Nigeria's Long Term Energy Demand Outlook to 2030

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ABSTRACT

In recent times, various national plans aimed at accelerating the socio-economic development of the country were articulated. These include the National Economic Empowerment and Development Strategy (NEEDS), which is the country's strategy for achieving the Millennium Development Goals (MDG) of the United Nations (UN), the Seven Point Agenda and the Vision 20: 2020. The Energy Commission of Nigeria is required by law to prepare, review and update national plans periodically to ensure that all reasonable demands for energy are met in a sustainable manner. In conformity with this mandate, the Energy Commission of Nigeria evaluated the energy implications of the development plans to prepare this Energy Demand Outlook covering the period 2005-2030. Such analysis will enable the design of appropriate policies, plans and programmes, which will ensure security of energy supply in the right quantity and quality for the economy. This paper presents the results of the detailed bottom-up analysis of Nigeria's energy demand and supply over the period 2005 – 2030 towards meeting the socio-economic development aspirations of the country encapsulated in the development plans. The energy requirements for the country's development aspirations were assessed within the framework of scenario analysis by using the Model for Analysis of Energy Demand, which was developed by the International Atomic Energy Agency. The model follows the end-use demand forecasting steps typical of an engineering-economy model. The total final energy demand is projected to increase from 32.5 Mtoe in 2005 to 80Mtoe by 2010, 202.74 Mtoe by 2020 and 747.27 Mtoe by 2030 for the Optimistic scenario, which represents the projections for Vision 20:2020. All of these require strong policy support and commitment. Sustainable electricity generation will require a range of technologies, including natural gas, hydro, advanced coal-fired generation, nuclear and non-hydro renewables.

1.0 INTRODUCTION

In recent time, Nigeria envisioned various development plans aimed at accelerating the socio-economic development of the nation. These include the National Economic Empowerment and Development Strategy (NEEDS), which is the country's strategy for achieving the Millennium Development Goals (MDG) of the United Nations (UN), the Seven Point Agenda of the current administration of focusing intensive actions on some specific sectors of the economy such as infrastructure development, food security, human capital development, and the Vision 20:2020 which aims at substantial improvement in the Human Development Index (HDI) rating of the country as well as growing the economy such that Nigeria will be in the league of the twenty (20) largest economies in the world by year 2020. Energy is a key driver of economic growth and social progress because it is required for fuelling industry, powering infrastructure, transportation of goods, people and services to markets and delivering basic services such as heating, cooling, lighting and cooking. Energy being an essential input for economic growth, Nigeria needs to provide sufficient and reliable energy to be able to achieve the socio-economic development aspirations. In conformity with its mandate, the Energy Commission of Nigeria evaluated the energy implications of the development plans to prepare this Energy Demand Outlook covering the period 2005-2030 for the various sectors of the economy and by energy form. To the best of our knowledge, there is no study to date, which provides scenarios of energy demand in Nigeria by sector and by energy type for the developmental aspirations considered and for a period as long as 25 years as done in this study.

Currently, the World Bank's ranking of economies of countries of the world places Nigeria in the 38th position on a Purchasing Power Parity (PPP) basis (World Bank, 2008). To move to the 20th position by 2020, Nigeria needs to grow its economy at an average rate of 13% p.a. from the present growth rate of about 6% (ECN, 2008).

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 goals. 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 (Olayande et al, 2008). Supply densities must match demand densities.

Presently, the supply of modern energy, especially

electricity, 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 (FRN-NPC, 2007). Energy-induced environmental degradation is already prevalent in the country (Sambo, 2009). This is characterized by deforestation as a result of felling of trees for fuelwood and charcoal production, air pollution in urban areas arising from vehicular emissions and the burning of traditional fuels for cooking in households, noise 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 (Adegbulugbe et al, 1992). These impact negatively on the quality of life of the population and hence on the development aspirations. The principal objective of the study is the evaluation of the energy requirements for the development aspirations of the country and assessment of alternative paths and strategies for the development of the energy and electricity sector to meet the future demand of energy and electricity in the country.

The organization of this paper is such that section 2 is a brief discussion of the historical patterns of energy consumption with emphasis on the last five years preceding the base year of the study, in order to understand the trends in energy consumption and identify sustainability issues in the energy demand and supply chain in the country. Section 3 discusses the methodologies for projection of energy demand and sustainable supply strategies, while Section 4 contains the results and the discussion of the results. The conclusions and recommendations are presented in Section 5.

2.0 PATTERNS OF ENERGY CONSUMPTION AND SUPPLIES IN NIGERIA

Appraising future energy demand for Nigeria requires a clear picture of the structure of energy consumption. This picture must include both the quantities of energy consumed by source and the activities or output for which energy is used (Eric et al, 1995).

Prior to the 1960s, energy demand and consumption constituted, very predominantly, of traditional energy sources, 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 (ECN, 2003).

