to provide 60 kW. In 1923 tin miners installed a 2 MW plant on the Kwali River [4-11], six years later, the Nigerian Electricity Supply Company, a private firm was established near Jos to manage a hydroelectric plant at Kura to power the mining industry. Then another private enterprise was established in Sapele by United Africa Company to power the activities of African Timber and Plywood Company. Between 1886 and 1945, electric power generation was rather low with power provided largely to Lagos and other commercial centers such as mining industries in Jos and Enugu. [12] The colonial government created an electricity department within the Public Works Department which then installed generating sets in many cities to serve government reservation areas and commercial centers. In 1950, the Legislative Council of Nigeria began moves to integrate the electricity industry when it enacted a law to establish the Electricity Corporation of Nigeria (ECN) [8] with the duties of developing and supplying electricity. ECN took over the electricity sector activities within PWD and the generating sets of Native Authorities. In 1951, the firm managed 46 MW of electricity. Between 1952 and 1960, the firm established coal-powered turbines at Oji and Ijora [10], Lagos and began making preliminary plans for a transmission network to link the power generating sites with other commercial centers.[11]. In 1961, ECN completed a 132 kV transmission line linking Lagos to Ibadan via Shagamu, in 1965, this line was extended to Oshogbo, Benin, and Ughelli to form the Western System.

In 1962, a statutory organization, the Niger Dams Authority (NDA) was formed to build and maintain dams along River Niger and Kaduna River.), NDA went on to commission a 320 MW hydropower plant at Kainji in 1969 with the power generated sold to ECN [4]. In 1972 NDA and ECN merged to form the National Electric Power Authority (NEPA) [5]. NEPA was the major electricity firm in Nigeria until power sector reforms resulted in the creation of the Power Holding Company of Nigeria (PHCN) and later privatization of electricity generation and distribution [9].

Several research have been carried out on issues concerning electricity generation ant its impact in Nigeria’s economic growth and development.[7] examined the relationship between electricity supply, development of industrial sector and economic growth using endogenous growth theory for the period 1980 to 2009. The result using Auto regressive Distributed Lag (ARDL) shows that productivity level of the industrial sector in Pakistan is declining as a result of power shortage. The study recommended that electricity problem should be fixed to improve industrial growth. [14] investigated the impact of electricity crisis on manufacturing productivity growth in Nigeria. Time series data from 1980 to 2008 were analyzed using OLS multiple regression. The results showed that electricity generation and supply in Nigeria impacted negatively on manufacturing productivity growth. This was attributed to unnecessary government spending on non economic and unproductive sectors. They advised that electricity generation and distribution should be restructured through the initiative of independent power projects, that is, there [13] conducted a study on the effect of electricity supply on industrial production in Nigeria over the period 1970 to 2010. Multiple regression methodology was employed to analyze the time series data. Empirical findings revealed a positive relationship between electricity supply and industrial production over the studied period. The study recommended that issues relating to electricity production and industrial development should be given priorities particularly in the budget scheme. [15] examined electricity crisis and manufacturing productivity in Nigeria over the period 1980 to 2008. The study employed the ordinary least square multiple regression to analyze the time series data. Empirical findings revealed that electricity generation and supply in Nigeria under the reviewed period impacted negatively on the manufacturing productivity growth [6]. The study recommended a reverse of the ugly trend of poor electricity supply through the initiative of independent power project as proposed by some states in Nigeria.

This research work sheds light on some part of the power sector in Nigeria. The Federal Government has made the power sector problems in Nigeria a critical issue to be adequately addressed. As part of the agenda, targets of generating, transmitting and distributing 6000MW by December 2009 were set. Although this dream never came to pass which is the part of the essence of this research work. ARIMA model was chosen for analyzing this data because it is the integration of both the Auto Regressive (AR) and Moving Average (MA) models for optimum results.

The aim of this research work is to analyse electricity generation in Nigeria with the following objectives to: Formulate suitable model for the data, test for the significance of the model and forecast the future based on the suitable model.

