International Institute for Sustainable Development
Institut international du développement durable
http://www.iisd.org

Clean Energy Investment in Nigeria
The domestic context

Felix B. Dayo

April 2008

A country case study completed for IISD's Clean Energy Investment Project

Clean Energy Investment in Nigeria

The domestic context

Felix B. Dayo

April 2008

Published by the International Institute for Sustainable Development

The International Institute for Sustainable Development contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change, measurement and assessment, and natural resources management. Through the Internet, we report on international negotiations and share knowledge gained through collaborative projects with global partners, resulting in more rigorous research, capacity building in developing countries and better dialogue between North and South.

IISD's vision is better living for all—sustainably; its mission is to champion innovation, enabling societies to live sustainably. IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Government of Canada, provided through the Canadian International Development Agency (CIDA), the International Development Research Centre (IDRC) and Environment Canada; and from the Province of Manitoba. The institute receives project funding from numerous governments inside and outside Canada, United Nations agencies, foundations and the private sector.

International Institute for Sustainable Development
161 Portage Avenue East, 6th Floor
Winnipeg, Manitoba
Canada R3B 0Y4
Tel: +1 (204) 958–7700
Fax: +1 (204) 958–7710
E-mail: info@iisd.ca
Web site: http://www.iisd.org/

Table of Contents

LIST OF ACRONYMS

BCfd (BCf/d): Billion Cubic Feet per day
BCM: Billion Cubic Meters
BPE: Bureau for Public Enterprise
BRT: Bus Rapid Transit
BTOE: Billion Tonne of Oil Equivalent
CBN: Central Bank of Nigeria
CCGT: Combined Cycle Gas Turbine
CDM: Clean Development Mechanism
CFL: Compact Fluorescent Lamp
CHP: Combined Heat and Power
CMM: Coal Mine Methane
CNG: Compressed Natural Gas
DPR: Department of Petroleum Resources
ECN: Energy Commission of Nigeria
EGP: Escravos Gas Project
ELP: Escravos to Lagos Pipeline
EPIC: Electric Power Sector Implementation Committee
EPSR: Electric Power Sector Reform
FAO: Food and Agricultural Organization
FAOSTAT: Food and Agricultural Organization Statistics
FDI: Foreign Direct Investment
FFV: Flex Fuelled Vehicle
FGN: Federal Government of Nigeria
FID: Final Investment Decision
FOS: Federal Office of Statistics
GGFR: Global Gas Flare Reduction
GHG: Greenhouse Gas
IISD: International Institute for Sustainable Development
IITA: International Institute for Tropical Agriculture
IPP: Independent Power Producer
LCA: Life Cycle Analysis
LGA: Local Government Area
LPG: Liquefied Petroleum Gas
MAN: Manufacturers Association of Nigeria
MFP: Multi-Functional Platform
MMSCFD (MMCF/D): Million Standard Cubic Feet per Day
MMCM/Day: Million Cubic Meters per Day
NAFDAC: Nigerian Agency for Food and Drug Administration and Control
NAOC: Nigerian AGIP Oil Corporation
NCC: Nigerian Coal Corporation
NCP: National Council on Privatization
NEDP: National Energy Development Project
NEPA: Nigerian Electric Power Authority
NEPP: National Electric Power Policy
NERC: National Electric Regulatory Commission
NGC: Nigerian Gas Corporation
NLNG: Nigerian Liquefied Natural Gas
NMC: Nigerian Mining Corporation
NNPC: Nigerian National Petroleum Corporation
NNPC GMD: NNPC Group Managing Director
NPDC: Nigerian Petroleum Development Company

OKLNG: Olokola Liquefied Natural Gas
OPEC: Organization of Petroleum Exporting Countries
OSAPE: Office of the Special Adviser to the President on Energy
PHCN: Power Holding Company of Nigeria
PHRC: Port Harcourt Refinery Company
PIN: Project Idea Note
PJ: Petajoule
PMS: Petroleum Motor Spirit
PPO: Pure Plant Oil
PPMS: Petroleum Pipeline and Marketing Company
REA: Rural Electrification Agency
RED: Renewable Energy Division
REF: Rural Electrification Fund
REMP: Renewable Energy Master Plan
RSUB: River State Utility Board
SCF: Standard Cubic Feet
SON: Standard Organization of Nigeria
SSA: Sub Saharan Africa
SPDC: Shell Petroleum Development Company
TOE: Tonne of Oil Equivalent
UNDP: United Nations Development Program
UNFCCC: United Nations Framework Convention for Climate Change
UNIDO: United Nations Industrial Development Organization
VAT: Value Added Tax
WAGP: West African Gas Pipeline
WEM: Wholesale Electricity Market
WRPC: Warri Refinery and Petrochemical Company

LIST OF TABLES

1. Introduction

1.1 Objective of the Report and the Concept of Clean Energy Investment

The objective of this study is to assess opportunities for clean energy investments in Nigeria. A key component of the assessment is the identification of key obstacles that have constituted barriers to investment in clean energy systems in the recent and past evolution of the Nigerian energy system. For a meaningful assessment, we need to clarify what are clean energy investments. For the purpose of clarity, clean energy investments can be considered as investments in energy delivery and utilization systems that provide required energy with minimal negative environmental and social consequences. The notion described here covers two components: provision of the quantity of energy required, and the need to provide the energy with minimal negative environmental and social consequences. It is generally accepted that since energy is a key input to the process of economic development, inadequate and/or non-affordable supply of energy will constrain the optimum productivity of any entity irrespective of its geographic location. Side by side with this notion is the fact that the energy supply and consumption framework, even where the energy is available and affordable, must be characterized by acceptable environmental and social impacts, without which the productive capacity of the entity will not be sustainably attained.

Put in another way, from the sustainable development point of view, while scarcity of energy is an important issue requiring adept consideration and handling in the planning of country or regional energy development policies, the need to minimize the negative environmental and social impacts of the supply and utilization of these energy resources is equally important and constitute the balanced outlook of what is here referred to as “clean energy investment”. Our definition of “clean energy investments” in this report can be summarized as follows: “investment in energy sources and technologies that are significantly less environmentally damaging than the baseline”. This report focused on elucidating the role that “clean energy investment” has played and can play in the evolution of Nigeria’s energy system. In order to provide a robust basis for this assignment, we carried out a review of the following characteristics of the Nigerian energy system: the primary energy resource base; final energy supply infrastructure; the evolution of historical consumption of energy in the different sectors of the country’s economy; trends in investment flows into the country’s energy sector; and evolution of energy and environmental policies and regulations that have impacted and continue to impact the development of the country’s energy system.

The outcome of this evaluation coupled with the emerging picture of the role that clean energy has been playing, is already planned to play and should play given sustainability considerations for the Nigerian energy system, are distilled out and utilized in the preparation of action plans to promote clean energy investments in Nigeria, which are reported here. We provide a discussion of the possible pathways to environmental damage of energy systems in the next sub-section.

1.2 Possible Paths for Environmental Damage by Energy Investments

It is now a generally accepted fact that when fossil fuels are combusted to release their inherent energy for useful work for mankind, noxious gases and particulates are released into the atmosphere. These gases, which include sulfur and nitrogen oxides, are now scientifically established to have debilitating effects on the various components of the ecosystem, living beings and plants included. These gases alone and/or acting in concert with other components of the ecosystem pose negative impacts on man, animals, plants and other living and non-living things in the ecosphere. One example of such impacts is discussed in Box 1. The important point here is that it is now a well established axiom that energy uses that are accompanied by the release of such obnoxious gases and particulates lead to unacceptable levels of environmental damages. In many countries, regulatory frameworks are in place to limit the emission of these materials into the environment from energy supply and utilization systems. The focus of such frameworks is to disallow investment in energy supply and utilization systems that allow such emissions without the incorporation of effective pollution control measures.

Box 1: Acid Rain and its Impacts

The term **acid rain** or, more accurately, **acid precipitation** is commonly used to mean the deposition of acidic components in rain, snow, dew, or dry particles. Acid rain occurs when sulfur dioxide and nitrogen oxides are emitted into the atmosphere, undergo chemical transformations, and are absorbed by water droplets in clouds. The droplets then fall to earth as rain, snow, mist, dry dust, hail or sleet. This increases the acidity of the soil, and affects the chemical balance of lakes and streams. The main source of the loading of the atmosphere with sulfur and nitrogen oxides comes from the combustion of fossil fuels in energy systems. Acid rain has become a serious environmental problem in many of the industrialized nations of the World For example, a recent EPA study concluded that acid rain from such sources affects large parts of the US and Canada. Acid rain accelerates weathering in carbonate rocks and accelerates building weathering. It also contributes to acidification of rivers, streams and forest damage at high elevations. When the acid builds up in rivers and streams, it can kill fish. Acid rain has been shown to have adverse impacts on forests, freshwaters and soils, killing off insect and aquatic life forms as well as causing damage to buildings and having possible impacts on human health.

Source: National Geographic, March 2007

There is also a considerable level of global scientific agreement that anthropogenic emission of greenhouse gases from economic activities in many nations of the world is responsible for global climate variability including the global warming phenomenon caused by a few degrees increase in average troposphere temperatures. This increase of earth temperatures has been causally linked to various adverse climate changes that have been noticed in many parts of the world. In recognition of the need for global partnership to check such unwanted phenomena and given the fact that if unchecked, such climate change can lead to serious compromise of present and future generations' sustainable living, the international community has responded by making commitments through the United Nations Framework Convention on Climate Change (UNFCCC) to protect the global environment with the ultimate objective of stabilizing greenhouse gases (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate. Activities of the energy sector are known to be a principal, if not the major, source of emissions of GHGs. An important global agenda that is receiving attention in almost all countries of the World is how to reduce the threat of human-induced climate change to socioeconomic sectors, human health and ecological systems. It is now increasingly becoming an acceptable fact that to do this will require a significant reduction in the emissions of greenhouse gases (GHGs) globally. For the energy sector, "clean energy investments" will be required to achieve the goal of significant reduction in GHG emissions now and into the future.

Box 2: Climate and Prevention of Climate Change can be viewed as Global Public Goods

Because of the recognition of common yet differentiated responsibilities in the United Framework Convention on Climate Change (UNFCCC) and because industrialized countries are responsible for most of the anthropogenic greenhouse gases currently in the atmosphere, developing countries are not expected to bear the additional costs of a low-carbon economy. There are only three sources of funding for mitigating GHG emissions: voluntary actions; international grants; and trade. While all are potentially important, trade is likely to confer the biggest flow of funds (between US$ 20-120 billion per year). An efficient trading system will require a long term, stable and predictable framework and accompanying regulatory system, which could be based upon targets, policies and other measures.

Source: World Bank, Clean Energy and Development, DC 2006-0002, April 5 2006

A challenge that will face the implementation of clean energy investments in many developing countries is how to balance the need for clean energy investments with the fact that many of these countries are currently at the onset of the development curve and as such, will need adequate and affordable supplies of energy to promote a reasonable level of economic development. The implication of this is that the approach to energy sector development will more often than not follow a path of aggressive expansion of energy supplies similar to those followed by the industrialised countries in past decades, since it seemed to have worked well for the economic expansion of these industrialized nations. This is a rational reaction given the likely relatively higher capital cost of clean energy systems, which may further exacerbate the ability of developing countries to break the poverty jinx. This seems to be one of the cardinal bases of the common but differentiated responsibilities enshrined in the United Nations Framework Convention on Climate Change. The notion is that since the industrialized countries are responsible for most of the anthropogenic GHGs currently in the atmosphere, developing countries are not expected to bear the additional costs of the low-carbon economy. Even then, for a sustainable global community, future energy systems be it in developed or developing nations must be less environmentally damaging than the historical baseline. Financing of these future energy systems will come from a combination of sources which are likely to include: in-country; and international. Some of the international sources will include the already established funding for mitigating GHG emissions which include: voluntary actions; international grants; and emissions trading (see Box 2).

1.3 Basic Characteristics of Clean Energy Investment in the Context of the Present Study

Given the discussions above, we provide below salient characteristics of what we shall consider in the context of this study as clean energy investments. They are investments in energy technology at the supply and end-use ends that will:

- Result in little or no emission of noxious gases and particulates or at worst will only allow emissions of these materials up to or below acceptable international best practices;
- In addition, such technologies will be expected to have a carbon footprint that are much lower than the baseline emissions or at best are neutral as far as GHG emissions are concerned;
- From the point of view of technology and investment requirements, will be accessible for adoption in the developing country e.g., Nigeria;
- Contribute to sustainable development and poverty eradication in the country.

The first two and fourth characteristics are necessary and sufficient conditions to make an energy investment a clean investment. We need to be flexible on the third characteristic, given the fact that:

(a) International technology transfer protocol, built into existing international intervention for GHG emission mitigation as well as poverty reduction programs, if well funded and managed should surmount the obstacle of technology inaccessibility in most developing countries;

(b) The availability of international financial mechanisms is also expected to ameliorate some of the investment barriers that may make the adoption of some clean energy technologies difficult in developing countries.

For the third characteristics, the availability of technical cooperation and financial support with developed countries will be considered on a case by case basis before this characteristic can be invoked in the characterization of clean energy investments.

1.4 The Organization of the Report

This report summarizes the salient outcomes of the study on clean energy investment in Nigeria which was commissioned by IISD. In carrying out the study, we evaluated the following issues for Nigeria: clean energy investment, if any, in the country in historical years; whether or not there are existing policy focus on clean energy investments in the country; potentials for clean energy investments in the country; and barriers that have constrained investment in clean energy in the country over the past decades. Historical data on Nigeria's energy system formed the baseline information utilized in the evaluation carried out in this study. The report is organised as follows: Following this introductory section, Section 2 provides country background information focusing on: historical country trends for energy demand, supplies of energy, clean energy technologies, and energy policies. Potential clean energy systems that could be employed in the different sectors of the

Nigerian economy are also discussed; Obstacles to clean energy investments in Nigeria and recommendations on incentives that must be put in place to promote clean energy investments are discussed in Section 3; A case study of a clean energy investment proposed or that will be implemented in the country is presented in Section 4; and the report is concluded in section 5 with the salient conclusions of the study, focusing on: lessons that can be drawn, if any, from the country's experience with clean energy investment; and recommendations of strategies and policies that the Federal Government of Nigeria should consider to increase the flow of clean energy investments into the country.

2. Country Background Information

A brief description of the Nigerian energy system is presented in this section. Information presented in this section forms the baseline situation of the country's energy system from which clean energy investment analysis as it has occurred, is currently occurring and are likely to evolve in the nearest future was carried out in line with one of the objectives of this study. The analysis presented in the next few sub-sections focuses on: energy resource endowment; available energy supply infrastructure; as well as energy demand situation during the historical period 1990-2005.

2.1 Nigeria's Energy Resource Endowment

Nigeria is richly blessed with primary energy resources. The country is endowed with the world's tenth largest reserves of crude oil currently estimated to be about 36 billion barrels (about 4.896 billion tonne of oil equivalent (toe)) in 2006. The country has also been described as more of a natural gas island than oil with an estimated endowment in 2006 put at about 166 trillion standard cubic feet (5,210 billion cubic meters). This includes associated and non-associated reserves, placing Nigeria among the top ten countries with the largest gas reserves in the World. Other significant primary energy resource endowment in Nigeria include: Tar sands – ~ 31 billion barrels oil equivalent (4.216 billion toe); Coal and Lignite – estimated to be ~ 2.7 billion tonnes (1.882 billion toe); Large Hydropower Potentials ~ 10,000 MW; Small Hydropower Potentials, provisionally estimated to be ~ 734 MW. Table 1 below provides a brief summary of these endowments in Nigeria. The table contains recent estimates of other renewable potentials apart from hydropower.

Table 1: Nigeria's Energy Reserves/Potentials (2005)

Resource Type	Reserves	Reserves (BTOE)*(1)*
Crude Oil	36.0 billion barrels	4.896
Natural Gas	166 Trillion SCF*(2)*	4.465
Coal & Lignite	2.7 billion tonnes	1.882
Tar Sands	31 billion barrel of Oil equivalent	4.216
Sub-Total Fossil		**15.459**
Hydropower, Large Scale	10,000 MW	
Hydropower, Small Scale	734 MW	
Fuelwood	13,071,464 Hectares*(3)*	
Animal Waste	61 million tonnes/yr	
Crop Residue	8.3 million tonnes/yr	
Solar Radiation	3.5 – 7.0 KWh/m^2-day	
Wind	2 – 4 m/s (annual average)	

1. BTOE Billion Tonnes of Oil Equivalent
2. SCF Standard Cubic Feet
3. Forest Land Estimate for 1981
Source: Nigeria's Renewable Energy Master Plan (2006)

2.2 Trends in Historical Demand for Energy in Nigeria

A sector approach is used here in the discussion of the trend in energy demand in Nigeria during the period 1990 – 2005. The sectors of the Nigerian economy considered in this report include: agriculture; industry; transport; commercial; and residential. Information on final and useful energy demand in each of this sector are presented in Tables 2 and 3. The useful energy was derived from the final energy in a recent energy demand/supply optimization study, after making assumptions on end use energy efficiencies in these sectors (F.B. Dayo et al. 2004). Both the final and useful energy demand database utilized in the earlier study was extended to the year 2005 for the purpose of the present study. We have used available data from FAO (FAOSTAT, 2005) on fuelwood utilization in the residential and industrial sector as well as charcoal utilization in the household sector to update energy balances during the period 1990-2005.

Table 2: Final Energy Demand in Economic Sectors in Nigeria

	Sector Energy Consumption (PJ)							
Years	Agric.	Industry	Transport	Commercial	Residential	Total	% Annual Growth	% Renewable(1)
1990	7.13	240.48	287.34	6.99	735.70	1,277.64		64.19
1991	7.18	248.67	260.07	6.48	717.30	1,239.70	-3.0	68.23
1992	7.56	247.30	354.41	6.40	770.19	1,385.86	11.8	62.96
1993	7.60	258.96	342.35	6.96	790.92	1,406.79	1.5	63.99
1994	5.54	259.98	246.32	4.63	817.55	1,334.02	-5.2	69.60
1995	5.38	261.75	278.76	7.00	810.18	1,363.07	2.2	70.24
1996	5.71	277.79	241.36	8.01	849.98	1,382.85	1.5	71.42
1997	7.17	311.97	272.58	7.74	918.19	1,517.65	9.7	70.69
1998	6.09	355.75	272.34	8.16	1,002.01	1,644.35	8.3	70.87
1999	6.57	494.64	260.98	7.97	1,074.93	1,845.09	12.2	68.61
2000	8.65	466.94	357.21	7.19	1,163.10	2,003.18	8.6	68.64
2001	7.58	609.64	404.55	8.91	1,274.81	2,305.49	15.1	64.78
2002	8.04	683.79	414.95	8.54	1,373.13	2,488.44	7.9	65.20
2003	6.34	702.88	402.67	9.87	1,462.67	2,584.43	3.9	68.19
2004	3.28	771.88	350.39	9.70	1,571.23	2,706.49	4.7	70.73
2005	5.05	868.16	486.34	10.35	1,758.40	3,128.30	15.1	66.47

1. Data on consumption of renewable energy from FAOSTAT. The renewable portion is mostly biomass (over 90%) especially fuelwood and charcoal
Source: F.B. Dayo et al. 2004 and 2007

Table 3: Useful Energy Demand of Economic Sectors in Nigeria

	Sector Energy Consumption (PJ)						
Years	Agric.	Industry	Transport	Commercial	Residential	Total	% Annual Growth
1990	5.70	122.86	258.39	6.29	234.70	627.95	
1991	5.74	127.33	233.85	5.76	210.92	583.60	-7.1
1992	6.05	124.14	318.80	5.76	240.62	695.37	19.2
1993	6.08	131.37	307.91	6.26	245.85	697.47	0.3
1994	4.43	129.81	221.51	4.17	254.68	614.60	-11.9

	Sector Energy Consumption (PJ)						
Years	Agric.	Industry	Transport	Commercial	Residential	Total	% Annual Growth
1995	4.30	127.98	250.72	6.30	237.83	627.13	2.0
1996	4.57	139.42	217.10	7.21	256.30	624.63	-0.4
1997	5.74	160.98	245.25	6.97	274.58	693.52	11.0
1998	4.87	188.42	244.97	7.34	301.52	747.13	7.7
1999	5.26	297.29	234.79	7.17	317.47	861.97	15.4
2000	6.92	264.49	321.49	6.47	340.08	939.45	9.0
2001	6.06	361.83	367.08	8.02	378.29	1,118.28	19.0
2002	6.43	424.62	373.44	7.69	402.06	1,214.24	8.6
2003	5.07	424.64	362.09	8.88	414.92	1,215.61	0.1
2004	2.62	470.07	315.20	8.73	437.34	1,233.96	1.5
2005	4.04	533.09	437.24	9.32	513.76	1,497.46	21.4

Source: F. B Dayo et al. 2004 and 2007

2.2.1 *Residential Energy Demand Profile*

During the period 1990-2005, residential energy demand maintained a major share of total energy demand when fuelwood and other biomass fuels are included in the energy consumption statistics. The sector accounted for more than half of the total final energy consumed in the country during the period 1990-2005. Typical residential sector energy consumption during the period under consideration included: a very small quantity of natural gas supplied to residential estates near natural gas pipelines; small quantity of coal, especially in households close to the few coal mines in the country; LPG; kerosene; electricity, especially to residential dwellings connected to the grid, or to local isolated grids or onsite power supplied by small to medium sized onsite generators; fuelwood; and charcoal. In-terms of end-use types, throughout the historical period under review, fuel use in cooking constituted the lion share of energy demand of the residential sector. For example, in 1990, cooking energy needs (on a final energy basis) was slightly over 93% of total energy demand in the residential sector when biomass is included in the statistics. Lighting requirements in the same year constituted slightly above 6%, while the balance was for energy requirements of household electrical appliances and other minor energy uses. Without biomass, this percentage becomes: about 47% for residential cooking; about 50% for lighting; and the rest for others. The statistics for 2005 was not markedly different. With biomass the following level of final end-use energy demand was recorded in that year: cooking (~ 96.4%); Lighting (3.3%); and others (0.3%). Without biomass: (cooking (~50%); Lighting (~47%); and others (~3.3%) (Data Source: Nigerian Energy Balances 1990-2005 F.B. Dayo et al. 2007).

Even then, because database on fuelwood and other biomass energy consumption in Nigeria like in many developing countries are usually not reliable and in many years not readily available, it is more likely that consumption of these fuels are underestimated. It is a known fact that dung, forest wastes and many other biomass residues that are not included in the database utilized in this study are also consumed in many rural locations in Nigeria. The view that biomass and other renewable energy are usually underestimated in country energy database is buttressed by the fact that majority of the estimated 70% of Nigerians who live in the rural areas depends almost entirely on fuelwood and other biomass energy forms to meet their residential energy demand and many of these consumption figures hardly enter into national statistics. A very important observation is that these biomass fuels are usually consumed in end-use devises with very low thermal efficiencies. End use energy efficiency of traditional cooking stoves in Nigeria has been reported to range between 5-25% (Anozie A.N. et al. 2006; Manibog F.R. 1984) depending on the service rendered (e.g., boiling water, food preparation) and the technology (three stone pods or slightly improved traditional cooking stoves) . As a result, in spite of the very large historical final energy demand of the residential sector, on a useful energy basis, energy use in the sector comes very close in many of the years and even in some years second to transport sector useful energy demand. An equally important observation is the unsustainable use of biomass as fuelwood or as feedstock for the production of charcoal in Nigeria. In most parts of the country household fuelwood consumption are usually sourced from non-sustainable biomass resources, while charcoal is commonly produced in old and very inefficient charcoal making technologies, further exacerbating the depleting forest resources in many parts of the country (Nash R. et al., 2006).

2.2.1.1 Clean Energy Investment Potentials in the Residential Sector

Available energy data during the period 1990-2005 indicate a substantial use of biomass in the energy profile of the Nigerian economy in an unsustainable manner. Fuelwood are sourced in a non-renewable manner and utilized in end-use equipment with very low energy efficiencies. Charcoal, another biomass energy resource, takes its feedstock fuelwood from unsustainably managed forests to produce charcoal from old and inefficient charcoal making technologies. In many countries, it has been established that many of the old and inefficient charcoal technologies have efficiency as low as 10% while the modern technologies such as the PNI Green Charcoal technology is known to have improved carbonization yield with up to 33% efficiency. It is generally known that efficiencies of charcoal making technologies varies not only from technology to technology (i.e. the type of kiln used), but also on the type of wood, its moisture content, density and diameter as well as the experience of the operator and even climatic conditions.

Although renewable energy like solar are passively utilized for drying using inefficient facilities, formal database on the extent of passive solar utilization is not available. The fact that technologies to utilize biomass and other renewable energy sources more efficiently are now available in the global market is an indication that the historical energy supply and consumption patterns in Nigeria can be shifted towards a cleaner path. The analyses carried out as part of this study showed that the potential for clean energy utilization in Nigeria in the immediate to the near future is very robust. As an example, a clean energy source such as solar, which has not been actively utilized in the historical past and for which we only identified marginal research activities during the period, can actually be effectively deployed in the country. The evidence of the marginal research activities and planning for the deployment of solar technology in Nigeria was found in the very weak funding of solar research in 2 Nigerian Universities, who were mandated in the eighties by the Nigerian Government to carry out solar energy research and development activities without what can be considered as adequate funding. In spite of this historically weak base for clean energy investment, our evaluation showed that the potential for the deployment of clean energy technologies in the residential sector of the Nigerian economy is very robust. Some of the opportunities for clean energy utilization in the residential sector which should attract more public and private investment from local and foreign sources will include:

- **More efficient passive and full utilization of solar technologies:** The abundant solar energy resources in the country, for example, can be tapped and can find expanded use in various residential applications such as drying, hot water generation, and as a valuable source of electricity.
- **Production of biogas from waste:** Also, programs to generate biogas from different forms of wastes available in the country can be developed to form a valuable source of cooking fuels in rural and peri-urban households in Nigeria.
- **Renewable biomass utilization programs:** Such programs will be focused at changing the pattern of consumption of biomass in the sector from the current sourcing of the biomass from non-renewable lots and its utilization in low end-use energy efficiency traditional stoves, to sourcing of wood from dedicated and managed woodlots and its use in higher efficiency stoves. This is a very sustainable way to introduce clean energy utilization in the sector.
- **Efficient charcoal production and utilization:** In addition, programs that will encourage charcoal production in higher efficiency charcoal making technologies with the charcoal utilized in more efficient charcoal stoves is another potential way to achieve clean energy utilization in the sector.
- **Use of biofuels in efficient stoves and lamps:** Good potentials also exist in the introduction of pure plant oil (PPO) from Jatropha as a residential sector fuel in Nigeria. Recent interest in Jatropha as an energy crop in Africa is focused on the extraction of PPO from the plant and transesterification of the oil to produce bio-diesel for use in the transport sector. Part of the PPO can be utilized in special stove designs as cooking fuels in the residential sector. Jatropha which grows very well in Nigeria is not a food crop as neither its seeds nor its fruit is edible. The plant is commonly used as a fence around homesteads, gardens and fields because it is not browsed by animals. Jatropha can be grown in almost all locations in Nigeria, all year round in even arid soil; it will not take up valuable

Box 3: Stove fueled by "tuba-tuba" (Jatropha Oil) launched in Leyte

An environmental-friendly cooking stove that uses coconut oil and other plant oils like those from the "tuba-tuba" or Jatropha is now being sold in Leyte, Philippines. The stove called Protos, resembles a kerosene pressure stove and can also use kerosene. But its manufacturer, Bosch and Siemens Home Appliances Group (BSH), is pushing for the use of plant oils, which are cheap and environmentally friendly. "The plant stove is easy to operate and offers a very safe cooking environment because plant oil can neither burn nor explode," said Dr. Elmar Stumpf, BSH plant oil stove project manager. Sisinio Balaga, 56, a resident of Baybay town and a user of the plant oil stove for over a year now, said the new stove was not only user-friendly but efficient and affordable. The stove cooks food faster than traditional stoves. "It takes only about 20 minutes to cook rice with the oil plant stove, while with a kerosene stove this usually takes about 30 minutes," Balaga said.

Source: Page A1 of the April 21 2006 Issue of the Philippine Daily Inquirer croplands for it to be in abundant supplies. An example of a technique to introduce PPO from Jatropha as a fuel in a residential end-use energy application in Nigeria especially in rural and peri-urban households is described in Box 3.

- **Energy Efficient Lighting:** For consumers that have access to electricity, the commonly used light bulb for lighting is the incandescent lamps. Compact fluorescent lamps (CFLs) which are more efficient and affordable are now available to replace incandescent lamps. Many CFLs can fit in the existing incandescent light fixtures. Compared to incandescent lamps of the same luminous flux, CFLs use less energy and have a longer rated life. In the United States for example, it has been estimated that a CFL can save over US$30 in electricity costs over the lamp's lifetime compared to an incandescent lamp and save 2000 times their own weight in greenhouse gases. The purchase price of a CFL is higher than that of an incandescent lamp of the same luminous output, but this cost is recovered in energy savings and replacement costs over the bulb's lifetime. Programs that introduce CFLs into the residential lighting system are one of the very feasible paths to clean energy investment in Nigeria.

2.2.2 *Transport Sector Energy Demand Profile*

Even when biomass and other renewable energy forms for which data are available are included in the Nigerian national energy demand profile, the transport sector still accounted for about one third of the country's energy demand in almost all the years in focus. Petroleum products, petroleum motor spirit, diesel, fuel oil and dual purpose kerosene are the main fuels consumed in the sector. The sector is responsible for the highest portion of petroleum fuels consumed in the country in all the years of focus. It is also the sector responsible for the highest consumption of fossil fuel in the country in all the historical years. In 1990 for example, about 287.34 PJ of energy, all petroleum products was consumed in the transport sector. This was about 67% of all the fossil fuels consumed in the country (excluding those consumed for electricity generation) in that year. Corresponding figures for the sector during the years 2000 and 2005 on a final energy and fossil fuel basis are presented in Table 4.

Table 4: Final Energy and Fossil Fuel Consumption in the Transport Sector

Years	Final Energy in Transport Sector (PJ)	% of Total Final Energy	% of Fossil Fuel(1)	% that is Petroleum Products
1990	287.34	35.03	66.96	100
1995	278.76	20.45	75.63	100
2000	357.21	17.18	59.84	100
2005	486.34	15.55	48.18	100

1.: Excluding Fossil fuel consumed for power generation
Source: F.B. Dayo 2004, 2007

2.2.2.1 Clean Energy Investment Potentials in the Transport Sector

Petroleum products are consumed in the sector to provide the necessary energy for road, water, rail and air transportation in Nigeria. Our evaluation of energy utilization in the Nigerian transport sector showed that the potential for the deployment of clean energy technologies in the sector is also very robust. Some of the opportunities identified include:

- **Utilization of Compressed Natural Gas (CNG) as a transport fuel:** The appreciable endowment of natural gas and especially the fact that about 40% of associated natural gas produced in the country's oil and gas sector is still flared (NNPC 2005), should be a catalyst for the promotion of increased domestic use of natural gas. The introduction of CNG as a fuel in road and rail transportation should contribute to this goal and will lead to a shift to a lower carbon fuel mix in the sector with better carbon footprint in the sector. The Nigerian Gas Company built a CNG fuelling station in Warri and converted some of the cars in the company's fleet to CNG fuelled cars to demonstrate the feasibility of the venture. An aggressive "catch-on" to this energy path has not happened because of the very slow speed at which the natural gas infrastructure in the country has been so far extended. Although the effort of the NGC has not resulted in investment in the development of CNG infrastructure in the country, more recently, a private sector company have started to work on a plan to introduce CNG as transport fuel in the Lagos Metropolis (see Case Study 1);
- **Utilization of bio-fuels as transport fuel:** Ethanol produced from Cassava feedstock is likely to be blended with petroleum motor spirit and introduced into the transportation sector fuel market as E10 by early 2008 (NNPC, 2007). E10 fuel is produced by blending 10% by volume of ethanol with 90% of petroleum motor spirit. Because E10 is partially a biomass fuel, it has a lower carbon footprint compared to the alternative PMS that will be partly displaced. The correctness of the statement above will depend on the lifecycle analysis (LCA) of bio-fuels from cassava. Although we could not lay our hands on an LCA implemented for ethanol from cassava in

Box 4: Ekiti Plan Policy on Tree Planting

Ekiti State plans to evolve a policy to allow corporate bodies and individuals to plant teak, gmelina, cashew, oil palm and other economic trees along inter-township roads. Gov. Segun Oni gave the indication in Ado- Ekiti when he presented certificate of occupancy to Crownec Green Energy, a company wishing to establish ethanol refinery at Iyemero Ekiti in Ikole Local Government Area. Oni said the policy would ensure proper maintenance of the roads and bring about increase in revenue from forestry and tree crops. The governor said the administration intended to create a tree crop and forestry belt along all inter-township roads. "What my administration intends to achieve with this policy is to create a forestry and tree crop belt from Osan-Ekiti in the North West to Eporo in the South East," he said. "Owners of these mini plantations will maintain the road networks for government," he said. He described the presentation of the C of 0 as a major step toward the production of ethanol and bio-Diesel. He urged cassava farmers to increase their production to ensure the availability of raw materials for the company. Earlier, the Chairman of the company, Chief Samuel Awoniyi, said it would cultivate cassava and Jatropha on the 50,000 hectares acquired in Iyemero-Ekiti. Cassava is the main raw material for ethanol production while Jatropha (lapalapa) is used in the manufacture of bio-diesel. Awoniyi, who is also the chief executive officer Crownec, said the refinery would be located on a part of the land. He said that 1,500 tonnes of cassava was required by the ethanol refinery daily.

