RENEWABLE ENERGY DEVELOPMENT IN NIGERIA*

By

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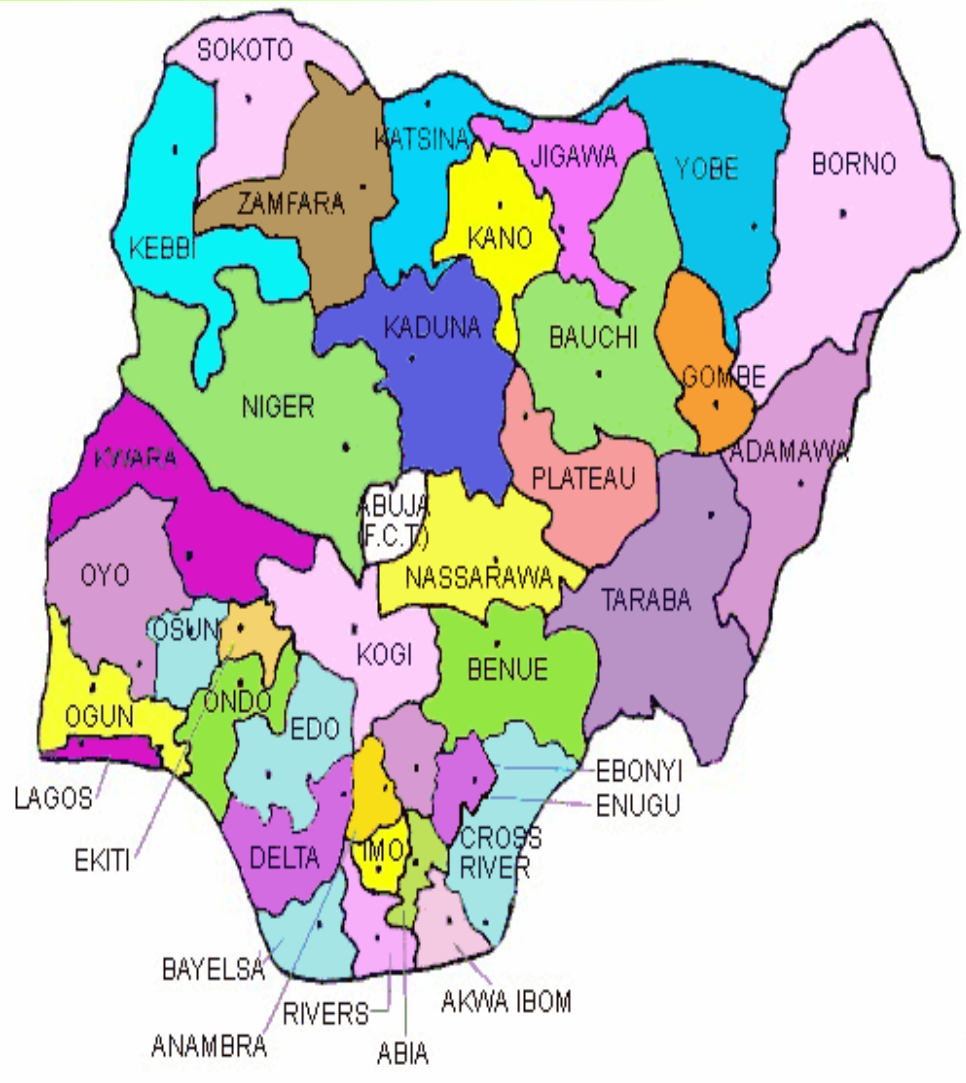
North
Atlantic
Ocean
Azores
(PORTUGAL)
Ponta Delgada
Madeira Islands
(PORTUGAL)
Funchal
Canary Islands
(SPAIN)
Las Palmas
PORTUGAL
Lisbon
SPAIN
Bilbao
Valencia
Balearic Islands
Strait of Gibraltar
FRANCE
Bordeaux
Marseille
Bern
SWITZ.
AUS.
SLO.
CRO.
HUNG.
BOS. and HERZ.
Serbia
ITALY
Rome
Naples
Corsica
Sardinia
Palermo
Sicily
MALTA
UKRAINE
MOLDOVA
ROMANIA
Bucharest
Sofia
BULG.
Mace.
Tirane
ALB.
GREECE
Athens
Black Sea
İstanbul
Ankara
TURKEY
RUSSIA
GEORGIA
T'bilisi
ARMENIA
Yerevan
AZERBAIJAN
Baku
KAZAKHSTAN
UZBEKISTAN
TURKMENISTAN
Ashgabat
CYPRUS
Nicosia
Beirut
LEB.
SYRIA
Damascus
ISRAEL
Jerusalem
Amman
JORDAN
Baghdad
IRAQ
Al Basrah
Tehrān
IRAN
Kuwait
KUWAIT
Persian Gulf
Manama
BAHRAIN
QATAR
Doha
Bandar-e Abbās
U.A.E.
Riyadh
Tropic of Cancer
SAUDI ARABIA
Admin. Line
Sanaa
YEMEN
Bab el Mandeb
Gulf of Aden
Mediterranean Sea
Tangier
Rabat
Casablanca
MOROCCO
Marrakech
Algiers
Oran
Constantine
Ghardaïa
Béchar
ALGERIA
Tindouf
Tamanrasset
Tunis
TUNISIA
Tripoli
Banghāzī
LIBYA
Al Jawf
Alexandria
Cairo
EGYPT
Aswān
Lake Nasser
Admin. Boundary
Red Sea
Port Sudan
El Aaiún
Western Sahara
MAURITANIA
Nouakchott
Néma
Dakar
SENEGAL
Banjul
THE GAMBIA
Bissau
GUINEA-BISSAU
Conakry
GUINEA
Freetown
SIERRA LEONE
Monrovia
LIBERIA
Tombouctou
MALI
Bamako
Niger
BURKINA
Ouagadougou
COTE D'IVOIRE
Yamoussoukro
Abidjan
GHANA
Accra
TOGO
Lomé
BENIN
Porto-Novo
Lagos
Niamey
NIGER
