The Effect of Electricity and Gas Losses on Nigeria`s Gross Domestic Product

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Abstract

Electricity and gas are key factor inputs that could reduce or increase economic activity over time. The conversion, transmission, and distribution process of electricity and gas could increase or reduce output. This study investigated the effect of electricity and gas losses on the Gross Domestic Product (GDP) of Nigeria from the period covering 1970 to 2012. The objective of the study is to examine the impact of Electricity and gas losses on GDP of Nigeria using the ordinary least squares method. Results show that gas loss was in line with the 'a priori' expectation while electricity loss was not in both short and long run. Hence, gas loss showed an inverse relationship with GDP while electricity loss showed a direct relationship. Further, electricity loss was significant in explaining variations in GDP while gas loss is insignificant. The model will return to equilibrium at the speed of 29 per cent as revealed by the error correction test. The study concludes that a reduction in electricity and gas loss will increase productive activity and GDP. The paper recommends a reinforced policy on gas loss via flaring to reduce the quantity of gas loss. In the same vein, investment in modern technology in the power sector will in no small measure reduce power transmission and distribution losses.

Key words: Electricity loss, Gas loss, Gross Domestic Product**1.0 Introduction**

Introduction

Electricity and gas are critical for modern existence and important infrastructural inputs for economic growth and development especially since the oil shocks of 1970's. There is a general belief and concession amongst researchers, analysts, economists, and policymakers, that energy use is related to economic activity, hence, plays a vital role in the process of economic growth and development (Alam, 2006; Ayodele, 204; Birol, 2007). In all economies, all economic units have extensive demand for electricity and gas demand propelled by economic factors like industrialization, population growth, urbanization, rising standard of living as well as modernized agriculture. Birol (2007) posit that demand for energy has surged and that, the unrelenting increase has helped fuelled global economic growth.

Shahbaz and Lean (2011) argue that production growth and an expansion of economic activities in Pakistan are restrained by its under-developed energy infrastructure. Ayodele (2004) opine that the quest to rapidly and firmly put the Nigerian economy on course of economic development is technically, a function of adequate and distribution of energy, particularly electricity. Considering the role of energy in the Nigerian economy, Aderibigbe (2010) assert that electricity delivery system (transmission and distribution networks) must be robust and flexible enough, every second of the day and every day of the year to accommodate the nations demand for electricity and deliver regular, reliable and affordable electricity especially in the production economy. The above underscore the importance of adequate energy use in the growth of an economy. Economic expansion in Nigeria is heavily restrained by undeveloped and poor managed energy sector, characterized by the limited supply, and poor quality of services given rise to captive energy production in Nigeria. Currently, however, the Nigeria economy is faced with insufficient and low quality energy use resulting partly from electricity and gas differentials.

Energy literature shows a good number of studies done on energy and economic growth in Nigeria. While some focused on causality others dwelt on energy pricing, unemployment, per capita income e.t.c. For instance, Odlaru and Okonkwo (2009) examined energy consumption and its contribution to economic growth. Mozumder and Marathe (2007) investigated the causal relationship between electricity consumption and economic GDP e.g. Of all these, non to the best of our knowledge is directed to study the effect of energy loss to the Nigerian economy except for Nwosu and Marcus (2013) who examined the relationship between electricity differentials and per capita income of Nigeria, and George and Oseni (2012) who considered the relationship between un-generated, wasted electricity and industrial electricity consumption and unemployment in Nigeria from 1970 to 2005. Again, Najid, Muhammad, Naqvi and Muhammad (2012) in estimating energy consumption and economic growth in Pakistan employing the Cobb- Douglas production function did not show link between their model and that of Cobb- Douglas and the place of total factor productivity (A) in production activity. Hence, this study fills these gaps which include the inclusion of gas loss in our model, the consideration of the Nigerian economy as against per capita income. Also, this study considers electricity loss as energy generated but not consumed due to transmission and distribution (not the un-generated or wasted) hiccups and in gas loss as those flared.

