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DISPELLING DARKNESS – **THE NIGERIAN EXPERIENCE**

By

PROFESSOR CHRISTOPHER OKWUCHUKWU AHIAKWO

Ph.D.(RSUST), M.Tech(RSUST), COREN Regd; MNSE; NIEEE; IEEE; SAMSA

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DEDICATION

This Inaugural Lecture is dedicated to Almighty God, my late parents (Chief Isaiah Ograbe Ahiakwo & Mrs Jerrinah Ugboko Ahiakwo), my wife Lady Roseline Ego Ahiakwo, my Children and Grand children.

The Vice-Chancellor,
The Registrar,
The Bursar,
The Provost, College of Health Sciences,
Deans of Faculties,
Directors of Institutes,
Heads of Departments,
Eminent Professors,
Your Royal Majesties and Royal Highnesses,
The Clergy,
Chiefs and Elders,
Distinguished Academic Colleagues,
Great NDU Students,
Gentlemen of the Press,
Distinguished Ladies and Gentlemen.

DISPELLING DARKNESS – THE NIGERIAN EXPERIENCE

1. PREAMBLE:

The history of creation as recorded in the Holy Scriptures, states that God created the heavens and the earth; and that the earth was void, without form and that darkness covered the entire surface of the earth. Then God said, “Let there be light” and there was light. (Gen.1:1-3) NKJV. Since creation, man has seen darkness as a condition of invisibility to his physical vision. Human movement is usually restricted in darkness as human vision is poor in darkness. Darkness is therefore a condition of black out, mainly experienced at night, especially in the rural communities where there is no electricity.

In urban cities, especially in Nigeria, where electricity supply is very irregular, there is always a relief of pain with a shout of joy from children when Electricity Distribution Company suddenly supplies light at night after a prolong power outage. This therefore shows that light brings joy and happiness to people.

Darkness can also be definite as a situation where people are living in ignorance, uninformed and uneducated. Usually persons in this category of darkness are uncivilized, uncultured and rude in behavior. A community in this category of darkness is not only undeveloped but its inhabitants are backward in all aspects of human development. They are

crude in psychological reasoning and even in physical appearance. It is a very derogating statement to say that a community is living in darkness (ignorance), let alone a nation. The truth is that, as Nigerians, we have all it takes (human and natural resources) to dispel darkness in all aspects of life. Hence, one can conveniently make the call "**Let there be Light in Nigeria".**

2. INTRODUCTION:

Dispelling darkness brings light. Light can be defined as energy from either a natural source (the sun) or artificial source (lamp/electricity). It is therefore, a medium that dispels darkness and brings brightness to the environment thereby providing physical vision to the human eye.

Fig 2.1: A Man Fishing in Darkness

Fig.2.2: Sunlight Providing Vision for a Man Fishing in the Dark

It can also be defined as intellectual ability that is acquired through formal or informal education that eradicates ignorance in the society. The later definition is centered on human capacity and societal exposure while the formal is on environmental development. This paper concentrates on the former definition.

2.1. Sources of Light

Sources of light, whether from energy or from intellectual ability, are all available with us here in Bayelsa State of Nigeria. All that is required is political and economic will to harness them properly for the benefit of the citizenry.

They can therefore be classified as (i) Energy Base and (ii) Intellectual Base.

2.1.i. Energy Base:

Energy base source of light is the nucleus of this paper. It includes the sun and energy derived from other primary sources such as thermal, hydro and renewable power plants.

Sun Energy:

The primary and natural source of light is the sun. About 44% of sun's electromagnetic radiation is in the visible region of human vision. Light can therefore be defined as electromagnetic radiation visible to the human eye, which is often known as daylight. Its primary property is the illumination of the environment to provide physical vision for the human eye. Its wave length is from $400x10^{-9}$m to $700x10^{-9}$m.

Fig.2.3: Sun Rays in an Open Environment.

Sun rays can be used as a means of producing electrical energy. This is achieved by the use of photovoltaic cells (commonly known as solar cells).

Fig.2.4: Sun Rays in a Community Forest.

Photovoltaic cells convert sun rays to electrical energy. This process is known as solar power system. It is the most commonly used source of renewable energy in Nigeria today.

Thermal Power Plant:

Energy is stored in fossil fuels (coal, oil and natural gas). This energy is converted to electrical energy in thermal power stations. The generated energy eventually produces the desired light for physical human vision.

Hydro Power Plant:

Hydro power plant uses the energy in falling water to generate electricity. Thus the plant converts the potential energy of water to kinetic energy as the water falls from a height. This eventually turns the shaft of the turbine and finally generates electricity. The generated electricity forms source of light

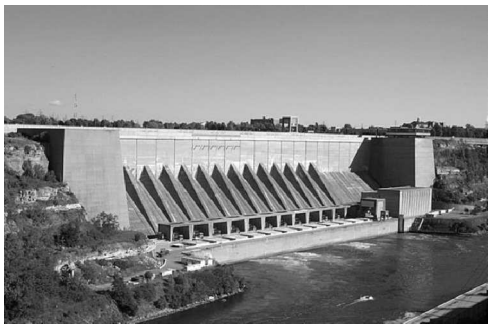

Fig.2.5: Hydro power plant

Intellectual Base:

Education generally produces intellectuals. A society with about 70% of its population properly educated is said to be a literate society. Whether formal or informal, education eradicates ignorance in the society. While a community whose inhabitants are predominantly illiterates is said to be a backward community. In short, inhabitants of such community are deemed to be living in darkness even when such community has regular electricity and water supply, courtesy of either Government or Multinational Companies.

3. HARNESSING ENERGY FOR LIGHT:

3.1. Ancient Time:

Man's primary wants in life are food, clothing and shelter. He initially derived light from the sun. Accidentally, he obtained fire by striking stones. He immediately realized that the stones around him were source of light. Gradually, he discovered that light can be obtained from other energy sources.

The provision of light for physical vision of human eye by these energy sources are the focus of this paper.

With light, man has now moved beyond looking at his immediate wants, to seeking ways of improving his environment and providing social collaboration with neighbours. He has constantly been involved in harnessing his environment to improve his social status.

The early man initially obtained light by striking stones. This progressed to the use of fire wood as storage implement for fire (light). In most rural communities, especially those from the Niger Delta region of Nigeria, there are special woods reversed for the storage of fire (light). In the 60s, inhabitants of these communities used processed palm fruit chaffs as source for the retention of light. A hand full of processed palm fruit chaff was used in retaining light for hours.

Fig.3.1: Local Lamp Using twisted Cloth Immersed in Palm Oil.

Later, twisted piece of cloth immersed in palm oil was introduced as a medium for retaining light. This continued until the use of kerosene was introduced with the evolution of oil.

Fig.3.2: Use of Kerosene Lamp in a Rural Community

The early man even discovered the usefulness of harnessing light energy for hunting. Thus, he introduced the use of HEAD LAMPS constructed with twisted piece of cloth immersed in palm oil to beam light rays on animals at night in hunting expeditions.

3.2. Modern Time:

Advancement in technology has led to various ways of harnessing energy from one form to other. This has therefore enhanced the production of light from many sources other than the sun.

Nigeria as a country is blessed with a lot of energy base sources. These sources range from solid, liquid to gaseous.