Agadez
Zinder
Kano
Maiduguri
NIGERIA
Abuja
Benue
Faya-Largeau
CHAD
N'Djamena
Khartoum
Nile
Al Fāshir
SUDAN
Wāw
Jūbā
Āsmera
DJIBOUTI
Djibouti
Berbera
Addis Ababa
ETHIOPIA
Provisional Admin. Line
SOMALIA
Mogadishu
CENTRAL AFRICAN REPUBLIC
Bangui
CAMEROON
Douala
Yaounde
Malabo
EQUATORIAL GUINEA
Gulf of Guinea
SAO TOME AND PRINCIPE
São Tomé
Bata
Libreville
GABON
Annobon
(EQUA. GUI.)
Equator
CONGO
Congo
Brazzaville
Pointe-Noire
ANGOLA
(Cabinda)
Kinshasa
Kisangani
ZAIRE
Kananga
Lake Albert
UGANDA
Kampala
Lake Rudolf
KENYA
Nairobi
Lake Victoria
RWANDA
Kigali
BURUNDI
Bujumbura
Lake Tanganyika
Kalemie
TANZANIA
Mombasa
Pemba
Zanzibar
Dar es Salaam
Mbeya
Lake Nyasa
Mtwara
Luanda
Malanje
ANGOLA
Lobito
Luena
Namibe
Menongue
Lubumbashi
Kasama
Ndola
ZAMBIA
Lusaka
Zambezi
MALAWI
Lilongwe
Nacala
MOZAMBIQUE
Harare
ZIMBABWE
Bulawayo
Beira
Mozambique Channel
NAMIBIA
Windhoek
SOUTH AFRICA
(Walvis Bay)
BOTSWANA
Gaborone
Pretoria
Johannesburg
Maputo
Mbabane
SWAZILAND
Orange
SOUTH AFRICA
Maseru
LESOTHO
Durban
Lüderitz
Cape Town
Port Elizabeth
South
Atlantic
Ocean
Ascension
(St. Helena)
St. Helena
(U.K.)
Tropic of Capricorn
Indian
Ocean
SEYCHELLES
COMOROS
Moroni
Mayotte
(admin. by FRANCE, claimed by COMOROS)
Glorioso Islands
(FRANCE)
Antsiranana
Mahajanga
Antananarivo
MADAGASCAR
Toliara
Bassas da India
(FRANCE)
Europa Island
(FRANCE)
Indian
Ocean
Scale 1:48,000,000
Azimuthal Equal-Area Projection
0 500 1000 Kilometers
0 500 1000 Nautical Miles
Boundary representation is not necessarily authoritative.