The objective of the study therefore is to investigate the effect of electricity and gas losses on the Nigerian economy using the ordinary least square method. This study differs from the others because it is positioned to study the effect of both electricity and gas losses on the gross domestic product of Nigeria. The study will enhance energy management and forecasting as well as contributing to energy literature development in Nigeria. Following the introduction is literature review in section 2, materials and method in section 3, presentation of results in section 4 and conclusion and policy recommendation is section 5.

2.0 Literature Review

2.1 Conceptual issues

For any type of fuel to be usable after production, it requires to go through the process of cleaning and beneficiation. This process of cleaning and beneficiation is necessary to remove impurities. Since most forms of energies like crude oil may not be put to use without processing or conversion in the case of electricity, they are transported to the various centers of conversion or use. After processing and conversion, energy is transported to the end users and all these involve losses.

Electricity Loss

According to International Energy Agency (2011) 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. Before consumption, some storage may be required for some of energy, while for electricity no practical and economic storage solution exists (Bhattacharyya, 2011). Energy Information Administration (n.d) defined electricity loss as the difference between electricity input and output as a result of an energy transfer between two points. Geitena (2008) states that electricity loss can be technical and non- technical. She further states that, technical losses are losses on power lines (such as Joule losses and losses by corona effect) and losses in transformers (such as losses in magnetic cores). These losses are the result of the inherent resistance of electrical conductors. Non-technical losses include more or less all energy, which gets lost because of energy theft, errors in metering, billing und data processing as well as differences between real consumption of customers with annual meter reading within a year and the estimated consumption within an accurately defined period.

Gas Loss

Gas loss is simply the difference of the physical inputs and the physical outputs of the pipeline system (Duane, n. d). A loss in this sense occurs whenever the physical inputs are greater than outputs of the pipeline system. This loss includes those of cleaning and beneficiation and flaring. For this study however, gas loss resulting from flaring only is considered. Paul Metro (n. d) Gas loss or unaccounted for is the difference between gas sales billed and gas send out. During a given period, the quantity of gas sold will differ from the quantity sent into the distribution system. According to him, gas loss does not always indicate a leak. Leakage is only one of a number of factors contributing to gas loss. Leaks are defined as gas escaping to the atmosphere at a given rate at an unknown location. The rate of gas loss is dependent on the pressure and the size of the hole.

2.2. Theoretical Perspective

The basis of neo-classical growth theory is that it is possible to explain the patterns of economic change within a country, by making use of an aggregate production function. The aggregate production function relates the total output of an economy to the aggregate amounts of labor, human capital and physical capital in the economy, and some simple measure of the level of technology in the economy as a whole. According to this theory, production in each period begins with given amounts of capital, labor and technology, and terminates in the production of goods. This implies that increase in the inputs will increase output as well, and decrease in the inputs will also decrease output.

The neoclassical economists are generally reticent about how labor is produced or reproduced; they assume that it grows exogenously. Technology is described as the stock of knowledge available to an economy. Knowledge may be embodied in machines, human skills, or it may take the form of social codes and arrangements. Not included in this account of the economy is the primary force that drives all economic activities- energy. Clearly, energy enters the neoclassical economy as the effort of labor, but this source of energy has been declining progressively over the past two centuries. Energy from non-human sources (coal, oil, electricity, food or fertilizer) enters the economy only as an intermediate input; it is incorporated into a country's national income accounts as value-added in the energy sector. Quite simply, energy is not a factor of production. In other words, neoclassical economics is built upon a disjunction between the economy and ecology (Alam, 2006). This study however argue in line with authors such as Stern (2003) to assume that energy inputs like electricity and gas could take the place of technology in the neoclassical theory considering the role of energy in driving technology.

Though the classical economists did not explicitly recognize energy as a factor of production in their macroeconomic framework, they understood clearly the limits which land-nature imposes on economic activities, especially as it affects agriculture. When classical economists speak of the "fertility of nature", (Adam Smith 1776), "the productive and indestructible powers of the soil" (David Ricardo),"the natural and inherent powers of the soil (John McCulloch)," or speak of the earth as "a wondrous chemical workshop wherein many materials and elements are mixed together and worked on (Jean-Baptiste Say)," their language conveys a clear understanding of the energy that nature contributes to the economy. In a similar vein, Mill (1848) wrote that matter contains "active energies by which it cooperates, with, and even be used as a substitute for, labor." Likewise, Bastiat (1850) identifies the different forms in which energy as light, heat, electricity, plant life, wind, gravitation contributes to production, but he sees these forces at work both in agriculture and manufacturing (as cited in Alam, 2006).

