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Sustainable Energy Future for Nigeria: The Role of Engineers

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Abstract. Energy is an essential input for social development and economic growth. It provides basic needs and services such as heating, cooling, cooking, lighting, and transportation and is a critical production factor in virtually all sectors of industry. Sustainable energy development has currently taken over the lead as the most focal point in determining the developmental level of countries in the world. This paper discussed the current status of energy, examined the development and energy infrastructure in Nigeria. Engineers have a unique role to play in order to achieve this objective when compared with other occupations in industrial organizations. They play a semi-independent role influenced by their national diversity. Engineers, therefore, are under increasing pressure to redefine their roles and re-equip themselves with necessary skills and knowledge to meet adequately the contemporary changes. The paper also looked at the challenges engineers face in carrying out this role and also made suggestion of the possible ways of addressing those challenges.

Keywords: sustainable energy, development, infrastructure, engineer's role.

1.0 INTRODUCTION

Energy is an essential input for social development and economic growth. It provides basic needs and services such as heating, cooling, cooking, lighting, and transportation and is a critical production factor in virtually all sectors of the economy. Progress towards sustainable energy goals requires the assessment of a broad range of relevant and interrelated issues that need to be analysed with quantifiable energy parameters or energy indicators (Unachukwu 2009). Today,

tens of millions of people are unable to reach their potential because they lack sufficient resources: access to clean, affordable energy being one of the major obstacles to their growth and development. Hundreds of millions more, particularly women and children, face a life of drudgery, increased morbidity and premature mortality because of the energy they do consume (EIA 2010). This can all be changed by building on the successes, sharing best practices, and working together to mainstream sustainable energy future.

Energy development is the effort to provide sufficient primary energy sources and secondary energy forms to fulfill civilization's needs (Unachukawu 2009). It involves both installation of established technologies and research and development to create new energy-related technologies. Major considerations in energy planning include resource depletion, supply production peaks, security of supply, cost, impact on air pollution and water pollution, and whether or not the source is renewable. Technologically advanced societies have become increasingly dependent on external energy sources for transportation, the production of many manufactured goods, and the delivery of energy services. This energy allows people who can afford the cost to live under otherwise unfavorable climatic conditions through the use of heating, ventilation, and/or air conditioning. Level of use of external energy sources differs across societies, as do the climate, convenience, levels of traffic congestion, pollution, production and greenhouse gas emissions of each society. Expanding human populations generally require an increased consumption of and dependence on external energy sources. Research, development and practice of energy efficiency and conservation by the populace allow a degree of mitigation of this dependence. Wise energy use embodies the idea of balancing levels of human comfort and energy consumption by researching and implementing effective and sustainable energy harvesting and utilization measures.

At this point, looking at the sustainable Energy future for the country, it is obvious that Engineers have great role to play for it to be actualized. Therefore we need to define who an Engineer is, so as to have a clear understanding of what roles an

engineer will play to make Nigeria have a future with sustainable energy, as is discussed later in this paper.

2.0 ENERGY AND DEVELOPMENT IN NIGERIA

Nigeria is a country that is blessed with abundant natural resources such as fossil fuels and renewable energy. It has the proven reserve of crude oil of about 35 billion barrels and 187 Trillion SCF of gas as shown in table 1.0. In terms of renewable energy, Nigeria has hydro power potential of about 15,000 MW (i.e. Large and Small hydro) and solar irradiation of 3.5 – 7.0 KWh/m^2/day which described in details in table 2.0. The estimated total energy consumed in Nigeria for the period of 2004 to 207 is in the range of 23.36 – 40.89 million toe while the per capita energy consumption of 0.209 to 0.324 toe/capita (CBN Annual report 2004 & 2007)

Table 1.0: Fossil and Nuclear Type Resources

S/No	Resource Type	Reserves		Production	Domestic Utilization
		Natural Units	Energy Units (Btoe*)		(Natural units)
1	Crude Oil	35 billion barrels	4.76	2.5 million barrels/day	450,000 barrels/day
2	Natural Gas	187 Trillion SCF	4.32	6 Billion SCF/day	3.4 billion SCF/day
3	Coal and lignite	2.175 billion tonnes	1.92	(insignificant)	(insignificant)
4	Tar Sands	31 billion barrels of equivalent	4.22	-	-
5	Nuclear Element	Not yet qualified	-	-	-

