OGUNYE: GIANT STRIDES IN ENGINEERING EDUCATION RESEARCH AND INNOVATIONS

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PREFACE

The purpose of this book, a Festschrift in honour of Professor Ayodele Francis Ogunye ACGI, BSc(ChemE),MASc, PhD, FNSChE, FNSE,FIChemE,FNAEng. on his 70th birthday (31st July 2012), is to improve upon and establish in Nigeria and Africa, a long cherished academic tradition of honour for academics in Europe especially Germany. This tradition was inaugurated at the University of Lagos at the 70th birthday ceremony of the much loved and cerebral Professor Emeritus Ifedayo O. Oladapo NNOM in November 2002 The main thrust of this book is contributions to Modelling and Simulation (MS) in Chemical Engineering.

The book contains contributions on "The Man –Ayo Ogunye"– from his origin and early years at Ijebu-Igbo through Molusi College and thereafter Government College Ibadan; through the academic training at Imperial College, London, UK and the University of Waterloo, Ontario, Canada; the short but foundational start-off at the then University of Ife (now Obafemi Awolowo University) and the leadership prowess displayed at the University of Lagos (with happy, sweet and sour days!) working hard for the youths and defending the rights of the young lecturers (securing scholarships, sponsorships, encouraging them to do research and publish, finding them accommodation off and on-campus, etc). For Ogunye, it has been a *life of service, indeed, dedicated to serving humanity*!

The Festschrift, put together by very close colleagues, associates, protégées and former students include chapters on the auto biography of Professor A.F. Ogunye, the contribution to Ijebu-Igbo Community(L Ogunkoya,SO Idowu,A Adefuye) especially the Saint Luke's Anglican Church at Japara; the leadership prowess exemplified by Ogunye at University of Lagos(O Abass,A Kehinde), and a major treatise by established experts including WH Ray, BA Ogunnaike, A Ogunye Jr(his son)., VOS Olunloyo and O Ibidapo-Obe on Modelling and Simulation in Chemical Engineering (Process Control).This section is followed by invited papers on Chemical Engineering and Society with contributions from B Oyelaran-Oyeyinka,EE Ubom,Akintimehin. The last section

dealt exclusively with Energy Sector Issues which were extensively discussed by OO Adewoye A O Denloye, B Solomon, RI Salawu and O Bamiro.

The overall objective of this book, edited by A.O. Denloye and L. Oyekunle is to present in totality "The Man-Ayo Ogunye – " and motivate the follow-up generation. The book includes AF Ogunye's growing up years, his academic career, family life, his humanity as well as his major philanthropic gesture in establishing the Professor Ayodele Francis Ogunye Endowment for the Chair of Chemical Engineering at the University of Lagos.

Oye Ibidapo-Obe, PhD, FAS,FAEng,FR

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Chapter Twenty-Eight

A SHORT EXCURSION INTO THE ENERGY SUPPLY MIX IN NIGERIA

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ABSTRACT

Abundant energy supply is the lifeblood of modern civilization. Energy poverty arising from poor management despite appreciable energy resource base continues to be a major constraint on the socio-economic development of Nigeria. The crucial challenge of the energy sector in the country includes inadequate energy supply, its security and sustainability. In this paper we briefly examine the roles of the major primary energy forms in the country as well as some of the alternative energy sources in the provision of adequate energy supply to meet the growing demand. The paper posits that poor energy mix, slow implementation of policies and inadequate private sector participation are the major constraints and challenges of the energy sector. Concerted efforts towards addressing these challenges will go a long way in solving the endemic energy problem in the country.

1.0 INTRODUCTION

Abundant and economical energy supply is the lifeblood of modern civilization. The importance and wide – ranging role of energy in the development process of a nation is well known and access to energy is central to sustainable development and poverty reduction. It affects all aspects of development – social, economic and environmental – including livelihoods, access to water, agricultural production, education and poverty – related issues.

Nigeria operates a centralized energy system and despite its huge primary energy resources such as oil and gas, abundant sunlight and significant hydropower; energy poverty, the lack of access to reliable, affordable, safe and clean energy resources

and services, is a widespread phenomenon amongst its 160 million inhabitants.

This paper presents a critical overview of the current energy supply mix in the country in terms of primary energy demand, supply and reserves in Nigeria. The security and sustainability of these primary sources as well as renewable energy sources like biomass, wind, solar and hydropower, are also examined. Besides, the paper draws attention to the various energy policies and programmes which are currently being implemented to improve the energy situation in the country.

2.0 ENERGY MIX IN NIGERIA

Nigeria is a vast country with a total area of 923,768 sq km, out of which 910,771 sq km or 98.6% of the total area is land. She is endowed with a variety of fossil and renewable energy sources. The Energy Mix in Nigeria is contributed by five main sources, namely: oil, natural gas, coal, biomass and renewable energy (such as wind, solar, hydro). With the advent of democratic governance in 1999, various programmes and plans have been introduced under a broad energy reform programme, with the major objective of encouraging and intensifying the conversion of energy resources and the utilization of renewable energy in the country. Table 1 shows a brief summary of the energy mix in Nigeria.