Nicholas Georgescu-Roegen (1971) is one of the first economists to comment on the absence of energy in economic theory as a productive resource or agent. He pointed out that Marxists and neoclassical economists abstract from nature suggest that they take resources and energy flows for granted. Other economists such as Solow, Romar and Cobb-Douglas have therefore included in their models technological progress and total factor productivity (TFP) to capture other inputs that affects production or growth other than labor and capital. Because technological progress is difficult to measure directly with the growth rate of the GDP, economists resorted to taking the part of growth that is not accounted for by observable growth of inputs to be a measure of technological progress. That is, residual of growth not accounted for by capital and labor- given the interaction with other observable inputs. Among these residual of growth or other inputs unaccounted for we assume includes energy.

The study of the characteristics of economic growth and electricity consumption has been an area of interest to scholars, analysts, economists and researchers. For instance, Chima and Freed (2005) confirm a relationship between energy consumption and real GDP. They further assert that Energy availability and consumption play a key role in the process of economic development as well as a key to industrialization and the development of industrial infrastructural facilities. According to them, Energy use is a function of, and a consequence of economic growth. Ovienimo (2006) agrees that energy efficiency is the indispensible component of any effort by an economy to improve productivity which then translates to income growth. In Bangladesh, Buysse, Begum, Alam, and Huylenbroeck, (2012) observe that inadequate supply of electricity to meet the growing demand of the economy, result to frequent electrical power outages or load shading used to manage the gap between power generation and demand of electricity and this has clear impact on economic activities. Balat (2007) highlights the importance of energy consumption in an economy. According to him, energy consumption in developing countries has been increased. For instance, he asserts that Turkish government is encouraging national and international investors to invest in energy projects.

Goerge and Oseni (2012) posit that Nigerians are resilience and hardly give up in the face of challenges that affect their welfare and aspirations and could explain the self help provisions of electricity from privately owned generators. Ayodele (2004) appreciates the linkage between the energy sector and the other sectors of the economy and assert that electricity development and utilization have pervasive impact on a range of socio-economic activities and consequently the living standard of the citizens in the country.

According to Odularo and Okonkwo (2009) energy is a bone for economic growth. They found positive relationship between energy consumption and economic growth in Nigeria and asserts that greater energy consumption means more economic activity of the nation and as a result higher economic growth. He suggests this sector should be given attention for the development of the country.

2.2 Empirical Issues

Buysse et al. (2012) investigated the relationship between electricity consumption, carbon emissions and economic growth in Bangladesh. The results indicate that uni-directional causality exists from energy consumption to economic growth both in short and long run, while bi-directional long run causality exists between electricity and electricity generation. Odularu and Okonkwo (2009) examined energy consumption and economic performance in Nigeria, findings show a positive relationship and economic growth for a period spanning from 1970 to 2005. Ferguson, William and Hill (2000), studies the relationship between electricity use and economic development for over one hundred countries. Their study reveals that wealthy nations have a stronger correlation between electricity use and wealth creation than do poor countries. Again, for the global economy as a whole, there is a stronger correlation between electricity use and wealth creation than there is between total energy use and wealth. And, in wealthy countries, the increase in wealth over time correlates with an increase in the proportion of energy that is used in the form of electricity.