They include coal for solid source, running water (hydro) and oil for liquid sources, and natural gas for gaseous sources. Renewable energy source is another useful source for electric power production. Light is currently being obtained from the use of renewable energy sources. This technology is yet in its primary stage in Nigeria.

3.2.1. Coal:

Coal is a rich source of energy. It was first discovered in Nigeria in 1909 in the present Enugu State. Coal mining began in Nigeria in 1916 with a recorded output of 24,500 tons. Production rose to a peak of 905,000 tonnes in 1958/59. This accounted to over 70% of commercial energy consumption of the country at that time. Available data showed that coal of sub-bituminous grade was found in about 22 coal fields which are in over 13 States of the Federation. The proven coal reserve so far in the country is about 639 million tonnes while the inferred reserve is about 2.75 billion tonnes.

Following the discovery of crude oil in commercial quantities in 1958 and the conversion of railway engines from coal to diesel, production of coal reduced drastically. The drop was such that coal constituted only about 0.02% of commercial energy consumption in the country in 2001. Nigeria's coal can be utilized for power generation, steam production, in cement production and for brick making. It can be used as a heat

source and reducing agent for steel production. Also it can be used as a domestic fuel and a feedstock for the production of chemicals, liquid fuels, gaseous fuels, batteries, carbon electrodes, etc.

3.2.2. Oil:

Oil exploration in Nigeria witnessed steady growth over the past few years. The nation had a proven reserve of 25 billion barrels of predominantly low sulphur light crude in 1999. This substantially increased to 34 billion barrels in 2004 and currently is about 36.5 billion barrels. This growth in oil reserve is attributable to improved funding of Joint Venture operations, timely payment of cash (call arrears), introduction of an alternative funding scheme, the emergence of new production technology/sharing arrangements and the opening up of new frontier in production and deepwater oil operations / offshore blocks. Based on various oil prospects already identified, especially in the deepwater terrain and development efforts being made by Federal Government, the proven reserve of oil is projected to progress progressively to about 40 billion barrels and may eventually get to 68 billion barrels by year 2030. Oil production in the country has also increased steadily over the years.

However, the rate of increase is dependent on economic and geopolitics in both

the producing and the consuming nations. Nigeria's current productivity is about 2.4 million barrels per day even though actual production fluctuates around this average production level. This is partly due to the problem of militancy/oil theft in the Niger Delta region and production restriction by Organization of Petroleum Exporting Countries (OPEC). However average daily production is projected to about 5.0 million barrels per day in year 2030. This level of production will however be realized only, with the adoption of high exploration strategic development policies and programmes covering the inland basins of Niger Delta, the offshore continental shelves and deepwater offshore terrains.

In the downstream oil sub-sector, Nigeria has four refineries with a total installed capacity of 445,000 barrels per day and 5001 km network of pipeline from the refineries to 22 oil depots. The Federal Government has also established petrochemical and fertilizer plants. The capacity utilization of these plants and facilities has been considerably low, due to the high level of decay arising from poor maintenance and operating conditions, under funding, vandalization of oil facilities (especially pipelines), and the various companies' lack of management autonomy for efficient operation. Consequently, annual domestic demand for petroleum products is not fully met by internal production and has to be supplemented by imports.

Fig.3.3: A Typical Oil Field in Niger Delta

3.2.3. Nuclear Energy

Nuclear energy is one of the major sources of base load electricity generation in the world today. The technology for harnessing nuclear energy demands great responsibility and expertise. Therefore, it requires careful planning of manpower development and material resources.

Essential requirement of any nuclear plant is the availability of nuclear minerals such as uranium and thorium. In 1947, an element containing uranium was found in appreciable quantities in the Jos Plateau and its environs. This mineral is yet to be extracted in commercial quantity in Nigeria. By 1979, about 617,000 km^2 of land area had been covered by aerial radiometric surveys and another 90,000 km^2 had been covered by other surveys. Since then no further work has been done. There is need to intensify efforts in the extraction of uranium and even in extending investigations to other areas of the country where traces of radioactive minerals are suspected to be found.

3.2.4. Natural Gas:

Nigeria's proven natural gas reserve was estimated at about 187.44 trillion standard cubic feet in 2005. Gas is believed to be higher in energy content when compared with its equivalent in oil resources.

Gas discovery in Nigeria was incidental. The discovery was from oil exploration and production activities. Gas was originally met to be flared out to allow the production of oil to be effective. Consequently, as high as 75% of the gas produced was flared in the past. However, gas flaring has been reduced to about 36% as a result of strident efforts by the Government to monetize natural gas. Domestic utilization of Natural gas is mainly for power generation which accounts for about 80%. The remaining percentage is used in the industrial and domestic sectors of the economy.

Given the current reserves and rate of exploitation, the expected life-span of Nigerian crude oil is about 44 years, based on about 2mb/d production, while that for natural gas is about 88 years, based on the 2005 production rate of 5.84 bscf/day.

3.2.5. Renewable Energy:

In most developing nations of the world today, rural communities with difficulties of connectivity to large grid electricity infrastructure, off-grid networks are made available

for such communities. This is done by the use of renewable energy.
However, billions of people particularly in poor rural areas still remain without access to clean and modern sources of energy.

Fig.3.4: Solar Panel

Energy provision, particularly through off-grid renewable energy systems, represents an important step for reducing the electricity gap in rural parts of the developing world.

Table 3.1: World Energy Pattern

Energy Resource	World					U.S.
	Theoretical Potential (TW)	Extractable Potential (TW_c)	**Technical Potential (TW_c)**	**2001 Supply (TW_c)**	2001 Supply (TW_c)	
Hydropower	12 TW_m[17]		3.5[18]	1.2[19]	0.23[20]	0.056[21]
Ocean Wave	34 TW_m[22]		8.5[23]	0.62[24]	~0[25]	~0[26]
Ocean Surface Currents	8.1 TW_m[27]		2.0[28]	0.012[29]	~0	~0
Ocean Thermal Gradient	3.9 TW_t[30]		0.033[31]	0.0033[32]	~0[33]	~0[34]
Ocean Salinity Gradient	3.0 TW_m[35]		0.74[36]	0.074[37]	~0	~0
Ocean Tidal	2.4 TW_m[38]		0.60[39]	0.037[40]	0.000050[41]	
Wind	1,000 TW_m[42]		250[43]	14[44]	0.0050[45]	
Geothermal	44 TW_t[47]		2.8[48]	1.9[49]	0.0050[50]	
Solar Electricity	89,000 TW_p[52]		58,000[53]	7,500[54]	0.00015[55]	

Solar Fuels[j]	89,000 TW_p[57]	61,000[58]	2,500[59]	0.19[60]
Solar Thermal[k]	89,000 TW_p[62]	19,000[63]	5,600[64]	0.00060[65]

Source: EIA IEO 2005. Energy Information Administration, International Energy Outlook 2005"
(U.S. Department of Energy, Jul 2005).

Nigeria is endowed with abundant renewable energy resources, the significant ones being solar energy, biomass, wind, small and large hydropower with potential for hydrogen fuel, geothermal and ocean energies. Except for large scale hydropower which serves as a major source of electricity, the current state of exploitation and utilization of the renewable energy resources in the country is very low. It is limited largely to pilot and demonstration projects.