(Source: Energy Commission of Nigeria 2010)

Table 2.0: Renewable Type Resources

S/No	Resource Types		Reserves			Production	Domestic Utilization (Natural Units)
			Natural Units	Energy Units (Btoe)			
1	Hydropower Large		11,250MW	0.8 (over 38yrs)		1938MW (167.4 million MWh/day)	,,
2	Small Hydropower		3,500MW	0.25 (over 38 yrs)		30MW (2.6 million MWh/day)	2.6million MWh/day
3	Solar Radiation		3.5 - 7.0 KWh/m²/day(485. 1million MWh/ day using 0.1% Nigeria land area)	15.0 (38 years and 0.1% Nigeria land area)		Excess of 240 KWp of solar PV or 0.01 million MWh/day	Excess of 0.01million MWph/day of solar PV
4	Wind		(2-4) m/s at 10m height	8.14 (4m/s@ 70m height Φ20m windmill, 0.1% land		„	„
5	Biomass	Fuel wood	11 million hectares of forest and woodland	Excess of 1.2m tonnes/ day	,,	0.120 million tonnes/day	0.120 million tonnes/day
		Animal waste	211 million assorted animals		„	0.781 million tonnes of waste/day	Not available
		Energy Drop & Agric Residue	72 hectares of Agric. Land		„	0.256 million tonnes of assorted crops/day	Not available

(Source: Energy Commission of Nigeria 2010)

Nigeria is the largest oil producer in Africa, the eleventh largest producer of crude oil in the world and a member of the Organization of Petroleum Exporting

Countries (OPEC). In 2006, Nigeria's total oil exports reached an estimated 2.15 million bbl/d. Approximately one million bbl/d (42%) of that quantity was exported to the United States, Europe 19% , South America 7.6% and the remaining to Asia and the Caribbean (Central Bank of Nigeria 2009). Despite shut-in production, major importers of Nigerian crude have experienced little to no decrease in Nigerian crude imports over the past 15 months. The steady exports suggest that the new production capacity additions (approximately 545,000bbl/d) have mostly offset shut-in production.

Nigeria is the 7th country in terms of proven reserve of natural gas in the world which was estimated to last for over 100 years (Facts & Figures on NLNG 2011).

Fig 1.0 shows the natural gas production for 20 years (1992 – 2012) with the highest production of 73,019 mmscm achieved in 2012 (NNPC ASB 2002 & 2012). Nigerian Natural gas is exported to countries such as Spain, France, Portugal, Italy, Turkey, Mexico and the United State (Facts & Figure on NLNG 2011).

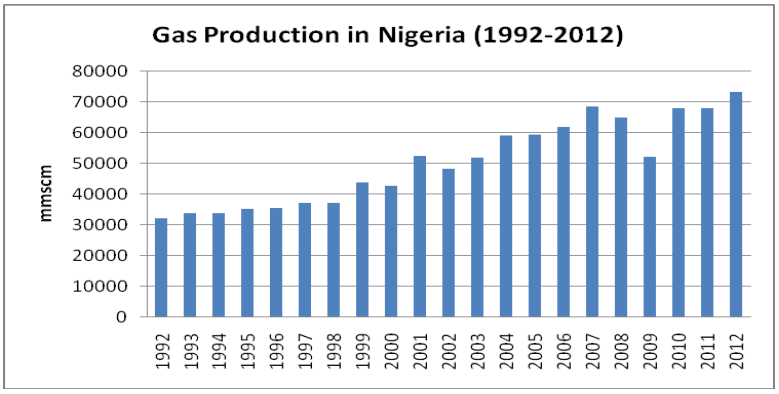

Fig. 1.0: Gas Production in Nigeria

(Source: NNPC Annual Statistical Bulletin 2002 and 2012)