An Aerial Photograph of the World at night

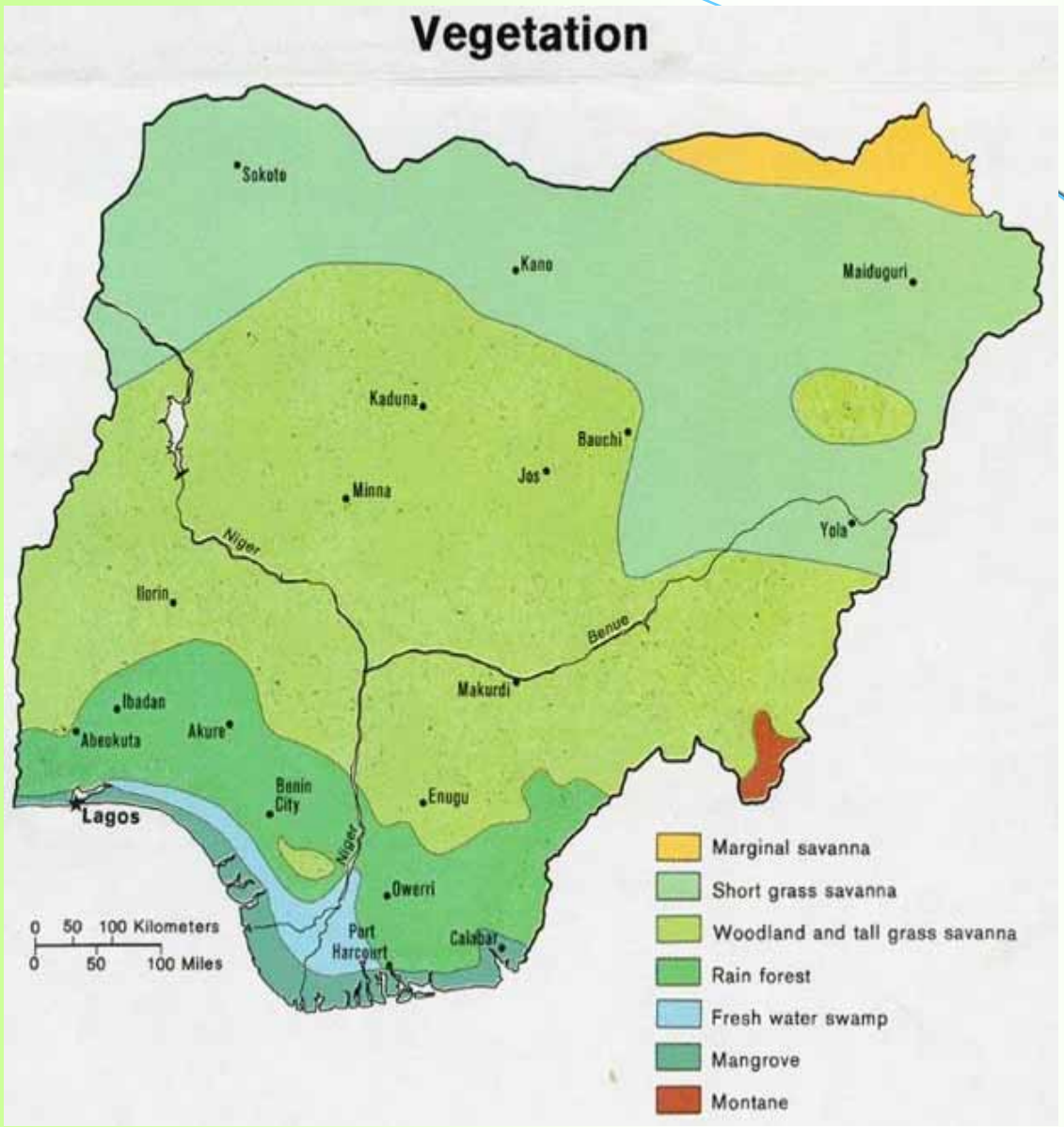
1. COUNTRY PROFILE

Geography



- Nigeria is one of the 54 African countries situated in Sub-Saharan Africa. Nigeria lies within latitudes. 4.32° N and 14° N and longitudes 2.72° E and 14.64 ° E with land area of about 924,000 sq km, which is about 3.1% of African land area.
- The population is about 140 million, which is about 15% of the continent's population.
- Nigeria is a federal republic, made up of 36 States and the Federal Capital Territory (FCT), which serves as the seat of the Federal Government.
- Government is operated through the presidential system, similar to that in North America.

1. Country Profile ..... Cont'd



- Nigerian vegetation is mainly forests (salt water swamp and fresh water swamp) and savannah (Guinea, Sudan and Sahel)

1. Country Profile ..... Cont'd

Economic Indicators

S/N	Indicator	2003	2004	2005	2006	2007
1.	Real GDP Growth (%)	9.6	6.6	6.5	6.0	6.2
2.	Inflation Rate (%)	23.8	10.0	11.6	8.5	6.6
3.	Monetary Policy Rate (%)	15.0	15.0	13.0	10.0	9.5
4.	Prime Lending Rate (%)	19.6	18.9	17.8	17.3	16.94
5.	a) Major Contributors to GDP @					
	1990 Constant Basic Prices:	41.010	40.98	41.19	41.72	42.20
	▪ Agriculture (%)	26.53	25.72	25.26	21.85	19.35
	▪ Crude Petroleum (%)					
	b) Major Contributor to foreign Exchange earnings	95.2	96.3	98.3	98.2	97.8
	▪ Crude Petroleum (%)					
6.	Energy Intensity (kgoe/$) [Energy Consumption/GDP]	0.244	0.186	0.157	0.086	0.063

Source: CBN (2007)

