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Electric Energy Pricing in a Deregulated Economy: A Case Study of Delta Thermal Power Plant, Delta State, Nigeria

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Abstract: Unit electric energy pricing in a deregulated economy: a case study of delta thermal power plant in Nigeria is presented in this research. The research became necessary because of the clamour in the need to attain sustainable development without considering the indices that play vital role in nations development politically, socially, infrastructuraly and economically. Thus, for a country not to continuously have depreciated currency one of the parameters that must seriously be guided are the GDP/GNP indices and for the GDP to raise the earned foreign reserve that guarantees imports power, the local resources must be adequately harnessed and sustained, hence the importance of a vibrant power sector that ensures stable unit electric energy cost. The research reviewed, the way forward for power industries in Nigeria in a deregulated economy, the analytical principles guiding GDP/GNP estimations, cost components of electricity generation and tariff were extensively looked at. Findings revealed that index values for the Nigeria GDP/GNP are not encouraging when compared with nations of the world that are not endowed with the natural resources the country is blessed with. The cost of generating electricity in the thermal station for the period presented, considering locational marginal pricing in a competitive market forces, for power industries in Nigeria that generates <2800 MW on daily basis as at June, 2009 to survive in the present day deregulation and provide power in acceptable availability standard close to 99.8% the current subsidy by the Federal Government of Nigeria demands for urgent review with the enacted regulatory bodies in order to improve on the position she currently occupies in the survey conducted by Finfacts Ireland. This stand is important because the station with utilization factor of 62.48:1 in 2006, which has not improved in 2009, if not for government funding the station ought to be bought over by striving power utilities in developed nations. The research also, revealed an average annual unitcost for the period reviewed to be #30.73 K kWh^{-1}, while Power Holding Company of Nigeria (PHCN) PLC current electricity tariff range from #6.00/-12.00 kWh^{-1} depending on the type of load and demand level.

Key words: Cost, energy charge, gross domestic product, gross national product, deregulated economy, regulatory bodies

INTRODUCTION

Discovering of the various forms of energy resources has made man better master of the environment. The planning, discovering, processing and utilization of these resources in form of electric energy entail the engineering, marketing and effective management for sustainable development of any nation. The cost of generating, transmitting and distributing electricity the prime mover of modern economy to a very large extent determines the Nations Gross Domestic Product (GDP) and Gross National Produces (GNP) indices. The GDP index portrays the social status, level of awareness, security, infrastructural, scientific, agricultural and industrial revolution of a country in strict term it gives the value of all final goods and services produce in a country in 1 year (Wikipedia, 2009), while the GNP and Net National Income (NNI) index shows the summation of the real-income from abroad to the GDP to obtain the GNP. GNP gives the value of (final) goods and services in a country in one year by the nationals, plus income earned by its citizens abroad, minus income earned by foreigners in the country (Wikipedia, 2009) (i.e., the total output of all national of region, e.g., Nigeria). In its true sense, this index gives the level of foreign reserve, technological development, international political will and social stability of the country that attracts foreign investors. Increase in the number of

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investors in any nation boosts her industrial and economic revolution. The GDP/GNP and its indices for Nigeria the leading issues identified is Iyoha and Itsede (2002).

- Evolution of the real or productive sector, in this wise urbanization rose to 14% in 1960 and 41% in 1997, while manufacturing sub-sector contributed 3.8% in 1969 and 4.85 in 1997 of the GDP
- Evolution of the financial sector and public sector, which are under developed, unorganized and characterized by dualism, market segmentation and spatial fragmentation, resulting in money and capital market that are thin and shallow. In recent time, the ratio of market capitalization to GDP has risen significantly
- Evolution of the external sector and the problem of rising external debt, since the shift from the era of agricultural produce to oil boom in the mid seventies the open market has not experienced any significant growth

Some factors that affect GDP and GNP are:

- The illegal economy
- The problems of goods and services
- Other non marketed activities and imputation
- Handling of government activity and badly measured output
- Other omitted market transaction and inventory valuation adjustment
- National income data revisions
- Depreciation
- Poor or lack of information
- Double counting