In Spain Ciarreta and Zarraga (nd) examined the linear and non-linear causality between Electricity Consumption and Economic Growth. Findings reveal unidirectional linear causality running from real GDP to electricity consumption and a nonlinear Granger causality between the series in either direction. Masuduzzaman (2012) studies the relationship between economic growth, electricity consumption and investment for Bangladesh through co-integration and causality analysis over the period 1981 to 2011. The results for this study show that long run elasticity of economic growth with respect to electricity consumption and investment are higher than their short run elasticity which implies that over time higher electricity consumption and investment in Bangladesh give rise to more economic growth. Ouedraogo (2010) investigated Electricity Consumption and Economic Growth in Burkina Faso using Co-Integration Analysis for the period spanning from 1968 to 2003. He found that there was a long run bi-directional causal relationship between electricity consumption and GDP and posit that electricity was a significant factor in economic development. Bekhet, and Othman, (2011) examined electricity consumption, consumer expenditure, gross domestic product (GDP) and foreign direct investment (FDI) in Malaysia. The results suggest that electricity consumption is an important element determining economic growth in Malaysia and a powerful tool in executing government policy for energy saving.

Chen, HI and Chen (2007) use different types of energy consumption (electricity) to test the causal relationship with GDP in Asian countries. They used data for 1971 to 2001 period to conclude that there was a unidirectional causality from GDP to electricity consumption in the short run in Malaysia. Mozumder and Marathe (2007) use the Granger causality analysis to analyze causality direction between GDP and electricity consumption. He found that GDP affected electricity consumption and no causality was found from electricity consumption to GDP.

Najid, et al (2012) investigated the relationship between energy consumption and economic growth in Pakistan. The results of Granger causality test show uni-directional causality running from GDP to energy consumption. The results of ordinary least squares test show positive relation between GDP and energy consumption in Pakistan meaning that Pakistan economy is energy dependent. Shortage of energy means lower the economic growth of Pakistan. Ugwu, Nwankwojike, Ogbonnaya, and Ekoi (2012) in studying energy and economic losses due to constant power outages in Nigeria found that the economic losses associated with self generation of electricity is high. Ubi and Effiom (2013) considered the dynamic analysis of electricity supply and economic development in Nigeria. Their result indicates that Per Capita GDP, lagged electricity supply, technology and Capital are the significant variables that influence Economic development in Nigeria. Furthermore, the outcome of the study reveals that despite the poor state of electricity supply, it influences economic growth in Nigerian though its impact is relatively very low.

3.0 Materials and Methods

3.1 Theoretical Framework

To investigate the relationship between economic growth and energy loss, the study employed a type of Cobb Douglas production function with constant return to scale as adopted by Najid etal (2012). The relationship can be expressed as follows:

$GDP = \varphi EC^{\beta 1}$ □…………………………………………1

Where, GDP is the Gross Domestic Product, φ is the total factor productivity, EC is the energy usage (in mw), β_1 is the coefficient of energy consumption and □ is the white noise error term.

The authors, however, did not show the link between the cob- Douglas function and their model in equation 1 and the place of the total factor productivity in production activities.

In its most standard form for production of a single good with two factors, the Cobb-Douglas function is stated as shown below;

$Y = AL^{\beta} K^{\alpha}$……………………………………………2

Where:
Y = total production
L = labor input
K = capital input
A = total factor productivity

α and β are the output elasticities of labor and capital, respectively.

Total-factor productivity (TFP) is a variable which accounts for effects in total output not caused by traditionally measured inputs of labor and capital. If all inputs are accounted for, then total factor productivity can be taken as a measure of an economy's long-term technological change or technological dynamism. Total Factor Productivity is often seen as the real driver of growth within an economy and studies reveal that whilst labour and investment are important contributors, Total Factor Productivity may account for up to 60% of growth within economies (Easterly, 2001)

Therefore, an increase in either A, K or L will lead to an increase in output and vice versa. While capital and labor input are tangible, total-factor productivity appears to be more intangible as it can range from technology to knowledge of worker (human capital). Hence,

$Y = A \times L^{\beta} \times K^{\alpha}$…………………………………………………3

It has been shown that there is a historical correlation between TFP and energy conversion efficiency, such that technology growth and efficiency are regarded as two of the biggest sub-sections of Total Factor Productivity. The assumption is that all forms of technology are energy driven while energy production requires heavy technology. In whichever way therefore, technological progress and energy correlates.

From the foregoing this study considers electricity and gas losses as an aspect of TFP and a factor that can affect production with the assumption that a reduction in them will increase output.

