ENERGY COMMISSION OF NIGERIA
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ENERGY IMPLICATIONS OF VISION 20: 2020 AND BEYOND

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CONTENT

ABBREVIATIONS

AGO	Automotive Gas Oil
ATK	Aviation Turbine Kerosene
BAU	Business as Usual
Bn	Billion
Boe	Barrels of Oil Equivalent
b/d	Barrel per Day
BPY	Barrels per Year
BSPD	Barrels per Stream Day
BTU	British Thermal Unit (energy unit)
CCGT	Combined Cycle Gas Turbine
CHP	Combined Heat and Power
CO_2	Carbon dioxide
^{O}C	Degrees Centigrade
EJ	Exajoule (= 10^{18} Joules)
GDP	Gross Domestic Product
GNP	Gross National Product
GT	Gas Turbine
GW	Giga Watt
GWe	Giga watt of electricity
h/d	Hour per Day
HDI	Human Development Index
HDR	Human Development Report
HHK	Household Kerosene
IAEA	International Atomic Energy Agency
IMF	International Monetary Fund
IPPs	Independent Power Plants
kg	Kilogram (thousand gram)
kgoe	Kilogram
km	Kilometer (thousand meter)
KRPC	Kaduna Refinery and Petrochemicals Complex
ktoe	Thousand tonnes of oil equivalent
$kW/m^2/day$	Thousand Watt per square meter per day
kWh/m^2	Thousand watt hour-square meter
kWyr	kilowatt per year
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
mb/d	million barrels per day
m/s	meters per second
M^3/y	Cubic meter per year
MAED	Model for Analysis of Energy Demand
MDGs	Millennium Development Goals
MESSAGE	Model for Energy Supply Strategy and their General Environmental Impacts
mm	Millimeter
MW	Mega watts

₦	Nigerian Naira (Nigerian unit of Currency)
N/A	Not Applicable
NG	Natural Gas
NIPPs	Nigerian Independent Power Plants
NPC	National Population Commission
WRPC	Warri Refinery and Petrochemicals Complex
OPEC	Organization of Petroleum Exporting Countries
OPRPC	Old Port Harcourt Refinery and Petrochemical Complex
PMS	Premium Motor Spirit
PPP	Purchasing Power Parity
PV	Photo Voltaic
Ref.	Refinery
RMS	Regular Motor Spirit
$	United States Dollars
Scf/d	Standard Cubic Feet per Day
Sq	Square
Toe	Tonnes of Oil Equivalent
Tscf	Trillion Standard Cubic Feet
UNDP	United Nations Development Programme
Wh/cap	watt-hour per capita
Wh/m^2	watt-hour per square meter
WRPC	Warri Refinery and Petrochemicals Complex

CHAPTER ONE

1.0 INTRODUCTION

Nigerian government has set ambitious goals for its socio-economic development, developing a unified plan of action on all issues relating to repositioning Nigeria from its current position in the world's GDP ranking to be among the top 20 most developed countries of the world by year 2020. This development blueprint is tagged Vision20:2020. As at 2010, the IMF's ranking of economies of countries of the world places Nigeria in the 31st position by GDP on Purchasing Power Parity (PPP) basis. To move to the group of first twenty by 2020, Nigeria needs to grow its economy at an average rate of 13.8% per annum (FGN, 2010) from the present growth rate of about 6%. The main thrust of the Vision, which is economy based, is to increase the GDP of the country to about US$900 billion and per capita income to US$4,000. The improvement in national and personal income is expected to translate into improvement in social aspects of the Vision, such as the Human Development Index (HDI).

Socio-economic development is driven by energy that powers the nation's industries, vehicles, homes and offices. Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development; social, economic, and environmental, including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues. None of the Millennium Development Goals (MDGs) can be met without major improvement in the quality and quantity of energy services in Nigeria. UNDP's efforts in energy for sustainable development support the achievement of the MDGs, especially MDG 1, reducing by half the proportion of people living in poverty by 2015. Through an integrated development approach, UNDP works to help create enabling policy frameworks, develop local capacity and provide knowledge-based advisory services for expanding access to energy services for the poor (UNDP).

To energize the Vision 2020, the Blueprint planned to increase the electricity production of the country from 4,000MW in 2007 to 35,000MW in 2020 and the petroleum refining capacity from current 445,000 b/d to 750,000 b/d in 2015 and 1,500,000 b/d in 2020. The objective of this study is to evaluate the adequacy or otherwise of the electricity production and petroleum refining targets of the Vision and proffer suggestions as to the energy supply that may be adequate for the realization of the Vision.

The methodology adopted is to first evaluate the energy demand, using the Model for Analysis of Energy Demand (MAED) developed by the IAEA. The energy demand projections then served as input to the Model for Energy Supply Strategy and their General Environmental impacts (MESSAGE), also developed by the IAEA, to evaluate the supply strategies for meeting the energy demands.

Manufacturing and services sectors are expected to be the major drivers of the growth. Nigeria needs to significantly upgrade the quality and size of its energy infrastructure in ways that are environmentally and socially sustainable to power the achievement of the Vision. Sustainable energy supply must be available, accessible, affordable and reliable. The quality of energy services cannot be inferior to the equivalent services provided by the established system; rather it must have the potential of becoming significantly better. Supply densities must match demand densities.

Presently, the supply of modern energy, especially electricity, liquefied petroleum gas, kerosene and diesel is grossly inadequate and there is so much dependence on traditional fuels by the rural dwellers and the urban poor who account for about 60% of the population. Traditional fuels accounted for 55% of the total energy consumption. Energy-induced environmental degradation is already prevalent in the country. This is characterized by deforestation as a result of felling of trees for fuelwood, air pollution in urban areas arising from vehicular emissions and the burning of traditional fuels for cooking in households, noise and air pollution from use of small generators to provide electricity due to inadequate supply from the national grid, and land and water pollution from oil spillages in the oil producing communities. These impact negatively on the quality of life of the population, hence on the development aspirations. There are many inputs necessary for the realization of the Vision, of which energy is one. Several individuals and government agencies have commented on the energy requirements for Vision 2020.

The objective of this study is to carry out an evaluation that provides more insight into the subject and to help us visualize better the many-faceted reality of the energy situation in Nigeria, to provide the basis for decision – making and action. It provides insights into what needs to be done in the energy sector to provide adequate and reliable energy or guarantee security of energy supply in order to achieve the Vision20: 2020.

The study employed the MAED to estimate energy demand for the Vision20:2020 and three other possible development scenarios and the MESSAGE to explore strategies for the supply of projected energy demands for the development scenarios. Although the MAED and MESSAGE models were applied for projections up to 2040, the focus of the analysis is the period up 2020 because it should be of interest to the current political leadership of the country.

CHAPTER TWO

2.0 PAST AND PRESENT SOCIO-ECONOMIC AND ENERGY SITUATION IN NIGERIA

2.1 Geography and Climate:

Nigeria a tropical Sub-Saharan West African country, lies within latitudes $4^o 1'$ and $13^o 9'$ North of the Equator and longitudes $2^o 2'$ and $14^o 30'$ East. It is bounded by Benin Republic, Niger, Chad and the Cameroon to the West, North, North East and East, respectively, and by the Atlantic Ocean to the South (Fig. 2.1) and occupies an area of 923,768 sq km. The vegetation is mangrove forests in the south, which is interspersed by a network of rivers and creeks. It transits to tropical rain forest further inland and progresses into a savannah region further north.

Fig. 2.1: Location Map of Nigeria

The climate in the southern areas is equatorial, with high humidity and rainfall. The coastal town of Port-Harcourt, for instance, has monthly minimum-maximum temperatures in the range of 18-36^{O}C over the year, relative humility at 9.00 am of 61-94% and at 3.00 pm of 30-86%. The average annual rainfall is about 1900 mm. The northern areas are semi-equatorial, with lower humidity and rainfall, for example Sokoto in the Northwest Region of Nigeria. The rainfall level demarcates the seasons into two, namely, the wet and dry seasons, for instance, with monthly minimum-maximum temperatures in the range of 13-41^{O}C over the year, relative humility at 9.00 am of 12-85% and at 3.00 pm of 7-68%. The wet season lasts over April to October, while the dry season lasts over November to March. However the coastal areas experience more rainy months while the extreme Northern parts have more dry months (IAEA/ECN 2008).

Solar radiation intensity varies from an annual average of 3.5 - 7.0 kWh/m^2-day, the annual average of daily sunshine hours varies from 4 - 9 hr/day. Wind speeds vary from 4.0 - 5.1m/s and 1.4 - 3.0 m/s in the north and south, respectively. The nation is blessed with a multitude of rivers. The overall hydropower potential is estimated at 15 GWe or 14,750MW. The coal reserves are 2.75 billion tonnes for inferred and 6.39 million for proven. Crude Oil reserved was estimated to be 4,500 million tonnes of oil equivalent (Mtoe), Tar Sand (30 billion barrels of oil equivalent), Natural Gas 4.5 trillion m^3 or 187 Tscf and preliminary investigations have since confirmed the availability of uranium in especially the north eastern region of the country but the magnitude of the reserve is yet to be quantified (Table 2.1).

Table 2.1: Nigeria Energy Resources

S/No	Resource Type	Reserves (Natural Units)	Utilization (2008)
1	Crude Oil	36.2 billion barrels	0.45mb/day
2	Natural Gas	187 Tscf (4.5Tm^3)	•59.1% - Fuel, Industries, re-injection and gas lift. •26.8% - gas flare
3	Coal and lignite	2.7 billion tonnes	Negligible
4	Tar sands	31 billion barrels of oil equivalent	0.224 million tones
5	Nuclear	Yet to be quantified	30kW
6	Large Hydropower	11,250 MW	1,972MW
7	Small Hydropower	3,500 MW	64.2MW
8	Solar	4.0kW/m/day – 6.5 kW/m^2/day	•10MW solar PV stand-alone •No solar thermal electricity
9	Wind	2-4 m/s @ 10m height mainland	•2x2.5KW electricity generator •10MW wind farm contracted in2009
10	Biomass		

(i)	Fuelwood	11 million hectares of forest and woodland	43.4 million tonnes of fuel wood/year
(ii)	Animal waste	245 million assorted animals	
(iii)	Energy crops and agricultural residue	72 million hectares of agricultural land and all waste lands	

2.2 Demography

The population of Nigeria has grown from 134 million in the 2005 to 154 million in 2009. Approximately 48% of the population lives in the urban areas (Table 2.2), the total population growth rate is about 3.16% per annum (FGN-NPC, 2009). The working population as at 2009 was about 55.33 million, total salaried working population was 5 million representing about 18% of the working population. Agriculture had the highest working population (30 million) followed by services (21.73 million), manufacturing (1 million) and construction, energy and mining having less than 1 million (FGN-NPC, 2009).

Table 2.2: Development of Population

Parameters	Unit	2005	2006	2007	2008	2009
Total Population	10^6 Person	137.49	140.00	144.48	149.10	153.88
Population in Urban Areas	10^6 Person	65.99	67.2	69.35	71.57	73.86
Population in Rural Areas	10^6 Person	71.49	72.8	75.13	77.53	80.02
Potential Labour Force	10^6 Person	56.17	58.93	61.25	62.95	64.96
Actual Labour Force	10^6 Person	49.49	50.89	52.33	53.81	55.33
Labour Force in Service Sector	10^6 Person	19.22	19.76	20.32	21.01	21.73

There are about 32.06 million dwellings in the country with an average household size of 4.8 persons per dwelling. 55.2% of the dwellings are electrified. While 0.7% of the electrified dwellings use electricity for cooking, 20.7% use kerosene, 15.9% use gas and 1.6% use coal briquettes; the rest basically are rural dwellers and they use fuelwood for their cooking purposes (Table 2.3).

Table 2.3: Population Lifestyles

Parameters	Unit	Amount
Total Number of Dwellings	10^6 Dwellings	32.06
Average Household Size	Person / Dwelling	4.80
Electrified Dwellings	%	55.20
Dwellings with Hot Water Facility	%	100.00
Dwelling with Solar Installation	%	0.00
Households using FF for Lighting	%	62.17
Households using Electricity for Cooking 2009	%	0.70
Households using Kerosene for Cooking 2009	%	0.70
Households using Gas for Cooking 2009	%	22.90
Households using wood for Cooking 2009	%	74.10
Households using Coal for Cooking 2009	%	1.60

2.3 Macroeconomics

The Gross Domestic Product (GDP) and the percentage contributions of the various sectors of the economy over the last five years as from 2005 are shown in the Tables 2.4 and 2.5 Agriculture consistently contributed the largest share ranging between 41.01% and 42.07% to the GDP over the five-year period. Of the agricultural components, namely: crop production, livestock, forestry and fishing, crop production contributed more than 80% of the share for the whole five year period. The major crops were yams, cassava, maize, guinea corn, millet, beans and groundnuts.

Table 2.4: Sectoral GDP at Constant 1990 Basic Price (₦ million)

Sector	2005	2006	2007	2008	2009
Agriculture	231,463.6	248,598.95	266,477.30	283,913.00	299,996.90
Construction	8,544.5	9,654.79	10,912.60	12,337.50	13,851.14
Energy	136,345.5	151,309.47	146,441.90	141,448.50	138,792.36
Manufacturing	21,305.1	23,305.87	25,535.60	27,905.10	30,013.82
Mining	1510.8	1,665.96	1,878.30	2,118.10	2,374.03
Services	159,027.4	161,286.58	183,005.90	207,166.60	231,921.44
GDP	561,931.4	595,821.60	634,251.60	674,888.80	716,949.70

Table 2.5: Sectoral Share of Total GDP (%) at Constant 1990 Basic Prices

Sector	2005	2006	2007	2008	2009
Agriculture	41.19	41.73	42.01	42.07	41.84
Construction	1.52	1.62	1.72	1.83	1.93
Energy	27.85	25.39	23.09	20.96	19.36
Manufacturing	3.79	3.91	4.03	4.13	4.19
Mining	0.27	0.28	0.3	0.31	0.33
Services	25.38	27.07	28.85	30.7	32.35
Total	100	100	100	100	100

Agriculture is very closely followed by services sector including transport (25.38-32.35%), and energy sector (27.85-19.36%). The major contributors in the service sector were trade, government service and banking & insurance, in that order. Together, they accounted for 70-80% of GDP in the service sector. Although energy mining and energy services sector (11-14%) includes utilities, by far the dominant sub-sector was crude petroleum and gas. It accounted for over 95% of the sector's contribution to GDP. In 2008, oil and gas accounted for over 72% of income to the Federation Account and 95% of total export income. This level of dominance by oil and gas over the sector has been maintained over the years. Since 2001, the contribution of gas has been growing, very significantly, with the commencement of the production and export of liquefied natural gas.

The contribution of manufacturing to GDP was low, at about 3-4%. Of this, large scale industries accounted for over 85%. Construction and mining made the least contributions at about 2% and 0.3%, respectively. The fastest growing sector of the economy was manufacturing with an average growth of 8.84%, followed closely by construction (8.80%). The growth rates for agriculture and services were comparable at 6.10% and 5.2%, respectively. While agriculture, construction, mining, services and the total GDP (at constant 1990 factor cost) showed modest positive growth rates over 1991-2000, manufacturing and energy declined, with growth rate of -1.26% and –0.025%, respectively. Manufacturing, in particular, showed continued decline from 1991 to 1999, with a slight recovery in 2000. A major contributor to this poor performance of the manufacturing sector was the fall in actual electricity supply capacity during the same period.

Table 2.6: Energy and the Economy

Indicator	2003	2004	2005	2006	2007	2008
Real GDP Growth (%)	9.6	6.6	6.5	6	6.2	6.4
Major Contributors to GPD @ 1990 Constant Prices:						
Agriculture (%)	41.01	40.98	41.19	41.72	42.2	42.07
Crude Petroleum (%)	26.53	25.72	25.26	21.85	19.35	17.54
Major Contributor to						
Federal revenue (net)						
Crude Petroleum (%)	75	77	72.4	76.7	67.7	71.8
Energy Intensity (kgoe/$) (Energy Consumption/GDP)	0.244	0.186	0.157	0.086	0.063	0.069
GPD/Capita (US$)	620.9	673.2	847.4	1,036,2	1,256.60	1,176.10
Energy Consumption/Capita (kgoe/capita)	151.3	125.5	132.6	87.1	81.4	80.8
Electricity consumption/capita (kWh/capita)	174.6	176.4	181.4	167.6	161.2	142.9
Electricity Access (%)	55.2% from 40% in 1993					

The structure of the economy remained essentially the same over the period. The small gains by agriculture (2.9%), services (2.4%) and construction (0.2%) constituted losses by mining, energy (3.1%) and manufacturing (2.5%).

2.4 Indigenous Energy Resources

A. Crude Oil

Nigeria is an oil exporting country with significant reserve that ranks 6th in the world and is a member of Organization of Petroleum Exporting Countries (OPEC). The oil reserve is presently estimated at 36.2 billion barrels of oil (4500Mtoe), while the production capacity is about 3 million barrels/day (mb/d). The OPEC quota restricts actual production to around 2.5 – 2.8 mb/d. The long-term policy is to continue to increase the reserve base to the highest-level possible, and increase OPEC quota in consonance with increases in reserve base and productivity.

Most of the production is from on-shore fields in the Niger Delta Basin. There's significant production, however, in the shallow and deep offshore concessions. The greater part of new fields will come from the offshore areas of the basin. The policy strategy adopted by government for the development of the deepwater fields is to use Production Sharing Contracts and Sole Risk Arrangements.

B. Natural Gas

The natural gas reserve is 4.5 trillion m^3 (4090Mtoe or 167.8EJ), composed of 53.5% associated gas and 46.5% non-associated gas. Nigeria is ranked 7th in the world gas reserves. Gas utilization has remained far below production. Of the 5.8 billion m^3 produced in 2002, 47.8% was flared. It is planned that all gas utilization projects will be based on associated gas until the latter is fully committed. The exception is the existing Nigeria Liquefied Natural Gas project, which predominantly uses non-associated gas, though it is planned to progressively increase the utilization of associated gas.

A study of natural gas utilization in the country estimated a projected demand potential of about 201 million m^3 per day by 2010 and 297 million m^3 per day by 2020, for the combined domestic and export markets, and for field use. At these utilization rates, the reserve life spans will be 55 and 35 years, respectively, so that there should be no resource constraint. The domestic market will be composed mostly of power, cement, fertilizer, steel and other projects (aluminum, petrochemicals, manufacturing and distribution). By far the largest present domestic consumer, as well as source of future potential for domestic market expansion is the power sector.

The export market potentials are in liquefied natural gas (LNG), natural gas liquids (NGL), gas to liquid (GTL), pipeline gas, and gas-based chemicals projects. Already, the Joint Venture Nigeria LNG plant at Bonny now has six producing trains with the total capacity to 20.4 million tonnes per yr (27.35 billion m^3 per yr). Expansion to ten trains is envisaged in the future, while other two private sector LNG plants are being planned, one at Olokola and the other at Brass. The West African Gas Pipeline project is underway. It involves a concession agreement by Nigeria, Benin Republic, Togo and Ghana to pipe Nigerian gas on an offshore route from the

Lagos end of the Escravos-Lagos Gas Pipeline at Alagbado to Takoradi in Ghana, with spur lines at Benin, Togo, Tema (Ghana) and Takoradi. The line may be extended to the Ghana-Cote D'Ivoire border at Effasu and later to Senegal. The pipeline capacity is to be 620 million scf/d. Preliminary considerations are being given to Nigeria-Algeria Trans Sahara Gas Pipeline, which is destined for the European market.

C. Coal

The inferred and proven reserves of coal in the country are respectively 2.75 billion tonnes and 6.39 million tonnes. It occurs in 13 states and 17 mine sites. Of these, only four mine sites have been developed, namely, Okpara and Onyeama underground mines at Enugu, Okaba surface mine in Kogi State and Owukpa underground mine in Benue State. Nigerian coals are mostly bituminous, with medium to high calorific values and so are good for power generation and for thermal applications. They are also low in sulphur and ash content and thus have a high export potential. They are mostly non-coking but can be blended with imported coal for coking use, for instance in Ajaokuta Steel Plant. Some coking coal deposits exist, however, at Lafia-Obi in Nassarawa State.

Presently, local consumption of coal is low due to loss of the power and train locomotives markets to natural gas, hydro and diesel, and due to the run down state of its other major consumer, the Nkalagu Cement factory. Due to the new focus on developing the solid minerals sector, especially with foreign and domestic private sector capital, the coal market will be re-built. The National Programme on Alternatives to Fuelwood will establish a coal briquette plants as one of the strategies for fighting desertification and soil erosion. In all, the estimated domestic potential demand for coal is in excess of 600,000tonnes/yr, while the current consumption is only about 10,000tonnes/yr.

D. Tar Sands or Bitumen

Tar sands deposits exist in the southwest region of the country, in a belt 4.6km wide and 120km long, which runs from Edo, through Ondo and Ogun to Lagos States. It is reputed to be the second largest deposit in the world, second only to Venezuela's Dada field. At 31billion boe, the reserves are almost equal to the currently known crude oil reserves. Heavy oil for the production of bitumen or asphalt and other heavy oil fractions are obtained from the tar sands.

E. Hydro Power

Hydropower is derived from the potential energy available from water due to the height difference between its storage level and the tail-water to which it is discharged. The technical hydropower potential in Nigeria has been estimated at about 15GW, of which about 14% (1.9GW from Kainji, Jebba and Shiroro) was being utilized as at 2000 which represented some 30% of the total installed grid-connected electricity generation capacity of the country.

F. Solar Energy

Nigeria is blessed with solar radiation intensity, which varies from an annual average figure of 7.0kWh/m2 at the extreme north to 3.5kWh/m^2 in the extreme south. These figures are more than sufficient for both thermal and photovoltaic applications.

G. Biomass Energy

The biomass resources of Nigeria consist of wood, forage grasses and shrubs, animal wastes arising from forestry, agricultural, municipal and industrial activities as well as aquatic biomass. The primary way to utilize biomass is through direct combustion. Biomass is the leading source of energy for Nigeria contributing about 37% of the total energy demand. Nigeria's estimated biomass resources are 144 million tonnes per year. The country is presently consuming about 43million tonnes of fuelwood annually.

H. Wind Power

Wind resources can best be exploited where the wind power density is At least 400 W/m^2 at 30m above ground. Wind speeds in Nigeria vary considerably, with the extreme North having from 4.0 to 5.12m/s and 1.4 to 3.0m/s in the southern part of the country. Nigeria was a poor/moderate wind regime. It is also observed that the wind speeds in the country are generally weak in the south except for coastal regions and offshore.

I. Uranium

Uranium ore exist mostly in the northern part of the country. It is believed that it is the same deposits that extend to Niger Republic where French companies have been mining the ore. More is required to quantify the Nigerian uranium ore. The nation shall promote private sector participation in the electricity sub-sector, while ensuring broad-based participation of Nigerians

2.5 Energy Related Policies

The National Energy Policy is an overall energy policy document for the country, with which all other energy sub-sectoral policies must be compatible with and be derived there from. It was approved in 2003 and its 9-point objectives summarize the thrust of the policy and are as follows:

a. To achieve national energy security and efficiently provide for the nation's energy needs with a diversified and optimal energy mix ;
b. To guarantee increased contribution of energy production activities to national income;
c. To guarantee adequate, reliable and sustainable supply of energy at appropriate costs and in an environmentally friendly manner;
d. To guarantee efficient and cost effective consumption pattern of energy resources;
e. To accelerate the process of acquisition and diffusion of technology and managerial expertise in the energy sector and indigenous participation in energy sector industries, for stability and self-reliance;
f. To promote increased investments and development of the energy sector industries with substantial private sector participation;
g. To ensure a comprehensive, integrated and well-informed energy sector plans and programmes;
h. To foster international co-operation in energy trade and projects development in both the Africa region and the world at large;
i. To foster international co-operation in energy trade and projects development in both the Africa region and the world at large;
j. To successfully use the nation's abundant energy resources to promote international co-operation.

The policy document has provisions for the exploitation of all the nation's energy resources (oil, gas, tar sands, coal, uranium, hydropower, solar, biomass, wind, etc). It further provides for energy utilization issues namely, electricity, energy efficiency and conservation, environment, industry, agriculture, research and development etc, as well as for energy management issues such as energy financing, planning and policy implementation. With regards to power, it provides for the re-introduction of coal for power generation (especially with cleaner coal technologies), increased use of natural gas and expansion of the gas network (which should also facilitate the termination of natural gas flaring by 2008), further utilization of the balance (9GW) of large-scale hydropower potential in the country, utilization of the smaller-scale renewable energy technologies (solar, wind, micro-hydro etc), - especially for distributed, isolated and rural power supply as well as the development of nuclear power for electricity generation in the long term. Further provisions in respect of electricity include that:

a. The nation shall make steady and reliable electric power available at all times, at economic rates, for economic, industrial and social activities;
b. The nation shall continue to engage intensively in the development of electric power with a view to making reliable electricity available to 75% of the population by the year 2020
c. The nation shall promote private sector participation in the electricity sub-sector, while ensuring broad-based participation of Nigerians.

For oil and gas, the policy provides for the increase of the reserve base, increase in value added to the natural resources, expansion of the domestic consumption and network for gas, indigenous and foreign private sector participation in addition to the deregulation and privatization of the upstream and downstream sectors of the industry.

Apart from the role envisaged in the National Energy Policy for renewable energy in rural and isolated power supply, as indicated above, the policy provides for de-emphasizing the use of fuelwood but rather it promotes the use of renewable energy and other and technologies as alternatives to fuelwood. In this regard, the policy also promotes the use of smokeless coal briquettes in place of fuelwood.

2.6 Environmental Aspects

The most serious environmental problems in Nigeria are land degradation due to desertification, soil erosion, land and sea pollution due to natural gas flaring, oil spillages, oil waste leakages and discharges; atmospheric pollution from exhausts of vehicles, power plants and other combustion equipment; environmental pollution from municipal wastes and blocked gutters. Power generation has linkages to most of these aspects of environmental damage. The increased availability and use of electricity for lighting and cooking by higher and medium income households will reduce the pressure on kerosene. The latter fuel may then be more available to lower income households who may use more of it for cooking, thereby reducing the use of fuelwood and thus, reducing the latter's contribution to soil erosion and desertification.

With regards to natural gas flaring (23.9 and 27.9 billion m^3 in 2000 and 2002, respectively), government has set the target year of 2008 for its termination. Increased use of natural gas for power generation is one of the key strategies for achieving the target. Indeed, most power plants currently under construction or being planned are gas based. With a CO_2 ratio for gas, oil and coal of 1:1.43:1.95, respectively, natural gas is environmentally cleaner than oil and coal for power generation. Thus, from environmental considerations, the existing policy, which favours the use of natural gas, is in the right direction.

Environmental problems also arise from hydropower plants, though mostly of a different nature from those due to thermal power plants. They arise from the flooding of catchment areas, displacement of persons and loss of agriculture and other lands, the emission of methane and ammonia from decaying vegetable matter in flooded areas, and the growth and spread of some water borne disease vectors.

All new power plant projects are subject to Environmental Impact Assessments before approval for construction, as required by the environmental law.