The data collected covers the amount of power generated in megawatt (MW) in Nigeria for the period of thirty years (1985-2014).
The data used for this research work is a secondary data extracted from the defunct Power Holding Company of Nigeria (PHCN) statistical record now Abuja Electricity Distribution Company (AEDC) and the Daily Sun Newspaper

2.0 Methodology

2.1 Auto Regressive Moving Average (ARMA) Process

The logical extension in modelling linear processes is to combine autoregressive and moving average coefficients. Many stationary time series can apparently be well represented by ARMA models with a relatively small number of non-zero coefficients to achieve parsimony. The ARMA process of order(p,q) is written as:

$$y_t - \phi_1 y_{t-1} - \phi_2 y_{t-2} - \cdots - \phi_p y_{t-p} = \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2} - \cdots - \theta_q \epsilon_{t-\epsilon} \quad (1)$$

Where ϵ_t the white noise process with is mean zero and variance σ_ε^2 and y_t is denoted as observed time series data that can be compactly rewritten as $\phi(B)y_t = 0\ (B)\epsilon_t$. Where

$$\phi(B) = 1 - \phi_1(B) - \phi_2(B)^2 - \cdots - \phi_p(B)^p \ and$$

$$\theta(B) = 1 - \theta_1(B) - \theta_2(B)^2 - \cdots - \theta_p(B)^q$$

For the ARMA process in equation (1) to be invertible, we require the roots of $\theta(z) = 0$ to lie outside the unit circle and for the model to be stationary, we require that the zeros for $\phi(z) = 0$ to lie outside the unit circle.

The stationary and invertible ARMA process can be written as a pure auto regressive representation as

$$\Pi(B)y_t = \epsilon_t \ where$$

$$\Pi(B) = \frac{\phi(B)}{\theta(B)} = [\theta(B)]^{-1}\phi(B)$$

$$= (1 - n_1 B - n_2 B^2 - n_3 B^3 - \cdots)$$

The ARMA in equation (1) can be written as a pure moving average representation as $y_t = \Psi\ (\mathrm{B})\epsilon_t$, Where

$$\Psi(B) = \frac{\phi(B)}{\theta(B)} = [\phi(B)]^{-1}\phi(B)$$

$$= (1 - \Psi_1 B - \Psi_2 B^2 - \Psi_3 B^3 - \cdots)$$

Note that both the Ψ_j and Π_j for $j = 1, 2, ...$

Weights are absolutely sumable i:e

$$\sum_{I=0}^{\alpha}(\Psi_j) < \alpha \ and \ \sum_{I=0}^{\alpha}(\Pi_j) < \alpha$$

It is readily verified that from a given ARMA(p,q) process, the Π_j and $\Psi_j$weights can be generated using either series expansion approach or recursive approach

2.2 Models for Non-Stationary Series

Many series actually encountered in practice in industries, business such as in stock prices exhibit non-stationary behaviour and in particular do not vary about a fixed mean. The model that is commonly used to represent these types of homogenous non-stationary behaviour is of the form.

$$\Psi(B)y_t = \theta(B)\epsilon_t \quad (2)$$

Where $\phi(B) = \phi(B)(1-B)^d$Where $(1-B)^d$ is called differencing operator. By a way of simplification, we can write$(B)w_t = \theta(B)\epsilon_t$, where $w_t = \forall^d y_t$ and the symbol $\forall = (1-B)$. The process defined by (2) provides a powerful model for describing stationary and non-stationary time series called Auto Regressive Integrated Moving Average (ARIMA) process of order (p, d, q). The process is defined by a functional relation as

$w_t = \phi_1 w_{t-1} + \phi_2 w_{t-2} + \cdots + \phi_\rho w_{t-\rho} + \epsilon_t - \theta_2 \epsilon_{t-2} - \cdots - \theta_q \epsilon_{t-q}$(3)

With

$$w_t = \begin{cases} y_{t,} & d > 0 \\ y_{t,} & d = 0 \end{cases}$$

Model (1) calls for the d^{th} difference of the given data, which are presumed to be non-stationary in behaviour, to produce a stationary model of the form (2). In practice, this is usually 0.1 or at most 2.