Table 1: Summary of Nigerian Energy Mix

	Resource Type	Reserves		Production	Domestic Utilization
		Natural units	Energy Units (Btoe)		
1.	Crude Oil	35 billion barrels	4.76	2.5 million barrels/day	445,000 barrels/day
2.	Natural gas	187 trillion SCF	4.32	7.1 billion SCF/day	3.4 billion SCF/day
3.	Coal and Lignite	2.734 billion tonnes	1.92	Insignificant	Insignificant
4.	Tar Sands	31 billion bbl of equivalent	4.22	-	-
5.	Large Hydropower	11,250MW	1.11(over 38yrs)	1,938MW (167.4 million MWh/day)	167.4 million MWh/day

6.	Small Hydropower	3,500MW	0.25 (over 38yrs)	30MW (2.6 million MWh/day)	2.6 million MWh/day
7.	Solar Radiation	3.5 – 7.0 kWh/m²/day (485-1 million MWh/day	15.0 (38yrs and 0.1% of Nigerian land)	Excess of 24.0kwp of solar PV or 0.001 million Mwh/day.	Excess of 0.01million MWph/day of Solar PV
8.	Wind	2 – 4m/s at 10m height	-	-	-
9.	**BIOMASS**				
	Fuelwood	11 million hectares of woodland	-	0.11million tonnes/day	0.120 million tonnes/day
	Animal waste	245 million assorted in 2001	-	0.78million tonnes/day in 2001	Not Available
	Energy crops and Agric residues	72 million hectares of agric land and all waste lands	-	Excess of 0.256million tonnes of crops residue/day in 1996	Not available
10	Nuclear Elements	Not yet quantified			

Sources: (i) Nigerian National Petroleum Corporation NNPC, 2007 (ii) Renewable Energy Master Plan (REMP), 2007 (iii) Ministry of Mines and Steel development, 2008

2.1 Oil

Crude oil is the singular most important Nigerian energy resource. The export of oil and gas accounts for more than 98% of export earnings and about 83% of the Federal Government of Nigeria (FGN) revenue. It also provides more than 40% of the country's GDP and provides 95% of foreign exchange earnings and 65% of governments' budgetary revenues (EIA, 2010).

Oil production started in Nigeria with the discovery of oil in 1956 at Oloibiri in the Niger Delta region of the country. Nigeria joined the ranks of oil producers in 1958 when its first oil field came on stream producing 5,100 barrels per day (bpd). Today with over 159 oil fields and 1,481 wells in operation, the daily

production is estimated at 2.4 million bpd. The country also has a proven oil reserve of 37.2 billion bpd (EIA, 2010).

Nigeria has four existing oil refineries run by the Nigerian National Petroleum Company (NNPC) with a combined designed capacity of 445,000 barrels per day or the equivalent of 22.2 million metric tonnes per annum (Table 2). However the current operational capacity of the refineries is between 60 and 75% (EIA, 2011). From Table 2 it can be seen that no new refineries were built in the last 30yrs.

The product slates from the four refineries are white products – Premium Motor Spirit (PMS), Dual Purpose Kerosene (DPK), Automotive Gas Oil (AGO) and liquefied Petroleum Gas (LPG). Other products are Low Pour Fuel Oil (LPFO), High Pour Fuel Oil (HPFO), Bitumen, base oils, Paraffin Wax and sulphur. In addition, the Warri refinery has a petrochemical plant for the production of polypropylene and carbon black, while the Kaduna refinery has a petroleum plant for the production of linear Alkyl Benzene, solvents and Benzene.

Table 2: Refineries in Nigeria

s/n	Year of Commission	Capacity (barrels per day)				
		1965	1971	1978	1988	2010
1.	Port – Harcourt Refinery I	35,000	60,000	60,000	60,000	60,000
2.	Port – Harcourt Refinery II	-	-	-	150,000	150,000
3.	Warri Refinery	-	-	100,000	125.000	125,000
4.	Kaduna Refinery	-	-	100,000	110,000	110,000
	Total	**35,000**	**60,000**	**260,000**	**445,000**	**445,000**

Source: Energy Information Administration (2011)

The inability of the refineries to meet local demand led to the liberalization of the sector and the licensing in 2002 of 18 new private refineries to compliment the operations of the four existing ones and to improve local supply of petroleum products. Eighteen (18) private refineries have been licensed. Although thirteen (13) of them have received approval by the FGN to commence construction, only two of them have so far commenced construction work. The two private refineries

under construction are the Amakpe Refineries Nigeria Ltd, Eket , Akwa – Ibom State with a capacity for 6,000 barrels per day of unleaded gasoline. The construction of the refinery started in February 2004. The second refinery is the Orient Petroleum Refinery at Nsugbe – Umuleri, Anambra State which commenced construction work in April 2006, with a capacity of 55,000 barrels per day. The slow completion of the two projects has been due to financial constraints. Also the NNPC has commenced work on the construction of three new green refineries to be located in Lagos, Kogi and Bayelsa States, while the Independent Petroleum Marketers of Nigeria (IPMAN) has commissioned three Chinese firms to build three refineries in Port – Harcourt, Ore and Lokoja.

The Pipeline and Products Marketing Company (PPMC), a subsidiary of the NNPC, manages petroleum products distribution. Distribution of products is done via pipelines, Bulk Road Vehicles (BRVs) and depots. The PPMC has twenty - three (23) depots, twenty (20) inland and three (3) refinery depots, with storage capacities of 1,070,919m^3 of PMS, 519,000m^3 of DPK, 826,300m^3 of AGO and 75,000m^3nof ATK (Table 3).

Table 3: National Fuel Products Storage capacity (M^3)

	PMS	DPK	AGO	ATK
Warri Refinery	99,200	87,700	97,000	-
Kaduna Refinery	135,000	65,000	97,000	-
Port – Harcourt Refinery	145,550	93,000	141,000	-
PPMC Depot	651,000	257,000	467,000	63,500
Marketers at Apapa	40,000	17,300	23,300	11,500
Total	1,070,919	519,000	826,300	75,000

Source: NNPC

The depots are connected to the refineries through 5,000km of pipelines and seven (7) strategically located booster pump stations. Distribution of petroleum products from depot retail outlets is by BRVs of various capacities. Bridging on pipeline breakdown is done also by using BRVs. There are also nine (9) strategic LPG storage depots located in Lagos, Ilorin, Gusau, Kano, Gombe, Markurdi, Enugu, Calabar and Kaduna. There are also ninety (90) LPG filling stations in Nigeria.