CHAPTER THREE

3.0 OVERVIEW OF NIGERIA'S VISION: 2020

Vision 2020 is the Federal Government's postulation for industrialization that is to be amongst the first 20 industrialized countries in the world by the year 2020. Below is an overview of that vision in a tabular form.

Nigeria 2020 will be bustling with energy, entrepreneurship and innovation. The country's 160 million people will be better fed, dressed and housed, healthier, more educated and longer living than any generation in the country's long history. Illiteracy and all major contagious diseases would have disappeared. These are encapsulated in the Human Development Index (HDI) in which Nigeria is currently (2010) occupying the 142nd position to between 71 and 100. Table 3.1 gives a summary of the major assumptions of the Vision.

Table 3.1: Overview of Nigeria Vision 2020 Targets

	Baseline, 2007	2015	2020
GDP (at 2007 current price)	$212bn	>$400bn	>$900bn
Per Capital Income	$ 1473.35		>$4,000
GDP Growth Rate			average of 13.8%
Sectoral Contribution to GDP			
-Agriculture	42.10%		3% to 15%
-Industry	23.80%		30% to 50%
-Manufacturing	4%		15% to 30%
-Services	34.10%		45% to 75%
Pillar 1			
% of population living on less than $1/day	54.4	21	15
% of underweight children under the age of 15	30	18	10
% of population with sustainable access to improve water source	49	80	100
% of population with access to improved sanitation	35	65	80
Life expectancy	46.5	60	70
Under 5 mortality rate (per 1000 live birth)	110	63	22

Infant mortality rate (per 1000 live birth)	138	30	15
Maternal mortality rate (per 100,000 live birth)	800	100	70
Adult literacy rate (% aged 15 and above)	69.1	75	100
% of primary school enrolment of children aged 6-11	89.6	100	100
Ratio to female to male enrolments in tertiary education	69	100	100
% increase in number of housing units	NA	20	50
HDI index ranking (country Group)	Low Human Development (158)	Medium Human Development (100 -155)	Medium Human Development (71-100)
Reduce the number of people who suffer from hunger and malnutrition		50%	75%
Increase irrigated arable land Home ownership to about 50%	1%	10%	25%
Pillar 2			
Aggregate GDP (at 2007 current price)	$212bn	>$400bn	>$900bn
Economic Structure (ratio of Agriculture, Industry and services contribution to GDP			
Agricultural Productivity	2009	3-fold increase	6-fold increase
Domestic refining Capacity	445,000bpd	750,000bpd	1,500,000bpd
Ratio of non-oil contribution to GDP	5 to 95	20 to 80	40 to 60
Average Local content value (material and human resources)across key industries			
Manufacturing contribution to GDP	4%	10%	25%
Private sector credit as a % of GDP	17%	30%	45%
Steel consumption per capital	10kg	40kg	100kg
Proven Oil Reserves	37.8bb	40bb	50bb
Proven Gas Reserves	187tcf	215tcf	250tcf
Pillar 3			
Inflation rate (%)(Dec-Dec)	15.10%	<9%	<9%
Ranking on ease of doing business index	125/180	<80	<60
Ranking on corruption perception index	121/180	<60	<60
Actual power generation capacity	6,000MW	20,000MW	35, 000MW

Private sector contribution to power generation	NA	50%	80%
Annual urbanization Rate	5.30%	4%	2%
Tele-density	45%	70%	100%
Gas Flares as a Percentage of total gas Production	40%	0% from 2010	0%
Tourism contribution to GDP	2.5% (2007)	5%	10%
Increase the computer Literacy rate/ penetration by		50%	80%
Forest Cover	6%	12%	18%

Source: Federal Government of Nigeria, Vision 2020 Blueprint

A look at the Vision 2020 Targets shows that the GDP will grow from US $212 in 2007 to US$ 400 in 2015 and US$ 900 in 2020. The per capita GDP is projected to increase from US$ 1473.35 in 2007 to US$ 4000 in 2020. To achieve these targets, the GDP is projected to grow at an average of 13.8% per annum over the period 2007 – 2020. Growing GDP at this rate requires enormous amount of energy.

Steel consumption, estimated at 10kg/person in 2007 is projected to increase to 40kg/person in 2015 and 100kg/ person 2020 for estimated populations of 188.7 million people in 2015 and 227 million people in 2020. Proven reserves of crude oil will increase from 37.8 billion barrels to 40 billion barrels and 50 billion barrels by 2015 and 2020 respectively. Similarly, natural gas reserves will increase from 187tcf in 2007 to 215tcf and 250tcf in to 2015 and 2020 respectively. Achieving these targets requires enormous amounts of energy.

CHAPTER FOUR

4.0 ENERGY DEMAND ANALYSIS

4.1 Energy Demand

Energy use is inextricably entwined with human history. Coal use helped fuel the industrial revolution of the 18th and 19th centuries; oil use has, inter alia, formed the basis of the mobility revolution of the 20th century. All fuel types have been used to increasingly provide access to electricity, which is powering the current information and communication revolution (OPEC 2010). A myriad of uses allows energy services to fuel economic growth, and bring about social progress. With the assumptions laid out in the Vision 2020, energy demand will continue to increase to 2020, as the national economy expands, the population grows and people's living conditions improve.

4.2 The MAED Model

The analysis of the energy demand projection was carried out using the MAED model which was developed by the IAEA. MAED evaluates future energy demand scenarios based on medium to long-term assumptions for socio-economic, technological and demographic development. The MAED model allows differentiation between energy demand for specific uses and substitutable energy demand. Energy demand is disaggregated into a number of end- use categories each corresponding to a given service or to the production of a certain good e.g. industrial sector, transport sector, household and services sectors (MAED Manual).

The nature and level of the demand for goods and services are a function of several determining factors, including population growth, GDP growth rates and changes of GDP structure, number of inhabitants per dwelling, number of electrical appliances used in households, peoples' mobility and preferences for transport modes, national priority for the development of certain industries or economic sectors, evolution of the efficiencies of certain types of equipment, market penetration of new technologies or energy forms. The expected future dynamics for these determining factors are exogenously introduced.

The analysis and projection of total energy demand using MAED involved the following steps:

- Total final energy consumption is disaggregated into consumption by economic sector e.g. industrial, transport, household and services sectors. Energy consumption in the industrial sector is further divided into consumptions by manufacturing, mining, construction and agriculture. The energy consumption for each sector is categorized into specific energy types, both non-substitutable and substitutable;
- Assumptions on socio-economic development and evolution of technologies;
- A set of scenarios, each consistently reflecting future evolution of the energy determinants is prepared;
- The establishment of relationships between the energy demand and the socio-economic and technological factors identified for each end use category, and based on these relationships, final energy demand is calculated.

4.3 Assumptions of the Scenarios

Four possible scenarios of the development of the economy were chosen based on the policy of the Nigerian government, namely: Reference Scenario (basic or moderate economic growth); High Growth Scenario (High economic growth); Optimistic I Scenario and Optimistic II Scenario (Vision20: 2020 Scenario).

Reference Scenario

The reference or low growth scenario was based on the possibility that the economy will evolve on the basis of 'business as usual' approach. The sectoral average growth rates recorded over the period (2009-2020) were therefore adopted for the first 5-year period of the plan. These were improved slightly over the remaining periods of the plan. The resulting overall annual growth rate for the total GDP over the plan period (2009-2020) is 7% per annum for this scenario.

High Growth Scenario

The overall growth rate of the economy over the plan period, for this scenario, is 10% p.a. Since agriculture and services constituted about 74.18% of the GDP their respective effective annual GDP growth rates for the plan period should not be greatly different from 10%, otherwise it would imply unrealistic growth rates for one or more of the other sub-sectors.

Optimistic I Scenario

The Optimistic I scenario with a GDP growth rate of 11.5% per annum was based on the possibility that the economy evolve faster than the 10% growth rate.

Table 4.1: Final Energy Demand by Sector and by Energy Form (Million toe), 2009

Economic sectors	Fossil (thermal use)	Motor Fuels	Coal Coke	Feed stock	Total	Electri city	Solar Syste ms	Total Commer cial	Non-Commercial (traditional fuels)	Grand Total
Manufacturing	353.6	0.0	50.8	37.7	442.1	483.9	0.0	926.0	112.4	1038.4
Agriculture	13.3	5.7	0.0	0.0	19.1	0.4	0.0	19.4	0.0	19.4
Construction	16.3	40.0	0.0	0.0	56.3	27.3	0.0	83.6	0.0	83.6
Mining	2.7	1.3	0.0	0.0	3.9	0.8	0.0	4.7	0.0	4.7
Transportation	0.0	7655.6	0.0	0.0	7655.6	0.0	0.0	7655.6	0.0	7655.6
Household	305.6	0.0	0.0	0.0	305.6	1336.4	0.3	1642.3	22447.9	24090.2
Services	74.1	0.0	0.0	0.0	74.1	629.6	1.9	705.6	2422.5	3128.0
Total	**765.6**	**7702.7**	**175.4**	**37.7**	**8556.7**	**2478.3**	**2.2**	**11037.3**	**24982.7**	**36020.0**

Optimistic II Scenario

The present administration pronounced a Vision 2020, which is aimed at taking Nigeria to the league of twenty (20) most developed economies in the world by year 2020. Nigeria is currently ranked 31st on GDP on PPP basis (Table 4.2). To achieve the vision, the administration intends to grow the economy at an average rate of 13.8% per annum. Thus this growth rate has been adopted as the Optimistic II Scenario. Hence, to be in the top 20 bracket, with a GDP of $900 million, Nigeria would have to displace at least the bottom five countries, namely, Turkey, Australia, Taiwan, Iran and Poland.

Table 4.2: World Top 20 Countries Based on GDP (PPP)

S/No.	Country	GDP, $ Billion
1	United States of America	14,660.00
2	China	10,090.00
3	Japan	4,310.00
4	India	4,060.00
5	Germany	2,940.00
6	Russia	2,223.00
7	United Kingdom	2,173.00
8	Brazil	2,172.00

9	France	2,145.00
10	Italy	1,774.00
11	Mexico	1,567.00
12	South Korea	1,459.00
13	Spain	1,369.00
14	Canada	1,330.00
15	Indonesia	1,030.00
16	Turkey	960.50
17	Australia	882.40
18	Taiwan	821.80
19	Iran	818.70
20	Poland	721.30
31	**Nigeria**	**380.23**

Source: International Monetary Fund, 2010

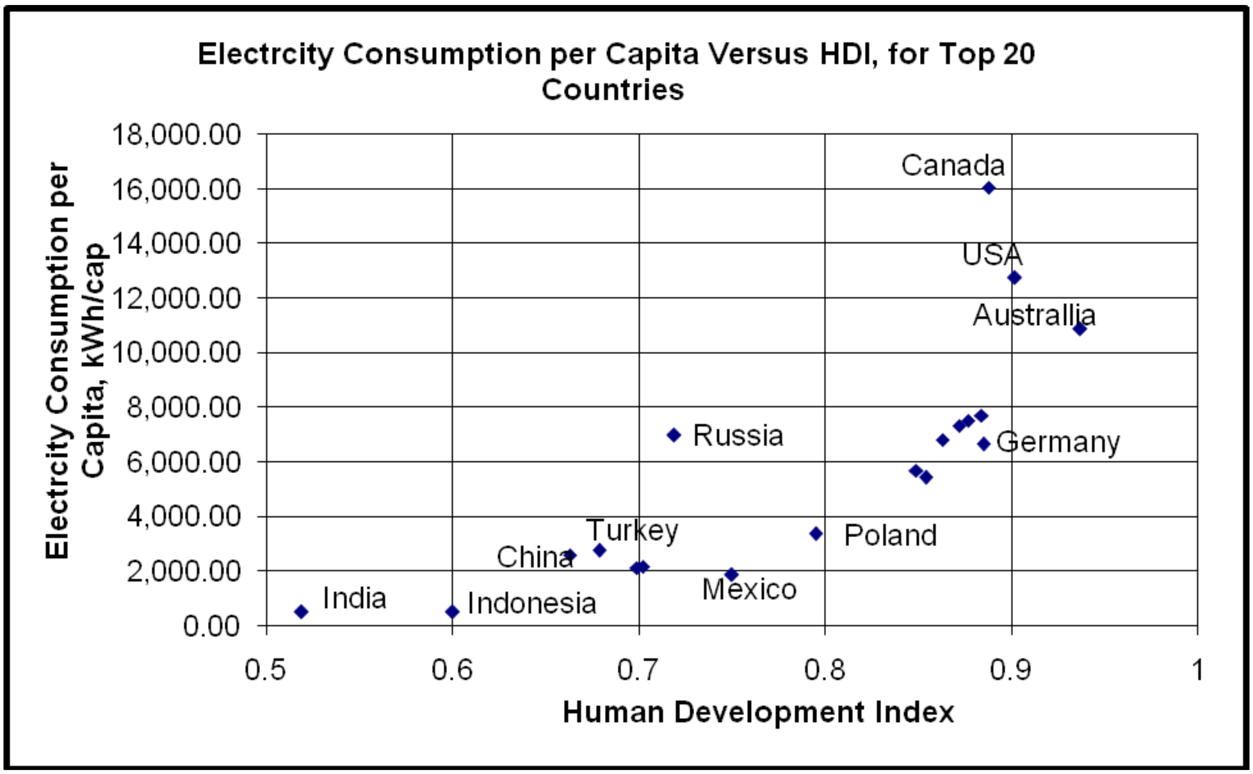


Fig. 4.1 Electricity consumption per capital versus HDI for top 20 countries

4.3 Assumptions for the Scenarios

The MAED model requires the determination of the future development of the most important indicators affecting energy demand in sectors of the national economy. The following are the main factors influencing the economic development: Demography; Economy Growth; Energy Efficiency; Freight and Passenger Transportation; Energy Consumptions.

4.4 Demographic Assumptions

The population projections were based on the 2006 population census data. Only one demographic scenario was considered for the four scenarios. It was assumed that the population growth rate will increase slightly from 3.2% per annum in 2009 to 3.8% per annum in 2020, based on assumptions regarding fertility, cultural practices, religious beliefs, mortality and migration, bringing the population to 188.7 million people in 2015 and 227 million people in 2020. A recent statement credited to the outgoing Chairman of the National Population Commission (NPC), Mr. Samu'ila Danko Makama while preparing this report after our calculations, shows that the current population is 167 million people. The statement also gave projections by NPC as 188 million people by 2015 and 221 million people by 2020. The projections are within 0.37% and 2.71% accuracies respectively, with the projections made in this study.

4.5 Energy Demand Projections

4.5.1. Patterns of Energy Consumption

Prior to the 1960s, energy demand and consumption constituted, very predominantly, of non-commercial energy, namely, fuelwood, charcoal, agricultural wastes and residues and solar radiation. The major commercial fuel was coal, which was used by the railways and for power generation. Modest contributions came from petroleum products (petrol and diesel) and electricity (from coal and diesel generators).

The structure of energy demand has drastically changed since then. Commercial production of crude oil started in December 1957, with the first exports in 1958. Coal production peaked in 1959 and has experienced continued decline since then, due in part to the introduction of diesel powered engines in the railways in the 1960s and eventual stoppage of power production from coal. The first gas turbine power plant was built at Afam, near Port Harcourt, in 1965 with an initial capacity of 56 MW. The first domestic refinery was also commissioned in Port Harcourt in 1965, with a capacity of 60,000 bpd. Furthermore, the first hydroelectric power plant, Kainji, started operations in 1968 with an initial capacity of 320 MW. These developments signaled the beginning of the change in the structure of the energy sector from coal to petroleum dominance of commercial energy. They also signaled the beginnings of the eventual dominance of the economy by the energy sector, especially by the oil and gas sub-sector. Fig. 4.2 shows the projected demand for energy by source and types over the period 2009 – 2030 for the Optimistic II Scenario.

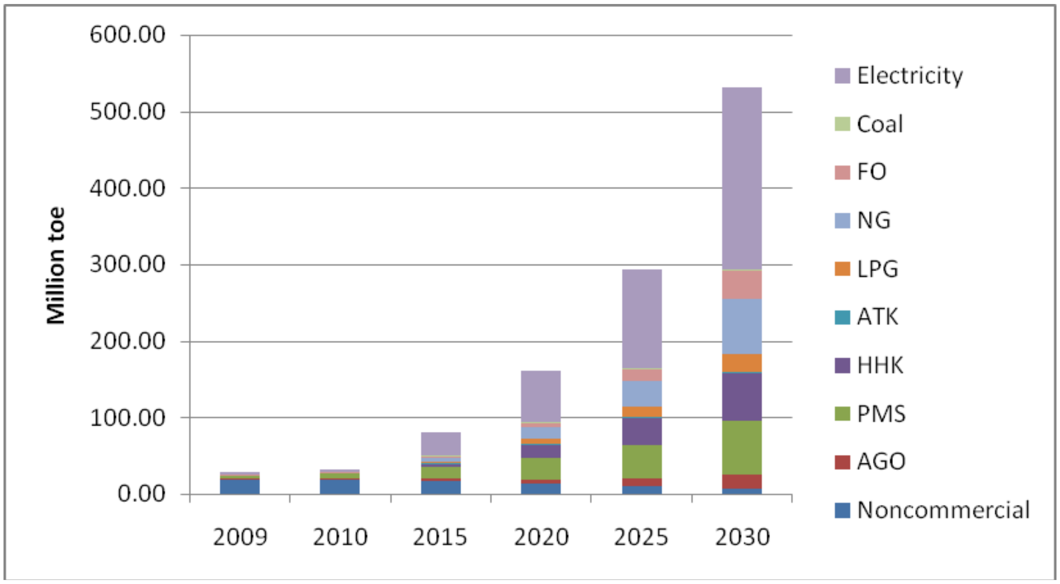
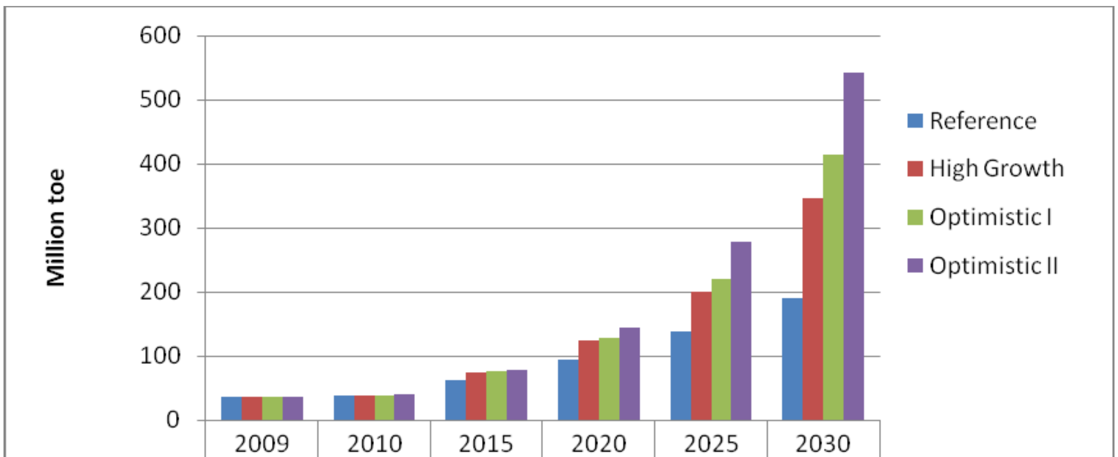


Figure 4.2 Consumption of Energy Sources

Up to the present, fuelwood and charcoal provided the single largest share of primary energy consumption in the country. Over the period 2009-2020, the share will decrease within the range of 55% - 5.3%. About 95% of the total fuelwood consumption was used in households for cooking and for cottage industries. A smaller proportion, of the fuelwood and charcoal consumed was used in the services sector (restaurants, schools, prisons, etc). The next most highly consumed energy resource was petroleum products with 36% in 2009 and 61% in 2020 consisting mostly of premium motor spirit (PMS) automotive gas oil (AGO) generally referred to as petrol and diesel for transportation and power generation, but also including kerosene (households), aviation kerosene (transport), fuel oil (industry), liquefied petroleum gas (households). Others include electricity 8.5% in 2009 and 27% in 2020 (i.e. thermal and appliances), natural gas 0.5% in 2009 and 6% in 2020 (steam production and feedstocks), in the manufacturing industries. However bulk of the natural gas consumption is captured in electricity generation. Furthermore, the use of natural gas as feedstock for liquefied natural gas production for export later became predominant.

4.5.2 Total Final Energy Demand

The total final energy demand will increase from 36.02 million toe (Mtoe) in the base year to 94.29, 124.16, 127.40 and 143.75 Mtoe in 2020 and 190.98, 346.90, 416.68 and 541.42 Mtoe in 2030 for the reference, high growth, optimistic I and optimistic II scenarios, respectively. The values include kerosene (fossil fuel) demand for lighting mostly in households and the services sectors. The growth rates of the total final energy demand over the period 2009-2030 are 10.85%, 16.32%, 15.79% and 19.90% p.a., for the reference, high growth, optimistic I and optimistic II scenarios respectively. The increase in the growth rates of energy demand for the reference, high growth and optimistic scenarios are due to additional energy requirements for increased economic activities especially with manufacturing sector making more contributions, increasing access to electricity by all the sectors of the economy, increasing mechanization and automation of the industrial sectors.



	2009	2010	2015	2020	2025	2030
Reference	36.02	37.11	61.43	94.29	138.84	190.98
High Growth	36.02	37.56	73.68	124.16	200.95	346.9
Optimistic I	36.02	38.15	75.68	127.4	220.31	413.68
Optimistic II	36.02	40.66	77.15	143.75	278.45	541.42

Fig. 4.4 Final Energy Demand in Nigeria by Scenario

Of the total final energy demand of 36.06Mtoe in the base year (2009), modern energy sources constituted 16.2Mtoe or 45%, while traditional energy (fuelwood, crop residue, animal dung and charcoal) constituted the balance of 20Mtoe or 55% (Fig. 4.2).

Table 4.3 shows the amounts of total final energy demand by the various sectors of the economy. In the reference case, the industrial energy demand will increase from 1.15 to 46.72 Mtoe by 2020 and to105.52 by 2030, at the annual growth rate of 24%. The energy demand in the industry will grow to 233.12 Mtoe at the annual growth rate of 26.38%, 300.01 Mtoe at the annual growth rate of 30.34% and 420.74 Mtoe at the annual growth rate of 32.45% in the High Growth, Optimistic I and Optimistic II growth scenarios by the year 2030, respectively. All other sectors indicate strong positive growths.

The rapid growth of the energy demand by the various sectors of the economy does not depend only on industrialization inclination but on high energy intensity too; the intensity is caused by several factors, which include: inefficiency of old technologies, old automobiles, poor energy control, inadequate metering of energy consumption.

Table 4.2 Final Energy Demand by Sector (Mtoe)

Scenario / Year	**2009**	**2010**	**2015**	**2020**	**2025**	**2030**	**Annual growth rate**
			Reference				
Total	**36.02**	**37.11**	**61.43**	**94.29**	**138.84**	**190.98**	8.27
Industry	1.15	0.47	23.34	46.72	73.80	105.52	24.01
Transport	7.65	9.26	11.63	15.53	21.12	28.51	6.46
Households	24.09	24.68	23.40	27.28	36.46	46.29	3.16
Services	3.13	2.71	3.055	4.76	7.46	10.67	6.01
			High Growth Scenario				
Total	**36.02**	**37.56**	**73.94**	**124.16**	**200.95**	**346.90**	11.39
Industry	1.15	1.73	30.46	62.21	115.30	233.12	28.78
Transport	7.65	7.36	11.04	16.49	24.02	34.88	7.49
Households	24.09	27.32	30.44	39.53	52.16	65.15	4.85
Services	3.13	1.15	3.305	5.93	9.49	13.75	7.30
			Optimistic I Scenario				
Total	**36.02**	**38.15**	**73.68**	**127.40**	**220.31**	**413.68**	12.33
Industry	1.15	3.05	30.00	66.20	134.79	300.01	30.34
Transport	7.65	8.69	11.07	16.50	24.20	35.50	7.58

Households	24.09	23.24	29.01	38.50	51.10	63.22	4.70
Services	3.13	3.17	3.600	6.20	10.22	14.95	7.73
Optimistic II Scenario							
Total	**36.02**	**40.66**	**77.15**	**143.75**	**278.45**	**541.42**	13.78
Industry	1.15	6.92	34.97	81.66	190.01	420.74	32.45
Transport	7.65	5.56	11.11	16.51	24.71	37.63	7.88
Households	24.09	24.72	26.3735	36.60	49.75	62.97	4.68
Services	3.13	3.46	4.70126	8.98	13.99	20.08	9.25

4.6 Petroleum Products Demand Projections

Reference Scenario (7%)	**2009**	**2010**	**2015**	**2020**	**2025**	**2030**	**Increment Over period 2009 - 2030**
Noncommercial (ML Tonne of FW)	60.96	60.06	58.66	54.72	49.62	42.67	0.70
AGO (ML litres)	565.64	791.68	2301.86	4176.76	6231.84	8902.43	15.74
PMS (ML litres)	5096.94	6180.00	14460.00	28170.37	39769.44	56457.15	11.08
HHK (ML litres)	306.06	389.00	3510.00	8521.10	14354.21	21027.58	68.70
ATK (ML litres)	50.00	75.00	278.00	517.61	730.73	1037.35	20.75
LPG ('000 tonne)	74.16	93.20	1107.00	2862.50	4823.96	7029.22	94.78
NG (ML cum)	229.22	280.00	3480.00	8847.54	14910.13	21726.27	94.78
FO (ML litres)	120.01	160.00	1800.00	4632.07	7806.10	11374.64	94.78
Coal (tonne)	6.00	6.66	114.43	222.53	390.31	568.75	94.79

Table 4.3a: Projected Demand for Fuels, Reference and High Growth Scenarios

High Growth Scenario (10%)	**2009**	**2010**	**2015**	**2020**	**2025**	**2030**	**Increment Over 2009 - 2030**
Noncommercial (ML Tonne of FW)	60.96	60.06	55.23	49.62	42.20	30.84	0.51
AGO (ML litres)	565.64	977.20	2936.04	5126.83	8392.65	14623.94	25.85
PMS (ML litres)	5096.94	7490.00	16900.00	30723.00	49406.24	76379.28	14.99
HHK (ML litres)	306.06	590.00	4909.00	13658.72	24968.64	41650.22	136.09
ATK (ML litres)	50.00	94.00	360.00	580.00	907.80	1403.41	28.07
LPG ('000 tonne)	74.16	110.80	1429.80	3928.90	7476.76	15323.90	206.63
NG (ML cum)	229.22	340.00	4480.00	12143.63	23109.52	47797.26	208.52
FO (ML litres)	120.01	200.00	2460.00	6357.72	12098.84	25023.94	208.52
Coal (tonne)	6.00	7.50	146.43	317.89	660.00	1251.23	208.54

The decomposed projected fuels demand, including petroleum fuels are presented in Tables 4.3a and 4.3b. It is indicated that by year 2030 AGO consumption will increase by 15.74, 25.85, 32.30 and 37.74 times the base year consumption value for the reference, high growth, optimistic I and optimistic II scenarios respectively. Similarly, by year 2030, PMS consumption will be 11.08, 14.99, 16.23 and 17.34 times the base year consumption value for the reference, high growth, optimistic I and optimistic II scenarios respectively. Increment of other petroleum fuels over the base year is also indicated in Table 4.3a and 4.3b.