2.3 Special Cases of ARMA(p, d, q) Model

The following models represent some special cases of ARMA model with $d \geq 1$, which seems to be a common phenomenon in practice.

2.3.1.The ARIMA (p, d, q) Process

This corresponds to a situation where $p = 0, d = 2$ *and* $q = 1$ in model in equation (10) and is defined by

$$\forall y_t = \epsilon_t - \theta_1 \epsilon_{t-1}$$

$$= (1-B)y_t = (1 - \theta_1 B - \theta_1 B^2)\epsilon_t$$

3.0. Data Analysis

Table 1 shows the rate of power generation over the given year.

Table 1: Data For The Research Work

Year	Total power generation (MW)
1985	815.1
1986	887.7
1987	973.9
1988	994.6
1989	1025.5
1990	1166.8
1991	1228.9
1992	1286.0
1993	1330.4
1994	1462.7
1995	1536.9
1996	1617.2
1997	1683.4
1998	1655.8
1999	1772.9
2000	1810.1
2001	1854.2

2002	1839.8
2003	1724.9
2004	1859.8
2005	1724.9
2006	1689.9
2007	2237.3
2008	6180.0
2009	2763.6
2010	2779.3
2011	3000.0
2012	4156.2
2013	3200.2
2014	1770.5

3.1. Time Series Modeler

Table 2: Model Description

	Model type
Model ID year model 1	ARIMA $(1, 2, 1)$

Table 2 descries the kind of model that will be applicable for the analysis of this work, which is the ARIMA $(1, 2, 1)$ Model.

Table 3: Model Statistics

Model	Number of predictors	Model fit statistics		Ljung-Box Q (18)			Number of outliers
		Stationary R-squared	R-squared	Statistics	DF	Sig.	
Year – model_1	1		1.0	58.710	16	.000	0

Table 3 describes the significance of the model which is 100% at 0.01 level of significance, with an R-squared value of 1.00.

Table 4: ARIMA Model Parameters

	Estimate	SE	t	Sig.
Yea- year Natural log constant	-2.522E-7	6.722E-		
model_1	.612	10	-375.262	.00
AR Lag 1	2	.381	1.608	.121
Difference	.163			
MA Lag 1	4.273E-13	.699	.233	.818
Power generation No Number Lag 0		2.447E-		
Transformation		13	1.746	.094

Table 4 shows that the estimate of the basic parameters of this analysis is thus: autoregressive value of 0.612 with difference 2 and a moving average value of 0.163 from the output above, it shows the model is hundred percent (100%) significant at 0.01 significance level and with $R^2$of 1.00.

3.2. Forecasts

One of the objectives of fitting ARMA/ARIMA models to a data set is to be able to forecast its future values. From table 4 which shows the model parameters that best fit the data, the model equation below was derived;

$$y_t = 0.612y_{t-1} + 0.163\epsilon_{t-1} + \epsilon_t - 0.2522 \qquad (4)$$

Equation (4) was further used to generate a three (3) year forecast using SPSS. The table below shows the forecast generated as:

Table 5: Forecasts

Years	Forecast (MW)
2015	3315.48
2016	3370.03
2017	3420.60

Table 5 illustrate the forecast pattern of the next three successive years and from the table, the values are increasing gradually although not enough to cover the demand of the general populace.
The analysis of this research work, which was carried out using ARIMA MODEL (1,2,1) at 0.01 level of significance, from which the future was forecasted for 3 years (2015, 2016 and 2017). It shows that demand cannot be met for the next 3 years.