The activities of the International Oil Companies (IOCs) and the perceived incompetence of the industry watchdog the NNPC have resulted severally in the calls for general reforms in the sector. The reform instrument in the sector has been the proposed Petroleum Industry Bill (PIB). The PIB is expected to reform the structure, governance and fiscal rules of the country's oil industry, which is beset by years of corruption and inefficiency. The PIB, amongst other things, is expected to restructure the upstream and downstream sectors of the oil industry and transform the oil industry into an engine of sustainable development, enhance governance and eliminate toxic social and environmental impacts on producing communities. Despite the laudable objectives of the PIB, the national governance system is still to display seriousness in handling its passage to law. Just at the point of sending this paper to the coordinator, I saw on the television screen a special announcement from the Presidency dissociating itself from a fake PIB document being circulated in the country. This epitomizes the complexity of irreconcilable interests in the sector. Suffice it to note that the sector is not in good shape at present as borne out by the mind-boggling revelations during the Oil Subsidy Probe conducted recently by the National Assembly.

2.2 Natural Gas

Nigeria has an estimated 187 Trillion Cubic Feet (TCF) of proven natural gas reserves, making it the seventh largest in the world. Nigeria's natural gas is a high grade gas with 0% sulphur and rich in high grade gas liquids. The vast majority of natural gas found in Nigeria is *associated* meaning that it occurs in crude oil reserve as free gas. Because many of the oil fields in the country lack the infrastructure to produce the associated natural gas, it is flared. Nigeria flares more natural gas than any country in the world, with 43% of its total annual natural gas production being flared (EIA, 2010).

Nigeria's natural gas resources are under-utilized domestically and most gas is exported. According to the US Energy Information Administration, in 2004, Nigeria produced 800

billion cubic feet, consumed 325 billion cubic feet, and exported 475 cubic feet. In 2008, Reuters reported that Nigeria was exporting about 3 billion cubic feet of gas per day (in the form of LNG), while flaring approximately 2.5 billion cubic feet per day, and delivering only 0.5 billion cubic feet per day to the domestic power sector (Shaad and Wilson, 2009). With so much gas being flared, Nigeria is missing out on significant revenue, while valuable resources are being wasted that could be used for power generation and other needs if the appropriate infrastructure were in place.

Nigeria is the second largest gas flaring country behind Russia. Gas flaring was officially banned in Nigeria in 1984 and a groundbreaking court case ruled against flaring in November 2005. Although IOCs have made efforts in the last 10 years to reduce gas flaring, it has been impossible to achieve a total "flares out" because of the lack of domestic gas pricing in Nigeria and the technological and political challenges of gas capture and transportation in isolated areas. Under the gas flaring policy that took effect from 1 January 2008, companies are to pay a fine of $3.5 for every 1000 standard cub feet of gas flared. They were also required to have shut down any oil field where associated gas was flared as far back as 31 December 2008. However, it proved impossible to ensure full compliance and the deadline for 'flares out' was shifted to 31 December 2011.

For the effective utilization of gas and reduction in the incidence of gas flaring in the oil producing areas of the country, the Federal Executive Council in February 2008 approved a Gas Master plan for the Nation. The Gas Master Plan is expected to make Nigeria a global player in the international gas market and lay a solid foundation and framework for gas infrastructure expansion within the domestic market. The Gas Master-Plan is a guide for the commercial exploitation and management of Nigeria's gas sector. It aims at growing the Nigerian economy with gas by pursuing three key strategies: stimulate the multiplier effect of gas in the domestic economy; position Nigeria competitively in high value export

markets; and guarantee the long term energy security of Nigeria.

The Nigerian Gas Master-plan is the first major attempt by the country to articulate a holistic framework for its gas. It comprises three key sections: Gas Pricing Policy; Gas Supply Obligation Regulation and a Gas Infrastructure Blueprint. The objective of the gas pricing policy is to create a structured and transparent framework for gas pricing that

supports the government's aspiration for accelerated domestic economic growth via rapid gas based industrialization and maximizing value from high value LNG and pipeline exports. The policy establishes three broad categories for buyers of gas in view of the unique strategic and market dynamics of the various demand sectors: *Strategic Domestic Sector*- primarily the power sector (grid power); *Strategic Industrial Sector* – which takes gas as main feedstock i.e. gas based industries such as fertilizer, methanol, GTL, LNG etc.; *Commercial Sector* – which takes gas for fuel. The policy does not fix gas prices, but provides a framework for establishing the minimum gas price that can be charged to any category of gas buyer.
The objective of the domestic gas supply obligation framework is to ensure gas availability for critical domestic gas utilization projects which will advance the domestic economic growth agenda. The gas infrastructure blueprint is expected to guide all future gas infrastructure developments in the country and is intended to be private sector led and commercially driven.

Specifically, the blueprint provides for the establishment of three gas gathering and processing facilities which is a network of gas transmission lines. This infrastructure will result in a reduced cost of gas supply from Nigeria and expedite the Nation's aspiration of gaining market share in the high value export market. The infrastructure for exploitation of the Nigerian natural gas is managed by the Nigerian Gas company (NGC), a subsidiary of NNPC. The company owns approximately 1,100km of various diameters of gas pipelines located east and west of the Southern part of River Niger, with

a northern extension to Ajaokuta. The system is capable of transmitting about 1,800MSCf/day of gas (Ige, 2010). The Nigerian Liquefied Natural Gas (NLNG) company in Bonny, Rivers state is responsible for the liquefaction and export of liquid natural gas for the country. It is a limited liability company owned by NNPC (49%), Shell (25.6%), ELF (16%) and AGIP (10.4%) as shareholders (Energy digest, 1999).