Table 4.3b: Projected Demand for Fuels, Optimistic I and Optimistic II Scenarios

Optimistic I Scenario (11.5%)	2009	2010	2015	2020	2025	2030	Increment Over 2009 - 2030
Noncommercial (ML Tonne of FW)	60.96	60.06	52.20	45.20	37.61	23.42	0.38
AGO (ML litres)	565.64	1072.35	3250.17	5780.33	9920.69	18270.18	32.30
PMS (ML litres)	5096.94	8370.00	18103.00	32512.11	53225.19	82712.31	16.23
HHK (ML litres)	306.06	685.00	6151.00	19113.38	33824.51	61147.19	199.79
ATK (ML litres)	50.00	108.00	398.00	607.38	978.31	1581.51	31.63
LPG ('000 tonne)	74.16	126.80	1680.45	5102.75	10012.52	19334.66	260.72
NG (ML cum)	229.22	410.00	5110.00	15101.56	34721.43	69243.34	302.08
FO (ML litres)	120.01	240.00	3011.00	8012.81	17003.12	36221.71	301.82
Coal (tonne)	6.00	8.13	178.54	371.56	842.00	1741.25	290.21

Optimistic II Scenario (13%)	2009	2010	2015	2020	2025	2030	Increment Over 2009 - 2030
Noncommercial (ML Tonne of FW)	60.96	60.06	49.85	40.81	31.63	18.78	**0.31**
AGO (ML litres)	565.64	1177.85	3651.10	6270.84	11408.42	21349.73	37.74
PMS (ML litres)	5096.94	8890.00	19510.00	35587.13	55459.38	88369.15	17.34
HHK (ML litres)	306.06	782.00	6599.00	22050.61	43266.41	75631.97	247.11
ATK (ML litres)	50.00	120.00	440.00	653.88	1019.02	1623.71	32.47
LPG ('000 tonne)	74.16	132.90	1871.20	5733.51	12852.25	22903.70	308.84
NG (ML cum)	229.22	450.00	5520.00	17721.43	39724.34	86799.68	378.67
FO (ML litres)	120.01	270.00	3380.00	9277.93	20797.42	45443.40	378.66
Coal (tonne)	6.00	8.82	215.75	429.00	1160.00	2272.22	378.70

4.6.1 Comparison of Petroleum Demand Projections with Vision20: 2020 Projections

The individual and total capacities of the existing refineries are presented in Table 4.4. showing the total capacity of the refineries per annum as 162.425 million barrels of oil equivalent (Million BOE) at a daily refining capacity of 445,000.00 barrels per stream day (BPSD). Table 4.5 shows the design capacities of each refinery to produce different petroleum products per year, expressed in the both the natural units of measurement of the physical quantity as well as in energy units of million barrels of oil equivalent. Addition of the quantities gives 156.33 MBOE which produces a statistical difference of -3.75%, that is, less than the expected 162.425MBOE; this is due to shrinkage, different conversion factors, etc. Energy petroleum products (fuel gas, LPG, premium motor spirit (PMS), regular motor spirit (RMS), household kerosene, jet fuel oil, diesel fuel oils) account for about 92.40% of the refinery output while non-energy products (sulphur, waxes, lubricating oil, asphalt and carbon black or petroleum coke) account for the balance of 7.60% when all products are expressed in BOE.

Vision20: 2020 envisages that the capacity of domestic refineries will increase to 750,000 b/d by 2015 and 1,500,000 b/d by 2020 (Table 3.1). Using the design capacities of existing refineries for products as basis for the design of the additional refining capacities, the products output from the refineries would be as shown in Table 4.6. The projected PMS, Jet Fuel Kerosene, Household kerosene and diesel consumption for the four scenarios in 2015 and 2020 and the refinery output are shown in Table 4.6 from which the following observations could be made:

(i) PMS demand will be 3.50 and 3.19 times the domestic production in 2015 and 2020 respectively;

(ii) Jet fuel kerosene will be 5.18 and 3.85 times the domestic production in 2015 and 2020 respectively;

(iii) Household kerosene demand will be 3.66 and 6.12 times the domestic production in 2015 and 2020 respectively; and

(iv) Diesel demand will be 1.58 and 1.35 times the domestic production in 2015 and 2020

Table 4.4 Capacities of Nigeria Refineries

Refinery	Year Commissioned	Daily Capacity, Barrels per stream day (BSPD)	Annual Capacity, Barrels per year (BPY)
Kaduna Refinery and Petrochemical Complex (KRPC)	1979	110,000	40,150,000
Warri Refinery and Petrochemical Complex (WRPC)	1978	125,000	45,625,000
New Port Harcourt Refinery and Petrochemical Complex (NPRPC)	1989	150,000	54,750,000
Old Port Harcourt Refinery and Petrochemical Complex (OPRPC)	1965	60,000	21,900,000
Total		**445,000**	**162,425,000**

Source: IAEA/ECN, 2008

Surveys conducted by ECN and analyses of various reports show that 20% of the consumption of petrol in the country is consumed for captive electricity generation in the household and services sectors. It is assumed that industry consumption of PMS for captive electricity generation is negligible and that all captive power generation in industry is by diesel generators. If grid electricity supply becomes more available with more access by households and industry, then the national demand for petrol and diesel for captive power generation will reduce gradually. Hence total demand for petrol and diesel consumption will be less than the projected for all the years in the study period.

A comparison of the annual production capacities of petroleum refineries to be established according to the Vision 2020 Blueprint with the refining capacities required for the production of energy petroleum products projected for the Optimistic II Scenario is presented in Fig.4.5. It shows that domestic production of petroleum products is consistently lower than demand in the period and the country will still depend on import petroleum products.

It should also be noted that the Old Port Harcourt Refinery is obsolete and that Nigeria's import dependency for petroleum products may be higher if the refinery is not rehabilitated. Over this period, 2009 – 2020, Nigeria would have produced about 10 billion barrels of crude oil out of the 37.2 billion barrels reserve and consumed a total of 3.4 billion barrels of crude oil internally.

These observations raise some policy issues. The additional refineries should be designed to be more flexible in the production of refined products, etc. There is need to encourage mass transportation to stem the growth rate of PMS demand which arises from high growth in passenger transportation demand by car.

Table 4.5 Design Capacities of Nigerian Refineries for Different Products

Product	Natural Unit	Kaduna	Warri	New Port – Harcourt	Old Port-Harcourt	Total, Natural Unit	Total, Million BOE	Percent of Total
Sulphur, tones	Tonnes	2,263	-	-	-	2,263	0.0004	0.00
Fuel Gas	Tonnes	338,720	-	-	91,250	429,970	3.22	2.06
Liquefied Petroleum Gas	Tonnes	10,037.50	1,648,340	129,210	20,075	1,807,663	14.30	9.15
Premium motor spirit	Litres	1,244,489,400	1,751,915,137.50	409,105,578.20	977,813,100	4,383,323,216	51.22	32.76
Regular Motor Spirit	Litres	668,700,440	-	361,660,056.20	-	1,030,360,496	0.00	0.00
Jet fuel kerosene	Litres	-	822,550,641	-	-	822,550,641	5.02	3.21
Household kerosene	Litres	799,189,400	-	1,234,280,233.20	492,523,700	2,525,993,333	15.40	9.85
Diesel	Litres	1,299,140,485	1,333,279,409.50	1,010,693,879.72	934,907,350	4,578,021,124	29.03	18.57
Low pour fuel oil	Litres	255,691,260	1,254,648,810	-	1,508,997,600	3,019,337,670	18.81	12.03
High pour fuel oil	Litres	341,300,550	-	-	855,195,000	1,196,495,550	7.45	4.77
Propane propylene (Petrochemical feedstock)	Tonnes	-	516,110,00	-	-	516,110	3.97	2.54
Waxes	Tonnes	24,455	-	-	-	24,455	0.18	0.11
H M Grade lubricating oil	Tonnes	197,465	-	-	-	197,465	1.43	0.92
MM Grade lubricating oil	Tonnes	52,925.0	-	-	-	52,925	0.38	0.25
Solid Grade Asphalt	Tonnes	454,425	-	-	-	454,425	3.33	2.13
Cut back Asphalt	Tonnes	234,330	-	-	-	234,330	1.72	1.10
Carbon black	Tonnes	-	141,072.50	-	-	141,073	0.86	0.55
						Total	156.33	100.00

Source: Adapted from Kayode Sote: "Beyond Crude Oil and Gas Resources", pg 100 - 102

Table 4.6 Expected Output of Total New Refineries by Vision 2020, Million BOE

Product	Unit	2015	2020
Sulphur	MBOE	0.0007	0.0013
Fuel Gas	MBOE	5.30	10.59
Liquefied Petroleum Gas	MBOE	23.52	47.04
Premium Motor Spirit	MBOE	84.22	168.44
Regular Motor Spirit	MBOE	0.00	0.00
Jet Fuel kerosene	MBOE	8.25	16.50
Household kerosene	MBOE	25.33	50.66
Diesel	MBOE	47.73	95.47
Low Pour Fuel Oil	MBOE	30.93	61.87
High Pour Fuel Oil	MBOE	12.26	24.52
Propane propylene (Petrochemical feedstock)	MBOE	6.53	13.06
Waxes	MBOE	0.29	0.59
HM Grade lube oil	MBOE	2.36	4.71
MM Grade lube oils	MBOE	0.63	1.26
Solid Grade Asphalt	MBOE	5.48	10.95
Cut back Asphalt	MBOE	2.82	5.65
Carbon Black	MBOE	1.41	2.82
Total	**MBOE**	**257.07**	**514.14**

Table 4.7 Comparison of Projected Demand for Petroleum Products with Refinery Output in Vision 2020, Million BOE

	2009	**2015**		**2020**		**2030**	
Units are in MBOE	**Reference**	**Optimistic II Scenario**	**Vision 2020 Blueprint**	**Optimistic II Scenario**	**Vision 2020 Blueprint**	**Optimistic II Scenario**	**Vision 2020 Blueprint**
Premium Motor Spirit	218.61	294.96	84.22	538.01	168.44	500.2	n.a.
Jet Fuel kerosene	27.01	42.76	8.25	63.54	16.50	87.4	n.a.
Household kerosene	49.35	92.78	25.33	310.01	50.66	461.4	n.a.
Diesel	47.47	75.30	47.73	129.32	95.47	134.3	n.a.

n.a. = not applicable (Vision20: 2020 did not make projections beyond year 2020)

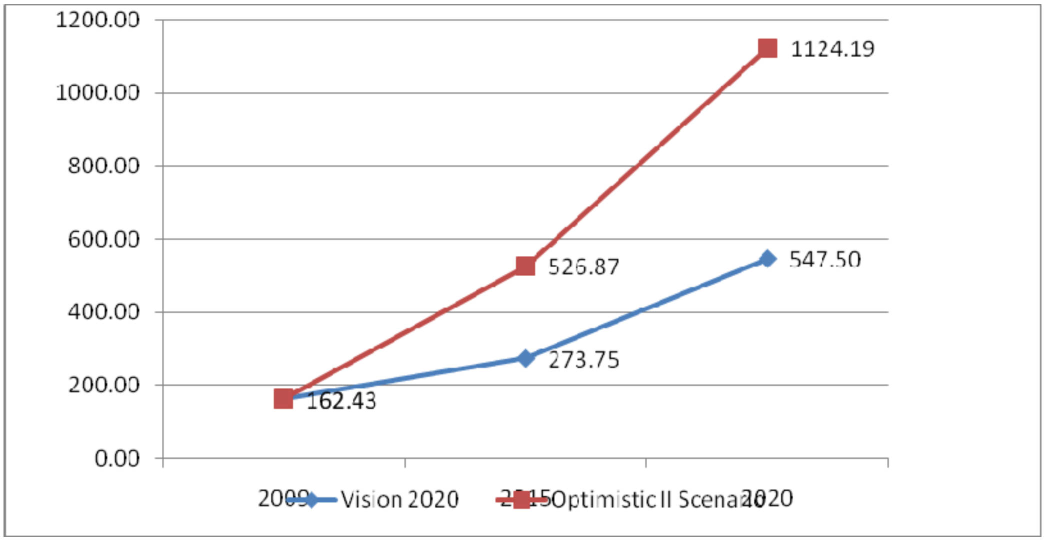


Fig. 4.5 Comparison of Vision 2020 Blueprint for Refining Capacity with Optimistic II Refinery Capacity Projections for Energy Petroleum Products, Million BOE/Year

Table 4.8 Petroleum Products Demand Less Demand of Products for Electricity Generation, (PMS -20%, AGO - 46%)

		2009	2015		2020		2030	
Product	**Unit**	**Base Year**	**Optimistic Scenario II**	**Vision 2020**	**Optimistic Scenario II**	**Vision 2020**	**Optimistic Scenario II**	**Vision 2020**
Premium Motor Spirit	Million BOE	174.89	235.97	84.22	430.41	168.44	400.2	n.a.
	Million litres	25026.76	33767.31	12051.88	61591.67	24103.76	70695.4	n.a
Diesel	Million BOE	25.63	40.66	47.73	69.83	95.47	72.5	n.a
	Million litres	4075.17	6464.94	7589.07	11102.97	15179.73	11528.8	n.a

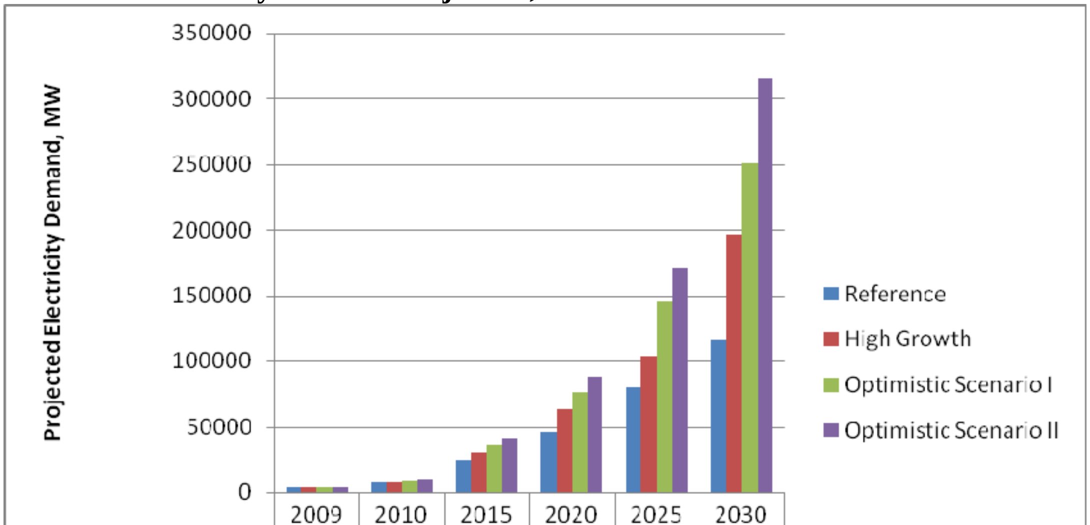
n.a. = not applicable (Vision20: 2020 did not make projections beyond year 2020)

Petrol and diesel are used for captive electricity generation in industrial, residential and services sectors of the economy because of inadequate supply of electricity from the national grid. This partly accounts for the high demand projections of petrol and diesel. If the public electricity demand is improved such that the proportions of petrol (20%) and diesel (46%) used for captive electricity generation would not be necessary, then the demand projections for petrol and diesel will be as shown in Table 4.7. Hence, petrol demand will be 2.8 and 2.56 folds the domestic production in 2015 and 2020 respectively while diesel demand would be 0.85 and 0.73 folds by 2015 and 2020 respectively. Thus, Nigeria could be a net exporter of diesel according to the Vision 2020 Blueprint.

4.8 Analysis of Electricity Demand Projections

The projected peak electricity demand for the four scenarios over the period 2009-2030 is shown in Table 4.6. The projections are equivalent to annual capacity additions of 5315MW, 9182MW, 11,770MW and 14,812MW for the reference, high growth, optimistic I and optimistic II scenarios respectively over the period of the study. The corresponding per capita electricity consumption is shown in Fig.4.6. The corresponding per capita electricity consumption is shown in Fig.4.7. At the base year, per capita electricity consumption was 148kWh. It is projected that the per capita electricity demand will increase to 2038kWh, 3468kWh, 4774kWh and 6081 kWh by 2030 for the Reference, High Growth, Optimistic I Scenario and Optimistic II Scenario respectively.

Table 4.8: Electricity Demand Projection, MW



	2009	2010	2015	2020	2025	2030
Reference	4052	7440	24380	45490	79798	115674
High Growth	4052	8420	30236	63363	103859	196875
Optimistic Scenario I	4052	9400	36124	76124	145113	251224
Optimistic Scenario II	4052	10230	41133	88282	170901	315113

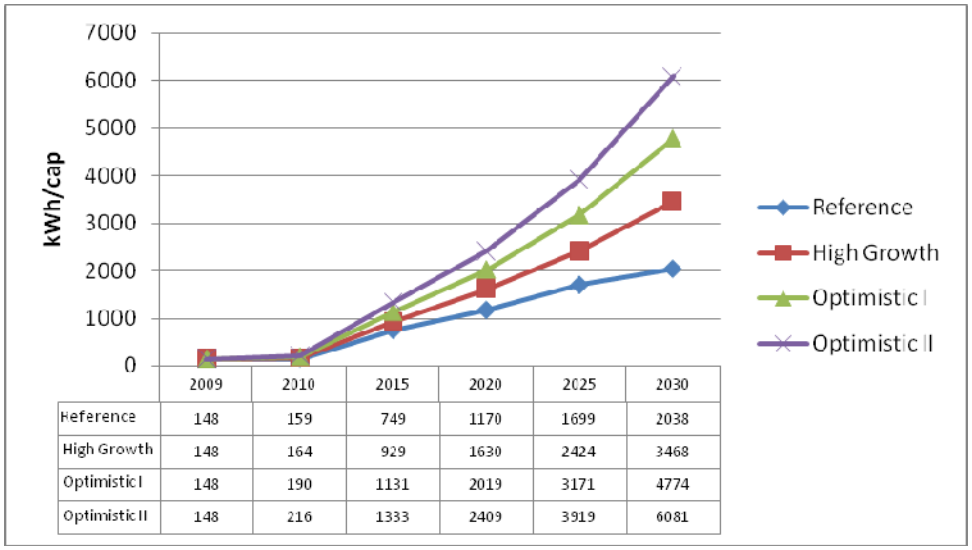


Fig.4.7 Projected Per Capita Electricity Demand, kWh/cap

4.8 Electricity Consumption per Capita Projection of bottom Six Countries of the World Twenty (20) Top Twenty GDP_PPP Countries

The historic data of electricity consumption per capita of the bottom six (6) of the top 20 countries from 2003 to 2007 were obtained and used to calculate the average growth rate of their electricity consumption per capita, the result of which is presented in Table 4.9 and Fig. 4.7.

Table 4.9 Electricity Consumption Per Capita (kWh/cap), of Bottom Six (6) Countries of World Top 20 GDP (PPP)

	2003	**2004**	**2005**	**2006**	**2007**	**Growth Rates (G.R)**				**Av. G.R**
	kWh per capita									
Indonesia	474	484	477	496	508	0.021	-0.015	0.038	0.024	1.7
Turkey	-	-	1790	1940	2756	-	-	0.077	0.296	18.7
Australia	10099	10427	10812	10721	10864	0.031	0.036	-0.009	0.013	1.8
Taiwan	-	9059	8806	9594	9594	-	-0.029	0.082	0.00	1.8
Iran	1990	2156	1996	2160	2160	0.077	-0.08	0.076	0.00	1.8
Poland	-	3250	3155	3311	3357	-	-0.030	0.047	0.014	1.0

Source:-http://www.nationmaster.com/graph/ene_ele_con_percap-energy-electricity-consumption-per-capita;

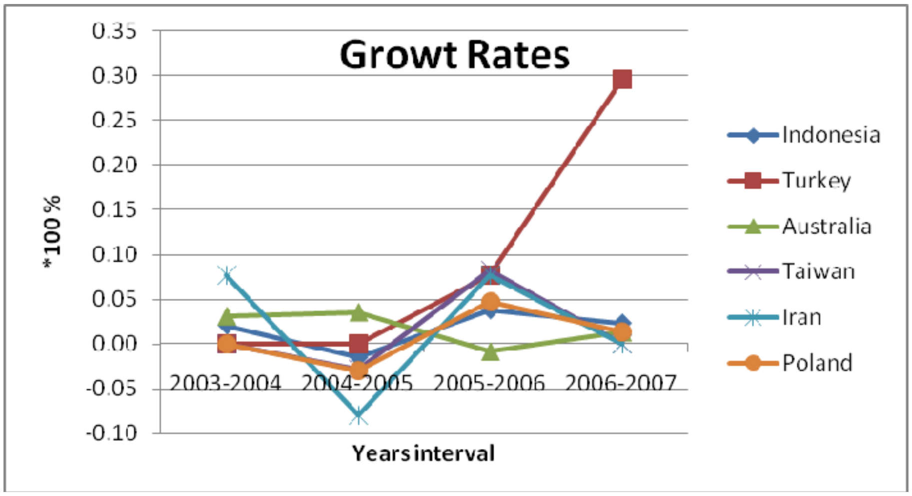


Fig. 4.8 Growth Rates of Electricity Consumption per Capita of some countries

In 2007, Indonesia was the country with the lowest electricity consumption per capita in the bottom six (6) countries of the top 20 GDP_PPP countries in the world consuming 508kWh/capita which is about four times that of Nigeria that was consuming 142.26 kWh / capita in the same period. Using the above average growth rates, we can project and see how their electricity consumption per capita would be like. Indonesia with an average growth rate of 1.7%, Turkey 18.7%, Australia, Taiwan and Iran all having 1.8% and Poland 1.0%, when projected may be consuming 632.86kWh/capita, 25594.02 kWh/capita, 13699.69kWh/capita, 12098.20kWh/capita, 2723.80kWh/capita, and 3820.58kwh/capita respectively. The result of the projection is presented in Table 4.10.

Table 4.10 Electricity consumption per capita projection of bottom six countries of world top twenty GDP_PPP

Year	Indonesia	Turkey	Australia	Taiwan	Iran	Poland
2007	508.00	2,756.00	10,864.00	9,594.00	2,160.00	3,357.00
2008	516.96	3,271.37	11,059.55	9,766.69	2,198.88	3,390.57
2009	525.75	3,883.12	11,258.62	9,942.49	2,238.46	3,424.48
2010	534.69	4,609.26	11,461.28	10,121.46	2,278.75	3,458.72
2015	581.71	10,861.38	12,530.60	11,065.78	2,491.36	3,635.15
2020	632.86	10,861.38	12,530.60	11,065.78	2,723.80	3,820.58
2025	678.68	10,861.38	12,530.60	11,065.78	2,930.24	3,994.19
2030	726.59	10,861.38	12,530.60	11,065.78	3,146.94	4,172.45

From the result of the analysis in Section 4.6, Nigeria will be consuming 2408.8kWh/capita in the year 2020 at GDP growth rate of 13.8%. This is more than three times what Indonesia may be consuming at the same period. Nigeria will be in league of Iran and Turkey that may be consuming 2156kWh/capita and 2723kWh/capita respectively. With projected population of about 227.40 million people in year 2020, this per capita consumption can be achieved when there is electricity in excess of 88.28 thousand MW for consumption.

The Nigeria's Vision20:2020 goal is to generate, transmit and distribute 35,000MW of electricity by the year 2020, although this was revised to 40,000MW in the Power Sector Roadmap. The Vision went ahead to make some medium term plans. In the medium term, the goal is to generate, transmit and distribute 16,000MW of electricity by 2013. Specifically, the overall target for the plan period is to increase electricity generation, transmission and distribution from the 3,700MW capacity as at December, 2009 to 8,000MW by 2010, and 16,000MW by 2013. Access to electricity is expected to increase from the current 40 per cent to 50 per cent, while per capita consumption will increase from the current 125kWh to 500kWh over the plan period.

With 500kWh/capita in 2013, Nigeria may be consuming more electricity per capita close to that of Indonesia that may be consuming 553.02kWh/capita in the same period. Considering 40,000 MW of electricity by 2020, with about 227.40 million people, consumption per capita will be about 1340kWh/capita. This figure is more than what Indonesia may be consuming.

The essence of these analyses is that the bottom six countries will not remain static in their development goals. They would also strive to improve their development indices in terms of GDP, GDP per capita and hence electricity consumption per capita, which can serve as an index for measuring whether Nigeria will be able to catch up with the pace of development of these countries.

4.9 Electricity Demand Projections and Human Development Index

A central objective of the UNDP Human Development Report (HDR) for the past 20 years has been to emphasize that development is primarily and fundamentally about people. The main objective of human development, as stated in the Human Development Report of the United Nations Development Programme (UNDP), is to create an enabling environment for people to enjoy long, healthy, and creative lives. In this context, income (GNP, GDP, GDP/capita) and economic growth are means and not an end to development, and people's wellbeing depends on how income is used to achieve higher quality of living standards. The UN analyzed various concepts raised in earlier development discussions and placed them in a comprehensive framework of human development that was defined as "a process of enlarging people's choices; the most critical ones are to lead a long and healthy life, to be educated and to enjoy a decent standard of living" (UNDP, 1990). The HDI itself is clearly a reductionist measure, incorporating just a subset of possible human choices; additional choices include political freedom, guaranteed human rights and self-respect.

Human Development Index (HDI), a measure of human well-being is compiled annually by the UNDP for each and every country. It was developed to capture the overall socio-economic health of a country due to the limitations of GDP. The HDI measures the average achievements in a country in three basic dimensions of human development:

(i) life expectancy at birth, (ii) level of education, and (iii) Gross Domestic Product (GDP) per capita. Life expectancy at birth is the index for population health and longevity. Knowledge and education is measured by the adult literacy rate (with two – thirds weighting) and the combined primary, secondary and tertiary gross enrollment ratio (with one third weighting). Standard of living is measured by the GDP per capita at purchasing power parity. Generally, HDI ranges from a theoretical minimum of zero (for a life expectancy of 25 years, complete illiteracy and a GDP per capita of \$100 at purchasing power parity) to a theoretical maximum of one (for a life expectancy of 85 years, 100% adult literacy and a GDP per capita of \$40,000 at purchasing power parity). In practice, the observed range is 0.3 – 0.97 (UNDP, 2005; Manuel G. 2006).

The causal relationship between energy consumption and HDI is being studied increasingly in the literature of energy economics and development. This reflects the growing awareness of the international community of the close correlation between human development levels and access to modern energy: countries with low HDI tend to have low energy access and a high proportion of the population relying on traditional biomass. Energy is thus an important vector for triggering economic development and for reaching the Vision 2020.