4.0. Conclusion and Recommendations

Based on the analysis, power generation is low compared to the demand of the general populace. The ARIMA MODEL (1, 2, 1) used to forecast the successive years 2015, 2016 and 2017 which will produce 3315.48, 3370.03 and 3420.60 respectively implies that there will still be shortage in power generation supply because it's demand is increasing by the day.
As a result of the analysis carried out in this research work, the following recommendations are given:
The government should ensure that power is being generated via other means aside from the hydro power generating type. These include: the use of coal, oil, natural gas, solar etc.
The government and PHCN officials are corrupt beyond measure; the federal government should make sure there is proper accountability for every money invested unto this sector to enhance positive results and not committees of all forms trying to deduce fraudulent acts.
The government should try and repair, expand and maintain obsolete power generating stations, as most of this station had not been checked since they were constructed.
The Federal government should tackle wastefulness-natural gas flaring because according to World Bank estimates. It currently loses more than $2.5 billion (N332.5 billion) annually to gas flaring. At about 57% of the daily production of over $2bn, the volume of flared gas is said to be capable of generating up to 6GW of electric power annually.

References

[1] Anderson, T.G., Bollwerslev T., Christofferson P.F. and Deibold F.X. (2006). " Volatility forecasting" Handbook of economic forecasting . Amsterdam: North-Holland.
[2] Bartlett M.S.(1946). " On the theoretica specification of sampling properties of autocorrelated time series". Journal of the Royal Statistical Society. B, 8,27-41.
[3] Box, G.E.P. and Pierce D.A. (1970). " Distribution of residual correlation in autoregressive integrated moving average time series models" Journal of American Statistical Association, 65, 1509-1526.
[4] Chan, K.S. and Tong, H., (1994). "A not on a noicsisy Chaos." Journal of the Royal Statistical Society. B, 56, 2, 301-311.
[5] Chan, K.S., Petruccelli J.D., Tong, H., and Woolford S.W., (1985). "A multiple threshold AR(I)model". Journal of Applied Probability. 22, 267-279.
[6] Davison A.C., and Hinkley D.V. (2003). " Bootstrap Methods and their application". 2nd ed. New York: Cambridge University Press.

[7] Ellahi, N. (2011). Testing the Relationship between Electricity Supply, Development of Industrial Sector and Economic Growth: An Empirical Analysis Using Time Series Data for Pakistan. International Journal of Management Science and Engineering Management, 6(4), pp. 272-277.

[8] Energy Commission of Nigeria. (2002). National Energy Policy, Abuja, Nigeria. August.

[9] Energy Commission of Nigeria. (2005). Renewable Energy Master Plan. Abuja. November.

[10] Energy Information Administration, International Energy Annual (2004). DOOE, Washington D.C.

[11] IAEA/ECN, (2007). Assessment of Energy Options and Strategies for Nigeria: Energy Demand, Supply and Environmental Analysis for Sustainable Energy Development. (2020-2030).