In a deregulated economy, the invisible hand of demand and supply i.e., the price mechanism determines the performance of the economy. Deregulation is said to mean allowing the economy to regulate its activities as a result of the market forces. Deregulation in essence is a systematic operation of an economy without government interference, its state of affairs is regulated by the performance of the economy itself, sector by sector. Most of government establishment like NITEL, NNPC, State Water boards, NEPA now PHCN PLC and other public utilities have all failed due to corruption, unpatriotic attitude and misappropriation of government funds and government lack of necessary control measures to curb this menace, it therefore, behooves the government to embark on privatization, which now characterize the Nigerian economy to help replace the old order of government ownership of parastatals or establishment except only in some sensitive jurisdiction as it is in the USA.

The current electricity tariff in Nigeria, cannot cover the cost of unit energy no matter how efficiently supervised and managed as often said by several analysts to justify why government should let go public utilities like PHCN into hands of private investors. In view of the foregoing this study looks at the equations of GDP/GNP, the statutory roles of regulatory bodies in a deregulated economy and the principle of operation of gas/steam power plants. The energy generated profile for 4 years, economics of supply and demand as it affects the power plant and findings are also presented in this research. After the conclusion, the reference presents the guide that enabled us to achieve this research.

MATERIALS AND METHODS

In this research, national dailies, websites, PHCN PLC annual technical reports and the thermal station efficiency department and logbooks formed the materials we consulted. The methodology adopted includes:

- Mathematical and Economic analysis of principles
- Comparing economic and social indices of nations
- Reviewing the ethics of deregulated economy
- Chemical processes that yields maximum power output
- Analysing the system to determine generation cost
- Concluding the research from the analyses and findings

GDP/GNP equations: The equations used in evaluating these indices are (Wikipedia, 2009):

The basic formula for domestic output:

$$GDP = C + I + G + (X - M) \quad (1)$$

Where:

- C = Household consumption expenditures/personnel consumption expenditures
- I = Gross private domestic investment
- G = Government consumption and gross investment expenditures
- X = Gross export of goods and services
- M = Gross import of goods and services
- X-M = Often written as Nx, stands for net exports

The equation for measurement of national income by income method:

Table 1: Some nation's power availability, GDP/GNP and regulatory bodies in the world (Abdul-Razaq, 2006; Workman, 2006; CIA, 2008; Olumuyiwa, 2008)

Countries	Population (Million)	Installed generating capacity (MW) For 2005	Peak demand (MW)	Spin reserve (MW)	Energy production for 2005 (Kwh capital^{-1})	GDP for 2008 (Million US$)	Total energy production (TWH)	Regulatory bodies
USA	296.68	-	-	-	13.640	14.330,000	4,046.60	
Germany	82.46	-	-	-	7.111	3,818,000	586.41	
UK	60.22	72,000.00	55,000.00	17,0000	6.254	2,787,000	376.63	OFGEM
South Africa	4,648.00	42,000.00	38,000.00	-	4.848	300,400	227.30	NERSA
China	1,304.50	-	-	-	1.781	4,222,000	2,322.72	
India	1,094.58	-	-	-	480	1,237,000	525.93	
Ghana	22.11	1,490.00	-	Nil	271	17,720	5.99	
Nigeria	131.53	5,898.00	6,500.00	Nil	136	220,300	17.90	NERC
Congo	57.55	180.00	-	Nil	144	12,960	5.35.00	
Tanzania	38.33	881.00	-	Nil	61	20,630	2.36.00	
Zimbabwe	13.01	2,099.00	-	Nil	961	4,548	12.50	
Isreal	6.92		-	-	6.759	188,700	46.80	
Kenya	34.26	1,211.00	-	Nil	144	31,420	4.93	
Cameroon	16.32	902.00	-	Nil	214	25,000	3.49	
Egypt	74.03	18,474.00	-	Nil	1.226	158,300	90.73	

$$\begin{aligned}\text{NDP at factor cost} = {} & \text{Compensation of employee} \\ & + \text{Operating surplus} \\ & + \text{Mixed income of self employee}\end{aligned} \quad (2)$$

$$\begin{aligned}\text{National income} = {} & \text{NDP at factor cost} + \text{NFIA} \\ & \text{(net factor income from abroad)}\end{aligned} \quad (3)$$

Some nation's power availability, GDP/GNP and regulatory bodies in the world are as shown in Table 1.

