Energy Systems:
Vulnerability – Adaptation – Resilience (VAR)

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Regional Focus: sub-Saharan Africa

Nigeria

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Executive Summary

Poor governance and endemic corruption plague Nigeria and negatively impact the energy sector. Despite being the world's seventh largest oil exporter and being blessed with the tenth largest oil reserves in the world (2007 data), the country remains a net importer of petroleum products and cooking kerosene fuel. The lingering resource control problem in the Niger Delta's oil and gas producing regions continues to bedevil the power sector. Oil and natural gas pipelines feeding the nation's power plants are under constant attack by militants and vandalism. Nigeria's vulnerability to the Niger Delta's restiveness has plunged the country's total generating capacity to 1,500MW from about a total installed capacity of 8,000 MW.

Nigeria's primary energy source has evolved over the last sixty years: during the 1950s and 60s, coal was the primary energy, followed by hydro in the 1970s and 80s. Currently gas is the primary energy source. Despite Nigeria's steady access to fossil-based and renewable energy sources, its per capita electricity has been among one of the lowest in Africa. As power demand studies have projected a medium- to long-term electricity demand of 30,000MW and 192,000MW respectively there will need to be substantial improvement in the energy production and supply sector if this demand is to be met.

Anticipated climate change impacts threaten to undermine Nigeria's aim of increasing energy services. Temperature variability, precipitation, humidity, sea level rise, wind patterns and amount of solar radiation per year will affect both the energy production/supply and consumption/demand equations.

Higher temperatures will lead to increased energy demand for space ventilation and air-conditioning as well as for refrigerated products. Energy demand for water pumping energy will increase significantly as the need for irrigation, municipal, commercial and household water grows. Solar radiation will be significantly reduced during the wetter, rainy season and considerably higher in the dry season, requiring better design strategies for optimal output. Adverse effects on hydroelectricity and fuelwood will be significant. Nigeria's major hydroelectric power stations are located in the northern, drought-prone zones. Reduced rainfall and drought conditions threaten to reduce electricity generation. Drought condition will likely eliminate some fuelwood sources, while flooding in the south (in the form of more frequent and intense thunderstorms and erosion) may damage forests.

Rising sea level will increase the landward penetration of salt water with the destruction of salt-intolerant tree species and vegetation, forests and fuelwood

sources. All coastal energy production facilities, e.g. oil and gas rigs and pipelines, flow stations, treatment facilities, etc., may be vulnerable to damage from rising sea levels, as well will low-lying power plants. Similarly, the extensive but fragile grid transmission and distribution lines could be damaged by heavy thunderstorms and excessive precipitation.

Policy, legislation, system-level measures need to be put in place to increase energy resilience and should include:

- a determined effort to meet the already set goal of increasing the share of renewable energy in the energy mix over the medium- and long-term
- increasing the renewable energy and low carbon energy sources' share to enhance Nigeria's energy resilience
- improving wood utilisation and management policies and practices
- developing a lasting solution to the Niger Delta conflict

Bibliography: Reporters

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List of Acronyms

AGO	Automotive Gas Oil
AIDS	Acquired Immune Deficiency Syndrome
ATK	Aviation Turbine Kerosene
Bscf	billion standard cubic feet (usually of natural gas)
CBN	Central Bank of Nigeria
CIA	Central Intelligence Agency of the United States
CO_2	Carbon Dioxide
DPK	Dual Purpose Kerosene
ECN	Energy Commission of Nigeria
EEC	European Economic Community
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GNP	Gross National Product
HDR	Human Development Report (of the UNDP)
HIV	Human Immunodeficiency Virus
HPFO	High Pour Fuel Oil
kha	kilo-hectares (103 hectares)
kWh	kilowatt hours (of electricity)
LPFO	Low Pour Fuel Oil
LNG	Liquefied Natural Gas
mbd	million barrels per day (usually of crude oil)
MDG	Millennium Development Goals
MWh	Megawatt hours (of electricity)
NEEDS	National Economic Empowerment and Development Strategies
NEMP	National Energy Master Plan
NEP	National Energy Policy
NES	National Energy System
NGC	Nigerian Gas Company
NIMET	Nigerian Meteorological Agency
OPEC	Organization of Petroleum Exporting Countries
PMS	Premium Motor Spirit (Petrol)
PPP	Purchasing Power-Parity
PV/PT	Photo-voltaic and Photo-thermal (solar energy systems)
REMP	Renewable Energy Master Plan
TOE	Tonnes of oil equivalent
UNDP	United Nations Development Programme
WHO	World Health Organization

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Country Overview: Current situation

Description of National Circumstances

Nigeria is located between latitudes 4 and 14°N and longitudes 3 and 14°E, along the Gulf of Guinea. The country currently occupies an area of 923,768 km^2 (comprising 910,768 km^2 of land and 13,000 km^2 of water) and is bordered respectively on the north, north-east, east and west by Republics of Niger (1,497 km), Chad (87 km), Cameroon (1,690 km) and Benin (773 km). To the south the country is bordered by the Atlantic Ocean with a total coastline of 853 km. The terrain thus varies from coastal swamps and tropical forest in the south, to savannah and semi-desert in the north. Of the total land area, approximately 33% or 300,550 km^2 is arable, while 3.1% or 28,234 km^2 is under permanent crops and approximately 2,820 km^2 or 0.31% is under irrigation (CIA 2009). The highest points are the Jos Plateau in the centre (1,200-2,000 metres above sea level) and the mountains along the eastern border. The River Niger, the third longest river in Africa, reaches the sea through an extensive delta of mangrove swamps. Some of the key national geographical and economic development indicators are presented in Figure 1 below.

Figure 1: Relief Map of Nigeria showing the 36 States and the Federal Capital Territory, FCT

The Nigerian economy is still largely dependent on the exploitation and export of crude oil and natural gas and their products on the international market. Other key sectors of the economy such as agriculture have continued to remain largely at subsistence levels and have failed to keep up with rapid population growth. Crude oil and natural gas and their products thus continue to provide up to 20% of Gross Domestic Product (GDP), 95% of foreign exchange earnings, and about 65% of budgetary revenues (Shinsato, 2005; CBN, 2004a,b). Although the upstream oil and gas sector has been relatively stable in terms of production and export, the performance in the downstream sector has not been particularly impressive, especially with regards to managing the supply of refined products to consumers.

There has been substantial increase in imports of refined petroleum products in the last few years, which has grossly affected domestic prices and has led to spiralling inflation in many sectors. Efforts to deregulate fuel prices based on the privatisation of the country's oil refineries, are on-going. In addition, there has been the introduction of the National Economic Empowerment and Development Strategy (NEEDS) that is domestically designed but does not differ significantly in concept from the policy model of the international financial institutions on poverty reduction and growth facility for fiscal and monetary management.. The result has been little economic progress.