Electricity or electrical energy plays a very important role in the socio-economic and technological development of a state and indeed every nation. Electricity demand in Nigeria far outstrips the supply that is very epileptic in nature. The country is faced with acute electricity supply problems, which hinders economic development in spite of its vast natural resources. It is widely accepted that there is a strong correlation between socio-economic development and the availability of

electricity. The history of electricity in Nigeria dates back to 1896 when electricity was first produced in Lagos, just fifteen years after its introduction in England. Despite the fact that its introduction in the country is over a century, the development has been at a slow rate. In 1950, a central body was established by the legislative council, which transferred electricity supply and development to the care of the central body known as the Electricity Corporation of Nigeria (Sambo 2009). Other bodies like Native Authorities and Nigeria Electricity Supply Company (NESCO) have licenses to produce electricity in some locations in Nigeria. There was another body known as Niger Dams Authority (NDA) established by an act of parliament. The energy produced by NDA was sold to Electricity Corporation of Nigeria for distribution and sales at utility voltages (Bala 2008). In 1972 a merger was made between ECN and NDA to form National Electricity Power Authority (NEPA), which later became Power Holding Company of Nigeria (PHCN) due to the creation of Electric Power Sector Reform Act of 2005(EPSRA 2005). Currently, the PHCN is unbundled into 7 generation companies (GENCOs), 1 transmission company and 11 distribution companies (DISCOs) (Federal Ministry of Power 2008). Nigerian Electricity Regulatory Commission (NERC) which was created by EPSRA 2005 grants over 20 licenses to Independent Power Producers. For over twenty years prior to 1999, the power sector did not witness substantial investment in infrastructural development (Sambo 2009). During that period, new plants were not constructed and the existing ones not rehabilitated, bringing the power sector to a deplorable state. In 2001, generation went down from the installed capacity of about 5,600MW to an average of about 1,750MW, as compared to a load demand of 6,000MW (Sambo 2009). Also, only nineteen out of the seventy-nine installed generating units were in operation. In 2005, Federal Government of Nigeria initiated National Integrated Power Projects (NIPP) to fast track the infrastructural development in the power sector. The electricity generation in Nigeria for a period of 2007 – 2012 is shown table 3.0.

Table 3.0: Electricity Generation in Nigeria (GWh)

	2007	**2008**	**2009**	**2010**	**2011**	**2012**
Hydro	7776	7645	7465	7416	6658	6455
Gas	15410	13952	13373	17604	21034	23117
Total	**23,187**	**21,597**	**20,838**	**25,020**	**27,692**	**29,573**

(Source: PHCN Generation and Transmission Grid Operations 2007- 2012 Annual Technical Reports)

3.0 ENERGY INFRASTRUCTURE IN NIGERIA

Nigeria had four petroleum refineries of cumulative capacities of 260,000 barrels/ day as at 1978. Ten year later the refineries were upgraded to a capacity of 445,000 barrel/ day. Since then the refineries did not witnessed any increase in capacity despite the manifold increase in demand. Even the existing capacities were not operating to full capacities which necessitate the importation of refined petroleum products. Table 4.0 shows the name of the refineries, years of commissioning as well as their installed capacities. Nigeria has fuel storage capacities of 1.071, 0.519 and 0.826 million m^3 of PMS, DPK and AGO respectively as shown in table 5.0. Nigeria has electricity installed capacity of approximately 10,000 MW in 2012 which was made up of hydro and gas power stations, but the average availability is slightly above 50% of the installed capacities. This is shown in table 6.0.

Table 4.0 Refineries in Nigeria with Installed Capacities

Refinery	Year Commissioned	Capacity [barrels/day]			
		1965	1971	1978	1988
P/H Refinery I	1965	35,000	60,000	60,000	60,000
P/H Refinery II	1988	-	-	-	150,000
Warri	1978	-	-	100,000	125,000
Kaduna	1980	-	-	100,000	110,000
Total		35,000	60,000	260,000	445,000

(Source**:** Energy Commission of Nigeria 2010)

Table 5.0 National Fuel Products Storage Capacity [m^3]