Source: The Nigerian Tide, Friday September 7, 2007

Nigeria, a recent study in China showed that on a LCA basis, while the cost of cassava based E85 fuelled FFV in Guangxi China is about 15% higher than a gasoline fuelled car, it has lower lifecycle emissions of CO2, and other common pollutants (Zhiyuan Hu et al. 2004). This is likely to be true in the Nigerian case. The Nigeria National Petroleum Corporation (NNPC) recently introduced a program to develop facilities for producing ethanol locally from cassava as part of a national investment in blended fuels. NNPC has announced that it will introduce E10 into the Nigerian fuel market by early 2008. The Renewable Energy Division (RED) of NNPC is collaborating with their Brazilian counterpart on bio-fuel projects in Nigeria. RED will import ethanol from Brazil, blend the ethanol with PMS to produce E10 fuels which will be sold to consumers at already selected petrol stations in key locations in the country. RED is in addition collaborating with some State Governments to catalyze the development of dedicated cassava plantation that will produce feedstock for some proposed ethanol plants in the country.

- **Utilization of bio-diesel as transport fuel:** Another clean energy fuel that RED is evaluating for introduction into the Nigerian transport fuel market is bio-diesel. The plan is to produce bio-diesel from the transesterification of pure plant oil that will be extracted from Jatropha, which is subsequently blended with petro-diesel in a 10:90 volume ratio to produce transportation fuel B10. As mentioned in an earlier section of this report international attention is currently being focused on Jatropha as a source of bio-fuel. Although Jatropha is not a food crop and has not been historically planted as a farm plant, it is known to grow very well in various soil conditions and vegetation areas of Nigeria.
- **Introduction of Bus Rapid Transit (BRT) Systems:** Introduction of BRT systems in big cities in Nigeria is a potential transport sector energy efficiency program

Box 5: "BRT Bogotá, Colombia: TransMilenio Phase II to IV" in Chile

Bus Rapid Transit (BRT) is a bus-based mass transit system that delivers fast, comfortable, and cost-effective urban mobility. A BRT system can reduce greenhouse gas emissions via:

- Improved fuel-use efficiency through new and larger buses.
- Mode switching due to the availability of a more efficient and attractive public transport system.
- Load increase by having a centrally managed organization dispatching vehicles.
- Potentially a fuel switch to low carbon fuels e.g., diesel to compressed natural gas.

BRT systems replace conventional public transport systems. The new bus system transports passengers who, in absence of the project, would have used the conventional public transport system or other modes of transport such as passenger cars. A reduction or retirement of some of the conventional buses through scrapping, reduction of permits or market-based instruments is thus an integral part of this methodology.

Source: UNFCCC-AM0031/Version 1:Sectoral Scope 7 <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

that can be introduced with significant reduction in energy consumption and hence reduced greenhouse gas emissions in the transport sector. That this type of system can be developed as a clean energy investment is evident from the fact that a registered methodology (AM0031) exist within the UNFCCC pipeline for this kind of projects. Even more, a real life project "BRT Bogotá, Colombia: TransMilenio Phase II to IV" in Chile has been registered as a CDM project with the UNFCCC. It has been estimated that this project will result in annual GHG emission reduction amounting to about 246,563 tCO2e. A description of the BRT extracted from AM0031 is presented in Box 5.

2.2.3 Industrial Sector Energy Demand Profile

Demand for final energy consumption in the industrial sector maintained a level close to that of the transport sector during the period 1990-2005. Final energy consumption in the industrial sector of the Nigerian economy during the year 1990 amounted to about 240.48 PJ. This figure of sector energy consumption included fuelwood utilization in cottage industries e.g.,, bakeries, block making etc. Final energy demand in the sector grew at an average annual rate of about 1.7% during the period 1990-1995. The annual growth rate of energy demand in the sector during the period 2000-2005 averaged over 13%. A plausible explanation for the difference in energy consumption growth in the sector during these two period is that the stagnation of industrial production in Nigeria that started in the late eighties was further worsened by the political instability that was witnessed in the country in 1993, which nearly collapsed industrial capacity in the country for almost two years and only stabilized around the middle of the decade of the nineties. The stabilization coupled with the successful democratic transition of 1999 facilitated the growth in industrial production and hence the growth in industrial final energy consumption. The trend in useful energy demand during the period 1990-2005 (see Table 3) also followed a trend that is consistent with the plausible explanation provided for the variation in the time series data of final energy utilization in the sector. For example, useful energy demand of the Nigerian industrial sector declined at an annual growth rate of about 5.7% during the period 1990-1998 compared to an annual growth rate of about 18% during the period 1998-2005. A recent study of energy use in the Nigerian industrial sector during the same period concluded that the marginal performance of the industrial sector of the Nigerian economy as evidenced in the marginal growth in industrial energy use during the period between 1990 and 2002 resulted from bad fiscal policies, which stimulated imports of goods at the expense of local production. The study also concluded that the political instability of the early to mid 1990s also compounded the problem of collapsed productivity of the industrial sector thereafter. In response to these observations, government introduced various fiscal measures between 1999 and the early 2001, aimed at addressing the declining productivity of the industrial sector.

Typical industrial sector final energy supplies during the period included: natural gas which is utilized to generate thermal energy e.g., steam; coal mostly used as boiler fuels and in cement kiln in industries close to coal mines; fuel oil used to supply thermal energy especially in industrial facilities without access to natural gas pipelines; electricity, which is supplied in most cases from the grid, supplemented with onsite power generation, using natural gas and diesel as fuels; and fuelwood used as thermal fuel in mostly cottage industries. Some few Nigerian industries are not connected to the national grid and maintain facilities onsite for energy generation (power and heat generation) using fuels such as natural gas or diesel. In almost all manufacturing industrial enterprises in Nigeria where power and thermal energy (steam) is required, the common supply mode usually involve standalone onsite thermal and power generating facilities and connection to the grid for power supplies whenever the grid is up and running.

2.2.3.1 Clean Energy Investment Potentials in the Industrial Sector

Many opportunities for cleaner energy systems exist in the Nigerian industrial sector. As elucidated in the previous section, power and heat are the two most important energy forms that are used in Nigerian industries. The low efficiency, stand-alone option for supplying onsite heat and power is common in Nigerian industries. Our evaluation of the existing energy supply options in Nigerian industries indicated that the following clean energy options can be adopted in the sector:

- **Shift from high carbon intensive fuels to natural gas for energy generation:** Many industrial facilities in the country still fire fuel oil and some little amount of coal to generate power and steam. In a country where significant amount of associated natural gas is still been flared, shift from these fuels to natural gas will provide good opportunities for clean energy investments. For example, in 2005, about 23,000 million m3 (~88.1x104 PJ) of natural gas was flared in Nigeria (NNPC 2005). In the same year, about 87.66 PJ of fuel oil was consumed for energy in Nigerian industries (F.B. Dayo 2007). The flared gas is therefore more than adequate to supply the Nigerian industrial sector thermal fuel needs. As a matter of fact harnessing the flared gas as an industrial fuel alone will not turn off the flares. More aggressive use of the natural gas in other ends will be needed to completely achieve flare-out. To promote the use of even this small portion of flared gas as a fuel for the thermal needs of the industrial sector will require massive development of gas transportation infrastructure to many locations in the country where these industries exist (or will exist), many of which are far from existing gas pipelines.
- **Development of CNG Infrastructure to distribute natural gas to industries located at sites remote from existing pipelines:** An impediment to the shift from fuel oil to natural gas in many industries in Nigeria is the lack of gas infrastructure near industrial parks. Even in the Lagos Metropolis where the Escravos-Lagos Pipeline System was built to supply natural gas, principally to the Egbin Power Plant, which subsequently promoted the development of a Lagos natural gas City Gate, there still exist industries within a 100 to 200 Km radius without access to the relatively cleaner fuel. A proposal currently being considered for implementation by a private sector group in several parts of Nigeria (GDSL, 2006) will involve: a Mother Station, built close to an existing natural gas pipeline where natural gas sourced from the pipeline is converted to a Compressed Natural Gas (CNG) and filled into CNG cylinders which are then transported by trucks to the industrial site where they will be used as fuel; the CNG in the cylinders are then decanted into the consumer's storage facility after being converted back to normal pressure gas at a Daughter station, built close to the consuming plant; retrofit of the end use equipment to burn natural gas, instead of the status quo fuel (i.e., fuel oil, diesel etc). This plan is reasonable as it will compliment government's plan to proliferate natural gas to all nooks and corners of the country in the medium to longer term (UNDP/World Bank ESMAP, 2004, FGN, 2007).
- **Combined Heat and Power (CHP) systems in industries:** The stand-alone power and steam systems commonly utilized in many industries in Nigeria for power and steam generation

usually achieve whole system (heat and power) efficiency of not more than 55%. A more energy efficient system that can be deployed in these industries is the CHP system which can achieve system energy efficiency of about 85%. In any industrial manufacturing entity with appreciable steam and even a modest power demand, a CHP system with enough steam generation to satisfy own steam consumption and perhaps excess power production can be implemented, if adequate framework to evacuate the excess power is put in place. The higher efficiency will result in savings in fuel consumption as well as lower emissions of the usual obnoxious gases and particulates. CHPs also have a better carbon footprint compared to other comparable technologies used in industries to deliver the same service of heat and power. Adding chilling requirements to the CHP using vapour absorption systems utilizing heat from the CHP instead of using vapour compression systems to produce chilling in what is usually referred to as "trigeneration" will also provide a better carbon footprint.

- **Implementation of energy efficiency improvements in manufacturing industries:** This presents win-win opportunities for efficient utilization of fuels in industries. As in many developing countries, many Nigerian industries consume energy inefficiently. It is common to see live steam being vented in operating industries in Nigeria, usually arising from malfunctioning or non-operating steam traps. Energy audit studies of manufacturing industries in Nigeria have concluded that abundant opportunities exist for demand-side energy efficiency improvement in many Nigerian industries (F.B. Dayo et al., 1989, 1990, 2003). Such opportunities will include: use of efficient motors; implementation of functional steam traps and better condensate recovery systems; better insulation of steam lines; recovery of energy from waste heat and waste gas lines; etc. These kinds of investment will not only yield fuel savings that are important for the bottom line of the industries, but also, many of such projects can also earn carbon credits as they will result in significant carbon emission reductions when compared to the baseline. The results of a recent study that analysed such opportunities in Nigeria when implemented as CDM projects, positively identified the existence of such project (F.B. Dayo, 2007B).

2.2.4 *Energy Demand Profiles of Agriculture and Commercial Sectors of the Nigerian Economy*

2.2.4.1 Agriculture Sector's Energy Demand Profile

Energy use in agricultural production in Nigeria as shown in Table 2 is relatively low in spite of the fact that about 70% of the Nigerian workforce is employed in this sector. In 2002, the agricultural sector contributed about 17.3% to the country's GDP compared to 53% by industry and 29.5% by the service sector. Energy use in the agricultural sector is historically low because the production system in the sector is based on subsistence agriculture characterized by high labor intensity, little or no irrigation (rain fed agriculture) and near zero mechanization. The little energy reported as consumed in agricultural production during these historical years were mainly diesel fuel consumed in some few existing irrigation pumps and farm tractors. Most tillage in many of these subsistence farms are powered by human using low technology farm implements. Animal power is used in few land cultivation in some areas of the country, especially in the northern part of Nigeria. These and other rural alternative sources of farm energy are not included in the statistics presented in Table 2. The trend of useful energy consumption in the Agricultural sector as estimated in a recent study has been presented in Table 3. Potential opportunities for clean energy investment targeted at the agricultural sector will include: use of solar energy for irrigation water pumping; utilization of agricultural residues for electricity generation; and generation of biogas from wastes generated from livestock and animal husbandry sub-sector. These potentials will depend very much on fiscal efforts by the Nigerian government to catalyze activities in this sector. Given the fact that increased mechanization of agriculture is seen as the best way to improve the productivity of the sector, it is likely that increased demand for energy will play an important role in the future development of the sector. The potential opportunities listed above will therefore need to be earnestly pursued as the sector's contribution to clean energy utilization in the country.

2.2.4.2 Commercial Sector's Energy Demand Profile

Energy consumption in this sector is low when compared to sectors like residential, industrial and transportation. The commercial sector of the Nigerian economy however had very comparable energy consumption to the agricultural sector in terms of quantity of final energy consumed during the period 1990-2005. Final energy consumption in the sector which is mainly LPG and electricity amounted to about 8.99 PJ in 1990, rising to a consumption level of 10.35 PJ in 2005. On a useful energy basis, the sector's energy consumption trend showed a period of sharp increases and drops during the period 1990-1995 and stabilization and flattening out during the period 1996-2005. Since power is utilized in the commercial sector for lighting and other non-substitutable electrical energy end-use applications, CHP utilizing the abundant natural gas resources in the country to produce power while the steam or hot water produced is used in vapor absorption cycles to produce refrigeration and air-conditioning requirements of the sector. This is a clean energy investment with good potentials in this sector. Various solar energy applications will also be useful clean energy alternative, especially in partial applications for the supply of hot water for various end uses in the sector.

2.3 Trends in Historical Energy Supplies in Nigeria

The Nigerian energy supply system will be considered here from the primary and final energy points of view. From the primary energy point of view, we shall provide information on the production of the following resources: crude oil; coal; and natural gas. From of the point of view of final energy, we shall discuss the supplies of: petroleum products; processed natural gas; electricity, charcoal and other renewable energy final forms. In discussing these final energy forms, information on relevant energy infrastructure will be presented.

2.3.1 Crude Oil Reserves, Production and Export Trends

(a) Crude Oil Reserves Trend

As stated in Table 1, estimates of crude oil reserves in Nigeria in 2006 were put at about 36 billion barrels of oil. The trend in crude oil reserve estimates in the historical period is presented in Table 5.

Table 5: Proven Crude Oil Reserve Estimates in Nigeria

Years	Crude Oil Reserves (Billions of barrels)	Years	Crude Oil Reserves (Billions of barrels)
1988	16.0	1997	25.0
1989	16.0	1998	27.0
1990	17.5	1999	28.0
1991	18.5	2000	30.0
1992	19.0	2001	30.5
1993	20.5	2002	32.0
1994	21.0	2003	33.0
1995	23.0	2004	33.5
1996	23.5	2005	35.0

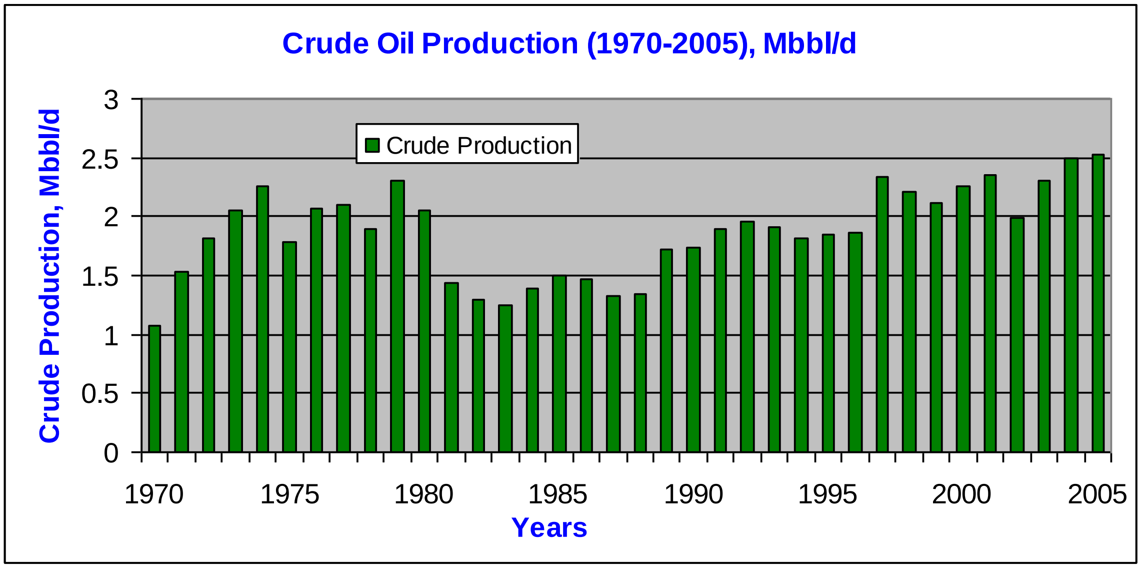
Sources: Nigerian Oil Industry Handbook & Directory (2004), NAPIMS (2006)

Majority of Nigeria's crude oil reserves are found in relatively simple geological structures along the country's coastal Niger River Delta. Newer reserves are however been discovered in deeper waters offshore Nigeria. Majority of the oil lies in about 250 small (i.e., less than 50 million barrels each) fields. At least 200 other fields are known to exist and contain undisclosed reserves. Nigeria's Crude Oil reserves have specific gravities ranging between 21° API and 45° API. The national target is to increase Crude Oil reserves to about 40 billion barrels by the year 2010.

(b) Crude Oil Production Trend

Nigeria produced about 2.2 million barrels per day of crude oil in 2003. The country is a member of the Organization of Petroleum Exporting Countries (OPEC). Production of crude oil in Nigeria is mostly by Joint Venture (JV) companies, which accounts for nearly all (about 95%) of the country's production in the past decades. The Federal Government of Nigeria currently participates in oil production through holding 60% in the operations of companies like Shell, Chevron, ExxonMobil, AGIP, Elf, Texaco and Pan Ocean. The largest JV, operated by Shell, produces nearly 50% of Nigeria's Crude Oil. Figure 1 below provides information on Nigerian crude oil production for the period 1970 and 2005.

Figure 1: Crude Oil Production in Nigeria (1970-2005)

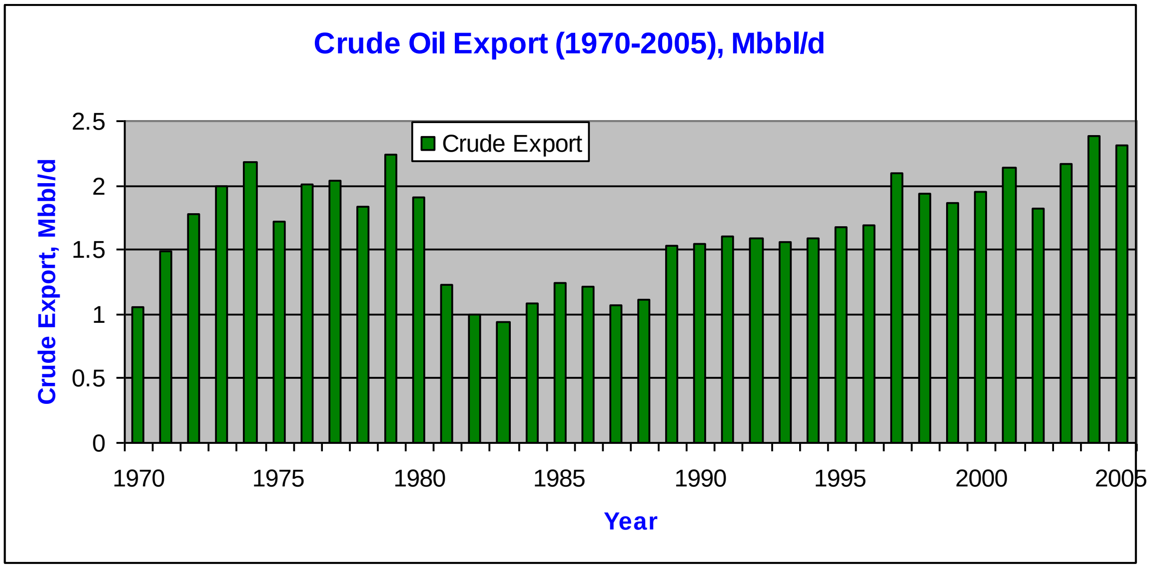


Note: Production includes condensates
Source: COMD, NNPC 2006 Annual Statistical Bulletin

(c) Crude Oil Export Trend

Crude oil production and especially export is the mainstay of the Nigerian economy providing almost 90 % of the country's export earnings. The share of Crude oil in total export value rose from less than 1% in 1958 to a peak of about 97% in 1984 and has not maintained a percentage less than 90% since then. Nigeria's main export crude blends are Bonny Light (37°API) and Forcados (31°API). Majority of Nigeria's crude oil exports are destined for markets in the United States and Western Europe, with Asia becoming an increasingly important market as well. In 2002, Nigeria's crude oil exports to the United States averaged 567,000 bbl/day (6.27% of U.S. imported crude oil) a decline from the 842,000 bbl/day in 2001 (9.03% of U.S. imported Crude). Nigeria was the 5th largest crude oil exporter to the United States in 2002, behind Saudi Arabia, Mexico, Canada, and Venezuela. Shell's 40-year-old Bonny Island oil export terminal was recently upgraded and expanded and currently has an export capacity of about 1.5 million bbl/day. The $600 million project was completed in 2006. Other major exporting terminals are the Forcados and the Escravos terminals. Figure 2 provides pertinent data on Nigeria's crude oil exports during the period 1970 and 2005.

Figure 2: Nigerian Crude Oil Export (1970-2005)



Source: COMD, NNPC 2006 Annual Statistical Bulletin

2.3.2 *Coal Supply Trend*

(a) Nigeria's Coal Endowment and Development History

In a recent memorandum (BPE, 2006) as part of its effort to seek private sector (local and foreign) investment in the development of the country's coal resources, Nigeria's Bureau of Public Enterprises said that: "Nigeria has extensive coal resources, but they have not been fully explored or even marginally developed". The best estimate available to us for now is the endowment of about 2.7 billion tonnes quoted in Table 1. Even then, it must be stressed that not much focused search for coal has been undertaken for many decades. In spite of this, coal has a long history as an energy resource in Nigeria. It was first discovered in central eastern Nigeria in 1909. Mining began in 1916, and in 1950, the Federal Government of Nigeria (FGN) formed the National Coal Corporation (NCC) with the responsibility of the exploration, development and mining of the coal resources which ownership was vested in the government. Since then, coal production has been sporadic with a peak in the 1950s at about 900,000 tonnes and declined significantly thereafter. In 1980, coal production in Nigeria had declined to about 100,000 tonnes. Production decline continued significantly in the 1990s and due to several problems in the last decades, the NCC has not produced any coal for so many years. Over the last four and a half decade, NCC had the monopoly on coal mining activities in Nigeria until 1999 when the FGN decided that it is in the best interest of the nation to revitalize the coal industry through privatization. The FGN then offered coal concessions to companies with expertise in developing and operating coal mines and marketing coal and/or developing and operating coal fired power plants, to explore and develop the country's coal resources. This has opened up the coal sector in Nigeria to private sector participation and the NCC over the recent years has been entering into joint ventures on an equity participation basis, while gradually divesting from all its operating interests in the sector. Although the goal of the FGN was to have all agreements with qualified parties reached by 2006/2007 and the parties commencing the exploration and development of the coal mines shortly thereafter, as of the end of 2007, such agreements were yet to be finalized.

(b) Coal Production Trend

As stated in the last section, coal production in Nigeria reached a peak in the 1950s, and significantly declined thereafter. Coal production in Nigeria during the period 1980-2003 is presented in Table 6:

Table 6: Coal Production in Nigeria

YEAR	PRODUCTION (Million Tonnes)
1980	0.19
1981	0.13
1982	0.06
1983	0.06
1984	0.09
1985	0.15
1986	0.16
1987	0.16
1988	0.09
1989	0.09
1990	0.10
1991	0.11
1992	0.10
1993	0.03
1994	0.03
1995	0.02
1996	0.01
1997	0.01
1998	0.01
1999	0.02
2000	0.003
2001	0.003
2002	0.05
2003	0.03
2004	0.02

Source: NMC Statistics 2005

(c) Historical Coal Production Infrastructure and Utilization Pattern

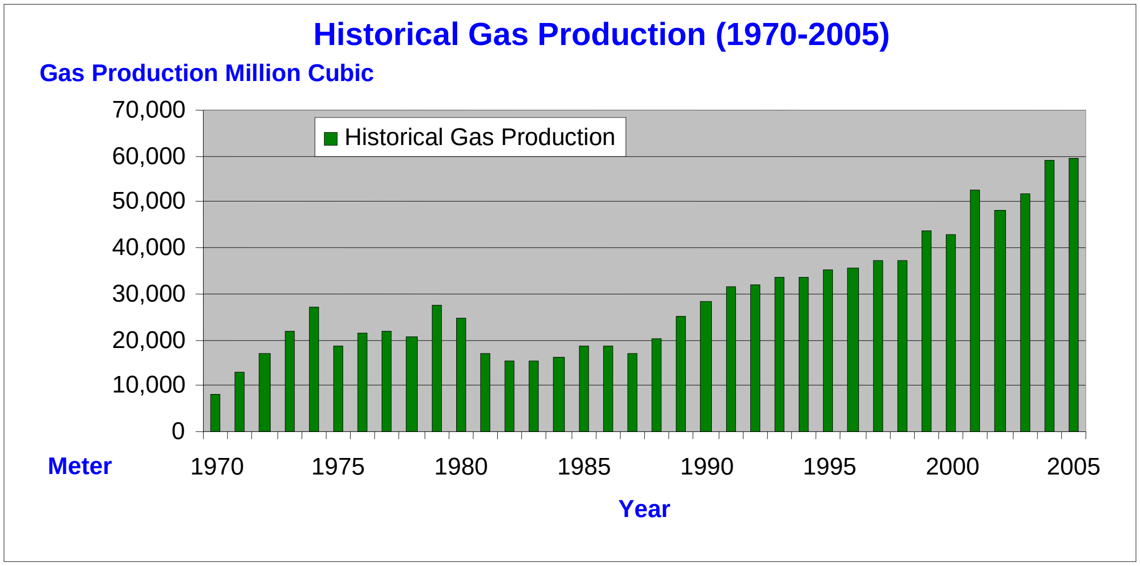
The NCC operated two underground coal mines: the Okpara mine located in Enugu State which at the time of its shutdown in the 1990s had 230 operations and 8 clerical employees, and the Onyeama mine also in Enugu State which has not operated since 1990. The NCC also operated two surface mines: the Okaba mine in Kogi State which by its shut down in the early 1990s had about 77 employees; and Orukpa in Benue State which has been shut down for several decades.

Nigerian coal is of very high quality both in terms of calorific value and its low sulphur content, yet it did not capture any significant fraction of the industrial fuel market or export. Historical production in the initial period of the industry was driven almost entirely by railroad fuel needs, but with the dieselization of the rail sector which started even before the 1966 civil war, coal consumption decreased significantly. The decline continued during the civil war period of 1966-1967 as a significant quantity of coal production was from areas affected by the war. After the civil war, coal mining commenced with the production of about 24,000 tonnes in 1970 and 1971 and peaked at 323,000 tonnes in 1972/73. In the 1970s, the Polish Overseas Mining Company, KOPEX, was commissioned by the FGN to upgrade the NCC mining technology by installing a long-wall system that was expected to increases capacity from 624,000 tonnes to 1 million tonnes, annually. Expectations were not met and production and productivity declined.

2.3.3 *Natural Gas Supply Trend*

Production of natural gas in Nigeria in recent years averaged about 4.6 billion cubic feet per day (Bcfd). This production figure is a summation of production mostly from the seven joint venture companies (Upstream Operators) - Shell, Mobil, Chevron, Elf, NAOC, Texaco, Pan Ocean, and NPDC operating in the country. The trend of natural gas production in Nigeria during the period 1970 – 2005 is shown below in Figure 3.

Figure 3: Historical Production of Natural Gas in Nigeria



Note: This includes data from PSC, Sole Risk and Independent Companies.
Source: NNPC 2006 Annual Statistical Bulletin

In 2002, about 51.5% of natural gas production or about 24.8 billion cubic meters was flared. By 2005, flared natural gas as a % of natural gas produced in Nigeria had declined to about 39%, representing the flaring of about 23.0 billion cubic meters. A report by the World Bank estimated that the monetary value of flared gas in Nigeria can be as high as about US$2.5 billion per year to the economy (World Bank, 2003).

(a) Gas Gathering Infrastructure

Most of the oil producing facilities in the country have extensive gas gathering facilities to handle natural gas produced in association with crude oil. In many cases, as a result of the non-existence of markets, such lines are geared towards gathering gas for field injection purposes and/or to be sent to the flare stack. In this section of this report, our focus here is to describe some of the gas gathering lines that have been put in place for the purpose of harnessing the natural gas for end-use, other than flaring. Key components of these facilities that constitute the national natural gas supply system include:

ChevronTexaco Facilities

A major component of ChevronTexaco's gas utilization infrastructure is what is referred to as the Escravos Gas Pipeline (EGP). The EGP project is a JV between NNPC (60%) and Chevron (40%). The first phase of the EGP (known as EGP-1) was completed in 1997 is a project that can be said to have had significant role in expanding the utilization of natural gas within the Nigerian economy. EGP-1 processes 165 MMcf/d (million cubic feet per day) of associated natural gas, which is supplied to the domestic market by Pipeline. Phase-II of the EGP (EGP-2), which processes an additional 135Mmcf/d of natural gas, began operation in late 2000. The gas is currently used within the domestic economy, but will also make gas available for exported to Benin, Togo and Ghana through the West African Gas Pipeline (WAGP) when completed. The third phase of the EGP (EGP-3) will increase gas processing to 400 MMcf/d of natural gas from Chevron's fields.

ExxonMobil Facilities

ExxonMobil in JV with the NNPC operates some gas utilization infrastructure in Nigeria. There is the gas re-injection facility, which was completed in 1978. The facility assisted the NNPC/ExxonMobil JV to reduce flaring of associated gas on its oilfields by about 1.2 Bcf from 49.9 Bcf in 1977 to 48.7 Bcf in 1978. There is also the NNPC / Mobil's OSO Gas Compression Platform which commenced operations in 1997. The OSO Gas Compression Platform was conceptualized to re-inject about 600 MMcf/d of associated gas to aid the recovery of about 100,000 bbl/d condensate deposits. The facility covers: 15 wells; 6 gas re-injectors; and a 61 KM Pipeline. The combined gas streams from the wells are compressed to 5500 Psia. The project is located at Bonny Island, Rivers State.

Shell Facilities

Shell Petroleum Development Company (SPDC) is the biggest upstream Oil and Gas producing company in Nigeria accounting for a lion share of the crude oil production in Nigeria, which in 2004 accounted for about 42% of the total of about 2.44 million BOPD produced in Nigeria. Correspondingly, SPDC leads in the total amount of gas produced and the extent of gas gathering infrastructure in place. As early as the seventies the company had gas transportation infrastructure in place to serve specific industrial customers in Port Harcourt and Aba areas in the southeastern parts of Nigeria. Gas gathering lines in SPDC operations in this area served these facilities. Examples of more recent gas gathering facilities being implemented by SPDC at different advanced stage of completion include: Cawthone Channel Gas Injection/Associated Gas Gathering, which involve the gathering of about 176 MMcf/d of rich gas, extraction of the liquids and the supply of the lean gas to the domestic market; Forcados Yokri Integrated Project which involves the gathering Of about 108 MMcf/d of Associated Gas (AG) for gas lift and about 53 MMcf/d as fuel. The project will also supply about 55 MMcf/d to NLNG train 3 while some will also be used for gas lift.

Nigerian AGIP Oil Company (NAOC) Facilities

NAOC operates two gas re-injection plants. The first was established in 1985 at Obafu/Obrikom. The second was commissioned in 1987 at Kwale/Okpai. Both Plants were established to reduce gas flaring in Nigerian Oilfields. In 1994, NAOC commissioned another gas plant for the supply of natural gas liquids to the Eleme Petrochemical Plant. Another more recent gas gathering facility that is being implemented by NAOC is the NLNG Gas Supply Phase 3 which will supply additional gas of up to about 164 MMcf/d to meet the LNG requirements of trains 3 and increase total capacity to 650 MMcf/d. This project came on stream in 2005; and Idu Field Revamping and Gas Recovery, which will gather about 100 MMcf/d of AG in Idu and Samabiri fields for gas, supply to NLNG Trains 4 and 5.

(b) Natural Gas Transmission and Distribution Infrastructure

The Nigerian Gas Company (NGC) is a subsidiary company of NNPC saddled with the responsibility of implementing natural gas transmission and distribution infrastructure to bring the resources from the producing region to domestic markets far from the fields. NGC sources natural gas from the gathering facilities of upstream oil and gas producing firms, which is then processed into sales gas in its gas processing facilities located in Warri, Delta State, before sending the gas into its transmission facilities. Since the establishment of NGC, the company has implemented several gas supply systems with a combined throughput of nearly 2.5 Bcf/d, over 1800 KM of gas gathering and transmission lines with over 14 compressor stations. Table 7 provides information on major gas supply Pipelines in Nigeria.

Table 7: Major Gas Supply Infrastructure in Nigeria

Gas Pipelines Systems	Design Capacity (MMSCFD)	Line Diameter (INCHES)	Pipeline Length (Kilometers)
Aladja Gas Pipeline System	70	6,8,14 &16	130
Oben-Ajaokuta Gas Pipeline System	200	24	198
Sapele Gas Pipeline System	200	10 & 18	44
Obigbo North/Afam Pipeline System	90	14	19
Imo River Aba Gas Pipeline System	35	12	28
Alscon Gas Pipeline System	160	14, 16 & 24	117
Alakiri-Onne Gas Pipeline System	138	14	17
Escravos-Lagos Gas Pipeline (ELP) System	1100	30 & 36	514
Ibafo-Ikeja City Gate System	50	24	48.4

These systems transport gas from sources in the Western and Eastern Niger Delta to consumers in several parts of the Country. Other gas supply systems in the Country include:

- Shell's gas supplies systems to NEPA in Delta I, II, & III, Aba industries and the Rivers

State Utility Board (RSUB);

- Nigerian LNG gas transmission system;
- Nigerian AGIP Oil Company (NAOC) gas supply system to Eleme Petrochemicals.