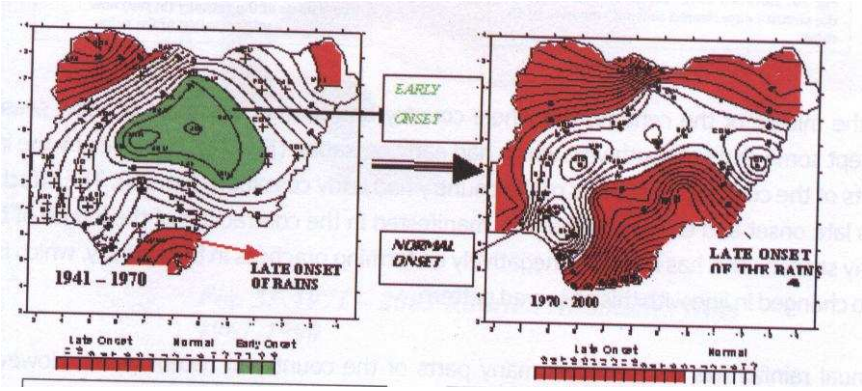
The West African sub-region is increasingly concerned about how global climate change will affect livelihoods and biophysical processes in general. The Nigerian Meteorological Agency recently published the Nigerian Climate Review Bulletin 2007 which gave a synopsis on the status of climate indicators ranging from mid 20th century to date. The review thus provides some information on variability and trends of temperature, rainfall amounts and well as on the on-set and cessation of rains. These indicators were used to evaluate the potential and prevalence of extreme weather events as compared to the long-term normal pattern. Some key weather and climatic indices show a strong variability based on long-term meteorological data:

- Discernable evidence of climate shifts suggesting potential tendency towards climate change. It has been established that most parts of Nigeria had what could be termed “normal or above normal” on-set of rainfall dates during the mid-20th century (1941-1970) except for Sokoto, Calabar and environs (Fig. 2) where rains were usually late. Then as the century progresses (1971-2000), late on-set of rains spread to more areas with only a narrow band in the middle belt and southwest regions remaining normal.

- Annual rainfall amounts in most parts of the country showed a decrease of two to eight mm/year with only a few places (Lokoja, Kano, Ibadan and Ondo) showing an increase ranging from two to four mm/year of rainfall for the period 1941-2000. Much more significant decreases were observed in Port Harcourt (on the coast) and Katsina (on the arid and semi arid zones of the north). In 2007, national rainfall ranged from normal to wetter than normal, when compared with the 1971-2000 base year. The summary is as follows: dryer than normal (less than -10%); normal (-10 to +10%); wetter than normal (+11 to+30%); and very wet (more than +30%).

- Evidence of long-term temperature increase were observed in nearly all parts of the country, with the exception of the Jos Plateau area, which experience slight cooling. The extreme north-east and north-west showed increases in the range 1.4-1.9C during the period 1941-2000.

Figure 2: Areas showing on-set of rains during two time slices: 1941 – 70; and 1971 – 2000



Note: early (green to white contours) to late (red contours)
Source: NIMET 2007

Important Social Concerns

The 2006 Millennium Development Goals (MDGs) Report indicates that Nigeria made some progress in only three of the eight set goals. These include basic education, combating of HIV/AIDS, malaria and related other diseases, as well as in the global partnership for development. Very little progress is measureable in other goals of the programme. Most of the social indicators, a few of which are presented below, show abysmal performance with more than half of the population still living below poverty line, due to the high levels of inequalities in access to resources and income. Similarly, the under-five mortality rate is currently at 197 per 1,000 live births. At 800 per 100,000 live births, the country continues to have one of the highest maternal mortality rates in the world.

Overview of Key Geographical, Social and Economic Statistics

Some basic and key geographical, social and economic statistics during the period 2004 and 2005 are presented in Table 1.

Table 1: Basic National Statistics for Nigeria

Basic Statistics	Year	Value	Units
Physical Area			
Area of the Country:	2005	923,890	km2
Cultivated Areas (arable land and lands under permanent crops):			
As % of total land area of the country		36.16	%
Arable land		305,028	km2
Area under permanent cultivation for domestic use		29,006	km2
Area under permanent cultivation for exports		NA	km2
Population:			
Total population	2005	141,356,000	Inhabitants
Rural Fraction		51.8	%
Fraction under 5 years of age			%
Fraction under 15 years of age		44.5	%
Population Density:	2005	153	Inhabitants/km2
Economically active population			Inhabitants
as % of population	2005		%
Male		52	%
Female		48	%
Population economically active in agriculture			Inhabitants
As % of economically active population			%
Male	2005	4	%
Female		2	%
Economy and Development			
Gross Domestic (GDP) – total	2005	99.0	billion USD
Gross Domestic Product (GDP) – per person	2005	148.3	PPP billion USD
GDP added in agriculture (% of GDP)		18	%
GDP per capita		1,128	USD/year
Balance of Trade			USD
% change from 1990 to current year	2004		%
Human Development Index (and Ranking)	2005	0.470 (158 of 177)	
Human and Income Poverty Index and Ranking	2005	80 (37.3%)	
Environmental Sustainability Index[1]	2005		
GHG Emissions			
CO2 Emissions	2004	114	Mt-CO2
Per Capita CO2- Emissions		0.9	t-CO2/cap
Access to portable water (less than 500 metres)[2]	2005	48	%
Infant Mortality	2004		Deaths/1000 live births
Male		101.83	
Female		89.28	
Literacy			
as % of population	2003	68	%
Male		75.7	%
Female		60.6	%

[1] Available in UNDP Development Report
[2] Available in UNDP Development Report and at WHO

Country's Greatest Vulnerabilities

The greatest vulnerabilities in Nigeria may be summarised in the following brief headings:

Environment

Approximately 80% of the population still depends largely on biomass-based fuels which calculates out to be 0.5 metric tonnes of fuel wood per capita. As a result, the rate of deforestation is very high. Deforestation rate is estimated at approximately 350 kha per year and is one of the key drivers of increasing desertification. Other environmental degradation issues, such as erosion, flooding, drought are also increasing. This degradation, in conjunction with other anthropogenic activities, has contributed to increasing rate of loss of biodiversity. The West African sub-region in general, is known to have one of the highest levels of atmospheric aerosols regions of the world. The main sources of this pollution come from: terrigenous particles from the desertic zones of Sahara and biomass burning that produce huge amount of black and organic carbon. Respirable and non-respirable dusts in the atmosphere are therefore an important feature of the region's air quality indicators. The importance of these dusts is not only for their impact on human health, but also because of the strategic role they play on atmospheric turbidity, which in turn severely impacts the weather/climate and effects the efficient functioning of the aviation industry.

Thus, while each of these issues generates a specific environmental challenge they collectively contribute to the stressors associated with weather and climate pattern modification, further compounding the environmental stresses experienced nationally.

Economics

Although Nigeria's GDP rose strongly in 2004, this was due to increased oil exports (+10.15%) and high global crude prices (+31.74%). The national economic performance in many sectors did not reflect recent high GDP growth rates.

In order to shore-up the economy, some economic and political reform measures have been reversed with a result that there have been significant negative impacts in the health, financial, transport, environment and agricultural sectors. The overall low human development as well as low performance of the economy are reflected in the 2007/2008 Human Development Report (HDR) which ranks Nigeria 158 out of 177 countries with a Human Development Index score of 0.470. Nigeria is about third down the list of the Low Human Development category of nations starting at HDI Rank 156 (Senegal) down to the lowers rank of 177 (Sierra Leone). The report presented the following summary of indices: life expectancy index (0.359), education index (0.648) and the GDP index (0.404).

Technical

Nigeria has witnessed significant growth in population and urbanisation over the last six decades. Despite this, there is an imbalance between urban growth and the required supporting infrastructure needed to reduce the impact of urbanisation on the environment. Electricity supply short fall is a key problem in Nigeria; this has resulted in a high dependence on electricity generators in households and businesses. This has

lead to accelerated urban air pollution, an increase in solid wastes and effluents management problems, and other forms of environmental degradation. Lagos and other emerging potential mega-cities are particularly impacted.