1. Country Profile ..... Cont'd

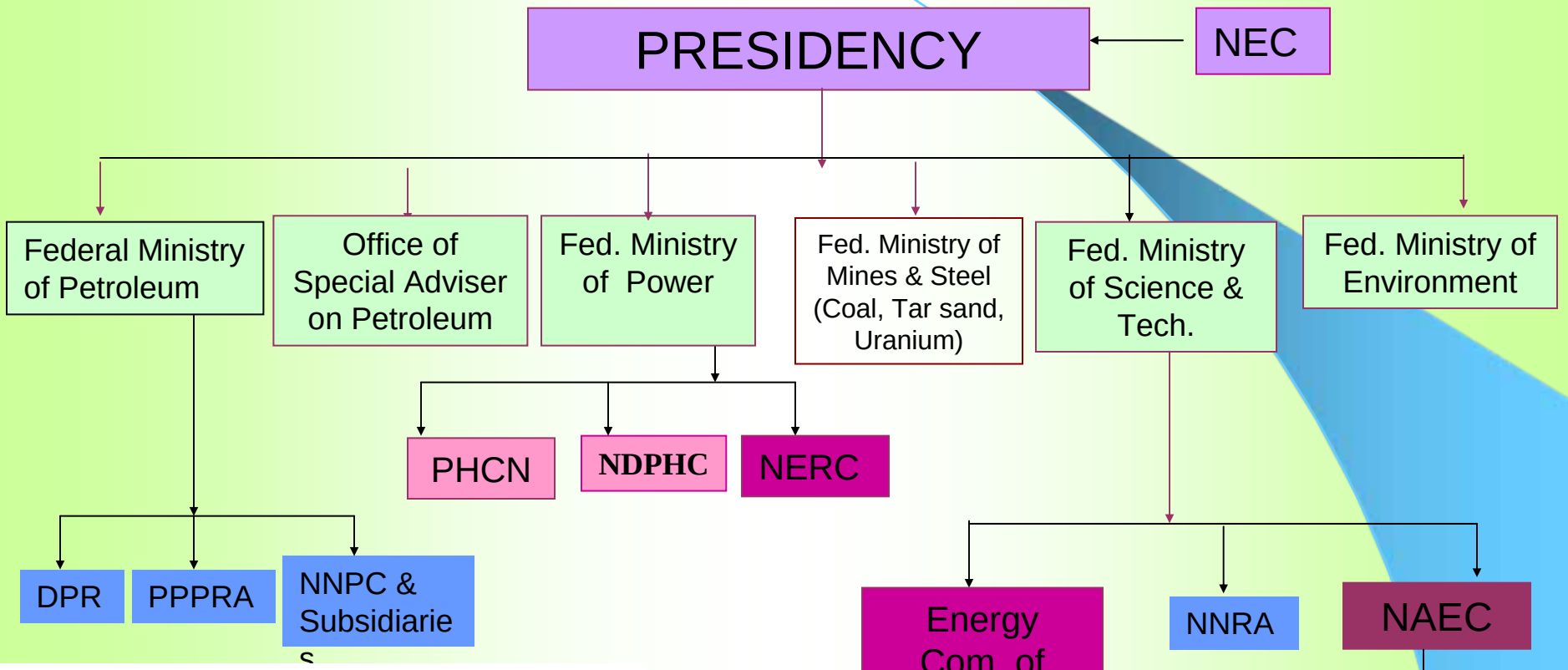
Economic Indicators

S/N	Indicator	2003	2004	2005	2006	2007
1.	GDP/Capita (US$)	620.9	673.2	847.4	1,036.2	1,256.6
2.	Energy Consumption/capita (kgoe/capita)	151.3	125.5	132.6	87.1	81.4
3.	Electricity consumption/ capita (kWh/capita)	174.6	176.4	181.4	167.6	-
4.	Electricity Access (%)				55.2% from 40% in1993	
5.	Population growth rate (%)	2.8	2.8	2.8	3.2	3.2
6.	Adult literacy rate (%)	57.0	62.0	57.0	64.2	64.2
7.	Incidence of poverty (%)	-	54.4	54.4	54.0	54.0
8.	Life expectancy (yrs)	54.0	54.0	54.0	54.0	54.0

Source: Central Bank of Nigeria (CBN) (2007)
National Bureau of Statistics (NBS) (2007)

1. Country Profile ..... Cont'd

Energy Sector Organizations



KEY:

PHCN - Power Holding Company of Nigeria
REA - Rural Electricity Agency (REA),
NERC - Nigerian Electricity Regulatory Commission
ECN - Energy Commission of Nigeria
NDPHC - Niger Delta Power Holding Company
NEC - National Energy Council
NNRA – Nigerian Nuclear Regulatory Authority
DPR - Department of Petroleum Resources
NAEC - Nigerian Atomic Energy Commission
PPPRA – Petroleum Product Pricing Regulatory Agency

2 ENERGY SUPPLY SITUATION

Fossil-Type Energy Resources

S/No.	Resource Type	Reserves (Natural Units)
1.	Crude Oil	36.2 billion barrels
2.	Natural Gas	187 trillion SCF
3.	Coal and lignite	2.7 billion tonnes
4.	Tar Sands	31 billion barrels of oil equivalent

Sources: (i) Nigerian National Petroleum Corporation (NNPC) 2007)
(ii) Renewable Energy Masterplan (REMP) 2005
(iii) Ministry of Mines and Steel Development (2008