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 continued to 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. Figure 1 shows the consumption of primary energy source types over the period 2001 – 2005.

Up to the end of the last decade, fuelwood and charcoal provided the single largest share of primary energy consumption in the country (FGN, 1992). Over the period 2001-2005, the share fluctuated within the range of 32-40%. 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 service sector (restaurants, schools, prisons, etc). The next most highly consumed primary energy resource was petroleum products (31%), consisting mostly of premium motor spirit (PMS) and automotive gas oil (AGO) generally referred to as petrol and diesel for transportation and power generation, but also including kerosene (household and services), aviation kerosene

(transport), fuel oil (industry), liquefied petroleum gas (household and services), as well as lubricating oil, bitumen and asphalt (construction). By 2000 however, natural gas surpassed petroleum products and by 2005, it contributed about 34% to total primary energy consumption (next to fuelwood's 37%). Up to 1999 natural gas was mostly used for power generation. As from 2000, however, the use of the gas as feedstock for liquefied natural gas production for export became predominant. There is also an increasing use of natural gas for thermal applications (steam production) and feedstock to other industries in the manufacturing industry. Combined use of gas in LNG, power generation and industrial heating is expected to terminate gas flaring, which was 54% in 2008. The share of oil product consumption by types in 2005 is shown in Figure 2 with PMS consistently accounting for more than 50% of the consumption over the period.

3.0 ANALYTICAL APPROACH

The ECN took advantage of the energy models already developed by the IAEA that provide framework for systematic analysis of various issues covering social, economic, technical and environmental aspects of energy decisions (IAEA, 2006). The International Atomic Energy Agency (IAEA), under Regional Cooperation Agreement, supports projects to carry out studies in member countries to address planning issues of nuclear power. Application of the MAED requires detailed information on demography, economy and energy consumption. The information is first assembled for a base year which is a year in recent past used as the reference year for perceiving the evolution of the country's energy system in order to gain an insight into the energy demand, consumption and supply patterns for the economy in consideration. This will enable comparison with the past consumption and the knowledge gained in addition to anticipated socio-economic and technical growth scenarios will enable projection for the future years. The period considered for the study is 2005-2030 in five year stages.

3.1 THE STRUCTURE OF ENERGY CONSUMPTION IN 2005

Identification of sustainable paths and policies for energy sector development in Nigeria requires a clear picture of the current structure of energy consumption and historical development (Eric 1995), which would help provide insight into how these may evolve in the future. In this section, the energy consumption structure for the base year of the study, 2005 is discussed. The primary data sources were aggregated annual energy consumption data from primary data sources, such as the Nigerian National Petroleum Corporation (NNPC), the Power Holding Company of Nigeria (PHCN) and secondary data from the Nigerian Bureau of Statistics (NBS) and the Central Bank of Nigeria (CBN) (Iloeje et al 2003). The Presidential Committee on Alternatives to Fuelwood (FGN, 1992) provided data on fuelwood consumption in Nigeria. This was used in conjunction with the national population figures to obtain the national fuelwood consumption in 2005. Charcoal utilization was provided by the Food and Agriculture Organization (FAO, 2008) of the United Nations. The electricity consumption reported is the sum of consumption from the grid electricity and the consumption from electricity generation by individuals, industries and establishments to meet essential services in the absence of grid electricity. Electricity generated by the industrial, services and residential sectors was estimated as 5% of grid electricity consumption (ECN, 2004)

Dissaggregation of data into sectoral levels was achieved through extensive field work, surveys and interviews, quantitative analysis, analytical models and comparison with countries in similar development stages with Nigeria (Sambo et al, 2006). Table 1 shows the structure of energy consumption in 2005. This table was prepared to construct the energy consumption pattern for the MAED model, details which can be obtained in the Energy Commission's full reports (ECN 2004, 2008).

Out of the total final energy demand of 32.5Mtoe, households accounted for the highest consumption with 56.86%, transportation 28.43%, manufacturing 6.43%, services 8.06% while agriculture, construction and mining jointly

accounted for the balance of 0.39%. Traditional fuels accounted for the highest consumption with 49.14%.

The traditional fuels, which include fuelwood, charcoal, crop residues and animal droppings, are consumed largely for cooking and water heating in rural and sub-urban households with small quantities consumed in the services sector also for cooking while some cottage industries, such as bakeries and other food processing also use it in the manufacturing processes. The high proportion of energy consumption in the households is due to the consumption of low quality traditional fuels with low efficiency of utilization. Fossil fuels used for transportation follow with 9.98%, electricity with 5.03%, fossil fuels used for thermal purposes accounted for 4.21% while coking coal and feedstock accounted for the balance. Soft solar (solar thermal applications) contribution was practically zero.

Feedstocks in this study represent energy sources used for non-energy purposes in the manufacturing sector only. Survey conducted by the ECN (Iloeje et al, 2003) indicated that LPG is used as propellants in the manufacture of aerosols such as insecticides and perfumes. Similarly, DPK is used by some pharmaceutical companies to wash their bottles prior to further cleaning with soap and detergents. Coking coal is used in steel manufacturing as reducing agent instead of energy purposes.