3.2.6. Hydro:

The total technically exploitable large scale hydropower potential of the country is estimated at over 10,000MW, capable of producing 36,000GWh of electricity annually. The small scale hydropower potential is estimated at 734MW. Current hydropower generation is about 14% of the nation's hydropower potential. This represents about 30% of the total installed grid-connected electricity generation capacity.

Despite its high initial capital cost, hydropower provides one of the cheapest and cleanest sources of electricity. The country is well endowed with large flowing rivers and some few natural falls which are together responsible for the high hydropower potential of the nation. It is estimated that hydropower will be a major provider of base load electricity, after gas, in order to achieve the projected 35,000MW electricity generation by 2020.

Fig.3.5: Hydro Power Plant.

Therefore, the nation needs to manage its water resources for the development of its hydro - electric potentials and for other uses. The policy should focus more on micro hydro plants.

3.2.7. Wind:

Utilization of wind energy is presently very minimal in the country. The only known and still functional wind pump in the country is the Sayya Gidan Gada Wind Electricity Project in Sokoto State.

Fig.3.6: Wind Mill

It has a capacity of 5.0 kW. Already, the wind energy mapping of the country has been done. The coastal areas have great potential for wind mill.

3.2.8. Solar:

Studies relevant to the availability of the solar energy resource in Nigeria have fully indicated its viability for practical use. Although solar radiation intensity appears diluted when compared with the volumetric concentration of energy in fossil fuels.

Fig.3.7: Solar Light in Urban City of Nigeria.

It has been confirmed that Nigeria receives 5200 kWh of energy per day from the sun. About 270 MWh of electric energy can be obtained from solar energy appliance of just 5% efficiency on 1% of the country's surface area. This amount of electrical energy is equivalent to 4.66 million barrels of oil per day.

3.2.9. Biomass:

The biomass energy sources of the nation have been estimated to be 144million tones/year. It is estimated that Nigeria consumes about 4730kg of fuel wood annually. Over 60% of Nigeria's population depends on fuel wood for cooking and other domestic uses. The consumption of fuel wood is worsened by the wide spread use of inefficient cooking methods, the most common of which is still open fire. The rate of consumption of fuel wood far exceeds its replenishing rate. This has resulted to desert encroachment, soil erosion and loss of soil fertility.

4. JOURNEY OF LIGHT IN NIGERIA:

The industry began in 1898 in Ikoyi, Lagos, when the first generating plant was installed by the Colonial Government for administrative use and also for the comfort of the whites only. The Public Works Department (PWD) was responsible for its management. The first electricity utility company was built in Kurra near Jos for the comfort of white settlers and the tourists

that were attracted to the place. Thus in 1929, the Nigerian Electricity Supply Company built in Kurra commenced operation. In 1950, the Federal Government of Nigeria passed Electricity Corporation of Nigeria (ECN) Ordinance No. 15 of 1950, to strengthen the industry. This ordinance was followed by the Niger Dam Authority (NDA) act of Parliament of 1962. This act mandated the NDA to develop the hydro-power potential of the country. However, in June 1972 decree No 4 of 1972 was established and this brought the merging of ECN and NDA to National Electric Power Authority (NEPA). The decree made NEPA to enjoy the monopoly of being responsible for generation, transmission, distribution and marketing of electricity in Nigeria. At the inception of NEPA in 1973, only five (5) of the then 19 state capitals were connected to the National grid. Though, electric power supply is grossly inadequate today, all the 36 state capitals including the Federal Capital Territory are now connected to the National grid.

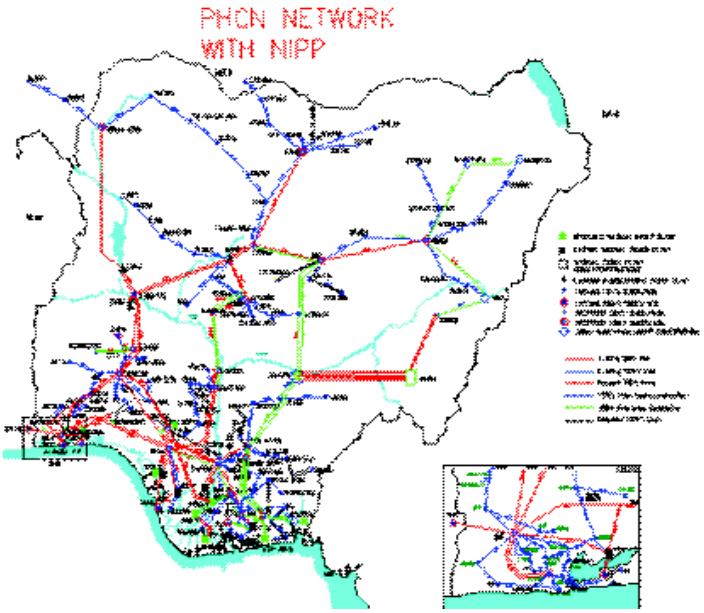

Fig. 4.1: Nigerian Power Network

As a public owned establishment, NEPA was very inefficient in service delivery, without innovation and coupled with poor management. This left the establishment in a dilapidated state with serious stagnation of fund for infrastructural expansion.

In 1998, I commenced a study on the Nigerian Power System under the supervision of Prof Thomas Nwodu of blessed memory. The study was concluded in 2000 with recommendation for the unbundling of the system. The recommendation formed a very important point of National discuss on the Nigerian power system and finally in 2005,

Electric Power Sector Reform Act was enacted with the sole aim of restructuring the power industry. Thus the industry was renamed "Power Holding Company of Nigeria (PHCN)".
Today, the Nigerian power industry is unbundled into eighteen (18) companies, consisting of the following:

(i) 6 Generating Companies (GENCOs),
(ii) 1 Transmission Company (TRANSCO), and
(iii) 11 Distribution Companies (DISCOs).

5. THE NATIONAL GRID:

Electric power sector is very critical to the economic, industrial, technological and social development of a nation. Electricity consumption in its self has become one of the indices for measuring the standard of living of a country.

Electricity industry in Nigeria was previously dominated by vertically integrated grid system that has now been upgraded to 330KV. Presently (2014), only 40% of the country's population has electricity. Majority of this 40% population are concentrated in urban areas. Meanwhile, the nation's electricity network is characterized by constant system collapses, resulting from low generating capacity by the few generating stations currently in service. The pre-deregulated installed generation capacity in Nigeria was about 6010 MW and National Electric Power Authority, NEPA (now Generation

Company of Nigeria GENCO) was only able to guarantee a maximum of 4000MW. This was achieved for only few months after which electricity power generation of the nation has be fluctuating between 2,200MW to 3,000 MW for a vast and populous country as Nigeria. This was grossly inadequate for the Nation. Even the present installed capacity of about 10,396MW is still not adequate for the entire nation. Unfortunately generation level is below 50% of the installed capacity. What we now have
load shedding to cope with the generation.