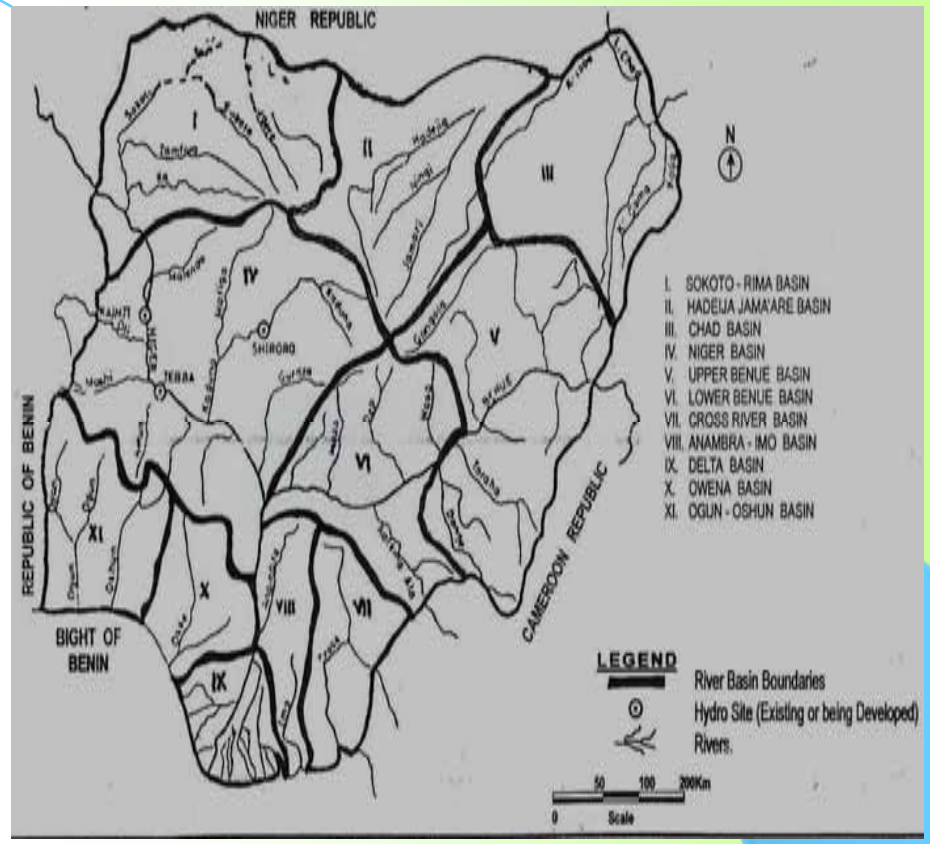
Renewable Energy Potentials

Resource	Capacity	Remark
Large Hydropower	11,500 MW	Only 1972 MW exploited
Small Hydropower	3,500 MW	Only about 64.2 MW exploited
Solar	3.5 kW/m/day – 7.0 kW/m/day	Refer to solar radiation map
Sunshine Hrs	(4-7.5)hrs/day	
Wind	2-4 m/s @ 10m height mainland	Electronic Wind Information disk (WIS) available
Biomass	Fuelwood	11 million hectares of forest and woodland
	Animal Waste	245 million assorted in 2001
	Energy Crops and Agric Residue	72 million hectares of Agric. Land

Sources: (i) Nigerian National Petroleum Corporation (NNPC) 2007)
(ii) Renewable Energy Masterplan (REMP) 2005
(iii) Ministry of Mines and Steel Development (2008

2 Energy Supply Situation ..... Cont'd

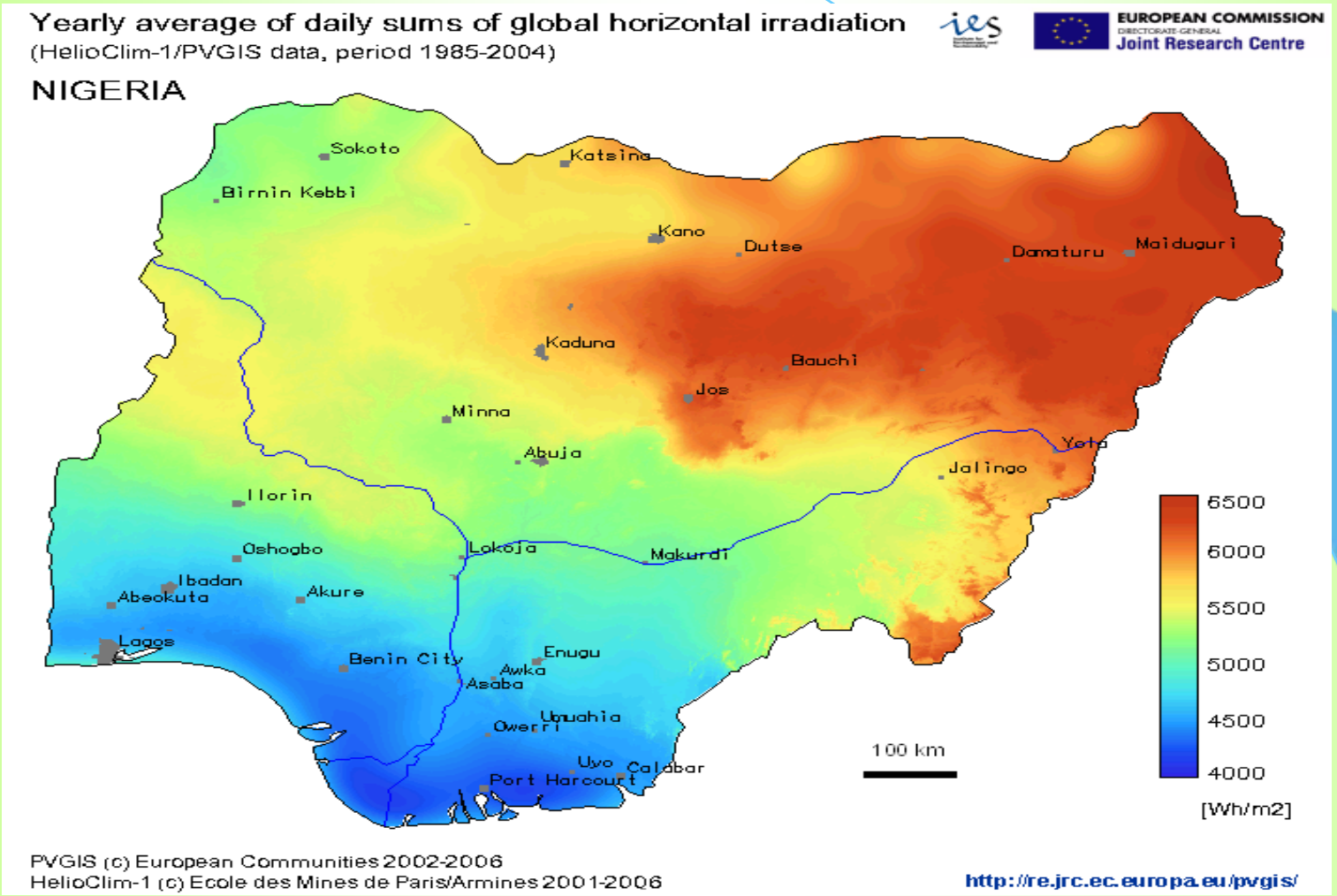
Niger Delta and the Gulf of Guinea – major source of oil and gas