Governance

Nigeria gained independence from British colonial rule October 1, 1960. Democratic governance lasted six years until military intervention in January 1966 (to stem disintegrative tendencies in the country). Civil war broke out later and lasted until 1970. Military rule however continued until 1979 when there was a peaceful handover to the second republic of democratic governance. The military struck again in 1983 and stayed in power until 1998 when the present fourth republic came into being.

Under the current democratic structure, the country is governed by an Executive consisting of the President and his Federal Executive Council, the latter which consists of the Vice-President, Federal Ministers, State Governors and top government functionaries. The 36 States of the Federation are each governed by a Governor and supported by its own State Executive Council that consists of the State Commissioners and top State Government functionaries.

The Federal Capital Territory of Abuja and environs is government by a Minister of the Federal Capital Authority and is a member of the Federal Executive Council. Each State is divided into a number of Local Government Areas (LGAs) or Councils; there are a total of 774 LGAs, each with its own Local Government Council headed by a Council Chairman. At national level, the Legislature comprises a Senate and a House of Representatives, both of which are occupied by elected representatives from each State of the Federation.

The fourth republic has weak governance structure riddled with endemic problems chief among which are: widespread corruption; general lack of accountability of public officials; inability to conduct free and fair elections at all levels; and a patent lack of development illustrated by sub-standard basic infrastructures (electricity, water, roads, fixed line telephones, public health, etc.) and a poor Human Development Index ranking (158 out of 177 nations) (UNDO 2007).

Assessing National Vulnerabilities

Environmental

Indicator 1: Change in rainfall patterns

Year	Rate	
2000	732.6mm	
2008	494.3mm	
2000 – 2008		% change = 32.5%

In the absence of a national average rainfall data, the figures in the table measures average month rainfall for the city of Sokoto.

Indicator 2: Variation in temperature

Year	Rate	Change
1990	35.2oC	
2008	36.1oC	
1990 – 2008		% change=2.56%

The temperature figures given above is the maximum daily temperatures measured for the city of Sokoto.

As data are published city by city, an assessment of annual mean values for Nigeria can only be evaluated based statistical means over the cities.

For the purposes of this report a quick assessment was conducted looking at three cities, Lagos, Abuja and Maiduguri as representatives of low-latitudes' (west-most), mid-latitude (median longitude) and high-latitude (east-most) spatial grids over Nigeria. Results show that mean maximum and minimum temperature deviations were +0.27 and -0.65% respectively, which indicates that, in general, there appears to be a combined effect of increase in mean temperatures (since mean max far exceeds mean minima temperatures). Additionally differences between minima and maxima are increasing.

A general trend, obtained by assessment of the overall changes taking all yearly data into consideration, indicates an increase in precipitation of between 11 and 30%, which is expected to boost hydroelectricity generation. The likelihood that precipitation would increase is further demonstrated by the observed 12.5% increase in cloud cover between 1990 and 2004.

Economic

Indicator 1: Per capita consumption of electricity (kwh)

Year	Rate	Change
2000	209	
2008	157	
2000 – 2008		% change - 24.9%

Source: UNDP Human Development Report 2000 and 2008

71.5% of the Nigerian population does not have access to electricity (Fagbenle 2009). However the more authoritative figure on population without access to electricity in Nigeria is 60%[3,4]

[3] David Hall " Water and Electricity Access", Public Services International Research Unit (PSIRU). A report commissioned by PSIRU. September 2006. www.rold-psi.org. Page 10 where it states:

> "Currently, only 10% of rural households and approximately 40% of Nigeria's total population have access to electricity." Note, however, that the 10% figure above is questionable, since a January 2006 Executive Report on Nigeria's Electricity Sector for the Sub-Committee of the Presidential Advisory Committee on 25 Years Electric Power Supply Plan on page 26 states that "At present, the access to electricity in the rural areas is estimated at about 18%"

[4] "Addressing electricity demand and supply issues in Nigeria, the presenter pointed out that access to electricity is barely 40% with the rural areas accessing less than 20% (mostly used for lighting application)."

In all likelihood, this figure should have improved by 2009 towards 50% considering the large number of rural connections made by the Rural Electrification Agency (REA) since 2005/2006.

Indicator 2: Level of increased energy autonomy

This is the increase in domestic Total Primary Energy Supply.

Year	Rate	Change
1990	70.9 Million TOE	
2005	103.8 Million TOE	
1990 – 2005		46.4%

Technical

Indicator 1: Change in the amount of energy supplied by renewables

Proxy: Proportion of renewable energy in total electricity generation in 1990 – 2004

Year	Rate	Change
1990	24.8%	
2004	33.4	
1990 – 2004		8.6%

Indicator 2: Change in the amount of energy contributed by renewable energy sources

Year	Rate	Change
1990	2,803.1 MWh	
2004	8,086.9 MWh	
2000 – 2008		188.5%

Social

Indicator 1: Change in prevalence of diseases

Infant mortality rates in Nigeria from birth to age 1 (per 1000 live births) were120 in 1990 and dropped to 97 in 2007. Adult mortality rate per 1000 population (between 15 and 60 years) dropped similarly from 424 in 1990 to 414 in 2007.[5] It is not clear what caused these decreases.

Indicator 2: Change in employment (labour force participation)

Year	Rate	Change
1996	75.6%	
2006	74.2%	
2000 – 2008		-1.85%

Source: ILO data - Sub-Sahara Africa

[5] WHO Statistical Information System, database on Mortality and Burden of Disease

Civic (Governance)

Indicator 1: Land reform improvement

Proxy Indicator: Presence of land ownership policies and enforcement of legislation.

There is a Land Use Decree which confers all land ownership on government which in turns issues Certificate of Occupancy to applicants. This is done at the State Government level by the State Governors. Several millions certificates have been issued since the decree came into effect in the mid-1970s.

Indicator 2: Change in public participation in planning process

There is little quantitative information on this, but it is well known that there is very little public participation in overall governance in Nigeria. The public sector makes effort to invite public participation but the degree to which this has been successful is not measured nor is statistical information available.

Current Energy Situation

Resources

Nigeria is endowed with abundant supply of oil, natural gas and coal. It is estimated to have proven reserve of approximately 36.5 billion barrels of oil, according to the 2007 Draft National Energy Master Plan, 2007. Although being one of the leading oil producing countries, Nigeria contributes a relatively small share of total world production which is estimated to be at 3%.

Despite proven reserves and a large amount of probable reserve, oil production has remained at less than 750 million barrels per year since 1990. Production was projected to increase to 40 billion barrels annually by 2010 with a daily production at 4 million barrels of oil per day (mbd) (up from its current average of 2 mbd). (Vision 2010). This development has not yet occurred.

In 2004, the total crude oil and condensate production combined was 911million barrels, averaging approximately 2.5 mbd. This represented an increase of 7.93% over 2003 production. Nigeria also exported approximately 871 million barrels or 2.38 mbd, compared to 2.2 mbd in 2003.

Total natural gas production was 2,082.28 billion standard cubic feet (bscf), of which 42.54% was flared. The remaining 57.46% of natural gas was utilised as follows:

- 411.9 bscf or 19.78% used as liquefied natural gas (LNG) feedstock;
- 72.77 bscf or 3.49% was sold to the Nigerian Gas Company (NGC);
- approximately 28833 or 11.45% was sold to third parties.