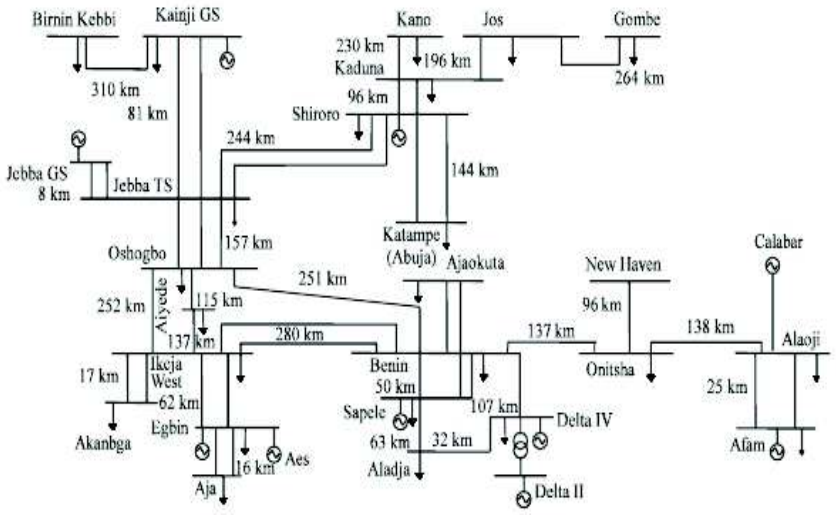

Fig.5.1: Nigerian Grid Network

Presently, the Nigerian power system is scheduled and constantly adjusted to achieve the following operational criteria.

Frequency	50Hz	± 1%
Voltage	132KV	+ 10%
		15%
Voltage	330KV	+ 5%
		15%

5.1. Pre-deregulated Grid:

Pre-deregulated era of the Nigerian power system was manned by National Electric Power Authority (NEPA) which was established in 1972 with a 330KV transmission line of 1,262km, 132KV transmission line of 1,012km and 7 units of 330/132/33KV sub-stations. In 1999, a marginal expansion was made in the grid. It then had 5 thermal power plants with 3 hydro plants, a 330 KV transmission line of 5,000km and a 132KV transmission line of 6,000km across the entire nation. The power plants consisting of both thermal and hydro are as follows:

5.1.1. Thermal Power Plants:

1. Afam power plants I-IV in Afam near Port Harcourt. It has a total installed capacity of 700MW.
2. Delta power plants I-IV near Ughelli in Delta State. It has a total installed capacity of 912MW.
3. Ijora power plants phases I-IV near Lagos with installed capacity of 105MW.
4. Egbin power plants (6x220)MW plants near Lagos. It has a total installed power capacity of 1,320MW.
5. Ogorode (Sapele) thermal plants has installed power capacity of 1,005MW.

5.1.2. Hydro Power Plants:

1. Jebba hydro plant with total installed capacity of 570MW

2. Kainji hydro plant is the oldest hydro power plant in Nigeria. It has a total installed power capacity of 760MW.

3. Shiroro hydro plant at Shiroro near Minna in Niger State. It has a total installed capacity of 600MW

Table 5.1: **330KV Transmission Lines.**

S/N	Description of Line	Type of Circuit	Length of Line (km)
A	**Lagos Region**		
1	Aiyede Ikeja West	Single Circuit	137
2	Ikeja West - Akangba	2 Single Circuits	36
3	Ikeja West - Egbin	Double Circuit	124
4	Egbin - Aja	Double Circuit	28
5	Aja - Alagbon	Double Circuit	52
B	**Oshogbo Region**		
1	Oshogbo - Jebba	3 Single Circuits	471
2	Oshogbo - Aiyede	Single Circuit	137
3	Oshogbo - Ikeja West	Single Circuit	296
4	Oshobgo - Benim	Single Circuit	251
C	**Jebba Region**		
1	Jebba - Shiroro	2 Single Circuits	486
2	Jebba - Kainji	2 Single Circuits	162
3	Jebba - Birnin Kebbi	Single Circuit	310
4	Jebba Gen. Station - Jebba Trans. Station	Double Circuit	16
D	**Kaduna Region**		
1	Shiroro - Kaduna	2 Double Circuit	192
2	Kaduna - Jos	Single Circuit	197
3	Kaduna - Kano	Single Circuit	230
E	**Gombe - Region**		
1	Jos - Gombe	Single Circuit	265
F	**Benin - Region**		
1	Benin - Onitsha	Single Circuit	137
2	Benin - Ajaokuta	Single Circuit	195
3	Benin - Ikeja West	Double Circuit	560
4	Benin - Sapele	2 Double Circuits	200
5	Benin - Aladja	2 Double Circuits	145
6	Onitsha - New Heaven	2 Double Circuits	96
G	**Aba - Region**		
1	Alaoji - Onitsha	Single Circuit	154
2	Alaoji - Afam (Port Harcourt)	Double Circuits	50

Fig.5.2: Existing Power Generation feeding the National Grid (PRE-DEREGULATED)

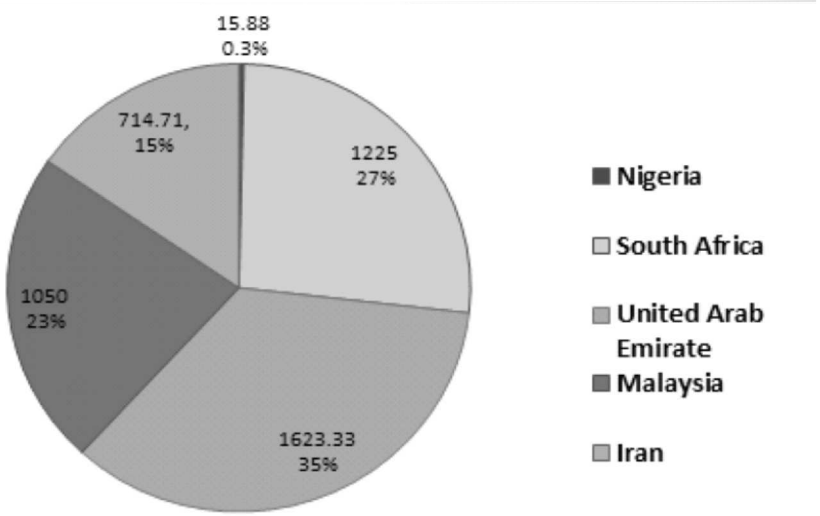

Figure 5. 3: Pie Chart showing the Per Capita Generation of Nigeria and selected Developing Nations

Table 5. 1: Per capital generation of Nigeria and Selected\ Developing Nations

Country	Population (Million)	Generation Capacity (MW)	Per Capita Generation (MW)
Nigeria	170	2,700	15.88
South Africa	48	58,800	1225.00
United Arab Emirate	6	9,740	1623.33
Malaysia	30	34,000	1050.00
Iran	68	48,600	714.71

5.2. Post Deregulated Grid:

Besides the unbundling of the national grid, Federal Government also introduced the involvement of independent power plants into the power sector and in 2008, total installed power capacity of the Nigerian Power System was 7,914.4MW for an estimated population of 150 million people. This is shown in Table 5.2. Figure 5.4 shows a bar chart of the capacities contribution of power plants that are fed into the national grid (Pre-deregulated grid). Today, total installed power capacity is about 10,396MW. Even though generation level is below 50% of installed capacity the transmission lines are adequate enough to evacuate the generated power to load centres.