River Basins in Nigeria – areas for hydropower development

2 Energy Supply Situation ..... Cont'd

Solar Radiation Map of Nigeria



2 Energy Supply Situation ..... Cont'd

Energy Production in Nigeria

S/N	Type	2003	2004	2005	2006	2007
1.	Coal (million tonnes)	0	0	0	0	0
2.	Oil (million barrels/ day)	2.3	2.5	2.5	2.2	2.2
3.	Natural gas (billion m^3) (% flared)	52.75 (44.1%)	59.76 (40.4%)	58.35 (39.4%)	61.80 (36.1%)	70.1 (31.1%)
4.	Electricity Generation (billion TWh)	22.03	22.92	24.22	23.47	16.94

Sources: (i) Central Bank of Nigeria (CBN) 2007)
(ii) www.Opec.org/Library
(iii) National Bureau of Statistics (NBS) (2007)

- Though Nigeria has a resource of 2.7 billion tonnes of coal, production declined from a peak of 0.91 million tonnes in 1959 to no production in 2001, because of petroleum, which was discovered in commercial quantities in 1956

2 Energy Supply Situation ……. Cont'd

Energy Consumption by Type

Energy Consumption by Type and % of Total

S/N	Type	2003	2004	2005	2006	2007
1.	Coal (%)	0.03	0.03	0.03	0.05	0.05
2.	Hydro (%)	14.2	17.39	12.0	17.03	23.90
3.	Natural gas (%)	1.9	4.54	5.50	7.52	8.73
4.	Petroleum Products (%)	83.87	78.04	82.50	75.44	67.53
5.	Total (Mtoe)	19.11	16.27	17.7	12.20	11.39

Source: Central Bank of Nigeria (CBN) (2007)

- Petroleum products is the widely consumed energy type and the largest amount of that consumed is imported, despite the country's status as the largest oil producer in Africa.

2 Energy Supply Situation ……. Cont'd

Energy Consumption by Sector -

(i) Percentage Electricity Consumption by Sector

S/N	Sector	1988	1989	1990	1995	1999	2002
1.	Industrial (%)	30.2	30.2	25.7	21.9	21.7	24.1
2.	Commercial & Street Lighting (%)	12.8	12.8	23.8	25.6	26.8	25.9
3.	Residential (%)	57.0	57.0	50.5	52.5	51.5	50.0
	Total (billion kWh)	7.865	8.854	7.944	9.435	8.576	12.118

Source: Central Bank of Nigeria (CBN) (1990), Federal Office of Statistics (FOS) (2002)

- Domestic or residential sector has been the largest consumer of electricity in the country.

2 Energy Supply Situation ……. Cont'd

(ii) Projected Sectoral Energy Demand in Nigeria based on 7% Growth Rate

S/N	Sector	2005 (Base Yr)	2010	2015	2020	2025	2030
1.	Industry (%)	13.81	28.92	37.01	40.75	44.69	48.78
2.	Transport (%)	30.80	27.62	24.56	22.92	22.27	21.62
3.	Household (%)	49.23	38.16	33.05	30.62	27.27	24.12
4.	Services (%)	6.13	5.30	5.39	5.72	5.78	5.49
	Total (mtoe)	32.14	49.92	76.45	112.67	158.95	224.54

Source: Energy Commission of Nigeria (2008)

- These projections are based on the Model for the Analysis of Energy Demand (MAED) of the IAEA.
- The projections are also based on the preferred scenarios of development for the country, where industry would make the highest contribution to GDP.

2 Energy Supply Situation ……. Cont'd

(iii) Projected Sectoral Energy Demand in Nigeria based on 13% Growth Rate

S/N	Sector	2005 (Base Yr)	2010	2015	2020	2025	2030
1.	Industry (%)	13.81	27.91	40.87	51.91	62.89	71.39
2.	Transport (%)	30.80	26.78	23.24	20.86	18.55	16.51
3.	Household (%)	49.23	38.46	28.84	21.26	14.08	8.95
4.	Services (%)	6.13	6.86	7.05	5.97	4.48	3.15
	Total (mtoe)	32.14	59.45	109.97	202.74	387.52	747.27

Source: Energy Commission of Nigeria (2008)

- This is the preferred economic growth rate by the Government to meet its aspirations.

3. RENEWABLE ENERGY POLICY, REGULATION AND LEGISLATION

(a) Policy Framework

- In 2003, the Federal Government approved a National Energy Policy, which encourages the optimum utilization of the country's energy resources, including renewables, for sustainable national development with the active participation of the private sector. For example, the following policies are articulated for solar energy, biomass and wind:
- Solar Energy:

  - The nation shall aggressively pursue the integration of solar energy into the nation's energy mix
  - The nation shall keep abreast with worldwide developments in solar energy technology.

3. RE Policy, Regulation and Legislation …… Cont'd

Policy Framework …. Cont'd

- Biomass:
  - The nation shall effectively harness non-fuelwood biomass energy resources and integrate them with other energy resources
  - The nation shall promote the use of efficient biomass conversion technologies.