This study has taken this issue into consideration because one of the cardinal objectives of the Vision 2020 Blueprint is to improve the position of Nigeria in HDI ranking from the current 142 to between 100 and 142 by 2015 and 71 and 100 by 2020. Countries with HDI ranking between 71 and 100 are those in the medium human development brackets. Table 4.11 shows the top 20 countries in terms of GDP in purchasing power parity, the corresponding HDI and the ranking, and the electricity consumption per capita in the countries. Fig. 4.8 shows a graph of the electricity consumption per capita versus the HDI. It can be seen that countries with the lowest electricity consumption per capita (India and Indonesia) have the lowest HDI's while countries with the highest electricity consumption per capita (Australia, USA) have the highest HDI's.

Table 4.11 HDI of Top 20 Countries

S/ No.	Country	GDP, $ Million	HDI	HDI Ranking	Electricity Consumption per capita, kWh/cap	Year of per capita electricity consumption data
1	United States of America	14,660	0.902	4	12,747.485	2008
2	China	10,090	0.663	89	2,584.876	2008
3	Japan	4,310	0.884	11	7,710.962	2006
4	India	4,060	0.519	11 9	502.714	2007
5	Germany	2,940	0.885	10	6,641.91	2007
6	Russia	2,223	0.719	65	6,968.565	2007
7	United Kingdom	2,173	0.849	26	5,659.724	2007
8	Brazil	2,172	0.699	73	2,116.723	2007
9	France	2,145	0.872	14	7,328.281	2006
10	Italy	1,774	0.854	23	5,417.236	2007
11	Mexico	1,567	0.750	56	1,858.310	2007
12	South Korea	1,459	0.877	12	7,515.579	2007
13	Spain	1,369	0.863	20	6,818.79	2008
14	Canada	1,330	0.888	8	16,055.64	2007
15	Indonesia	1,030	0.600	10 8	508.321	2007
16	Turkey	960.5	0.679	83	2,755.491	2008
17	Australia	882.4	0.937	2	10,864.15	2007
18	Taiwan	821.8				
19	Iran	818.7	0.702	70	2,160.441	2006
20	Poland	721.3	0.795	41	3,356.851	2007
31	**Nigeria**	**380.23**	**0.423**	**178**	**142.263**	**2007**

Sources: IMF 2010; UNDP, 2010 ; http://www.nationmaster.com/graph/ene_ele_con_percap-energy-electricity-consumption-per-capita, 25/11/2011

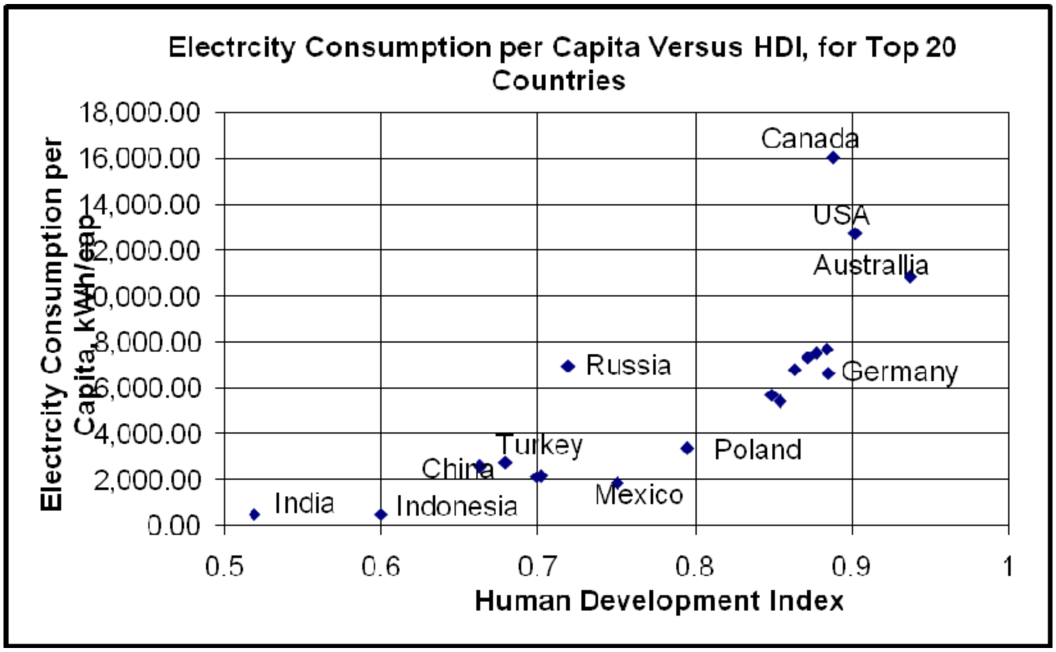


Fig. 4.8 Electricity Consumption per Capita versus HDI for Top 20 Countries

Table 4.12 and fig. 4.9 show the countries in the medium HDI brackets, that is, 71 – 100 that Nigeria aspires to be by 2020. The HDIs of these countries ranged between 0.622 and 0.701. The average HDI for the group is 0.669 while the average per capita electricity consumption for the group is 1,523.57kWh/cap. This would give about 39,500MW capacity which must be operational throughout the year, without any downtime. To be on the safe side, there must be reserve capacity which varies from country to country depending on the levels of stability each country wants to achieve and there must be provision for transmission and distribution losses. A reserve margin of 10% would give about 4,000MW, which is about the operational capacity at present, while transmission and distribution losses of 10% would also give about 4,000MW. Hence we need to have additional 8,000MW if we want to operate at 40,000MW capacity.

Table 4.12 Medium HDI Countries

S/No.	Country	HDI 2010	HDI Ranking	Electricity Consumption kWh/capita	Year
1	Macedonia	0.701	71	4,207.86	2007
2	Mauritius	0.701	72	1,725.18	2007
3	Brazil	0.699	73	2,116.73	2007
4	Georgia	0.698	74	1,490.44	2008
5	Venezuela	0.696	75	3,190.19	2007
6	Armenia	0.695	76	1,653.52	2007
7	Ecuador	0.695	77	1,149.34	2007
8	Belize	0.694	78	674.287	2007
9	Colombia	0.689	79	869.544	2007
10	Jamaica	0.688	80	2,282.27	2007
11	Tunisia	0.683	81	1,136.41	2008
12	Jordan	0.681	82	1,718.10	2007
13	Turkey	0.679	83	2,755.49	2008
14	Algeria	0.677	84	850.203	2007
15	Tonga	0.677	85	342.026	2007
16	Fiji	0.669	86	939.396	2007
17	Turkmenistan	0.669	87	1,957.15	2006
18	Dominican Republic	0.663	88	1,356.00	2007
19	China	0.663	89	2,584.88	2008
20	El Salvador	0.659	90	637.011	2007
21	Sri Lanka	0.658	91	398.367	2007
22	Thailand	0.654	92	2,052.12	2008
23	Gabon	0.648	93	993.905	2007
24	Suriname	0.646	94	3,116.08	2007
25	Bolivia, Plurinational State of	0.643	95	447.432	2010
26	Paraguay	0.64	96	899.674	2007
27	Philippines	0.638	97	556.096	2006
28	Botswana	0.633	98	1,458.55	2007
29	Moldova, Republic of	0.623	99	1,011.46	2007
30	Mongolia	0.622	100	1,137.48	2006
31	**Nigeria**	**0.423**	**178**	**142.263**	**2007**

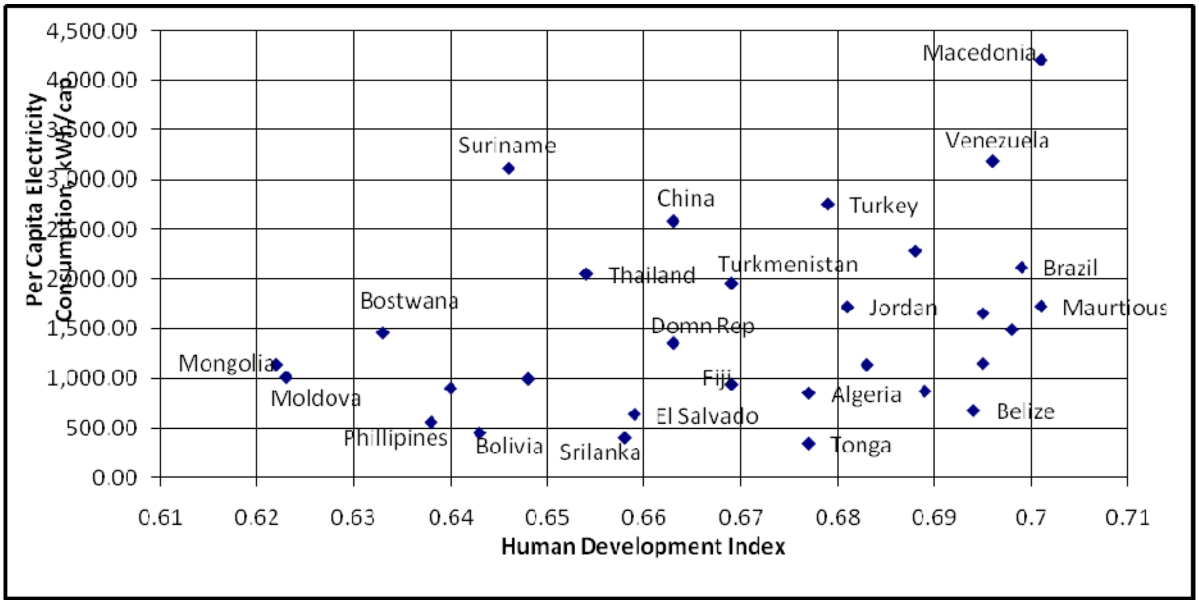


Figure 4.9 Medium HDI Countries

4.10 Sectoral Electricity Demand Projections

Tables 49a to 49d show the breakdown of the projected electricity demand for the four scenarios. In the base year, the electricity demand was 30.9TWh. This is projected to increase by 26.4%, 32.4%, 33.0% and 38.2% per annum over the period for the reference, high growth, optimistic I and optimistic II scenarios respectively.

The projected sectoral electricity demands are presented in Tables 50a to 50d while the sectoral shares are presented in Figures 47a to 47d. In the base year, the household sector accounted for the highest proportion of total electricity consumption of about 62%. This is followed by the services sector (29.5%) and the industry sector, comprising agriculture, construction, mining and manufacturing, which accounted for about 8.5% of the total electricity consumption. Electricity was not used at all in the transport sector in the base year. By year 2030, households will account for 44%, services 17.98%, industry 38.02% and transport 0.01% of electricity consumption in the Reference Scenario. In the Optimistic II Scenario, households demand would decline to 25.91% of the total electricity consumption in 2030 while services sector will account for 12.18%, industry sector will account for the highest proportion of 61.90% and transport sector 0.01%. It is assumed that electricity will be used for urban mass transportation in major cities of the country such as Abuja, Lagos and Portharcourt.

Table 49a: Electricity Demand Projections, Reference Scenario

Year	Demand (TWh)	Export Demand (TWh)	Domestic Demand (TWh)	T&D Losses (%)	Sent Out (TWh)	Own Consumption (% of generation)	Generation (TWh)	Load Factor (%)	Peak Demand (MW)
2009	30.09	1.3	28.8	15.0	34.61	2.5	35.49	75	3,489.66
2010	31.38	1.3	24.1	14.2	28.98	2.5	29.72	75	4,523.82
2015	137.90	5.9	132.0	13.3	156.17	2.5	160.18	75	24,380.13
2020	259.41	16.6	242.8	12.3	291.39	2.5	298.87	75	45,489.52
2025	458.20	38.9	419.3	11.6	511.16	2.5	524.27	75	79,797.82
2030	668.75	70.7	598.1	10.8	740.98	2.5	759.98	75	115,674.15

Table 49b: Electricity Demand Projections, High Growth Scenario

Year	Demand (TWh)	Export Demand (TWh)	Domestic Demand (TWh)	T&D Losses (%)	Sent Out (TWh)	Own Consumption (% of generation)	Generation (TWh)	Load Factor (%)	Peak Demand (MW)
2009	30.09	1.3	28.8	15.0	34.61	2.5	35.49	75	3,489.66
2010	33.44	1.3	32.1	14.2	38.18	2.5	39.16	75	5,959.81
2015	171.03	7.3	163.8	13.3	193.69	2.5	198.65	75	30,236.36
2020	361.33	23.1	338.3	12.3	405.89	2.5	416.29	75	63,362.68
2025	653.78	55.5	598.2	11.6	729.35	2.5	748.05	75	113,859.09
2030	1138.20	120.3	1017.9	10.8	1261.13	2.5	1293.47	75	196,874.51

Table 49c: Electricity Demand Projections, Optimistic I Scenario

Year	Demand (TWh)	Export Demand (TWh)	Domestic Demand (TWh)	T&D Losses (%)	Sent Out (TWh)	Own Consumption (% of generation)	Generation (TWh)	Load Factor (%)	Peak Demand (MW)
2009	30.09	1.3	28.8	15.0	34.61	2.5	35.49	75	3,489.66
2010	38.62	1.3	39.3	14.2	46.38	2.5	47.57	75	7,239.84
2015	187.63	19.2	168.4	13.3	212.49	2.5	217.94	75	33,171.69
2020	393.30	46.5	346.8	12.3	441.80	2.5	453.13	75	68,969.02
2025	731.75	114.9	616.8	11.6	816.34	2.5	837.28	75	127,439.27
2030	1343.22	122.8	1220.4	10.8	1488.29	2.5	1526.45	75	232,336.00

Table 49d: Electricity Demand Projections, Optimistic II Scenario

Year	Demand (TWh)	Export Demand (TWh)	Domestic Demand (TWh)	T&D Losses (%)	Sent Out (TWh)	Own Consumption (% of generation)	Generation (TWh)	Load Factor (%)	Calculated Peak Demand (MW)
2009	30.09	1.3	28.8	15.0	34.61	2.5	35.49	75	5,402.55
2010	40.84	1.3	23.5	14.2	28.36	2.5	29.09	75	4,427.90
2015	232.7	9.9	222.8	13.3	263.49	2.5	270.25	75	41,133.27
2020	503.4	32.1	471.3	12.3	565.51	2.5	580.01	75	88,282.22
2025	981.3	83.3	898.0	11.6	1094.75	2.5	1122.82	75	170,900.87
2030	1821.8	192.6	1629.2	10.8	2018.53	2.5	2070.29	75	315,112.60

Table 50a: Sectoral Electricity Demand (TWh), Reference Scenario

Sector	2009	2010	2015	2020	2025	2030
Industry	2.57	2.23	47.55	102.57	175.25	254.25
Transport	0.00	0.00	0.00	0.00	0.04	0.09
Households	18.65	15.13	55.73	103.25	198.74	294.17
Services	8.87	14.02	34.63	53.59	84.17	120.24
Total	**30.09**	**31.38**	**137.90**	**259.41**	**458.20**	**668.75**

Table 50b: Sectoral Electricity Demand (TWh), High Growth Scenario

Sector	**2009**	**2010**	**2015**	**2020**	**2025**	**2030**
Industry	2.57	10.44	62.61	143.22	283.70	606.40
Transport	0.00	0.00	0.00	0.00	0.10	0.22
Households	18.65	12.24	70.94	151.91	264.12	377.90
Services	8.87	10.77	37.48	66.20	105.86	153.68
Total	**30.09**	**33.44**	**171.03**	**361.33**	**653.78**	**1138.20**

Table 50c: Sectoral Electricity Demand (TWh), Optimistic I Scenario

Sector	**2009**	**2010**	**2015**	**2020**	**2025**	**2030**
Industry	2.57	19.58	69.75	163.07	344.64	801.41
Transport	0.00	0.00	0.00	0.00	0.11	0.25
Households	18.65	12.31	88.34	181.33	310.52	436.35
Services	8.87	6.73	29.54	48.89	76.48	105.21
Total	**30.09**	38.62	187.63	393.30	731.75	1343.22

Table 50d: Sectoral Electricity Demand (TWh), Optimistic II Scenario

Sector	**2009**	**2010**	**2015**	**2020**	**2025**	**2030**
Industry	2.57	2.26	49.07	103.29	230.37	413.93
Transport	0.00	0.00	0.00	0.00	0.06	0.10
Households	18.65	15.46	59.38	106.61	156.79	173.28
Services	8.87	13.66	29.45	49.52	70.98	81.44
Total	**30.09**	**31.38**	**137.90**	**259.41**	**458.20**	**668.75**

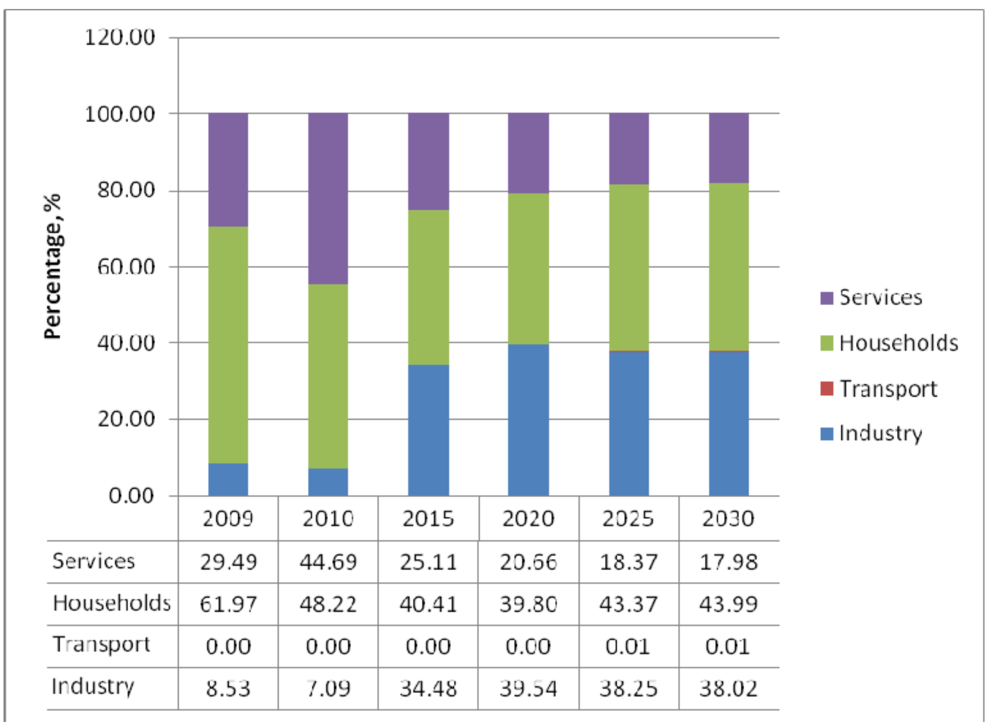
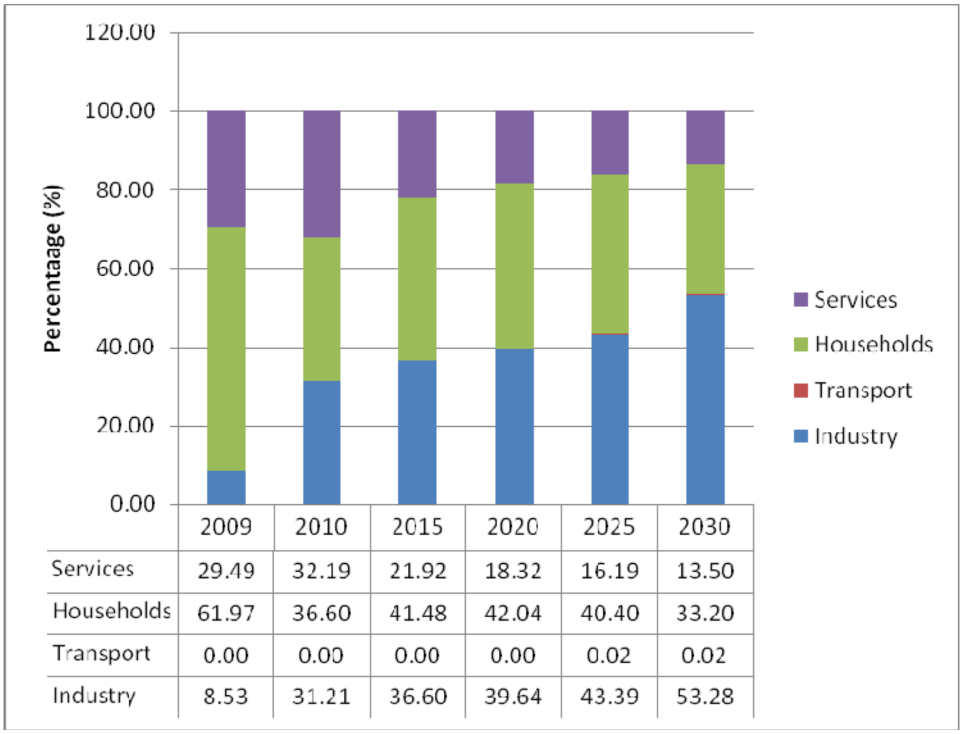
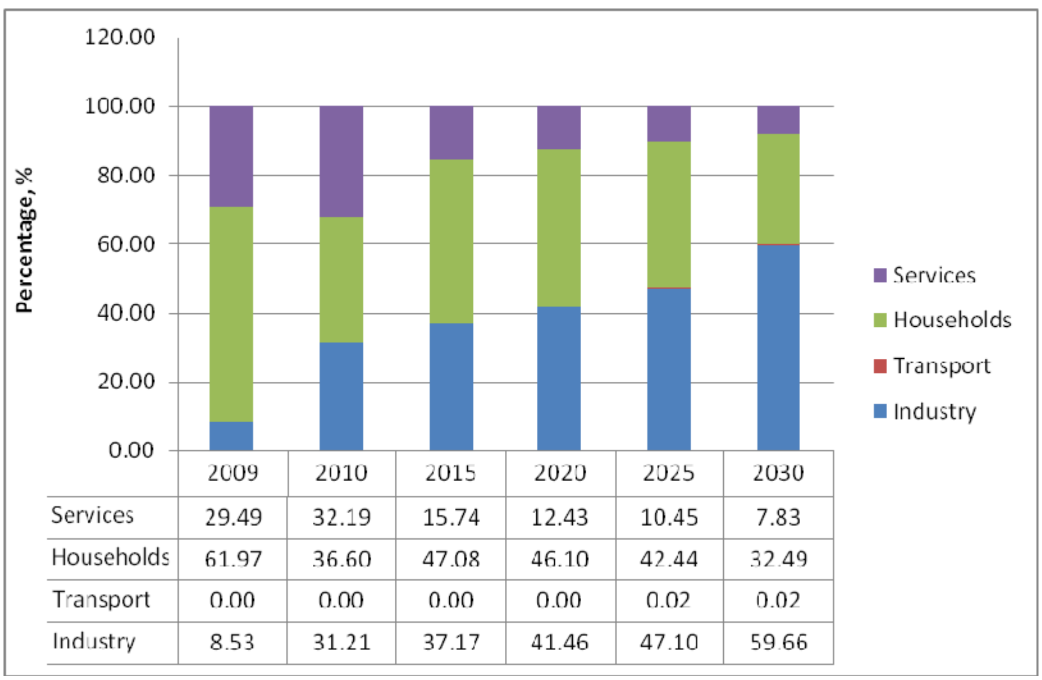


Figure 4.7a: Sectoral Electricity Demand, Reference Scenario



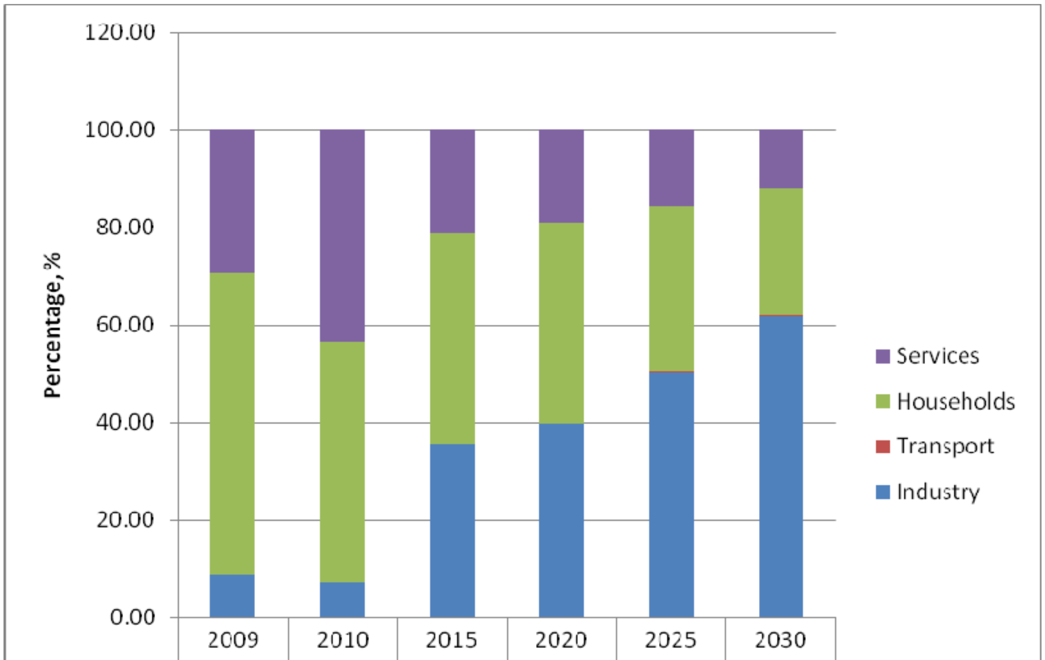
	2009	2010	2015	2020	2025	2030
Services	29.49	32.19	21.92	18.32	16.19	13.50
Households	61.97	36.60	41.48	42.04	40.40	33.20
Transport	0.00	0.00	0.00	0.00	0.02	0.02
Industry	8.53	31.21	36.60	39.64	43.39	53.28

Figure 4.7b: Sectoral Electricity Demand, High Growth Scenario



	2009	2010	2015	2020	2025	2030
Services	29.49	32.19	15.74	12.43	10.45	7.83
Households	61.97	36.60	47.08	46.10	42.44	32.49
Transport	0.00	0.00	0.00	0.00	0.02	0.02
Industry	8.53	31.21	37.17	41.46	47.10	59.66

Figure 4.7c: Sectoral Electricity Demand, Optimistic I Scenario



	2009	2010	2015	2020	2025	2030
Services	29.49	43.54	21.36	19.09	15.49	12.18
Households	61.97	49.26	43.06	41.10	34.22	25.91
Transport	0.00	0.00	0.00	0.00	0.01	0.01
Industry	8.53	7.20	35.59	39.82	50.28	61.90

Figure 4.7d: Sectoral Electricity Demand, Optimistic II Scenario

CHAPTER FIVE

5.0 ELECTRICITY SUPPLY STRATEGY PROJECTIONS FOR VISION20:2020

This Chapter covers the electricity supply strategy using the Model for Energy Supply Strategy Alternatives and their General Environmental impacts (MESSAGE) developed by the International Atomic Energy Agency (IAEA) . The supply study covers the period 2010-2030.

5.1 Optimal Energy Supply Strategies

For the present study, four energy supply scenarios were developed, like the demand scenarios (Section 4.2), with conventional fuels contributing most of the resources for electric power generation in the Reference Scenario.