Part of the natural gas reported as “utilised” also includes 332.8 bscf or 15.98% as re-injection, and 71.53 bscf or 3.44% as gas consumed as fuel in oil field operations.

Total crude received by the three refineries was 40.5 million barrels of which 38.03 million barrels were processed into 4.63 million tonnes of various petroleum products.

Table 2 illustrates that Nigeria’s three refineries were unable to satisfy the national demand in all but fuel oils (LPFO and HPFO) in 2003 and 2004, a situation that still exists in 2009.

The primary commercial fuel sources remain crude oil and natural gas and are the most developed source of fossil energy nationally. These are complemented, to a much lesser extent, by domestic coal which was once in high local demand in the colonial period for the steam locomotives and today is used marginally in local coal-producing States as cooking fuel.

Table 2: Refined petroleum products sales and imports (2003 - 2004)

	PMS	DPK	AGO	ATK	LPFO	HPFO
	(kt)	(kt)	(kt)	(kt)	(kt)	(kt)
	2003					
Sales	6,394.13	1,145.09	288.02	324.69	1,129.04	-
Imports	5,404.16	637.62	1,146.68			
Total	1,1798.29	1,782.71	14,34.70	324.69	1,129.04	-
	2004					
Sales	6,073.33	1132.88	1,437.46	72.10	548.06	9.55
Imports	5,696.40	418.24	170.28	211.47	-	-
Total	11,769.730	1,551.120	1,607.740	283.570	548.060	9.550

Contribution to the Economy

According to the classification for accounting the Gross Domestic Product (GDP) Nigeria's commercial energy sector is categorised into two main sub-sectors: mining, consisting of coal, petroleum and metal ores, and utilities, which consist of electricity, gas and water.

At current factor prices, the mining sector (which contributed 1.2% of GDP in 1960) had grown to contribute 13.2% of the GDP by 1990. Further examination of the period 1960 to 1990 reveal the important role the energy sector has played in the Nigerian economy.

The tremendous growth of this sector during the 1970s can be traced to crude oil extraction. The highest contribution of the mining category was in 1975 with a share of 31.6% declining steadily to 28.8% and then to 16.5% in 1980 and 1985 respectively. Other sectors in the mining sector contributed decreasing shares of GDP during the same period: oil sector contribution was 30.15% in 1975 and only 16.07% in 1974. Coal and metal ore contributions decreased from 0.01% and 1.73% in 1974 respectively to 0.0% and 1.32% in 1975 respectively.

An examination of Nigeria's historical structure of GDP by sector reveals that in 1960, the agricultural sector contributed more than 60% of the country's GDP whereas oil and mining contributed only 1.2% and manufacturing about 4.8%. By 1980, the share from agriculture had decreased to 22.2% and the contribution from oil and mining had increased to 26.8%. This was a result of increased production as well as the enhanced sector proceeds resulting from crude oil price increases started in the early 1970s.

The decrease in agriculture's contribution to the nations GDP is directly linked to oil boom era prices (EEC Project, 1991)[6] which led to an almost complete neglect of the agricultural sector.

[2]Central Bank of Nigeria Statistical Bulletin, Vol. 10, No.1 June 1999
[3]Central Bank of Nigeria Annual Report & Statement of Accounts, 31st December 2000
[4]EEC Project Report *Energy Masterplan for Rural development Nigeria*, Vol. I: The Nigerian Energy Situation, EEC Project No. 6100.52.41.027, November 1991

Non-commercial Energy Sector

The non-commercial energy sector is dominated by primary biomass resources in the country include wood, charcoal, grasses and shrubs, residues and wastes (agricultural, forestry, municipal and industrial), and aquatic biomass.

Total biomass potential in Nigeria, consisting of animal and agricultural wastes, and wood residues, was estimated to be about 1.2 PJ in 1990 (Obioh et al 2004).

An estimate of the potential annual sustainable wood yield is about 22 million m^3/year. The estimate is based on an annual increment of 1 m^3/ha and 0.5 m^3/ha from forest and savannah zones respectively.

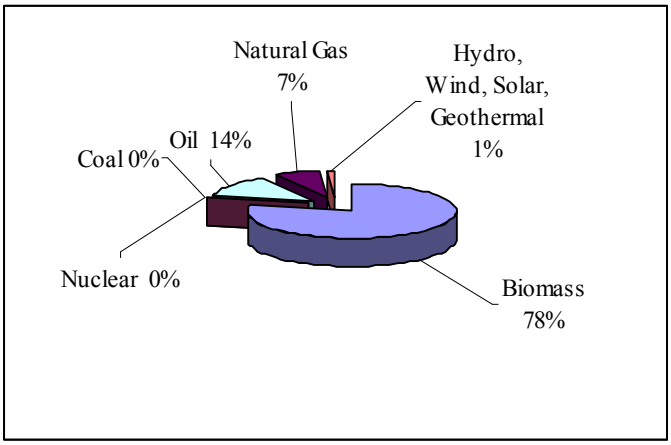
The levels of fuel wood consumption and charcoal remains based on the early data by FAO as reported by EMRD (1991). Based on the 1991 population consensus that projected an annual growth rate of 2.8%m t fuel wood and charcoal consumption ranges were estimated to be 77.4 to 83.5 million tonnes (720 to 777 PJ) and 1.87 to 1.97 Mt (17.4 to 18.3 TJ) respectively for the period 2003 to 2006.[7]

Sectoral Contribution to National Energy Mix

Energy Supply

In 2005, the gross primary energy supply was 105 MTOE with contributions coming primarily from oil, natural gas and biomass and illustrated in Figure 3.

Figure 3: Gross contributions to the total primary energy supply (2005)



Source: UNDP 2007

Energy Consumption

As part of the national emissions inventories for the energy sector for the period 1988 to 2000, the gross energy consumption in each sector has been computed (Obioh

[7] This is in comparison 1990 consumption rates of 54.5 Mt (507 PJ)and 1.45 Mt (13.5 TJ), based on extrapolations from data presented by Obioh (2004)

2004; Obioh et al 2004). These and the projections to 2006 based on established annual consumption growth rate per sector are presented in Table 3. This table lists residential, industrial and construction, agriculture and forestry, transportation, and energy industries (public power plants, refineries, etc).