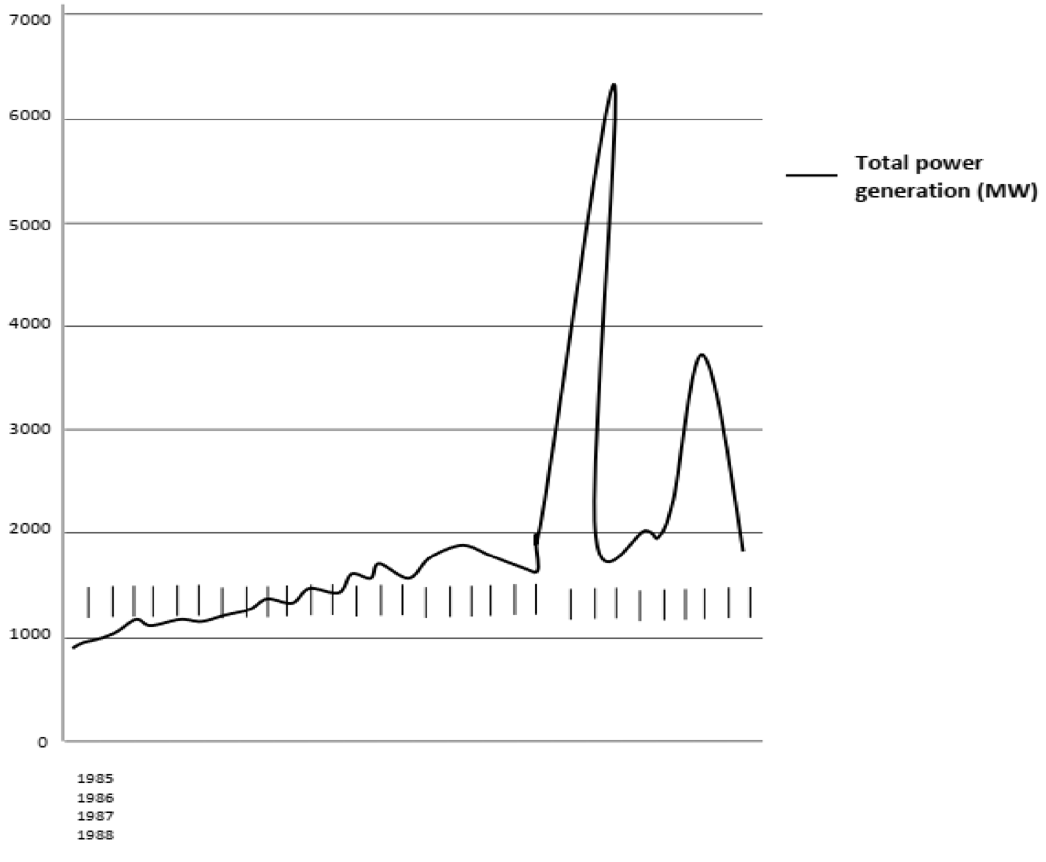
[12] Ibitoye, F. And Adenikinju, A., (2007). "Future Demand for Electricity in Nigeria" . Applied Energy. 84, 492-504.

[13] Nwanko, O. C. & Njogo, B. O. (2013). The Effect of Electricity Supply on Industrial Production within the Nigerian Economy (1970-2010). Journal of Energy Technologies and Policy, 3(4), pp. 34-42.

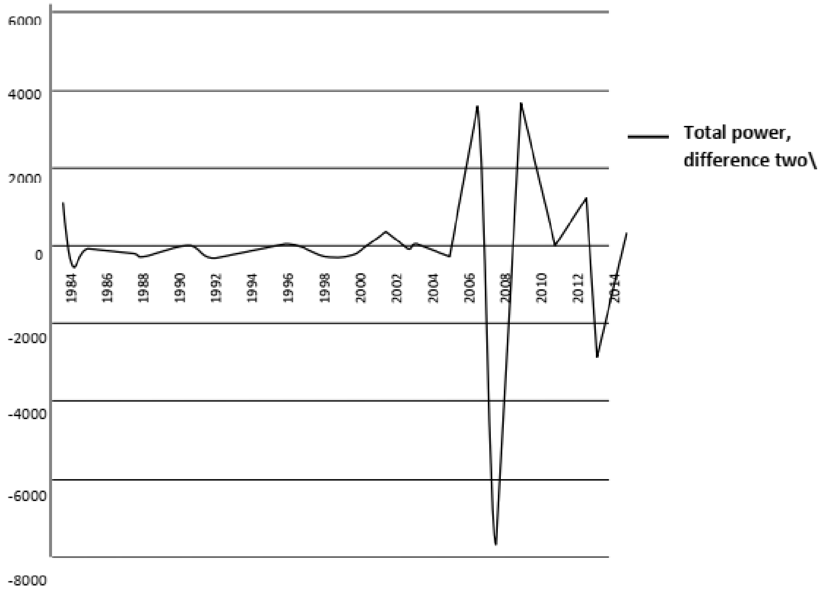
[14] Olayemi, S. O. (2012). Electricity Crisis and Manufacturing Productivity in Nigeria (1980-2008). Developing Countries Studies, 2(4), pp. 16-21.