(c) Nigerian Liquefied Natural Gas Facilities

The Nigerian Liquefied Natural Gas (NLNG) Company completed its trains 1 and 2 in September 1999, and is currently the largest gas utilization facility in Nigeria. The LNG project was meant to utilize Nigeria's abundant natural gas reserves. Trains 1 and 2 have a gas utilization of about 900 MMcf/d (25.5 MMcm/day). With the 3rd train, which came on stream in November 2002, the Plant now utilizes about 1.5 Bcf/d (42.5 MMcm/day) of natural gas bringing the Plant's processing capacity to 383 Bcf per year (10.8 Bcm/year). The plant's train 4 was commissioned in November 2005 while train 5 came on stream in February 2006. The combined capacity of trains 4 and 5 is about 363.5 Bcf per year (10.3 Bcm/year). In January 2006, NLNG sent its first shipment of LNG to the USA from its newly commissioned train 4. The five production trains at the NLNG production facilities are currently supplied by 2.8 Bcf of gas a day (79.2 MMcm/d) and produce about 18 million tonnes of LNG a year, plus 3.4 million tonnes of liquefied petroleum gas. A sixth train is approaching completion, while the final investment decision (FID) is expected on yet another production train, which would be the biggest in the world and which would boost total capacity to more than 30 million tonnes a year by 2011 (NLNG, 2007). It is important to state that NLNG receives its associated gas supply from Upstream Operators.

In addition to the NLNG facilities, other LNG projects at different stages of planning and implementation include:

- The OK LNG project was initially planned as two separate projects each by Chevron Nigeria in partnership with British Gas and Shell Gas and Power at Olokola in Western Nigeria and were later merged. The OK LNG project is a US$7 billion investment with an initial capacity of 11 million tonnes of LNG per year with a potential maximum capacity when all the trains are in place of about 33 million tonnes of LNG per year. Construction started on this facility in mid 2006 and it is expected that the facility will be commissioned sometime in 2009;
- The Brass River LNG Project: in December 2005, Conoco Phillips, Chevron Nigeria and AGIP signed a shareholders' agreement with NNPC for the establishment of this LNG project. The plan is to have two operational LNG trains by late 2009. Although the FID which was expected to be in place by September 2006 was delayed, a recent announcement by Royal Boskalis Westminster NV that it has been awarded a contract worth about $88.5 million to prepare the Brass LNG site for development, is an indication that the scheme is likely to proceed (Neil Ford, 2008).

(d) Utilization Trend of the Nigerian Natural Gas Resources

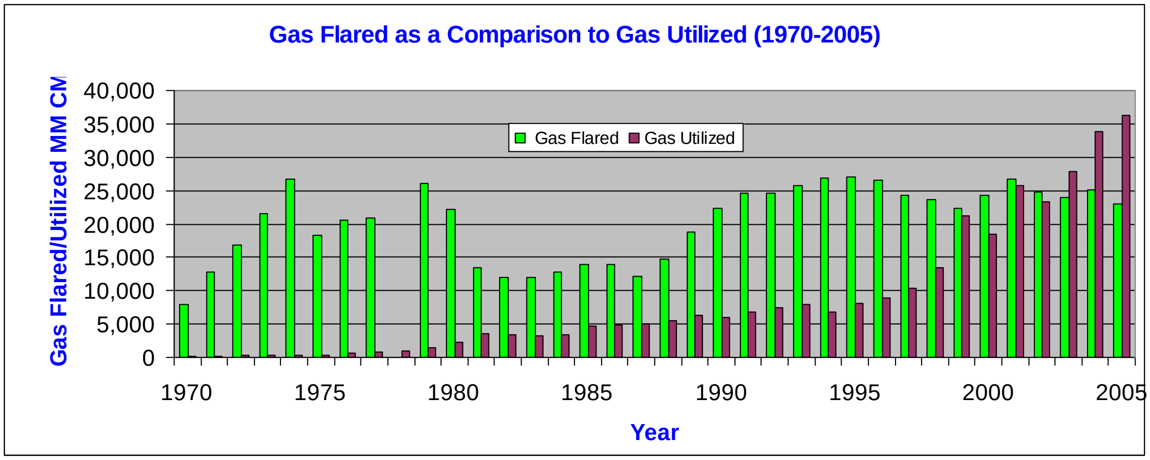
Over the years, there has been a growing utilization of natural gas in the country. For example, in 1970, about 8.1 Bcm of natural gas was produced in Nigeria. Of this quantity, about 0.1 Bcm (slightly less than 1.4%) was utilized for productive activities mostly for gas injection in oil fields for field pressurization and oil lifts, and some small amount for power generation, mostly in the oil fields. The balance of about 98.6% amounting to about 8.0 billion cubic meters was wastefully flared. In 2005, the picture was very different. In that year about 59.3 Bcm of natural gas was produced in Nigeria. Of this amount, about 36.3 Bcm representing about 61.2% of total production was utilized in the domestic economy as: input in the production of LNG; injected in oil fields; utilized as fuel in power generation even in power facilities outside the oil and gas fields; as fuel in industries while the balance was flared. The trend in the domestic utilization and export of natural gas produced in Nigeria is discussed below:

Domestic Utilization

The quantum jump in domestic utilization of this resources witnessed in recent years was propelled by its increased use to generate power, and more recently the penetration of natural gas as an industrial energy fuel. The later was catalyzed by the proliferation of the long distance gas pipeline infrastructure from Escravos in the Niger Delta to supply fuel to the Egbin thermal power generating plant located in Lagos. This gas transmission infrastructure is commonly referred to as the Escravos-Lagos Pipeline (ELP). The realization of the ELP opened up the possibility of gas utilization for manufacturing outfits along the pipeline route.

This catalyzed the shift from fuel oil to natural gas by Cement manufacturing plants such as Ewekoro and Sagamu Works in Ogun State. Some few years later, with the completion of the Ibafo-Ikeja City Gate transmission facilities by the Nigerian Gas Company and the City Gate-Ikeja Industrial Business District distribution facilities by Gaslink Nigeria Ltd., more industries in the Lagos area had access to natural gas and actually shifted from the use of fuel oil and diesel for thermal energy and onsite power generation respectively. Another recent development that has contributed to the reduction of gas flaring in Nigeria is the successful takeoff of the NLNG project in September 1999. By the end of 2007, five trains were on stream with a combined natural gas feedstock capacity of about 24.6 Bcm/year (about 67.8% of the national gas consumption in 2005). The other natural gas feedstock options that entered into the domestic consumption equation during the last decade were as feedstock for the production of fertilizers. However, due to the low capacity utilization of fertilizer facilities that came on stream in Nigeria, this consumption of natural gas has been relatively negligible. Relevant statistics on domestic consumption of and flaring of natural gas in Nigeria during the period 1970-2005 are presented in Figure. 4.

Figure 4: Natural Gas Flaring and Consumption in Nigeria



Export of Nigerian Natural Gas

Export of Nigerian natural gas commenced in October 1999 when a consignment of liquefied natural gas (LNG) was shipped out of the facilities of the Nigerian Liquefied Natural Gas Company (NLNG) in Bonny. NLNG base project (Trains 1 and 2) has a total contract quantity of 7.22 billion cubic meters per year (BCM). The entire production from this base facility is exported under a long term sales and purchase Agreement with the following international buyers:

- Enel of Italy — 3.50 BCM per annum
- Gas Natural/Enagas of Spain — 1.60 BCM per annum
- Botas of Turkey — 1.20 BCM per annum
- Gas De France — 0.50 BCM per annum
- Trangas of Portugal — 0.35 BCM per annum

As at February 2003, NLNG had loaded 318 LNG cargoes to its long-term customers since inception. Compared to the plan to load 103 LNG cargoes, 107 were actually loaded in 2002. Four out of the 107 cargoes were sold as spot cargoes. In 2007, 130 cargoes were loaded (NLNG, 2007B)

Train 3 also known as the Expansion Project, began operation during the fourth quarter of 2002. The design capacity of Train 3 guarantees the delivery of 3.7 Bcm/year. 21-year Sales and Purchase Agreements have been executed with the following for the entire volume capacity of Train 3 as follows:

- Gas Natural/Enagas — 2.7 Bcm per annum
- Transgas — 1.0 Bcm per annum

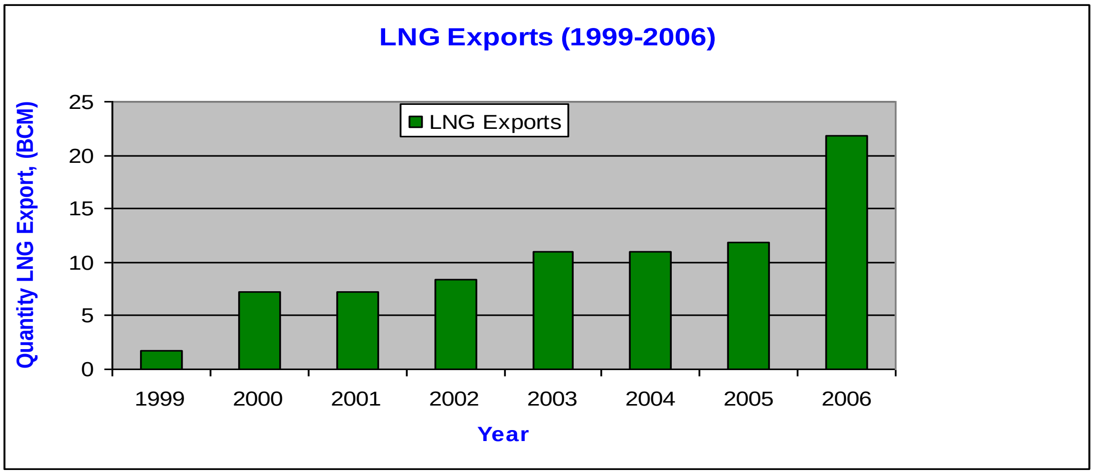
This makes Nigeria LNG Limited the largest supplier of LNG to Portugal. Estimates of natural gas export volumes from Nigeria during the period 1999-2006 are provided in Figure 5. The following assumptions were made in the estimation procedure:

- Only a quarter of the base project capacity was exported in 1999 as a result of the time the first cargo left Nigeria;
- A quarter of the capacity of the expansion project was added to export volume in 2002 and

by 2003, the total capacity was exported;

- Only one sixth of train 4 capacity was added to the 2004 capacity to obtain the export volume in 2005 because train 4 commenced cargo dispatch in November 2005;
- Export volume in 2006 consisted of: repeat of the full 2004 volume plus the entire capacity of train 4 plus eleven months of the annual capacity of train 5 which commenced exports in February 2006;
- The export volume in each year is made up of firm contracts plus spot cargoes.

Figure 5: Trend of Export of Nigerian Liquefied Natural Gas (LNG)



2.3.4 *Petroleum Products Supply Trend in Nigeria*

Petroleum products were supplied to the Nigerian market during the period 1990-2005 from two sources: domestic crude oil refineries; and imports. The split between the two modes was heavily dependent on the availability of the domestic crude oil refining facilities. In order to provide a basis for understanding the supply trends for petroleum products in Nigeria we have decided to discuss in the next subsection, the structure of consumption of the products in Nigeria during the historical years.

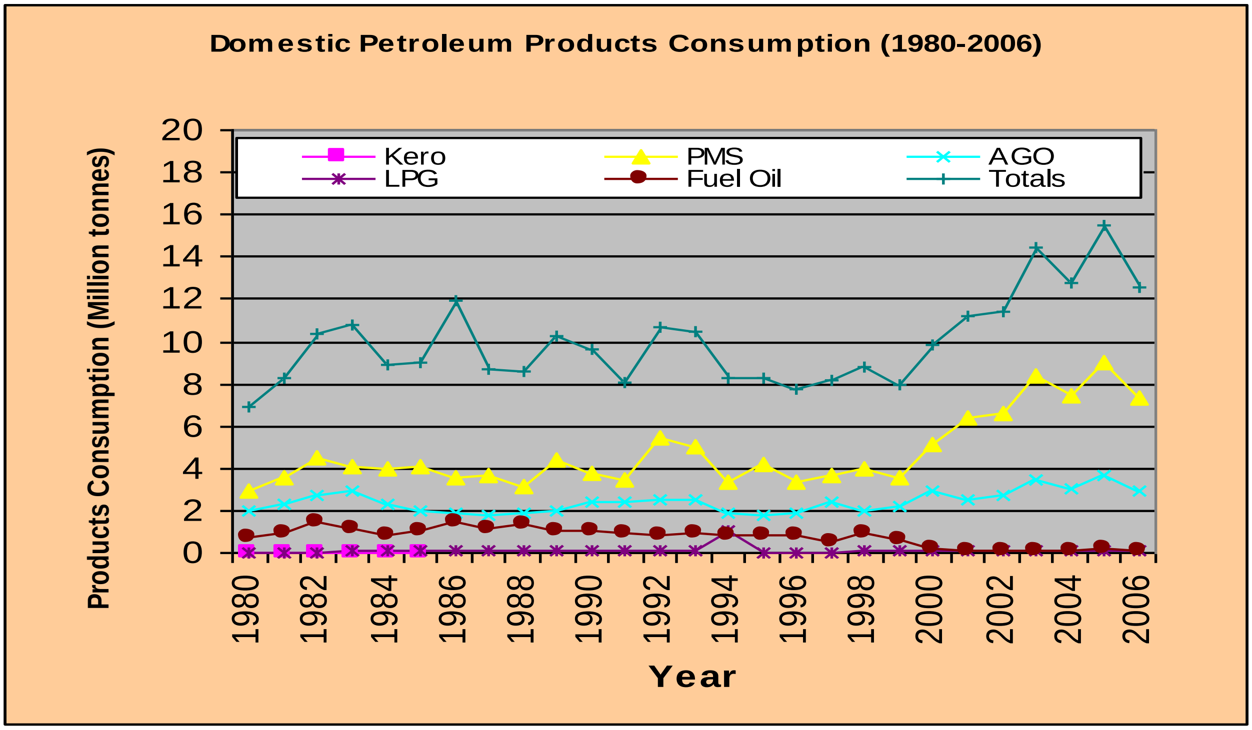
(a) Consumption Trend of Petroleum Products in Nigeria

Consumption of petroleum products grew at an average annual rate of about 18.63% during the period 1970-1979, by about 6.32% during the period 1980-1989. A decline in consumption averaging about 0.97% per annum was recorded during the period 1990-1999, a substantial period of which was characterized by political instability and unprogressive military rule. The period 2000-2002 was characterized by rebounded petroleum product consumption with an average growth rate of about 7.7% per annum. This later period was the beginning of the new democratic dispensation in the country. The average changes in petroleum product consumption mentioned above however shield the fluctuating demand sequence experienced during the periods.

The fluctuating series is a strong indication of an unstable market where there were appreciable levels of un-served demand, and where the supply sequence is also unstable. In terms of product utilization, gasoline which is a transportation sector fuel accounted for the biggest share of consumption, accounting for about 34% of total petroleum product consumption in 1970, 42% in 1980, 40% in 1990, 52% in the year 2000, rising to about 58% in 2002 and stabilized around this share of the market during the period 2003-2006. Diesel, another transportation fuel, which is also utilized in on-site power generation, follows with a share of about 26% in 1970, 29% in 1980, 25% in 1990, 29% in 2000 and 24% in 2002. The share of diesel stabilized around 24% during the period 2003-2006.

Kerosene, consumed mostly as a household fuel comes next in line with a share of about 20% in 1970, 17% in 1980, 24% in 1990, 18% in 2000 and about 17% in 2002. The share of kerosene stabilized around 17% throughout the period 2003-2006. While LPG had the lowest share of petroleum product consumption in all the periods (about 1%), it had the highest growth rate of about 10.4% per annum during the period 1970-2006 The other household fuel kerosene also grew at an average annual rate of about 4.1 % during the same period. The impressive growth rates of Kerosene and LPG during this period has been attributed to the effect of the higher urbanization rate (5 to 6 percent) compared to the average annual population growth rate (about 3 percent) in the country during the period. Fuel oil demand grew during the period 1980-1990 by a yearly average of about 6.6%. A slowdown in this growth started in the early 1980s resulting in an average annual decline of about 6.4% during the period 1990-2000. A slightly higher decline of about 7.2% per annum has been witnessed during the period 2001-2006. The decline in fuel oil utilization witnessed in the 90s and the first half of this decade has been attributed to the shift by NEPA to natural gas at Egbin Power station, and more recently by manufacturers in the Lagos industrial areas. Figure 6 provides information on the trend of historical petroleum product consumption in Nigeria during the period 1980-2006.

Figure 6: Petroleum Products Consumption Trend in Nigeria (Million Tonnes)



Sources: (a) FOS Statistical Bulletins (b) CBN Annual Report and Financial Statement (c) NNPC Statistical Bulletins (2003-2006) (d) Nigerian Energy Balance Tables [10]

(b) The Nigerian Crude Oil Refining Infrastructure

The Federal Government, through its company, the Nigerian National Petroleum Corporation (NNPC), owns the four existing crude oil refineries in Nigeria. The four Refineries include: - Warri Refinery and Petrochemical Company (WRPC); Old Port Harcourt Refinery; The New Port Harcourt Refinery and Petrochemical Company (PHRC); Kaduna Refinery and Petrochemical Company (KRPC), with a combined installed capacity of 445,000 bbl/day. Each of these Refineries is a subsidiary company under the management of the NNPC. Table 8 provides pertinent details on each of these refineries including: their nameplate capacities and year of commissioning.

Table 8: Crude Oil Refining Capacity in Nigeria

PLANT	DATE OF COMMISSION	INSTALLED CAPACITY, BBL / DAY
OLD P/HARCOURT	1965	60,000
NEW P/HARCOURT	1989	150,000
WARRI	1978	125,000
KADUNA	1980	110,000
TOTAL		445,000

(c) Historical Petroleum Product Supply Trend

As stated in an earlier section of this paper, petroleum product supply for the Nigerian market has been through the domestic crude refining capacities as well as from imports. The split between these two modes of supplies depended on the availability of refining capacities of the local crude oil refineries. The inability of the NNPC refineries to meet local demand for petroleum products especially the premium motor spirit, has translated to a heavy reliance of the Federal government of Nigeria on importation to meet local demands. Table 9 provides information on quantities of petroleum products supplied from these two sources during the period 1990-2005.

Table 9: Petroleum Product Supplies in Nigeria (Million Tonnes)

Years	Imported	Local Refineries	Total	% Imported
1980	2.46	4.45	6.91	35.6
1981	2.08	6.15	8.23	25.3
1982	2.05	8.29	10.34	19.8
1983	3.60	7.18	10.78	33.4
1984	2.68	6.20	8.88	30.2
1985	2.59	6.41	9.00	28.8
1986	2.89	9.07	11.96	24.2
1987	2.81	5.84	8.65	32.5
1988	1.59	7.01	8.60	18.5
1989	2.05	8.23	10.28	19.9
1990	0.93	8.67	9.60	9.7
1991	0.03	8.04	8.07	0.4
1992	2.15	8.56	10.71	20.1
1993	3.20	7.29	10.49	30.5
1994	2.79	5.44	8.23	33.9
1995	1.51	6.72	8.23	18.3
1996	2.36	5.44	7.80	30.3
1997	1.25	6.92	8.17	15.3
1998	3.69	5.09	8.78	42.0
1999	2.64	5.36	8.00	33.0
2000	7.26	2.59	9.85	73.7
2001	4.47	6.77	11.24	39.8
2002	4.54	6.86	11.40	39.8
2003	7.18	7.30	14.48	49.6
2004	6.50	6.31	12.81	50.7

Years	Imported	Local Refineries	Total	% Imported
2005	6.15	9.39	15.54	39.6
2006	6.49	6.08	12.57	51.6

Source: NNPC Annual Statistical Bulletin (2003-2006)

2.3.5 *Electrical Power Supply Trend*

(a) Existing Power Generation Infrastructure in Nigeria

Existing power generation facilities are located in close proximity to the energy resources, with the exception of one thermal power plant: the Egbin Power Plant. For this plant, a dedicated long distance natural gas transportation infrastructure was built to supply fuel to the plant located in the close vicinity of the prime power market of Lagos. The hydro stations at Kanji, Jebba and Shiroro, take advantage of the geo-topography of the river catchment basins in the north. The thermal stations at Sapele, Afam, and Ughelli (Delta) harness the rich oil and gas deposits of the Niger Delta in the south. Other smaller installations include the only coal-fired power station at Oji in Enugu state and isolated stations at Calabar, Kaduna, Markurdi, Mubi Maiduguri, Minna and Suleja. These isolated stations were mainly diesel units, operated off-line to serve specified cities. Information on these generating capacities is provided in Table 10.

Table 10: Existing Power Stations in Nigeria

S/N	YEAR	UNIT	MW ADDED	LOCATION	REMARKS	CUMMULATIVE MW
1	1956		20	IJORA	RETIRED	
2	1956		10	OJI	RETIRED	
3	1965	GT1,GT2 GT3,GT4	2X10.5 2X15	AFAM I	RETIRED	
4	1966	GT1, GT2	2X36	DELTA I	GT1 RETIRED	36
5	1968	1H7-1H10	4X80	KAINJI		356
6	1975	GT3-GT8	6X20	DELTA II		476
7	1976	GT5-GT8	4X23.5	AFAM II		570
8	1976	1H11-1H12	2X100	KAINJI		770
9	1977	GT4-GT6	3X20	IJORA	GT6 RETIRED	810
10	1978	1H5-1H6	2X120	KAINJI		1050
11	1978	GT9-GT12	4X25	AFAM III		1150
12	1978	GT9-GT14	6X20	DELTA III		1270
13	1978	ST1-ST6	6X120	SAPELE (STEAM)		1990
14	1981	GT1-GT4	4X75	SAPELE (GAS)		2290
15	1982	GT13-GT18	6X75	AFAM IV		2740
16	1984	2H1-2H6	6X90	JEBBA		3280
17	1985	ST3&ST2	2X220	EGBIN		3720
18	1986	ST1&ST4	2X220	EGBIN		4160
19	1987	ST5&ST6	2X220	EGBIN		4380

S/N	YEAR	UNIT	MW ADDED	LOCATION	REMARKS	CUMMULATIVE MW
20	1989	3H1	1X150	SHIRORO		4530
21	1990	3H2-3H4	3X150	SHIRORO		4980
22	1990	GT15-GT20	6X100	DELTA IV		5580
23	2001	GT19, GT20	2X138	AFAM V		5856
24		DGS	4	CALABAR		5860

GT: Gas Turbines; H: Hydro; ST: Steam Turbines; DGS: Diesel

(b) Existing Power Transmission and Distribution Infrastructure

The transmission network of the country is organized into a regional structure. Details of the regional structure are presented in Table 11. The first 132 KV transmission line was constructed in 1962, this line served as a linkage between Ijora and Ibadan Power Stations. The total inventory of transmission infrastructures in Nigeria include: 5000 km of 330 KV lines, 6000 km of 132 KV lines, 23 Km of 330/132KV substations and 91 Km of 132/33KV sub-stations. Power distribution activities are carried out through the 10 Zonal and several district offices nationwide. Each District Office is divided into Undertaking Offices and Service Centers for operational convenience. These zonal offices and the component districts are presented in Table 11. The distribution infrastructure includes the following: 23,753km of 33KV lines, 19,226km of 11KV lines, 697 of 33/11KV sub-stations and 20,543 of 33/0.415KV or 11/0.415KV. There are also 1790 distribution transformers and 680 injection sub-stations across the country. These represent the current distribution facilities in Nigeria. The distribution sub-sector is in dire need of upgrading as many of its distribution transformers are overloaded while the lines look more like “Cobwebs”. Overall transmission and distribution losses have been severally put in the range of 30 – 40 % (Capoor, K., 2005; OECD/AfDB, 2004; World Bank, 2002; World Bank, 1992). When these are added to the poor payment record of consumers, collections are less than 50% of power generated. The distribution capacity from 1999 to 2003 is presented in Figure 6, while the distribution zones and districts are presented in Table 12.

Table 11: Existing Six Region Transmission Stations in Nigeria.

S/N	Kaduna Regional Stations	S/N	Lagos Regional Stations	S/N	Oshogbo Regional Stations	S/N	Enugu Regional Stations	S/N	Ajaokuta 132	S/N	Gombe Regional Stations
1.	Kaduna (mando).	1.	Akangba 330.	1.	Oshogbo 132.	1.	Benin 132	1.	Awka.	1.	Dakata.
2	Jebba 330(GS).	2.	Akangba 132.	2.	Oshogbo 330.	2.	Benin330 .	2.	Oji-River.	2.	Kumbotso.
3.	Jebba 330(TS).	3.	Ojo.	3.	Ife.	3.	Effurun.	3.	Kingsway .	3.	Dan-Agudi
4.	Bida.	4.	Maryland.	4.	Omu-Aran.	4.	Irrua.	4.	Nkalagu.	4.	Hadejia.
5.	Kontagora.	5.	Ilupeju.	5.	Offa.	5.	Okene.	5.	Abakiliki.	5.	Kankia.
6.	Birnin-Kebbi.	6.	Isolo.			6.	Ukpilla.	6.	Oturkpo.	6.	Katsina.
7.	Sokoto.	7.	Ikorodu.			7.	Ughelli.	7.	Nsukka.	7.	Bauchi.
8.	Talata- Mafara.	8.	Itire.			8.	Ajaokuta 330.	8.	Yandev.	8.	Gombe.

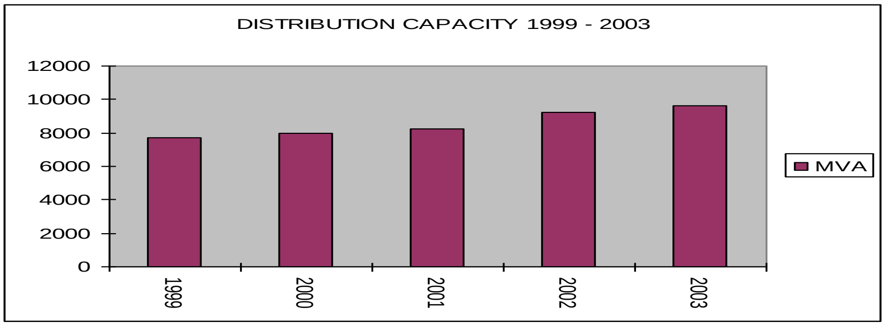
S/N	Kaduna Regional Stations	S/N	Lagos Regional Stations	S/N	Oshogbo Regional Stations	S/N	Enugu Regional Stations	S/N	Ajaokuta 132	S/N	Gombe Regional Stations
9.	Kaduna Town.	9.	Ijora.			9.	Onitsha.	9.	Alaoji 330.	9.	Jos.
10.	Zaria.	10.	Ikeja West 132			10.	New Haven	10.	Alaoji 132.	10.	Maiduguri
11.	Funtua.	11.	Ikeja West 330			11.	Calabar.	11.	Aba.	11.	Yola.
12.	Gusua.	12.	Ogba.					12.	Afam.	12.	Potiskum.
13.	Shiroro330/132.	13.	Alimosho.					13.	Port-Harcourt Town.	13.	Biu.
14.	Shiroro132/133.	14.	Papalanto					14.	Port-harcourt Main.	14.	Savannah.
15.	Abuja.	15.	Abeokuta					15.	Eket.	15.	Damboa.
16.	Suleija.	16.	Ejigbo.					16.	Itu.		
17.	Minna.	17.	Agbara.					17.	Uyo.		
18.	Katampe	18.	Aja 132.					18.	GCM		
19.	Keffi	19.	Aja 330.								
20.	Akwanga	20.	Oworonsoki.								
21.	Tegina	21.	Alagbon.								
		22.	Apapa Road.								
		23.	Akoka.								
		24.	Amuwo-Odofin								
		25.	Ayede 132.								
		26.	Ayede 330.								
		27.	Jericho.								
		28.	Ibadan North.								
		29.	Shagamu.								
		30.	Ijebu-Ode.								
		31.	Iseyin.								
		32.	Iwo.								

Table 12: The Distribution Zones and Districts in Nigeria

S/N	ZONES.	DISTRICTS UNDER EACH ZONES
1.	Abuja	Abuja, Lafia, Lokoja, Minna.
2.	Benin	Ado-Ekiti, Akure, Asaba, Benin, Ugbowo, Warri.
3.	Enugu	Aba, Abakaliki, Awka, Enugu, Onitsha, Owerri, Umuahia.
4.	Ibadan	Abeokuta, Dugbe, Ilorin, Ijebu-Ode, Molete, Oshogbo, Oyo.
5.	Jos	Bauchi, Gombe, Jos, Markurdi.

S/N	ZONES.	DISTRICTS UNDER EACH ZONES
6.	Kaduna	Birnin-Kebbi, Doka, Gusau, Makera, Sokoto, Zaria.
7.	Kano	Dala, Dutse, Nassarawa, Katsina.
8.	Lagos (North)	Alimosho, Ikeja, Ikorodu, Oshodi, Shomolu.
9.	Lagos (South)	Festac, Ijora, Island.
10.	Port- Harcourt	Borokiri, Calabar, Diobu, Ikom/Ogoja, Uyo, Yenegoa.
11.	Yola.	Damaturu, Jalingo, Maiduguri, Yola.

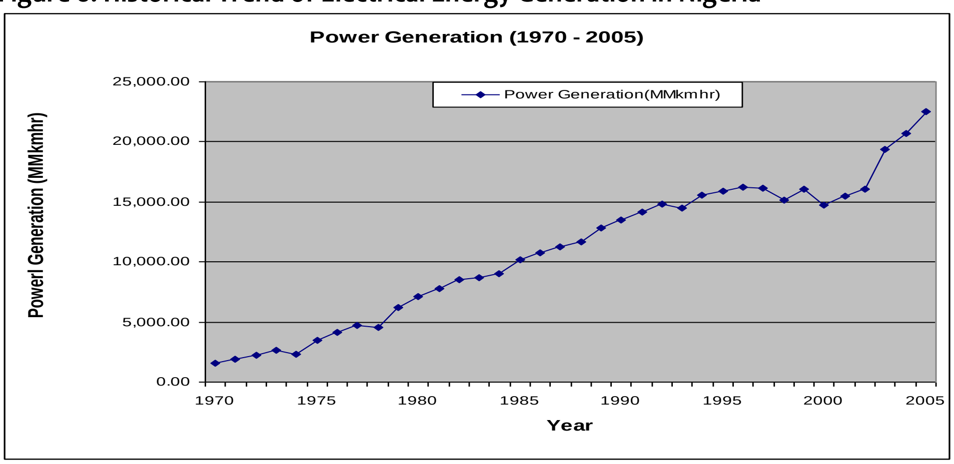
Figure 7 : The Distribution Capacity of NEPA from 1999 to 2003.



(c) Trend of Electrical Energy Generation in Nigeria

Historical energy generation during the period 1970 – 2005 by all power generation facilities in Nigeria is presented in Figure 8.

Figure 8: Historical Trend of Electrical Energy Generation in Nigeria



2.3.6 *Discussion of Potential Clean Energy Investments on the Nigerian Energy Supply Side*

In this section, we present a discussion of the potentials for clean energy investment on the supply side of the Nigerian energy system. The discussion will cover clean energy potentials in the following sub-systems: Oil and Gas Production; Coal Production; Power Generation; and Crude Oil Refining.

2.3.6.1 Potential Clean Energy Investments in the Oil and Gas Sector

Crude oil and natural gas are the two primary energy types produced in this sector. Our review of the operations in this sector indicated that the main opportunity for clean energy investment in this sector will have to focus on the elimination of the current practice of flaring associated natural gas produced with oil as a result of not finding easily connected market for the gas when produced. In 2003 for example, Nigeria produced about 42 billion m3 of associated natural gas, flared about 19 billion m3 of the gas (~45%), and emitted an estimated 77 million tCO_2e thereby contributing to Nigerian carbon emission footprint. Clean energy investment in this sector will have as a goal the elimination of the GHG emissions from gas flaring.

Other opportunities for clean energy investment that should be considered in addition to use in power generation will include:

- **Utilization of Natural Gas as fuel in Multi-Functional Platforms (MFP) to Supply Energy to Oil and Gas Communities:** Experience from the Nigerian Niger Delta indicate that often, communities living in oil and gas producing regions of Nigeria usually lack the facilities for better life. The oil and gas endowment can be employed to provide improved living conditions in the area. MFP has been employed in other regions of the World as a poverty alleviation tool in rural communities. The MFP will consist of a gas driven engine, capable of driving several anciliary modules. The ancilliary modules which will be taylored to meet the need of each community will include: a press (for pressing the oil oils); a generator to provide electricity (for water pumping, lighting, workshop tools, de-huskers, battery chargers, etc.), a mill (for grinding cereal), or a compressor (for inflating tires) etc. This will not only provide cleaner energy to the communities but also add to the improvement of the carbon footprint in the region;
- **Utilization of Natural Gas as Feedstock in the Production of Petrochemicals LNG for the export market,etc.:** Emission reduction of this part will depend on how the life cycle emissions of the baseline use of the fuel stacks against emissions from the production of the petrochemical goods and LNG.
- **As a source of LPG for the domestic market and for export:** Increased use of LPG, which has been a constant goal of various Federal Governments in Nigeria can be seen as one of the ways to reduce fuelwood consumption in the country.