The NLNG currently has six trains facility for liquefaction and export of liquid natural gas with capacity of 22 million tonnes per annum (MTPA) of LNG. The seventh train is under construction, while the OK, Brass and other third party facilities are currently under evaluation (Ige, 2010). Currently Nigeria has now the second fastest growing LNG capacity after Qatar. At the regional level, the West African Gas Pipeline Project (WAGPP), has been put in place for the export of natural gas across West Africa and has a capacity of 20 million SCF/day. The pipeline originates from the Lagos end of the ESCRAVOS Lagos gas pipeline and terminates in Accra, Ghana. There is also continued progress on the Trans – Sahara Gas project which is expected to supply gas to Europe through Algeria and the Equatorial Guinea Gas supply project (Ige, 2010).

With the new Gas Master Plan, three (3) central gas gathering and processing facilities CPFs are under construction and located in Western Delta (Warri/Forcados area), Obiafu (North Port – Harcourt) and Akwa ibom/Calabar Area. Also three (3) gas transmission systems that will link the existing gas transmission lines are under construction. They are: 120 Km South – North line; 700 Km Western System with 200 Km offshore extension; and a 200 Km interconnection system to link the old and new systems to give the country a gas supply grid.

2.3 Coal

Coal is the oldest commercial fuel, and was discovered in Njgeria in 1909 and its subsequent mining began at Ogbutte in Enugu in 1916 with a total production of 24,000 tons. Coal Production peaked at near one million tons in 1959, before declining to the present insignificant level. Between 1950 and

1959, coal contributed over 70% of the total commercial energy consumed in Nigeria but today its contribution is 0%. This situation arose due to the reduction in the demand for coal arising from dieselization of rail transportation, and switching from coal to gas for thermal power generation. For example, the licenses granted by NERC (National Electricity Regulatory

Commission) so far to Independent Power Producers (IPPs) are all for gas – powered plants and only one for coal – fired. Nevertheless, Nigeria's coal reserves are large with over 2 billion metric tonnes, of which 650 million tonnes are proven. Coal reserves are currently found in 14 out of the 36 states - Enugu, Imo, Kogi, Delta, Plateau, Anambra, Abia, Benue, Edo, Bauchi, Adamawa, Gombe, Cross – River and Ebonyi States (Dolbear, 2005)

There are two major types of coal namely anthracite and bituminous. A little below bituminous in quality is sub-bituminous which is the major type found in Nigeria. It is important as fuel because it burns slowly and gives out a lot of heat. Nigerian sub bituminous coal has a high calorific value (5,000-6,000 cal/g or 5500-6500 air dried), low ash and low sulfur contents coupled with good storage characteristics (Onlinenigeria, 2009). Nigerian sub – bituminous coal will be very attractive for export, because of its low sulfur content, which is environmentally acceptable.

The Nigerian Coal Corporation (NCC) was established in 1950 under the Coal Ordinance No. 20. NCC had the exclusive rights to mine Coal in Nigerian until 1999, when the FGN established a policy and legislation that de-regulated mineral exploration and exploration. This opened up the sector to private industry participation and resulted in NCC entering into joint ventures on an equity participation basis. The Agency has recently entered into several joint ventures with outside entities to mine coal, but those efforts have met with limited success. Nigeria's only significant coal mine is the Okaba mine (Okaba coal field), which is operated under a production sharing agreement with Nordic Industries Limited. Production of 2,712

tonnes was recorded in 2001. The NCC is currently divesting from all its operations in the sector. Suffice it to note that Nigeria has major coal resources that have not been well explored or exploited, if fully revitalized, the coal industry could fetch up to 5 billion Naira in export earnings. The FGN, under the Electric Power Sector Reform Act (EPRSA) and the Vision 20:2020, has placed a high priority on utilizing these resources to

increase the country's electrical generating capacity. Nigeria's goal is to revitalize the coal mining industry and expand power generation by attracting foreign companies to develop these large coal resources and construct coal-fired generating plants that will connect to the country's electrical distribution grid.

There is also a significant potential domestic demand for coal briquettes to replace wood for cooking and domestic and industrial heating. The use of wood by the country's growing population is causing increasingly rapid deforestation in many parts of the country. The exploitation of coal for electricity generation and the production of coal briquettes for domestic and industrial heating will bring a number of benefits including: increased and more reliable electricity supply; lower cost electrical energy; expanded industrialization of the economy; increased employment and human resources development; increased capacity utilization of existing industries; increased national income through taxes and reduced deforestation and prevention of desert encroachment in the northern parts of the country.

2.4 Electricity

The provision of adequate electricity supply is the major energy constraint in Nigeria. About 60 per cent of Nigeria's population has no access to electricity (90 per cent in rural areas). Electric power is required for industrial, domestic and social activities. Electricity is the most convenient form of energy to meet these needs. Lighting is the most expensive energy need. The poorest African households may spend 10-15 per cent of their income on kerosene lamps or candles. Nigeria's poorest households earn 1-2 USD per day, but they

spend on average 0.40 USD per day on their energy needs (Hammond et al. 2007).

Electricity Generation

Currently, the Nigerian electricity power generation sector can be sub – divided into three sub – sectors, namely: Existing FGN power generation facilities, Independent Power Projects (IPPs) and National

Integrated Power Projects (NIPPs). The total installed generating capacity of the FGN power generating units is 6,904 MW comprising 1,900MW for hydro and 5,004MW for thermal plants. However the available capacity is 1,380MW of hydro and 1,978MW of thermal power.