To highlight the importance of Table 1, the role of energy in sustainable national development the price surveys covering 192 countries in the world conducted by the international comparison program placed Nigeria in the 149th position with 520 for 2005 and 640 for 2006, as the GNI per capita estimate into international dollars using Purchasing Power Parity (PPP) rates (Finfacts Ireland, 2009).

The country's electricity utility up to may, 2009 on average, generates <2800 MW daily owning to corruption, political, lack of fund and mismanagement reasons. Despite these lapses the federal government intends to increase power supply to 10,000 MW by year 2017 by presidential mandate. As of today Nigeria needs 1 billion ($Ibn) per year over the next 10 years to satisfy our power requirements (Obikwelu, 2006). In view of the huge financial involvement and nation treasury cannot fund this hence, the reform program of government in the power sector. The reform objectives also include:

- Unbundling of NEPA (PHCN, plc) into eighteen new business unit
- The establishment of an independent regulating agency, Nigeria Electricity Regulatory Commission (NERC)
- The development of a wholesale electricity market, the establishment of a Consumer Assistance Fund to ensure the efficient and targeted application of subsidies to less privileged members of society
- The establishment of a rural electrification agency to manage the rural electrification fund and ensure a separate but equally focused application of subsidies thus, ensuring the efficiency in the distribution of scarce resources for competing rural electrification project

NERC statutory role: To ensure the delivery of an efficient power supply in Nigeria, the Nigeria Electricity Regulatory Commission (NERC) was established on October 31st 2005, under the Electric power Sector Reform Act 2005, as an independent regulator. There statutory function includes (Abdul-Razaq, 2006; Momoh, 2003):

- Evolve policies to attract investment loc ally and internationally
- Develop and enhance indigenous capacity in the electricity sector
- Issue license to utilities engaged in generation, transmission and distribution
- Monitor the efficient functioning of the licenses
- Fix transmission tariff and retail consumer tariff
- Arbitrate in dispute amongst licenses
- Ensure viability of the electricity industry
- Formulate transparent policies regarding subsidies
- Protect consumers interests
- Promote efficient and environmentally sound policies

The licensing regime established is in line with global best practices. The main issue here revolves around the setting of tariffs that will not be burdensome on the consumers, while at the same time ensuring a return on investment for the operator.

Basic operating principle of the gas turbine: A compressor draws gas (generally air) into the turbine, fuel is burned in a combustion chamber to heat the gas and the expansion of the gas through the turbine blades transfers the kinetic energy of the gas to the rotational energy of the turbine (i.e., in very simple terms the gas is burnt to release heat energy, which is then used in heating water to raise steam. The pressurized steam then does work on the turbine blades coupled to alternator to generate electricity.

The two most important determinant of gas-turbine performance are the pressure ratio of the compressor and the working temperature of the gas. Both factors act to boost kinetic energy-the compressor working to increase the total mass of gas flowing through the turbine and the temperature determining the mean Kinetic energy of the individual gas molecules. Overall organization of gas-turbine-based generating plant is with a view to fundamentally improving the maximum realizable thermodynamic efficiency.