2.3.6.2 Potential Clean Energy Investments in Coal Mining

Although activities have declined significantly over the past few decades in this sector, the Federal Government of Nigeria has renewed its plan to revitalize the sector. With the assumption of increased coal mining activities in the very near future, opportunities exist for the capture of coal mine methane (CMM) that are usually partly vented and flared to be captured and utilized for energy generation. The result of an analysis of GHG emission reduction from capture and use of CMM for power generation in Nigeria using 2003 data on coal production showed the potential to be very marginal. Increased production of coal that is likely to result from the current plan to increase activities in a revamped coal sector will make this a good potential for clean energy investment in

Nigeria.

2.3.6.3 Potential Clean Energy Investments in the Power Sector

The Nigerian power sector is currently characterized by demand surplus arising from a combination of inadequate power generation capacities and existence of a sizeable number of consumers without access to the national grid. Capacity expansion will always be required for some years to come until adequate capacity is in place. In a 2001 profile prepared by NEPA only about 35% of Nigerians were served by NEPA (446 Local Government Areas (LGA) out of a total of 774 LGAs are connected to the grid). The implication of this fact is that there is a significant level of unserved demand in Nigeria and, as such, we should expect a higher capacity expansion for generating, transmission and distribution facilities in the coming years compared with what has been seen during the past years. As a matter of fact, the very low electricity consumption per capita is actually due to the low proliferation of capacities to potential markets in the countries. As shown in Table 13, Nigeria is at the bottom of the ladder when compared to other countries in the World on the basis of electrical energy production/cap and electrical energy production/cap. Development activities will require the country to climb up on these indices, resulting in increased power generation and the strengthening of power transportation facilities in the country.

Table 13: Electrical Energy Production and Consumption in Selected Countries (2001)

S/N	Continent/Countries	Production per cap (KWh/Cap)	Consumption per Cap (KWh/Cap)
A.	**Africa**		
1.	South Africa	4.60	4.20
2.	Libya	3.60	3.33
3.	Egypt	0.99	0.92
4.	Algeria	0.77	0.71
5.	Morocco	0.45	0.41
6.	Ghana	0.42	0.40
7.	Nigeria	0.16	0.11
B.	**G8**		
1.	Canada	17.40	15.50
2.	USA	12.70	12.30
3.	France	8.60	6.90
4.	Japan	8.10	7.60
5.	Germany	6.60	6.20
C.	**Australasia**		
1.	Australia	9.95	9.26
2.	Taiwan	6.60	6.20
3.	South Korea	6.00	5.60
D.	**Latin America**		
1.	Paraguay	7.25	6.43
2.	Venezuela	3.50	3.30
3.	Chile	2.63	2.54
4.	Argentina	2.50	2.40

Source:Triple "E", "Energy Infrastructure in Nigeria: Impact on the Manufacturing Sector", Prepared for Manufacturing Association of Nigeria, MAN, March 2005.

The need for aggressive addition to existing power generation capacities in the country will provide big opportunities for clean energy investment in the country in the years to come. Not only will the opportunity come from capacity expansion of the centralized generation that are on the grid, but the need for the generation of more power in Nigeria should be utilized as a vehicle for the development of distributed generation capacities as a means of increased genration of power and also a means of reducing the problematic transmision and distribution losses associated with centrally generated power in developing countries. Some of the relevant clean energy investment that we have identified for this sector will include:

Closure of Selected Existing Single Cycle Gas Turbines

There are many thermal power plants currently operating in Nigeria that are single open cycle gas turbines. The energy efficiency that can be attained by such plants is limited. The exhaust gases still contain high energy potentials, which can be recovered to produce steam and spin a steam turbine to generate additional power. Installing a second cycle allows the production of additional electricity at no additional fuel consumption. In systems where either the operating margin or the built margin are based on thermal plants, such projects reduce CO_2 emissions of the sector because they avoid the burning of fossil fuels that would be required to generate the same amount of electricity. But transforming a single cycle plant to a combined cycle increases considerably the efficiency of the plant, making this type of investment a theoretically profitable one most of the time. As a consequence, it will be dispatched more frequently, adding a duration effect to the efficiency effect. Its load factor can be increased from 20% to 70%. The result is that the same plant will displace more of the other low efficiency fossil-fuel fired plants currently ran at the operating margin, avoiding more emissions.

The Nigerian power sector is currently endowed with many open cycle gas turbine plants. For example, of the existing installed power generating capacity totalling 5,890 MW in 2004, more than 40% were single cycle turbine engines, many of which are run as base load plants. In addition, about 3,000 MW of additional new Single Cycle Gas Turbine facilities are at different stages of completion and are expected to enter the generation profile of the country sometimes in 2008. In a recently completed study (F.B. Dayo 2007), it was concluded that if about 95% of the existing and firmly planned single cycle gas turbines in Nigeria were converted to combined cycle gas turbines (CCGT), then additional power totalling more than 48% of current installed grid capacity can be generated, without additional fuel combustion. This would require an investment of about 3.4 billion US$;

Implementation of Greenfield Combined Cycle Gas Turbines

Given the fact that power supply in Nigeria today and in the foreseeable future is likely to continue to be characterized by surplus demand, capacity expansion utilizing mostly natural gas that would have been flared should be the basis of greenfield CCGTs. In a recent study (F.B. Dayo, 2007), using gas flaring data of 2005, it was shown that if all the gas flared in that year in Nigeria is used to generate power in CCGT technologies, then slightly more than 12,000 MW can be produced or about 205% of installed grid capacity in the country in 2005. It was also estimated that if the CCGT facilities were implemented as CDM projects, it will yield a conservative annual GHG emission reduction amounting to about 24.7 million tCO_2e, requiring an investment of about US$14.5 billion. Investing in greenfield CCGT is a clean investment, especially when it contributes to flare reduction, and consequently a more environmentally benign energy system.

Cogeneration of Electricity and Heat in Industries
Implementation of combined heat and power (CHP) systems in industries can also serve as a medium to bridge the gap between power supplies and demand in Nigeria. Industries in Nigeria who require steam and power for their production processes usually generate such using stand-alone systems consisting of boilers to supply the steam and power from an onsite generator and/or power imported from the grid. The combined thermal efficiency of this stand-alone systems is usually not more than 55% (F.B Dayo et. al, 2001). CHPs provides the opportunity to have an alternative system for supplying steam and power to Nigerian industries at a higher combined energy efficiencies usually not less than 85%. This is a clean investment in that it will lead to a more effcicent utilization of energy resources and lower emission of GHG and noxious gaseous and particulate emissions.

Expansion of the Large Hydro Power Capacity in Nigeria
Of the 10,000 MW estimated resource base of large hydro potentials of Nigeria, only about 1,900 MW has been developed. Firm plans are in place to add an additional 2,600 MW large hydro capacity on the Mambilla River in the very near future. Development of the large hydro resources can be considered a clean investment as long as the balance of the environmental impact is not an unsustainable development and the creation of the needed reservoir does not lead to net GHG emissions.

Development of Small Hydro Power Facilities
Small Hydro Power facilities will play important roles in the expansion of clean energy to consumers in the rural and peri-urban areas in Nigeria.

Development of Wind Farms for Electricity Generation
Nigeria's endowment of wind energy has been put at slightly over 700 MW. This should be developed to add diversification to the generation mix.

Implementation of Biomass Fuelled Power Plants
Biomass fuelled power plants is another way to develop clean energy facilities in the power sector in Nigeria. Biomass is a carbon neutral fuel in that it emits an amount of carbon when it is combusted as an energy fuel, equal to the amount that it absorbs when it is cultivated, returning a zero net emissions. Biomass fuels can come as agricultural residues, generated during the cultivation of food and cash crops, or can be derived as resides from forestry operations, when wood is logged from the forest and from residues generated when wood is turned into useful products in wood processing industries.

Biofuels for Power Generation
In an earlier section of this report, we discussed the potential of production of biodiesel from Jatropha in Nigeria. Biodiesel is produced from the trans-esterification of pure plant oil (PPO) extracted from the seeds of Jatropha. Petroleum-diesel consumption for power generation which currently constitute only a small fraction of grid generation, but constitute a substantial fraction of

off-grid generation can be displaced by the use of bio-diesel and in some cases by PPO. Programs to utilize bio-diesel and PPO are already in consideration in Nigeria. For instance, through the World Bank assisted National Energy Development Project (NEDP), the Power Holding Company of Nigeria (PHCN) in collaboration with the Energy Commission of Nigeria (ECN) are already working on a pilot project in a rural community to extract oil from Jatropha seeds and use the oil to generate electricity. This is with the aim of developing a business model for bio-diesel use as a fuel for electricity generation in the country.

Implementation of Solar PV for Power Generation
Solar technologies are perhaps the most widely disseminated renewable options in Nigeria both as solar thermal as well as solar photovoltaic. Solar PV technologies are increasingly being recognised as affordable in most parts of the country. JICA of Japan recently completed a planning survey study to generate data for the design of solar electrification of 100 selected villages in 5 States in Nigeria. Given these ongoing activities, we are of the opinion that opportunities for clean energy investment in solar systems in Nigeria are very robust.

2.4 Trends in Energy Policies in Nigeria

Energy policy setting in Nigeria has been very dynamic, especially in the area of deregulation of the various sub-sectors geared principally at better management and delivery of services to consumers. Our focus in this report is on policies focusing on the deregulation of the various energy sub-sectors, especially those with relevant importance to the emergence of enabling environment where clean energy investments can thrive. The objective in this section of the report is to provide information on the policy settings in relevant sub-sectors that can provide the reader with a good understanding of the trends in energy policies in the sub-sector and the impact such trends are likely to have on clean energy investments in Nigeria. The following policy formations will be covered in this section: the Nigerian power sector reforms; the oil and natural gas policy; the national rural electrification policy; and the bio-fuel program at the NNPC.

2.4.1 The Nigerian Power Sector Reforms

The reform of the Nigerian Electricity Industry became inevitable due to the high inefficiencies, strategic problems and constraints facing the industry plus governments inability to meet the huge capital requirements needed to overhaul and upgrade the technology and operational details in the sector. The need for reform in this sector was attributed to the need to: attract and encourage private investment flows into the sector; attract capital (foreign, domestic, public and private) to fund activities in the sector; and ensure a level plain ground for all investors (BPE, 2006B). According to the Bureau of Public Enterprises (a quasi government agency formed specifically for the purpose of deregulating public enterprises in the country), the objective of the power sector reforms can be summarized as follows:

(a) The promotion of competition to facilitate more rapid and efficient provision of power services throughout Nigeria;

(b) The establishment of a new legal and regulatory environment for the sector to create a level playing field, encourage private investment and expertise, and meet social goals;

(c) The restructuring and privatization of the Nigerian Electric Power Authority (NEPA-a vertically integrated power utility);
(d) Encouraging the successors of NEPA to undertake a very aggressive investment program.

Government commenced the reform program by instituting a comprehensive reform study that was aimed at entrenching best sector practices, ensuring an enabling environment to increase private sector participation, and promoting the influx of private investments into the sector. The National Council on Privatization (NCP) facilitated the study which culminated in the preparation of a National Electric Power Policy (NEPP), which was adopted by the Federal Government in March 2001. This was followed with the preparation and passage of the enabling legislation (Electricity Power Sector Reform Act, 2005), which was signed into law on March 2005. The salient steps taken in achieving these reforms and a conclusion on the effectiveness or otherwise of the reform effort can be summarized as follows:

(a) Formation of an Electrical Power Implementation Committee (EPIC)

In the early stages of the reform process, the National Council on Privatization (NCP) appointed a steering committee referred to as the Electric Power Sector Implementation Committee (EPIC) to carry out, on behalf of the Council the functions of synchronizing, coordinating and monitoring all activities relating to the reform, restructuring and privatization of the power sector. The EPIC broad mandate and terms of reference included:

- Formulation of sector reform proposal for the approval of the council to create conditions for the sustainable development of the power sector.
- Provision of advice to the Council on policies and programs to promote competition, efficiency and transparency in restructuring and privatization within the power sector.
- Formulation of proposals, for the approval of NCP, for attracting private financing and investment to the power sector.
- Advise Council on steps to be taken while undertaking the reform of the power sector to improve the efficiency, quality and spread of electrical services in Nigeria
- Oversee the activities of government agencies, parastatals, operators and consultants to the Council in the power sector leading to restructuring and ultimate privatization of NEPA
- Provide information brief to all applied consultants of Council on the execution of their assignment
- Carry out functions related to the reform, restructuring and privatization of NEPA as may be assigned from time to time by the Council

(b) National Electric Power Policy (NEPP), 2001

In 2000, EPIC made recommendations to the NCP to promote total liberalization, competition and private sector participation in the electric power sector. EPIC's recommendations crystallized into NEPP and the Federal Executive Council approved the policy in April 2001. The key objective of the NEPP is to ensure that Nigeria has an electricity industry that can meet the needs of its citizens in the twenty-first century. The Policy envisages a 3 stage legal and regulatory reform of the power sector as follows:

- **Transition Stage:** characterized by private power generation through Independent Power Producers (IPPs) and Emergency Power Producers (EPPs); corporate restructuring, unbundling and privatization of NEPA through sale or license of all thermal plants to private operators or concessionaires and transfer of management, ownership and control of selected distribution companies (discos).
- **Medium Term:** *(after the unbundling and privatization of NEPA is completed)* - Characteristics that are contemplated will include competition among generating companies; energy trading between generation and distribution companies primarily on the basis of bilateral contracts through contact exchanges and sales; payment of full price by generators for natural gas and other fuels; and, sale of energy by companies generating power in excess of their needs to distribution companies.
- **Long run Competition Structure:** It is envisaged that during this phase, the various power generation, transmission and distribution companies will be operating optimally. Additionally, there would be economic pricing of electricity to cover the full costs of supply, including expectation of a reasonable, risk-adjusted rate of return on capital; opportunity for large industrial consumers to choose their suppliers; a well developed wholesale market with formal membership rules, procedures, etc.; and, full retail sales competition.

(c) The Electric Power Sector Reform (EPSR) Act of 2005

The EPSR Act 2005 was signed into law on 11th March 2005. The Act provides for the: vertical and horizontal unbundling of the electricity company into separate and competitive entities; development of a competitive electricity markets; setting out of legal and regulatory framework for the sector; framework for rural electrification; the framework for the enforcement of consumer rights and obligations and; establishment of performance standards. Shortly after the coming into law of the EPSR, NEPA as a public corporation was de-registered and a Holding Company, the Power Holding Company of Nigeria (PHCN) took over the assets and liability of NEPA. PHCN was specifically incorporated to manage the unbundling of NEPA. The important components of the EPSR are summarized below:

- **Unbundling (Horizontal & Vertical) and Privatization of the National Utility:** Unbundling is the process by which PHCN will be separated into its constituent functions which are: generation; transmission and distribution; and marketing. The successor companies that would emerge will be privatized using various options.
- **Registration of the Nigerian Electricity Regulatory Commission (NERC):** An entity NERC was registered and vested with the responsibility of regulating activities in the power sector. NERC is expected to carry out economic and technical regulation that would be in line with global best practices. It would issue licenses to market participants and ensure compliance with market rules and other market operating guidelines.
- **Wholesale Electricity Market (WEM):** WEM is the market in which distribution companies would have the option of buying power from any of the competing generating companies.
- **Rural Electrification:** A rural electrification agency would exist that will manage the rural

electrification fund, which would be used to expand electricity access to rural communities in Nigeria.

- **Independent Power Producers (IPP):** These are private sector operatives in the market that would produce electricity using their generating plants. IPPs can enter into bilateral contracts with eligible customers and distribution companies.

The following components of the power sector reforms have been successfully implemented:

- The Electricity Power Sector Reform Act was enacted on March 11, 2005
- National Electric Power Authority (NEPA) was transformed into Power Holding Company of Nigeria (PHCN) Plc as a holding company for the assets, liabilities, employees, rights and obligations of NEPA. The process of incorporation of PHCN was concluded on May 5, 2005.
- NEPA's assets, liabilities, rights and obligations were transferred to PHCN via a Transfer Order dated 1st July, 2005 and gazetted.
- Nigeria Electricity Regulatory Commission (NERC) Commissioners were inaugurated in October 2005 as the sector regulator and have since commenced operation with start-up staff pooled from the Federal Ministry of Power & Steel, BPE and PHCN.
- In November 2005, PHCN was unbundled into eighteen (18) New Successor Companies on the basis of Six (6) generation Companies, one (1) transmission company and eleven (11) distribution/marketing entities)
- New market rule and grid code has been developed for the transitional market.
- A Rural Electrification Agency has been established.
- Privatization program for the generation, transmission and electricity distribution companies approved by NCP in 2005
- Successor Companies (SCs) that resulted from the unbundling of NEPA became autonomous effective 1st July, 2006. Issuance of Interim Licenses to Successor Companies by NERC concluded.
- Board of Rural Electrification Agency established in April 2006.
- Privatization of the individual power companies ongoing;
- Operationalization of Transitional Electricity Market by the Successor Companies and other Market participants also ongoing.

(d) An Evaluation of the Effectiveness of the Reform Effort

The effectiveness of the Nigerian power sector reform can best be measured by the extent to which the four objectives laid out by the BPE are currently playing out. First and foremost, the power sector reform is expected to promote competition in the sector and facilitate more rapid and efficient provision of power services throughout Nigeria. It can be rightly argued that the establishment of the reform process, its implementation so far and the various legal backing that has been put in place to support it, are promoting the emergence of an environment conducive for competition in the sector. This is particularly so when one takes into the consideration the monopolistic framework that had been the order of the day in the sector for the past several decades. Private sector operators are now allowed by law to participate in most aspects of the power business in Nigeria. Private sector investors can now own power generation enterprises in Nigeria, and can be engaged in the business of wholesale and retail distribution of electrical energy, a terrain that was previously reserved for the vertically integrated public utility, the Nigerian Electric Power Authority (NEPA). This in itself and the fact that there are indications that the reform process itself seems to be catching the interest of potential investors (both Nigerian and foreign) is an indication that if the process is managed well with transparency, then the kind of business environment envisaged may yet occur in the not too distant future.

The second part of the first objective of the power sector reform is that the competitive business environment will facilitate more rapid and efficient provision of power services throughout Nigeria. Critics of the reform process or better still, its implementation method have often pointed to the fact that this aspect of the reform objectives is not being met and as a matter of fact openly point to the declining availability of power supplies in Nigeria in recent times. As far as they are concerned, not only should the reform process be seen to be changing the business environment, it should change it fast enough to lead to measurable positive impact on delivery of power services in the country in the short to medium terms. To buttress their point, they point to the fact that between US$7-16 billion has been expended on the on-going power sector reform without any positive improvement in power supply in the country (The Vanguard, March 18 2008). It is important to stress however that a substantial portion of this fund was spent on the National Integrated Power Plant projects, which is only indirectly related to the reform process. The failure of the government to ensure that the reform process is associated with positive measurable developments in the power sector, has led to public outcry on the funds invested in power supply projects without commensurate results. This has further eroded public confidence in the ability of the Federal Government of Nigeria to lead in finding effective solutions to the almost perennial power shortage problems in Nigeria.

Even critics of the power sector reform process will agree with the fact that the establishment of a new legal and regulatory environment for the sector is progressing somehow smoothly, using international best practices and is likely to eventually result in the creation of a level playing field, which in the medium term may encourage private investment and expertise to the sector. This is one of the cardinal objectives of the reform process. There is now in place a legal instrument to back up the slowly but surely emerging regulatory framework (NERC) sending unambiguous signals to the market about the seriousness of national authorities to create a functional enabling environment to the power market in Nigeria. The process in our opinion has also partially achieved its target of restructuring the sector through the unbundling of the Nigerian Electric Power Authority (NEPA-a vertically integrated power utility). For the benefits of the unbundling of the very efficient public utility to be realized, true and transparent privatization of the entities carved out of NEPA must happen. If this does not happen on time (as it currently has not) then it will be difficult to achieve the fourth element of the objective which is to encouraging the successors of NEPA to undertake aggressive investment program. An aggressive investment program of the successor companies of NEPA is needed to enhance the putting in place of power supply infrastructure for appropriate level of access that can promote sustainable development in Nigeria. Their action in this line will also send the right signals to overseas investor who may be looking at the restructured power sector for their venture capital investments.

A key issue that we believe has not helped the proliferation of new power infrastructure investment in Nigeria over the years is the inadequate and sometimes uncertain availability of natural gas in many parts of Nigeria. Government is putting effort in place to ensure that the natural gas market is revamped to encourage investment and proliferation of the valuable power sector fuel to various regions of Nigeria.

2.4.2 *Oil and Natural Gas Policies*

2.4.2.1 The Regulatory Framework

Nigerian oil and gas legislation have existed since 1897 when the first Petroleum ordinance was enacted. The current major laws are the Petroleum Act and its attendant Petroleum (Drilling and Production) Regulations, both of which came into force in 1969. These have been the main legal framework guiding oil and gas sector activities in the country for about the past four decades. Others important laws and legislations that have been enacted since 1958 and with relevance to oil and gas operations in Nigeria are presented in Appendix A.

In April 2000, the FGN set up a national committee (the oil and gas implementation committee) to study the potential framework for reforming the oil and gas sector of Nigeria. The committee was mandated to focus on the deregulation and privatization of the parastatal, NNPC and its subsidiary companies which controls both the upstream operations of the oil and gas industry in the country. The effort to reform this sector continued throughout the life of the Obasanjo administration which ended in May 2007. The report of this committee and the sub-sequent report produced by the committee of the National Council on Privatization (NCP, headed by former Vice-President Atiku Abubakar), became the framework for the efforts of the administration of President Musa Yar Adua that took office from Chief Olusegun Obasanjo on May 29 2007. One of the first actions taken by this President was the setting up of the National Council on Energy (NCE) headed by him, with a mandate to unbundle the Nigerian National Petroleum Corporation (NNPC) into five functional companies (Onowu, September 28, 2008). These companies include:

(a) The National Oil Company (NOC) to take over the function of NNPC
(b) The National Petroleum Directorate to replace the existing Federal Ministry of Energy
(c) The Petroleum Inspectorate Commission (PIC) to replace the Department of Petroleum Resources (DPR)
(d) The Petroleum Products Distribution Authority (PPDA) which will replace the Petroleum Products Marketing Company (PPMC)
(e) The National Oil and Gas Assets Holding, and Management Services (NOGAHMS) which will manage the assets of both the ministry and the NNPC

In a recent interview, the chairperson of the sub-committee of the legal regulatory framework of the Presidential Committee on Oil and Gas Sector Reform clearly laid out what can be considered as the mindset of the FGN in its plan to restructure the oil and gas sector. She assured Nigerians that the decentralization of the Nigeria National Petroleum Corporation (NNPC) as a policy of the Yar Adua Administration will make the sector beneficial to every citizen of the nation (Leadership 2008**).** She pointed out that the implementation framework will concentrate on the following six key areas: a legal framework aimed at putting in place a new enabling legislation for the sector; a new policy formulation, implementation and coordination mechanism that is focused on professionalism; a regulatory framework that is not only professionally competent but is characterized by an effective level of autonomy from both the state and the sector; a restructured national oil company which amongst others shall be fully capitalized, and which shall operate as a strict commercial entity, managed in accordance with global best practices and shall be capable of operating beyond Nigeria's national borders; and laying emphasis on asset management system that functions on the basis of incorporated joint venture companies operating in a strictly commercial manner.

This is essentially how far the regulatory framework for the oil and gas sector in Nigeria has proceeded. Despite the powerful interplay between political and socio-economic realities that often exist in Nigeria when a drastic change in status quo policies is to be effected, the process is expected to succeed. This is because the present administration seems to be relatively more committed to this program and is implementing it with more seriousness of purpose that confidence seems to be building among stakeholders that a sound regulatory framework may yet emerge, everything being equal. Large strides have also been made on the gas sector regulatory and policy framework.

2.4.2.2 Framework for a Robust Oil and Gas Sector Policy in Nigeria

The importance of the oil and gas sector to the Nigerian economy makes it imperative to have a national oil and gas policy. According to a recent BPE publication (BPE, 2007), the policy will aid in maximizing the benefits of Nigeria's oil and gas resources. The establishment of a clear energy policy will result in improved investment and maintenance of Nigeria's energy infrastructure and erode the present results of the ineffective utilization of energy. BPE in the same publication summarized the principal objective of a cohesive energy policy in Nigeria as follows: to maximize the economic benefit of oil and gas resources in an environmentally acceptable manner to meet the nation's fuel needs at a competitive cost. BPE also summarized the key issues that must be addressed by a robust energy policy setting as:

- Ensuring that the industry operates in an environmentally acceptable manner.
- Ensuring derivation of maximum economic benefit.
- Ensuring competitive cost.
- Exploitation of natural resources to ensure longevity and sustainability for the domestic economy.

Some of the other pertinent issues that were elucidated in the BPE report that must be covered by the policy are summarized as follows:

(i) How the economic benefit of the sector can be maximized through:

- Fiscal regimes [lease bonus payments / royalty collections / corporate income tax / equity interest ownership in commercialized industry.]
- Sustained profitability of industries.
- Development of additional commercial activities.

(ii) What should be the principal instruments that must be incorporated in the oil and gas

policies are:

- Investments in oil and gas infrastructure, downstream and upstream services.
- Support to downstream enterprises through technical assistance, research and development activities and the dissemination of relevant results of such activities and promotion and assistance in the field of education and training.
- Subsidies, grants, loans and loan guaranties.
- Taxes and user charges.
- Laws, rules, regulations and norms.
- Operation of public enterprises and facilities, as well as transferring certain
- Activities to the private sector, either by sale or by any other means of privatization.

(iii) The effective institutional and organizational structure that must be incorporated:

- Appropriate legal framework.
- Appropriate distribution and delineation of functions and responsibilities between the institutions involved.
- Effective organization structures within the institutions, agencies or enterprises concerned.
- Effective monitoring or information system, which would enable meaningful control, as well as the identification of problems and difficulties, which may require action.

(iv) Principles that should form the basis for the assessment of the existing situation and the proposals for change:

- Clearly defined functions, duties and responsibilities defined in the legislation, and at the lower level by a clear "mission definition", approved by higher authority.
- Functions defined in a way, which avoids duplication of work between organizations, or units within the same organization. If permanent cooperation between different organizations or units is required, clear arrangements to ensure cooperation and coordination.
- How conflict of interest within an organization will be avoided. Especially important is a clear delineation between regulatory and control functions on one hand, and operations on the other.

(v) The priority issues and policy statement for the Oil and Gas sector that must be incorporated to cover economic, environmental and social objectives.

- energy price trends
- international aspects
- incentives for investment
- liberalism and competition in energy markets
- energy security of supply
- expansion of gas sector

- industrial strategy issues
- health and safety issues
- corporate governance
- fiscal policies
- marginal fields
- environmental sustainability
- institutional barriers and trade offs

2.4.2.3 Comments on the Effectiveness of the Proposed Sector Policy Methodology Framework

The framework as described in the BPE publication comprehensively covered what should be the component of a robust oil and gas sector policy. Although the framework is described as an energy policy in the BPE publication, it is clearly focused on the oil and gas sector. A consideration that may not necessarily be captured by the policy setting is the potential competition between oil and gas and other substitute fuels within the economy. Also, the framework as conceptualized will be dominated by oil issues without adequate focus on the gas sector. It is therefore not surprising that a gas sector focused regulatory framework is also in the finalization process in Nigeria.

2.4.2.4 The National Domestic Gas Supply and Pricing Policy

The increasing global role of natural gas as a relatively clean energy fuel has continued to create an upward push on gas prices in key international markets leading to increase in export of LNG from producing countries. This global development has led to a rapidly rising demand for Nigerian LNG which has also resulted in a disproportionate focus by gas suppliers in Nigeria for LNG projects over domestic gas supply projects. This is creating an anomaly in a domestic energy market that is characterized by a significant shortfall in the availability of natural gas. In a nation where natural gas is the dominant power sector fuel, the lack of supply of gas has begun to take a toll on the health of the nation's economy. Over the recent years, the FGN have seen LNG export as a source of high return funds through tax receipts and dividend from equity stakes. The government is however beginning to also recognize the fact that beyond economic rent, there are broader strategic benefits to the economy if domestic utilization and value addition to natural gas is encouraged as a part of a strategic energy policy for the nation. Hence the recent focus on the development of a national gas policy for Nigeria. It is expected that the enormous energy that will be required for the economic development envisaged for the future in Nigeria will require an equally enormous energy inputs and given the appreciable country endowment of natural gas, it is expected that this energy resource will play a leading role in the country's future energy balance. The resulting expected demand growth of natural gas will translate to significant reserves and production capacity development requirement. In addition to this is the fact that domestic demand sectors have varying capacity to bear gas prices and this must be factored into the resource utilization decision making. These are some of the issues that have been very well elaborated in many of the policy framework and planning documents that we have reviewed to clearly provide an understanding on the direction of the gas policy in Nigeria (FGN, 2008). The Nigerian gas policy is expected to (OSAPE, 2007):

- Provide solutions to the issue of gas pricing;
- Address domestic gas supply availability in a manner that delicately balances the need for

domestic economic growth and revenue generation from exports;
- Provides an implementation approach for the gas pricing that enables full participation of all gas suppliers in the country in a manner that ensures sustained gas supply to the domestic market.

The implication of these issues on the emerging Nigerian gas policy is that it is likely that the development of strategies and regulatory framework will be driven more by the need to evolve a strong and sustainable domestic gas market in the very near future. Towards this end, the FGN has grouped the entire country demand (including domestic and export) into strategic sectors. According to the policy paper obtained from OSAPE, the strategic sector concept has been introduced to capture the non-direct economic benefit inherent in these sectors through adequate pricing of gas to promote economic growth of the sectors. The broad grouping that has been proposed includes:

(i) Strategic Domestic Sector

This refers basically to the power sector with the most significant direct multiplier effect on the economy (supplying power to the national grid rather than power for captive use). The intent of prime classification for this market is to spur access to low cost gas for this market to stimulate rapid economic growth. The plan is to also increase the component of this market from time to time as applicable. An example of a candidate that is likely to be considered in the near future is Compressed Natural Gas (CNG) for transportation. The Honourable Minister for Energy may from time to time consider inclusions that may be applicable.

(ii) Strategic Export Sector

These are domestic industries that utilize gas as feedstock in the production of value added products that are primarily destined for export or consumed locally. It is expected that access to affordable gas by this sector will enhance the diversification of Nigeria's gas related export portfolio whilst also ensuring that value is added to Nigerian gas before it is exported. This will promote industrialization which also will lead to job creation. Projects targeted by this strategic plan include: Methanol; Gas to Liquids (GTLs) and Fertilizer. The strategic intent for this sector in the proposed national gas policy will be not only to ensure that the needed feed gas is available to these projects, but that gas prices are affordable and predictable to enhance the competitiveness of the products in international markets.

(iii) Other Commercial Sectors

These are sectors where gas is utilized as fuel as opposed to feedstock. The importance of this category lies with the fact that gas using projects here are considered as potential major direct revenue earner for Nigerian gas due to their capacity to bear higher gas prices compared to projects in the previous two classifications, due to the fact that competing alternative fuel is LPFO. They are therefore less vulnerable to a crude oil based gas pricing. Typical projects in this category include: LNG; CNG; Cement and domestic manufacturing industries.

Gas Pricing Reform Strategy

Given the market structure described above, the strategy of the pricing reform that is being worked out is expected to put in place a framework that will promote access of the various market segments to natural gas at prices that are affordable and sustainable. The Nigerian gas is known to be very rich in liquids and given the relatively high market value of gas liquids, the pricing regime being planned is expected to utilize the high value that can be earned from the gas liquid to leverage the price of the lean gas such that the lean gas can be delivered at relatively little or no cost as the project remains profitable to gas suppliers on the strength of the gas liquids contract alone. Based on this philosophy, the gas pricing reform strategy is being hinged on the assumption that there is a significant amount of gas reserves in Nigeria for which the residue (lean) gas can be delivered at low prices, if the benefits of the gas liquids are fully captured. Using an assumption of a base case price of US$40/barrel of gas liquids, a minimum rate of return of 15% for the gas supplier and a minimum price of US$0.10/MMBTU at the fence of the gas supplier for natural gas, it was shown that the upstream suppliers on the aggregate should be able to earn adequate return for the limited amount of gas reserves within their portfolio that is rich in gas liquids. The gas reform policy is therefore being put together with the aim of requiring that the rich gas be first directed to supply the needs of the strategic domestic and export sectors. Based on existing gas transmission infrastructure costs in Nigeria and international benchmarks, a transmission tariff of US$0.30/MMBTU has been proposed, with the caveat that this will be updated from time to time as appropriate. The overall import of the philosophy of leveraging gas liquids to price dry gas is the determination of a floor price of gas in Nigeria of about US$0.40/MMBTU. This is the price that is expected to be applied to the power sector, the main component of the strategic domestic sector.