The IPPs, which are all thermal plants, are the non – FGN funded investments in the Nigerian power sector and their current installed and available capacities are respectively 1,759MW and 1,484MW. The NIPPs, which are also thermal plants, are power projects funded by the three tiers of government in Nigeria (Federal, State and Local government). These facilities are currently being constructed with total designed generating capacity of 4,775MW (BPE, 2010). Thus, the total installed generating capacity of the power sector in Nigeria as shown in Table 4 and 5 is about 8,663MW (excluding about 4,775MW under construction) as at December 2010 (Onaguruwa, 2011). However available capacity is about 4,842MW. Figure 1 shows the installed and available generating power in the country, while Table 6 shows the NIPP power plants under construction in various parts of the country.

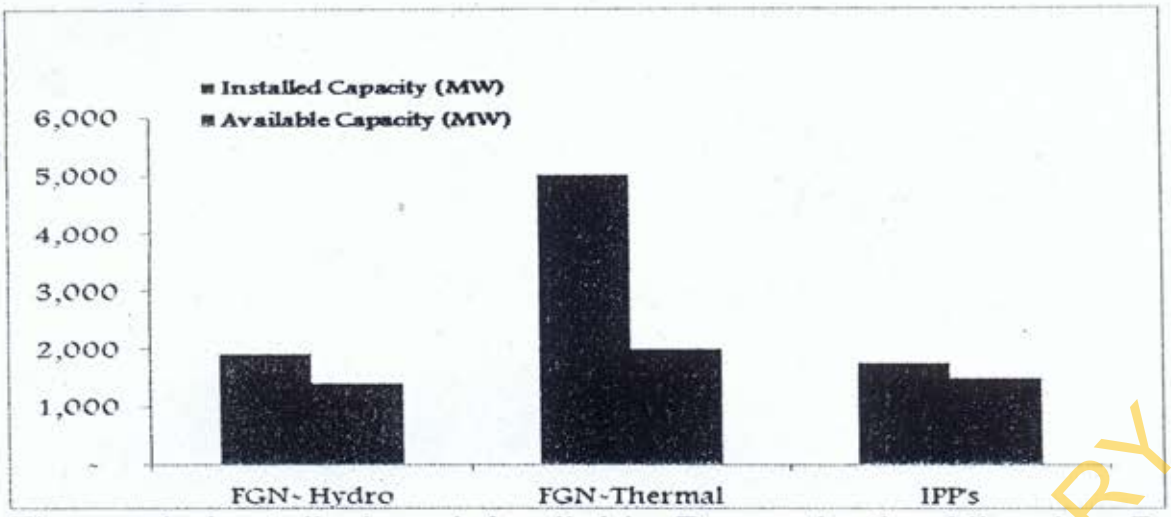

Figure 1: Installed and Available Power in the Nigerian Power Sector.

Table 4: Existing Government Owned Thermal and Hydro Power Plants

S/N	Name of Generation Company	Year of Const	Type	Location	Installed Capacity (MW)	Available Capacity (MW)
1	Egbin Power PLC	1986	Thermal	Egbin, Lagos State	1320	1100
2	Geregu Power PLC	2007	Thermal	Geregu, Kogi State	414	276
3	Omotosho Power PLC	2007	Thermal	Omotosho, Ondo State	304	76
4	Olorunsogo Power PLC	2008	Thermal	Olorunsogo, Ogun State	304	76
5	Delta Power PLC	1966	Thermal	Ughelli, Delta State	900	300
6	Sapele Power PLC	1978	Thermal	Sapele, Delta State	1020	90
7	Afam (IV – V) Power PLC	1963/01	Thermal	Afam, Rivers State	726	60
8	Calabar Thermal Power Station	1934	Thermal	Calabar, Cross – River state	6.6	Nil
9	Oji River Power Station	1956	Thermal	Oji River, Anambra State	10	Nil
10	Kainji/Jebba Hydroelectric PLC – Kanji Power Station	1968	Hydro	Kainji, Niger State	760	480

11	Kainji/Jebba Hydroelectric PLC – Jebba Power Station	1985	Hydro	Jebba, Niger State	540	450
12	Shiroro Hydroelectric PLC	1989	Hydro	Shiroro, Niger State	600	450
	TOTAL				**6904.6**	**3,358**

Source: Nigerian Bureau of Public Enterprises (BPE, 2011)

Table 5: Existing Independent Power Projects in Nigeria

S/N	Name of Generation Company	Type	Location	Installed Capacity (MW)	Available Capacity (MW)
1	AES Power Station	Thermal	Egbin, Lagos State	224	224
2	Shell Afam IV Power Station	Thermal	Afam, Rivers State	650	650
3	Agip Okpai Power Station	Thermal	Okpai, Delta State	480	480
4	ASG Ibom Power Station	Thermal	Akwa Ibom State	155	76
5	RSG Trans Amadi Power Station	Thermal	Port Harcourt, Rivers State	100	24
6	RSG Omoku Power Station	Thermal	Omoku, Rivers State	1150	30
	TOTAL			**1,759**	**1,484**

Source: BPE, 2011

Electricity Transmission

The network of transmission lines constituting the national grid that transverses the country is now owned and managed by the Transmission Company of Nigeria (TCN). The TCN was created as a result of the unbundling of NEPA in 2005. It is owned by the FGN and has responsibility of undertaking the system operation and market settlement functions. The TCN is currently divided into two departments namely: the Transmission Service Provider (TSP) and the System Operator

(SO).which includes the Generation Companies (GENCOs) and the Distribution Companies (DISCOs). It does this by deciding which power station comes on and when and by how many Megawatts (MW) and decides which transmission line or transmission station should be supplied what quantity of MW i.e. load shedding. The SO also enforces grid discipline. The TCN operations cover the 36 states of Nigeria and administratively it is divided into 8 transmission regions and 35 work centers.