Thermal stability of blade materials has been the main limitations on gas-turbine output. The high gas temperateness-up to 1300°C and high rotational forces induce high creep stress in turbine blades, causing distortion and failure. Temperature limits have usually been the governing factor on turbine development and major advances can normally be tied to improvements in blade technology (e.g., blade cooling extends the material life of turbine blades). Design for heat recovery means reduced exhaust mass flow and higher temperatures. Current designs trends are leading to gas turbines with pressure ratio of 14:1 (Haigh, 1991) and exhaust temperatures approaching 600°C and having reliability of up to 8000 h $year^{-1}$ (Kuale, 2004). It's important to note that impurities in the steam/gas mix can not only damage turbines blades, but can also corrode the heat-exchanger surfaces. Natural gas remains the most popular choice as it requires little or no pre-treatment and produces few noxious emissions (i.e., faster and cheaper to build as well as more environmental friendly). For a given quantity of gas, in which the single stage is SMW, the combined will give 1.5 SMW. Other that Gas-fired/combined-cycle technology are used for base-load duty, other advantages includes; gas resources for power generation will last longer, less gas consumption/kWh, final cost of 1 kWh is less than that of single cycle and produces few noxious emissions to the environment (Kuale, 2004). Other variety includes gaseous or liquid fuels, solid fuels (e.g., coal, lignite or bituminous oil in combined-cycle plant, it must be extensively treated) and viscous fluid fractions of petroleum. The equations those governors this electromechanical energy-conversion includes (Matsch, 1997):

Chemical energy input = Mechanical energy input
= Electrical energy output
+ Increase in stored energy in
coupling field + Associated losses (4)

In differential form, the energy balance Eq. 5 is:

$$\delta W_{mech} = \delta W_{elec} + \delta W_{fld} \quad (5)$$

Where:

δW_{mech}	=	Mechanical energy in differential form
δW_{elec}	=	Electrical energy in differential form
δW_{fld}	=	Energy absorbed by the coupling field in differential form

The conventional conversion device, like steam heat engines its efficiency is governed by the carnot cycle given as:

$$\text{Carnot efficiency, } \eta = 1\text{-}T_c/T_H \approx 40\% \text{ max} \quad (6)$$

Where:

T_C	=	Temperature of the cold sink at absolute temperature
T_H	=	Temperature of the hot source at absolute temperature

Energy generated profile: Sapele Oghorode power plant has its first 6 steam turbine units with installed capacity of 720 MW commissioned in 1956, while the four gas/steam-turbine units with installed capacity of 300 MW where commissioned in 1978. The expected full load installed capacity is 1020 MW, but the generated electricity from the power plant for four years is as shown in Table 2. Station gas rate used to determine the rate, at which the gas used in electricity generation is produced and at which it aids in the generation process and the Station thermal efficiency used in the determination of the efficiency of the overall performance of the plant in terms of its gas production rate for the year 2006 are as shown in Table 3. Factors like daily load factor, annual load factor, over all system load factor, Plant factor (capacity factor) and Station utilization factor all indicate how well the system capacity is utilized and operated.

Table 2: Available energy from gas/steam oghorode Sapele Power Plant (2006)

	2003			2004			2005			2006		
	Generated energy	Energy consumed internally	Assumed energy sold	Generated energy	Energy consumed internally	Assumed energy	Generated energy	Energy consumed internally	Assumed energy	Generated energy	Energy consumed internally	Assumed energy
Months	(MWH)											
Jan.	79001	5534	73467	95092	7096	87996	93980	7591	86389	-	536	-
Feb.	73083	5203	67880	90725	6154	84571	72501	611	66390	-	555.5	-
Mar.	60423	5609	54814	101436	6924	94512	109927	8270	101657	-	1338	-
Apr.	87561	6522	81039	91208	6236	84972	99759	7799	91960	-	650	-
May	62600	4450	58150	116343	7225	109120	92431	7692	84739	-	584	-
June	86143	5666	80477	61123	4412	56711	101247	7036	94210	-	588	-
July	91261	5936	85325	48167	5297	42870	95555	6985	88570	-	559.4	-
Aug.	76479	4949	71530	62255	4780	57475	90632	6314	84318	17297	527	16770
Sep.	83486	6044	77442	85564	6173	79392	76739	1149	75590	41648	2478	39170
Oct.	69616	5848	63768	69616	5848	63768	20487	1087	19400	44961	3811	41150
Nov.	53944	3550	50394	98176	6133	92043	25156	1179	23980	43129	4679	38450
Dec.	81043	5853	75190	80882	5407	75475	-	589	-	38044	2474	35570
Total	904,640	65,164	839,476	1,000,589	71,685	928,904	878,417	61,803	817,230	185,079	187,799.9	171,110
Station utiliz. factor	12.78:1	-	-	11.56:1	-	-	13.16:1	-	-	62.48:1	-	-