[15] Simeon-Oke, O. O. (2012. Electricity Crisis and Manufacturing Productivity in Nigeria (1980-2008). Developing countries Studies, 2(4), pp. 16-21.

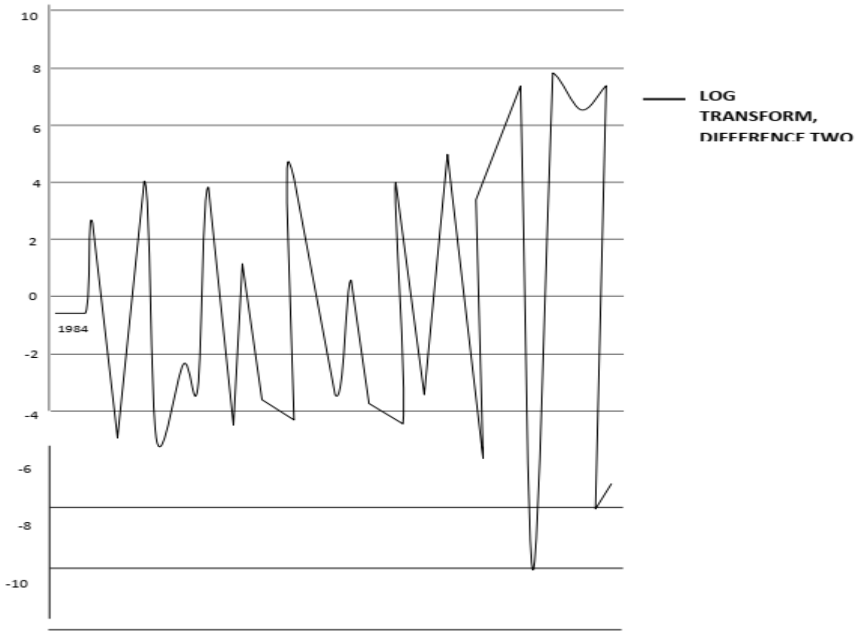
Appendix I
Total power generation (MW)



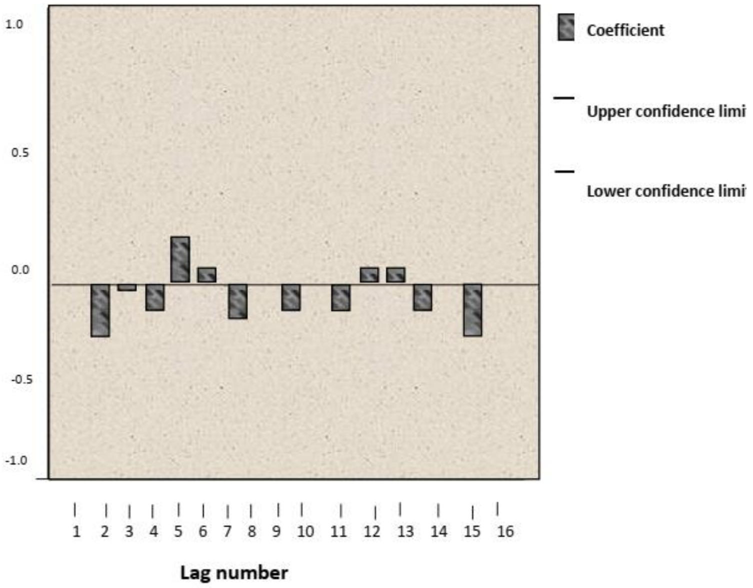
Appendix II
Total power, difference



Appendix III
Log Transform, Difference Two



Appendix IV
Power generation



Autocorrelation graph

Appendix IV
Power generation