Table 5.2: Power Generating Plants in Nigeria
(Post Deregulated Grid)

S/No	Power Plants Feed to the National Grid	Age of Plant (Years)	Installed Capacity (MW)	Available Capacity (MW)	Operational Capacity (MW)
1	Kainji	39 - 41	760	440	400
2	Sapele	27 -31	1020	90	65
3	Afam	27	702	350	300
4	Jebba	26	578.4	385.6	300
5	Egbin	24	1320	880	600
6	Shiroro	23	600	600	300
7	Delta	19	840	540	330
8	Egbin AES Enron-Lagos	8	270	270	220
9	Okpai	4	480	480	400
10	Obrikom (Omoku)	4	150	100	70
11	Geregu	3	414	414	414
12	Ajaokuta	3	110	100	80
13	Omotosho	2	335	80	75
14	Olorunsogbo	2	335	80	35
TOTAL (MW)			7,914.5	4,815.6	3,589

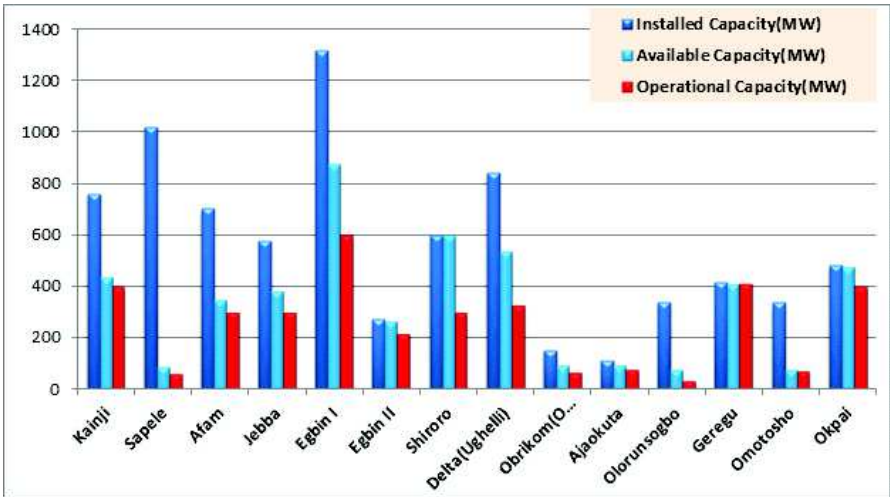

Figure 5.4 Power Generation Plants Feeding The National Grid (POST DEREGULATED GRID)

Total power generated at the end of that year was 2,403.2MW. In 2009, more fund was injected into the power sector with a projected generation of 6000MW before the end of that year. Not until the end of 2010, power generated into the grid reached 4000MW. This quantity of power however dropped at the beginning of the following year 2011.

In 2005, the power industry was privatized and reorganized to become Power Holding Company of Nigeria (PHCN). Consequently, the vertically integrated grid system was unbundled into (i) Generation Companies (ii) Transmission Company (iii) Distribution Companies. These companies are now known as GENCO's, TRANSCO and DISCO's

respectively.

5.2.1 Generation Companies (GENCO's)

The GENCO's are saddled with the responsibilities of Power generation only.
They include:

- Kainji Power Plc.
- Shiroro Power Plc
- Ughelli Power Plc
- Sapele Power Plc
- Afam Power Plc
- Geregu Power Plc

Fig. 5.5: National Integrated Power Project (NIPP) of Niger Delta Power Holding Company Limited (NDPHC)

5.2.2 Transmission Company (TRANSCO):

The TRANCO transmits the power generated by the GENCO's. Only one company is saddled with this responsibility as at now.

5.2.3 Distribution Companies (DISCO's):

The DISCO's are responsible for the distribution of electrical power that is evacuated from the generating stations by TRANSCO. Some of the distribution companies (DISCO's) include:

- Ibadan Electricity Distribution Co. Plc
- Eko Electricity Distribution Co
- Port Harcourt Elect. Distribution Co. Plc
- Enugu Electricity Distribution Co. Plc
- Kaduna Electricity Distribution Co. Plc
- Kano Electricity Distribution Co. Plc
- Jos Electricity Distribution Co. Plc
- Yola Electricity Distribution Co. Plc

6. RURAL ELECTRIFICATION USING RENEWABLE ENERGY:

Nigeria is endowed with abundant renewable energy sources, the significant ones being solar energy, biomass, wind, etc. These renewable energy sources are available in rural communities across the nation. Nearby communities can be networked with distributed generation (DG). This is

very appropriate for Oil Bearing Communities that are very close to each other. Nigeria has great potentials in renewable energy sources. These potentials can be harnessed to produce clean power for rural electrification. Renewable energy sources in Nigeria are as shown in table 6.1. Figures 6.1 and 6.2 show the possible locations of wind mill and solar panels for adequate power generation.

Fig. 6.1: Wind Mill

Table 6.1: Renewable Energy Sources of Nigeria

S/No	Resource Type	Potential Site	Estimated Quality of Production
1	Solar Radiation	Available all year round in country	3.5-7.0 KWh/m^2/day
2	Wind	Available both in coastal and arid-zone areas	2-4m/s at 10m height in main land area.
3	Small Hydro Plant	1. Plateau State -- 2Nos each in Bagel and Lere Rivers, 1No in Kurra River. 2. Sokoto State – 1No in Bakalori River 3. Kano State – Tiga River 4. Benue State – 5Nos in Benue River	3,500MW for small rural community
	Small Hydro plant	5. Ogun/Osun S tates – 3Nos in Ogun and Osun Rivers. 6. Edo State – 3Nos in Owena River. 7. Anambra/ Imo States – 3Nos in Anambra and Imo States. 8. Borno State – 3Nos	3,500MW
		Fuel wood	11 million hectares of forest and wood land.
4	Bio- Mass	Animal waste	211 million assorted animals.
		Energy Crops and Agricultural Residue	28.2 million hectares of arable land.

6.1: Photovoltaic (PV):

PV is the most viable alternative source of DG for the oil bearing communities of Nigeria. It is a clean source of energy with zero emission, having no noise, air or water pollution to the environment. Studies have shown that average isolation in Nigeria (Oil bearing communities inclusive) is 5080TWh/day and that PV unit of 1% efficiency in 1% surface area has 508GWh of electrical energy which is equivalent to about 1 million barrels of oil.

Fig. 6.2: Solar Panel

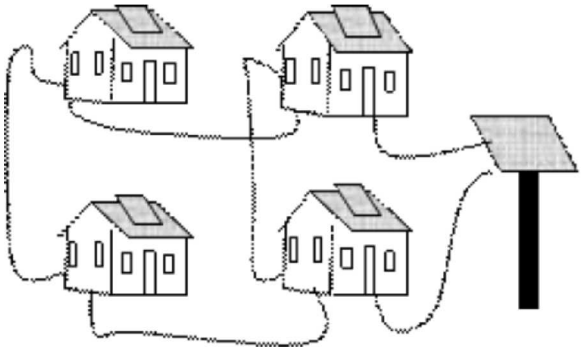

Fig.6.3: DG Network

Unlike the conventional power system, DG system has its generation close to load centre and this adds to stability and reduction of losses. Though, PV has network related advantages which include improved security of system, power quality and reliability, it has some disadvantages. These disadvantages are mainly

(i) High installation cost and

(ii) Large surface area for solar panel coverage.