The Proposed Gas Pricing Framework

Using the philosophy and analysis presented in the last section as the basis for the determination of a floor price for the Nigerian market, the following are summarized as the salient components of the proposed gas pricing framework for Nigeria:

- The framework which can be applied generically to any sector comprises of three sections:
  - A regulated regime;
  - A Pseudo-regulated regime; and
  - A market led regime;
- Within the framework are defined sector strategic saturation indices through which the capacity of a sector is measured against the demand for its products. At a specific threshold of saturation index, applicable gas price changes for a sector;
- Price of gas are in all cases indexed to inflation and to end product price, with the indexation mechanism to end product price determined by gas suppliers and purchasers during the development of their respective Gas Sale and Purchase Agreements;
- The regulated pricing regime will apply to the Strategic Domestic sector (i.e., power supplied to the national grid;
- The pseudo-regulated regime will apply to the strategic industrial sectors where it is assumed that the feed gas will be used for the creation of products that are targeted primarily for export with application to some local consumption. Here it is assumed that domestic demand is very small or non-existent and a target export level is set beyond which the price regime will change;
- Prior to reaching export saturation, the applicable gas price for the sector under this regime will be the netback price (which varies from sector to sector) that assures the sector operator

can achieve a post tax rate of return of not less than 15% based on an assumed end product price

- The market led pricing regime will apply to all sectors of the economy in the following manner:
  - For strategic domestic and export sectors whose capacities are in excess of a well defined export saturation index; and
  - For other commercial domestic and export sectors that are able to bear a high price such as LNG, CNG, Cement, and industries
- The market-led pricing regime will be negotiated between the buyer and seller of gas with a floor price-the Nigerian Gas reference marker price set. The marker price will be the floor price for all sectors in the market-led regime. It is considered the fair value for Nigerian gas commodity which every non-strategic sector must ascribe to pay at the minimum;
- Because the LNG is the sector with the highest potential economic return to the Nigerian government and also the highest consumer of gas, the reference marker price has been established in the proposed pricing regime as the LNG netback price to the Nigerian gas plant. The LNG sector has therefore been considered as the price setter for the market led regime, and for the proposed framework, a discount of about 25% has been applied to the netback price;
- To ensure stability in the market, the proposed price regime has applied a cushion above the gas reference marker price, referred to as the reference marker tunnel, with an upper limit of US$2.50/MMBTU. Beyond the tunnel, the Gas Regulator is empowered to intervene in the event of conflict between a buyer and seller.

It is important to utilize some illustrations to elucidate some of the issues contained in the proposed gas pricing framework summarized above. The first issue is the strategic sector saturation index: Using as an example the Fertilizer Industry, which is in the strategic export sector regime, the domestic saturation of the fertilizer sector is assumed attained when the country fertilizer production capacity fully meets an aspired domestic requirement. Beyond this point, there is a shift in applicable price as it will be assumed that any additional fertilizer capacity will be for export and the price regime will transit into the market led regime where the prices are commercially determined; Secondly, it is stated that the feed gas price will be indexed to the end product price. For the Fertilizer industry, the feed gas price will be set based on an assumed long run price of fertilizer (the particular type of fertilizer) in the export market. This will be the lowest price that gas will be supplied to the fertilizer investor and subject to the adopted indexation mechanism, the feed gas price will increase accordingly when international prices for fertilizer increase.

The Components of the Proposed Implementation Strategy

The following are the components of the proposed National Gas Supply and Pricing Regulations (FGN, 2007), especially the implementation aspects of the national gas policy:

(a) A Downstream Gas Act which spells out the modus operandi of a Gas Regulator, the Department of Gas, which will have the power to regulate the gas sector including pricing of gas in Nigeria;

(b) A Domestic Gas Reserve and Production Obligation which makes it compulsory for all holders of gas assets in Nigeria (associated and non-associated) to dedicate a specific proportion of their reserves and production for the supply to the domestic market.

(c) Establishment of a Domestic Gas Aggregator within the Gas Regulator establishment in consultation with the suppliers of gas in Nigeria. The gas aggregator will among other responsibilities: implement a protocol that can facilitate effective monitoring of demand and supply of gas within Nigeria; ensure transparency in dealings between gas suppliers and purchasers; act as an intermediary between suppliers and purchasers; ensure the supply of gas to the strategic sectors in accordance with the approved national gas pricing framework; etc.

All these components are contained in the National Gas Supply and Pricing Regulation which is drafted as a subsidiary legislation in the Petroleum Act of Nigeria (Under Section 9 of the Petroleum Act and Paragraph 34 of the first schedule to the Petroleum Act). The other important coverage of this Subsidiary Legislation (apart from the ones elucidated above) includes:

- Elaboration on the powers of the regulator, the Department of Gas;
- The functions and powers of the of the domestic gas aggregator;
- Domestic gas demand requirement;
- Procedure for gas supply;
- Power of the Minister;
- Interpretation of various terms of the regulation.

These blueprint of the gas sector regulations and policies have been discussed and approved at the Federal Executive level and is currently going through the legislative process which is the last step before it eventually becomes the law of the land.

It is our opinion that the gas sector regulatory and policy framework described has undergone very careful development. The framework has been carefully considered and contains elements which if properly implemented as planned will enhance the aggressive development of domestic use of natural gas in Nigeria. Furthermore it will ensure that Nigeria transit from a net exporter of raw energy to exporter of value-added goods, an important requirement for facilitating sustainable economic development of the country.

2.4.3 Rural Electrification (RE) Policies

The medium term reform program of the power sector as contained in the recently approved National Electric Power Policy (NEPP) covers a rural electrification segment with the goal of expanding access to affordable and reliable electricity to rural communities in Nigeria in a cost-effective way (FGN, 2006). Over the last few decades, governments at the Federal and State levels have paid some attention to the need to have access to electricity in rural areas through the implementation of rural electrification programs. While the focus has always been access of rural communities to what has often been described as "modern energy", this reference to modern energy is only relative to the status quo energy supplies in the absence of those programs. For example, in many of these rural areas in the absence of rural electrification and where no connection to the national grid exists, status quo lighting is more likely to be supplied from locally made equipment, using biomass residue e.g., palm oil residue as fuel, with its attendant energy inefficiencies, smoky lighting production and particulate and other gaseous emissions that are detrimental to human health. Prior to the introduction of the latest RE policies and program in Nigeria, rural electrification programs were mostly composed of mini or isolated small grids populated by low efficiency diesel generators, which may not be classifiable as "clean energy systems"

The NEPP was formulated, with one of its components, being the full use of the national grid and off grid, mini grid and non-thermal renewable etc. approaches in the rural electricity access expansion program. Towards this end, and in line with NEPP, a Rural Electrification Agency (REA) has been put in place and an independent Rural Electrification Fund (REF) started with a seed fund from the Federal Government of Nigeria (FGN) to be managed and operated by the REA. A review of the terms of reference of a recently commissioned consultancy to structure the goals and operations of the REA provided some insights into the plan of what roles the Agency will be expected to play in the emerging re-orientation of the Nigerian energy system. The following study objectives were elucidated in that TOR (REA, 2006):

- Develop a rural energy policy that:
    - Clearly establishes the government long-term vision for access to modern energy sources and use in rural areas
    - Agrees with the power sector policy paper, related government policies, laws in other sectors and ongoing restructuring of the power sector
    - Creates an enabling environment for private sector led, commercially oriented provision of modern energy including but not limited to rural electrification
    - Explicitly incorporates renewable energy in the portfolio of energy options
    - Agrees with international and regional best practices in the provision of modern energy in rural areas
- Develop an informational baseline i.e., consumer survey assessment and business opportunity reviews, as a means of establishing the rural energy access strategy
- Develop a rural electrification strategy formulation and implementation plan
- Design the Rural Electrification Fund
- Develop capacity building and knowledge transfer plans
- Build the rural electrification regulatory structure
- Prepare the rural electrification implementation plan
- Prepare design specifications for low cost systems

An evaluation of the issues listed above will show that the new path for rural electrification program in Nigeria, which still has the goal of expanded access to modern energy in rural areas, is along a route that will facilitate focus to be placed on clean energy investment offered among others by renewable energy systems.

The First International Renewable Energy Conference and Workshops with the Theme: **Development of Renewable Energy Resources as Alternative Energy Options for Nigeria** took place at the Sheraton Hotel, Abuja from 16^{th} – 20^{th} October 2006. The forum was utilized by the REA to spell out to the public, the intentions of the Agency, within the framework of the ongoing restructuring of the Nigerian power sector. Some of the salient conclusions and recommendations reached at the end of the conference as contained in the conference communiqué as listed below also lend credence to the focus on clean energy investment at both the energy source and use ends. Some of the important conclusions include:

- Transition to sustainable energy system through the development and harnessing of other types of renewable energy, especially wind, biogas, solar and mini-hydro power as alternatives to the dominant fuelwood sources must be aggressively pursued in Nigeria;
- No one primary source of energy can be all important. All resources must play their appropriate parts balancing the needs of present and future and securing the different uses of resources and amenities. In this regard, public participation in all phases of projects at the local level must be seen to be important for the success of any field project
- Presently the three tiers of government spend billions of naira on long insufficient and expensive connections of rural communities to the national grid merely for political gain rather than the provision of reliable, affordable and sustainable electricity supply. Since technical solutions are becoming well known, what is needed is for the three tiers of government to commit an agreed proportion of their annual budgets to rural electrification by developing renewable energy infrastructure especially solar and mini hydro power.
- The Federal Government should through the Rural Electrification Agency place more emphasis on renewable energy as a viable option for the electrification of rural communities.
- In all cases, consideration should always be given to the environmental and health aspects as well as the habits and social acceptability of the systems including simplicity and low cost of applications.
- The conference recommended that a National Roundtable for Renewable Energy Matters be set up in Nigeria to represent all stakeholders. The roundtable should develop a Master Plan for Renewable Energy in Nigeria taking into consideration a robust framework for its implementation. The Roundtable should meet frequently to dialogue on the implementation and progress of the Master Plan.

2.4.4 Development of a Nigerian Bio-Fuel Policy

2.4.4.1 The Road to the Development of the Policy

The NNPC in August 2005 established a Renewable Energy Division (RED) at its corporate headquarters with the responsibility of coordinating a vision of the development of a viable bio-fuel industry in Nigeria. The key elements of the bio-fuel vision can be summarized as follows (NNPC, 2007):

- Energy self sufficiency especially in future years when the country's fossil fuel endowment are depleted;
- Development of a thriving home-grown bio-fuel industry;

- Integration of the oil and gas sector with the agriculture sector of the Country's economy;
- Maximization of Carbon credit opportunities;
- Promotion of sustainable development;
- Promotion of an environmentally friendly energy sector; and
- Support of rural wealth and job creation;

Given these elements, RED has introduced a three pronged approach to achieve its mandate. These include:

(i) The Development of a Domestic Industry Program

The plan here will be to detail out a clear vision for a Nigerian bio-fuel industry which will be systematically pursued. RED will within this framework also identify suitable feedstock for the industry and the places in Nigeria where the feedstock can be sourced. RED will promote strong technical support to these sources to ensure their viability and sustainability as part of its strategy of establishing industry foundation. The establishment of a strong foundation for the industry will also involve the development and implementation of a growth model for the industry supported by the establishment of few initial medium to large scale integrated bio-fuel projects;

(ii) Development of a Bio-Fuel Policy for Nigeria

The policy will focus on incentives and the regulatory framework that must be in place to promote the emergence of a strong and internationally competitive bio-fuel industry in Nigeria. In putting this policy together, RED articulated the need to incorporate best practice lessons from other countries;

(iii) Development of a Seedling Program

This aspect will be characterized by the early introduction of the use of ethanol and the creation of a bio-fuel market in Nigeria. To facilitate this, RED will develop the infrastructure for the effective marketing and distribution of ethanol bio-fuel in Nigeria.

RED's initial efforts at catalyzing the development of a corporate bio-fuel program crystallized into a national program. The national program, which took off from the initial efforts started by NNPC, involved extensive collaboration of various stakeholders under the supervision of an Inter-Ministerial Committee. An Inter-Ministerial Steering Committee (IMSC) consisting of the following members: Minister of Petroleum (Chair); Minister of Agriculture, Minister of Finance; Minister of Industry; Minister of Environment, Science and Technology; NNPC GMD; NITDA DG; and DPR Director. The IMSC was assisted by two bodies: A Technical Sub-Committee that derived membership from the Ministries; and a Resource Experts. The activities of the IMSC and its technical support teams culminated in the drafting of a Bio-Fuel Policy for Nigeria. The Policy Document was approved by the Federal Executive Council on June 20th 2007 and gazetted as a national bio-fuels policy the same June 2007. The framework of the policy and the incentives that were built into it provides the enabling environment that is expected to sensitize and catalyze the development of the country's bio-fuels industry.

Some key elements of the Policy include:

(a) Approval of the blending of gasoline with 10% ethanol by composition and diesel with 20% bio-diesel by composition to create a demand for bio-fuel in Nigeria;
(b) Official designation of Bio-fuels as an Agro-Allied Industry;
(c) Commercial off-take to be guaranteed by NNPC for bio-fuels produced within Nigeria;
(d) Designation of bio-fuel industry sector as a pioneer sector, which provides the basis for a package of tailored fiscal incentives, e.g., total tax, tariff and VAT, exemptions for 10 years;
(e) Creation of a Bio-Fuel Energy Commission to govern the industry in relationship with established Ministries and Agencies;
(f) Market entry shall be through the registration of Bio-fuel plants/project by the Bio-Fuel Energy Commission;
(g) Creation of mechanisms designed to promote integrated agro-industrial operations, out-grower schemes and research, e.g., through subsidized loans, issuance of licenses, public-private-partnerships, etc;
(h) Creation of a Bio-Fuel Research Agency to coordinate and promote long-term development of improved varieties, techniques and processes across existing Agencies.

2.4.4.2 The Journey So Far

According to information available from RED, between the fourth quarter of 2007 and the first quarter of 2008, the following has so far been achieved:

- The PPMC Facilities at Atlas Cove and Mosimi were modified to handle the receipt of Ethanol which will be imported as part of the seedling program to introduce E10 fuel to the Nigerian market by the first quarter of 2008;
- Initial training of PPMC/RED staff on the handling of fuel ethanol, especially in the area of quality assurance undertaken at Petrobras Facilities in Brazil;
- Fuel ethanol and E10 specifications approved by Standards Organization of Nigeria (SON);
- Marketing plan developed and selection of participating retail outlets carried out for the phased launch/penetration;
- E10 Implementation Working Group comprising DPR, Major Oil Marketers and other relevant stakeholders set up;
- Permit to import fuel ethanol secured from NAFDAC;
- Public awareness campaign commenced.

It was confirmed by RED that plans were in top gear by March 2008 for the upgrading of other PPMC facilities nationwide to handle fuel ethanol to ensure the proliferation of the E10 fuel to other parts of the country after the initial test stage hopefully which is expected to take-off not later than the beginning of the 2nd quarter of the year 2008.

3. Clean Energy Investments in Nigera

3.1 Past, Present and Future Evaluation of Clean Energy Investment in Nigeria

Investments in clean energy facilities in Nigeria have been in large and small hydroelectricity generation, solar PV, biomass, bio-fuel, and wind energy.

3.1.1 Large Hydropower Investments

Major investments in the past have been in large hydroelectricity generation in Kainji, Jebba and Shiroro. Kainji Hydropower Scheme which is located in Kainji, New Bussa in Niger State was commissioned in 1968 with a capacity of 760 MW. The facility is still operating at near full capacity and is currently undergoing modification, expansion and rehabilitation. Shiroro Hydro Electric Power Project, located in Shiroro, Niger State, was commissioned in 1990 was built at a cost of US$600 million with a capacity of 600 MW. The World Bank recently approved a loan facility totalling US$500 million for the purpose of funding the development of irrigation systems and hydropower generation on the River Niger Basin. 9 countries in West Africa are expected to be the beneficiary of the loan. The first five-year phase of the 12-year tenure of the loan will involve US$186 million (in loans and grants) to Benin, Mali, Nigeria, Guinea and Niger. Nigeria will receive US$135 million in loans out of this tranche. Nigeria has already started to utilize the loan for the rehabilitation of Kanji Hydropower facilities.

A new investment in large hydro is currently being planned in Nigeria. This is the Mambilla Hydropower project which is located in central Nigeria will harness all its waters from the Mambilla plateau as the entire catchments fall within the boundary of the country. The project will be jointly financed by the Federal Government of Nigeria and the Chinese Government. The US$1.46 billion contract for the construction of the 2,600 MW hydropower facilities was recently awarded to China Gezhouba Group Corporation (CGGC). The Mambilla station is part of Nigeria's National Integrated Power Plants (NIPP).

3.1.2 Small Hydropower Investments

The existing and functional small hydro schemes in the country are privately owned and operated by the Nigerian Electricity Supply Company (NESCO) in Bukuru, Plateau State. These include:

- Kwali Falls Hydroelectric scheme located in New Miango, Bassa Local Government Area, Plateau State with a capacity of 2.0 MW built at a cost of N25 million (US$194,000). The plant is now 86 years old and is still operational. The facility was implemented to supply power to the mining companies and the general public located near the infrastructure
- Jekko-Kurra Falls Hydroelectric Scheme located in Ankwil/Kurra and Kurra/Jekko, Jos, Plateau State with a capacity of 8.0 MW. The cost of the project could not be ascertained. The power plant which is now 78 years old supplies power to the nearby mining companies and the public living close to its site.

Other small hydropower developments of note include:

- Under the National Energy Development Project (NEDP), a World Bank assisted Energy Project in the country, the Power Holding Company of Nigeria, Federal Ministry of Water Resources, Federal Ministry of Energy and the Energy Commission of Nigeria are collaborating to build a number of small hydro power schemes across the country.
- An initiative between the Federal Government, the United Nations Industrial Development Organization (UNIDO) and Bauchi State Government known as the Waya Dam Small Hydropower Scheme located in Ganjuma Local Government Area of Bauchi State. The project which is under implementation has a capacity of 150 kW and is being built at a cost N6 million (US$ 47,000).
- There are others small hydro schemes which have been dormant for more than two decades and need rehabilitation. These are being managed by the River Basin Development Authorities (Energy Commission of Nigeria, 2007).

3.1.3 Investment in Wind Energy Systems

Utilisation 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. It has a capacity of 5.0 kWp and was built at a cost of about ₦5 million (US$40,000) by the Energy Commission of Nigeria (ECN), the Government Agency responsible for the development and implementation of energy policy issues in the country. A recent Study Report (Energy Commission of Nigeria, 2007) indicated that Sokoto and Jigawa States are currently making efforts to install wind pumps for small scale irrigation and electricity generation. The Renewable Energy Master Plan (REMP) projection for wind power in the country is 1 MW in the short term, 20 and 40 MW in the medium and long term respectively. Already, the wind energy mapping of the country has been done and Government has mandated that 10 MW of wind power farm be built in each of the six geopolitical regions in the country in the medium term.

3.1.4 Investment in Biomass/Biogas Energy Systems

Most of the existing biomass/biogas plants in Nigeria are either demonstration or pilot projects. They were/are being funded by the Sokoto Energy Research Centre (SERC), Sokoto and the National Centre for Energy Research and Development (NCERD), Nsukka under the supervision of the Energy Commission of Nigeria. As part of the biomass energy program of SERC, 200 units of improved woodstove were disseminated in Danjawa, Sokoto State while 8 units were disseminated in Kuje Prison, Abuja. Biogas plants of capacity sizes of 10 m^3 and 20 m^3 have also been disseminated in Kaduna, Ogun, Lagos, Borno, Anambra, Enugu, and Imo states (Energy Commission of Nigeria, 2007). One of such is the Achali-Nru Nsukka Biogas Plant located at Achalla-Nru in Nsukka Local Government Area of Enugu State was built in 1999 with a capacity of 10 m^3 at a cost of ₦300,000 (US$2,400). The plant which is to produce gas for cooking is to demonstrate the benefit of biogas technology and the immediate beneficiaries are members of the community engaged in Gari (cassava product and staple food in Western Nigeria) processing.

Some efforts are also being made in the deployment of biofuels in the country. For instance, through the World Bank assisted National Energy Development Project (NEDP), the Power Holding Company of Nigeria in collaboration with the Energy Commission of Nigeria are already working on a pilot project in a rural community to extract oil from Jatropha seeds to generate electricity. This is with the aim of developing a business model for biodiesel which can be used to replicate biodiesel based electricity generation in the country. Similarly, the Renewable Energy Division of the Nigeria National Petroleum Corporation (NNPC) is working on the production of automotive biomass ethanol using sugar cane and cassava. To achieve this, NNPC is seeking to create a JV ownership structure with three categories of partners – active investors, passive investors, and technical partners, which supports the following objectives:

- Ensure operational control
- Guarantee supply security for the plant to ensure maximum utilization
- Provide opportunity for additional active and passive investors to invest in order to align interests and provide access to best expertise and capabilities available

Investment requirement requirements using sugar cane are: $250-300 million consisting of Farm: $100-125 million (incl. land & irrigation) and Plant: $150-$175 million. Investment requirements using cassava are in excess of $39-45 million consisting of Farm: $4-5 million (excl. land & irrigation) and Plant: $35-40million

3.1.5 Investment in Solar Energy Systems

Various applications of solar PV in the country include Solar PV electrification particularly in rural areas. These applications have a nationwide distribution. Solar PV water pump, Solar PV Street Lighting. Solar thermal system applications in the country are Solar Dryers, Solar Chick Brooders and Solar Water Heaters. There are quite a good number of solar thermal energy projects in the country. The solar systems were financed by various bodies including the Energy Commission of Nigeria, Sokoto Energy Research Centre, the National Centre for Energy Research and Development, Nsukka, some state governments such as Sokoto State Government, Jigawa State Government, Ondo State Government, international organisations such as UNDP, JICA, United States Agency for International Development and the United States Department of Energy. Power Holding Company of Nigeria through the World Bank-assisted National Energy Development Project is also investing part of the proceeds of this credit to establish a solar PV community in a rural community in Cross River State which is very far from the national grid to address virtually all of the things that a community needs energy for. Under the same project, Power Holding Company of Nigeria in collaboration with Energy Commission of Nigeria and Fadama II Project (a World Bank assisted project in the Agriculture Sector) are also implementing some solar PV projects in Fadama communities. This is with the aim of using solar PV technologies to solve the energy problems of these agricultural and rural communities and thereby enhance their productivity, economic empowerment, and consequently standard of living.

The report of a recent study (Energy Commission of Nigeria, 2007) concluded that while a small number of the renewable energy technologies that have been deployed across the country have positively impacted energy access for livelihood activities in some of the rural areas, quite a significant percentage have been complete failures. It was observed that in the few cases where some level of success have been reported, there were very conclusive indications that: the stakeholders were significantly involved in many stages of the project cycle from planning to implementation; capacities of the users to maintain and in many cases operate the facilities, with only little technical support from the implementing agencies, were developed; the financial and technical support from the funding agencies which were in many cases foreign were very robust and adequately supported with local matching funds; and in many of the cases, early and practical community involvement resulted in the community taking ownership of the projects and this enhanced the provision of an enabling environment for project sustainability. In many cases where clear failures were recorded, many of the indices for success listed above were absent. Furthermore, it was observed that many of these failed projects were characterized by: low quality of the technical design of the project, which eventually was further compounded by improper installation/construction of facilities; very poor after installation facility maintenance framework and poor training for facility operators who eventually ran the facility aground. Many of these shoddy outcomes were attributed to mediocre supervision, monitoring and evaluation of the process of project implementation by the relevant agencies. There is also the negative impact of the weak financial support from Government for Agencies saddled with renewable energy initiatives in Nigeria. Once the external funding runs dry, government is usually unwilling to make funds available to continue the initiative. One very important lesson from the study is that bilateral and multilateral donors must build into such initiatives medium to long-term sustainability through guarantees from host government before even funding the initiative.

3.2 Obstacles to Clean Energy Investments in Nigeria

In discussing obstacles to clean energy investment in Nigeria, we shall approach it from two dimensions. The first dimension will cover general obstacles to clean energy investment. This will touch on those barriers that are general to all types of clean energy investments. The second dimension shall focus on barriers that are specific to particular types of clean energy investments. For example, in several parts of this report, we have focused on the potential role that energy from natural gas that is flared in the Nigerian oil and gas sector can play as a clean energy source in Nigeria. The fact that Nigerian gas is not playing the role that it should be playing especially at the level it should be playing it given that it is a relatively cleaner energy resource may be an indication that some barriers are limiting this opportunity. We therefore present a discussion of barriers that seems to be inhibiting the adoption of gas-flareout-to-energy projects in Nigeria amongst others. Barriers to other specific clean energy investment are discussed under the section on clean development mechanism.

3.2.1 Obstacles to Investment in General

Key general obstacles to investment in Nigeria in can be summarized as follows:

(i) Drastically Reduced Returns Due to Infrastructure Constraints

The cost of doing business in Nigeria is generally high as a result of poor infrastructures. This include: poor quality and unreliable supply of power; poor transportation infrastructure; ineffective communication facilities; etc. All these usually lead to erosion of the profit margins. The Federal Government of Nigeria is aware of this barrier, especially its impact on foreign direct investment and as such government efforts have consistently focused on alleviating these barriers through the implementation of policy initiatives that directly and indirectly mitigates these issues. Example of such recent policy initiatives include: the deregulation of the telecommunication sector, which has made communication both within Nigeria and to outside the country no more a barrier to doing business in Nigeria. The recent Electric Power Sector Reform Act of 2005 and the huge investments in the oil and gas, and power sectors are also expected to contribute to the removal of these barriers.

(ii) Political Risks

Compared to 5-10 years ago, Nigeria is relatively politically stable with a few rumbles here and there. One of the few hotspots is the ethnic rumbles such as in the Niger Delta Area where militant activities such as kidnapping for extortion are sending negative signals to potential foreign investors. The government have started to seek a solution to this through dialogue and consultation as well as the implementation of a massive development program for the Niger Delta area of the country.

(iii) Legal Uncertainties

According to a report (World Bank, 2008), Nigeria ranked 108 out of 178 countries categorized in terms of the ease of doing business in the countries. The report provides quantitative indicators on business regulations and the protection of property rights that can be compared across 178 economies. Legal uncertainties in terms of property rights, contract law, lack of international investment treaties, intellectual property concerns are at tolerable levels although when compared to international best practices it can be improved. Over the years, international investment has been coming into Nigeria to finance the oil and gas sector and as such one can conclude that the legal uncertainties have not been insurmountable.

(iv) Uncertain Evolution of Governance

Governance in Nigeria about a decade ago constituted a hindrance to the flow of investment into the country. Corruption, dysfunctional bureaucracy, non-independent judiciary all contributed to make the country a pariah nation in those times and foreign direct investment became a trickle. The relatively successful transition to a democratic government in 1999 has helped to turn things around. While the situation with many of the indices of the governance issues have not completely turned around to international best practices, it is obvious that the democratic governance over the last 8 years have set a solid base on which to build a sustainable governance, which will ensure flow of investment funds into the country. To ensure that this is the case, the Federal Government of Nigeria have set up several bodies to fight corruption in the country and these bodies have been endorsed to a slight extent, by some international watchdogs to be getting close to effectiveness in curbing corrupt practices and thereby enhance good governance and pave a smooth way for flow of investment into the country.

3.2.2 Specific Obstacles to Clean Energy Investment Flow into Nigeria

Some key obstacles to the flow of clean energy investment into Nigeria include:

(i) Lack of a Level Playing Field

A key current priority policy objective in Nigeria is the transformation of energy market to an effective and an efficiently functioning one. To achieve this objective it is important to create a level playing field in the energy market. It involves the removal of hidden subsidies and internalizing external cost. Without addressing these concerns it will be impossible for renewable energy technologies to compete with the already established alternatives. In Nigeria, as in many countries of the world, developed or developing, the price of conventional energy, especially petroleum products and electricity, with which energy produced from renewable energy technology can compete for market shares, are more often than not subsidized. This creates barriers for renewable energies to achieve any decent level of market share. Subsidies on petroleum products and electricity are mostly consumer subsidies, but in some cases, with some indirect producer subsidies. The domestic refineries in Nigeria when they function are publicly owned and provided by government with crude oil input at input cost levels that are order of magnitude lower than international market/border price of the crude. Furthermore, the pump prices are administratively set by government agencies, usually at price levels that do not take into consideration the need to recoup input costs not to talk of return on investment. When the refineries are not functioning, which is very often the case in recent years, government agencies, supported in some cases by subsidized private sector companies import these products in the country and they are made available at pumps at the same administratively set prices. Similar situation characterizes prices paid by consumers for electricity from the national grid in Nigeria. In a recent survey of 171 countries covering OECD and non-OECD (GTZ, 2007) the consumption subsidy on gasoline in Nigeria in 2005 was estimated to be about 19% of reference pump price. The reference pump price was defined as the international spot market plus distribution costs. Using this index, subsidy on diesel and electricity in Nigeria were estimated to be 17% and 24% respectively. The survey also showed that there were subsidies on other petroleum products consumed in the country in that year. The aggregate economic value of energy subsidy in Nigeria in 2005 was estimated to be about US$2 Billion. Similarly, external costs – including environmental, health, and safety- which are often significant in conventional energies are generally not taken into account in market prices of these energy carriers. In addition, benefits of renewable energies such as increased employment are often not reflected in the energy market conditions.

Market distortions should be addressed within the policy framework, a process often referred to as 'leveling the playing field', if the potentials of clean energies are to be realized.

(ii) Lack of a Renewable Portfolio Standard (RPS)

Beyond creating a level playing field, another key element of the overall framework which is not yet in place is the setting of firm and realistic portfolio standards for clean energies. A Clean Energy Portfolio Standard (CEPS) refers to minimum targets of clean energy contents of the overall energy supply to specific areas. Essentially, a policy should be put in place that will require that a certain percentage of annual electricity and thermal energy use in the country comes from clean energy. Such a portfolio will be all inclusive for all clean energy forms in the country. It will set the minimum requirement of clean energy in the overall energy mix in the country as well as the target quantity and year of entry into the energy mix. It will also include the target quantity and target year of each specific clean energy form in the overall clean energy requirement. In many cases, regulatory instruments, including legislation are often used to achieve the targets.

(iii) Lack of Fiscal and Market Incentives

Another essential but missing element of the policy framework is the creation of innovative fiscal and market incentives to encourage clean energy technology supply companies at the initial stages of introduction. This is essential especially for clean energy such as wind energy technology. The capital cost of wind turbine is still currently above the cost of fossil fuel based base–load power plant. One factor contributing to this is the lower capacity factor of wind power plants, which is about 24%

compared to excess of 70% for fossil fuel base-load power plants. The implication of this is that to produce a given amount of electricity, it is necessary to install about 2 – 2.5 times more capacity than with fossil fuel power plants. This tends to make wind energy more expensive at the initial phase of the life cycle both because of the need for more generation capacity and because of the need for greater capacity in transmission from wind power sites. This can constitute a barrier to investment and economic decisions on wind energy development. Hence, fiscal incentives such as tax credits, tax exemptions, tax reductions, or accelerated depreciation. They can be used to reduce the investment costs of renewables and attract investors. Deductions of income tax and of profit tax for corporations and higher write-off possibilities in the initial years for investors or users (accelerated depreciation allowance) have in many countries proved to be powerful means to stimulate the use of renewables. Consideration should also be given to capital subsidies incentives for example in the form of investment grants, for the purchase and installation of renewable energy systems. Direct investment grants are of particular importance when the technology to be assisted is still far away from being competitive, since other financial assistance such as loans and tax breaks by and large cannot sufficiently guarantee an economical operation. Direct grants offer the advantage that they directly increase the investor's liquidity, and even small amounts often act as an important psychological incentive for investment. Their disadvantage however is that the grants are paid out regardless of the performance or extent to which the installation operates.

As is the practice in many countries, the obstacle of lack of market incentives is being addressed in Nigeria through government-led initiatives and entrepreneurial response. Some of these initiatives include fixed price or fixed payment system and fixed capacity or fixed quantity target pursued by competitive mechanisms.

(iv) Barriers to Gas-Flare-to-Energy Projects in Nigeria

In spite of the appreciable endowment of natural gas resources in Nigeria and the fact that natural gas is a relatively cleaner energy compared to petroleum and other fossil fuels, associated natural gas is still being flared. Flaring of this clean energy resource is still occurring in a country that is characterized by frequent power shortages, and where many of the finished goods that can be produced from the flared gas as feedstock are still being imported. In this sub-section, we present a discussion of specific barriers that have constrained investment in gas-flareout projects in Nigeria. Specific barriers to natural gas flare-out projects in Nigeria in this discussion are considered as either "hard" or "soft" in line with the grouping commonly used by Global Gas Flare Reduction program at the World Bank.

The "hard" barriers include:

(a) Domination of Gas Investment by LNG Facility Development;

Investment in LNG for export provides higher returns to downstream oil companies who are usually the leading developers of such projects that have contributed immensely to mopping up a substantial fraction of gas that would have been flared in Nigeria in recent years. LNG export projects also give the FGN high returns through tax receipts and dividends from equity stakes. The major international oil companies in Nigeria have therefore shown preference for the more lucrative export of gas through LNG, and with the rising prices of natural gas in the international markets, more and more LNG export projects are being planned in Nigeria, in an environment where investment in gas transportation infrastructure to serve the domestic market is lacking. This condition is likely to continue, with gas projects for LNG exports continuing to be the focus, while infrastructure development to supply the domestic market continues to lag seriously. This situation will not result in turning out the Nigerian gas flare because there is a limit to what quantity of gas Nigeria can sell on the international market, given the competition with other suppliers. What will turn out the flare is a combination of the use of the Nigerian gas that would have been flared in both the LNG for export and aggressive domestic utilization routes. An aggressive domestic utilization of the Nigerian gas will call for a very aggressive development of domestic gas infrastructure, well beyond the levels seen in recent past. This is unlikely to happen until the FGN implement a paradigm shift in its approach to gas resource development in Nigeria. This seems to be happening as the draft of the Nigeria gas Policy that has just been approved has shown that the FGN has now recognized the fact that the continued shortfall of natural gas supply in Nigeria-a gas rich country- is an anomaly that threatens the economic aspirations of the nation. The FGN can therefore be said to be taking action to change the status of gas resource development in Nigeria from one that is LNG for export centric to one that focus first at having enough gas to power domestic activities and also add value to the gas before it is exported before contributing a decent quota to international demand for natural gas through LNG for export. This is what we call a good "paradigm shift".