- Wind:
  - The nation shall commercially develop its wind energy resource and integrate this with other energy resource.
  - The nation shall take necessary measures to ensure that this form of energy is harnessed at sustainable costs to both suppliers and consumers in the rural areas.

3. RE Policy, Regulation and Legislation …… Cont'd

(b) Policy Framework …. Cont'd

- In 2005, the Energy Commission of Nigeria in collaboration with the United Nations Development Programme (UNDP) drafted a Renewable Energy Masterplan from the National Energy Policy strategies. The masterplan provides a roadmap or activities that will enable the implementation of the policies on renewable energy, with targets/milestones and timelines in the short, medium and long terms.
- In 20007, a biofuel policy initiated by the country's National Petroleum Corporation (NNPC), was approved by the Federal Government. The policy articulates amongst other things, a seeding, programme within which up to 10% mixture of ethanol in premium motor spirit (E10) and 20% of biodiesel in petro-diesel (B20)by volume are to be imported and used as automotive duels in the country.

(b) Regulation and Legislation

- Major renewable energy applications in Nigeria are in the areas of:
  - Electricity production
  - Biofuel for transportation
  - Other thermal applications (cooking, drying, heating, etc.)
- The coordination of the national policies on energy in all its ramification rests on the Energy Commission of Nigeria, established by law in 1979.
- Generally, the Nigerian electricity sector was liberalised by the Electric Power Sector Reform Act of 2005, and a strong regulatory institution, the Nigerian Electricity Regulatory Commission (NERC) was thereafter established.
- NERC has the general mandate to regulate the entire electricity sector in the country with regards to tariff setting and regulation, supervision of market rules, performance monitoring, and overseeing the orderly transformation of the power sector to a more competitive environment. Licenses are required for generation of 1MW aggregate and above at a site; and distribution of power of capacity greater than 100kW in aggregate at a site.

3. RE Policy, Regulation and Legislation …… Cont'd

Regulation and Legislation ….. Cont'd

- Generally, automotive fuels in Nigeria are regulated by the Department of Petroleum Resources (DPR). Automotive fuels include both mineral fuels and biofuels.
- Other relevant regulatory institution to renewable energy is the Standard Organization of Nigeria (SON), charged with responsibility of setting and enforcing standards of goods and services in Nigeria. Therefore, the quality standards of solar PV modules, inverters, batteries, solar cookers, improved woodstoves, biogas digesters etc. should be enforced by SON; after the standards have been set in conjunction with relevant bodies like the Energy Commission of Nigeria, Manufacturers Association of Nigeria, Nigeria Society of Engineers, NERC, etc
- The National energy Masterplan, which includes renewable energy, as well as the masterplan are yet to be passed into law through an Act of National Assembly.
- The National Assembly is, however, being sensitized to facilitate the consideration of an energy bill that would enable the enactment of the National Energy Policy and Masterplan into law.

4. RENEWABLE ENERGY APPLICATIONS IN NIGERIA

Early use of RE:

- Open-to-sun drying
- Use of solar energy in crop production – photosynthesis
- Use of fuelwood for cooking
- Use of wind energy in Winnowing process.

4. Renewable Energy Applications in Nigeria …… Cont'd

Pilot Water Heater at UDUTH by SERC, Sokoto

2-tonne Solar Rice Dryer atAdarice Co. Enugu built by NCERD

- Solar water heaters and dryers are now being developed in our Research Centres. However, their use is not yet wide.

4. Renewable Energy Applications in Nigeria …… Cont'd

Solar PV for Telecommunication
20km Kaduna-Abuja Road

Solar PV at Ilaje, Ondo State of Nigeria

- Solar PV installations is growing (≅ 1MW total dispersed installations country wide – water pumping, street lighting, vaccine refrigerators, community lighting.)

4. Renewable Energy Applications in Nigeria …… Cont'd

Solar PV mini-grid in a village in Sokoto, Sokoto State

Solar Street Lighting in Uyo, Cross River State

Solar Water Pumping for Students in Sokoto, Sokoto State

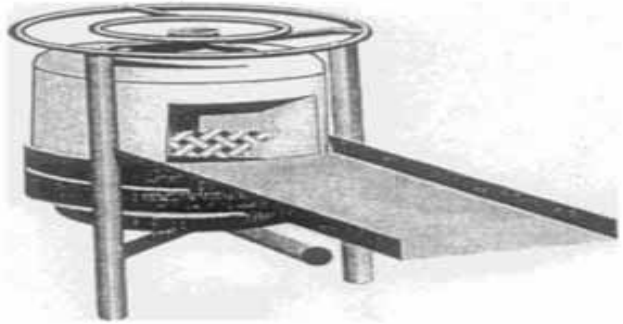
Solar PV at Itu.Mbuzo, Abia State

4. Renewable Energy Applications in Nigeria …… Cont'd

- Three-stone stable using fuelwood with efficiencies of about 5%-7%. (Traditional technology of cooking and heating

4. Renewable Energy Applications in Nigeria …… Cont'd

SERC Improved Woodstoves



a. NCERD Single-seater

NCERD Biogas digester

- Improved woodstoves improve efficiencies to 10%-20%
- Biogas production from organic waste through anaerobic digestion is yet to be popular.