Table 3: Energy consumption by sector (calculated for the period 1988 to 2000 and Eetrapolated to 2006

	Energy Consumption by Sector (PJ)									
	Residential	Industry & Construction	Transportation				Agric. & Forestry	Energy Industries		
			Road	Rail	Aviation	Navigation		Liquid	Natural	TOTAL
Year							(Diesel)	Fuels	Gas	
1988	492	75.67	50.66	1.78	6.5	6.54	1.3	1.2	97.1	865.6
1989	506	70.09	48.14	1.69	5.1	13.23	1.24	0.9	107.6	895.0
1990	520	53.56	52.58	1.85	5	13.58	1.35	0.9	61.2	850.8
1991	535	67.89	54.94	1.93	3.2	13.97	1.41	0.9	108.7	930.8
1992	550	66.68	69.89	2.45	5.3	15.86	1.8	0.9	113.9	1000.9
1993	565	69.33	70.34	2.47	8.1	17.09	1.81	0.9	121.8	1016.1
1994	580	63.11	104.95	3.68	12.3	22.05	2.7	1	135.9	1206.1
1995	597	79.81	49.74	1.75	8.4	20.21	1.28	0.7	171.7	1062.1
1996	613	124.54	70.61	2.48	34.7	16.55	1.82	0.9	186.1	1265.5
1997	630	75.39	85	2.98	5.3	21.99	2.18	0.6	160.1	1236.2
1998	648	61.35	45.58	1.6	7.7	19	1.17	0.4	148.0	1089.6
1999	666	123.17	67.36	2.36	5.5	18.06	1.73	0.6	157.0	1290.2
2000	684	368.38	82.96	2.91	4.7	23.33	2.13	0.5	209.9	1648.0
2001[8]	702	451.39	86.10	3.02	4.62	25.10	2.21	0.49	223.21	1781.5
2002	719	553.11	89.36	3.13	4.55	27.00	2.29	0.49	237.36	1936.1
2003	738	677.74	92.75	3.25	4.48	29.05	2.38	0.49	252.41	2116.1
2004	756	830.47	96.26	3.37	4.40	31.25	2.47	0.49	268.42	2326.8
2005	775	1017.61	99.91	3.50	4.33	33.62	2.56	0.49	285.44	2574.7
2006	795	1246.91	103.69	3.63	4.26	36.17	2.66	0.49	303.53	2867.6

Electricity Production

In 2004, use of liquid and solid fossil fuels accounted for approximately 58% of the gross national consumption with natural gas and hydroelectricity contributing 34% and 8% respectively. Coal, nuclear and other renewable are not yet part of the primary energy mix used to produce electricity.

[8] Figures for 2001 to 2006 presented as Extrapolations from the 1988 to 2000 Computed Values

Figure 4: Relative locations of major electrical power stations

Plant Name and AreaLocation	Thermal (MW)	Hydro (MW)
AES GT -Lagos	270	
AFAM - Port Harcourt;	??	
DELTA - Warri	882	
DELTA- Warri -	936	
EGBIN - Lagos	1,320 MW	
GEREGU - Abuja	414	
JEBBA - vertical drop of Niger		540
KAINJI - vertical drop of Niger		720
OKPAI - Port Harcourt	??	
OLORUNSOGO - Lagos	335	
OMOTOSHO	335	
SAPELE - Warri	1020	
SHIRORO -Kano		600

Vulnerability and Resilience of National Energy System

Energy systems are developed by global, regional, national bodies to support industry, commerce and households/institutions with the energy services and fuels they need to sustain their operations.

They operate within financial and cost reliability imperatives and are expected to perform across a range of sustainability criteria. In many instances energy systems fail to meet these expectations.

An energy system is considered resilient if it possesses the capacity "to tolerate any disturbance which acts as impedance to its effectiveness, and to continue to deliver affordable energy services" to its consumers. A resilient energy system is thus one which can withstand shocks and provide alternative means of satisfying its energy service needs in the event of changed external circumstances. When the energy system is affected by any factor external to it, which inhibits it from maintaining a state of resilience, it is said to become vulnerable to such external factors. Among such external factors are sabotage, natural and anthropogenic induced disasters, terrorism etc.

In recent years, climate change is being recognised as one of the key environmental issues that has tremendous impact on the resilience of the National Energy System (NES), even for the most developed countries. The challenges of climate change stems from the need to withdraw carbon-rich fuels and replace them with zero or low carbon fuels and improve on energy efficiencies across all sectors. Similarly, some impacts such as changes in global temperatures could lead to demand for more energy for space cooling or potential damage to infrastructure which implies that investment in new infrastructure may need to be planned and implemented at higher investment costs and insurance.

In Nigeria, energy systems are very weak structurally, they lack the technological support to manage the complex systems, and their efficient functioning is undermined by the political environment. Below is an assessment of the key vulnerabilities within the Nigerian energy system.

Structural inadequacies and lack of lack of legislative follow through on the Draft National Energy Master Plan: The structure of the national energy system has changed from one dominated by coal during the 1950s to 1960s, to is now dominated by crude oil and natural gas. As noted earlier, oil contributes up to 58% of gross national consumption. Even though Nigeria has in abundance nearly all other energy sources (coal, solar, geothermal, wind and other renewable), these do not yet play a significant part in formal and informal energy sector.

In the informal sector—dominated by household and small scale enterprises—biomass energy is the dominant fuel used, despite the inefficiencies associated with the consumption technologies used. Extensive reliance on primary biomass fuels has led to a loss in land cover which has exacerbated a number of environmental problems. The Energy Commission of Nigeria (ECN) developed the Draft National Energy Master Plan in 2007. It has short, medium and long timelines but it is yet to have any legislative follow-up as it still remains in the Executive domain.

Dominance of single revenue source for national development: In the last two to three decades, oil and gas exports have dominated foreign exchange revenue earnings by as much as 90% or more. Any unfavourable shifts in oil/gas supplies, e.g. violence in the Niger Delta, by dwindling prices in the international market, or by demand for oil/gas and their products (induced by other countries shifting towards low or zero carbon energy sources) will and does adversely affect the Nigerian economy. Most developed countries are now seriously engaged in developing new technologies to make themselves more energy independent, principally in response to the crises in the Middle East and to meet national obligations on climate change.

Dominance of single energy source for primary fuels and electricity supply: The NES in Nigeria is dominated by carbon rich fossil fuels. Crude oil and its products are the key fuels used in the transportation sector, as well as for powering private generators in public and residential buildings to off-set short-falls in electricity supply. Even though most of the in-country power plants are now shifting to natural gas, the contribution of hydropower is still very low. Moreover over the years hydropower has been affected by uncertainties in water supplies from the inland water ways. Low to zero-carbon fuels such as nuclear and renewable energies play are not present on the energy scene.

Supply and demand short-falls for refined petroleum products and electricity due to poor Infrastructure and maintenance capacity: Nigeria's population is currently growing at approximately 2.8% per annum. Projections anticipate that the population may exceed 300 million people sometime between 2025 and 2030. Within the same period, the economy, according to current national projections and streamlining, is also expected to improve, leading to increased per capita consumption in all sectors. Increased per capita consumption added to increased population will dwindle further current deficits in the supply and demand for both fuels, and electricity nationally. There does not appear to be any plans on how to meet these deficits, implying that electricity short-falls, which is now at an extremely low level, may even get worse. Moreover, Nigeria's refining capacity is insufficient to meet domestic demand, forcing the country to import petroleum products to offset local refining capacity which has dropped from the combined capacity of 438,750 to 214,000 barrels per day (bbl/d). This decline is attributable to problems that include sabotage, fire, poor management and lack of regular maintenance.

Inadequacy and reliability of the electricity network: The electricity sector has also been significantly hindered by inefficiencies associated with both limitations in the gross annual output of power plants, as well as by the transmission and distribution network. While gross annual production is still within the range of 3,000 to 4,000 megawatts per annum, the transmission infrastructure is old, leading to transmission and distribution losses of between 25% and 30%. The electricity sector has received tremendous government attention over the past decade, with billions of US dollars in expenditures in the generation, transmission and distribution sub-sectors, as well as into natural gas supply infrastructures to the power plants. Unfortunately the results are yet to be felt.