Table 3: Station gas rate and thermal efficiency for 2006 (Sapele Power Plant, 2006)

Months	Gas rate (SCF/MWH)	Gas rate (SCF/MWH)	Thermal efficiency η_T (%)
Jan.	-	-	-
Feb.	-	-	-
Mar.	-	-	-
Apr.	-	-	-
May	-	-	-
June	-	-	-
July	-	-	-
Aug.	18018. 00	509. 91	16. 00
Sep.	15076.00	426.67	17.78
Oct.	13140.11	371.87	19.84
Nov.	12976.02	402.15	19.57
Dec.	14210.00	415.56	18.75
Mean	14684.03	425.23	18.39

Table 4: Some of the unit energy cost components (Sapele Power Plant, 2006)

Variables	2003	2004	2005	2006
Wages and man- power cost	386,421,860.17	401,317,410.00	468,110,740.28	517,240,111.18
Insurance cost	28,117,015.51	36,017,586.05	42,011,413018.00	59,117,842.15
Oil cost	41,687,137.18	73,028,512.14	92,471,333.00	108,014,146.15
Cost of spares	78,558,241.00	115,131,872.33	122,212,715.05	148,315,440.00
Cost of gas	193,803,491.00	202,855,214.00	188,148,438.00	78,427,872.00
Cost of dematerialized water	98,427,408.00	18,435,832.00	14,354,592.00	5,398,320.00
Contingencies	52,118,240.00	71,018,742.00	48,217,812.00	72,805,111.00
Fuel cost	19,514,357.00	19,833,876.01	18,881,308.58	8,808,188.28
Total	810,222, 341.80	937,599,044.50	994,408,352.10	998,127,329.70

Economics of supply and demand: In this study, the ex-power plant tariff based on type A was used because of the difficulties in accessing data. In a dynamic power systems, input indexes (prices paid by producers) and output indexes (prices received by producers), coupled supply and demand, transmission cost and Locational Marginal Pricing (LMP), incremental product cost, price elasticity of consumers dictates utility supply tariff. Transmission constrains limiting power flow on the grid and economic dispatch also has effect on tariff since payment of energy consumed is base on energy consumed and not estimation to drive in competitive marketing and not dissatisfaction on consumers. The LMP congestion pricing approach ensures perfect compressibility between bilateral and spot market traders expressed as:

$$\begin{aligned}\text{LMP} = &\ \text{Generation marginal cost} \\ &+ \text{Transmission congestion cost} \\ &+ \text{Cost of marginal losses cost}\end{aligned} \tag{7}$$

Based on the information gathered from the station, the cost components considered in Table 4 were used in determining the unit energy cost shown in Table 5.

Table 5: Annual unit energy cost (Sapele Power Plant, 2006)

Years	Unit energy cost #/KWH
2003	22.00
2004	19.99
2005	21.24
2006	37.79
2007	49.86
2008	33.50
Average annual unit energy cost	30.73

RESULTS AND DISCUSSION

In computing the unit energy cost of a typical gas-firing plant data in a Nigeria environment, 25 mscf of gas yields 13.6 MWof electrical power and the price of natural gas benchmarked with the price of Low Pour Fuel Oil (LPFO) or industrial fuel by Nigeria Gas Company (NGC) Limited a subsidiary of Nigeria National Petroleum Corporation (NNPC) at 1000 stranded cubic feet of #335.06 (Ekanem, 2004) were considered. Looking at Table 2, of the installed capacity of 1020 MW, the highest available power was 114.22 MW in 2004, while in 2006 the available power from the station became 21.13 MW from the units functioning.