Table 6: NIPP Power Plants

S/N	Name Of Power Plant	Location	Designed Capacity (MW)
1.	Calabar Power Project	Calabar, Cross river State	563
2.	Egbema Power Project	Egbema, Imo State	338
3.	Ihovbor Power Project	Ihovbor, Edo State	451
4.	Gbaran Power Project	Gbaran, Bayelsa State	225
5.	Sapele Power Project	Sapele, Delta State	451
6.	Omoku Power Project	Omoku, Rivers State	225
7.	Alaoji Power Project	Alaoji, Abia State	961
8.	Olorunsogo – Phase 2 – Project	Olorunsogo–Ogun State	676
9.	Omotosho – Phase2 – Project	Omotosho, Ondo State	451
10.	Geregu Phase2 – Project	Geregu, Kogi State	434
	TOTAL		4,775

Source: BPE, 2011

The TSP develops the transmission grid to new areas and maintains the infrastructure in the Grid while the SO operates the whole system As shown in Table 7, there has been an impressive increase in the number of transmission lines between 1973 to date. The current average available transmission capacities on the 330/132 KV and 132/33KV transformers are respectively 7,364MVA and 8,448MVA, representing 95.8% and 94.1% of installed capacity

respectively. Also the current average transmission loss is 8.5% (Labo, 2010).

There are also various on-going transmission projects as shown in Table 8 which are financed both by the Federal Government of Nigeria and the NIPPs, with the objective of improving the

transmission capacity of the Nigerian power sector. The total transformation capacity of the transmission network as shown in Table 7 currently stands at a capacity of 16,818 MVA (14,295.3MW) (Akarakiri, 1999& Labo, 2010).

Table 7: Nigerian Transmission Infrastructure (1973 – 2010)

Description	1973	1996	1999	2010	Current Transformation Capacity MVA(MW)
330 KV Transmission lines (Km)	1262	5000	4889.2	5523.8	-
132 KV Transmission lines (Km)	1012	6000	6319.33	6801.49	-
330/132 KV Substations	6	23	21	32	7,688 (6,534.8)
132/33 /11KV Substation	14	91	99	108	9,130 (7,760.5)

Source: Akarakiri (1999) & Labo (2010)

Electricity Distribution

Electricity distribution in Nigeria is currently done through the Distribution Companies (DISCOs) which perform the functions of distributing electricity in apportioned areas on 240V up to 33KV networks of the Nigerian electricity Industry. In addition, DISCOs are expected to have the responsibility of overseeing retail operations to end users of electricity. Currently the Nigerian power sector has 11 Discos and span across the country.

Table 8: On – going Nigerian Power Transmission Infrastructural Projects

Project	FGN	NIPP
330 KV Transmission lines (Km)	986.5	2194
132 KV Transmission lines (km)	705.3	809
330/132 KV Transformer capacity (MVA)	1350	5590
132/33 KV Transformer capacity (MVA)	3000	3313
Others	Reinforcement of Overloaded transmission stations with additional capacity.	Installation of 10 new 330KV substation and 7 new 132KV substation.
	Overloaded transmission lines are being re – conductor with high capacity conductors.	Expansion and reinforcement of 32 existing 330KV and 132 KV substations

Source: Labo (2010)

The trend in the increase of distributive capacity of the companies since 1999 is shown in Table 9. The current distributive capacity is stated as (FGN, 2010): 50,179km of total installed 33KVA line; 34,868km of total installed 11KVA line; 10,506 MVA – total installed injector substation capacity; 17,899 MVA – total installed distributive substation capacity; 1,078 No. of 33/11KV transformers and 41,477 No. of 33/0.415/11KV transformers. In order to improve the

distributive capacity of the power sector, the FGN invested $0.5225 billion (N81billion) in various distributive projects in the country. These projects are on – going and consist of 1,707km of new 33KV lines, 2,666Km of new 11KV lines, additional 3540MVA sub – station capacity and 22, 598 transformers (Labo, 2010).

Table 9: The Distribution Network of the Nigerian Power Sector

S/N	Distribution Network	1999	2008	2010
1.	33KV lines (km)	37,173	48,409.62	50,179
2.	11KV lines (km)	29,055	32,581.49	34,868
3.	415V (km)	70,799	126,032.79	193,822
4.	Transforming Capacity (MVA)	8,342.56	12,219	17,899

Source: Maigada (2008)

The electricity sector in Nigeria is currently undergoing very much needed reform. The reform was initiated with the approval by the FGN in March 2001 of the National Electric Power Policy (NEPP). The key policy objectives of the NEPP are geared towards ensuring: a system of generation, transmission, distribution and marketing that is efficient, safe, affordable and cost – effective throughout the country; and a power sector that attracts private investment both from within and outside the country and promote competition to meet growing demands through the full liberalization of the electricity market. (El – Rufai, 2001).

The major fall out of the policy was the vertically unbundling of NEPA – National Electric Power Authority - into generation, transmission and distribution in 2004 and the passage into law of the Electric Power Sector Reform Act (EPSRA) in March 2005. The EPSRA became the legal and regulatory framework

for driving the power sector reforms. The EPSRA has set in motion the necessary legal framework for the unbundling of NEPA into 18 autonomous companies – 11 distribution companies, one generation company, and one transmission company; the establishment of the Nigerian Electricity Regulatory Commission (NERC) and the creation of the Power Holding Company of Nigeria (PHCN) which came into effect in June 2005.

In pursuance of its powers, the NERC on July 1, 2008 established a 15 years tariff path for the Nigerian Electricity Industry, the Multi – Year – Tariff – Order (MYTO) for the determination of charges and tariffs for electricity generation, transmission and retail tariffs over the period of July 1st, 2008 to June 30th 2013. Also in February 2009, the agency licensed a total of 28 firms as Independent Power Producers (IPP) to compliment government efforts at providing sufficient power to meet domestic needs, (Table 10).