Depots/Refineries	PMS	DPK	AGO
WRPC	99,200	87,700	97,000
KRPC	135,00	65,000	97,000
PHRC	145,550	93,000	141,000
PPMC Depot	651,000	257,000	467,900
Marketers@ Apapa	40,000	17,300	23,300
Total	1,070,919	519,000	826,300

(Source: Sambo 2009)

Table 6.0 Electricity Power Stations in Nigeria as at 2012

S /N	Plant	Availability factor	Average Availablity (MW)	Installed Capacity (MW)
1	Kainji	0.39	295.38	760.00
2	Jebba	0.72	414.42	578.40
3	Shiroro	0.83	497.46	600.00
Total Hydro		**0.62**	**1,207.26**	**1,938.40**
4	Egbin	0.77	1,022.56	1,320.00
5	Afam (I-V)	0.27	95.32	351.00
6	Sapele ST	0.14	98.52	720.00
7	Delta	0.27	246.23	900.00
8	Geregu	0.66	274.96	414.00
9	Omotosho	0.34	113.02	335.00
10	Olorunsogo	0.64	214.39	335.00
Total PHCN Thermal		**0.47**	**2,065.00**	**4,375.00**
11	Olorunsogo II	0.66	496.20	750.00
12	Omotosho II	0.29	144.73	500.00
13	Sapele NIPP	0.58	218.26	375.00
Total NIPP Thermal		**0.53**	**859.19**	**1,625.00**

14	AfamVI	0.93	603.70	650.00
15	AES	0.68	203.99	302.00
16	Okpai	0.92	440.86	480.00
16	Omoku	0.26	38.53	150.00
17	Ibom	0.21	32.08	155.00
17	Trans-Amadi	0.31	30.65	**100.00**
18	Rivers IPP	0.2	35.12	**180.00**
Total IPP Thermal		**0.69**	**1,384.93**	**2,017.00**
Total Thermal			**4,309.12**	**8,017.00**
Total Installed Capacity		**0.55**	**5,516.38**	**9,955.40**

Source: PHCN Generation and Transmission Grid Operations 2012 (Annual Technical Report)

4.0 ROLE OF ENGINEERS TO SUSTAINABLE ENERGY FUTURE FOR NIGERIA

Engineers have a unique role when compared with other occupations in industrial organizations, and therefore are most affected by organizational changes. In the introduction of new products, processes and methods and/or new equipment and technologies, engineers find themselves a target of change, and are required to adapt to the new work environment continuously. In another role, they themselves are originators of change in technologies, processes and products, and at times are responsible for the implementation of organizational changes. They are neither an extension of labour nor an arm of management. They play a semi-independent role influenced by their national diversity. Engineers, therefore, are under increasing pressure to redefine their roles and re-equip themselves with necessary skills and knowledge to meet adequately the contemporary changes. With the boundaries between technical roles and managerial roles becoming increasingly blurred in organizations today, the changing role of engineers has considerable influence on organizational performance. While the majority of engineers in developed countries and developing countries such as India and China seem to be continuously and successfully adjusting to these new roles, the status in the community, the

employers' view of engineers' inability and their lack of contribution, and the perspectives that guide the career paths and education of engineers, are some factors influencing the effectiveness of their transition. The profession is trying to reinvent itself by proposing radical changes to the engineering education, career development, training and management of engineering, and professional formation. Engineers are always in transition; now, and perhaps forever.

Managerial Role of an Engineer:

Decision making

The decision making role of engineers are seen in almost every establishment or stakeholder organization in the energy sector where Engineers belong to the management and board members of such organizations making decisions that will affect the overall energy development of the country. By this role, Engineers are to use their ingenuity as originators and problem solvers to make decisions that will enhance the sustainable energy development of Nigeria.

Governance and Policy Formulation

There is need for Engineers who are in positions of authority in the Government to use their offices to make good policies that will promote and sustain the energy development of Nigeria. These Engineers may be political office holders who are expected to work hard towards making laws that will foster safe, affordable, available and acceptable energy resources that will contribute to the overall sustainable energy development of Nigeria. This role may also involve policies and laws on how Engineers will be trained, in what areas they are to be trained, giving free hand to engineers to work in the energy sector, involving Engineers in technical works where they are most suited for and granting funds to Research and Development of Energy projects being carried out by Engineers.