Unlike the conventional power system, DG system has its generation close to load centre and this adds to stability and reduction of losses. Besides, it is cheaper on the long run to have DG (renewable energy) installation than fossil powered electricity supply.

6.2. Wind Energy:

A study on the wind energy potentials for a number of Nigerian cities shows that annual wind speed of the country ranges from 2.32 m/s for Port Harcourt to 3.89 m/s for Sokoto. The maximum extractable power per unit area, for the same two sites are estimated as 4.51 and 21.97 watts per square metre of blade area, respectively. When the duration of wind speed that is greater than 3 m/s is considered, the energy per unit area would be 168.63 and 1,556.35 kWh per square metre of blade area for Port- Harcourt and Sokoto respectively. As at 2009, Nigerian total wind energy generation capacity was

8,876MW but only 3,653MW was available. This is equivalent to 41% of the total installed capacity. Estimated wind energy potentials for some selected states of Nigeria are as shown in table 6.2

Table 6.2: Wind Energy Potentials in Selected States of Nigeria.

S/No	Selected State	Area (Km^2)	Windy Area %	Potential Capacity (Mw)	Potential Generation (Mwh/yr.)
1.	Adamawa	37,957	45	854	2244
2.	Bauchi	48,197	50	1204	3166
3.	Borno	72,767	100	3638	9561
4.	Gombe	17,428	100	871	2290
5.	Jigawa	23,415	100	1170	3076
6.	Kaduna	44,217	60	1326	3486
7.	Kano	20,389	90	917	2411
8.	Katsina	23,822	100	1191	3130
9.	Kebbi	36,320	25	454	1193
10.	Plateau	26,539	90	1194	3138
11.	Sokoto	32,146	90	1446	3801
12.	Taraba	59,180	40	1183	3110
13.	Yobe	44,880	100	2244	5897
14.	Zamfara	33,667	80	1346	3539

Fig. 6.4: Plant Sites for Wind Energy

Possible plant sites for wind energy in the Oil Bearing Communities of Nigeria are on the coastal areas. Average annual wind speed is 2.32m/s with extractable power per unit area of 4.51W/m^2 of blade area. Aerodynamic power of the wind turbine is expressed as shown in Equation 6.1

$$P = \frac{1}{2}\rho\pi R^2 V^3 C_p \quad (6.1)$$

Where: ρ = Air Density;
R = Turbine Blade Radius;
V = Velocity of Wind;
and C_p= Turbine Coefficient.

Like the photovoltaic energy source, this source of energy generation is also environmental friendly. With renewable energy (photovoltaic or wind energy) the electricity and water supply needs of oil bearing communities can adequately be

met without pullulating the environment.

Renewable Energy, apart from being environmental friendly, it is available in every part of the country. It has network related advantages which include improved security of system, power quality and reliability. It has no radioactive disposal waste which can lead to environmental pollution and climatic change. While the conventional sources of power generation (thermal, nuclear and big hydro plants) produce pollutants. Emissions from the thermal and nuclear sources are agents of climatic change while noise from big hydro plants cause noise pollution. So renewable energy sources can be used to dispel darkness in rural communities of Nigeria especially in the Niger Delta communities where connectivity to the National grid seems difficult.

7. DISPELLING DARKNESS IN BAYELSA STATE:

Creation of States in Nigeria in 1967 brought both intellectual and energy based light to most rural communities. More institutions of leaning were built and oil bearing communities were able to persuade the oil companies to provide their various communities with social amenities (provision of electricity and water).

With the creation of Bayelsa State and the establishment of Niger Delta University, light has been brought to the door step

of Bayelsans. More communities are enjoying electricity and more families now have their wards in tertiary institutions.

In Electrical and Electronic Engineering (EEE) Department of NDU, a lot of studies on electrical power demand of Bayelsa State are on. The sole main of these studies is to dispel darkness completely from the Niger Delta Region. They are:

(i) Study on the best possible tilt angle for optimal solar radiation on inclined surface for photovoltaic solar lightning in Yenagoa, the Bayelsa State capital. This study has shown that the best tilt angle for mounting solar panels in the Niger Delta Region is between 15° – 45°. The study has also shown that radiation peaks at the months of October to March and falls at the months of April to September. This corresponds to the two seasons of dry and rainy seasons in Nigeria.

(ii) Study on the use of renewable energy for major streets of Yenagoa.

A team of Final Year Students of the department have just concluded a study of Power supply and Load distribution pattern of the entre Bayelsa State. This study has shown that Bayelsa State is fed from a 2 x 40 MVA, 132/33KV Sub-station at Gbaratoru. This sub-station is fed from Ahoada by two parallel 132KV transmission lines as shown in Fig.7.1

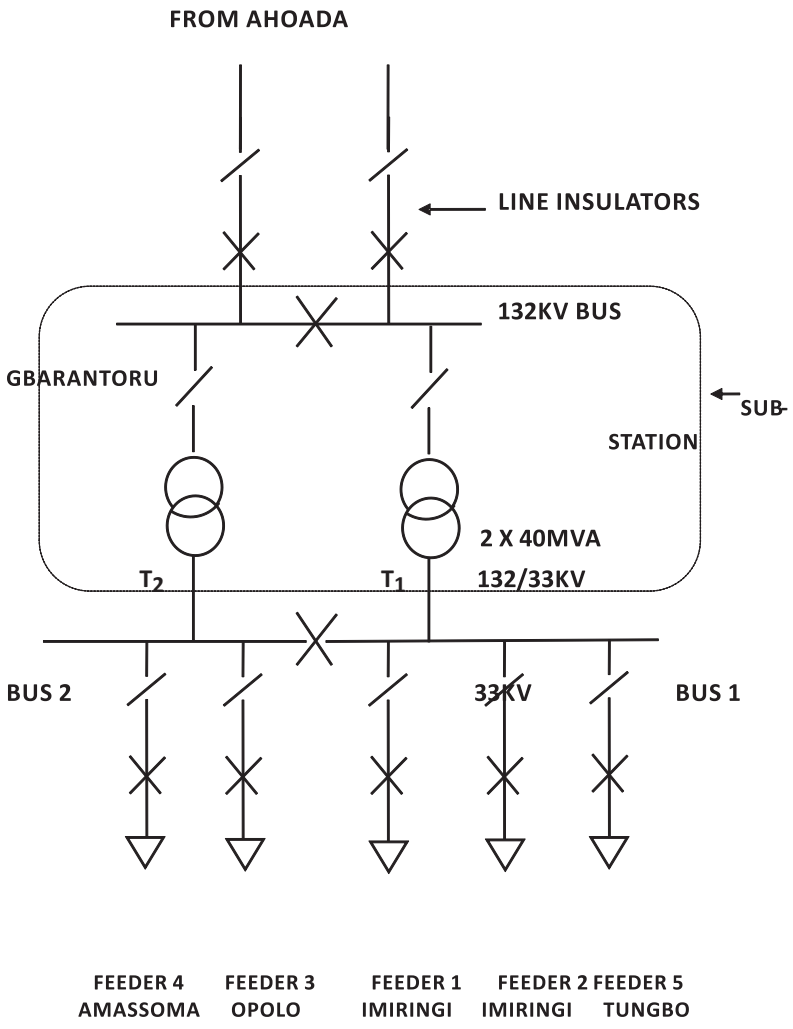

Fig.7.1 Single Line Diagram of Power Supply to Bayelsa State.