Absence of local research to grow traditional and emerging energy technologies: Even though the national economy has been built on earnings from oil and gas exports, Nigeria is completely dependent on importation of technologies to support both upstream and downstream operations. As a result it has become increasingly difficult for the country develop this sector. With an economy largely dependent on exports of crude oil and natural gas, Nigeria has yet to demonstrate any achievements from its major research institutes to contribute to the development of basic technologies in exploration, production, conversion and utilisation of crude oil and natural gas products. All technologies currently in use and all plans to replace existing technologies are imported. With economy in recession, increasing population growth, and very little national capacity to develop technologies to add value to its oil and gas and emerging energy resources, the country is not prepared to diversity its energy

resource base. It is unlikely that the country will be able to achieve energy systems resilience even over the long-term, as many of its problems are infrastructure based.

Politically-induced violence in the Niger Delta: Nigeria is now experiencing increased violence in the upstream oil and gas sector, which now includes pipeline vandalism, kidnapping, and forced takeover of oil/gas facilities by militants in the Niger Delta.[9] This is leading to significant insecurity for most operations in the upstream oil and gas sector. It also effects national production.

Climate-induced Impacts on Specific Energy Systems

Given the trends observed from 1990 to the present, it is likely that mean annual temperatures and precipitation will continue to increase. Within the same scenario, mean clouds, floods and droughts are also showing slight to medium increases (depending of which parts of the country). No significant changes are observed for average wind speeds and frequency of extreme weather events and there not yet any model results that indicate how sea surface temperatures are changing, and how these are likely to affect ocean-land circulations.

Based on observed and predicted climatic changes, the following section summaries anticipated impacts for key energy systems.

Electricity system

Reduced transmission expected from transmission lines destruction during floods, which are mainly expected in the southern states of the Federation. Following interruptions in house-hold and institutional demands, as well as reduction in supplies, sharp reduction in both demand and supplies are expected. Electricity use may also decline due to interruptions. The national grid network is already in very poor state, these would further worsen the electricity supplies, and would require both re-design and increased provisions for grid surveillance and maintenance.

Fossil Fuel-based Energy

Fossil fuel based energy is almost entirely dependent on oil and gas supplies. These supplies are not easily affected by any of the above meteorological variables, except in the flooding of power plants which is not anticipated to be likely. However, consumption efficiency for power plants, the transportation and other sectors would be reduced by expected increased mean air temperature which would lead to an increase in demand for cooling.

Hydroelectricity Generation

There is some potential for increases in hydro-electricity generation, since precipitation levels have increased by as much as 30% when compared to historical

[9] They are fighting for what they term as unfairness in the sharing of oil and gas revenue to the people of the Niger Delta, on whose land oil/gas is produced and whose environment is by local and international concerned groups judged to be devastated.

records. This will increase flow regimes of the inland water ways which supplies the hydroelectric turbines. This increase may be countered by decreases in generation associated with siltation and debris in flooded areas, as well as decreases associated with reduced river flows in areas, affected by drought. Current production output plans for large and small hydroelectric systems have not been adapted to take into account change in flow regimes and the effect on electricity generation.

Biomass Energy

Biomass availability and biomass energy generation may increase based on the statistics showing precipitation increases (11- 30%). However decreases are likely due to the reduction in land area from sea level rise and flooding in the south, and droughts in the north. Ultimately it is unlikely that there will be a net increase in biomass. Moreover, poor penetration and use of energy efficient biomass technologies would undermine any net gain.

See Annex 1 for a schematic representation of anticipated climate impacts on Nigeria's energy systems

Measuring Energy System Vulnerability

Vulnerability indicator	Calculation
Coal	
1. Number of coal mines plants located at less than 1m above sea level and within the area that could be flooded by a flood within a current recurrence period of 100 years.	0
Oil and gas	
1. Share of offshore oil and gas installations likely to be hit by a storm of more than 70m/s gusts within the next 20 years (%) *Yearly maximum gusts as given by Fagbenle & Karayiannis[10] over the period 1984 – 1988 in 13 localities in Nigeria falls within the range 20 – 50 m/s.*	10-15%
2. Share/number of refineries likely to be hit by a storm of more than 70m/s gusts within the next 20 years (%) *All four refineries have about the same likelihood, and are subject to wind gusts between 20 – 50 m/sec*	10-15%
All fossil fuels	
1. Number of thermal (coal, oil and gas) power plants located at less than 1 m above sea level and within the area that would be flooded by a flood with a current recurrence period of 100 years. *There are no power plants located less than 1 metre above sea level*	0

[10] *Fagbenle, R. 'Layi and Karayiannis, T. G. (1994), On the wind energy resource of Nigeria. Int. J. Energy Research, vol. 18, 493-508 Table 9.*

Vulnerability indicator	Calculation
Hydro	
1. Expected precipitation change over the next 20-50 years (%) and/or probability of floods in each watershed. *Nigeria's 1st National Communication under the UNFCCC, Chp.4,[11] affirms that generally, the rainy season will be wetter while the dry season will be drier. Scenarios considered for several cities indicate 5 to 12% increase in rainfall.The northern part of the country is expected to experience droughts as a result of decreased precipitation, while the south is expected to experience increased precipitation during the rainy season.*	10% increase
2. Number of multiple-use dams in the country today Volume of water (m3) of each dam *The four dams were constructed to serve water Boards in States in their locality, for fishing, irrigation & power generation. The power component is yet to take off in all four dams.*	4 Dadin Kowa Dam 1.77 x 109 m3 & 34 MW Bakolori Dam, Sokoto State - 450,000 m3 & 3 MW Oyan Dam, Ogun State 270 X 106 m3 & 9 MW Ikere Gorge, Ogun State 265 X 106 m3 & 9 MW
2b. % of water used for non-electricity generation purposes	Agriculture: approx. 30% Power: 0% Domestic use: approx. 70%
Transmission and distribution	
1. Length of in country, above ground transmission and distribution lines (km). --High (transmission) --Middle and low voltage lines (distribution) *Data as of Dec. 2005:*	 HT: 5000 km of 330 kV & 6000 km of 132 kV M &LT: 23, 753 km of 33 kV & 19, 226 km of 11 kV.
2. Number and length of power cuts (due to drought) *Interruptions have many causes, including low water heights due to drought. The number due to drought specifically is not known.* Average hours of interruption per year *Varies, from as little as a few minutes to as much as hours and days*	600[12] NA

[11] Section 4.4.3 – Projections from SRES, p. 67.
[12] from Manufacturers Association of Nigeria (MAN)] Power supply reliability indices; MAN presentation at the Electric Power Sector Reform Workshop, Abuja, 2005

Vulnerability indicator	Calculation
3. Percentage of energy supply requiring regional transport over 50 km. *75% of power generation is thermal with 100% of the fuel requiring pipeline and tanker transportation.* *The remaining 25% of the energy supply is hydro and does not need transportation from source to power generation site.* *Total energy supply noted above also includes biomass; the biomass energy requires transportation both for rural & urban use.* 3b. % of fossil fuel transported over 50 km 3c. % of biomass transported over 50 km *Biomass energy in form of fuelwood and charcoal is transported all over the country. According to the Renewable Energy Master Plan (REMP) the project demand for fuelwood in 2010 is approximately 88,138,000 m3 up from 81,700,000 m3 in 2008*	65.5% 75% 50%
Biomass	
1. Proportion of biomass used for energy purposes (%) in total biomass production *From the REMP, a fuelwood supply deficit of about 22% and 28% was projected for 2008 and 2010 respectively. Biomass & waste make up 78% of total primary energy supply (TPES) as noted in HDR 2007/2008, World Bank.* --Agricultural biomass harvest --Electricity --Heat *It is unlikely that all agricultural biomass harvest is used for heat. A significant amount of corn husks, paddy husks, shells, etc are left to decompose on the farms. In the absence of study data, a fair estimation would be 50%.*	34% 0% 0% 50%
2. Expected precipitation change over the next 20-50 years *The 1st Nigerian National Communication to the UNFCC4 (last bullet on p.6), states that "with respect to moisture, the projections are for an increase rather than a decrease"* *From the data provided, the range of the increase in the 7 cities studied is 6 – 15% for the SRES A2 scenario and 3% to 11% for the SRES B1 scenario.*[13]	Increase of 3 – 15%