Technical Role of an Engineer:

Energy Planning

The first and paramount role Engineers need to play in ensuring sustainable Energy Development in Nigeria is to always have a workable plan because integrated energy planning approach is an essential way of achieving security of energy supply on a sustainable basis in order to capture the numerous factors that shape energy sector development. This responsibility has been vested on Government agencies such as Energy Commission of Nigeria. Therefore there is need for all stakeholders in the Energy sector to involve Engineers in the Planning stage of every Energy related project. More so, Engineers should make themselves available to be used and should also make meaningful contributions when they are called upon to do so. Engineers should also set out concrete plan on how to replace existing technologies for new energy sources, such as renewable energy technologies, particularly wind and solar power which are promising resources. There is need for Engineers to roll out plan that will provide reliable and secure energy mix for sustainable energy development in the Country. The use of internationally recognised energy planning tools should be adopted by Engineers working in the energy sector to forestall sustainable energy development in the country.

Enlightenment (Energy Efficiency & Conservation)

Although energy conservation and efficiency is not a resource per se, it is acknowledged that its adoption in the country can significantly mitigate the supply challenge. Efficiency is increasing by about 2% a year, and absorbs most of the requirements for energy development (Source). Introduction of energy efficient technologies such as compact fluorescent lamp (CFL) to replace Incandescent lamp, new machines and thermal insulation. With little modification of some parts, existing power plant can be more efficient. New designs for buildings may incorporate techniques like passive solar. There should be improvement of the

already existing design such that new small scale energy sources may be placed closer to the consumers so that less energy is lost during electricity distribution.

In addition to this, Engineers should through the Nigerian Society of Engineers or COREN endeavour to perform the following functions:

(i) Develop guidelines for energy efficient end-use products and be ready to advise on their implementation;

(ii) Develop energy efficiency codes, standards and specifications for domestic, industrial and commercial facilities for the Country.

(iii) Disseminate information on energy efficiency and conservation concepts through public awareness programmes such as seminars, workshops, publications, etc.

Sustainability

Sources which have no Engineers should promote the renewable energy sources and their sustainability by carrying out research on how to make it work in Nigeria and also to improve the already existing ones. Engineers in collaboration with stakeholder in the energy sector needs to scale up campaign for the use of renewable energy sources in the country's energy mix in a sustainable manner so as to reduce the global warming caused by burning of fossil fuels.

Professionalism in Project Execution

This has been the bane of energy infrastructural development in Nigeria, looking at the rate of failed contracts in the Energy sector which were most of the time are executed by unqualified Engineers. It is pertinent to note at this point that if energy infrastructures are not built in professional manner, there is bound to be total collapse of the system in future thereby taking the country back to a worse situation than it were before. Therefore Engineers should rise up to this challenge and live up to the expectations of the society and also play the leading role in the sustainability of energy development in the country.

Monitoring and Maintenance of Energy Facilities

It is a well know fact that for any system to be sustained, there must be proper

monitoring to make sure that there is no deviation from the designed mode of operation of the system. This as is known, is one of the cardinal roles of engineers in any given project that is technology driven. Therefore there is need for Engineers to rise up to this onerous task of proper monitoring to ensure effective and efficient use of Energy facilities in the country as this will surely enhance the sustainable energy development of the country. Also, timely maintenance and servicing of energy facilities by Engineers will go a long way to ensuring the sustainability of energy development in this country.

5.0 Challenges and the Way Forward of Sustainable Energy Future in Nigeria

Challenges:

Weak technological base

This is perhaps one of the greatest obstacles that face sustainable energy development in Nigeria. The Country has gross defects in technological know-how, maybe with the exception of few locally manufactured renewable energy technologies like improved woodstoves, biodigesters etc. For instance 90% of Photovoltaic (PV) modules that are used in Nigeria are imported (Wamukonya, 2005). Currently, National Agency for Science and Engineering Infrastructure (NASENI) is the only organization that produces PV modules in Nigeria.