Load distribution pattern in Bayelsa State is shown in table 7.1 feeder by feeder.

S/N	Feeder Name	Area of Coverage	Distance covered by Feeder (km)	Line Voltage (KV)	Load (MW)
1	Imiringi Feeder 1	Isaac Boro Express way up to Ovom, Govt. House, Swali town and across Ikoli river.	54.94	33	18.3
2	Imiringi Feeder 2	Edepie, Akenfa, Agudama, Azikoro Village, AIT road, Otuoke, Elebele, Emeyal 1 and 2	57.21	33	18.7
3	Opolo	Opolo, Kpansia, Okutukutu, Igbogeni	23.49	33	18.2
4	Amassoma	Tombia town, Akaibiri, Ogobiri, Amassoma.	29.96	33	2.9
5	Tungbo	Zarama, Gbarain, Odi, Kiama, Trofani and Tungbo axis	97.96	33	12.9

Table 7.1: Load/ Feeders Distribution in Bayelsa State

Presently, the department has achieved Centre of Excellence in Satellite and Communication Technology (CS&CT). We are looking forward to exploring the area of **Smart Grid Technology**. This dream requires proper funding.

Meanwhile, the department has looked at the primary occupation of people in the Niger Delta region which is mainly

fishing and has designed a fishing tool known as **Electrode-Fishing Tool.** This was articulated from students' final year project supervised by Prof. S. A. Adekola, Prof. C. O. Ahiakwo and Engr. Ebipuado Sapere-Obi. The stimulated results of the Electrode–Fishing have shown that it would be very useful for modern fishermen.

8. CHALLENGES:

There are very serious challenges in the three sub-systems of the Nigerian power system. The sub-systems are Generator, Transmission and Distribution.

● Generation Sub-system:

The major challenge of the generation sub-system is gas supply. The various power plants of Nigerian Independent Power Producers (NIPP) are powered by gas from Nigerian National Petroleum Corporation (NNPC). Often times, the power plants are starved of gas due to government bureaucracy. The Federal government is yet to put some legal frame work in place that will ensure regular supply of gas to the NIPP power plants. Presently, the GENCO'S are struggling to maintain a generation level of 4000 MW at full supply of gas. Meanwhile, generation level that will show some significant improvement in the power supply sector is 10,000MW. Efforts to get at this generation level and surpass it are on.

● Transmission Sub-system:

The challenge on the transmission sub-system is mainly on the transmission lines. They are as follows:

(i) Obsolete Lines: Most of the transmission lines across the country are obsolete. Some were installed in early 70s and have become obsolete.

(ii) Transmission Line Vandals: Most times, transmission lines are vandalized by hoodlums. This practice is very common in southern part of the country.

● Distribution Sub-system:

This sub-system is characterized by illegal connections. People would not like to pay tariff for the electricity they have consumed.

In Niger Delta University, our major challenge is lack of infrastructure that will enhance research. This can be found in the following areas.

● Office Space/Furniture.

● Internet Facilities in the Departments.

● Staff Accommodation. This has made the university a non residential institution.

9. CONCLUSION:

This nation is endowed with abundant energy base resource that can dispel
Darkness in all aspects of human life. All that is required is the political and economic will to “ARISE and TAP” the resources. Effective development of the
nation's IPP will demonstrate Government's commitment in this direction.

Meanwhile, the Nigerian power sector has been successfully deregulated.
Efforts are presently being made to improve the generation , Transmission and distribution sub-systems so as to provide the citizens of the nation with adequate power supply

10. RECOMEDATIONS:

The projection of the Federal Government is to provide reliable, efficient and
affordable electric power supply for all Nigerians. This is achievable. All that is
required is an edit that will enhance the following :

(I) The development of renewable Energy potential (Solar and Wind Mill) of
the nation and expand it to accommodate Distributed Generation (DG)
Bearing Communities that have difficulties of connectivity to the Nation grid

(ii) Creation of enabling environment that will attract Independent power
Producers (IPPs) to focus more on micro hydro

power plants. The nation is
endowed with fast flowing rivers and a number of water-falls. These source
of energy can be properly harnessed to generate electricity thereby increasing
the power generating capacity of the counting.

(iii) Strengthening the existing transmission and distribution lines by upgrading the
network

ACKNOWLEDGMENT

Mr. Vice Chancellor Sir, my profound gratitude comes to Almighty God for His loving kindness and making me to be what I am today. I would also like to appreciate Him for giving me loving and caring parents (LATE CHIEF ISAIAH OGRABE AHIAKWO and LATE MRS. JERRINAH UGBOKO AHIAKWO). If HE allows reincarnation and choice of parenthood, I would like to be parented by them as many times as reincarnation revolves. They inculcated good virtues of life into me. I grew up to understand that "Integrity, Respect for Elders and Humility" are the virtues God require from man. I wish they were alive today to see the product of their labour.

Distinguished Ladies and Gentlemen, this crusade of dispelling darkness in Nigeria started in 1954 in a small community called OBRIKOM in Ogba/Egbema/Ndoni Local Government Area of Rivers State by a couple LATE CHIEF ISAIAH OGRABE AHIAKWO and his wife LATE MRS. JERRINAH UGBOKO AHIAKWO, all from Obrikom. They gave birth to a bounding baby boy and named him OKWUKACHUKWU, translated as WORD OF GOD. They went further to christen him CHRISTOPHER, a name they derived from "KNIGHT OF ST. CHRISTOPHER". This couple saw something in name which many in their time never saw. At

school age, the name OKWUKACHUKWU was shortened to OKWUCHUKWU to accommodate WAEC registration form but they maintained the name “Okwukachukwu” till their demise. They were not educated but they had the conviction that Christianity with the right education will dispel darkness. They ensured that all their children and wards were properly educated. The boy Christopher Okwukachukwu was not only baptized in the Anglican Communion but was properly educated in a mission school.

As I grew up in my primary and secondary school days, I had two fathers. My biological father (LATE CHIEF ISAIAH OGRABE AHIAKWO) and the Headmaster of my school in Obrikom (LATE CHIEF GILBERT OSSIA). This Headmaster identified my potentials at the earlier stage of my life and ensured that I become part of his family. Thus, his first son became my very close friend and brother throughout our school days. Today we are as close as that.

I sincerely appreciate my academic father and mentor (Late Professor Thomas C. Nwodo) for his academic inspiration that energized me to be what I am today. He was divinely brought to Rivers State University of Science and Technology, Port Harcourt to accelerate my Master's and Ph.D programmes. He was a good man. He could go extra miles to inconvenience

himself to please others. May his SOUL rest in the bosom of the Lord.

I also sincerely appreciate Engr. Chief Giandomenico Massari of Danelec Nigeria Ltd. He provided his office and house, all full with internet facilities 24/7 hours as research centers for my Ph.D work. He initiated the formation of Internet Society of Nigeria in Port Harcourt in 1999 and championed free internet training of Nigerians in tertiary institutions. It was through this platform that I got materials for my Ph.D work.