5.2 Techno-economic Data for Future Power Plants

This study focuses on the power, oil and gas planning and competiveness of alternative electricity generation and oil refining options. In addition to fuel availability, the price of fuels and techno-economic data for the future plants are critical in determining the competitiveness of the alternative sources of electricity generation. Table 5.1 provides the assumed input parameters for electricity generation and oil refineries technologies modeled in this study. These data have been obtained from various published sources and analyzed to conform to local situation. The cost does not represent the final contractual sum. The MESSAGE model has been applied to find optimum expansion path of the energy/electricity sectors in all the four scenarios.

Table 5.1: Data for Future Power Plants

Name	Investment Cost ($/kW)	Variable O&M Cost ($/kWyr)	Fixed O&M Cost ($/kWyr)	Plant Factor (Fraction)	Construction Period (Year)	Efficiency (Fraction)
CCGT (I-XVI)	1000-1200	480.92	14.90	0.8	3	0.55
GT (I-VII)	800-900	613.20	35.92	0.8	3	0.33
Coal (I-VI)	1400-1600	231.26	55.19	0.5	3	0.33
Large Hydro	2500	62.19	30.66	0.5	5	N/A
Small Hydro	2500	62.19	30.66	0.8	4	N/A
Nuclear	2500	82.34	102.49	0.8	6	0.33
Wind Offshore	2200	0.1	208.40	0.35	2	N/A
Wind Onshore	2000	0.1	91.10	0.35	2	N/A
Solar PV	4000	0.1	56.06	0.4	1	N/A
Solar Thermal	3000	0.1	190.90	0.7	3	N/A
Biomass	2250	231.26	55.19	0.5	3	0.25

5.3 Results of the MESSAGE Model

MESSAGE is designed to formulate and evaluate alternative energy supply strategies in line with the user-defined constraints such as limits on new investment, fuel availability and trade, environmental regulations and market penetration rates for new technologies. The result of MAED is a major input into MESSAGE. The supply strategy was modelled based on the availability (potentials) of the primary source of energy. Table 2.1 gives the reserves and potentials of energy resources of the country; the country has the potential to generate more 700,000MW from solar energy using solar PV and Concentrated solar power (CSP).

The results of the modeling are presented in Tables 5.2 to 5.5. The total installed capacity of the power sector includes the existing, NIPPs, IPPs and candidate plants. The total installed capacity for the Reference Scenario is 52,174MW and 161,411MW by 2020 & 2030 respectively (Table 5.2). In the High Growth Scenario, the projected installed capacities are 71,495MW and 229,086MW by the year 2020 and 2030 respectively (Table 5.3). For the Optimistic I Scenario total installed capacity are 78,095MW and 265,794MW in 2020 and 2030 respectively while total installed capacity are 88,698MW and 315158MW in 2020 and 2030 respectively for the

Optimistic II Scenario (Tables 5.4 & 5.5). The individual power plants making up the installed capacities are presented in Appendices I, II, III and IV.

The percentage contribution of various energy resources to electricity supply are presented in Tables 5.6 to 5.9. At the base year, natural and large hydro contributed 66.10% and 33.55% of the total grid electricity supply respectively while small hydro contributed 0.35% in the same base year. By year 2030, coal, nuclear, solar, wind and biomass are also expected to play some roles in electricity generation for the country in all the four scenarios.

Table 5.2: Installed Capacity by Energy Form for the Reference Scenario, MW

	2009	2010	2015	2020	2025	2030
Coal	0	609	1805	6527	7545	10984
Electricity import	0	0	0	0	0	31948
Gas	3803	4572	18679	33711	61891	80560
Hydro	1930	1930	3043	6533	6533	6533
Nuclear	0	0	1000	1500	2500	3500
Small hydro	20	60	172	409	894	1886
Solar	0	260	1369	3455	7000	25917
Wind	0	10	19	22	25	29
Biomass	0	0	3	16	35	54
Total	**5753**	**7440**	**26092**	**52174**	**86422**	**161411**

Table 5.3: Installed Capacity by Energy Form for the High Growth Scenario, MW

	2009	2010	2015	2020	2025	2030
Coal	0	870	2579	9324	10778	15691
Electricity import	0	0	0	0	0	45640
Gas	3803	6957	21328	44763	82702	115086
Hydro	1930	2174	4348	9332	9332	9332
Nuclear	0	0	1500	2500	3500	3500
Small hydro	20	81	246	585	1277	2694
Solar	0	377	1956	4936	10000	37025
Wind	0	18	28	32	36	42
Biomass	0	0	4	23	50	77
Total	**5753**	**10476**	**31989**	**71495**	**117675**	**229086**

Table 5.4: Installed Capacity by Energy Form for the Optimistic I Scenario, MW

	2009	2010	2015	2020	2025	2030
Coal	0	1000	2966	10723	12395	18045
Electricity import	0	0	0	0	0	52486
Gas	3803	8000	23377	45728	106607	132348
Hydro	1930	2500	5000	10732	10732	10732
Nuclear	0	0	2500	4500	5500	6369
Small hydro	20	93	283	672	1469	3098
Solar	0	434	2250	5677	14127	42578
Wind	0	20	32	36	42	48
Biomass	0	0	4	27	58	88
Total	**5753**	**12047**	**36412**	**78095**	**150929**	**265794**

Table 5.5: Installed Capacity by Energy Form for the Optimistic II Scenario, MW

	2009	2010	2015	2020	2025	2030
Coal	0	3353	3353	12122	14011	20399
Electricity import	0	0	0	0	0	59333
Gas	3803	13110	26426	49996	120512	164307
Hydro	1930	4157	11207	12132	12132	12132
Nuclear	0	0	3600	7200	7200	7200
Small hydro	20	105	320	760	1660	3502
Solar	0	490	2543	6417	15970	48132
Wind	0	23	36	41	47	54
Biomass	0	0	5	30	65	100
Total	**5753**	**21238**	**47490**	**88698**	**171598**	**315158**

Table 5.6: Percentage Contribution to Electricity Supply by Energy Form, Reference Scenario

	2009	2010	2015	2020	2025	2030
Coal	0.00	15.79	7.06	13.67	8.17	6.47
Electricity import	0.00	0.00	0.00	0.00	0.00	18.83
Gas	66.10	61.73	55.65	56.37	70.23	52.13
Hydro	33.55	19.57	23.60	13.68	7.07	3.85
Nuclear	0.00	0.00	7.58	8.12	4.20	2.28
Small hydro	0.35	0.49	0.67	0.86	0.97	1.11
Solar	0.00	2.31	5.36	7.23	9.31	15.27
Wind	0.00	0.11	0.08	0.05	0.03	0.02
Biomass	0.00	0.00	0.01	0.03	0.04	0.03
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table 5.7: Percentage Contribution to Electricity Supply by Energy Form, High Growth Scenario

	2009	2010	2015	2020	2025	2030
Coal	0.00	8.30	8.15	13.73	8.21	6.79
Electricity import	0.00	0.00	0.00	0.00	0.00	19.75
Gas	66.10	66.41	64.20	58.55	70.63	49.79
Hydro	33.55	20.75	13.73	13.74	7.11	4.04
Nuclear	0.00	0.00	6.87	5.76	3.64	2.40
Small hydro	0.35	0.77	0.78	0.86	0.97	1.17
Solar	0.00	3.60	6.18	7.27	9.36	16.02
Wind	0.00	0.17	0.09	0.05	0.03	0.02
Biomass	0.00	0.00	0.01	0.03	0.04	0.03
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 5.8: Percentage Contribution to Electricity Supply by Energy Form, Optimistic I Scenario

	2009	2010	2015	2020	2025	2030
Coal	0.00	8.30	8.06	13.04	9.16	6.85
Electricity import	0.00	0.00	0.00	0.00	0.00	19.92
Gas	66.10	66.41	66.67	62.61	70.28	50.24
Hydro	33.55	20.75	13.59	13.05	7.93	4.07
Nuclear	0.00	0.00	4.69	3.50	2.97	1.53
Small hydro	0.35	0.77	0.77	0.82	1.09	1.18
Solar	0.00	3.60	6.12	6.90	8.50	16.16
Wind	0.00	0.17	0.09	0.04	0.03	0.02
Biomass	0.00	0.00	0.01	0.03	0.04	0.03
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 5.9: Percentage Contribution to Electricity Supply by Energy Form, Optimistic II Scenario

	2009	2010	2015	2020	2025	2030
Coal	0.00	8.18	6.92	12.51	8.73	6.80
Electricity import	0.00	0.00	0.00	0.00	0.00	19.79
Gas	66.10	61.44	71.59	64.61	71.61	49.91
Hydro	33.55	25.94	11.66	12.52	7.56	4.05
Nuclear	0.00	0.00	3.83	2.88	2.89	2.17
Small hydro	0.35	0.80	0.66	0.78	1.03	1.17
Solar	0.00	3.49	5.25	6.62	8.10	16.06
Wind	0.00	0.14	0.07	0.04	0.03	0.02
Biomass	0.00	0.00	0.01	0.03	0.04	0.03
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

5.3.1 Primary Energy Requirements

The total primary energy requirements for generation of electricity from fossil fuel (natural gas and coal) are presented in Tables 5.10 and 5.11 for the reference, high growth, optimistic I and optimistic II scenarios, respectively. There is an increase in gas utilization from about 379 billion scf in 2010 to about 3,552 billion scf of gas in 2030 for the reference scenario. The cumulative gas requirement for the study period will be between 54 trillion scf for the reference scenario and about 170 trillion scf optimistic II scenarios respectively. This shows that the country will utilize about 30% and 94% of the gas reserves for electricity generation for the reference and optimistic II scenarios, respectively. In calculating the cumulative resource requirements in Tables 5.10 and 5.11, it was assumed that the annual resource requirement level for a particular year was maintained for every year till the beginning of another period. Hence, for gas requirements, 378,577 million scf will be required for every year for the five years 2010 – 2014; 1,352,337 million scf will be required for every year for the five years 2015 – 2019; etc for the reference scenario.

Table 5.10: Natural gas requirements, million standard cubic feet (MMSCF)

	2010	2015	2020	2025	2030	Cumulative
Reference	378,577	1,352,337	2,070,343	3,616,224	3,552,043	54,847,619
High Growth	463,047	1,466,785	2,655,432	4,718,871	6,649,473	79,768,037
Optimistic I	534,258	1,679,703	3,358,640	7,077,140	8,424,859	105,372,996
Optimistic II	810,305	3,399,780	5,727,838	10,501,192	13,638,103	170,386,091

The coal requirement will increase from about 5.5 million TCE to about 26 million TCE by 2030 with cumulative requirement of more than 360 million TCE, which is about 13% of the coal reserves of the country (Table 5.11).

Table 5.11: Coal requirements, Tonnes of coal equivalent (TCE)

Scenario	2010	2015	2020	2025	2030	Cumulative
Reference	-	5,500,751	18,556,558	22,714,886	25,666,814	362,195,049
High Growth	-	7,949,260	26,945,943	31,017,537	44,001,604	549,571,722
Optimistic I	-	9,595,067	34,082,668	38,857,850	55,614,032	690,748,081
Optimistic II	-	9,469,553	39,340,121	45,501,221	66,504,541	804,077,183

5.3.2 Capacity Additions for Electricity Generation

Capacity additions in the power sector for all the scenarios are also given in appendices I, II, III and IV. The study constrained the capacity additions based on hydro, coal, gas, nuclear and renewable, considering their supply potentials and other techno-economic barriers. The total installed capacity of the power sector includes the existing, NIPPs, IPPs and candidate plants. Table 5.12 gives the periodic addition for each of the scenarios. The power sector will need to add 7,698MW, 10,930MW, 12,687MW and 14,696MW annually for the reference, high growth, optimistic I and optimistic II scenarios respectively.

Table 5.12: Periodic Addition of Power Plant in MW

Scenario	2015	2020	2025	2030	Annual Average Increment
Reference	18,652	26,082	34,249	74,988	7,698
High Growth	21,513	39,507	46,179	111,412	10,930
Optimistic I	24,365	41,683	72,834	114,865	12,687
Optimistic II	26,252	41,208	82,899	143,560	14,696

The standby and embedded generation owned by some households, industries and commercial establishments, which are intended for operations during extended periods of blackouts or brownouts, are not captured due to lack of information on the total installed capacity of these captive generations.

5.3.3 Electricity Supply Projections

The initial fuel mix for electricity generation in Nigeria is only two types, hydro and natural gas. One of the objectives of the National Energy Policy is to broaden the energy options for generating electricity. Eight different types of fuels were used for optimization. These are natural gas, hydro, coal, nuclear, small hydro, biomass, solar and wind. The contributions of these fuels to electricity generation options have considerably changed the supply of electricity pattern in the country over the period of the study. The electricity generation mix for the reference and high growth scenarios are shown in Figures 5.1 and 5.2. There is general increase of electricity supply for all the scenarios, generation will increase from less than 10,000MWyr for the base year (2010) to more than 100,000MWyr and 160,000MWyr by 2030 for the reference and high growth scenarios, respectively.

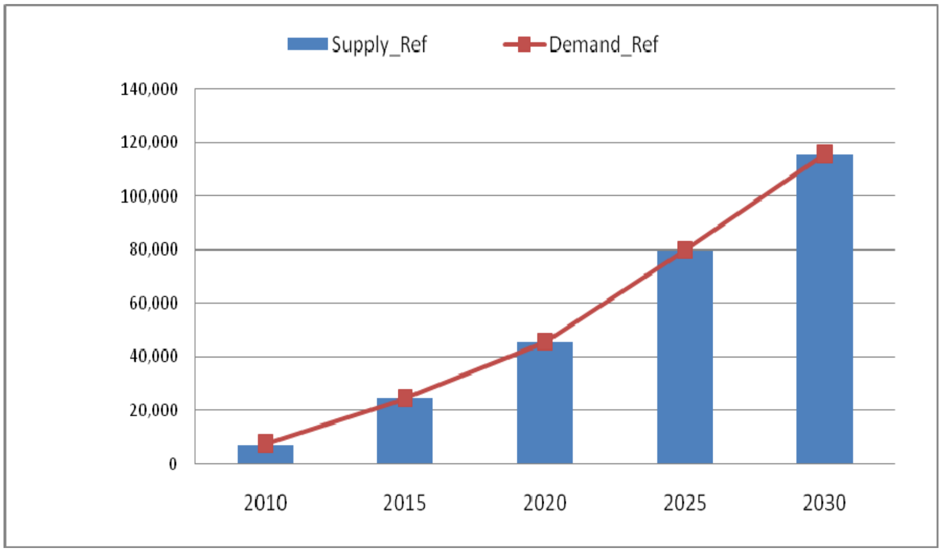


Fig 5.1: Electricity Supply projections by Source (Reference Scenario)

Also for the optimistic I and II scenarios, there is increase from less than 10,000MWyr in 2010 to about 250,000MWyr and about 315,000MWyr in 2030 as shown in Figures 5.3 & 5.4, respectively.

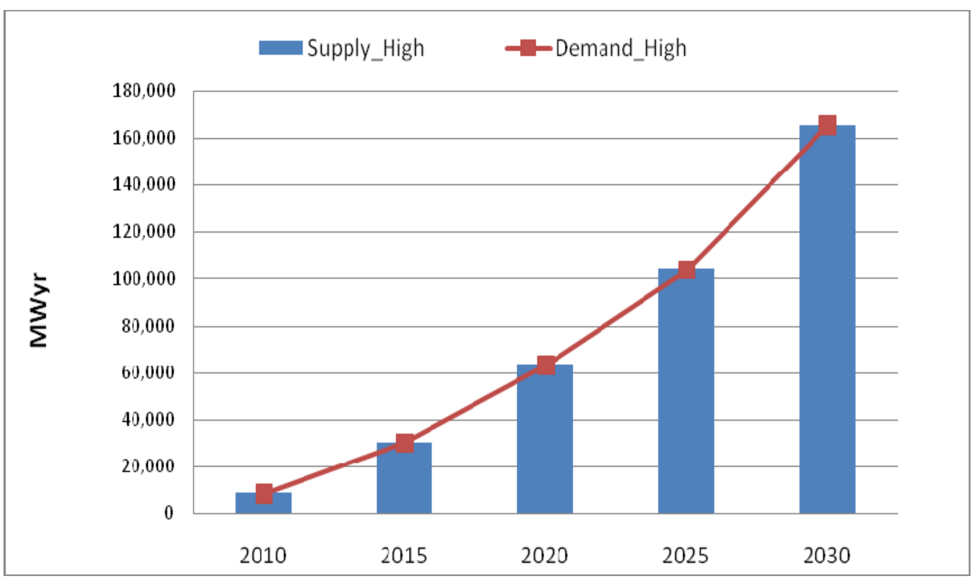


Fig. 5.2: Electricity Supply Projections by Source (High Growth Scenario)

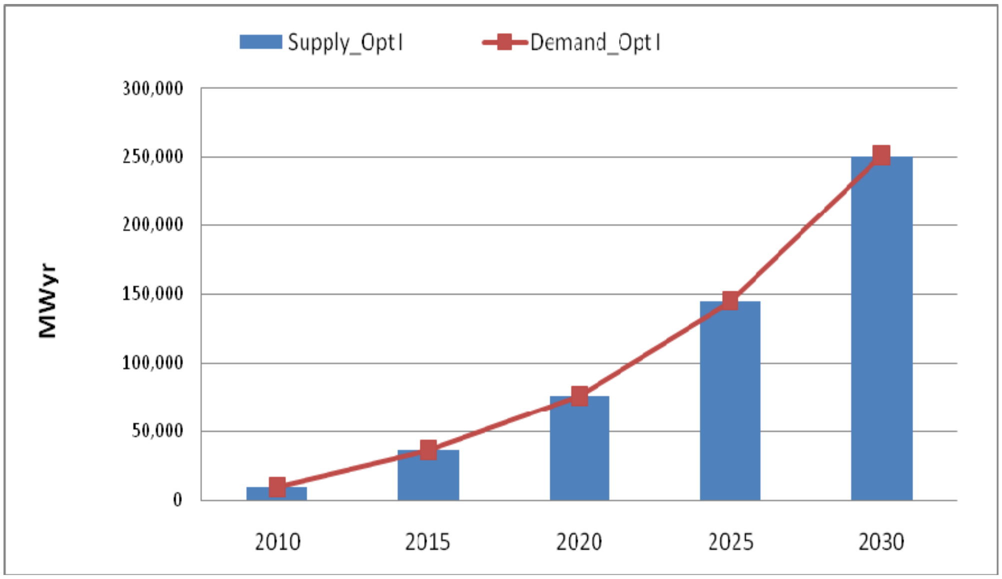


Fig. 5.3: Electricity Supply Projections by Source (Optimistic I Scenario)

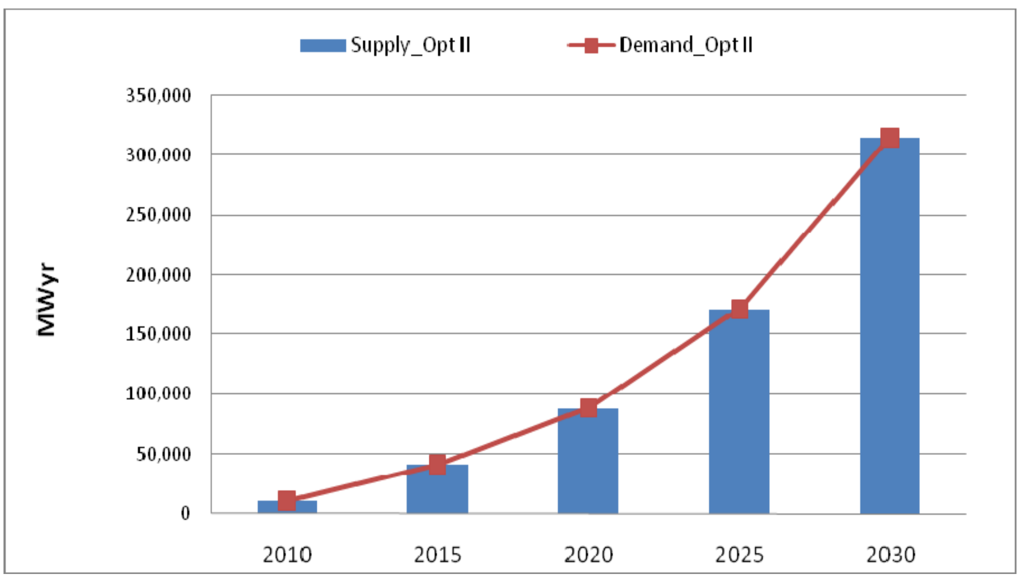


Fig. 5.4: Electricity Supply Projections by Source (Optimistic II Scenario)

The share of gas in the total electricity generation will decrease from 72% in 2010 to 50% in 2030 for the reference scenario (Fig. 5.5). Coal is assumed to be introduced in 2015 with 7% contribution and expected to increase to about 13% in 2020 and then back to 7% of the total generation by 2030 for the reference scenario.

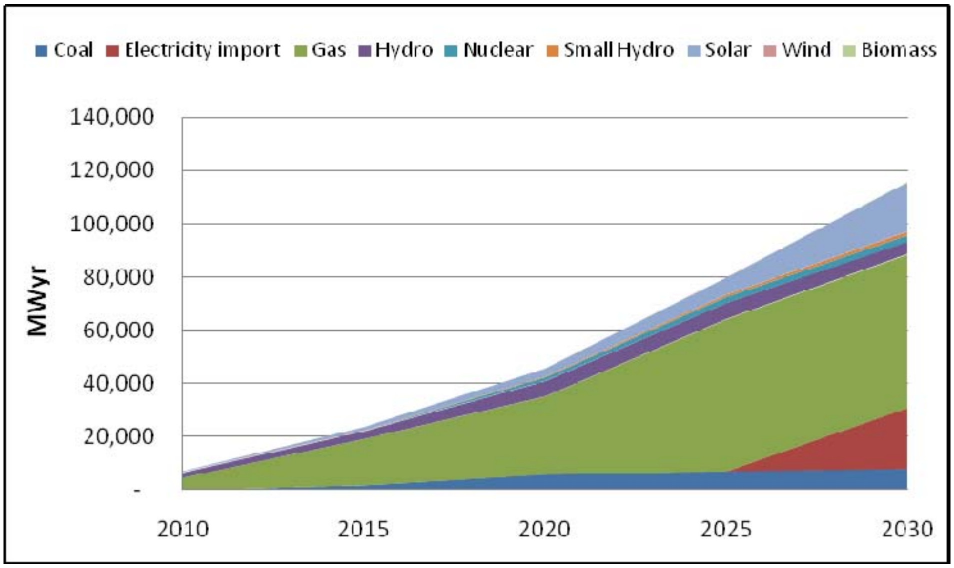


Fig. 5.5: Shares of Electricity Supply by Fuel Type (Reference Scenario)

The share of the high growth scenario is similar to the reference scenario for gas with initial contribution of 72% and reducing to about 50% by 2030 (Fig.5.10), whilst coal will contribute about 7-10% of the electricity mix for the whole study period. Likewise, contribution of gas in the optimistic I & II scenarios will reduce to about 50% in 2030 (Fig. 5.7 & 5.8) and this is due to the depleting reserves of the natural gas, unless new discoveries are made.

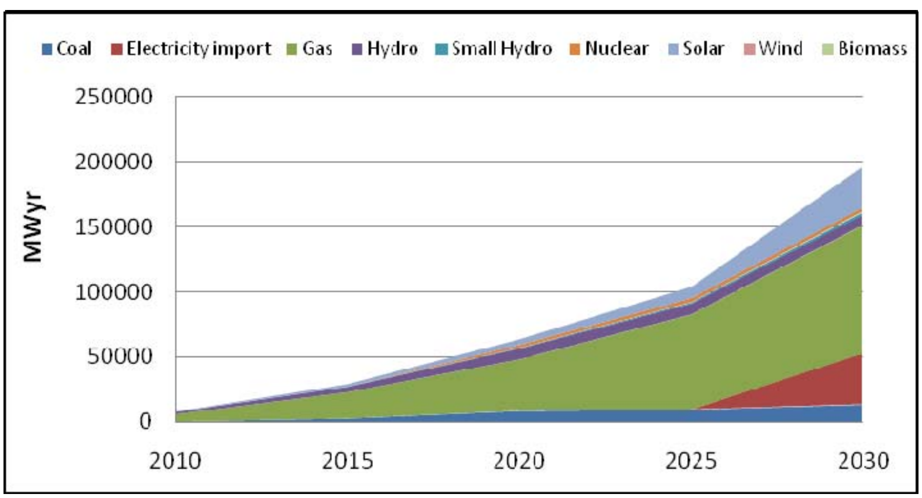


Fig. 5.6: Shares of Electricity Supply by Fuel Type (High Growth Scenario)

The share of hydro power will decrease from about 28% in 2010 to 15% in 2020 and decline to 5% by the year 2030 for the reference scenario, as no additional hydro plant is constructed after reaching the hydro potential. The share of hydro power will reduce to about 5% for the Optimistic I & II scenarios by 2030. Nuclear energy will be introduced by the year 2020 with 3% contribution in reference and high growth scenarios while in the case of optimistic I and II the contribution is 6 & 8% respectively. The share of nuclear energy will decrease to 2% for the four scenarios.

Solar energy for electricity in Nigeria was providing vital services in other remote and off-grid rural locations in the country; this was largely via photovoltaic but was insignificant in terms of primary energy share. Solar power system was mostly installed by government institutions with an installed capacity of almost 15MW. The share of solar energy will increase steadily for the reference, high growth, optimistic I & II scenarios. Solar energy will be contributing more to the electricity by 2030 in all the four scenarios, and this is attributed to the availability and reduced cost of solar equipment.

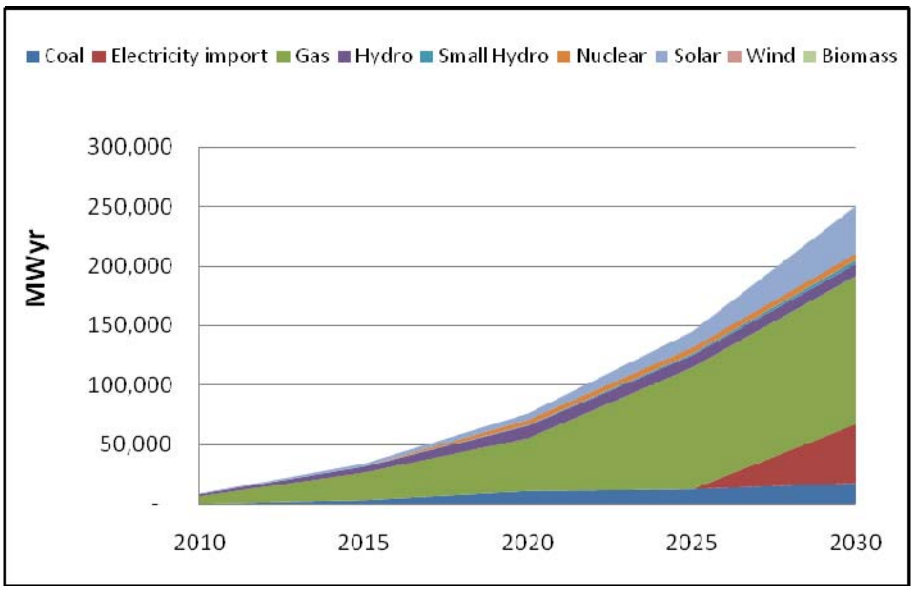


Fig. 5.7: Shares of Electricity Supply by Fuel Type (Optimistic I Scenario)

Biomass energy is considered in this study, with the introduction of combined heat and power (CHP) plants based on biomass wastes to generate essentially steam for their operations and some amount of electricity to supplement their grid electricity supply. Also considered is the biodiesel for generation of electricity and will contribute less than 1% of the total electricity for the two scenarios.