Poor infrastructural Facility

Despite the abundant energy resources in Nigeria, inadequate infrastructure to generate, refine, transmit/ transport the resources is a major issue in the energy sector which affects almost all the part of the country. The existing infrastructures are overstretched. Poor delivery networks resulting in poor services are obstacles to sustainable development of energy services in the Country.

Financial Obstacles

Massive financial resources are required for energy resource development. Unfortunately, power sector did not witness a substantial investment from late 1970s to late 1990s. Similarly the oil sector did not witness the increase in refinery capacity since 1988. Government has invested about $16 billion from 1999 to 2007, but Nigerians are yet to witness a substantial improvement of electricity supply.

Energy Policy Issues

Non-passage into law of the National Energy Policy and non implementation of the provisions of the National Energy Master Plan has been a big setback to the sustainable energy development of the country. Absence of energy law which will have in it the road-map for implementation with strong focus on achieving target results and the recommended penalties for offenders is also an obstacle to sustainable energy development in Nigeria. Government policies on energy are important in terms of resource mobilization, dissemination and encouragement of private sector participation.

Inadequate Reliable Data

Most energy systems, especially energy planning which is the foundation to sustainable energy development is directly or indirectly dependent on availability of reliable and sufficient data. The data required includes data on energy resources, energy utilization, macro and socio-economic parameters, weather and climate conditions. Inadequate reliable data causes a serious setback in energy planning to achieve sustainable energy development.

Poor Utilization of Resources

Most energy resources in Nigeria especially the renewable energy resources are poorly utilized due to the non implementation of reports on strategic planning on sustainable energy supply mix. . Other resources are poorly utilized because the

technologies are inefficient in performance, some are obsolete, while some other are not properly stored because of lack of inadequate storage facilities in the country.

Inertia towards Change

Inertia towards adaptation to emerging and more efficient technologies leads to end-use energy waste and thus inimical to sustainable energy development. Most equipment and appliances used in homes and industries in Nigeria are old, obsolete and energy inefficient.

The Way Forward

Good Maintenance Culture

Engineers should stick to the ethics of engineering and follow global best practices in operation and maintenance of the equipments. This will leads to the optimal utilisation of the equipments and may even increase the economic life span of the system.

Public Private Partnership

Since huge investment is required for the energy sector to be sustained, a public private partnership will be the best options to fund the sector.

Implementation of National Energy Policy

Proper implementation of National Energy policy and National Energy Master Plan will address a lot of issues such as optimal utilisation of resources. This will contribute immensely in the sustainable energy development in Nigeria.

Adherence to the ethics of Engineering Profession

Engineers shall commit themselves to making the analysis, design, specification, development, testing and maintenance of engineering systems beneficial so as to earn respect for the profession. In carrying out any project in energy sector,

Engineers should endeavour to maintain the standard recommended for such jobs, they should only do works within their areas of calling. This will also solve the problem of quarks, failed projects and systems, as is stated in the code of ethics of engineering in Nigeria. Adherence to the ethics of the profession in carrying out projects in the energy sector of the economy will surely guarantee sustainable energy future in the country.

Sensitizing the Public

Engineers should take the leading role of sensitizing the public on the importance of using improved and new technologies in the areas of energy efficiency and conservation use of renewable energy resources which are more environmentally friendly, design of buildings to conserve energy etc. There should also be awareness from the Engineers on the need for synergy among all the stakeholders in the energy sector to achieve sustainable energy future for Nigeria.

References

[1] C.C. Okoro 2010, Professional ethics in Engineering, A 3-Day Refresher Course for Prospective and Corporate members.

[2] *Ravi Seethamraju, 2010.* The changing roles of engineers*, University of Sydney, Australia,(* www.eepublishers.co.za*) accessed 20th July 2012.*

[3] D.S. Yawas: 2009, Role of engineering entrepreneurship in the sustainable development of the Nigerian economy.

[4] www.wikipedia.org/wiki/Engineering, accessed 20th July 2012.

[5] A.S. Sambo, 2009 - The challenges of sustainable energy development in Nigeria

[6] 'A.S. Sambo, 2009. Energy Issues and Challenges in Nigeria: Paper presented to the Nigerian Society of Engineers Forum, Abuja Chapter, 2nd April 2009.