3.2 Model Specification

Considering GDP loss as a function of energy loss, A in equation 3 becomes energy loss (in mw). $GDP = A^{\beta}$………………………………………………4

Where, A is energy loss in form of electricity and gas losses. Equation (4) can be expressed as follows:

$GDP = ELs^{\beta 1} GLs^{\beta 2}$ ………………………………………5

Where EL is electricity loss, GL is gas loss, $\beta 1$, β_2 are negative parameters of the variables. The functional form of equations (5) is presented below;

$GDP = f(Els, Gls)$…………………………………………6

The operational form of equation 5 and 6 can further be written in a linear form by taking the natural log of both sides of the equation.

$lnGDP_t = \varphi_0 + \beta_1 lnEls_t + \beta_2 lnGls_t + \varphi_t$ (7)

Where,

lnGDP = the natural log of Gross domestic product,

lnEls = the natural log of electricity loss,

lnGls = the natural log of gas loss,

β_1, β_2 = the elasticities of energy loss while

φ_0 = the constant term.

'apriori', it is expected that: $\beta_1 < 0$ $\beta_2 < 0$

To ascertain the stationarity of the variables, the unit root test was carried out using the Augmented Dickey Fuller criterion. The linear combination of the variables was obtained employing the Granger representation theorem which confirmed the long run equilibrium among the variables. Due to the rigorous process involved in ascertaining the number of co-integration equation using GRT, the Johansen co integration rank test was used. The error correction model was estimated to obtain the short run behavior of the variable and the speed of adjustment of the model to its long run value. The ECM is estimated as shown below:

$\Delta GDP = \alpha_0 + \alpha_1 \Delta Els_t + \alpha_2 \Delta Gls + \alpha_3 \delta_{t-1} + \varepsilon_t$ 8

where Δ is the first difference operator, δ is the estimated residual from equation (7) ie ($GDP - \square_1 Els - \square_2 Gls$) i.e. the error correction term, and ε_t the error term. The Granger representation theorem requires that the coefficient of the error term in short run equation (8) be negative and statistically significant to confirm the co integration of the variables.

3.3 Sources of data

Data for the study was from the central bank of Nigeria statistical bulletin 2007, 2010 and 2012 and the ordinary least squares method was employed.

4.0 Presentation and analysis of results

The results of the study which includes the stationarity tests, Johansen co-integration test, and the long run and short run estimates are presented as shown in tables 1 to 4 below.

Table 1: Augmented Dickey Fuller Unit root test

variables	Level	First Diff	Remarks.
GDP	-2.369	-6.135	stationary at first diff
Els	-2.488	-5.619	stationary at first diff
Gls	-2.751	-4.997	stationary at first diff

Test critical values at 0.05 levels: -2.94

Results from the above table show that all variables considered in this study have unit root process but are stationary at first difference *I*(1).

Tables 2: The unrestricted co integration rank test (trace and Max Eigen)

No of CEs	Trace	Crt. val	Max Eigen	Crt. val
None*	38.655	29.797	24.009	21.132
At most 1	14.647	15.495	8.386	14.265
At most 2*	6.261	3.841	6.261	3.841

Trace and Maximum Eigen statistics indicates 1 co integrating equation each at 5 % level of significance. * indicates rejection of the hypothesis.

The trace and Eigen maximum tests in Table 2 above revealed that a long run relationship exists among the variables.

Table 3: Ordinary least squares equation, dependent variable, DGDP

Variables	Coefficients	Std Error	T- statistic	Prob.
DGls	-0.375	0.352	-1.065	0.293
DEls	1.326	0.094	14.125	0.000
C	7.811	3.247	2.406	0.021
R^2	0.86			
Adjusted R^2	0.85			
F-statistic	121.074			
Prob(F-stat)	0.0000			
DW	1.542			

The error correction model estimated from equation 8 is presented as follows;

Table 4: ECM result, dependent variable, DGDP

Variables	Coeff	Std Error	T- statistics	Prob. Val
DEls	0.297	0.073	4.04	0.0003
DGls	-0.834	0.223	-3.736	0.0006
(ECM)	-0.285	0.075	-3.837	0.0005
C	0.096	0.035	2.716	0.010
R^2	0.51			
F-Stat	12.335			
Prob(F-stat)	0.000			
DW	2.6			