With deep sense of appreciation, I say thank you to Prof. S. A. Adekola,FAS who provided the window that brought me to NDU. We never knew ourselves until we met at FUTO as external examiners in 2010. Both of us found ourselves compatible to each other and when the opportunity of coming to NDU came, I did not hesitate to apply, though without his knowledge, he did not frown at that, but remained a friend and brother till today. It is therefore on record that the First Professor of Electrical Engineering in the Old Rivers State of Nigeria (i.e present Rivers and Bayelsa States) is produced by NDU. I give GOD the glory.

My deep appreciation goes to Prof. E.N.C. Okafor whom i regard as a brother from Obrikom because of our closeness to

each other. We were both academic sons of Professor Thomas C. Nwodo of blessed memory. My coming to NDU was facilitated by his encouragement and that of the University Librarian Mr Esbra Ft. Blakes and family.

I now see NDU as my second home coming to IJAW Land. My parents had constantly put me at the centre of their canoe in mid 60s in voyages along the creeks of Niger Delta as traders. We moved from our creek Ebiam to Urashi River, crossed to Taylor creek through Joinkerma to Ogboloma, OKolobiri, Palaku to Sabageri and joined boats going to Ontisha from Amassoma. I found the Ijaws very hospitable with their women very industrious then. I am not sure the situation is the same today.

I also appreciate Engr. Ebipuado Sapere-Obi for his support and companionship in NDU. The application letter that brought me to NDU was submitted by him. Right from my sabbatical days in NDU till now, we have become close friends, brothers and colleagues. Often times, we communicate in my dialect and he keeps reminding me of his good old days in Omoku.

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NDU, you are lovely people. The Dean of Post Graduate School Prof. Mrs Osa Tawari in particular, will hardly entre her personal office without knocking at my door to greet. I am so humbled by her humility. The Dean of Faculty of Education Prof. A. Egumu and Prof. Cletus A. Sorgue, I say thank you for your encouragement in the development of this paper. Since I was scheduled for this lecture their first greeting each time we meet have always been “How are you preparing?”

I appreciate The Dean, Faculty of Engineering Prof. J.C. Igbeka for his fatherly disposition in the faculty and commitment to the growth of education in Nigeria. I count myself very fortunate of being in his team as a Head of Department.

I would not fail to sincerely appreciate God for giving me a visionary, loving and praying wife (Lady Roseline Ego Ahiakwo) a Deputy Director in Rivers State Housing and Property Development, Port Harcourt. She has been very supportive, playing the role of a wife, sister, friend and mother. I couldn't have got to where I am today without her.

I also want to appreciate my God given children, their spouses and my grand children. They have never failed in supporting me. Even when I was not ready to engage a personal driver, they insisted and now the difference is clear. They are:

1. Bar. Mrs. Obraori Adiela, Faculty of Law, RSUST, Port Harcourt and her husband Dr. Uche Peters Adiela, NAOC; Port Harcourt.

2. Engr. Dr. Ograbe A. Ahiakwo, United Kingdom.

3. Engr. Ndulaka Ahiakwo, NAOC; Port Harcourt and his wife Engr. Mrs. Grace Ahiakwo.

4. Dr. Chukwuladi Ahiakwo, Rivers State Primary Health Care, Port Harcourt.

5. Ogorchukwu Ahiakwo, Garden City University, Kumasi, Ghana.

My prayer is that the Mercy of GOD shall continually be upon all of you and that you will all enjoy your marriages.

Finally, I sincerely appreciate the Vice Chancellor, Prof. Humphrey A. Ogoni for his humility and finding me worthy to work with him as Head of Department, even though HOD is never an attractive position in Nigerian Universities, especially the situation we have found ourselves in NDU.

To all in attendance, I say Aluwa, Nnuwa, Nbana and God Bless.

REFERENCES:

Ahiakwo, C. O, 2011 "Renewable Energy for Rural Electrification To Ameliorate

Climatic Change" International Journal of Engineering Science and Technology, Vol.2, No.1, pp.10-19

C.O. Ahiakwo and S.Orike, 2010. "Distributed Generation (Renewable Energy) - Best Option for Oil Bearing Communities". Journal of Engineering Science and Technology, Vol.5, No.1, pp.8-12

Jona Chivela Johannes, and Kehinde Awodele 2010. "*The Impact of Distributed Generation on Distribution Voltage Quality and Network Power Lossest*". Conference Proceedings, 8th International Conference on Power System Operation and Planning (ICPSOP), Abuja, Nigeria 2010, pp. 1-10.

Sanusi Lamido Sanusi, 2009. "*The Role of Banks in the Financing of Power Projects in Nigeria*". International Round Table Conference, Port Harcourt 25th – 26th November, 2009.

The Minister of Power, 2010. The Guardian News Paper, 7th January 2010.

Peter Mark Johnson at el, 2008. "*Integrated Large-Scale Photovoltaic Power Plants into the Grid"* IEEE Energy 2030 Atlanta, GA. USA 17th-18th 2008.

Ahiakwo, C. O., Uwakwe C. Chukwu, and Nwaorgu, A.O., 2010. "*Renewable Energy for Poverty Alleviation in Nigeria: A Review*". Conference Proceedings, 8th International Conference on Power System Operation and Planning (ICPSOP), Abuja, Nigeria.

Momoh, J. A. and Xu, K., 2005. "*Evaluation of Renewable Energy Options for National Electricity Needs"*, Conference Proceedings, 6th International Conference on Power System Operation and Planning (ICPSOP), Cape Verde, South Africa, pp: 13-21

Gabriel Adolphus, 2001. "Power should be treated as Business not as an Obligation to the Nation"

Ojosu, J.O., and Salawu, R.I., 1999. "*Wind Energy Development in Nigeria"*, Nigerian Journal of Solar Energy, vol.9, pp: 209-222.

Ahiakwo, C. O., 2008. "*Electricity Survey of Rivers State, Nigeria".* IEEE (Nigeria) Technical Meeting, June 14, 2008. Available at: http://ewh.ieee.org/r8/nigeria/gold/

Salawu, R. I., Okafor, F. N., and Adetona, S. O., 2009. "*Evaluation of Electrical Load Growth Rate in a Wholesale Electricity Market".* Conference Proceedings, 2nd International Conference on Adaptive Science and Technology, Accra, Ghana, December 14-16, 2009, pp: 182-186.

Ekeh, J. C., 2010. "*Harnessing Renewable Energy Potentials for Reliable Power Supply in Nigeria Deregulated Power Market*". Conference Proceedings, 8th International Conference on Power System Operation and Planning (ICPSOP), Abuja, Nigeria 2010, pp: 11-18.

Davidson, I. E., and Oni, J. O., 1991. "Energy Conversion Strategies and Alternative Sources for Africa", 2 (1): 85-90.

Carlton Blue, 2010 "Distrubted Network Proposed Approach to Solar System". Conference Proceedings, 8th International Conference on Power System Operation and Planning (ICPSOP), Abuja, Nigeria 2010, pp: 19-21

EIA IEO 2005. Energy Information Administration, International Energy Outlook 2005" (U.S. Department of Energy, Jul 2005).

Agbetuyi et al; “Nigeria Climate Assessment, LCD Power Sector Preliminary Report”.

Ahiakwo, C.O; 2000 “Fault Analysis of the Nigerian Network”