2.5 Biomass

Biomass is defined as organic material, available on renewable basis, which is produced directly or indirectly from living organisms without contamination from other substances or effluents. Biomass includes forest and mill residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residues, aquatic plants, fast growing trees and plants, municipal and industrial wastes. The various types of plant biomass are shown in Table 11.

The biomass resources of Nigeria consist of wood, forage grasses and scrubs, animal wastes arising from forestry, agricultural, municipal and industrial activities, as well as aquatic biomass. Previously, biomass dominated Nigeria's energy landscape, contributing 37% of total energy demand, and the energy of choice for the vast majority of rural dwellers and the urban poor. The biomass energy resources of Nigeria have been estimated to be 144million tonnes/year. Nigeria presently consumes about 43.4×10^9 kg of firewood annually. The average daily consumption is about 0.5 to 1.0 kg of dry

wood per person. Table 5 shows the total area of Nigeria, distributed among the various uses.

Table 10: Independent Power Producers (IPPs) Licensed by NERC by 20/02/09

S/N	Name of Applicant	Type of License	Total capacity	Fuel Type	Site Location	State
1.	Ethiope Energy Ltd	Generation on Grid	2800MW	Gas	Ogorode	Delta
2.	Farm Electric Supply Ltd	"	150MW	Gas	Ota	Ogun
3.	ICS Power Ltd	"	624MW	Gas	Alaoji	Abia
4.	Supertick Nig. Ltd	"	1000MW	Gas	Akwete	Abia
5.	Mabon Ltd	"	39MW	Hydro	Dadinkowa	Gombe
6.	Geometric Power Ltd	"	140MW	Gas	Aba	Abia
7.	Aba Power Ltd	Distribution	-	-	Aba	Abia
8.	Weatern Technologies & Energy Services Ltd	Generation on grid	1000MW	Gas	Sagamu	Ogun
9.	Lotus & Bresson Nig. Ltd	"	60MW	Gas	Magboro	Ogun
10.	Anita Energy Ltd	"	90MW	Gas	Agbara	Lagos
11.	First Independent Power Co. Ltd	"	150MW	Gas	Omoku	Rivers
12.	First Independent Power Co. Ltd	"	136MW	Gas	Trams Amadi	Rivers
13.	First Independent Power Co. Ltd	"	95MW	Gas	Eleme	Rivers
14.	Hudson power Station Ltd	"	150MW	Gas	Warewa	Ogun
15.	Ibafo Power Station Ltd	"	200MW	Gas	Ibafo	Ogun
16.	Shell Distribution Co. Ltd	"	640MW	Gas	Afam	Rivers
17.	Agbara Shoreline Power Co. Ltd	"	100MW	Gas	Agbara	Lagos
18.	Nigeria Agip Oil Co. Ltd	"	480MW	Gas	Okpai	Delta

19.	Ikorodu Ind. Power ltd (Phase II)	"	140MW	Gas	Ikorodu	Lagos
20.	Ming Holdings Ltd	"	115MW	Coal	Enugu	Enugu
21.	Ibom Power Ltd	"	190MW	Gas	Ikot Abasi	Akwa Ibom
22.	Notore Power ltd	"	50MW	Gas	Onne	Rivers
23	Ewekoro Power Ltd	Generation off grid	13MW	Gas	Ewekoro	Ogun
24.	Ikorodu Industrial. Power Ltd	Distribution	-	-	Ikorodu	Lagos
25.	CET Power Projects Ltd	Generation off grid	20MW	Gas	Tinapa	Cross Rivers
26	Ikorodu Industrial Power Ltd	Embedded Generation	39MW	Gas	Ikorodu	Lagos
27.	CET Power Projects Ltd	Generation off grid	5MW	Gas	NBL,	Lagos
28.	Tower Power Utilities ltd	Generation off grid	20MW	Gas	Ota	Ogun
	Grand Total		**8,446MW**			

Source: Sambo, 2008

Table 11: Types of Plant Biomass

Woody Biomass	Non – Woody Biomass	Processed Waste	Processed Fuels
Trees	Energy crops such as sugar cane	Cereal husks and cobs	Charcoal (wood and residues)
Shrubs and Scrub	Cereal straw	Bagasse	Briquetted or densified biomass
Bushes such as coffee and tea	Cotton, cassava, tobacco stems and roots (partly woody)	Wastes from pineapple and other fruits	Methanol and ethanol (wood alcohol)
Sweeping from forest floor	Grass	Palm oil cakes	Plant oils such as palm, rapeseed (canola) and sunflower
Bamboo	Bananas and Plantains	Sawmill waste	Producer gas
Palms	Soft stems, such as those of pulses and potatoes	Industrial wood bark and logging wastes	Biogas

	Swamps and water plants	Black liquor from pulp mills	
		Municipal wastes	

Table 12: Nigeria's Size and land use parameters

NIGERIA	QUANTITY (Million hectares)	PERCENTAGE %
A. SIZE		
Land Area	79.4	85.9
Water bodies (rivers, lakes etc)	13	14.1
TOTAL AREA	**92.4**	**100**
B. LAND USE		
Total Agricultural Land	**71.9**	**77.8**
Arable Cropland	28.2	30.5
Permanent Cropland	2.5	2.7
Pasture Land	28.3	30.6
Forest and Woodland	10.9	11.6
Fadama	2	2.2
Others	7.5	8.1

Source: Federal Ministry of Agriculture

From Table 12 it can be seen that of the total land area of 92.4 million hectares, 79.4 million is occupied by land while water bodies occupy the remaining 13.0 million hectares. With regards to land use pattern, the table also shows that agricultural lands occupy 71.9 million hectares, which are demarcated as shown in the table.