4.1 Discussion of Results

Results show that gas loss affected the economy negatively in both short and long run. This means that increase in gas loss decreased the gross domestic product in Nigeria within the period of study. Reason for this relationship may not be unconnected with the fact that most industrial and commercial machines in Nigeria as well as most power stations are gas driven. Hence, gas loss or even insufficient supply of it will affect negatively the productive activities of the sectors. On the other hand, electricity loss negated the '*apriori*' expectation. This implies that increased electricity loss increased gross domestic product in Nigeria for the period covering 1970-2012. A possible reason for this outcome is that the Nigerian economy is driven by auto- production of electricity. The implication is that production and other economic activities continued to increase while there was loss of electricity from the providers.

Electricity loss however, is significant in explaining systemic variations in gross domestic product in both short and long run. This is because it drives all productive, research and development processes and a persistent trend may cripple economic activities because of high cost private electricity generation. Gas loss on the other hand, is significant in the short run but insignificant in the long run in explaining systemic variation in GDP. The long run result showed that gas loss was not a major factor determining systemic variations in gross domestic product of Nigeria within the period of study; rather factors such as electricity loss play a more significant role hence, an insignificant result. Also very important to note is the effect of all variables not capture in the model, represented by the intercept term. Its probability value of 0.021 and the standard error of 3.25

imply its significance in explaining changes in gross domestic product of Nigeria with the period under study. Though the Durbin Watson shows a weak autocorrelation, the F-statistics and the R^2 shows that the explanatory variables collectively explained variations in gross domestic product of Nigeria, hence, a well specified model. The error correction test shows that the speed of adjustment is 29 per cent. This means that the model will return to equilibrium at the rate of 29 per cent when the variables are above their equilibrium.

4.2 Trend Analysis

Electricity loss is electricity generated but not consumed due to transmission and distribution and not those un-generated or wasted. Electricity loss covering the period of study is 23,178.9 mw representing an average of 551.88mw per annum. Electricity loss increased in the 80's to 3912 mw from 723.7mw in the 70's or a 441 per cent increase. It further increased in the 90's to 7168.2 mw and 11374.5 mw in the 2000'(see appendix 2).The study connects the continuous increased loss of electricity to inadequate maintenance of equipments, investments and expansion, and robust policies in the power sector.

In Nigeria, gas flaring or loss is attributed to inadequate storing due to lack of development in the sector. Total gas loss within the period under consideration is 887,917.4million cubic meters representing an average of 20,649.25 million cubic meters loss per year. Gas loss in the 80's reduced to 148,292 million cubic meters from 191,273 million cubic meters in the 70's representing a 22.5 per cent reduction. The loss increased in the 90's and 2000's to 251,718 million cubic meters and 296,634 million cubic meters respectively or a 69.7 per cent and 17.8 per cent increase respectively. The increase from the 90's to 2000's was 0.8 per cent (see appendix 1). This study does not have any explanation for the decrease in gas loss in the 80's but attributes the increase in loss in the 90's and 2000's to increase in production of gas in those year.

5.0 Conclusion and Policy Implications

The study examined the effect of energy loss on Nigeria economy for the period of 43 years. Based on literature, the study adopted the Cobb Douglas production function as its theoretical framework. From the basics of this framework, and considering the centrality of energy in modern economies, a model was specified using real GDP as a function of electricity and gas loss. The study applied methods of econometric tests of stationarity, co integration and ordinary least square. Although the study did not dwell on the causes of energy loss in Nigeria, a major finding is that energy loss affects the gross domestic product of Nigeria in both short and long run. The study concludes that a drastic reduction of annual average electricity and gas loss of 551.88mw and 20649.24 million cubic meters respectively will increase productive activities and subsequently the GDP. Government should reinforce Policy issues on gas flaring to reduce the quantity of gas loss. In the same vein, investment on modern technology in power sector will in no small measure reduce power transmission and distribution losses.