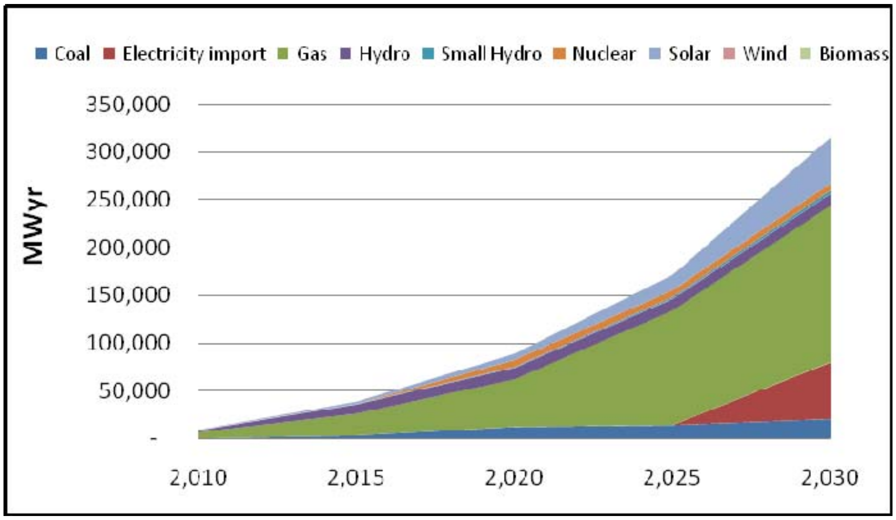


Fig. 5.8: Shares of Electricity Supply by Fuel Type (Optimistic II Scenario)

The electricity generations for the four scenarios are given in the appendices V, VI, VII and VIII. We assumed that all the on-going power plants, that is, the NIPPs and IPPs and the rehabilitation of the existing plants will be concluded. The new candidate plants are the sixteen CCGT, six GT and six coal fired plants, in addition to the new hydro, nuclear, wind and solar power plants.

5.3.4 Comparison of Installed and Production Capacities

Figures 5.9 to 5.12 show the comparisons of the installed and production capacities for electricity generation. For all the four scenarios, installed capacities have to be more than the production capacities to take care of reserves, losses in transmission and distribution. Moreover, the renewable energy power plants, such as hydro, solar and wind have plant factors of between 35% and 40%. For the reference scenario, the ratios of the installed to the production capacities varied between 1.0 and 1.4 over the study period. The ratios varied between 1.1 and 1.4, 1.0 and 1.3, as well as 1.0 and 2.6 for the high growth, optimistic I and optimistic II scenarios respectively.

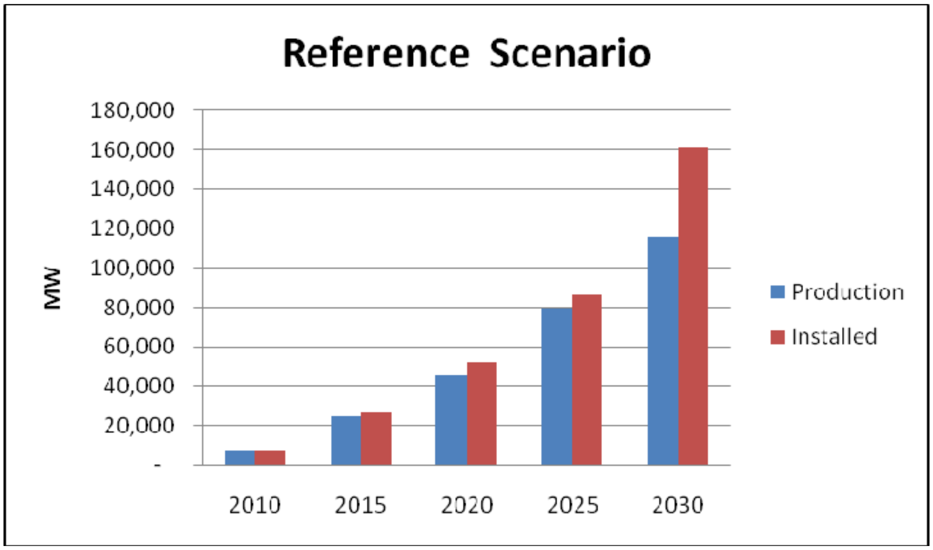


Figure 5.9 Comparison of installed and production capacities for the reference scenario

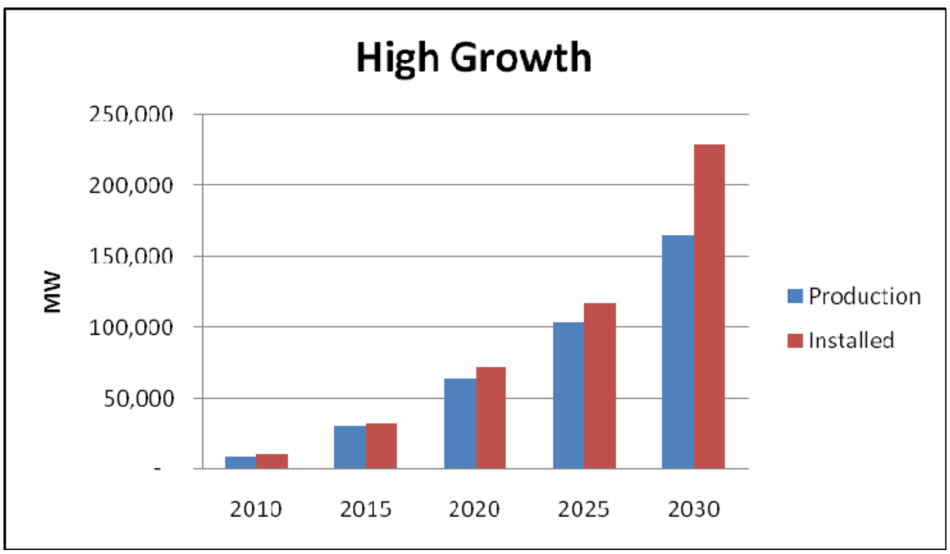


Figure 5.10 Comparison of installed and production capacities for the high growth scenario

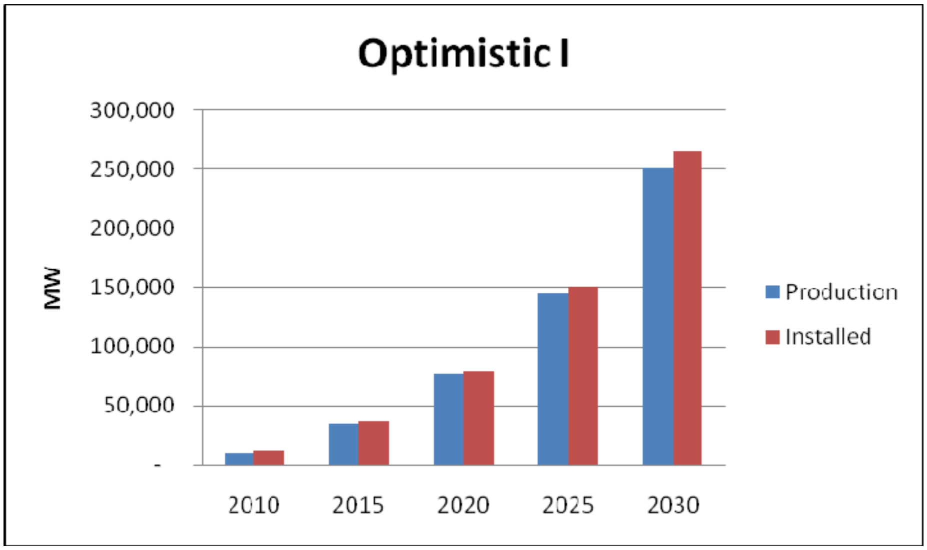


Figure 5.11 Comparison of installed and production capacities for the high growth scenario

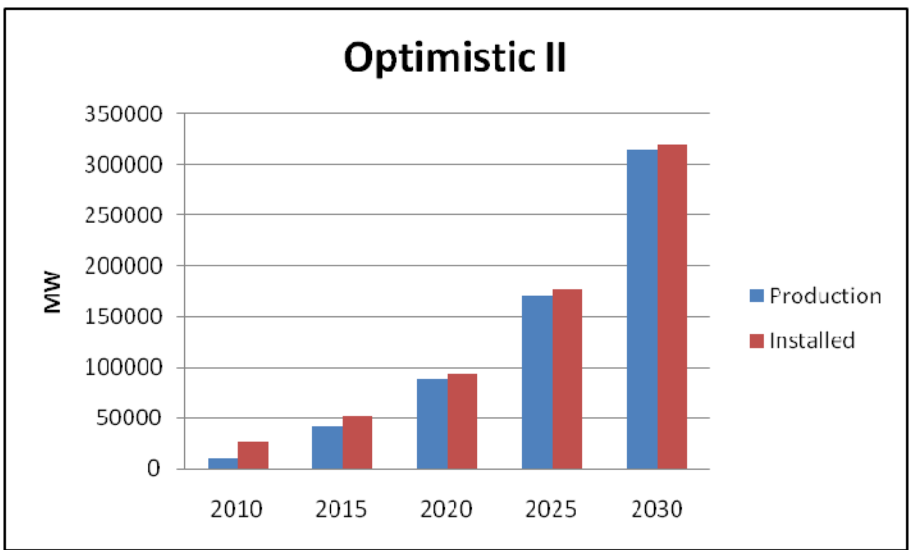


Figure 5.12 Comparison of installed and production capacities for the high growth scenario

5.3.5 Transmission and Distribution

The transmission and distribution loss for the studies is 15%. In order to transmit and distribute the required generation efficiently, there is need to expand the transmission and distribution infrastructure by:

- Enhancing supply reliability and improving voltage stability, since its capacity will be exceeded with growing load and additional power plants coming on line.
- Upgrading and expansion of transmission and distribution circuit.
- Upgrading transmission system-wide reactive compensation capability.

5.3.6 Cost Analysis of Electricity Capacity Additions

The cost analysis was based on the technical cost (not the contractual sum) the costs are the capital cost, which is the total overnight cost or the total initial investment cost. The variable operation and maintenance (O&M) is the cost of the fuel and related cost based on the usage of the plant, whilst the fixed (O&M) cost are cost that are fixed whether a plant is use or not. The summaries of the capital cost for the four scenarios are given in Tables 5.13 – 5.16. For the reference scenario the total projected cost is expected to reach US $248 billion.

Table 5.13: Capital Cost of Additional Generating Capacity by Technology in Billion US Dollars for the Reference Scenario

	2015	2020	2025	2030
Coal	1.79	7.08	1.53	5.16
Electricity Import	0.00	0.00	0.00	0.00
Gas	11.67	20.98	37.99	27.61
Hydro	2.78	8.73	0.00	0.00
Nuclear	2.50	1.25	2.50	2.50
Small Hydro	0.28	0.59	1.21	2.48
Solar	3.88	7.30	21.35	76.67
Wind	0.02	0.01	0.01	0.01
Biomass	0.00	0.02	0.03	0.03
Total	**22.94**	**45.96**	**64.62**	**114.46**

In The high growth scenario which is based on 10% economic growth rate, the cost of installation of new power plant in 2030 is US $133.75 with highest contribution from solar plant.

Table 5.14: Capital Cost of Additional Generating Capacity by Technology in Billion US Dollars for the High Growth Scenario

	2015	2020	2025	2030
Coal	3.87	10.12	2.18	7.37
Electricity import	0.00	0.00	0.00	0.00
Gas	14.36	30.02	54.24	41.65
Hydro	6.07	12.55	0.00	0.00
Nuclear	3.75	2.50	2.50	0.00
Small Hydro	0.54	0.85	1.73	3.54
Solar	7.46	8.40	16.60	81.19
Wind	0.00	0.00	0.00	0.00
Biomass	0.01	0.03	0.06	0.06
Total	**36.04**	**64.44**	**77.25**	**133.75**

The capital cost for the optimistic I scenario will increase from 37 billion US Dollars to 142 billion US Dollars in the period 2015 to 2030.

Table 5.15: Capital Cost of Additional Generating Capacity by Technology in Billion US Dollars for the Optimistic I Scenario

	2015	2020	2025	2030
Coal	4.45	11.63	2.51	8.48
Electricity import	-	-	-	-
Gas	16.26	31.10	78.44	36.85
Hydro	7.75	12.50	-	-
Nuclear	-	11.25	2.50	2.50
Small Hydro	0.63	2.88	1.92	4.07
Solar	7.97	11.02	30.67	90.46
Wind	0.06	0.01	0.01	0.01
Biomass	0.01	0.04	0.05	0.05
Total	**37.14**	**80.44**	**116.09**	**142.42**

Table 5.16: Capital Cost of Additional Generating Capacity by Technology in Billion US Dollars for the Optimistic II Scenario

	2015	2020	2025	2030
Coal	5.03	13.15	2.84	9.58
Electricity import	-	-	-	-
Gas	20.20	33.56	85.07	57.57
Hydro	23.17	0.11	-	-
Nuclear	9.00	13.00	-	-
Solar	5.02	-	2.25	2.40
Wind	9.06	12.90	33.65	109.70
Biomass	0.03	0.01	0.01	0.01
Total	**71.51**	**72.73**	**123.82**	**179.26**

The energy scenarios analyzed in this study indicate that:

- Natural gas is the most preferred fuel for electricity generation due to its higher efficiency of use and lower investments costs for combined cycle power plant. But, only limited quantity of gas from indigenous sources can be allocated to the power sector after meeting the essential requirement for non-power sector.
- Maximum exploitation of hydro power, renewable energy and introduction of nuclear power are required as they are economical. Model selects whole of the allowed large and small hydro potential in its optimal solutions for all the scenarios.
- The Environmental benefits of hydro, nuclear and renewables have not been considered in the present study. Hydro, nuclear and renewables will be even more competitive if environmental benefits of these options are considered.

CHAPTER SIX

6.0 CONCLUSION

In this study, we have analyzed the energy requirements for Nigeria's Vision20:2020 of and up to year 2030. The major findings of the study for the Optimistic II scenario, which is akin to the Vision's target of growing the economy at an average GDP growth rate of about 13% per annum include the following:

i. PMS demand will be 3.8, 7 and 17.3 times the base year demand of 5096.64 million litres in 2015, 2020 and 2030 of respectively;
ii. Jet fuel kerosene demand will be 8.8, 13, and 32.5 times the base year demand of 50 million litres in 2015, 2020 and 2030 of respectively;
iii. Household kerosene demand will be 21.56, 72 and 247 times the base year demand of 306 million litres in 2015, 2020 and 2030 respectively;
iv. Diesel demand will be 6.45, 11 and 37.7 times the base year demand of 565.64 million litres in 2015, 2020 and 2030 respectively.

For the electricity sector the study revealed that for the optimistic II scenario:

v. The electricity production will increase from 4052MWyr in 2009 to 88,282MWyr in 2020 and 315,000MWyr in 2030;
vi. That per capita electricity consumption will increase from 2409kWh by 2020 and 6081kWh by 2030;
vii. The installed generation capacity will increase from 5,753MW in 2009 to 88,696MW in 2020 and 315,158MW in 2030;
viii. The cumulative gas requirement for the study period will be between 55 trillion scf for the reference scenario and about 170 trillion scf optimistic II scenarios respectively. This shows that the country will utilize about 30% and 94% of the gas reserves for electricity generation for reference and optimistic II scenarios, respectively;
ix. The coal requirement will increase from about 6 million TCE to about 66 million TCE by 2030 with cumulative requirement of more than 700 million TCE, which is about 30% of the coal reserves of the country;
x. The cumulative capital requirement for capacity additions for the optimistic II scenario is US$447 billion.

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APPENDICES

Appendix I: Electricity Installed Capacity in MW (Reference Scenario)

	2009	2010	2015	2020	2025	2030
CCGT_CCS_PP_I/total inst cap	0	0	0	5000	7000	8000
CCGT_CCS_PP_II/total inst cap	0	0	0	1274	2538	5332
CCGT_CCS_PP_III/total inst cap	0	0	0	1274	1869	1869
CCGT_CCS_PP_IV/total inst cap	0	0	0	1235	1910	3101
CCGT_CCS_PP_IX/total inst cap	0	0	0	0	4000	7000
CCGT_CCS_PP_V/total inst cap	0	0	0	0	1881	1881
CCGT_CCS_PP_VI/total inst cap	0	0	0	2433	5543	8000
CCGT_CCS_PP_VII/total inst cap	0	0	0	0	3000	6000
CCGT_CCS_PP_VIII/total inst cap	0	0	0	0	4000	7000
CCGT_CCS_PP_X/total inst cap	0	0	0	0	0	1235
CCGT_PP_I/total inst cap	0	0	1253	1547	2018	2018
CCGT_PP_II/total inst cap	0	0	0	1930	1986	1986
CCGT_PP_III/total inst cap	0	0	0	1547	7000	8000
Cap_Gas_Akute/total inst cap	0	0	13	13	13	13
Cap_Gas_CETPower1/total inst cap	0	0	20	20	20	20
Cap_Gas_CETPower2/total inst cap	0	0	0	5	5	5
Cap_Gas_Coronation/total inst cap	0	0	0	0	20	20
Exi_Gas_Afam/total inst cap	499	515	960	960	960	960
Exi_Gas_Delta/total inst cap	900	900	900	900	900	900
Exi_Gas_Egbin/total inst cap	1320	1320	1320	1320	1320	1320
Exi_Gas_Geregu1/total inst cap	414	414	414	414	414	414
Exi_Gas_Olurunsogo1/total inst cap	335	335	335	335	335	335
Exi_Gas_Omotosho1/total inst cap	335	335	335	335	335	335
Exi_Gas_Sapele/total inst cap	0	0	300	300	300	300
Exi_Steam_Sapele/total inst cap	0	720	720	720	720	720
IPP_Gas_AES/total inst cap	0	0	270	270	270	270
IPP_Gas_AgbaraShoreline/total inst cap	0	0	56	56	56	56
IPP_Gas_AnitaEnergy/total inst cap	0	0	90	90	90	90
IPP_Gas_DILPower/total inst cap	0	0	135	135	135	135
IPP_Gas_ENCON/total inst cap	0	0	0	0	140	140
IPP_Gas_Eleme/total inst cap	0	0	95	95	95	95
IPP_Gas_Ethiope/total inst cap	0	0	2800	2800	2800	2800
IPP_Gas_FarmElectric/total inst cap	0	0	78	78	78	78
IPP_Gas_HudsonPower/total inst cap	0	0	150	150	150	150
IPP_Gas_ICSPower/total inst cap	0	0	270	270	270	270
IPP_Gas_IbafoPower/total inst cap	0	0	200	200	200	200

IPP_Gas_IbomPower/total inst cap	0	0	0	0	190	190
IPP_Gas_LotusBresson/total inst cap	0	0	30	30	30	30
IPP_Gas_MinajHolding/total inst cap	0	0	115	115	115	115
IPP_Gas_NotorePower/total inst cap	0	0	50	50	50	50
IPP_Gas_Okpai/total inst cap	0	0	480	480	480	480
IPP_Gas_Omoku/total inst cap	0	0	150	150	150	143
IPP_Gas_ParasEnergy/total inst cap	0	0	96	96	96	96
IPP_Gas_Shell_(AfamVI)/total inst cap	0	0	642	642	642	642
IPP_Gas_Supertek/total inst cap	0	0	458	458	458	458
IPP_Gas_TransAmadi/total inst cap	0	32	136	136	136	136
IPP_Gas_Westcom1/total inst cap	0	0	458	458	458	458
NIPP_Gas_Alaoji/total inst cap	0	0	1020	1020	1020	1020
NIPP_Gas_Calabar/total inst cap	0	0	563	563	563	563
NIPP_Gas_Egbema/total inst cap	0	0	338	338	338	338
NIPP_Gas_Gbarain/total inst cap	0	0	225	225	225	225
NIPP_Gas_Geregu2/total inst cap	0	0	434	434	434	434
NIPP_Gas_Ihovbor/total inst cap	0	0	451	451	451	451
NIPP_Gas_Olurunsogo2/total inst cap	0	0	700	700	700	700
NIPP_Gas_Omotosho2/total inst cap	0	0	450	450	450	450
NIPP_Gas_Sapele/total inst cap	0	0	451	451	451	451
OCGT_CCS_PP_I/total inst cap	0	0	0	0	380	380
OCGT_CCS_PP_II/total inst cap	0	0	0	0	400	400
OCGT_CCS_PP_III/total inst cap	0	0	0	0	0	0
OCGT_CCS_PP_IV/total inst cap	0	0	0	0	0	0
OCGT_PP_I/total inst cap	0	0	35	74	600	600
OCGT_PP_II/total inst cap	0	0	685	685	703	703
Gas	**3803**	**4571**	**18680**	**33711**	**61891**	**80560**
Exi_Hyd_Jebba/total inst cap	540	540	540	540	540	540
Exi_Hyd_Shiroro/total inst cap	600	600	600	600	600	600
Exi_hyd_Kainji/total inst cap	760	760	760	760	760	760
Future_Hdr_PP_I/total inst cap	0	0	754	1294	1294	1294
Future_Hdr_PP_II/total inst cap	0	0	0	0	0	0
Future_Hdr_PP_III/total inst cap	0	0	0	0	0	0
IPP_Hyd_Mabon/total inst cap	30	30	39	39	39	39
NIPP_Hyd_Mambilla/total inst cap	0	0	0	2600	2600	2600
NIPP_Hyd_Zungeru/total inst cap	0	0	350	700	700	700
Hydro	**1930**	**1930**	**3043**	**6533**	**6533**	**6533**
Small_Hyd_PP/total inst cap	0	40	142	379	863	1856
IPP_Hyd_NESCO/total inst cap	20	20	30	30	30	30

Small Hydro	**20**	**60**	**172**	**409**	**893**	**1886**
Coal_PP_I/total inst cap	0	609	1000	3000	3000	6000
Coal_PP_II/total inst cap	0	0	805	2000	3017	3456
ASC_FGD_CCS_PP/total inst cap	0	0	0	0	0	0
ASC_FGD_PP/total inst cap	0	0	0	0	0	0
IGCC_CCP_PP_II/total inst cap	0	0	0	0	0	0
IGCC_CCS_PP_I/total inst cap	0	0	0	1527	1528	1528
IGCC_PP/total inst cap	0	0	0	0	0	0
Coal	**0**	**609**	**1805**	**6527**	**7545**	**10984**
Small_Biomass_PP/total inst cap	0	0	3	16	35	54
Large_Biomass_PP/total inst cap	0	0	0	0	0	0
Biomass	**0**	**0**	**3**	**16**	**35**	**54**
Wind_Offshore_PP/total inst cap	0	0	0	0	0	0
Wind_Onshore_PP/total inst cap	0	10	19	22	25	29
Wind	**0**	**10**	**19**	**22**	**25**	**29**
CSP_PP/total inst cap	0	0	0	0	3157	6585
Cap_Solar_PV/total inst cap	0	260	1369	3455	5953	8938
Cap_Solar_Storage_PV/total inst cap	0	0	0	0	0	7344
Cap_Solar_Wedotebary/total inst cap	0	0	0	0	0	0
Emb_Solar_Storage_PV/total inst cap	0	0	0	0	0	4284
Grid_Solar_PV/total inst cap	0	0	0	0	1047	5351
Solar	**0**	**260**	**1369**	**3455**	**7000**	**25917**
Nuclear_PP/total inst cap	0	0	1000	1500	2500	3500
Nuclear_PWR_PP/total inst cap	0	0	0	0	0	0
Nuclear	**0**	**0**	**1000**	**1500**	**2500**	**3500**
Electricity Import	**0**	**0**	**0**	**0**	**0**	**31948**

Appendix II: Electricity Installed Capacity in MW (High Growth Scenario)

	2010	2015	2020	2025	2030
Exi_Gas_Afam/total inst cap	960	960	960	960	960
Exi_Gas_Delta/total inst cap	822	822	822	822	822
Exi_Gas_Egbin/total inst cap	1320	1320	1320	1320	1320
Exi_Gas_Geregu1/total inst cap	414	414	414	414	414
Exi_Gas_Olurunsogo1/total inst cap	335	335	335	335	335
Exi_Gas_Omotosho1/total inst cap	335	335	335	335	335
Exi_Gas_Sapele/total inst cap	300	300	300	300	300
Exi_Steam_Sapele/total inst cap	720	720	720	720	720
CCGT_CCS_PP_I/total inst cap	0	0	0	5000	5000
CCGT_CCS_PP_II/total inst cap	0	0	0	6207	8000
CCGT_CCS_PP_III/total inst cap	0	0	4000	6000	8000
CCGT_CCS_PP_IV/total inst cap	0	0	2001	4000	7000
CCGT_CCS_PP_IX/total inst cap	0	0	0	4000	7000
CCGT_CCS_PP_V/total inst cap	0	0	3000	5000	7000
CCGT_CCS_PP_VI/total inst cap	0	0	3000	6000	8000
CCGT_CCS_PP_VII/total inst cap	0	0	0	3000	6000
CCGT_CCS_PP_VIII/total inst cap	0	0	0	4000	7000
CCGT_CCS_PP_X/total inst cap	0	0	0	723	723
CCGT_PP_I/total inst cap	0	1856	5000	6500	8000
CCGT_PP_II/total inst cap	0	3000	4000	6000	8000
CCGT_PP_III/total inst cap	0	0	5000	7000	8000
Cap_Gas_Akute/total inst cap	0	13	13	13	13
Cap_Gas_CETPower1/total inst cap	0	20	20	20	20
Cap_Gas_CETPower2/total inst cap	0	5	5	5	5
Cap_Gas_Coronation/total inst cap	0	20	20	20	20
IPP_Gas_AES/total inst cap	0	270	270	270	270
IPP_Gas_AgbaraShoreline/total inst cap	0	56	56	56	56
IPP_Gas_AnitaEnergy/total inst cap	0	37	37	37	37
IPP_Gas_DILPower/total inst cap	0	135	135	134	227
IPP_Gas_ENCON/total inst cap	0	140	140	139	245
IPP_Gas_Eleme/total inst cap	0	53	53	52	53
IPP_Gas_Ethiope/total inst cap	0	1493	1493	1493	1493
IPP_Gas_FarmElectric/total inst cap	0	79	80	79	80
IPP_Gas_HudsonPower/total inst cap	0	88	89	89	89
IPP_Gas_ICSPower/total inst cap	0	273	273	273	273
IPP_Gas_IbafoPower/total inst cap	0	113	113	113	113
IPP_Gas_IbomPower/total inst cap	95	190	190	190	190
IPP_Gas_LotusBresson/total inst cap	0	32	32	32	32
IPP_Gas_MinajHolding/total inst cap	0	115	115	115	213