Based on the 2003 recorded crop production for Nigeria, there was an aggregate crop production of about 93.3 million tonnes for the major crops. This quantity refers to the harvested useful parts of the plants. The discarded parts consisting of roots, leaves, stalks, straws, chaff and other parts of plant shoot (otherwise called crop biomass) would be far in excess of this figure (REMP, 2005).

Table 13 further underscores Nigeria's potential for the production of manure, which is a key component of agricultural biomass. From the table it can be seen that Nigeria's livestock manure aggregated production of 285.1 million tonnes is potentially able to produce far more than 3 billion cubic meters of biogas yearly, which is more than 1.25million tonnes of fuel oil per annum.

Table 13: Calculated manure production of Nigeria's livestock

	ENGLAND			NIGERIA			Manure Produced
	Live-stock	Populatio n (million)	Manure Prod (Million tonnes)	FMA (1997) Population (Millions)	Manure Produced (Cal. figures) (Million tonnes)	Population Based on FMA (1997) Figures (millions)	2001 (calculat ed figures) (million tonnes)
1.	Cattle	85	80	18.1	170.4	21	197.6
2.	Sheep	28	11	33.2	13	38.5	15.1
3.	Goat			53.8	21.1	62.4	24.5
4.	Pig	69	11	8.3	13.2	9.6	15.3
5.	Poultry	104	30	97.3	28.1	112.9	32.6
	Total		**132**		**245.9**		285.1

Estimates made in 1985 give the number of cattle, sheep, goats, horses and pigs as well as poultry birds as 166 million. These produce 227,500 tonnes of animal wastes daily which come to 2.2 x 109 MJ taking the calorific value of animal dung to be 9,800 MJ/tonne. Animal residue can be converted to biogas and estimates show that this is of the order of 5.36 x 109 m3 which has an energy content amounting to 2.93 x 109 kWh.(Sambo, 2005)

The foregoing shows that Nigeria has a huge and enormous potential for production of agricultural biomass. Other possible

biomass resource base includes aquatic plants such as water hyacinth and municipal wastes both of which constitute major environmental problems. These present opportunities for meeting energy needs sustainably.

Although the biomass availability as at 1973 was put at 9.1 x 1012 MJ, it is expected that the overall biomass resource availability at present is lower than the 1973 figure. This is largely due to the

demand of wood also for construction and furniture industries in addition to its use as an energy source. As for forage grasses and shrubs, estimates show that 200 million tonnes of dry biomass can be obtained from them and this comes up to 2.28 x 106MJ of energy. For crop residues and wastes, estimates of the 6.1 million tonnes of dry biomass that are produced annually leave residues whose energy content approximate to 5.3 x 1011 MJ.

2.5 Renewables

Renewable energy and technologies have great potential to provide solutions to the long – standing energy problems being faced by the developing countries including Nigeria. In promoting the diffusion of renewable energy into the country's energy supply mix for sustainable development, the government approved in November 2005, the Renewable Energy Master plan (REMP). The Energy Commission of Nigeria (ECN) in collaboration with the United Nations Development Programme (UNDP) prepared the REMP.

The overall objective of the Renewable Energy Master Plan (REMP) is to articulate a national vision, targets and a road map for addressing key energy development challenges facing Nigeria through the accelerated development and exploitation of renewable energy. It is to put in place a comprehensive framework for developing renewable energy policies, legal instruments, technologies, manpower, infrastructure and market to ensure that the visions and targets are realized.

As a further boost to developing renewable energy technology in Nigeria, in 2007, the Federal Executive Council approved a Biofuels Policy Framework for the Nigerian National Petroleum Corporation (NNPC). The Nigerian government is also piloting large-scale biofuels production for use in automobiles and generators, and for biogas production. The NNPC also received a grant of 70,000 Euros from the Renewable Energy and Energy Efficiency Partnership (REEEP) to support a detailed feasibility study into high ethanol-yielding cassava

varieties and other biofuels feedstock for production of two types of automotive fuel: ethanol fuel and palm oil diesel (Shaad et al, 2009). The government has also signed an MOU with Brazil for technology transfer and supply of ethanol from sugar cane, including importing ethanol from Brazil until Nigeria is ready to start producing. There is a further agreement with Cuba on ethanol supply. Ethanol will be used as an additive to petrol, constituting a proposed 10 per cent of the mix.

Also, government has also embarked on several projects in its plans to increase power generation through the incorporation of renewable energy resources. Notable are the:

- *Construction of a 10MW Katsina Wind project* which upon completion is to supplement electricity supply to communities in Katsina and serve as pilot project for wind technology development for potential private sector investors;
- *Construction of 2600MW Mambilla Hydroelectric Power Project (HEPP)* to generate 2600MW base load electricity power;
- *Construction of 700MW Zungeru Hydropower Project* to deliver an optimal capacity of 525MW, with future expansion to 700MW.

3.0 Challenges and Prospects of the Energy sector in Nigeria

From the foregoing, it is clear that the Nigerian energy sector is confronted by a lot of challenges, which were created due to inadequate planning, implementation and expansion of the

sector to meet the growing demand base, which was created primarily by an appreciable increase in population and economic activities over the past twenty years.There is no gainsaying the fact that the overall management of the energy sector leaves a lot to be desired. The existing policies aimed at restructuring the sector for greater effectiveness, which, on the surface, seem to be well thought out, are still to be pursued with the expected vigour to achieve optimal performance. For the country to attain sustainable energy supply to meet its various needs it is recommended that:

- The ongoing reforms in the oil & gas and power sector be pursued with renewed vigour and seriousness;
- The existing underutilized energy infrastructure in the country should be upgraded to operate at optimal conditions;
- New energy infrastructures should be put in place at a faster rate; and
- The energy mix to drive the economy should be diversified to include Nuclear, Coal, Solar, Wind and biofuels.

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