This trend of power availability reflects how effectively managed the station is in terms of downtime, spare parts, testing instruments and attitude to research, availability of fund, decision making, pipe line vadalization etc. That supply cost of goods and services is dynamic and is presented in Table 4 and in order to justifier that the present tariff covers the unit energy cost; Table 6 helps in this regard. The electricity tariff in Table 6 can be expressed mathematically in 2 parts (Symonds, 1980):

$$\begin{aligned}\text{Electricity tariff} &= \text{Constant charge} + \text{Variable charge}\\ &= (\text{Fixed charge/Month}\\ &\quad + \text{Meter maintenance charge/Month})\\ &\quad + (\text{Demand charge/kVA}\\ &\quad + \text{Minimum charge/month})\end{aligned} \quad (8)$$

Looking at the figures, shown in Table 6 PHCN plc tariff does not cover her average cost of production inclusive of generation (#5-7.00), transmission (#2.00) and distribution (#3.00) costs, which for now stands at #10.00 to #12.00/kWh (Afolabi, 2008). In order to compare the cost of selling generated electric energy from a thermal plant with tariffs obtained in developed nations. Table 7 shows, the tariff of some nations in the world.

Table 6: New tariff structure by PHCN 1st February, 2002 (PHCN, 2002)

Type of load	New tariff codes	Customer demand levels	Energy charge kWH^{-1} #: K
Residential	R1-R5 (MD)	<5 kVA to <20 MVA	1.20-8.50
Commercial	C1-C4 (MD)	<5 kVA to <20 MVA	6.50-8.50
Industrial	D1-D5	<5 kVA to >2 MVA	6.50-8.50
Street lighting	S1	1ph, 3ph	6.50
Special tariff class	AI-A6	<15 kVA to <20 MVA	5.80-12.00
Welders	D1, D2	>5 to <15 kVA	6.50
	D2, D4	>15 to <45 kVA	8.50
Staff	S1-S6	<5 to <5 kVA	4.00
Pensioners	P1-P6	<5 to <5 kVA	4.00

Table 7: Electricity tariffs of some nations in the world

Countries	Tariff (Cents kWh^{-1})
USA	8.10
UK	11.10
Spain	14.30
Mexico	5.90
Germany	15.20
Japan	21.20
Indian	3.40
Nigeria	3.00-6.00 not a definite value

CONCLUSION

Every government owned and wholly managed utilities in Africa are characterized with failure and non-profit yielding set-up. If public utility must be managed to break-even point and ensure steady power supply for a sustainable development the present power holding company of Nigeria as a matter of urgency must be fully debundled and deregulated to allow free supply and demand market. When, this is done it will attract foreign investors with technical know-how and financial resources to be major player in our power industry that have plunged the nation into power mess. For any nation to have attractive GDP and GNP its power reserve should almost close with the country peak load demand. Competitive economy to a very large extent suppresses corruption, mismanagement, tribalism and all forms of vices that militate against business growth, be it public or private set-up, it's objective cost implication must out weight the investment. In this wise, the unit energy cost comparing Table 5-7 for the period reviewed excluding the transmission congestion and distribution costs of electricity to end users are far too low considering the present tariff currently operated by PHCN, the only body (i.e., public enterprise) allowed by law to generate, transmit and distribute electric power in Nigeria to pay for the investment. Based on the foregoing the present privatization of PHCN into GENCOS, TRANSCOY, DISCOS should be pursued with all intent and purpose, for the quality and quantity of electricity generated and made available to the end users to a very large extent determines the total value of goods and services a nation can produces, which translated to income and development of the citizens and nation in general.