[13] *The results of the IPCC IS92 & SRES scenarios using Hadley Centre HadCM3 models are presented in Chapter 4, pp. 50-69 of the Nigeria's 1st National Communication under the UNFCCC, Nov. 2003.*

Vulnerability indicator	Calculation
Wind	
1. Number of wind tubes less than 1m above sea level.	0
2. Projected change of average wind speed in the next 20 years based on regional climate models. *In a study by Fagbenle and Adelaja[14] on wind density trends in Nigeria, it was found to decrease by about 5% for the 1990 to1999 data used.*	-5%
Solar	
1. Capacity of solar installations already in place (m2) --PV (MW) *Rough estimate can be obtained, using an average of 9 m^2/kW giving 2,375 m^2 of 250 kW maximum installed capacity* --Thermal (m^2) *Most of the solar installations are in government projects and those supported by international bodies such as UNDP, World Bank, UNICEF, etc.* --Quality of the insulation and of the building on which systems are installed and type of ownership. *Generally insulation is not provided in buildings in tropical Nigeria as space heating is not required.*	2,375 m^2 < 0.250 MW of solar PV Insignificant solar thermal
2. Expected temperature increase in the next 20 years (^oC relevant for PV capacity) *Chp. 4 of the 1st Nigerian National Communication to the UNFCCC referenced above states that changes in max and min temperatures of the order of 7^oC or higher can be expected.*	7^oC or higher.

Identifying Energy System Resilience

Adaptation Indicator	Calculation
Implementation	
1. Domestic capital formation (million USD per year) *Gross National Savings from the NEEDS Document6 is 29% of GDP in 2007, i.e. US$48 billion.[15] Thus an average yearly value of US$50 billion may be assumed.*	US$50,000 million

[14] Fagbenle, R. O., Adelaja, A.O. and Bello, A.K. Modelling of wind energy potential in Nigeria. Manuscript prepared for publication in Energy, the International Journal by Elsevier

[15] USD 165.5 billion from the World Bank – reference: Nigeria at a Glance http://devdata.worldbank.org/AAG/nga_aag.pdf

Adaptation Indicator	Calculation
2. Domestic investment in renewable energy (million USD per year) *From the 2009 Federal Budget on Energy Projects, the renewable energy component is N13.2 billion approx. Using an exchange rate of N150/US$, this amounts to US$88 million, which may be assumed as the annual domestic investment.*	US$88 million
3. Number of technical engineers graduating annually as a percentage of the total population. *From the 2007/2008 World Bank HDR, tertiary students in science, engineering and manufacturing for Nigeria was not indicated but the average for African countries listed was about 25% of tertiary students. Using this for Nigeria with average of 100,000 graduating annually, gives 25,000. Assuming engineering:science ratio of 1:10 gives an average of about 2500 engineering graduates annually.*	2500 = 0.0018%
4. Availability of hazard maps for floods/droughts	NA
5. Existence and enforcement of power plants siting and construction guidelines taking climate change into consideration.	NA
6. Existence of emergency plans to react to meteorological extreme events and availability of local emergency repair teams. *The following public sector organizations are responsible for such plans: National Emergency Management Agency (NEMA); National Oil Spill Detection & Response Agency (NOSDRA); the International Red Cross Society; State emergency response agencies, etc.* *The government has made much progress in developing the National Climate Change Response Master Plan led by the National Planning Commission. There are also the Inter-Ministerial Committee on Climate Change and the National Committee on Climate Change.*	Yes
7. Domestic availability of insurance schemes. *Generally, the insurance schemes are affordable but the length of time and the great difficulty in being paid from the schemes has eroded public confidence Limited availability due to general lack of public confidence.*	Yes
8. Existence of citizens' users groups in the energy governance structure (enforcement of participatory decision-making) *Citizen's user groups exist, however, their role is very limited.*	Yes
Coal, oil and gas	
1. Existence and use of siting map for mines and power plants taking into account projected storms, floods and drought areas.	NA
2. Implementation of national regulations for thermal power plant siting at sites with sufficient cooling water availability over the next 50 years.	Yes

Adaptation Indicator	Calculation
Hydro	
1. Existence of a national plan for optimised operation of hydro plants under projected flow regimes for systems. *It is assumed this exists for the exiting three large hydro plants – Kainji, Jebba and Shiroro; as well as for the cluster of NESCO small hydro plants in Palteau State. However this could not be confirmed.*	NA
2. Number of dams equipped with desilting gates and/or number of up-stream land use management and water catchment plans for each hydro installation.	3
Biomass	
1. Research, development and dissemination budget for heat and drought resistant crops, bio fuels, agricultural waste for energy and vulnerability of forest (million USD/year).	NA
2. In country utilisation of biomass fuels not traditionally used by private enterprises and cooperatives (% of total fuels). *As indicated earlier, biomass & wastes constitute 78% of the Total Primary Energy Supply (TPES) in 2005. It is not clear what percentage of this is non-traditional.*	NA
3. % of households used improved woodstoves out of total number of households using woodstoves.	NA.
Wind	
1. Existence and enforcement of national regulations requiring storm proofing of wind power plans to withstand highest anticipated wind speed. *Not likely, as there are no wind power large wind power plants currently in Nigeria.*	NA
2. Existence of siting maps that detail projected changes in: wind speed; flood plains; and areas impacted by sea level rise. *Not likely, as indicated above.*	NA
Solar	
1. Existence of siting map that detail projected changes in cloud cover. *Highly unlikely – could not confirm existence of maps.*	NA
2. Existence and enforcement of national regulation requiring storm proof concentrating solar power plants (CSP) to withstand the highest anticipated wind speed. *There are no CSP's in Nigeria.*	NA

Recommendations

1. **Enhance national energy system structure and institute immediate legislative and executive action**

The structure of the national energy system has to be enhanced to include all the plausible renewable energy technologies as the basis for ensuring that the nation voluntarily moves towards a low carbon economy. This should be done regardless of no emission reduction targets imposed by the Kyoto Protocol. Both the Executive and the Legislature need to effect the various renewable energy plans, programmes and projects in the Renewable Energy Master Plan, the National Energy Master Plan, the Renewable Electricity Action Plan, and the JICA solar PV Master Plan. The government should establish a separate Ministry of Low Carbon and Renewable Energy Sources and Technologies (MLCREST) which would be responsible for development and implementing renewable energy options including hydrogen, fuel cells, and other low carbon future energy technologies.

2. **Move from single revenue source for national development**

Climate change is already propelling many countries to seek alternative sources of energy to ensure reduced reliance on oil/gas importation. This has been stimulated not only by the need to stem unfavourable changes in oil/gas supplies internationally, but also in view of price uncertainties on the international market, by demand for oil/gas products from emerging economies which are raising prices up, as well as by the need for countries to either voluntarily or mandatorily shift towards low or zero carbon energy economy.