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Appendix
Charts

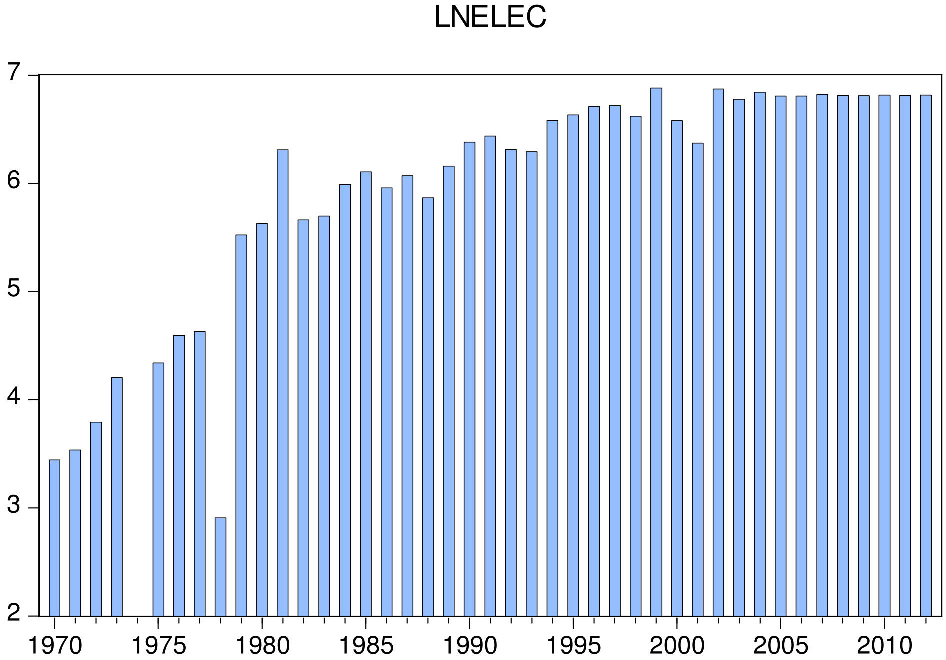

Fig 1 electricity loss 1970-2012

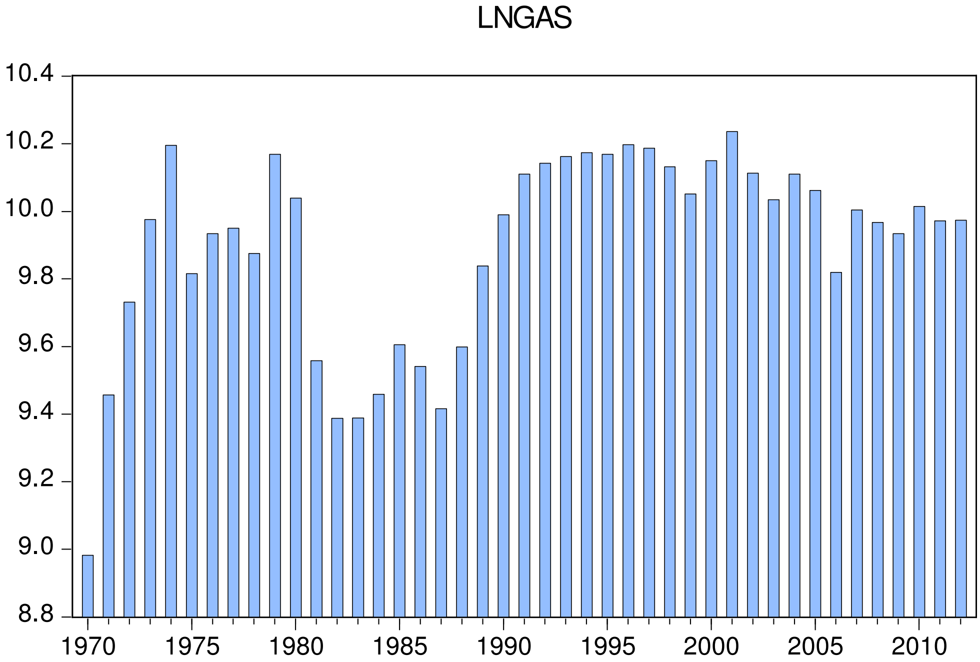

Fig 2 Gas loss 1970-2012