In summary, there is no general agreement regarding precise relationship between government spending and economic growth, using 96 developing countries, inferred that big governments measured by the share of government consumption expenditures in Gross National Product (GNP) or Gross Domestic Product (GDP), reduced the growth per capital incomes (Finfacts Ireland, 2009). It stated that other variables influencing economic growth includes per capital income, the structure of production, population and global economic conditions. Long-term development effort; like President Umaru Musa Yar' Adua seven points agenda in Nigeria must evolve strategies that will move the nation low-skill and low-productivity sectors to skill-intensive and higher-productive ones (Iyoha and Itsede, 2002). The non definite unit energy cost as reflected in Table 7 operate able for a time considering all constraints gives concern to foreign investors in Nigeria power sector. In that deregulated electric utilities base rate or tariff schedule on their production cost, which is proportional to energy charge and peak demand, these 2 parts depend on time of day and time of year and this make electricity pricing simpler (Borbely and Kreider, 2001). Also, of interest from this research is that deregulating, debundling and restructuring our power sector, with the present state of the power stations producing electric energy of 7.82% for 2003 and 1.60% for 2006 negates competitive market economy and principles of return on investment.

REFERENCES

Abdul-Razaq, A., 2006. Licensing regime under the Electricity Regulatory Commission (NERC). PHCN Official Journal of News/Review, pp: 28.

Afolabi, A.D., 2008. Investigation of electricity energy demand in Nigeria form 1978-2006. B. Engineering. Project work, Electrical/Electronic and Computer Engineering, Benin University, Nigeria, pp: 38.

Borbely, A.M. and J.F. Kreider, 2001. Distributed Generation: The Power Paradigm for the New Millennium, CRC Press, Boca Raton London New York Washington D.C., pp: 219-220. ISBN: 0-8493-0074-6.

Ekanem, V.B., 2004. A research project on the use of combined cycle natural gas-fired turbogenerator. (A case study of Akwa Ibom State), Project, work, Electrical/Electronic Department, University of Benin, Nigeria.

Finfacts Ireland, 2009. Global income Per capital from World bank Development Indicators 2007, Feb. 2008: International Comparison Program, pp: 1-9. http://www.finfacts.com/biz10/globa/worldincomepercapital.htm.

Haigh, I.T., 1991. Lighter Fuel the Gas Turbine comes of age. IEE Review, pp: 97-102.

Iyoha, M.A. and C.O. Itsede, 2002. Nigeria Economy: Structure, growth and development. Mindex Publishing Co. Ltd. Benin, Nigeria, 39 (112): 189. ISBN: 978-8035-49-3.

Kuale, P.A., 2004. Independent Power Producers in the Power Supply Industry.

Matsch, L.W., 1997. Electromagnetic and electromechanical machines. A Donnelley Publisher, 666 Fifth Avenue, New York, 10019, pp: 1-6. ISBN: 0-7002-2501-3.

Momoh, J.A., 2003. Proceedings of the National Engineering Conference and Annual General Meeting LAGELU 2003 of the Nigeria Society of Engineers, Ibadan, Oyo State.

Obikwelu, G.N., 2006. Deregulated and Commercialized Natural Gas Pricing: A Challenge to local electricity generation. PHCN Official Journal of News/Review, pp: 28.

Olumuyiwa, S., 2008. Why Africa Lags Behind in the Energy Sector: A Study Presented to the OfID Conference on Energy Poverty in Sub-sahara Africa. Abuja, Nigeria.

PHCN, 2002. New Tariff Structure by PHCN. PHCN, Coporate Head Office, Abuja, Nigeria, pp: 1-2.

Sapele Power Plant, 2006. Sapele, Oghorode Power Plant Efficiency Logbook. Delta State, Nigeria.

Symonds, A., 1980. Electrical Power Equipment and Measurements (With Heavy Current Electrical Applications). 2nd Edn. McGraw-Hill Book Company (UK) Limited.

Wikipedia, 2009. Measures of national income and output, pp: 1-5. http://en.wikipedia.org/wiki/measures_of_national_income-and-output.

Workman, D., 2006. World's Poorest Countries: Lowest GNP Nations Highlight African Poverty. Suite 101TM. com. The Genuine Article Literally, pp: 1-3. http://internationaltradesuite101.com/article.cfm/world_s_poorest_countries.