(b) Lethargy in Government Leadership in the Development of a National Gas Transportation Network

Given the large endowment and production capacities for associated natural gas in Nigeria, the fact that local markets for gas are usually small, most of the time inadequate on a single end-user basis, to sustain gas flare-out projects except clustered, and more often than not far removed from the oil and gas regions where the gas is produced, a national gas pipeline transportation network is often needed to reach the goal of gas distribution to end-users. It is only when such a network is in place that domestic gas utilization can become a robust contributor to gas flare-out reduction process. When clusters of potential users are identified, access to all such markets in the country will be guaranteed when such a national gas supply grid is in existence. The inability to put this in place in Nigeria has inhibited the utilization of the clean energy resource for energy generation in many parts of the country instead of the baseline situation of flaring. The inability to implement main pipeline transmission lines to carry gas to regions far from the oil and gas producing regions of Nigeria has been one of the major barriers inhibiting the wide use of gas within the Nigerian economy. It is a well known fact that to widely expand natural gas use in Nigeria, there will be a need to implement a backbone transmission line from the South-South part of Nigeria where the gas is gathered in oil producing activities, to the northernmost part of Nigeria. Thereafter, distribution lines, driven by the relative closeness of the backbone transmission line to economically viable cluster markets can then be feasibly implemented, almost at project levels as spurs of to the different parts of the country. Such will require good planning and financial commitment of the FGN and the mobilization of private sector venture investments. The importance and resulting benefits of this pivot strategy has been demonstrated by the development of the southwest section of the existing gas grid in Nigeria. Gas utilization in Nigeria, other than for power generation did not become appreciable until the implementation of the Escravos-Lagos Pipeline (the ELP) that was constructed to transport natural gas to the Egbin Power Station in Lagos, about 1000 Km from the gas production fields of the

Niger Delta (Triple E, March 2005). With the implementation of the ELP, gas utilization in many industries along the ELP (Cement and Foods) became feasible. The implementation of the ELP has also helped in bringing natural gas to the Lagos industrial areas, where a substantial fraction of major industries in Nigeria are located, providing further opportunities for continuous shift from fuel oil to natural gas. It is also expected that availability of natural gas in the Lagos Industrial area will catalyze the implementation of Greenfield projects such as fertilizer, methanol, cement, aluminum & steel. It is therefore important that power sector planning in Nigeria should take cognizance of the fact that development of gas infrastructure to serve power generation needs can be carefully planned to ameliorate the weak markets and infrastructure barrier.

(c) High Capital Intensive Nature of Gas Infrastructure Development and Scarcity of Funds in Nigerian Financial Market

The high capital intensive investment usually required for gas infrastructure projects is another hindrance to gas flare-out-to energy project in Nigeria. This is further exacerbated by the low availability of investible funds in Nigeria coupled with the peculiar nature of gas investments. Apart from being capital intensive, gas infrastructure investments are characterized by lower return on investment compared to alternative investment opportunities in most economies. Once these investments are made, they are usually guaranteed via long-term supply contracts usually characterized by take or pay clauses. The high capital intensiveness nature of most gas supply infrastructure and the usually difficult nature of the task of putting together critical mass of start-up consumers for the local markets is usually an inhibiting factor in the development of gas flare-out to energy/clean energy projects in Nigeria.

(d) Reliability of Supply of Associated Gas (AG)

Since AG is produced with crude oil, its supply is only as reliable as the oil productions are. Any disruption to oil supplies will affect the volume of AG available to consumers. To avoid this negative impact, most gas supply programs usually have linked supplies from non-associated gas (NAG) fields. This is because relying on associated gas supplies without a back-up plan can be somewhat challenging since AG is subject to interruptions and varied output due to its direct links to oil production. This is a risk which may deter the development of gas supply contracts especially if amelioration schemes are not included in the contract. It is important that in planning gas-flare out projects, this barrier can be mitigated by coupling the supplies of natural gas from AG fields to a reliable amount of supplies from NAG fields in the gas supply schemes to guarantee that shortages that may occur during reduced oil production or interruptions can be adequately handled.

Key "soft" barriers include:

(a) Undeveloped Gas Utilization Regulatory Framework in Many of the SSA Countries

> **Box 6: *Nigeria "Flare Reduction Committee" To Develop Road Map For Minimum Gas Flaring***
>
> At the end of 2007, in an effort to reduce gas flaring in Nigeria to minimum levels, major stakeholders came together in a newly created forum for cooperation expected to develop a road map for the elimination of flaring within a realistic time frame and taking into account the complex challenges that inhibit a faster reduction of gas flaring in Nigeria. The Committee emerged out of a workshop on Gas Flaring Reduction held by the World Bank/GGFR in Abuja earlier in the year. At the meeting, high-level representatives from several ministries and sector companies agreed to establish an ad-hoc "Flare Reduction Committee" to reduce routine flaring to a minimum in the shortest possible timeframe. The work of the Committee, facilitated by the GGFR, is forward-looking, and focuses on working in the preparation of assessments on the environmental, health, and financial impacts of stopping or continuing routine flaring after December 2008, given the major inhibitors to a faster gas flaring reduction in Nigeria. These factors include: lack of adequate infrastructure to transport the gas, inadequate gas pricing, lack of capital availability for gas utilization projects, security issues in the Niger Delta, and others. The "Flare Reduction Committee" expects to provide input to the Federal Government Nigeria (FGN) and to draft an integrated 'Nigeria Flare Reduction Plan'.
>
> *Source: GGFR, World Bank 2008*

The very weak enabling regulatory framework guiding production of oil and gas in Nigeria is a critical barrier to the utilization of the resources. Traditionally, associated gas is considered a waste output of the crude oil production process in many existing national oil production regulations. This is because revenue from oil is usually a very important input in the economic development of these nations, and as such, the lack of market for the associated natural gas is usually conveniently dealt with by institutionalizing flaring as a disposal option. Ownership rights to the associated gas are either unclear or non existent. As a result, in most cases gas development prospects have been held up by the low value placed on natural gas compared with other energy sources, in particular oil and coal. In addition, contractual provisions in production contracts mostly recognize that associated gas can be used by operators within their oil fields (i.e., for EOR or energy) but provide no right to sell or commercialize it downstream. In Nigeria gas produced with the oil for years is considered a waste that is disposed off-by flaring and venting-and has zero economic value in the benefit appropriation calculation protocols used in estimating benefit sharing between production partners. This has been the common feature until very recently, whether in a joint venture or production sharing agreements. Many of the existing production sharing agreements do not allow for the recovery of costs incurred in harnessing associated gas recovery for productive uses. In the eighties, when international discussion on the need to utilize the otherwise wasted associated natural gas was at the peak, and buffered by the concerns for the environmental impacts of flaring, the Nigerian Government introduced a very feeble penalty for gas flaring. The penalty was so marginal that the oil companies rarely implemented gas flaring programs and paid the penalties rather than use the gas for even beneficial gas lifting operations in their fields. In recent times however, the situation seems to be changing as efforts are being made to develop collaborative approaches between all stakeholders (i.e., operators, government, communities, third parties, etc.) to accelerate and effectively achieve flare down through enabling frameworks, as is articulated in the Voluntary Standard for Global Gas Flaring and Venting. This is for example the case in Nigeria (see Box 6) where an emerging national regulatory framework guiding the oil and gas industry in Nigeria and specific contractual obligations between oil and gas production partners are being developed to place adequate premium on the value of the otherwise flared natural gas. More work is needed in this direction in many of the oil producing SSA countries. The Global Gas Flaring Reduction (GGFR) program of the World Bank has been very helpful in this direction and will continue to be relevant in the reduction of the impact of this barrier to gas flare-out projects in Nigeria.

(b) Poor Fiscal and Gas Pricing Regimes in the Country

In many SSA countries, energy prices in general are administratively determined and usually do not reflect market realities. As such, production of energy is in many of these countries are subsidized, sending wrong signals to market participants. In many of the countries where oil and gas activities are occurring in SSA, the need for gas price subsidy are initially driven by the need to promote gas utilization in the power sector, to displace expensive petroleum product use in the sector. This strategy has worked in some of these nations as over the years, impressive development of gas fired power facilities has occurred. The problem is that it has always been very difficult to remove the subsidy and allow for competitive pricing of natural gas which will essentially promote efficiency of utilization and optimal capacity expansion of the infrastructure required over time for the production and distribution of the energy resource. Another inherent impact is that low gas prices becomes a negative incentive to the expansion of gas infrastructure beyond the ones developed for the power sector, as under such energy pricing and fiscal regimes, it is often difficult to attract the required investment (from local and international sources) to develop gas infrastructure to the level that will reduce flaring significantly. This is a barrier that has been recognized as inhibiting the development of the gas industry in many of these countries and ongoing efforts are in place in some of the countries, for example Nigeria, to restructure the natural gas sector to promote an aggressive development of the sector under a competitive market regime.

It is important to point out that recent gas policy and regulatory development in Nigeria seems to be pointing to the fact that the days of this and other related barriers are coming to an end. Some of the salient pointers to this conclusion can be summarized as follows:

- A National Gas Infrastructure Blueprint (NGIB) has recently been developed and was formally presented to the Federal Executive Council as recent as the first quarter of 2008. This blueprint when implemented is designed to mitigate the infrastructure limitations discussed in previous sub-sections of this report;

- The National Gas Infrastructure will be made up of three components namely:
    - A wet gas transmission system which carries wet gas from the oil and gas fields to the Central Processing Facilities (CPFs);
    - CPFs which gather and process the raw wet gas and feed the resulting dry gas into the transmission lines;
    - A network of domestic dry gas transmission lines that will take processed gas from the CPFs and transport it to end users, ensuring a wide-scale penetration of gas to various regions of the country.
- The transmission infrastructure will have the following core components:
    - A wet gas transmission system made up of the existing discrete network of pipelines which carry gas from the fields to either the LNG facilities or to other small processing centers. The discrete systems will be consolidated into an integrated network or "ring road" of wet gas. The integrated network will be managed as one entity with decisions on capacity expansion determined, planned and executed in a truly integrated mode, driven by national demand requirement as opposed to the current corporate investment planning priority schedule of the joint venture operators;
    - The first ever Nigerian South-North transmission line from Calabar/Akwa Ibom through Ebonyi to Ajaokuta, Kaduna, Kano and Katsina. This South-North Backbone will form the basis for the spur line extensions to the Southeast, Northeast and Northwest opening up gas access to all parts of Nigeria;
    - The inter-connector, an East-West link at Obiafu to Oben and Ajaokuta. This will consist of a short link (about 110 Km) to the gas reserve base in the East of the Niger Delta;
    - The Western System which comprises the existing ELPS, a new proposed offshore pipeline to Sagamu which will intersect the ELPS, to provide additional supply capacity for the extensive demand in the Lagos area as well as system redundancy and future extension of the ELPS to the North.
- Three Central Gas Processing Facilities (CGPF) will also be a component of the planned NGIB. They will be the major gas hubs in the domestic gas market, where gas from the fields will be processed, and residual dry gas will be fed into the transmission system;
- The 3 CGPFs will be delineated into Central Franchise Areas which will be offered to private sector operators with stipulations on gas processing capacity and firm instruction to gas producers operating within a franchise to direct the necessary volume of gas to the CGPF within the franchise area. It is hoped that this will eliminate the current practice of individual JV companies developing own gas processing facility to promote synergy and reduce or even eliminate unnecessary sub-optimal duplication of infrastructure;
- The NGIB will be developed using the philosophy of 3rd Party private sector participation that will be driven by the need to reduce funding burden on the FGN. It will also serve to introduce new players into the gas value chain;
- It has been estimated that a total investment of between US$15-20 billion in the short to medium terms will be needed to implement the NGIB;
- A comprehensive gas pricing framework utilizing the domestic gas market centric principles described earlier in Section 2.4.2.4 of this report has also been developed and will be

effective in the nearest short time period.

3.3 Existing Incentives for Clean Energy Investments in Nigeria

In this section we present a discussion of measures and policies that have so far been put in place by the government to increase the attractiveness of the country as a destination for clean energy investment. These include:

- The development of the Renewable Energy Master Plan for the country,
- The enactment of a strong Bio-fuel Policy.
- The government has also mandated that 10 MW of wind power farm be built in each of the six geopolitical regions in the country.
- The National Gas Supply and Pricing Policy/Regulations

The REMP is a strong statement that provides government intentions as far as the development of renewable energy in Nigeria is concerned. It provides a clear pathway that government in Nigeria will like the clean energy development in Nigeria in coming years to take. By forming a division within the national oil company with mandate to execute the bio-fuel policy of Nigeria, government have also indicated its keen interest in pursuing this clean energy path to its logical conclusion. The successful implementation of the directive that at least a 10 MW wind power farm must be implemented in each of the six geopolitical regions of the country, it has sent strong signals to investors, local and foreign that the highest support will be available to such projects in Nigeria. The successful implementation of the directive will lead to the first major wind power project in the country and will serve as a template for replication and an attraction of both local and foreign investments in clean energy technologies in the country.

The existence of these general policy framework and mandates are very strong signals that will catalyze the drawing of investment for clean energy into Nigeria. If this is not going to be a mirage, there will be a need to put in place an "Action Plan" for aggressive deployment of clean energy technologies into the national energy market as mapped out in the REMP. One of the solutions to the energy crisis confronting the nation is the diversification of the present energy supply base using optimal supply mix strategies, which considers the various energy resources available in the country. Renewable energy technologies offer a lot of advantages and opportunities particularly as decentralised technologies for distributed generation of electricity and as fuels in meeting the energy needs of the vast rural populace and even peri-urban dwellers. Thus enhancing and improving the economic empowerment of these populations; and thereby reducing poverty and promoting sustainable development.

It is also important to point out that when the National Gas Supply Policy/Regulations that is currently being finalized becomes fully operational in Nigeria, then the potential use of natural gas in several ends will clear a solid pathway for investment in the increased use of natural gas as a clean energy alternative.

3.4 Opportunities for Clean Development Mechanism (CDM) as a Catalyst for Clean Energy Investment in Nigeria

Many of the clean energy investments identified and discussed in the previous section will yield energy savings compared to status quo systems, and as such will also have better carbon emission footprints. The implication of this is that the Clean Development Mechanism of the Kyoto Protocol can also serve as a source of funding for the clean energy systems through the sales of the carbon emission reduction achievable when the projects are implemented. In this section, we present a summary of a recently completed study (World Bank, 2008) that analyzed the potential for CDM projects in the energy sector of Sub Saharan African Countries. The result of that analyses is abstracted and summarized in this section for the case of Nigeria.

3.4.1 Efficient Charcoal Production

Biomass energy, mostly in the form of charcoal, is used by low-income urban as well as many rural households in Nigeria. Charcoal is also used to a significant extent in the country as fuel for cottage industries such as bread baking, cottage metal smelting operations, brick kilns etc. Charcoal production has been fingered as one of the causes of forest degradation and deforestation in many African nations, as such, the need for more efficient wood fuel gathering and charcoal production in response to the increasing urban need of energy sources has consistently been one of the critical issues of consideration in energy planning, natural resources and environmental management in Africa. Charcoal, volatile tars and a mixture of gases including GHGs are produced when wood is heated in the absence of air. The relative amounts of these three types of products depend on the equipment used and on the characteristics of the original wood. The moisture content is an especially important parameter. Dry wood produces more charcoal than wet wood. Charcoal production technologies can be broadly categorized into: the traditional earth pit charcoal production method and the earth kilns; the improved earth kilns; and the high yield, low emission systems.

The most common traditional charcoal producing technologies more common in Africa are characterized by very low yields (typically 1 kg of charcoal from 8 to 12 kg or more of wood), inconsistent quality (because it is difficult to maintain uniform carbonization) and environmental pollution from the release of tars, noxious gases, and GHGs. The high yield low emission charcoal making facilities are made with the philosophy of improving both the environmental performances of the equipment as well as their charcoal yield. Many of these kinds of systems that are commercially available can achieve yield as high as 1 Kg of charcoal from 3 to 4 Kg of wood. They are also usually equipped with systems where part of the energy of initial combustion that are more often wasted in traditional processes is recuperated and utilized in drying the initial wood charge. In a typical system, steel vessels or retorts are filled with pre-dried wood and placed in a ceramic brick-lined carbonization furnace heated to 900 degree centigrade. The tars and gases produced as the wood heats up are led to a separate high-temperature combustion chamber. The flue gas from this combustion chamber is used to heat the carbonization furnace, and the remaining heat from the furnace is used to pre-dry the wood. The new high-yield, low-emission charcoal factories have higher investment costs than the old-fashioned brick or steel kilns or retorts. However, in many cases the improved yield more than compensates for the higher investment, so the improved emissions come as a no-cost bonus. As a result, this relatively new technology has spread in the past two years, not only in the environment-conscious countries of the European Union (France, the Netherlands), but also in Eastern Europe (Estonia) and in developing regions (China, Ghana, South Africa).

Another example of the kind of modern charcoal making technology that can be adopted for clean energy projects in Nigeria is the Retort Kiln ('Adam's Retort") also called the Improved Charcoal Production System (ICPS).

The transformation of wood into charcoal occurs in a heterogeneous process with three phases namely: the ignition; carbonization and cooling. It takes about 6-12 hours to heat up and ignite the kiln from cold start and once the ignition process is started, it is kept going via a small amount of air allowed into the kiln chambers until completion, signified by the onset of carbonization. The carbonization process commences when the kiln temperature reaches about 180 ^{0}C. Most of the exothermic heat is released during the carbonization phase thus increasing kiln temperature further. Up to now, the processes produces a host of gases including CO_2 and CH_4. Research has shown that CH4 production occurs at higher kiln temperatures. It has also been demonstrated through research that the temperature in the kiln plays a major role in the carbonization process and it is the key to the efficiency of wood to charcoal conversion achievable. At the end of 2-3 days of carbonization, the kiln is fully sealed to allow the cooling phase to commence. When the temperature in the kiln is low, it is opened and the charcoal is discharged.

The following assumptions were made in the evaluation of the CDM potential of the scenario involving the introduction of efficient charcoal making technologies to replace the traditional (and very inefficient) charcoal kilns common in SSA countries. Some of the assumptions are required in the implementation of the analytical framework presented above:

- The baseline is made up of the traditional charcoal making facilities in all the SSA countries.
- For the baseline scenario therefore, we have assumed a minimum yield of about 250 Kg of charcoal from about 1200 Kg wood.
- For the CDM project we have assumed the replacement of the traditional charcoal making facilities with high yield, low emission charcoal making systems. Specifically, we have assumed that the "Adam's Retort" with a yield of 250 Kg of charcoal from about 650 Kg of wood on a dry basis will be adopted in all the countries
- Since data on charcoal consumption in each of the SSA countries from the FAO was available for the period 1990-1996, we extrapolated this statistics (FAO 1997: Fuelwood and Charcoal Consumption in Africa) for the period to obtain an estimate of charcoal consumption in each SSA country in the year 2003.
- Although both CO2 and CH4 are produced and released in typical charcoal technologies, we have considered the estimation of emission reductions from CH4 as a result of the implementation of the project scenario because: the existing approved methodology (AM0041) which is the basis of this estimation is valid only for CH4 emissions; since CO2 emissions in the process is from a biomass resource, emission reduction cannot be claimed

as it is CO2 within the normal carbon cycle (according to the prevailing rules of the CDM process).

- The CH4 emission factor used in the analysis is based on the characteristic equation relating CH4 emissions to charcoal yield in the Plantar, Brazil Charcoal Project, which is the underlying project activity for AM0041 (UNFCCC: PDD for Plantar_Brazil_Charcoal Project NM0110_Rev).
- Each "Adam Retort" of the ICPS technology is capable of producing 250 Kg of Charcoal in each batch process with batch duration of 30 hours. At a capacity utilization of 80% each Retort has an annual production of 58.4 tonnes of charcoal;
- We have assumed that each CDM project contains a minimum of 150 Adam retorts with a total capacity of 9,855 tonnes of charcoal per annum;
- The capital cost of each CDM project is assumed to be about US$ 126,000 (made up of the cost 500 Euros per Retort plus allowance for 20% to cover other capital costs);
- It has been assumed that losses from the production facility, transportation and distribution to the consumers of charcoal in each SSA country will not exceed 5%.

Table 14 provides a summary of the results of the analysis of the CDM potentials of introducing more efficient Adam's Retort as the charcoal making technology to replace the inefficient traditional charcoal facilities prevalent in many SSA countries, using 2003 statistics on charcoal for the countries.

Table 14: Potential Benefits of Improved Charcoal Production as a CDM Project in Nigeria

Charcoal Consumption in 2003 (tonnes/annum)	Estimated GHG Emission Reduction (tCO_2e/annum)	Estimated Project CAPEX (million US$)	Estimated Carbon Revenue (million US$/annum
1,214,100	1,605,440	16.30	14.69

In calculating the carbon revenue that can accrue from the CDM projects, we have assumed a price of US$10/$tCO_2e$ will be achieved in the emission reduction purchase agreement. From the report from which this summary was abstracted, over 120 of such CDM projects organised more likely into a national program of activities can be developed to achieve such a carbon fund transfer.

3.4.1.1 Barriers to the Implementation of Efficient Charcoal Production as CDM Projects in Nigeria and Potential Mitigation Actions

The following specific barriers have been identified as limiting the ability to introduce efficient charcoal production technology in Nigeria:

(i) The Barriers

(a) Policy and Legal Barriers

The introduction and success of the improved charcoal technology will require the existence of appropriate government policy that will promote the assimilation of these technologies under a sustainable resource management environment. Such government policies are required for: providing the enabling environment in which such technology will thrive; ensuring that the required resources are mobilized; and encouraging the needed private sector investment to complement public investment in the sector. This is not only true for improved charcoal technology but for all other types of renewable energy technologies. The absence of appropriate policy and legal framework to perform these roles may inhibit the smooth introduction of improved charcoal technologies as a replacement for the traditional technologies in Nigeria.

(b) Sustainability of Forest Resource Utilization

In order to produce charcoal, trees must be removed from the forest hence the deforestation link. Sustainable supply of wood is therefore an important consideration in charcoal production and management policies. Although the project considered in this section of the study will involve the introduction of more efficient charcoal making technology to replace the traditional ones, which will reduce the amount of wood needed to produce a unit of charcoal, still sustainable forest resource issues must still be tackled. One common argument that has always gone against expanded promotion of the use of charcoal in many SSA countries is that the introduction of more efficient charcoal production technologies to SSA countries may result in expanded utilization of charcoal within the economies. The great concern for expanded consumption of charcoal in SSA countries is that charcoal is most likely to be produced from core forest resources compared to fuelwood which is usually from residues and non-core forest resources. In this respect, the increased use of core forest resources for charcoal production could pose a threat to the future of forest resources in local terms, especially in situations of high demand for charcoal such as is usually seen in the periphery of large urban zones, especially in countries where there is lack of proper forest management practices and regulation. This perception even if it is not going to happen in real terms may constitute a real barrier to the introduction of more efficient charcoal technologies in Nigeria. An important point here is that if charcoal were produced on a sustainable basis, (i.e., without causing deforestation), it would be neutral to the carbon cycle and not only will its production in more efficient technologies lead to lower GHG emissions (compared to the traditional technologies), its use as a fuel in end-use facilities will be neutral to the carbon cycle, as its burning will simply release timescale CO_2 back into the air. The cardinal issue here is that the introduction of improved efficiency charcoal technologies should be carried out within the scope of national forest resource management in Nigeria.

(c) Insufficient Institutional Capacity to Develop Clear, Cost-Effective and Feasible Charcoal Production Implementation Strategy

A successful and sustainable charcoal production program will require careful resource planning as well as technology assimilation. The usually inadequate capacity for analyses, planning, implementation, monitoring and evaluation of programs which is prevalent in many SSA countries may constrain resource planning and technology assimilation. Institutional framework needed for the coordination of the implementation of sustainable resource use in charcoal production and use are usually not found in most SSA countries, and this may constrain the success of charcoal programs in those nations.

(ii) Potential Mitigation Actions

The following actions must be taken as part of a strategic framework to promote the development and implementation of efficient charcoal production technologies in Nigeria

- To discourage increased use of unsustainable biomass resources for charcoal production, large charcoal production facilities should only be approved for dedicated fuelwood plantations (sustainable biomass). Not only will this earn emission credits from the improved and efficient charcoal production, but carbon sequestration from the dedicated woodlot may also qualify for additional credits.
- Institutional, policy and regulatory framework must be in place to guide the organized development of this technology in the country. Such a framework will provide clear signal to project developers of governmental support for their business and thus aid in mobilizing the needed private sector investment.

3.4.2 Replacement of Incandescent Light Bulbs with CFLs

For consumers with access to electricity, the commonly used light bulb for lighting is the incandescent lamps. CFLs which are more efficient and now becoming more affordable are now available to replace incandescent lamps. Many CFLs can fit in the existing incandescent light fixtures. Compared to incandescent lamps of the same luminous flux, CFLs use less energy and have a longer rated life. In the United States for example, it has been estimated that a CFL can save over US$30 in electricity costs over the lamp's lifetime compared to an incandescent lamp and save 2000 times their own weight in greenhouse gases. The purchase price of a CFL is higher than that of an incandescent lamp of the same luminous output, but this cost is recovered in energy savings and replacement costs over the bulb's lifetime (Energy Star www.energystar.gov/index.cfm?c=cfls.pr_cfls). Programs that introduce CFLs into the residential lighting system are one of the very feasible paths to clean energy investment in SSA countries. Projects involving changing the use of incandescent lamps currently commonly used for lighting in many of these countries to the use of CFLs will lead to a reduction in electricity consumption, due to the higher energy efficiency of the CFLs. These types of projects can use the approved methodology AM0046. Two types of projects are foreseen:

- The bulb changes are effected at the level of the subscribers and are initiated by the electric utility;
- The bulb changes are effected at the level of the subscribers in rural environment and are initiated by a concessionary agent other than the electric utilities.

A summary of the evaluation of the potential of CFL lighting implemented as CDM projects in Nigeria is presented in Table 15.

Table 15: CFL Replacing Incandescent Lamps in Lighting Application as CDM Projects in Nigeria

Annual Electricity Generation in 2003 (GWH/annum)	% Electricity that can Potentially Saved by a National CFL Project	Estimated Emission Reduction (tCO_2e)	Estimated CAPEX (Million US$)	Estimated* Earnings from Carbon Trading (Million US$/annum)
20,700	6.8	1,221,385	235.6	12.21

**It is assumed that the CER price will be about US$10/tCO2e*

3.4.2.1 Barriers to the Implementation of Efficient CFL Lighting as CDM Projects in Nigeria and Recommended Mitigation Actions

(i) The Barriers

The following are barriers that are likely to hinder the implementation of a program to replace incandescent lamps with CFLs as CDM projects in Nigeria, if they are not properly mitigated:

(a) Multiplicity of Actors

As this program is likely to involve a multiplicity of actors (the households, project proponents, the State etc) who are likely to have different focus, lack of proper coordination may inhibit the ability to achieve success.

(b) Getting the Initial Interest of Project Actors

Households will be an important component of this project in whatever form they are developed. In order to enhance their interest, there is usually a need to subsidize some of the project inputs, e.g., the prices of CFLs. It is important that this properly organized and managed in a way that its objective is achieved without hiding the cost of the subsidy.

(c) The Usually Long-life of the CFLs

CFLs have longer lifetimes when compared to the more common incandescent lamps. As a result, it is usually difficult to maintain reliable sales points for CFLs using the traditional stores. CFLs are not frequently replaced, hence many regular stores in developing countries usually do not maintain required stock levels to properly service big demands. More often than not, sale points often are centralized in the big stores in city centers, which may be far from peri-urban dwellings. They are often also not very easily available in rural stores where majority of consumers in a national Nigerian program of activities lives. This has been known to constitute a barrier to the access of these bulbs. In other CFL programs that have been implemented in recent past in developing countries. In many of these programs, it was discovered that CFL sales points eventually turn out to be located diffusely, making the commodity not easily accessible to consumers.

(d) Weak Quality Control Regimes in Many SSA Countries

Quality control regimes in most SSA countries including Nigeria are weak and as such it may be difficult to control the quality of CFLs available in the country market after the implementation of the program. Lower quality bulbs are therefore likely to find their way into the market. The lower performance of such bulbs may discredit the performance of the project in the minds of consumers and hence constrain success.

(ii) Potential Mitigation Actions

The strategies to mitigate the barriers identified in the last sub-section are discussed in this sub-section:

- This CDM projects should be packaged as Program of Activities (POAs). This will facilitate effective interactions and engagement of the multiple project participants who will host the CDM Project Activities (CPAs). Problems associated with multiplicity of diverse actors can be solved by ensuring that:
    - The participating partners (households or industries), are clearly identified and properly carried along on the objectives and the implementation cycle and requirements of the

project;
  - The participating partners must be given a sense of ownership and active participation in the project from the inception of the program;
  - Some level of tangible benefits must be shown to accrue to them as project participants to engender their cooperation through the lifetime of the project.
- The longer lifetime of some of the project components e.g., CFLs relative to Incandescent Lamps that will be substituted in the program has been identified as a likely constraint to the sustainability of the program. Towards this end, to ensure availability and good access, of CFL retail and wholesale points, there may be a need for financial support for selected sales shops to stock optimum number of these bulbs at the beginning of the program. There may also be a need for funding support to develop new sales points in rural and peri-urban areas;
- Standards organizations and authorities in each country should ensure that international standards guiding the quality of CFLs are adopted in each country. They should also work with the country Agencies that are usually saddled with the responsibility of monitoring the quality of goods on the country markets, to ensure that the CFLs on each country's market adhere strictly to the adopted standard.

3.4.3 Opportunity for Biomass Fuelled Power Plants as CDM Projects

In an earlier section of this report, generation of power using the carbon neutral biomass as fuel was decsribed as a clean energy potential. The biomass fuels considered in the presentation were: agricultural residues generated in the crop cultivation process and forest residues generated in the lumber industry as well as in the processing of wood. We evaluated the potentials of using these different types of residues as fuels for power generation in a recent study (F. B. Dayo, 2007). The summary of the results of the analysis is presented in Table 16.

Table 16: Power Generation Potentials of Biomass Residue in Nigeria

Biomass Type	Biomass Available (thousand tonnes)	Power Generation Potential (MW)	% of Country Installed Capacity	Estimated Cost (Million US$)	Estimated Emission Reduction (tCO_2e/annum)	Estimated Earnings from Sales of CERs (Million US$/annum)
Agricultural Residues	35,687	4,113	69.8	5,758	20,959,400	209.59
Forest Residues	14,054	1,824	31.0	2,553	9,142,100	91.42
Wood Residues	3,249	703	11.9	984	3,522,400	35.22
Total	52,990	6,640	112.7	9,295	33,623,900	336.24

Source: F. B. Dayo, "Opportunities for CDM Projects in Anglophone SSA Countries", World Bank 2007,

The results above shows the robustness of the potential of biomass fuelled power generation in Nigeria. About 6,640 MW power capacity fuelled by biomass residues can be implemented in Nigeria. This clean energy potential will require slightly over US$9 billion to put in place. Apart from revenues from sales of the power, about US$ 336 million per year can be generated from the sales of the cabon emission reduction when the projects are implemented under the CDM process.

3.4.3.1 Barriers to the Implementation of Biomass Residue to Energy as CDM Projects in Nigeria and Recommended Mitigation Actions

(i) Barriers that can Limit the Implementation of Agricultural Residues to Energy as CDM Projects in Nigeria

Specific barriers that may inhibit this potential CDM opportunities in Nigeria will include:

(a) Access to and Recoverability of Agricultural Residues

The residues produced during the management of cultivated plots and harvesting of agricultural products in many Nigerian farms are usually located in areas that may not be easily accessible for collection. Access to these materials is likely to be difficult as a result of the poor and in some instances non-existing transportation infrastructure prevalent in many parts of the country. This will to a certain extent inhibit the recoverability of the agricultural residue.

(b) Residue Pre-Use Transformation Technology Requirements

More often than not, residues normally collected from agricultural operations cannot be used in the form collected as a fuel for energy generation. There may be a need to pre-dry it before use, size reduction may be needed or there may be a need to briquette the residues to increase its energy density before being used as a fuel. These are transformation needs that may require technology skills not usually available in many developing countries and may constitute a barrier to the use of agricultural residue as a fuel for energy generation.

(c) Cost of Biomass to Energy Production Compared to Energy Generation Using Fossil Fuels

Compared to fossil fuel fired energy generation systems, biomass fuelled systems tend to have higher initial capital cost requiring higher investment which may constrain firm investment decisions (FID) in a capital constrained environment such as the one usually found in Nigeria. This may constitute a barrier to the adoption of biomass energy investments in these countries. Apart from the slightly higher cost of the biomass-energy conversion technologies, most of the other cost components which are specific to biomass systems (e.g., extra cost for pre-fired biomass handling and processing) can be considered as incremental cost that must be covered by special financing mechanism if the biomass energy system is to be competitive relative to other alternatives.