4. Renewable Energy Applications in Nigeria …… Cont'd

Rehabilitated Windmill for Water Pumping at Kadawa Village, Kano State

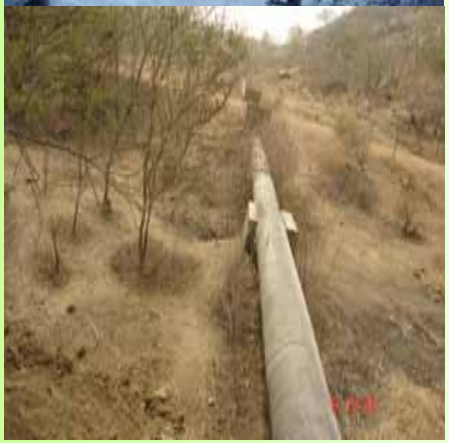
5kW aero generator in Sayya Gidan Gada, Sokoto State

- Winnowing – ancient technology for separation of grains from husks using wind energy
- Wind mills used for water pumping installed in the 1950s and 1960s, mostly in the Northern part of Nigeria. Most of them are now not functional.
- Electricity generation from wind energy is yet to come on stream.

4. Renewable Energy Applications in Nigeria …… Cont'd

Fig. 10: 150 kW Capacity Waya Dam Hydro-Power Station under Construction






30 kW Ezioha Mgbowo SHP Station






- Small hydropower (SHP) development commenced by a private company, the Nigerian Electricity Supply company (NESCO) in 1929 with an initial installation of 1,000 kVA (800 kW) hydroelectric power plant in Kurra Falls, Jos. Plateau State. Installed capacity has now reached 30 MW
- SHP plants of 2 x 35 kW are being installed in Waya Dam, Bauchi State and 30 kW in Enugu State, through collaboration between UNIDO and the Nigeria Government.

4. Renewable Energy Applications in Nigeria …… Cont'd

- The country now has three (3) large hydropower stations as follows:

S/N	Name of Hydro Power Plant	Year Established	Installed Capacity (MW)	Availability as of June 2010 (MW)
1.	Kainji	1968	760	465
2.	Jebba	1986	578	482
3.	Shiroro	1990	600	450
		Total	1,938 MW	1,397 MW

4. Renewable Energy Applications in Nigeria …… Cont'd

Existing SHP Stations

S/N	Location	State	Installed Capacity [kW]	Current Status
1	Kwall Falls	Plateau	6,000	IPP (Operational)
2	Kurra Falls	Plateau	19,000	IPP (Operational)
3	Bakalori	Sokoto	3,000	Dam construction - Completed. Electro-mechanical equipment - Never installed.
4	Tiga	Kano	6,000	Dam construction - Completed. Electro-mechanical equipment - Never installed.
5	Ikere Gorge, Iseyin	Oyo	6,000	Dam construction - Completed. Electro-mechanical equipment - Never installed.
6	Oyan	Ogun	9,000	Dam construction - Completed. Electro-mechanical equipment - Never installed.
7	Waya Dam	Bauchi	150	Completed 2006 (Technical assistance from UNIDO)

4. Renewable Energy Applications in Nigeria …… Cont'd

Existing SHP Stations … Cont'd

8	Ezioha-Mgbowo Dam	Enugu	30	completed 2006 (Technical assistance from UNIDO)
9	Challawa Gorge Dam	Kano	7,000	Dam construction - Completed. Electro-mechanical equipment - Never installed.
10	Gurara Dam	Niger	30	IPP – under construction
11.	Tunga Dam	Taraba	400	Under construction – Electromechanical systems on site (Technical assistance from UNIDO)
	Total		56,610	

4. Renewable Energy Applications in Nigeria …… Cont'd

On-going RE Projects and Programmes

- 2,000 MW hydropower plant in Mambilla, Taraba State
- 30 MW hydropower plant in Gurara, Niger State
- 33 MW hydropower plant in Dadin Kowa, Gombe State
- 10 MW wind farm at Lambatr, Rimi, Katsina State
- 1 MW Solar PV mini-grid at the National Hospital, Abuja.
- Isolated water pumping, street lighting and mini-grid schemes for rural communities (≅ 5 MW installations)
- Research and training in our six (6) Renewable Energy Research Centres:
  - Centre for Energy Conservation and Energy Efficiency, Lagos
  - Centre for Hydropower Research, Ilorin
  - Centre for Energy Environment Research, Benin City
  - National Centre for Energy Research and Development (NCERD), Nsukka
  - Sokoto Energy Research Centre, (SERC), Sokoto.
- Review of Energy Policy and Masterplan; and preparation of a bill to pass it into an energy law by the National Assembly

5. CHALLENGES

- Off-shore wind mapping required
- Detailed studies of hydropower and biomass resources required.
- Inadequate incentives for renewable energy development.
- The National Energy Policy and the Masterplan need a review and passed into an energy law.
- Inadequate human capacity in renewable energy
- Absence of local manufacturing capacity for renewable energy components and systems

6. CONCLUSIONS

- Nigeria is endowed with appreciable RE sources of solar, wind, biomass and hydro.
- National Energy Policy exists that encourages the exploitation of RE resources and its integration into the nation's energy supply mix for sustainable national development, through private sector participation.
- A Draft National Renewable Energy Masterplan also exists to fast track RE development in the country
- Energy Commission of Nigeria, Nigerian Electricity Regulatory Commission, Department of Petroleum Resources and Standard Organisation of Nigeria, make up the institutional framework for the promotion, regulation and standardization of renewable energy and its systems in Nigeria.
- Efforts are being made to get the energy policy and masterplan passed into an energy law.

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THANK YOU AND GOD BLESS