IPP_Gas_NotorePower/total inst cap	0	50	50	50	83
IPP_Gas_Okpai/total inst cap	480	480	480	480	480
IPP_Gas_Omoku/total inst cap	0	150	150	150	150
IPP_Gas_ParasEnergy/total inst cap	0	96	96	96	158
IPP_Gas_Shell_(AfamVI)/total inst cap	642	642	642	642	642
IPP_Gas_Supertek/total inst cap	0	460	467	467	467
IPP_Gas_TransAmadi/total inst cap	100	129	136	136	136
IPP_Gas_Westcom1/total inst cap	0	461	467	467	467
NIPP_Gas_Alaoji/total inst cap	0	1020	1020	1020	1020
NIPP_Gas_Calabar/total inst cap	0	563	563	563	563
NIPP_Gas_Egbema/total inst cap	0	338	338	338	338
NIPP_Gas_Gbarain/total inst cap	0	225	225	225	225
NIPP_Gas_Geregu2/total inst cap	434	434	434	434	434
NIPP_Gas_Ihovbor/total inst cap	0	451	451	451	451
NIPP_Gas_Olurunsogo2/total inst cap	0	700	700	700	700
NIPP_Gas_Omotosho2/total inst cap	0	450	450	450	450
NIPP_Gas_Sapele/total inst cap	0	451	451	451	451
OCGT_CCS_PP_I/total inst cap	0	333	333	333	333
OCGT_CCS_PP_II/total inst cap	0	702	714	714	8211
OCGT_CCS_PP_III/total inst cap	0	0	714	714	714
OCGT_CCS_PP_IV/total inst cap	0	0	0	514	714
OCGT_PP_I/total inst cap	0	0	1540	1540	1540
OCGT_PP_II/total inst cap	0	0	0	0	0
Gas	**6957**	**21329**	**44764**	**82701**	**115085**
Exi_Hyd_Jebba/total inst cap	540	540	540	540	540
Exi_Hyd_Shiroro/total inst cap	600	600	600	600	600
Exi_hyd_Kainji/total inst cap	760	760	760	760	760
Future_Hdr_PP_I/total inst cap	274	1950	1950	1950	1950
Future_Hdr_PP_II/total inst cap	0	476	899	899	899
Future_Hdr_PP_III/total inst cap	0	0	1010	1010	1010
NIPP_Hyd_Mambilla/total inst cap	0	0	2600	2600	2600
NIPP_Hyd_Zungeru/total inst cap	0	0	950	950	950
IPP_Hyd_Mabon/total inst cap	0	21	23	23	23
Hydro	**2174**	**4348**	**9332**	**9332**	**9332**
Small_Hyd_PP/total inst cap	51	216	555	1247	2664
IPP_Hyd_NESCO/total inst cap	30	30	30	30	30
Small Hydro	**81**	**246**	**585**	**1277**	**2694**
ASC_FGD_CCS_PP/total inst cap	0	0	0	0	0

ASC_FGD_PP/total inst cap	0	0	0	0	0
IGCC_CCP_PP_II/total inst cap	0	0	0	454	3367
IGCC_CCS_PP_I/total inst cap	0	0	2000	3000	5000
IGCC_PP/total inst cap	0	0	4000	4000	4000
Coal_PP_I/total inst cap	870	1579	1580	1580	1580
Coal_PP_II/total inst cap	0	1000	1744	1744	1744
Coal	**870**	**2579**	**9324**	**10778**	**15691**
Nuclear_PP/total inst cap	0	1500	2500	3500	3500
Nuclear_PWR_PP/total inst cap	0	0	0	0	0
Nuclear	**0**	**1500**	**2500**	**3500**	**3500**
CSP_PP/total inst cap	0	1000	1000	3200	30000
Cap_Solar_PV/total inst cap	377	951	2136	5000	5225
Cap_Solar_Storage_PV/total inst cap	0	0	0	0	0
Cap_Solar_Wedotebary/total inst cap	0	5	0	0	0
Emb_Solar_Storage_PV/total inst cap	0	0	0	0	0
Grid_Solar_PV/total inst cap	0	0	1800	1800	1800
Solar	**377**	**1956**	**4936**	**10000**	**37025**
Small_Biomass_PP/total inst cap	0	4	23	23	23
Large_Biomass_PP/total inst cap	0	0	0	27	54
Biomass	**0**	**4**	**23**	**50**	**77**
Wind_Offshore_PP/total inst cap	17	28	32	36	42
Wind_Onshore_PP/total inst cap	0	0	0	0	0
Wind	**17**	**28**	**32**	**36**	**42**
Electricity import	**0**	**0**	**0**	**0**	**45640**

Appendix III: Electricity Installed Capacity in MW (Optimistic I Scenario)

	2009	2010	2015	2020	2025	2030
Exi_Gas_Afam/total inst cap	960	960	960	960	960	960
Exi_Gas_Delta/total inst cap	822	822	822	822	822	822
Exi_Gas_Egbin/total inst cap	1320	1320	1320	1320	1320	1320
Exi_Gas_Geregu1/total inst cap	414	414	414	414	414	261
Exi_Gas_Olurunsogo1/total inst cap	335	335	335	335	335	335
Exi_Gas_Omotosho1/total inst cap	335	335	335	335	335	335
Exi_Gas_Sapele/total inst cap	300	300	300	300	300	300
Exi_Steam_Sapele/total inst cap	720	720	720	720	720	720
CCGT_CCS_PP_I/total inst cap	0	0	0	4315	7000	7000
CCGT_CCS_PP_II/total inst cap	0	0	0	3000	6000	8000
CCGT_CCS_PP_III/total inst cap	0	0	0	4000	6000	8000
CCGT_CCS_PP_IV/total inst cap	0	0	0	2000	4000	7000
CCGT_CCS_PP_IX/total inst cap	0	0	0	3000	4000	7000
CCGT_CCS_PP_V/total inst cap	0	0	0	0	5000	7000
CCGT_CCS_PP_VI/total inst cap	0	0	0	0	6000	8000
CCGT_CCS_PP_VII/total inst cap	0	0	0	0	3000	6000
CCGT_CCS_PP_VIII/total inst cap	0	0	0	0	4000	7000
CCGT_CCS_PP_X/total inst cap	0	0	0	0	0	1100
CCGT_PP_I/total inst cap	0	0	3498	4495	6500	8000
CCGT_PP_II/total inst cap	0	0	4500	4500	6000	8000
CCGT_PP_III/total inst cap	0	0	0	5000	7000	8000
Cap_Gas_Akute/total inst cap	0	0	0	13	13	13
Cap_Gas_CETPower1/total inst cap	0	0	0	20	20	20
Cap_Gas_CETPower2/total inst cap	0	0	0	5	5	5
Cap_Gas_Coronation/total inst cap	0	0	20	20	20	20
IPP_Gas_AES/total inst cap	270	270	270	270	270	270
IPP_Gas_AgbaraShoreline/total inst cap	0	0	56	56	56	56
IPP_Gas_AnitaEnergy/total inst cap	0	0	37	37	37	37
IPP_Gas_DILPower/total inst cap	0	0	135	135	135	227
IPP_Gas_ENCON/total inst cap	0	0	140	140	140	245
IPP_Gas_Eleme/total inst cap	0	0	53	53	53	53
IPP_Gas_Ethiope/total inst cap	0	0	1475	1475	1475	1475
IPP_Gas_FarmElectric/total inst cap	0	0	79	79	79	79
IPP_Gas_HudsonPower/total inst cap	0	0	88	88	88	88
IPP_Gas_ICSPower/total inst cap	0	0	270	270	270	270
IPP_Gas_IbafoPower/total inst cap	0	0	112	112	112	112
IPP_Gas_IbomPower/total inst cap	0	157	190	190	190	190

IPP_Gas_LotusBresson/total inst cap	0	0	32	32	32	32
IPP_Gas_MinajHolding/total inst cap	0	0	115	115	115	213
IPP_Gas_NotorePower/total inst cap	0	0	50	50	50	50
IPP_Gas_Okpai/total inst cap	480	480	480	480	480	480
IPP_Gas_Omoku/total inst cap	0	0	150	150	150	150
IPP_Gas_ParasEnergy/total inst cap	0	0	90	90	90	90
IPP_Gas_Shell_(AfamVI)/total inst cap	642	642	642	642	642	642
IPP_Gas_Supertek/total inst cap	0	0	461	461	461	461
IPP_Gas_TransAmadi/total inst cap	0	0	136	136	136	136
IPP_Gas_Westcom1/total inst cap	0	0	461	461	461	461
NIPP_Gas_Alaoji/total inst cap	0	1020	1020	1020	1020	1020
NIPP_Gas_Calabar/total inst cap	0	0	563	563	563	563
NIPP_Gas_Egbema/total inst cap	0	0	338	338	338	338
NIPP_Gas_Gbarain/total inst cap	0	225	225	225	225	225
NIPP_Gas_Geregu2/total inst cap	0	0	434	434	434	434
NIPP_Gas_Ihovbor/total inst cap	0	0	451	451	451	451
NIPP_Gas_Olurunsogo2/total inst cap	0	0	700	700	700	700
NIPP_Gas_Omotosho2/total inst cap	0	0	450	450	450	450
NIPP_Gas_Sapele/total inst cap	0	0	451	451	451	451
OCGT_CCS_PP_I/total inst cap	0	0	0	0	333	333
OCGT_CCS_PP_II/total inst cap	0	0	0	0	6000	6000
OCGT_CCS_PP_III/total inst cap	0	0	0	0	5000	5000
OCGT_CCS_PP_IV/total inst cap	0	0	0	0	4000	4000
OCGT_PP_I/total inst cap	0	0	0	0	7000	7000
OCGT_PP_II/total inst cap	0	0	0	0	4357	4357
Gas	**6,598**	**8,000**	**23,377**	**45,727**	**106,607**	**132,349**
Exi_hyd_Kainji/total inst cap	760	760	760	760	760	760
Exi_Hyd_Jebba/total inst cap	540	540	540	540	540	540
Exi_Hyd_Shiroro/total inst cap	600	600	600	600	600	600
NIPP_Hyd_Mambilla/total inst cap	0	0	0	2600	2600	2600
NIPP_Hyd_Zungeru/total inst cap	0	0	0	950	950	950
IPP_Hyd_Mabon/total inst cap	0	0	39	39	39	39
Future_Hdr_PP_I/total inst cap	0	600	1500	1950	1950	1950
Future_Hdr_PP_II/total inst cap	0	0	480	1059	1059	1059
Future_Hdr_PP_III/total inst cap	0	0	1081	2234	2234	2234
Hydro	**1900**	**2500**	**5000**	**10732**	**10732**	**10732**
Small_Hyd_PP/total inst cap	0	63	253	642	1439	3068

IPP_Hyd_NESCO/total inst cap	30	30	30	30	30	30
Small Hydro	**30**	**93**	**283**	**672**	**1469**	**3098**
Coal_PP_I/total inst cap	0	1000	1500	3000	3670	6000
Coal_PP_II/total inst cap	0	0	1466	2000	3000	5000
ASC_FGD_CCS_PP/total inst cap	0	0	0	0	0	0
ASC_FGD_PP/total inst cap	0	0	0	0	0	0
IGCC_CCP_PP_II/total inst cap	0	0	0	0	0	0
IGCC_CCS_PP_I/total inst cap	0	0	0	2000	2000	3322
IGCC_PP/total inst cap	0	0	0	3723	3724	3723
Coal	**0**	**1000**	**2966**	**10723**	**12394**	**18045**
Nuclear_PP/total inst cap	0	0	2500	2500	3000	4000
Nuclear_PWR_PP/total inst cap	0	0	0	2000	2500	2369
Nuclear	**0**	**0**	**2500**	**4500**	**5500**	**6369**
Cap_Solar_PV/total inst cap	15	15	1496	2979	5958	8769
Cap_Solar_Storage_PV/total inst cap	0	419	754	754	3672	7344
Cap_Solar_Wedotebary/total inst cap	0	0	0	0	0	0
Emb_Solar_Storage_PV/total inst cap	0	0	0	0	2553	4167
CSP_PP/total inst cap	0	0	0	1944	1944	1944
Grid_Solar_PV/total inst cap	0	0	0	0	0	20354
Solar	**15**	**434**	**2250**	**5677**	**14127**	**42578**
Wind_Offshore_PP/total inst cap	0	0	0	0	0	0
Wind_Onshore_PP/total inst cap	0	20	32	36	42	48
Wind	**0**	**20**	**32**	**36**	**42**	**48**
Small_Biomass_PP/total inst cap	0	0	4	27	58	89
Large_Biomass_PP/total inst cap	0	0	0	0	0	0
Biomass	**0**	**0**	**4**	**27**	**58**	**89**
Electricity import	**0**	**0**	**0**	**0**	**0**	**52486**

Appendix IV: Electricity Installed Capacity in MW (Optimistic II Scenario)

	2009	2010	2015	2020	2025	2030
Exi_Gas_Afam/total inst cap	960	960	960	960	960	960
Exi_Gas_Delta/total inst cap	822	822	822	822	822	822
Exi_Gas_Egbin/total inst cap	1320	1320	1320	1320	1320	1320
Exi_Gas_Geregu1/total inst cap	414	414	414	414	414	414
Exi_Gas_Olurunsogo1/total inst cap	335	335	335	335	335	335
Exi_Gas_Omotosho1/total inst cap	335	335	335	335	335	335
Exi_Gas_Sapele/total inst cap	300	300	300	300	300	300
Exi_Steam_Sapele/total inst cap	720.00022	720	720	720.00022	720.000218	720.000218
CCGT_CCS_PP_I/total inst cap	0	0	1502	4574	7000	10000
CCGT_CCS_PP_II/total inst cap	0	0	0	4000	6000	10000
CCGT_CCS_PP_III/total inst cap	0	0	0	4000	6000	10000
CCGT_CCS_PP_IV/total inst cap	0	0	0	2000	4000	9000
CCGT_CCS_PP_IX/total inst cap	0	0	0	0	4000	8258
CCGT_CCS_PP_V/total inst cap	0	0	0	3000	5000	8000
CCGT_CCS_PP_VI/total inst cap	0	0	0	3000	6000	8000
CCGT_CCS_PP_VII/total inst cap	0	0	0	0	3000	4647
CCGT_CCS_PP_VIII/total inst cap	0	0	0	0	4000	4000
CCGT_CCS_PP_X/total inst cap	0	0	0	0	5589	5589
CCGT_PP_I/total inst cap	0	0	3500	5000	6500	8000
CCGT_PP_II/total inst cap	0	0	3000	4000	6000	8000
CCGT_PP_III/total inst cap	0	0	3000	4999	7000	8000
Cap_Gas_Akute/total inst cap	0	0	13	13	13	13
Cap_Gas_CETPower1/total inst cap	0	0	20	20	20	20
Cap_Gas_CETPower2/total inst cap	0	0	5	5	5	5
Cap_Gas_Coronation/total inst cap	0	0	20	20	20	20
Exi_Gas_Afam/total inst cap	960	960	960	960	960	960
Exi_Gas_Delta/total inst cap	822	822	822	822	822	822
Exi_Gas_Egbin/total inst cap	1320	1320	1320	1320	1320	1320
Exi_Gas_Geregu1/total inst cap	414	414	414	414	414	414
Exi_Gas_Olurunsogo1/total inst cap	335	335	335	335	335	335
Exi_Gas_Omotosho1/total inst cap	335	335	335	335	335	335
Exi_Gas_Sapele/total inst cap	300	300	300	300	300	300
Exi_Steam_Sapele/total inst cap	720	720	720	720	720	720
IPP_Gas_AES/total inst cap	270	270	270	270	270	270
IPP_Gas_AgbaraShoreline/total inst cap	0	0	56	56	56	56
IPP_Gas_AnitaEnergy/total inst cap	0	0	37	37	37	37
IPP_Gas_DILPower/total inst cap	0	0	135	135	135	227
IPP_Gas_ENCON/total inst cap	0	0	140	140	140	245
IPP_Gas_Eleme/total inst cap	0	0	53	53	53	53

IPP_Gas_Ethiope/total inst cap	0	0	1475	1475	1475	1475
IPP_Gas_FarmElectric/total inst cap	0	0	79	79	79	79
IPP_Gas_HudsonPower/total inst cap	0	0	88	88	88	88
IPP_Gas_ICSPower/total inst cap	0	270	270	270	270	270
IPP_Gas_IbafoPower/total inst cap	0	0	112	112	112	112
IPP_Gas_IbomPower/total inst cap	0	190	190	190	190	190
IPP_Gas_LotusBresson/total inst cap	0	32	32	32	32	32
IPP_Gas_MinajHolding/total inst cap	0	115	115	115	115	213
IPP_Gas_NotorePower/total inst cap	0	50	50	50	50	83
IPP_Gas_Okpai/total inst cap	480	480	480	480	480	480
IPP_Gas_Omoku/total inst cap	0	150	150	150	150	150
IPP_Gas_ParasEnergy/total inst cap	0	15	96	96	96	158
IPP_Gas_Shell_(AfamVI)/total inst cap	642	642	642	642	642	642
IPP_Gas_Supertek/total inst cap	0	461	461	461	461	461
IPP_Gas_TransAmadi/total inst cap	0	136	136	136	136	136
IPP_Gas_Westcom1/total inst cap	0	461	461	461	461	461
NIPP_Gas_Alaoji/total inst cap	0	1020	1020	1020	1020	1020
NIPP_Gas_Calabar/total inst cap	0	563	563	563	563	563
NIPP_Gas_Egbema/total inst cap	0	338	338	338	338	338
NIPP_Gas_Gbarain/total inst cap	0	225	225	225	225	225
NIPP_Gas_Geregu2/total inst cap	0	434	434	434	434	434
NIPP_Gas_Ihovbor/total inst cap	0	451	451	451	451	451
NIPP_Gas_Olurunsogo2/total inst cap	0	700	700	700	700	700
NIPP_Gas_Omotosho2/total inst cap	0	450	450	450	450	450
NIPP_Gas_Sapele/total inst cap	0	451	451	451	451	451
OCGT_CCS_PP_I/total inst cap	0	0	0	0	6000	8000
OCGT_CCS_PP_II/total inst cap	0	0	0	0	6000	8000
OCGT_CCS_PP_III/total inst cap	0	0	0	0	5000	7000
OCGT_CCS_PP_IV/total inst cap	0	0	0	0	4000	6000
OCGT_PP_I/total inst cap	0	0	0	0	7000	9000
OCGT_PP_II/total inst cap	0	0	0	0	7000	9000
Gas	**11804**	**18316**	**31632**	**55202**	**125718**	**169512**
Exi_Hyd_Jebba/total inst cap	540	540	540	540	540	540
Exi_Hyd_Shiroro/total inst cap	600	600	600	600	600	600
Exi_hyd_Kainji/total inst cap	760	760	760	760	760	760
Future_Hdr_PP_I/total inst cap	0	2000	2000	2000	2000	2000
Future_Hdr_PP_II/total inst cap	0	0	2000	2000	2000	2000
Future_Hdr_PP_III/total inst cap	0	257	1718	2643	2643	2643
IPP_Hyd_Mabon/total inst cap	0	0	39	39	39	39
NIPP_Hyd_Mambilla/total inst cap	0	0	2600	2600	2600	2600

NIPP_Hyd_Zungeru/total inst cap	0	0	950	950	950	950
Hydro	**1900**	**4157**	**11207**	**12132**	**12132**	**12132**
IPP_Hyd_NESCO/total inst cap	30	30	30	30	30	30
Small_Hyd_PP/total inst cap	0	75	290	730	1630	3472
Small Hydro	**30**	**105**	**320**	**760**	**1660**	**3502**
Coal_PP_I/total inst cap	0	1353	1353	3000	3889	6000
Coal_PP_II/total inst cap	0	2000	2000	2000	3000	5000
ASC_FGD_CCS_PP/total inst cap	0	0	0	0	0	0
ASC_FGD_PP/total inst cap	0	0	0	0	0	
IGCC_CCP_PP_II/total inst cap	0	0	0	0	0	2277
IGCC_CCS_PP_I/total inst cap	0	0	0	3122	3122	3122
IGCC_PP/total inst cap	0	0		4000	4000	4000
Coal	**0**	**3353**	**3353**	**12122**	**14011**	**20399**
Nuclear_PP/total inst cap	0	0	0	5200	5200	5200
Nuclear_PWR_PP/total inst cap	0	0	3600	2000	2000	2000
Nuclear	**0**	**0**	**3600**	**7200**	**7200**	**7200**
Emb_Solar_Storage_PV/total inst cap	0	0	0	857	857	4166
Grid_Solar_PV/total inst cap	0	0	0	0	5357	10000
CSP_PP/total inst cap	0	0	0	741	3000	9700
Cap_Solar_PV/total inst cap	15	15	1490	2979	3551	15000
Cap_Solar_Storage_PV/total inst cap	0	475	1053	1835	3200	9261
Cap_Solar_Wedotebary/total inst cap	0	0	0	5	5	5
Solar	**15**	**490**	**2543**	**6417**	**15970**	**48132**
Wind_Offshore_PP/total inst cap	0	0	0	0	0	0
Wind_Onshore_PP/total inst cap	0	23	36	41	47	54
Wind	**0**	**23**	**36**	**41**	**47**	**54**
Small_Biomass_PP/total inst cap	0	0	5	30	65	100
Large_Biomass_PP/total inst cap	0	0	0	0	0	0
Biomass	**0**	**0**	**5**	**30**	**65**	**100**
Electricity import	**0**	**0**	**0**	**0**	**0**	**59333**

Appendix V: Electricity Production Projections in MWyr (Reference Scenario)

	2009	2010	2015	2020	2025	2030
Exi_hyd_Kainji/Electricity	520	734	412	562	498	386
Exi_Hyd_Jebba/Electricity	408	524	310	423	374	291
Exi_Hyd_Shiroro/Electricity	431	671	345	470	416	323
NIPP_Hyd_Zungeru/Electricity	0	0	370	703	622	483
NIPP_Hyd_Mambilla/Electricity	0	0	1254	1710	1513	1174
IPP_Hyd_Mabon/Electricity	0	0	7	10	9	7
Future_Hdr_PP_I/Electricity	0	0	350	1108	1127	874
Future_Hdr_PP_II/Electricity	0	0	0	0	607	471
Future_Hdr_PP_III/Electricity	0	0	0	709	867	673
Hydro	**1359**	**1930**	**3048**	**5696**	**6032**	**4682**
IPP_Hyd_NESCO/Electricity	14	4	7	7	11	19
Small_Hyd_PP/Electricity	0	55	154	349	814	1333
Small Hydro	**14**	**60**	**161**	**357**	**825**	**1351**
Exi_Gas_Afam/Electricity	206	187	455	528	517	463
Exi_Gas_Egbin/Electricity	257	233	565	611	628	510
Exi_Gas_Sapele/Electricity	51	47	113	122	126	118
Exi_Steam_Sapele/Electricity	154	140	339	367	377	392
Exi_Gas_Delta/Electricity	154	140	339	367	377	306
Exi_Gas_Geregu1/Electricity	103	93	226	243	246	195
Exi_Gas_Omotosho1/Electricity	62	56	136	187	193	150
Exi_Gas_Olurunsogo1/Electricity	62	56	136	190	193	150
NIPP_Gas_Alaoji/Electricity	231	210	530	603	635	459
NIPP_Gas_Ihovbor/Electricity	77	70	181	194	220	153
NIPP_Gas_Gbarain/Electricity	51	47	118	126	149	102
NIPP_Gas_Egbema/Electricity	87	79	198	223	243	174
NIPP_Gas_Calabar/Electricity	154	140	361	384	401	306
NIPP_Gas_Sapele/Electricity	103	93	235	252	297	204
NIPP_Gas_Olurunsogo2/Electricity	165	149	571	650	659	522
NIPP_Gas_Omotosho2/Electricity	118	107	389	418	424	336
NIPP_Gas_Geregu2/Electricity	103	93	347	403	409	324
IPP_Gas_Shell_(AfamVI)/Electricity	129	117	282	383	395	335
IPP_Gas_IbomPower/Electricity	41	37	95	108	112	142
IPP_Gas_Omoku/Electricity	21	19	45	53	61	56
IPP_Gas_TransAmadi/Electricity	26	23	56	79	81	89
IPP_Gas_Eleme/Electricity	0	19	45	49	50	39
IPP_Gas_AES/Electricity	62	56	141	151	151	123

IPP_Gas_Okpai/Electricity	103	93	226	304	308	338
IPP_Gas_Ethiope/Electricity	0	0	1266	1369	1389	1114
IPP_Gas_FarmElectric/Electricity	0	0	68	73	74	60
IPP_Gas_ICSPower/Electricity	0	96	232	251	254	204
IPP_Gas_Supertek/Electricity	0	163	395	428	434	344
IPP_Gas_Westcom1/Electricity	0	163	395	428	434	345
IPP_Gas_LotusBresson/Electricity	0	11	27	29	30	24
IPP_Gas_AnitaEnergy/Electricity	0	13	32	34	35	28
IPP_Gas_HudsonPower/Electricity	0	31	76	82	83	67
IPP_Gas_IbafoPower/Electricity	0	40	96	104	105	84
IPP_Gas_AgbaraShoreline/Electricity	0	18	43	46	47	37
IPP_Gas_ENCON/Electricity	41	37	91	104	110	88
IPP_Gas_MinajHolding/Electricity	39	35	85	95	99	80
IPP_Gas_NotorePower/Electricity	13	12	29	33	36	29
IPP_Gas_DILPower/Electricity	36	33	79	93	99	80
IPP_Gas_ParasEnergy/Electricity	26	23	57	66	71	57
Cap_Gas_Akute/Electricity	4	4	9	10	10	8
CCGT_PP_I/Electricity	0	233	1147	1520	2012	1594
CCGT_PP_II/Electricity	0	233	1144	1897	1981	1569
CCGT_PP_III/Electricity	0	233	1148	1520	6981	6320
CCGT_CCS_PP_I/Electricity	0	140	1163	4632	6981	6320
CCGT_CCS_PP_II/Electricity	0	140	572	1252	2473	1959
CCGT_CCS_PP_III/Electricity	0	0	572	1252	1900	1505
CCGT_CCS_PP_IV/Electricity	0	0	565	1252	1905	2449
CCGT_CCS_PP_V/Electricity	0	0	0	626	1876	1486
CCGT_CCS_PP_VI/Electricity	0	0	0	2391	5984	6320
CCGT_CCS_PP_VII/Electricity	0	0	0	0	2992	4740
CCGT_CCS_PP_VIII/Electricity	0	0	0	0	3989	5530
CCGT_CCS_PP_IX/Electricity	0	0	0	0	3989	5530
CCGT_CCS_PP_X/Electricity	0	0	0	0	0	975
OCGT_PP_I/Electricity	0	233	565	609	623	495
OCGT_PP_II/Electricity	0	233	565	613	633	505
OCGT_CCS_PP_I/Electricity	0	140	339	364	370	293
OCGT_CCS_PP_II/Electricity	0	0	565	613	633	505
OCGT_CCS_PP_III/Electricity	0	0	0	613	633	502
OCGT_CCS_PP_IV/Electricity	0	0	0	0	633	502
Gas	**2679**	**4571**	**17454**	**29393**	**57147**	**57733**
Coal_PP_I/Electricity	0	520	1000	1552	1791	1687
Coal_PP_II/Electricity	0	0	805	1035	1194	1406
IGCC_PP/Electricity	0	0	0	2069	1990	1687