(d) Non-Existing or Weak Power Purchase Agreement

Electricity generation from these biomass projects is likely to be in excess of electricity requirements of the non-power utility enterprises where the projects are located. Because agreements for buy back of power from such generators of excess power by operators of existing power grids usually are not in place or are often not well established in Nigeria, selling excess generation to the grid is usually problematic and the inability to evacuate power generated has been known to deter investment in such facilities in many developing countries.

(e) Negative Impact on Agriculture When Residues are Collected

Another consideration when evaluating recoverability of agricultural residue generated is the importance of the residues to agricultural production. In many agricultural operations, agricultural residues do provide certain functions which may have implications for agricultural productivity and if collected as a fuel for energy generation may impair such functions. The important point here is that not all the residue generated should in principle be recovered as they are needed on the field as part of sound agricultural practices. The primary consideration in agriculture is maintaining the productivity of the soil where crops are grown. Since one of the cardinal values of the CDM process is the promotion of sustainable development in the non-Annex 1 host countries, use of the residues may be seen to impair an essential component of sustainable development, i.e., agricultural productivity.

(ii) Recommendations on Barrier Mitigation for Agricultural Residues to Energy CDM Projects

The following actions must be undertaken as part of an overall strategy to promote the use of agriculture residues as fuels for generating energy in SSA countries:

(a) A comprehensive review of the impact of existing transportation infrastructure on access to and recoverability of the residues should be carried out on a national scale in each country prior to developing such projects. Such national reviews should utilize geographic information system (GIS) techniques to map the occurrence of the residues with infrastructure availability and potential sites of the energy generation facilities. Such a mapping will be used on a case by case basis by project proponents to propose actions that will eliminate access and recoverability barriers to the barest minimum;

(b) A national program geared towards promoting generation of energy using biomass resources, including residues should be established in each SSA country. The inventory of biomass residue availability and transportation infrastructure review should be one of the pioneering activities of the program, among others. Efforts should also be made as part of this national program to develop relevant capacities in each country on residue pre-firing transformation technologies and biomass energy generation technologies that will be used in such projects. These will enhance the capacity to develop these projects under the CDM process;

(c) A comprehensive regulatory and institutional framework that will provide transparent operating environment for the adoption of clean energy technologies must be put in place in each of the SSA country. Such a framework should carefully address issues such as: power purchase tariffs; power purchase agreement format; reform of the power sector; roles and rule of engagement of Independent Power Producers (IPPs); technology adaptation, specification and quality control protocols, among others;

(d) Since agricultural productivity in the subsistence farming practiced in Africa is very sensitive to the amount of residues left on the farm after harvesting, an expanded use of residues for energy may grossly affect farming activities. For example, residues serve as mulch in farms in SSA countries. Some of the important functions in farms include: protection of the soil from erosion; reduces compaction from the impact of heavy rains; conserves moisture, thereby reducing the need for frequent watering (irrigation); maintains a more even soil temperature; prevent weed growth; etc., all important functions for agricultural productivity. The implication of these is that in using agricultural residue as fuel for energy generation there will be a need to strike an optimal balance in alternative residue utilization. Therefore it is very important that agricultural research should be carried out to develop optimum agricultural extension service procedures to assist farmers to cope with the likely increase in the use of the residues.

(iii) Barriers that can Limit the Implementation of Forest and Wood Residues to Energy as CDM Projects in Nigeria

The following barriers can limit the potential implementation of forest and wood processing industry residues to energy as CDM projects in Nigeria:

(a) Access to and Recoverability of Forest and Wood Processing Industry Residues

Access to residues generated in the forests during the harvesting of round wood and perhaps to a lesser extent for residues from wood processing industries can be a problem in Nigeria due to the very bad transportation infrastructure prevalent in many parts of the country. The situation are however likely to be less of a bottleneck compared to the situation with agricultural residues. This is because in the logging operations, access roads are usually created for the lumber trucks to facilitate the timely evacuation of the logged round wood. This will create some motorable access to the residues. Another important issue arises from the fact that even when access to the residues is not a constraint, not all the residues produced during logging operations in the forest should and can be recovered. Woody debris left on the ground has been known to deter erosion and, its decomposition, helps maintain soil fertility and tilth.

(b) Pre-Use Transformation Requirements

Residues normally available for collection after forest logging operations are usually with high moisture content usually requiring drying before it can be used as a fuel in energy generation facilities. This is also true for residues produced in the processing of these round wood products. Also, residues produced in forestry operations as well as in the processing of these woods apart from been wet, can also be available in sizes that requires some amount of size reduction or in some cases a fair amount of densification, before it can be optimally used as a fuel. The levels of transformation needs may constitute a barrier to the use of these residues as a fuel for energy generation.

(c) Cost of Biomass to Energy Production Compared to Energy Generation Using Fossil Fuels

The arguments presented under this barrier category in the section on agricultural residue to energy projects is also applicable for the case when wood processing residues are used as fuel for power generation. Additional revenues that will be generated when such facilities are implemented as CDM projects are likely to improve the financial standing of such projects, compared to without CDM. Implementing these projects as CDM may also bring to the table, knowledgeable technology partners, who will bring to the project not only the mastery of the technologies but also incremental financial contributions that will help to overcome the barriers relating to the relatively unattractive economics and innovative/complexity aspects of the projects.

(iv) Barrier Mitigation Recommendations

The following actions may need to be undertaken as part of an overall strategy to promote the use of wood processing residues as fuels for generating energy in Nigeria:

(a) A comprehensive review of the impact of existing transportation infrastructure on access to and recoverability of the residues should be carried out on a national scale. Such a national review will have to utilize geographic information system (GIS) technique to map the occurrence of the residues with infrastructure availability and potential sites of the energy generation facilities. Such a mapping will be used on a case by case basis by project proponents to propose actions that will eliminate access and recoverability barriers to the barest minimum;

(b) Efforts should be made at the onset of the national program to develop relevant capacities in each country on residue pre-firing transformation technologies and biomass energy generation technologies that will be used in such projects. These will enhance the capacity to develop these projects under the CDM process;

(c) A comprehensive regulatory and institutional framework that will provide transparent operating environment for the adoption of clean energy technologies must be put in place in the country, specifically as part of the Renewable Energy Agency mandate as well as the ongoing power sector reforms. Such a framework should carefully address issues such as: power purchase tariffs; power purchase agreement format; reform of the power sector; roles and rule of engagement of Independent Power Producers (IPPs); technology adaptation, specification and quality control protocols, among others;

(d) The awareness of the wood processing industry sector on the importance of utilizing the waste generated in their operations for energy generation should be raised. Not only must they be encouraged to invest in such facilities for energy generation, but also, their capacity to develop the projects as CDM from the design stage of such projects should also be built using government led international collaborations. Other stakeholders such as energy planners, industrial sub-sector, banking sector, municipalities, and civil society should be targeted to develop their interest in such ventures.

3.4.4 Opportunities for Bio-Diesel Produced from Jatropha as Energy Based CDM Projects in Nigeria

3.4.4.1 Opportunity for Bio-diesel as a Fuel for Power Generation in Nigeria

In an earlier section, we discussed the potential of producing biodiesel from Jatropha in Nigeria. A fraction of the biodiesel so produced can be used to replace petroleum diesel used currently to generate onsite power in Nigeria. As a result of the inadequate and unreliable supply of power from the grid in Nigeria, onsite generation in various sectors of the country's economy is said to be more than half of the grid installed capacity. Most of these supplies are fulled by petroleum diesel. Subtituting petroleum diesel is a potential clean energy system, and when implemented as a CDM project, it can earn valuable monetary benefits from the sales of the CERs in addition to revenues from the power generated. This potential was recently evaluated (F.B. Dayo, 2007). Table 17 is an extract of some of the results of the analysis, especially as it relates to the use of bio-diesel from Jatropha as a replacement for petroleum-diesel for power generation in Nigeria.

Table 17: Potentials of Bio-diesel Fired Power Generation in Nigeria

Petro-Diesel Used for Power Generation in 2003 (Thousand Barrels/day)	Bio-Diesel Replacement (Thousand Barrels/day)	Power Generation from Bio-diesel (MW)	% of Installed Grid Capacity in 2003	Estimated Cost of the Substitution Project (Million US$)[1]	Estimated Emission Reduction (tCO_2e/annum)	Estimated CER Eranings (Million US$/annum)
6.62	7.35	163	2.76	4.77	923,980	9.24

The cost of the substitution is the amount needed to retrofit the existing diesel engines to utilize bio-diesel as fuel.
Source: F. B. Dayo, "Opportunities for CDM Projects in Anglophone SSA Countries", World Bank 2007

The cost of the project in the Table does not include the cost of the petro-diesel but only the cost of retrofiting existing petro-diesel engines for the use of bio-diesel. The bio-diesel will be sourced from a project developed to produce bio-diesel from jatropha for: domestic use as a transport sector fuel; as a fuel for other greenfield bio-diesel fuelled power plants; and for export of bio-diesel. According to the analyses, assuming that 2% of Nigerian available arable land is dedicated to Jatropha plantation, about 20,000 barrels of bio-diesel can be produced in Nigeria. Out of this: about 12.6% will be dedicated to meeting the demand for bio-diesel in the B-20 transport fuel program; about 12.2% will be used to displace petroleum diesel used in power generation; while the balance will be available for other domestic uses and export to other countries. Of course, a more aggressive Jatropha plantation program is likely to be pursued in Nigeria, given the likely international demand for biofuels.

3.4.4.2 Opportunity for Bio-Diesel from Jatropha as Transport Sector Fuel as CDM Projects in Nigeria

Although as of the time of carrying out this study methodology for considering bio-fuels as clean energy option able to yield significant GHG emission reduction has not been firmly established within the UNFCCC framework, it is obvious that efforts in that direction are intensive. Some of the issues that have consistently made it very difficult to have a reliable CDM methodology for bio-fuels in the UNFCCC project methodology repository include:

- The fact that Life Cycle Analysis (LCA) may not support the generally accepted notion of carbon neutrality of bio-fuels, especially when the analysis is extended to cover the cycle from cradle to grave;
- Shift of pre-project activities when they occur as a result of the bio-fuel project activity, may nullify some emission reduction claims;
- If the CDM project causes deforestation in an otherwise vegetation rich ecosystem, emission reduction claims will be further eroded;
- The food versus fuel pressure when the bio-fuel feedstock is also a food commodity tends to have an upward pressure on food prices and a negative impact on sustainable development.

In spite of these, bio-fuels if carefully implemented can be considered a clean energy system. The direction of analyses in a recently concluded study that analyzed the potential of bio-fuel production and utilization as CDM projects in SSA was to factor the issues elucidated above and others that are likely to degrade the quality of the GHG emission reduction achievable in the analysis of the CDM potential. The Jatropha route seems to fit into the goal of promoting sustainable development in

Nigeria as in other SSA countries as the seed from where crude Jatropha oil is extracted is not a food commodity and as such the food versus fuel issue do not apply here. The assumption was made in the evaluation carried out in that study that the land that will be used for the cultivation of Jatropha in the SSA countries will be degraded land. This will ensure that the impacts of shift of pre-project activities are kept to the barest minimum. In addition, since the cultivation of Jatropha will only be carried out on degraded lands, deforestation argument due to cultivation was ruled out. Furthermore, in the top-down analyses carried out in the study, GHG sequestration that will occur as a result of the afforestation of the degraded land due to Jatropha cultivation was excluded in emission reduction calculations. Emissions arising from agricultural practices (application of fertilizers, mechanical tillage etc.) for the case of Jatropha were also assumed to be negligible. Relevant scenarios used in evaluating this CDM opportunity in SSA countries applied to the case of Nigeria, covered the following elements:

- The cultivation and harvesting of Jatropha curcas on 2% of Nigerian land area;
- Extraction and transesterification of crude Jatropha oil to produce refined oil (B100);
- Blending of a quantity of B100 as an equal replacement of petro-diesel to produce B20 containing up to 20% blend (the level at which no engine modification is required) as domestic fuel for existing stock of diesel autos in the country is implemented as CDM projects.

Other key assumptions used in that study that are also adopted here to simulate the CDM opportunities from the cultivation of Jatropha on 2% of degraded land in Nigeria, the extraction of PPO from the resulting seeds; the esterification of the PPO to produce bio-diesel; the blending of a portion of the resulting B100 with gasoline to produce B20 fuel for the transportation sector in Nigeria include:

- The Jatropha plantation are in units of 10,000 hectares implemented in different parts of Nigeria where degraded land is available;
- The Capital Cost for the implementation of the plantation is US$700,000 per 1000 hectares;
- The capital cost of the bio-diesel production plant is US$100 per tonne of Jatropha oil produced;
- The maximum capacity of each Jatropha crude oil processing plant is 100,000 tonnes/yr;
- A CDM project is equivalent to a single bio-diesel production facility with a processing capacity of 100,000 tonnes/yr or less together with its ancillary jatropha cultivation;

The results of the analysis of the production of B20 transportation fuel (a blend of refined jatropha oil with petro-diesel) as a CDM project in each of the country is presented in Table 18.

Table 18: Potential of B10 as a Transport Sector Fuel Implemented as CDM

Estimate of Jatropha Oil Produced from 2% Cultivated Land (BBls/day)	Quantity of Jatropha Oil Blended in B20 (BBLs/day)	Emission Reduction of the B20 Project (tCO_2e/annum)	Estimated CAPEX of the B20 Program (million US$)	Estimated Earnings from CER Sales (million US$/annum)
60,280	7,500	1,187,800	1,565	11.88

One very important conclusion from the analysis is that cultivation of Jatropha on 2% of the land area in Nigeria will yield over 60,000 Barrels per day of bio-diesel (B100) out of which about 12% will be needed to blend domestic consumption of B20 and about 0.01% will be needed to replace all the petro-diesel utilized in Nigeria for power generation and the balance of about 88% will be available for alternative uses including: for power generation in Greenfield generators; as fuel in other domestic energy needs e.g., lighting in rural areas to replace kerosene; and exports to both Annex 1 and non Annex 1 countries. The emission reduction reported in Tables 17 and 18 are only for domestic power generation (using existing diesel generators) and for blending in domestic B20 consumption.

3.4.4.3 Barriers to the Implementation of Biodiesel for Energy Program as CDM Projects in Nigeria and Recommended Mitigation Actions

(i) Barriers that can Limit the Bio-Diesel from Jatropha Program as CDM Projects in Nigeria

Jatropha as a feedstock for bio-diesel production is likely to exhibit some advantages over other likely feedstock candidates because: it is a crop that grows all year round and thrives in almost any kind of environment, even in arid regions; it is not a food plant and as such it is unlikely to suffer price pressure originating from the food versus fuel dichotomy like many other potential energy plants. Notwithstanding these advantages, the following specific barriers have been identified as likely to inhibit the success of a sustainable Nigerian bio-diesel for power generation program:

(a) Sustainability of Jatropha Farming for Bio-diesel

The subsistence nature of agricultural practices in many African countries which are rain fed, which does not involve the optimal use of fertilizers, and for which mechanization to achieve high yield per hectare is not common, will make it difficult to achieve yields in excess of 1 tonne per hectare in organized Jatropha farming. For Jatropha farming targeted at bio-diesel production, the key question will be the introduction of Jatropha farming techniques that will facilitate the production of bio-diesel that will be competitive with petrol-diesel to make the substitution economic and hence sustainable. The cultivation of Jatropha in formal farm lots is a recent phenomenon in many African countries except a few (e.g., Malawi). In many of these countries, Jatropha has not been grown in the past for its economic or food value and as such, not much attention has been paid to techniques to promote sustainable Jatropha farming techniques. The situation is changing and the weak agricultural extension service focus on Jatropha is also changing with the increasing importance of Jatropha as a feedstock for bio-diesel production.

(b) Low Capacity for Technical Know-how for Jatropha Oil Extraction and Bio-diesel Processing in Most African Countries

The oil must be extracted from the oil seeds first and pre-processed to yield clear pure plant oil (PPO). The technology for extracting PPO from Jatropha seed have started to be slowly disseminated to some few African countries. The speed of technology dissemination and assimilation in more African countries will have to be increased if a sustainable continental bio-diesel supply axis is to be developed. The Nigerian bio-diesel supply activities, starting from the technology to extract the PPO to the technology for transesterification, will have to be properly planned with adequate levels of process-engineering research to complement the usual traditional turnkey importation of technology approach. The low technical capacity in Nigeria like in many other African countries may constitute a barrier to this CDM project opportunity in Nigeria.

(c) Weak Institutional Infrastructure

For the success of this national program, it is essential that an institutional framework be put in place to coordinate and manage the program. Weak institutional infrastructure that currently exists in the deployment of renewable energy opportunities in Nigeria can constitute a barrier to the success of the bio-diesel from Jatropha project in the country.

(d) Availability of Adequate Infrastructure and Logistics to Handle the Volume of Bio-diesel Expected

Only in very few African countries (e.g., Malawi) do we find a tradition of making oil from seeds in rural oil mills which can easily be adapted to Jatropha. In Malawi for example, it has been reported that processing raw Jatropha oil into bio-diesel exist on a small scale. The recent introduction of the Multi-Functional Platform (MFP) utilizing Jatropha in some African countries, through which PPO from Jatropha will be utilized as a fuel, is extending such experience to more countries in Africa (Brew-Hammond, 2002). Such experience does not currently exist in Nigeria. To operate Jatropha business even at the scale called for by the dedicated cultivation of only 2% of Nigeria's land area will call for the implementation of medium to large scale extraction and processing plants involving partnership with more technologically advanced countries. Handling such volumes of oil within Nigeria, transport, storage, drying, and blending of such oil, engine conversion in addition to the processing technology needs will call for a significant level of technology know-how and infrastructure development which may require technical partnership with other nations. Another logistic issue that may be a barrier if not properly planned is the cost of transporting bio-diesel from the factory to the blending plant where it is blended with petroleum diesel. The bio-diesel factory is generally located near the plantation while the blending usually takes place in an existing refinery. Where these two locations are far apart, logistics in terms of cost and adequacy can constrain even a modest program.

(e) Irrigation Issues

Cultivation of Jatropha plant at the level required for the Nigerian petro-diesel to bio-diesel for power substitution program may require proper irrigation and in many cases application of fertilizers in order to reach the optimum level of yield required. Although Jatropha in comparison to most other bio-fuel feedstocks (sugarcane, soybeans etc) does not require much water to thrive, water requirement for irrigation at the level required can become a constraining factor, especially in arid Middle to Northern parts of Nigeria where water scarcity for agriculture may be a problem. In such areas, water use and yield response to droughts can be very critical to the success of the planned program. In such areas, Jatropha may have to compete with other food crops and sometimes with drinking water for irrigation water. Jatropha to thrive with appreciable yield will require adequate irrigation, especially when cultivated in areas with water shortages. It is therefore important that accurate annual water balance for Jatropha must be established to accurately determine irrigation frequency if ability to achieve acceptable yield levels is not to constrain the success of the bio-diesel from Jatropha program.

(ii) Barrier Mitigation Recommendations

Key components of actions that must be taken to limit the negative impacts of the barriers to the production of bio-diesel from Jatropha and its use as a substitute as a power generation fuel in existing and new diesel generating sets in Nigeria are discussed below:

(a) For sustainable Jatropha farming in Nigeria, a national program to generate data on factors and optimal inputs for enhancing the yield of Jatropha crop in organized plantation as well in small farm holdings must be immediately developed within an agricultural extension framework, and collaborative actions between government agencies, the Universities, and International Agricultural Institutes such as the IITA. Such a program should through the FGN seek the collaboration of the FAO. Such a database is unlikely to be available in the country as Jatropha has not been a food or cash crop in the past;

(b) A sustainable nationally financed (perhaps with multi-lateral support) agricultural extension services focusing on Jatropha cultivation must be established, within the framework of a national bio-fuel program, to develop best practices that will assimilated into the national program to enhance productivity of the Jatropha cultivation in the country;

(c) Plans for putting in place infrastructure for handling the volume of bio-diesel that will be produced in this program must be put in place in a timely fashion. Such infrastructure will include: storage facilities; fuel pumping and transfer stations; blending facilities at the refineries specifically for E10; piping system etc;

(d) Strengthening of the institutional infrastructure available at the REA and RED of NNPC and other relevant Agencies must be a key priority for proper organization, management, regulatory and performance evaluation of activities of the bio-diesel industry.

3.4.5 E10 as a Transport Sector Fuel Implemented as CDM

In 2002, global production of cassava was about 184 million tonnes (FAO, 2003). The lion share of this global production figure and was held by Africa producing just over 99 million tonnes. About 50 million tonnes was produced in Asia and 33 million tonnes were produced in Latin America and the Caribbean. Increasing crude oil prices, coupled with concerns over greenhouse gas emissions from the combustion of petroleum products which are the main fuel for the transportation sector has catalyzed the search for alternative fuels. Increasing attention is being focused on the production of bio-fuels especially ethanol and bio-diesels as the alternatives that will contribute to global reduction in GHG emissions, while at the same time contributing to the alleviation of the growing global stress caused by skyrocketing oil prices. Over the decades, primary source of ethanol has been from sugarcane and corn. In a recent publication (Science News, April 2007) it has been said that "while most of the world is scrambling after corn and sugar for answers to its renewable energy needs, many developing countries are focusing on a lesser known plant—cassava". This statement coupled with the fact that Africa is responsible for more than half of global production of cassava, provides a strong basis for our assumption in this study that

Box 7: NNPC revives fuel ethanol project, secures 70 retail outlets

Nigerian National Petroleum Corporation (NNPC) has secured 70 retail outlets in the country for dispensing of fuel ethanol during the first phase of the scheme.

This move reassures prospective investors that the fuel ethanol program is still on course, after earlier reports that the scheme might have been put on hold.

Dr. Levi Ajuonuma, group general manager, public affairs, NNPC, said the affected retail outlets belonging to major marketers were selected and positioned to support the corporation's mega filling stations for receipt and distribution of blended ethanol called E10. This was approved after the completion of modification works at Atlas Cove and Mosimi for the purposes of anhydrous ethanol receipt, transfer, blend and distribution to retail outlets. "The corporation has ordered for 15,848 metric tonnes (MT) of anhydrous ethanol for the blending project; equipments have been delivered ready for distribution to the retail outlets and awareness workshops have been organized for some stake holders", he explained. Ajuonuma said the program is designed on three-way approach through industry sub-program, seeding sub-program, policy and incentives development. In pursuit of the implementation, he said the corporation has recorded success through the signing of memoranda of understanding (MOU) with some state governments for the provision of land in their various states. "When the Federal Government of Nigeria, directed NNPC to start the introduction of ethanol into gasoline, it was expected that the nation will benefit through job creation, direct engagement and its ripple effects estimated at over 20,000 per site. The program is also to enhance building of capacity in large scale farming and ethanol production, supplement power production, through co-generation plants and improvement in infrastructure in the rural community", Ajuonuma said.

Source: Financial Standard News 2007

ethanol production from cassava will become a principal energy commodity produced in Africa. In this study, we have carried out a quantitative analysis of the potentials of: ethanol production from cassava in Nigeria; its use as a transportation fuel when blended with gasoline; and estimates of the GHG emission reduction potentials that can be associated with a partial shift from petro-fuelled future to bio-fuels-petroleum fuel blends. Two compelling reasons convinced us to focus attention in this study on ethanol from cassava. These are: first and foremost, Nigeria is the leading producer of cassava in the World. The country accounted for about 36% of the global production of cassava in 2002. Production of cassava in Nigeria in 2005 is estimated to be about 38 million tonnes; secondly, the Nigerian government recently mandated its national oil company, the Nigerian National Petroleum Corporation (NNPC) to lead in the development and adoption of bio-fuels as an alternative energy to crude oil. To carry out this mandate, NNPC recently set up a Renewable Energy Division (RED) within its corporate structure with the primary responsibility of providing management and technical wherewithal for the program. RED has identified cassava and sugarcane as the two major crops for the Nigerian fuel ethanol initiative. RED has even gone far in its plan to introduce E10 fuel to the Nigerian market in that not only is its plan for test blending and marketing using imported ethanol from Brazil in top gear, firm framework is being put in place for the distribution of the E10 (see Box 7).

Given these considerations, we carried out a quantitative analysis of the production of ethanol from cassava feedstock and its use as a component in a 10%:90% (by volume) blend of ethanol and petroleum motor spirit in Nigeria. A summary of the assumptions utilized in the quantitative analyses, which were in line with assumptions made in a recent study of the opportunity in SSA (World Bank 2008) are presented below:

- We have assumed that a blend of 10:90 % by volume of ethanol and PMS (E10) is marketed as transport sector fuel in Nigeria;
- We have used the PMS consumption figures for the year 2003 taken from the Nigerian database as the basis of estimating how much ethanol would have been needed for the bio-fuel in that year;
- The entire ethanol required in Nigeria is produced in-country using domestically cultivated cassava;
- FAO statistics on cassava production in 2003 (FAO,2003) for Nigeria and the estimated cassava required for the production of the needed ethanol were used to estimate the % of total cassava produced in that year that would have been needed for energy purposes;
- In line with the assumption used in the SSA study (World Bank, 2008), we have also assumed that 280 litres of 96% ethanol can be produced from each tonne of cassava in Nigeria;
- The CAPEX estimates covers only the ethanol plant and consist of 4 possible plant sizes: Very Small-10,000 litres/day (US$ 8.7 Million); Small-25,000 litres/day (US$ 15 Million); Medium-50,000 litres/day (US$ 22.7); Large-100,000 litres/day (US$ 34.5 Million); Very Large-500,000 litres/day (US$ 90.5 Million).

The summary of the result of the quantitative analysis of the CDM potential of the production of ethanol from cassava and its use in E10 transportation fuel in Nigeria using 2003 statistics are presented in Table 19.

Table 19: Potential of E10 as a Transport Sector Fuel Implemented as CDM

Country's Cassava Production (million tonnes/annum)	Fraction of Country Cassava Production Required for E10 (%)	Emission Reduction of E10 Project (tCO_2e/annum)	Estimated CAPEX of the E10 Program (million US$)	Estimated Earnings from CER Sales (million US$/annum)
38.2	9.0	1,346,824	487.1	13.45

3.4.5.1 Barriers to the Implementation of E10 from as a Transport Sector Fuel as CDM Projects in Nigeria and Recommended Mitigation Actions

(i) Barriers that can Constrain the Success of the E10 Program as CDM Projects in Nigeria

Unlike Jatropha, Cassava is both a food and a cash crop. It is the vital base of staple food types in many African countries. In Nigeria and other African nations, cassava is also exported overseas, primarily to China for Nigeria, in form of cassava chips which is used as an input in the production of several food products and ethanol in that country. Therefore a critical issue in the use of cassava as a feedstock in the production of bio-ethanol is the food versus energy issue. The critical barriers that can negatively impact the success of a bio-ethanol from cassava program in Nigeria will include:

(a) Sufficient Feedstock Production

The sufficiency of cassava production can become a limiting factor to the success of bio-ethanol from cassava program in Nigeria. This is because firstly, cassava is the basis of some staple food types in many parts of Nigeria and as such, its use as a bio-ethanol feedstock can cause upward pressure on the price of cassava as a food product in Nigeria if adequate care is not taken in the planning of the bio-ethanol program. This will be unacceptable from the point of view of sustainable development and global poverty alleviation objectives. It may also be politically dangerous to follow a path that will take away a staple food from the tables of low income population of the country. Cassava is known to require adequate irrigation and as such water shortages may also impair the ability to provide optimal irrigation of the cassava plantation, and hence a reduction in yield per hectare.

(b) Bio-fuel Plant's Technical Know-how

Technical Know-how required for the design, construction and even operations of bio-ethanol plants are usually beyond the local capacities found in Nigeria. In addition to this, process equipment remain expensive and technical and engineering skills required to run and maintain these equipment may be in short supply even in Nigeria with its strong crude oil sector. Experience with the crude oil refining sector in Nigeria also indicate that dynamic development of local technical capabilities in several related engineering and facility management areas can limit the sustainability of a domestic bio-ethanol program if it is not carefully planned.

(c) Weak or Absent Government Policies and Legislation

Government policies to support a virile bio-fuel industry must be in place if the Nigerian program is to be successful. For example, real commitment by government on mandatory blending must be in place and strategies to achieve the blending plans must also be firmly implemented. Clear and transparent legislation to develop the industry is critical and must be put in place at the right time to assure investors, farming communities and equipment suppliers that the market for bio-fuels in Nigeria is real, sustainable and profitable, and will not end up like the current state of the crude oil refining industry in the country. Without this legislation it can be expected that Nigeria may start aggressively as it is now posturing but eventually end up as only feedstock supplier for other countries thus loosing the true value of bio-fuels to the nation's economy. Sustainability is the key – even if global crude oil prices were to decrease. Nigeria must avoid allowing non-clear regulatory signals and policies to turn it to an eventual supplier of cassava feedstock to other countries for the production of bio-ethanol.

(d) Supply Chain Management

Good supply chain management is very critical to the success of any bio-diesel program. In the Nigerian country program, the supply chain management must at the minimum: guarantee a continuous feedstock supply; have in place strategies to overcome the usually poor infrastructure challenges prevalent in Nigeria that may impair the distribution of the blended fuel; and ensure optimum location of the ethanol and the blending plants.

(ii) Barrier Mitigation Recommendations

Cassava has been cultivated as a food crop over time in many SSA countries. Until recently when it started to be cultivated for exports, it was primarily a food crop. Barrier removal action plans that will be needed in Nigeria will include:

(a) Research to establish annual demand for cassava as food in the country must be carried out to establish whether the use of cassava as a feedstock for ethanol production will produce a price pull effect on the demand for cassava as a food crop;

(b) Capacity Building on Bio-Ethanol Production technology must be organized to develop local know-how through aggressive development of local manpower in research, engineering and facility management capabilities, enhanced through appropriate and focused bilateral and multilateral arrangements;

(c) Adequate institutional infrastructure for coordinating the national program and for ensuring that best practices are utilized in the development and operation of the bio-fuel industry in Nigeria must be put in place. This may involve the strengthening of existing institutions such as the REA and RED with specific and clear mandates to create enabling environment for the development of the domestic bio-fuel industry;

(d) We take note of the fact that a bio-fuel policy has been developed by the FGN to guide the development of the bio-fuel industry in Nigeria. A process should be put in place to facilitate periodic review of the policy to ensure that international best practice and salient experiences from other countries bio-fuel industry development are built into the Nigerian policy.

3.4.6 Gas Flare to Power Projects

In the same study quoted in the last sub-section (World Bank 2008), the potentials of utilizing the otherwise flared gas as fuel for energy generation was evaluated. The result of the analysis if all the gas flared in Nigeria was utilized as fuel to power Combined Cycle Gas Turbines (CCGT) to produce electricity is summarized in Table 20.

Table 20: GHG Emission Reduction Potential of Power Production in Nigeria Using Gas Flared in 2003

Gas Flared (Billion m3)	Installed Country Power Capacity (MW)	Additional Capacity from CCGT (MW)	% of Installed Country Capacity	Emission Reduction Achievable (Million tCO_2e)	Estimated CAPEX Required (Billion US$)
19.02	5,890	12,077	205	24.7	14.5

The emission reduction estimate is only from the combustion of the otherwise flared gas in a CCGT and does not include emission reduction achievable as a result of the likely displacement of more carbon intensive power facilities from the country's grid operating and build margins. Since the flared gas is likely to be used not only for power but also as a feedstock in the production of petrochemicals and other durable goods, it is expected that the emission reduction achievable will be much larger than the number in Table 25. The number however provides a good indication that at least about one third of GHG emissions from gas flaring in Nigeria can be eliminated if the gas is utilized in cleaner energy production facilities.

Barriers for this category of projects and recommendations for mitigating them was presented in an earlier section of this report (3.2.2 (d)).

3.4.7 Improved Energy Utilization in Transport Sector: The BRT Option

Traffic congestion usually results when many vehicles are plying a road infrastructure, which does not have the capacity to allow easy flow of traffic. Traffic congestion occurs when traffic demand is greater than the capacity of a road (or of the intersections along the road). Extreme traffic congestion is the situation, where vehicles are fully stopped for periods of time, is colloquially known as a traffic jam. Traffic congestion is very common in most big urban cities in SSA countries. From the energy point of view, traffic jams results in the use of more transportation fuels than would have been required in their absence. It has been known that good traffic management coupled with road network planning can reduce traffic jams where it is occurring leading to a substantial reduction of fuel usually consumed when vehicles are idling, accelerating and braking in a traffic jam situation. The Bus Rapid Transit (BRT) system which involves the provision of bus corridor with dedicated lanes, timely schedules and un-congested network is also a good approach to reducing traffic congestions and the inefficient use of energy in urban road transportation, where congestions are usually more common. *BRT* is a broad term given to a variety of transportation systems that, through improvements to infrastructure, vehicles and scheduling, attempt to use buses to provide a service that is of a higher quality than an ordinary bus line. Each BRT system uses different improvements, although many improvements are shared by many BRT systems. The goal of such systems is to at least approach the service quality of rail transit while still enjoying the cost savings of bus transit. In a recent World Bank study (World Bank 2008), the potential of a BRT in all cities in Nigeria with population of 500,000 or more was simulated and their GHG emission reduction potentials were evaluated. A summary of the results of the evaluation is presented in Table 21.