[7] G.O. Unachukwu 'Obstacles to Sustainable Energy Development in Sub-Sahara Africa, May 2009, Paper presented at the Workshop on Sustainable Energy Development in Sub-Saharan Africa

[8] E.J. Bala- An Overview of Energy situation in sub-saharan Africa, Paper presented at the Workshop on Sustainable Energy Development in Sub-Saharan Africa, 2009.

[9] Iwayemi A. (2008). Nigeria Dual Energy Problems: Policy Issues and Challenges.

[10] Olayinka S. O. (2010). Energy Utilization and Renewable Energy Sources in Nigeria. Journal of Engineering and Applied Sciences, 5: 171-177.

[11] Michael A., E.L. Virginie (2005). Forcasting Electricity Demand in Developing Countries: A case study of Household Income and Appliance Ownership.

[12] Madubansi M, C.M. Shackleton (2005). Changing Energy Profiles and Consumption Pattern following Electrification in Five Rural Villages in South Africa.

[13] Irimya F, N.B Audu, M. Saidu. (2010). Evaluation of Rural and Urban Areas Energy Utilization and the Impact on Environment and Economic Development: A case study of Kona_Garu and Yola-Jalingo_Wukari JunctionSettlements (Road Block) in Jalingo LGA, Taraba State. NIJOSTEE, Vol. 3, No. 1.

[14] Bodger Pat, Z. Mohamed (2005). World, Regional, Country and New Zealand Electricity Pattern.

[15] Ramachandra T.V. (1998). Energy Utilization in Rural Industries in Karantaka, India.

[16] Energy Commission of Nigeria (2005). National Energy Master Plan.

[17] Energy Commission of Nigeria (2005) National Energy Policy.

[18] RIDOLFI Inc. and Shuksan Energy Consulting (2005) Samish Indian Nation Long-Term Strategic Energy Plan: Tribal Energy Vision, Current Energy Status and Action Plan.

[19] Guidebook for the Municipal Energy Profile Project (MEPP) of Chicago, United States of America (February 2011), by the Center for Neighborhood Technology USA.

[20] Dayo F.B. (April 2008): Clean Energy Investment in Nigeria; The domestic context.

[21] http://nigeria.unfpa.org/abuja.html, sourced on 4th November, 2011.

[22] Barki Emmanuel (2009):Socio-Economic Constraints to the Adoption and Sustainability of Biogas in Nigeria (Project Proposal submitted to the Mechanical Engineering Department, University of Agriculture, Makurdi, Nigeria).

[23] City of Cape-Town Energy Report (2007); Palmer Development Group.

[24] www.energy.gov.ng: accessed on 11th November, 2011.

[25] Jekayinfa S. O. (2006) “Energy Consumption Pattern of Selected Mechanized Farms in Southwestern Nigeria”. Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 06 001. Vol. VIII. April, 2006.

[26] Enebeli E.E. (2010): Causality analysis of Nigerian Electricity Consumption and Economic Growth, Journal of Economics and Engineering, ISSN: 2078-0346, №4, December, 2010.

[27] Abubakar M. and B.Umar “Comparison of Energy Use Patterns in Maiduguri and Yobe Flour Mills, Nigeria”. Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 06 004. Vol. VIII. August, 2006.

[28] AKPAN M, A. WAKILI and C. AKOSIM ; Fuel Wood Consumption Pattern in Bauchi State: A Guide For Energy Planners In Nigeria, ASSET Series A (2007) 7 (1): 1-11

[29] Sambo A.S. (2005): Renewable Energy for Rural Development: The Nigerian Perspective, ISESCO Science and Technology Vision - Volume 1 (May 2005) (12-22)

[30] Federal Ministry of Energy (2008): Investment Opportunities in the Nigeria's Power Sector

[31] NNPC (2002, 2012): Annual Statistical Bulletins

[32] NLNG (2011): Facts and Figures on NLNG

[33] PHCN (2007 -2012): Generation and Transmission Grid Operations Annual Technical Reports