Since Nigeria depends on oil and gas for its economic grown and sustainability, the success of these countries in implementing new energy technologies will adversely affect the Nigerian economy. It is thus crucial that policies driving investments in new energy technologies in particular, as well as revenue diversification for the country in general be implemented. If such action is not taken, Nigeria could become not only a net importer of traditional energy technologies, but also an importer of emerging fuels and other technologies that are clean and carbon-neutral. The resilience of the national energy system and national economy are thus strongly anchored in the country's capacity to develop its intellectual capital to develop and deploy these technologies, either independently jointly with other countries

The proposed Ministry of Low Carbon and Renewable Energy Sources and Technologies (MLCREST) must invest in R&D for alternative energy sources and particularly in those technologies needed to support their market development. Ensuring that these technology can exported will not only help ensure Nigeria's energy security but will also add to the national economy.

3. **Reduce the dominance of a single energy source for supply of primary fuels and electricity generation**

The national energy system must be consciously be re-designed to have a balanced mix where no single energy source constitutes more than 40% of the gross national consumption. The Draft Energy Master Plan developed by the Energy Commission of Nigeria is a policy and planning document with details on strategies, activities, implementing agencies, funding sources, energy financing and timelines (short-,

medium- and long-term). Details on the targeted schedules for introduction of a diversified energy mix are available in the Renewable Energy Master Plan which was submitted to government in 2005. This Renewable Plan must be taken up by the government as a central component of its Energy Plan.

4. Reduce supply and demand short-falls for refined petroleum products and electricity by improving infrastructure and maintenance capacity

With current population growth rate, there is an increasing challenge that the current short falls in the supply of both petroleum products and electricity will only increase. Policies and programmes are needed to address this supply/demand gap and should include actions to increase generation and transmission capacities, and to improve the performance of the electricity grid to stem high transmission and distribution losses. Although independent power plants exist in many parts of the country, most of these are hampered by uncertainties such as access to natural gas and fluctuating feed-in tariffs. With the dwindling performance of the country's refineries, it is imperative that policies restricting attempts to enhance private sector participation in refineries operations be revisited and aligned with government objectives. Private sector participation is currently inhibited by policies on oil and gas supplies to private refineries and the independent power plants (IPP) operators.

5. Address electricity network inadequacy and reliability

Government pronouncements about Nigeria's power sector problems consistently focus on increasing generation capacity to the total exclusion of the other two legs of the "electricity tripod" – transmission and distribution. In Nigeria these two "legs" are the weakest links in the system. Among the transmission constraints identified are: (i) the radial and fragile transmission grid which is incapable of wheeling more than 4000 MW; (ii) poor voltage profile (low voltage) in most parts of the network, especially in the north; (iii) inadequate dispatch and control infrastructure; (iv) frequent system collapse; (v) high transmission los factor (at least 10%)

The National Integrated Power Project (NIPP), which has been in progress for the past three to four years, includes projects to remedy these transmission and distribution shortcomings. The Power Sector Reform Committee inaugurated by President Yar'Adua on 7 September 2007 and in its final report submitted on 23rd May 2008, summarised the financial requirement for the short-, medium- and long-terms to enable generation, transmission and effective distribution of 20,000 MW by 2020. The cost was estimated at N9.81 trillion, which at today's N150/US$ is approximately US$65.4 billion. The government will need to source financing for this huge amount. Moreover the international energy lending market that will need to be convinced such money will be well invested and repaid. Good governance is perhaps the real problem faced by Nigeria's government in solving the country's energy problem. The technical aspect is indeed the least of its worries.

6. Institute energy management, conservation and efficiency programmes

Energy efficiency, energy conservation and energy management can be a delayed investment in increasing power plant capacity. Issues such as energy labelling, plant and equipment efficiency improvements, energy conservation and the optimal use of energy, can yield great benefits for such a society in delayed investment in generating plant capacity expansion. This entails well-planned public information dissemination

and training on the benefits energy management and conservation. A well informed and sensitised society is central.

7. **Develop an agenda to improve local research to develop traditional and emerging energy technologies**

There is currently very little national capacity to develop technologies that can add value to its oil and gas sectors as well as to other emerging energy resources. The country is not yet prepared to diversify its energy resource base and may even become a net importer of energy resources in future. A national strategy to ensure that existing energy R&D centres are able to deliver on their missions and mandate has to be developed. Simultaneously there should be a long-term investment in R&D programmes to develop emerging energy technologies, such as hydrogen fuels, solar thermal and solar PV, biomass based fuels, small hydro, etc. This will not only ensure a diversified, national energy mix, but also enhance national capacity in its development agenda.

8. **Reduce politically-induced violence in the Niger Delta**

Many of the oil and gas production problems in the Niger Delta are associated with on-going militancy over the sharing of the wealth derived from the exploitation of the region's resources. A lot of effort has already been invested to find appropriate solutions. However, it is important that these efforts are sustained to ensure that a return to status quo does not happen.

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Annex 1: Potential vulnerabilities and resilience of the national energy resources and systems due to climate induced impacts

Change in Meteorological Variables	Relative Change Since 1990	Potential Impacts On National Energy Resources and Systems										
		Electricity System		Fossil-Fuel Based Energy		Hydro-Electricity Generation	Biomass Energy		Wind Generated Electricity	Gridded Connect Solar PV/PT System based Electricity Generation	Stand Alone Solar Thermal Systems based Electricity Generation	
		Electricity Transmission	Electricity Use	Fuel Availability	Energy Generation		Biomass Availability	Energy generation			Hot Water Generation	Hot Water Use
Temperature Increase	Generally Increasing	None	Increase	None	Decrease in Generation Efficiency					Decrease due to lower efficiency	Increased generation	Decreased use
Average Precipitation	Increase of 11 to 30% above normal			None-on oil/gas supply	None	Some increase expected	Some increase expected	Some increase expected				
Mean Cloud cover	Slight increase	None	Slight Increase expected							Slight increase expected	Slight increase expected	None
Average wind speeds	No systematic change observed								No significant change expected			

Change in Meteorological Variables	Relative Change Since 1990	Potential Impacts On National Energy Resources and Systems										
		Electricity System		Fossil-Fuel Based Energy		Hydro-Electricity Generation	Biomass Energy		Wind Generated Electricity	Gridded Connect Solar PV/PT System based Electricity Generation	Stand Alone Solar Thermal Systems based Electricity Generation	
		Electricity Transmission	Electricity Use	Fuel Availability	Energy Generation		Biomass Availability	Energy generation			Hot Water Generation	Hot Water Use
Glaciers Melting	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Floods	Slight Increase (south mainly)	Reduced transmission expected lines destruction	Sharply reduced demand & supply due to interruption	Very little impacts on oil/gas production	Very little, since power plants flooding are not expected	Decrease, due to increased siltation & debris	Decrease expected in flooded areas	Decrease due to decrease in available biomass	None			
Droughts	Medium Increase (north mainly)	Increased risk of transmission lines destruction	Slightly reduced electricity supply (interruptions induced)	None	Reduction: reduced supply of cooling water.	Decreased due to reduced river flows	Decrease	Decrease				
Frequency and/or strengths of storms (hail occurrence)	No systematic change observed			Very little or None	Very little or None	Very little or None	Very little or None	Very little or None	Very little or None	Very little or None	Very little or None	Very little or None