Table 21: GHG Emission Reduction Potential of BRT Systems in Nigerian Cities

Oil Consumption in Nigeria in 2003 (Bbls/day)	Estimated Savings in Oil Consumption Due to BRT (Bbls/day)	Estimated GHG Emission Reduction (tCO_2e/annum	Estimated Earnings from Sale of CERs
297,000	21,205	*3,078,732*	30.78

Table 22 is a summary of the CDM opportunities that can be implemented in Nigeria as clean energy investment. CDM will provide additional revenues from the sales of carbon emission reductions that will be earned by the projects, in addition from normal revenues from energy sales.

Table 22: Summary of CDM Projects as Clean Energy Investments in Nigeria

S/N	Potential CDM Project	Emission Reduction (tCO_2e/annum)	CAPEX (Million US$)	PotentialCarbon Emission Reduction Sales (Million US$/annum)
1.	Efficient Charcoal Production	1,605,440	16.30	14.69
2.	Replacement of Incandescent Light Bulbs with CFLs	1,221,385	235.60	12.21
3.	Biomass fuelled Power Plant	33,623,900	9,295.00	336.24
4.	Biodiesel as a fuel for Power Generation in Existing Diesel Engines *(1)*	923,980	4.77	9.24
5.	Introduction of Ethanol from Cassava E10 Transportation Fuel	1,346,824	487.10	13.45
6.	Biodiesel from Jatropha blended as B20 Transportation Fuel	1,187,800	1,565.00	11.88
7.	Gas Flare to Power Projects	24,700,000	14,500.00	247.00
8.	Introduction of Bus Rapid Transit Systems in Cities	3,078,732	NA	30.79

(1)The cost of the substitution is the amount needed to retrofit the existing diesel engines to utilize bio-diesel as fuel.

The CDM opportunities listed in Table 22 are by no means exhaustive. They have been presented to provide an indication of the benefits that can accrue from implementing clean energy projects using the mechanism. This is possible as long as a project will: contribute to sustainable development in Nigeria; the project is additional, i.e., it would not have been implemented in the absence of the CDM process due to the presence of barriers which would have prevented their implementation; and will result in real and measurable GHG emission reduction.

4. Case Study of a Proposed Clean Energy Investment

4.1 The Proposed Project

This project which will be supported and co-sponsored by the Government of Ebonyi State (A state in the South Eastern Region of Nigeria) will involve the utilization of the large stockpile of rice husk produced in the milling of parboiled paddy rice at a mill cluster in Abakaliki, the capital of the State. At the Rice Mill Cluster, about an average of about 218,000 tonnes of Paddy Rice is processed per annum to yield about 148,000 tonnes of semi-parboiled rice. The process of dehusking the paddy rice at the mill produces an average of about 55,000 tonnes of rice husk per annum. The data above represent capacity utilization at the mill of not more than 40%. The low capacity utilization that has been prevalent over the last few years is a result of erratic power supplies to the mill which has hindered higher capacity utilization. Since over 90% of Ebonyi State's endowment of rice milling capacity is located at the Abakaliki cluster, it was decided that the proposed project will be sited at the cluster. At best practices capacity utilization, the Abakaliki mill cluster can process slightly over 2 million tonnes of paddy rice. This throughput was used as the design basis of the proposed project. The rationale for this is that since power supply has been the most constraining factor to the productivity of the mill and since the project itself will involve the refurbishment and modernization of the mill, then it is expected that the mill will be able to operate at international best practices level after the project is implemented. The proposed project will consist of the following components:

- A combined heat and power (CHP) system, adequately sized to utilize the rice husk produced at the Abakaliki Rice Mill Cluster and rice husk sourced from other rice mills as the only or main fuel;
- Modern paddy rice parboiling equipment, utilizing steam from the CHP to produce hot water for the soaking and steaming processes in paddy rice parboiling;
- Modern rotary dryers for the drying wet parboiled rice and heat it to optimum temperature to facilitate optimum yield from the rice milling process. Steam from the CHP will be utilized in a heat exchanger to produce the hot air needed in drying wet parboiled rice;
- A suitably sized cold storage facility, equipped with vapor absorption refrigeration systems, driven by steam (or hot water) from the CHP. The facility will provide cold storage to Ebonyi farmers who will store a variety of agricultural produce, which in the status quo because of the lack of such facility usually get spoilt and thrown away;
- Balance of plant including: water supply and treatment; waste handling and treatment; other utilities; bus-bar connection to the nearby power grid; steam and water distribution systems; etc.;
- Part of the power generated at the CHP will be consumed at the cluster and the balance will be exported to the nearby national grid;
- The entire steam produced at the CHP will be used up at the cold storage facility.

4.2 Description of the Rice Mill Status Quo Situation

The status quo situation at the existing rice mill cluster at Abakaliki which is similar to other mills in the state can be summarized as follows:

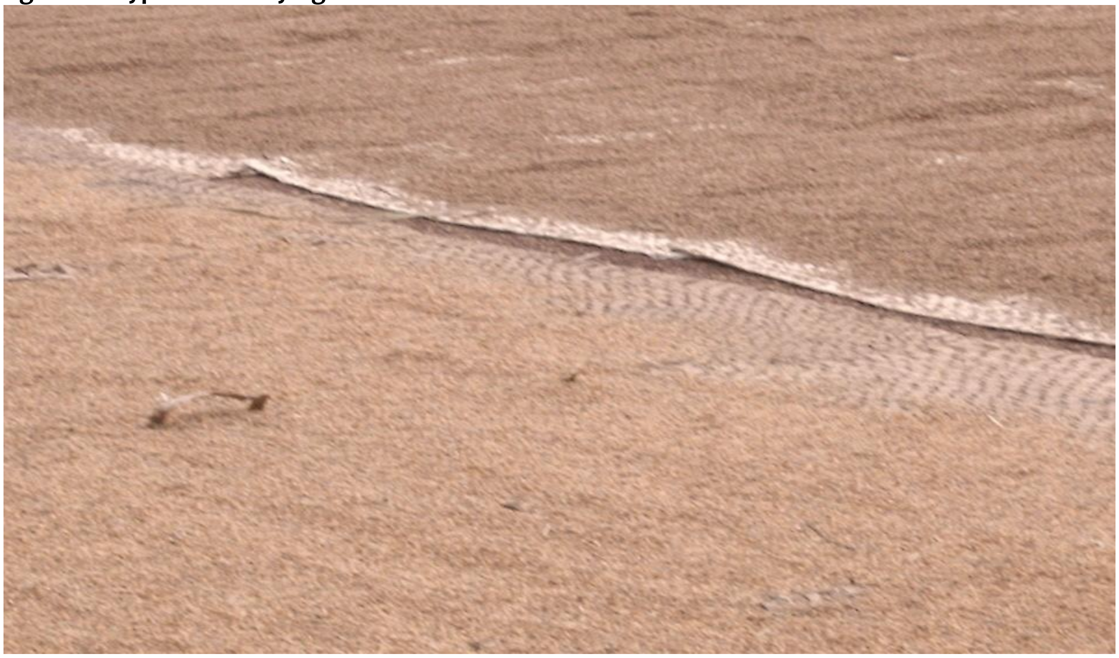
- The cluster is made up of over 1,000 rice mills;
- The entire mill cluster is connected to a nearby segment of the national grid;
- Almost all the mills at the cluster rely on alternative supply of power from onsite diesel generating sets especially during the very frequent grid power interruptions;
- Paddy rice produced by small holding farmers is currently parboiled (by the farmers) either on or outside the cluster site, before it is supplied to the mills;
- Very crude parboiling facilities are currently utilized. This consist of cylindrical drums filled

with some amount of water and the paddy rice which is then boiled over a three-stone traditional stove utilizing fuelwood (most often bamboo wood) as fuel;

- Parboiled rice from this process leaves the process at a moisture content of between 32%-40%, which is way above the required moisture content of 14% required for optimum milling. To get the parboiled rice as close as possible to the optimum pre-milling moisture content, the wet parboiled rice is sun dried in an open space (see Figure 10).

The status quo energy process described above is not only energy inefficient it is also very low in overall productivity, which added to the unreliable supply of power to the site is responsible for the low capacity utilization of the rice mill cluster. The proposed project will change these weaknesses while at the same time providing green power and heat from the biomass residue.

Figure 10: Typical Sun-Drying of Wet Parboiled Rice at the Abakaliki Rice Mill Cluster



The characteristics of energy supply at the rice mill cluster given the project are presented in Tables 23 and 24.

Table 23: Post Project Power Supply Characteristics at the Abakaliki Rice Mill Cluster

	Units	Value
A. CAPACITY INFORMATION		
1. Capacity of Rice Milling	**Thousand Tonnes of White Rice per year**	1,152.00
2. Capacity of the CHP	**MW**	30.97
3. Capacity of the Parboiler	**Thousand Tonnes of Paddy Rice**	1,706.67

4. Capacity of Cold Store	**Thousand Bushels**	148.13
B. ELECTRICITY DEMAND/SUPPLY		
1. Electricity Demand-Rice Mill	**GWh/Yr**	55.36
2. Electricity Demand-CHP (Own Use)	**GWh/Yr**	10.95
3. Electricity Demand-Parboiler	**GWh/Yr**	2.19
4. Electricity Demand-Cold Store	**GWh/Yr**	4.38
Total Cluster Electricity Demand	**GWh/Yr**	**72.88**
Electricity Generated by CHP	**GWh/Yr**	**219.40**
Electricity to the Grid	**GWh/Yr**	**146.52**

Table 24: Post Project Steam Supply Characteristics at the Abakaliki Rice Mill Cluster

	Units	Values
STEAM DEMAND/SUPPLY		
A. Steam Demand		
1. Steam Demand-Parboiler/Dryer	**Tonnes/Hr**	193.98
2. Steam Demand-Cold Store VAC	**Tonnes/Hr**	8.97
Total Steam Demand	**Tonnes/Hr**	**202.95**
B. Steam Extracted (For Process Use)	**Tonnes/Hr**	**202.98**

4.3 Preliminary Cost Estimate for the Project

In this section, we present preliminary estimates of project costs covering all items including: land and land clearing; project main equipment; auxiliary equipment; civil works; installation & commissioning; operation and maintenance costs; and fuel costs. These estimates are required as inputs in a preliminary assessment of the project plan.

4.3.1 Preliminary Project Cost Estimates

Table 25 provides a preliminary estimate of project capital costs, while estimates for O & M as well as fuel costs are presented in Table 26.

Table 25: Preliminary Capital Cost Estimates for the Project

COST CATEGORIES	**LOW CASE SCENARIO**		**MEDIUM CASE SCENARIO**		**HIGH CASE SCENARIO**	
	Specific Costs	**Total Cost (million US$)**	**Specific Costs**	**Total Cost (million US$)**	**Specific Costs**	**Total Cost (million US$)**
1. Land	US$ 3,700/Plot	0.03	US$ 3,990/Plot	0.032	US$ 4,350/Plot	0.035
2. Land Clearing & Preparation	LS	0.003	LS	0.003	LS	0.004
3. Capital Cost of CHP	US$ 1,310.00/Kwe	39.30	US$ 1,392/Kwe	41.76	US$ 1,474/Kwe	44.22

COST CATEGORIES	LOW CASE SCENARIO Specific Costs	Total Cost (million US$)	MEDIUM CASE SCENARIO Specific Costs	Total Cost (million US$)	HIGH CASE SCENARIO Specific Costs	Total Cost (million US$)
4. Capital Cost of Parboiler*	US$ 300/Parboiler Tonne Capacity	0.36	US$ 330/Parboiler Tonne Capacity	0.40	US$ 360/Parboiler Tonne Capacity	0.44
5. Capital Cost of Cold Store VAC	US$ 500/RT	0.70	US$ 540/RT	0.756	US$ 580/RT	0.812
6. Cold Store Building + Insulation	US$ 20/m2	0.034	US$ 25/m2	0.042	US$ 30/m2	0.051
6. Steam Distribution System	NA	1.38	NA	1.46	NA	1.55
7. Power Connection Facilities	NA	0.69	NA	0.73	NA	0.78
8. Paddy Dry-Down Silos and other Bins	NA	0.25	NA	0.28	NA	0.30
9. Engineering	NA	0.10	NA	0.15	NA	0.20
10. Other Installation & Commissioning Costs	5%	2.143	5%	2.281	5%	2.420
11. Contingencies	5%	2.143	5%	2.281	5%	2.420
TOTAL COST		47.133		50.175		53.232

Capital cost of 2 units of parboiling equipment each with a capacity ~ 600 Tonnes

4.3.2 Key Assumptions for the Estimation of the System Capital Costs

A combination of open literature sources and direct contacts with system vendors were utilized in building the cost estimates in Table 18. One of the Vendors contacted, NEGRIS Limited of Nigeria, collaborated with two Indian suppliers, namely BHEL and THERMAX. This collaboration provided capital cost estimates covering: detailed engineering; engineering procurement; installation and commissioning of a 30 MW trigeneration plant. The trigeneration plant is made up of: the rice husk fired boiler; extraction steam turbine; and 1400 RT absorption chillers for the cold store. Some of the pertinent key assumptions utilized in building the estimates provided in Table 16 are summarized below:

- The total additional land area required for the new facilities at the Abakaliki Rice Mill Cluster is assumed to be about 1 Acre (8 Plots);
- A standard plot in Abakaliki Area is assumed to have a size of about 60 ft X 120 ft;
- The average cost of a plot of industrial land in Abakaliki area is assumed to range between US$ 3,700 – US$ 4,350;
- The specific cost of the CHP used in Table 16 is made up of the cost of: detailed design engineering; procurement; installation and commissioning;
- The total factory space for the cold store is estimated to be about 1,680 m2;
- The cost of construction of the cold store building plus the installation of the necessary insulation and other appurtenances is estimated to range between US$ 20 –US$ 30 per m2;
- Steam distribution facilities have been estimated at 3.5% of the capital cost of the CHP;
- Connection of the CHP power facilities to the national grid for the evacuation of excess

power (after own cluster use has been taken) to the grid has been estimated at about 1.75% of the capital cost of the CHP;
- Paddy dry-down silos are intermediate storage facilities for parboiled rice before it is de-husked at the mill;
- Other silos are provided on site for the storage of paddy rice and other intermediate products between batch processes as will be comprehensively elaborated by the detailed design engineering;
- The cost estimate in items 9 and 10 in Table 18 are for other engineering design costs that are not included in the detailed engineering, procurement, installation and commissioning of the trigeneration system.

Some of the key conclusions of the engineering study are summarized below:

- Using the technical details prepared in this conceptual engineering study, bids should be invited from equipment vendors covering: detailed engineering design of the system; procurement of all necessary components; installation, commissioning and start-up;
- The cost estimate presented in this study are preliminary at best and will have to be firmed up when better details of the proposed system are revealed by the detailed engineering design process;
- It is important that the details of the financing of the project should be worked out once more comprehensive and firm design and cost estimates has been worked out. It is recommended that this project should be implemented as a public-private-partnership. The State Government should only have marginal equity shares not more than 20%. The balance equity should be held by private sector investors both local and international;
- Debt funding should also be pursued. The project should be immediately marketed to International and local financial organizations. With the participation of UNIDO, it may be possible to obtain a good loan gearing ratio from such organizations;
- Another source of funding that should be pursued is the carbon fund. The trigeneration system as well as the cold store project can be packaged as a Clean Development Mechanism (CDM) project, even while the detailed engineering design process is ongoing. This will ensure that the project as a CDM enters the CDM project cycle as soon as possible so as to access the carbon fund through the Kyoto Protocol process.

The study was completed in mid 2005 and in 2007, the Government of Ebonyi State signed an MOU with the Government of Austria who has shown interest in co-developing the project as a CDM project. A Project Idea Note (PIN) was recently developed as a first step in the process of commencing the preparation of documentation for the CDM.

5. Conclusions and Recommendations

5.1 Lessons from the Country's Clean Energy Experience

Outside the gas sector, and perhaps the large hydro energy projects (when they can really be classified as clean energy investments), most of the historical clean energy investments (and even new plans) are either by the Federal and State Governments, Government Agencies or Energy Research Centres. Bilateral and Multilateral Grants and Loans, have played a significant part in the funding of these projects. As shown in the very sound clean energy project case study presented in the previous section, in spite of the support received in recent past from bilateral and multilateral sources, investment in clean energy system has lagged and lack of financing has been a major factor. The experience so far also showed very sub-optimal performance in the planning, implementation, monitoring and evaluation of clean energy projects. The outcomes of past projects have not been sufficiently impressive as to generate laudable success stories which can enhance the necessary public awareness of their advantages and benefits, which can ultimately be the catalyst for attracting local and foreign investment into the sector.

Nigeria is endowed with many clean energy investment opportunities. The absence of many existing operational systems is not an indication of the absence of such opportunities; rather barriers exist that has made it almost impossible to have these systems as strong a part of the country's energy system as they should be. Some of the key barriers can be summarized as follows:

- A key barrier is the absence of coherent national energy policy in the country that provides holistic elucidation of the roles of various energy options (see recommendation below for more in depth discussion);
- The fact that Nigeria is endowed with oil and gas resources has also made the need to utilize renewable options to seem inferior to more fossilization of the energy system;
- A regime of monopolistic vertically integrated public utility that existed for decades in Nigeria did not allow for the creation of a level playing field where all real and tangible costs are internalized in energy delivery options;
- Poor governance has also contributed immensely to a tradition of poor planning which does not enable the full consideration of options for sustainable development;
- Financial matters have been a major barrier to investment in infrastructure development (including clean energy) for decades. This is in spite of the several billions of dollars generated over the last decades from the export of crude oil and in recent years from natural gas exports. The inability to harness the earned petro-dollars into real development is related to the poor governance impact that has been mentioned. It can be argued that the FGN contributed to this situation by maintaining the policy of domiciling a substantial proportion of the petro-dollars earned from oil exports in overseas banks and allowing only a trickle into the treasury of Nigerian Banks for a long time. In fairness to the government, it knew that the sector was not financially strong and stable to handle the volume of oil earnings and had to depend on overseas financial institutions for the secured handling of the petro-dollars. The result of the poor capitalization of Nigerian Banks during the pre-reform era was that venture capital were either not available from many of the domestic Banks or when

it was available, it was with terms that can only sustain short term investments that does not augur well for medium to long-term financing of infrastructure projects. Good projects during this era did not have access to financing. Prior to the recent reform of the Nigerian financial sector, Banks in Nigeria concentrated on trading in foreign currency and funding short-term consumer-goods importation and were not serving as centers of fund mobilization for economic development. Their capitalization was too low to attract venture capital funds both from local and international sources that can be channelled into development projects. A drastic new recapitalization rule for the banking sector was introduced in early 2006 by the Central Bank of Nigeria as part of a sector reform agenda. The rule called for a massive 12-fold increase in minimum capital requirement, to N25bn (over US$200 million), from a paltry level of about US$15 million. Although the deadline was put off several times to give threatened institutions time to be eligible, many banks went under while many were taken over, resulting in the consolidation of the over 89 Banks then operating in Nigeria to now about 25 hopefully, strong and reliable partners in development. The restructuring efforts seems to be paying off as many of the institutions that emerged from the process are already participating in infrastructure financing and/or have set up venture capital departments that are currently active in soliciting for proposals for financing good projects.

- Foreign Direct Investment (FDI) inflows into the Nigerian economy, especially into the development of the country's oil and gas infrastructure have also been occurring in historical years. Not much however goes into the other sectors not to talk of the clean energy sector. For example according to a Press Release by EIU (EIU/CPII, 2007) FDI inflow into SSA dropped by about 20% between 2005 and 2006. FDI inflow into Nigeria during this period grew by about 25% from US$2 Billion in 2005 to US$2.5 Billion in 2006. According to the press release most of these inflows went to fund the oil sector investment. This was collaborated by the information obtained from an informal discussion with a CBN official who informed us that about three quarters of this inflow was to the oil and gas sector. Less than US 1.0 million of the FDI flow went into clean energy investment in 2005 and 2006 (CBN, 2007). For example in 2006, of the about US$0.875 million FDI inflow into the clean energy sector, about 94% was for hydro power, less than 2% for biomass energy and the balance went into solar. FDI inflow has therefore not been playing the role that one will expect it to play in the emergence of a strong clean energy system in Nigeria. This is not surprising as an enabling environment that can ensure the security and good performance of foreign investors' funds was not in place and is just slowly emerging.
- Technical barriers also exist. The fact that most facilities are engineered and built outside Nigeria meant that the country had to rely on importation of technologies almost on all spheres. Even in the oil sector, the situation has been the same. Not surprisingly, local content development has been a very key component of the ongoing requirements for the participation of Nigerians in that sector. The situation has also been worsened in recent times by the incoherent educational system that has been the order of the day in Nigeria in recent years;
- A weak regulatory framework at all levels has also played its part in ensuring that clean energy investment has not become a common practice in Nigeria. Many of the barriers that were discussed in earlier sections of this report were created by the absence of an enabling

environment which was the result of inadequate or non-existing regulatory and fiscal framework. The FGN has made some positive strides in recent years with the various sector reforms and development of regulatory framework that should have positive impact on clean energy investment in Nigeria.

5.2 Recommendation on Policies and Actions that Must be Taken to Promote Clean Energy Investment in Nigeria

Given the lessons learnt from the evaluation of the past, present and future potentials of clean energy investment in Nigeria, we recommend the following as necessary actions that must be immediately taken to increase the inflow of clean energy investment into the country:

(a) Need to have in place a coherent and holistic analysis of Nigeria's energy systems

Over the years, the energy policy framework in Nigeria has been based on ad-hoc evaluation of energy resource endowment, energy demand evolution, technology changes and energy-environment-economic interactions, including the influence of own and cross energy prices on the evolution of the energy markets in Nigeria. The ad-hoc nature of the planning which are usually the pivot of most energy pronouncements (not energy policies) have resulted in sub-optimal development of the energy sector, outside the supply of crude oil and natural gas for export. A coherent and holistic analysis of Nigeria's energy system and its linkage to other sectors of the economy, its implication for the environment, both local and global and the opportunities offered by the variety of energy resources (renewable and non-renewable), must be immediately carried out. Such an holistic framework will be important for clean energy opportunities in that externalities can be incorporated into the quantitative analysis and can yield important results on: the role of clean energy in future development of the country's energy system; interventions needed to ensure that their sustainability roles are adequately tapped; and fiscal and other incentives that must be put in place to promote clean energy investments in the country.

(b) Timely Adoption of the National Energy Master Plan (NEMP)

The holistic setting of the analysis of the country's energy system must come before the adoption of the NEMP. This is because many cross cutting issues that may not currently be adequately addressed in the NEMP may gain insight from the results of the analysis. Once the results are fed into the NEMP, then the Federal Government of Nigeria (FGN) will need to put in place a process for a quick adoption of the plan. Not only this, the plan must be given a legal and legislative muscle via its enacted into an enforceable law that will make its implementation mandatory for any government in power.

(c) FGN must Provide Leadership in Clean Energy Investment

Many clean energy potential will require that the FGN act as the leading investor to catalyze the process. For example, natural gas as a clean fuel can proliferate into several end-use sectors in Nigeria and into several geographical locations if, and only if, the FGN is a leading actor in the provision of the first tranche of funding required to put in place main arteries of a national gas network in the country. The hope that the huge gas resources in Nigeria will catalyze the influx of Independent Power Producers into Nigeria has failed basically because no such investors will be willing to invest in the gas infrastructure in addition to its power infrastructure investment. The FGN may have to put funds into this low return business or provide adequate guarantees to investors who may be willing to participate in the development of such gas arteries. The kind of initiative currently taken by the FGN in mandating investment (and actually participating) in wind farms across the country is a pointer in that right direction.

(d) Introduction of Fiscal and Market Incentives to Promote Clean Energy Investment

Creative and transparent fiscal and market incentives must be put in place to encourage both the end use technology consumers and supply technology investors to ensure an increase in the inflow of clean energy investment. Some of the tools that can be introduced will include: pioneer status which will accord clean energy investment tax holidays during the pioneer status period; reduction or outright removal of import surcharges on imported clean energy equipment and facilities; introduction of sovereign guarantees for funds that will be brought in by foreign investors etc.

(e) Other necessary policy tools will include:

- Ensuring international standards for all clean energy end use and supply technologies imported into the country
- Developing robust Power Purchase Agreements (PPA) that put the interests of all parties concerned into consideration.
- Appropriate energy pricing that will guarantee appropriate return on investments particularly in the electricity sector is essential for attracting increasing inflow of clean energy investment.
- Regular conveyance of a "Clean energy investors' forum" is very essential promotion tool. This will serve as an avenue for the government and interested investors (local and foreign) to meet as an information flow and sharing feedback mechanism. This will facilitate a robust road map for deployment of clean energy technologies in the country.
- The FGN should work into its development plans, the recognition by all sectors, the importance of achieving carbon emission reduction as a bona fide component of sustainable development program.

References

African Review of Business and Technology, *"Bio-fuels"*, July 2006

Bureau of Public Enterprises (BPE), *"Nigerian Power Sector Reform Document"*, BPE 2006B;

Anozie A.N., Bakare A.R., Sonibare J.A. and Oyebisi T.O., *"Evaluation of cooking energy cost, efficiency, impact on air pollution and policy in Nigeria",* Energy, Vol.32, Issue 7, July 2007, 1283-1292;

BPE, *"Nigerian Mining Corporation: Briefs on the Nigerian Mining Corporation and its Holdings"*, BPE 2006;

Brew-Hammond, Abeeku, "Rural Energy Poverty and the Environment: A Case for Bio-Fueled Multi-Functional Platforms." Energy and the Environment, Technology Policy Briefs Volume 1 Issue 4, 2002. United Nations University/Institute for New Technologies.

Capoor, Karan, *"Carbon Finance and Infrastructure: African Region Experience",* Presentation at the Urban Week, March 2005;

Dayo F.B., and Adegbulugbe A.O., *"Initial Energy Audit of Warri and Kaduna Crude Oil Refineries"*, Final Report of a UNIFECS Consultancy to Corporate Planning Department, Nigerian National Petroleum Corporation, Lagos Nigeria, 1989;

Dayo F., Adegbulugbe A., and Ogali B., *"Comprehensive Energy Audit and Estimation of Energy Efficiency Improvement Options at a Cement Work"*, Final Report Submitted to the Benue Cement Company, Gboko, Nigeria, IBCON & Associates/Triple "E", August 1990;

Dayo F.B., S.B. Bogunjoko S.B., and Sobanwa A.C., *"Cogeneration: A Win-Win Option for Cadbury Nigeria"*, in Cogeneration and On-Site Power Production (COSPP), Vol. 2, Issue 1, Jan.-Feb. 2001;

Dayo F.B. *"Energy Efficiency in Industrial Steam and Power Generation: Power and Heat Matching for the Design of a CHP System at a Food Manufacturing Facility"*, Technical Report of a Consultancy Study Implemented by Triple "E" Systems Associates Ltd. for and on behalf of Cadbury Nigeria Plc., September 2003

Dayo F.B., Adegbulugbe A.O., Ibitoye F., Adenikinju A. and Voss A., *"Estimating the Economic Benefits of Kyoto Protocol to the Nigerian Economy"*, UNIDO (Economy, Environment, Employment), Vienna 2004;

Dayo F.B., *"Nigerian Energy Balances: 1990-2005"* Technical Paper, Triple "E" Systems Inc., September 2007A;

Dayo F.B., *"Opportunities for CDM Projects in Anglophone Sub-Saharan African Countries"*, Report of a Study Funded by AFTEG, World Bank, October 2007B;

FAO *"Major food and agriculture commodities and producers"*, 2002, 2003, 2004 and 2005;

FAOSTAT *"Various issues on Fuel-wood and Charcoal Production and Consumption"*, FAO, 2002, 2003, 2004 and 2005;

FGN, *"Draft National Electric Power Policy"*, 2006;

FGN, *"The National Gas Supply and Pricing Policy"*, Final Draft 2007;

GDSL, *"An innovative Strategy to Market Natural Gas in Off-grid Areas in Nigeria"*, A Project Proposal Prepared by GDSL Nigeria Ltd, April 2005;

GTZ, *"International Fuel Prices", Federal Energy Ministry for Economic Cooperation and Development"*, Bonn, 2007;

Manibog F.R., *"Improved Cooking Stoves in Developing Countries: Problems and Opportunities"*, Annual Review of Energy, Vol. 9 199-227;

Nash R. and Luttrell C., *"Crisis to Context: The Fuel-wood Debate"*, ODI Forest Policy and Environment Programs' Forestry Grey Literature Collection, 2006;

Neil Ford, *"Investors Line up for Nigerian LNG"*, African Business, February 14 2008;

NLNG, *"Private Discussion with an Official of NLNG, Bonny"*, Nigeria, May 2007;

NLNG, *"Frequently asked questions"*, www.nlng.com/NLNGnew/faq/, 2007B;

NNPC, *"Nigeria on the March to Bio-fuels"*, News Flash from Corporate Headquarters, March 2007;

OECD/AfDB, *"African Economic Outlook: 2003/2004";*

Office of the Special Adviser to the President on Energy (OSAPE), *"Draft of the National Oil and Gas Policy"*, 2006

REA, *"Terms of Reference (TOR) Document on a Consultancy Assignment to Structure the Goals and Operations of the REA"*, 2006

Science News, *"Thailand Fuels Up with Cassava: Net Energy Value Calculations Favor Ethanol Production from Cassava"*, April 11 2007;

Thu Lan Thi Nguyen, Shabbir H. Gheewala and Savitri Garivait, *"Energy Balance and GHG-Abatement Cost of Cassava Utilization for Ethanol in Thailand'*, Energy Policy, Vol 35, Issue 9, September 2007, Pgs. 4585-4596;

United Nations Department of Economics and Social Affairs, *"Small-Scale Production and Use of Liquid Biofuels in Sub-Saharan Africa: Perspectives for Sustainable Development"*, Background Paper No. 2, DESA/DSD/2007/2 UNDESA 2007;

UNDP/World Bank ESMAP, *"Strategic Gas Plan for Nigeria"*, February 2004;

World Bank, *"Energy Efficiencies in Developing Countries",* Development Brief, Number 8, December 1992;

World Bank, *"Electric Power Transmission and Distribution Losses"*, in World Development Indicators, New York, 2002;

World Bank, *"Nigeria: Issues and Options in the Energy Sector"*, ESMAP Report The World Bank, 2003;

World Bank, *"Draft Report: Opportunities for CDM Projects in SSA Countries"*, March 2008

Zhiyuan Hu, Gengqiang Pu, Fang Fang and Chengtao Wang, *"Economics, environment, and energy life cycle assessment of automobiles fueled by bio-ethanol blends in China"*, Renewable Energy, Vol.29, Issue 14, Nov. 2004, 2183-2192;

APPENDIX A: MAJOR LAWS GUIDING THE OIL AND GAS SECTOR IN NIGERIA

S/N					
1.	Petroleum Profits Tax Act	1958	2.	Oil in Navigable Waters Act	1964
3.	Oil Terminal Dues Act	1965	4.	Petroleum Regulations	1967
5.	Petroleum Control (Amendment) Act	1968 (No.15)	6.	Oil in Navigable Waters Act	1968 (No.34)
7.	Oil in Navigable Waters Regulation	1968	8.	Oil Terminal Dues Act	1969 (No.9)
9.	Petroleum Act	1969 (No.9)	10.	Petroleum (Drilling And Production) Regulations	1969 (Ln No.69)
11.	Petroleum Profit Tax (Amendment) Act	1970 (No.22)	12.	Oil Terminals (Application Of Ports Act Etc) Regulation	1970
13.	The Escravos, The Idoho, The Pennington, The Qua Iboe, The Ugheli/Forcados Oil Terminal (Establishment) Orders	1971	14.	Offshore Oil Revenues (Regulation Of Grants)	1972 (No.23)
15.	Petroleum Training Institute Act	1972 (No.37)	16.	Petroleum Profits Tax (Amendment Act)	1973 (No.15)
17.	Petroleum (Amendment) Act	1973 (No.16)	18.	Petroleum Technology Development Fund Act	1973
19.	Petroleum (Uniform Price Of Petroleum Products) Order	1973	20.	Petroleum (Drilling And Production) Amendment Regulation	1973
21.	Bonny Offshore Oil Terminal (Establishment) Order	1974	22.	Petroleum Equalization Fund (Management Board Etc) Act	1975
23.	Petroleum Production and Distribution (Antisabotage) Act	1975	24.	Petroleum Training Institute (Amendment) Act	1976
25.	Petroleum (Amendment Act)	1976 (No.49)	26.	Nigerian National Petroleum Corporation Act	1977 (No.33)
27.	Petroleum (Amendment) Act	1977 (No.55)	28.	Petroleum (Amendment) Act	1977 (No.55)
29.	Federal Environmental Protection Agency Act		30.	Environmental Impact Assessment Act	
31.	Petroleum Profit Tax (Amendment) Act	1979	32.	Nigerian National Petroleum Corporation (Amendment) Act	1978 (No.16)
33.	Petroleum Profit Tax (Amendment) Act	1979	34.	Petroleum Profit Tax (Amendment) No.2 Act	1979
37.	Acquisition and Assets (British Petroleum & Co. Ltd) Act	1979	38.	Associated Gas Re-Injection Act	1979 (No.99)
39.	Associated Gas Re-Injection (Amendment) Decree	1985	40.	Crude Oil (Transportation And Shipment) Regulations	1984
41.	Oil And Gas Export Free Zone Act	1998	42.	Deep Offshore And Inland Basin Production Sharing Contracts Decree	1999
43.	Niger Delta Development Commission Act	2000			