IGCC_CCS_PP_I/Electricity	0	0	0	1035	1194	1406
IGCC_CCP_PP_II/Electricity	0	0	0	0	796	1125
ASC_FGD_PP/Electricity	0	0	0	0	0	562
ASC_FGD_CCS_PP/Electricity	0	0	0	0	0	0
Coal	**0**	**520**	**1805**	**5691**	**6966**	**7872**
Nuclear_PWR_PP/Electricity	0	0	612	1308	1319	1555
Nuclear_PP/Electricity	0	0	0	0	989	953
Nuclear	**0**	**0**	**612**	**1308**	**2308**	**2508**
Grid_Solar_PV/Electricity	0	260	640	1284	2140	4875
CSP_PP/Electricity	0	0	640	1729	4324	13698
Solar	**0**	**260**	**1280**	**3013**	**6463**	**18573**
Wind_Onshore_PP/Electricity	0	5	12	13	16	14
Wind_Offshore_PP/Electricity	0	5	6	6	8	7
Wind	**0**	**10**	**18**	**19**	**23**	**21**
Large_Biomass_PP/Electricity	0	0	2	11	26	29
Small_Biomass_PP/Electricity	0	0	1	3	6	10
Biomass	**0**	**0**	**3**	**14**	**32**	**39**
Electricity import	**0**	**0**	**0**	**0**	**0**	**22896**

Appendix VI: Electricity Production Projections in MWyr (High Growth Scenario)

	2009	2010	2015	2020	2025	2030
Exi_hyd_Kainji/Electricity	514.018	720	595.864	758.5395	678.7039	661.3299
Exi_Hyd_Jebba/Electricity	367.1344	540	445	570.6659	510.6042	497.533
Exi_Hyd_Shiroro/Electricity	478.201	600	498.0908	634.0735	567.338	552.8147
NIPP_Hyd_Zungeru/Electricity	0	0	680	700	700	700
NIPP_Hyd_Mambilla/Electricity	0	0	1800	2000	2000	2000
IPP_Hyd_Mabon/Electricity	0	0	21.29361	21.29361	21.29361	21.29361
Future_Hdr_PP_I/Electricity	0	0	280	1717.282	1536.54	1497.205
Future_Hdr_PP_II/Electricity	0	0	0	899	827.3674	806.1876
Future_Hdr_PP_III/Electricity	0	0	0	1320.985	1181.953	1151.696
Hydro	**1359.353**	**1860**	**4320.248**	**8621.84**	**8023.8**	**7888.061**
IPP_Hyd_NESCO/Electricity	14.08656	64.91976	17.22915	20.58337	23.00078	31.78502
Small_Hyd_PP/Electricity	0	0	215.3643	497.4313	1104.037	2284.989
Small Hydro	**14.08656**	**64.91976**	**232.5935**	**518.0147**	**1127.038**	**2316.774**
Exi_Gas_Afam/Electricity	205.7183	228.3243	408.8037	670.6832	734.3624	631.6875
Exi_Gas_Egbin/Electricity	257.141	285.4216	499.8303	922.1896	1009.748	868.5708
Exi_Gas_Sapele/Electricity	51.43267	57.08411	99.96434	209.5886	229.4883	197.4024
Exi_Steam_Sapele/Electricity	154.2918	171.252	299.8919	503.0123	550.7716	473.7658
Exi_Gas_Delta/Electricity	154.2918	171.252	299.8919	574.2728	628.7978	540.8825
Exi_Gas_Geregu1/Electricity	102.869	114.1708	198.4395	182.644	199.9854	172.0193
Exi_Gas_Omotosho1/Electricity	61.71922	63.71922	130.238	234.0405	256.2618	220.4327
Exi_Gas_Olurunsogo1/Electricity	61.71922	61.71922	132	234.0405	256.2618	220.4327
NIPP_Gas_Alaoji/Electricity	231.4441	231.4441	555.6785	690.9653	636.8601	671.169
NIPP_Gas_Ihovbor/Electricity	77.14638	77.14638	199.4155	242.75	205.9726	296.7616
NIPP_Gas_Gbarain/Electricity	51.43267	51.43267	121.2953	134.8431	123.7864	148.0518
NIPP_Gas_Egbema/Electricity	87.43371	87.43371	187.0499	208.6622	225.8285	222.4068
NIPP_Gas_Calabar/Electricity	154.2918	154.2918	339.5784	377.7502	370.5049	370.4586
NIPP_Gas_Sapele/Electricity	102.869	102.869	242.7778	315.0816	237.748	296.7616
NIPP_Gas_Olurunsogo2/Electricity	164.59	164.59	531.3694	489.04	535.4727	460.6056
NIPP_Gas_Omotosho2/Electricity	118.2934	118.2934	341.5947	314.3828	344.2322	296.1036
NIPP_Gas_Geregu2/Electricity	102.8691	102.8691	329.4492	303.2048	331.9931	285.5755
IPP_Gas_Shell_(AfamVI)/Electricity	128.5771	128.5771	280.5795	448.5194	491.1048	422.4413
IPP_Gas_IbomPower/Electricity	41.14606	41.14606	98.97654	132.7394	97.43592	125.0215
IPP_Gas_Omoku/Electricity	20.57183	20.57183	43.47662	47.05866	49.47306	98.70124
IPP_Gas_TransAmadi/Electricity	25.7142	25.7142	56.79252	95.01343	104.0347	89.48908
IPP_Gas_Eleme/Electricity	0	0	39.69146	36.79577	40.2894	34.65635
IPP_Gas_AES/Electricity	61.71917	61.71917	152.8575	180.9914	141.113	177.6622

IPP_Gas_Okpai/Electricity	102.869	102.869	223.8557	335.3416	367.1812	315.8439
IPP_Gas_Ethiope/Electricity	0	0	1117.815	1043.264	1142.318	982.6056
IPP_Gas_FarmElectric/Electricity	0	0	59.75153	55.88624	61.19244	52.63685
IPP_Gas_ICSPower/Electricity	0	117.0195	204.9348	190.9406	209.0698	179.8388
IPP_Gas_Supertek/Electricity	0	199.8011	349.8612	326.0154	356.9694	307.0598
IPP_Gas_Westcom1/Electricity	0	199.8011	349.8612	326.0154	356.9694	307.0598
IPP_Gas_LotusBresson/Electricity	0	13.7001	23.99346	22.35467	24.47716	20.0549
IPP_Gas_AnitaEnergy/Electricity	0	15.98221	27.99048	26.08022	28.55645	24.56384
IPP_Gas_HudsonPower/Electricity	0	38.24729	66.97821	62.40606	68.3313	58.7776
IPP_Gas_IbafoPower/Electricity	0	48.52308	84.65097	79.17305	86.69026	74.56968
IPP_Gas_AgbaraShoreline/Electricity	0	21.69114	37.7057	34.95435	38.27315	32.922
IPP_Gas_ENCON/Electricity	41.14605	41.14605	81.21611	97.80803	107.0945	107.0945
IPP_Gas_MinajHolding/Electricity	38.57482	38.57482	75.55905	80.34232	87.97051	87.97051
IPP_Gas_NotorePower/Electricity	12.85825	12.85825	25.60401	34.93141	38.24802	54.40445
IPP_Gas_DILPower/Electricity	36.00147	36.00147	71.51285	94.31484	103.2697	149.0396
IPP_Gas_ParasEnergy/Electricity	25.7142	25.7142	51.06428	71.01354	77.75601	77.75601
Cap_Gas_Akute/Electricity	4.114647	4.114647	8.390344	9.616413	10.52946	9.057289
CCGT_PP_I/Electricity	0	285.4217	1952.084	3698.621	5264.731	5573.717
CCGT_PP_II/Electricity	0	285.4217	1586.26	2958.896	4859.75	5573.717
CCGT_PP_III/Electricity	0	285.4217	2411.258	3698.621	5669.709	5573.719
CCGT_CCS_PP_I/Electricity	0	171.2521	2411.258	3698.621	5669.709	5573.718
CCGT_CCS_PP_II/Electricity	0	171.2521	518.1722	2958.897	4859.751	5573.714
CCGT_CCS_PP_III/Electricity	0	0	518.1722	2958.897	4859.751	5573.714
CCGT_CCS_PP_IV/Electricity	0	0	518.172	1479.449	3239.835	4877.002
CCGT_CCS_PP_V/Electricity	0	0	0	2219.173	4049.792	4877.002
CCGT_CCS_PP_VI/Electricity	0	0	0	2219.173	4859.753	5573.719
CCGT_CCS_PP_VII/Electricity	0	0	0	0	2429.876	4180.286
CCGT_CCS_PP_VIII/Electricity	0	0	0	0	3239.834	4876.999
CCGT_CCS_PP_IX/Electricity	0	0	0	0	3239.834	4877.002
CCGT_CCS_PP_X/Electricity	0	0	0	0	0	860.1108
OCGT_PP_I/Electricity	0	285.4218	498.4571	462.3086	2900.895	6270.429
OCGT_PP_II/Electricity	0	285.4216	501.384	1666.748	5039.741	5573.718
OCGT_CCS_PP_I/Electricity	0	171.252	297.8229	274.0981	300.1228	258.161
OCGT_CCS_PP_II/Electricity	0	0	501.384	469.6251	514.2144	4954.413
OCGT_CCS_PP_III/Electricity	0	0	0	469.6251	514.2144	1400
OCGT_CCS_PP_IV/Electricity	0	0	0	0	514.2144	514.2144
Gas	**2678.56**	**5377.951**	**20164.81**	**39671.48**	**72992.15**	**92697.67**
Coal_PP_I/Electricity	0	800	812	2254	2446	2446
Coal_PP_II/Electricity	0	0	542	1503	1631	1631
IGCC_PP/Electricity	0	0	1084	3005	2718	2718

IGCC_CCS_PP_I/Electricity	0	0	0	1502	1631	1631
IGCC_CCP_PP_II/Electricity	0	0	0	0	1087	1087
ASC_FGD_PP/Electricity	0	0	0	0	0	0
ASC_FGD_CCS_PP/Electricity	0	0	0	0	0	0
Coal	**0**	**800**	**2438**	**8264**	**9513**	**9513**
Nuclear_PWR_PP/Electricity	0	0	900	2215.632	1765.188	1601.812
Nuclear_PP/Electricity	0	0	0	0	1323.89	1408.188
Nuclear	**0**	**0**	**900**	**2215.632**	**3089.077**	**3010**
Captive_Solar_PV/Electricity	0	303.1753	919.7361	1841	4021	4021
CSP_PP/Electricity	0	0	929.4511	929	3200	26215
Cap_Solar_Storage_PV/total inst cap	0		0	0	0	0
Cap_Solar_Wedotebary/total inst cap	0		5	5	5	5
Emb_Solar_Storage_PV/total inst cap	0		0	0	0	0
Grid_Solar_PV/total inst cap	0		0	1600	1600	1600
Solar	**0**	**303.1753**	**1854.187**	**4375**	**8826**	**31841**
Wind_Onshore_PP/Electricity	0	7.110259	17.44981	18.81532	21.46343	23.85885
Wind_Offshore_PP/Electricity	0	7.110259	8.725134	9.135725	10.44572	11.86423
Wind	**0**	**14.22052**	**26.17495**	**27.95105**	**31.90915**	**35.72308**
Large_Biomass_PP/Electricity	0	0	2.804459	15.62475	35.82788	50.04716
Small_Biomass_PP/Electricity	0	0	0.83095	4.827235	8.301797	16.10668
Biomass	**0**	**0**	**3.635409**	**20.45199**	**44.12968**	**66.15385**
Electricity import	**0**	**0**	**0**	**0**	**0**	**18000**

Appendix VII: Electricity Production Projections in MWyr (Optimistic I Scenario)

	2009	2010	2015	2020	2025	2030
Exi_hyd_Kainji/Electricity	514	640	719	958	850	836
Exi_Hyd_Jebba/Electricity	367	420	441	721	640	629
Exi_Hyd_Shiroro/Electricity	478	480	501	801	711	699
Future_Hdr_PP_I/Electricity	-	412	400	2,169	1,925	1,892
Future_Hdr_PP_II/Electricity	-	-	-	-	1,037	1,019
Future_Hdr_PP_III/Electricity	-	-	-	1,669	1,481	1,456
NIPP_Hyd_Zungeru/Electricity	-	-	699	1,198	1,063	1,045
NIPP_Hyd_Mambilla/Electricity	-	-	2,187	2,914	2,586	2,542
IPP_Hyd_Mabon/Electricity	-	-	13	31	27	27
Hydro	**1,359**	**1,952**	**4,960**	**10,461**	**10,319**	**10,144**
IPP_Hyd_NESCO/Electricity	14	72	21	26	29	40
Small_Hyd_PP/Electricity	-	-	260	629	1,383	2,888
Small Hydro	**14**	**72**	**281**	**655**	**1,412**	**2,928**
Exi_Gas_Afam/Electricity	206	417	417	618	878	799
Exi_Gas_Egbin/Electricity	257	598	598	849	1,208	1,098
Exi_Gas_Sapele/Electricity	51	60	199	193	274	250
Exi_Steam_Sapele/Electricity	154	191	477	463	659	599
Exi_Gas_Delta/Electricity	154	191	545	529	752	684
Exi_Gas_Geregu1/Electricity	103	127	173	168	239	217
Exi_Gas_Omotosho1/Electricity	62	76	146	216	307	279
Exi_Gas_Olurunsogo1/Electricity	62	76	162	216	307	279
NIPP_Gas_Alaoji/Electricity	231	287	676	656	933	849
NIPP_Gas_Ihovbor/Electricity	77	96	299	290	413	375
NIPP_Gas_Gbarain/Electricity	51	64	149	145	206	187
NIPP_Gas_Egbema/Electricity	87	108	224	218	309	281
NIPP_Gas_Calabar/Electricity	154	191	373	362	515	468
NIPP_Gas_Sapele/Electricity	103	127	299	290	413	375
NIPP_Gas_Olurunsogo2/Electricity	165	204	464	450	640	582
NIPP_Gas_Omotosho2/Electricity	118	147	298	290	412	374
NIPP_Gas_Geregu2/Electricity	103	127	288	279	397	361
IPP_Gas_Shell_(AfamVI)/Electricity	129	159	386	413	587	534
IPP_Gas_IbomPower/Electricity	41	51	126	122	174	158
IPP_Gas_Omoku/Electricity	21	25	43	97	137	125
IPP_Gas_TransAmadi/Electricity	26	32	90	88	124	113
IPP_Gas_Eleme/Electricity	-	25	35	34	48	44
IPP_Gas_AES/Electricity	62	76	179	174	247	225
IPP_Gas_Okpai/Electricity	103	127	318	309	439	399

IPP_Gas_Ethiope/Electricity	-	-	977	949	1,350	1,227
IPP_Gas_FarmElectric/Electricity	-	-	52	51	72	66
IPP_Gas_ICSPower/Electricity	-	131	179	174	247	225
IPP_Gas_Supertek/Electricity	-	223	305	297	422	383
IPP_Gas_Westcom1/Electricity	-	223	305	297	422	383
IPP_Gas_LotusBresson/Electricity	-	15	21	20	29	26
IPP_Gas_AnitaEnergy/Electricity	-	18	24	24	34	31
IPP_Gas_HudsonPower/Electricity	-	43	58	57	81	73
IPP_Gas_IbafoPower/Electricity	-	54	74	72	102	93
IPP_Gas_AgbaraShoreline/Electricity	-	24	33	32	46	42
IPP_Gas_ENCON/Electricity	41	51	77	90	128	203
IPP_Gas_MinajHolding/Electricity	39	48	70	74	105	177
IPP_Gas_NotorePower/Electricity	13	16	25	32	46	69
IPP_Gas_DILPower/Electricity	36	45	70	87	124	188
IPP_Gas_ParasEnergy/Electricity	26	32	50	65	93	139
Cap_Gas_Akute/Electricity	4	5	9	9	13	11
CCGT_PP_I/Electricity	-	319	2,456	3,407	6,297	7,046
CCGT_PP_II/Electricity	-	319	2,105	2,725	5,812	7,046
CCGT_PP_III/Electricity	-	319	2,105	3,407	6,781	7,046
CCGT_CCS_PP_I/Electricity	-	191	2,105	3,407	6,781	7,046
CCGT_CCS_PP_II/Electricity	-	191	1,403	2,725	5,812	7,046
CCGT_CCS_PP_III/Electricity	-	-	1,403	2,725	5,812	7,046
CCGT_CCS_PP_IV/Electricity	-	-	730	1,363	3,875	6,166
CCGT_CCS_PP_V/Electricity	-	-	-	2,044	4,844	6,166
CCGT_CCS_PP_VI/Electricity	-	-	-	2,044	5,812	7,046
CCGT_CCS_PP_VII/Electricity	-	-	-	-	2,906	5,285
CCGT_CCS_PP_VIII/Electricity	-	-	-	-	3,875	6,166
CCGT_CCS_PP_IX/Electricity	-	-	-	-	3,875	6,166
CCGT_CCS_PP_X/Electricity	-	-	-	-	-	1,087
OCGT_PP_I/Electricity	-	319	439	3,407	6,781	7,927
OCGT_PP_II/Electricity	-	319	445	3,028	6,028	7,046
OCGT_CCS_PP_I/Electricity	-	191	260	252	359	326
OCGT_CCS_PP_II/Electricity	-	-	445	2,423	5,167	6,263
OCGT_CCS_PP_III/Electricity	-	-	-	1,817	4,306	5,481
OCGT_CCS_PP_IV/Electricity	-	-	-	-	3,444	4,698
Gas	**2,679**	**6,680**	**23,192**	**44,574**	**102,499**	**125,094**
Coal_PP_I/Electricity	-	330	981	2,851	3,064	3,655
Coal_PP_II/Electricity	-	-	654	1,900	2,043	3,046
IGCC_PP/Electricity	-	-	1,308	3,801	3,405	3,655
IGCC_CCS_PP_I/Electricity	-	-	-	1,900	2,043	3,046

IGCC_CCP_PP_II/Electricity	-	-	-	-	1,362	2,437
ASC_FGD_PP/Electricity	-	-	-	-	-	1,218
ASC_FGD_CCS_PP/Electricity	-	-	-	-	-	-
Coal	**-**	**330**	**2,943**	**10,453**	**11,917**	**17,056**
Nuclear_PWR_PP/Electricity	-	-	1,000	4,386	2,847	3,204
Nuclear_PP/Electricity	-	-	-	-	2,441	2,816
Nuclear	**-**	**-**	**1,000**	**4,386**	**5,288**	**6,020**
Captive_Solar_PV/Electricity	-	350	1,100	693	394	571
CSP_PP/Electricity	-	-	1,132	4,841	13,189	39,674
Solar	**-**	**350**	**2,232**	**5,534**	**13,583**	**40,244**
Wind_Onshore_PP/Electricity	-	8	21	24	27	30
Wind_Offshore_PP/Electricity	-	8	10	12	13	15
Wind	**-**	**16**	**32**	**35**	**40**	**45**
Large_Biomass_PP/Electricity	-	-	3	20	45	63
Small_Biomass_PP/Electricity	-	-	1	6	10	20
Biomass	**-**	**-**	**4**	**26**	**55**	**84**
Electricity import	**-**	**-**	**-**	**-**	**-**	**49,609**

Appendix VII: Electricity Production Projections in MWyr (Optimistic II Scenario)

	2009	2010	2015	2020	2025	2030
Exi_hyd_Kainji/Electricity	514	640	640	640	640	640
Exi_Hyd_Jebba/Electricity	367	500	500	500	500	500
Exi_Hyd_Shiroro/Electricity	478	540	540	540	540	540
IPP_Hyd_Mabon/Electricity	0	0	32	32	32	32
NIPP_Hyd_Zungeru/Electricity	0	0	700	700	700	700
NIPP_Hyd_Mambilla/Electricity	0	0	2000	2000	2000	2000
Future_Hdr_PP_I/Electricity	0	937	2504	2504	2512	2559
Future_Hdr_PP_II/Electricity	0	0	1214	2224	2224	2224
Future_Hdr_PP_III/Electricity	0	0	1599	2935	2935	2935
Hydro	**1359**	**2617**	**9729**	**12075**	**12083**	**12130**
IPP_Hyd_NESCO/Electricity	14	51	21	30	34	48
Small_Hyd_PP/Electricity	0	0	457	726	1620	3454
Small Hydro	**14**	**51**	**477**	**756**	**1653**	**3502**
Exi_Gas_Afam/Electricity	206	257	535	690	1028	1049
Exi_Gas_Egbin/Electricity	257	321	735	948	1414	1442
Exi_Gas_Sapele/Electricity	51	64	167	216	321	328
Exi_Steam_Sapele/Electricity	154	193	401	517	771	787
Exi_Gas_Delta/Electricity	154	193	458	591	881	898
Exi_Gas_Geregu1/Electricity	103	129	146	188	280	286
Exi_Gas_Omotosho1/Electricity	62	77	187	241	359	366
Exi_Gas_Olurunsogo1/Electricity	62	77	187	241	359	366
NIPP_Gas_Alaoji/Electricity	231	289	568	733	1093	1114
NIPP_Gas_Ihovbor/Electricity	77	96	251	324	483	493
NIPP_Gas_Gbarain/Electricity	51	64	125	162	241	246
NIPP_Gas_Egbema/Electricity	87	109	188	243	362	369
NIPP_Gas_Calabar/Electricity	154	193	314	404	603	615
NIPP_Gas_Sapele/Electricity	103	129	251	324	483	493
NIPP_Gas_Olurunsogo2/Electricity	165	214	390	503	750	765
NIPP_Gas_Omotosho2/Electricity	118	152	251	323	482	492
NIPP_Gas_Geregu2/Electricity	103	136	242	312	465	474
IPP_Gas_Shell_(AfamVI)/Electricity	129	161	358	461	688	701
IPP_Gas_IbomPower/Electricity	41	51	106	137	204	208
IPP_Gas_Omoku/Electricity	21	26	84	108	161	164
IPP_Gas_TransAmadi/Electricity	26	32	76	98	146	149
IPP_Gas_Eleme/Electricity	0	26	29	38	56	58
IPP_Gas_AES/Electricity	62	77	150	194	289	295

IPP_Gas_Okpai/Electricity	103	129	267	345	514	524
IPP_Gas_Ethiope/Electricity	0	0	822	1060	1580	1611
IPP_Gas_FarmElectric/Electricity	0	0	44	57	85	86
IPP_Gas_ICSPower/Electricity	0	132	150	194	289	295
IPP_Gas_Supertek/Electricity	0	225	257	331	494	504
IPP_Gas_Westcom1/Electricity	0	225	257	331	494	504
IPP_Gas_LotusBresson/Electricity	0	15	18	23	34	35
IPP_Gas_AnitaEnergy/Electricity	0	18	21	26	40	40
IPP_Gas_HudsonPower/Electricity	0	43	49	63	95	96
IPP_Gas_IbafoPower/Electricity	0	55	62	80	120	122
IPP_Gas_AgbaraShoreline/Electricity	0	24	28	36	54	55
IPP_Gas_ENCON/Electricity	41	51	78	101	150	267
IPP_Gas_MinajHolding/Electricity	39	48	64	83	123	233
IPP_Gas_NotorePower/Electricity	13	16	28	36	54	90
IPP_Gas_DILPower/Electricity	36	45	75	97	145	247
IPP_Gas_ParasEnergy/Electricity	26	32	57	73	109	182
Cap_Gas_Akute/Electricity	4	5	8	10	15	15
CCGT_PP_I/Electricity	0	321	2064	3803	7373	9254
CCGT_PP_II/Electricity	0	321	1769	3043	6806	9254
CCGT_PP_III/Electricity	0	321	1769	3803	7941	9254
CCGT_CCS_PP_I/Electricity	0	194	1769	3803	7941	9254
CCGT_CCS_PP_II/Electricity	0	193	1180	3043	6806	9254
CCGT_CCS_PP_III/Electricity	0	0	1180	3043	6806	9254
CCGT_CCS_PP_IV/Electricity	0	0	590	1521	4537	8097
CCGT_CCS_PP_V/Electricity	0	0	0	2282	5672	8097
CCGT_CCS_PP_VI/Electricity	0	0	0	2282	6806	9254
CCGT_CCS_PP_VII/Electricity	0	0	0	0	3403	6940
CCGT_CCS_PP_VIII/Electricity	0	0	0	0	4537	8097
CCGT_CCS_PP_IX/Electricity	0	0	0	0	4537	8097
CCGT_CCS_PP_X/Electricity	0	0	0	0	0	1428
OCGT_PP_I/Electricity	0	321	1769	3803	7941	10411
OCGT_PP_II/Electricity	0	321	1573	3381	7058	9254
OCGT_CCS_PP_I/Electricity	0	193	219	282	420	429
OCGT_CCS_PP_II/Electricity	0	0	524	2705	6050	8226
OCGT_CCS_PP_III/Electricity	0	0	1000	2028	5042	7198
OCGT_CCS_PP_IV/Electricity	0	0	0	0	4033	6169
Gas	**2679**	**6315**	**23889**	**49762**	**120023**	**164283**
Coal_PP_I/Electricity	0	400	964	3290	3588	4371
Coal_PP_II/Electricity	0	440	645	2194	2392	3642
IGCC_PP/Electricity	0	160	1191	4387	3987	4371

IGCC_CCS_PP_I/Electricity	0	0	0	2194	2392	3642
IGCC_CCP_PP_II/Electricity	0	0	0	0	1595	2914
ASC_FGD_PP/Electricity	0	0	0	0	0	1457
ASC_FGD_CCS_PP/Electricity	0	0	0	0	0	0
Coal	**0**	**1000**	**2800**	**12065**	**13954**	**20396**
Nuclear_PWR_PP/Electricity	0	0	0	7166	3861	3831
Nuclear_PP/Electricity	0	0	0	0	3310	3368
Nuclear	**0**	**0**	**0**	**7166**	**7171**	**7199**
Captive_Solar_PV/Electricity	0	236	593	245	252	408
CSP_PP/Electricity	0	0	3609	6142	15654	47717
Solar	**0**	**236**	**4203**	**6387**	**15905**	**48125**
Wind_Onshore_PP/Electricity	0	6	21	27	31	36
Wind_Offshore_PP/Electricity	0	6	10	13	16	18
Wind	**0**	**11**	**31**	**41**	**47**	**54**
Large_Biomass_PP/Electricity	0	0	3	23	53	76
Small_Biomass_PP/Electricity	0	0	1	7	12	24
Biomass	**0**	**0**	**4**	**30**	**65**	**100**
Electricity import	**0**	**0**	**0**	**0**	**0**	**59324**