From the foregoing, it is clear that the current energy system in Nigeria in which traditional fuels account for a very high proportion of energy consumption is not sustainable. Traditional fuels cannot power the industrialization of the country. Electricity supply is grossly inadequate to support the development aspirations with only 151.3kW per capita consumption. Dependence on hydropower is insecure as a lot of evaporation takes place in the reservoirs and availability is subject to weather conditions and natural gas is a depletable resource.

3.2 METHOD OF ENERGY DEMAND ANALYSIS

The Model for the Analysis of Energy Demand (MAED) has been used for the projection of energy and electricity demand in the long-term (2005-2030). It is a widely used bottom-up model for forecasting medium to long-term energy demand and runs on PCs using EXCEL software (World Bank, 2010). MAED is a simulation model that uses a bottom-up approach. The model allows the breakdown of the country's final energy consumption into various sectors and within a sector into individual categories of end-uses in a consistent manner. The breakdown helps in the identification of the social, economic and technical factors influencing each category of final energy demand in the residential, commercial, agriculture, transport and industrial sectors of the economy. For example, in the residential sector electricity is used for cooking, air conditioning, refrigeration, and lighting, and in agriculture for irrigation and on farm processing. The end-use method is based on the premise that energy is required for the service that it delivers and not as a final good. The end-use energy accounting models with detailed sector representation produce more realistic projections compared with econometric models (World Bank, 2009) for medium-to-long term projections.

In the MAED methodology, the industry includes agriculture, construction, mining and manufacturing sectors of the economy. The energy demands of these economic sectors are driven by the economic growth (value added) of the respective sector and the national priority for the development of certain industries or economic sectors. Movement of goods and passengers are the main activities of the transport sector. The driving parameters are tonne – kilometre for freight transport and passenger – kilometre for passenger transport respectively. People's mobility and preferences for transport modes also determine passenger- kilometers. The end-use energy categories of the household sector are air-conditioning, water heating, cooking and electricity for appliances (refrigerators, television, sound system, electric irons, lighting, washing machines, etc.) and space cooling and heating. The factors determining the energy demands of the household sector are related to demography, e.g. number of dwellings, number of persons per household and living conditions (life style) e.g. hot water requirements per person, dwellings with air-conditioning. For the services sector, MAED model projects energy and

electricity demand on the basis of floor area and the specific consumption for each end-use. Evolution of the efficiency of certain types of equipment, market penetration of new technologies or energy forms are also parameters that determine future energy demand. The expected future dynamics for these determining factors are exogenously introduced. Equation 1 is the generic demand projection method of MAED (IAEA, 2006).

$$E_i = e_i * VD_i = e_o * F_i * VD_i \quad \text{----------} \quad (1)$$

where E_i is energy demand in year i by sector or by energy form; e_o is base year energy intensity, or energy consumption per unit of VD in the base year; e_i is the energy intensity in year i; F_i is modifier of e_o for year i and it depends on factors such as penetration of technology, energy use efficiency, economy, life style, demography, etc, in year i relative to the base year; and VD_i is value of the driving parameter of energy demand in year i. This, when summed over different end-uses in a sector, gives the aggregate energy demand.

This takes into account improvements in efficiency of energy use, utilization rates, inter-fuel substitution, etc. in a sector as these are captured in the energy required by an appliance. In the process the approach implicitly captures the price, income and other economic and policy effects as well (GOP, 2010). Through scenarios, the model specifically captures structural changes and evolution in the end-use demand and markets.

3.3 INPUT DATA AND MAJOR ASSUMPTIONS

Realizing the fact that the 13% target growth rate of the economy envisaged by the government is very high, three possible scenarios of the development of the economy were considered for the energy demand projection to provide alternative views for the decision makers. These are, the Reference Scenario with 7% average GDP growth rate, which represents the most plausible growth scenario without policy changes. This is based on the observation that the average GDP growth over the period 1995 – 2005 was about 7.40% per annum (National Bureau of Statistics, (2008), CBN (2005, 2008), High Growth Scenario with 10% average GDP growth rate and Optimistic Scenario with 13% average GDP growth per annum all over the period 2005 – 2030. Table 2 presents the composition of the real GDP for each scenario in 2020 and 2030 (ECN, 2008). Agriculture accounted for the largest share of 41.19% in 2005, while manufacturing accounted for 3.39%.

Based on the national population census conducted in 2006, the population of the country in 2005 was calculated to be 137.49 million people with the inter-census (1991 – 2006) growth rate of 3.16% per annum. Government's plans to stabilize the population growth rate at 2% per annum (NPC, 2010) has not been achieved, hence the growth rate of the population is assumed to increase to 4.00% by 2020 and thereafter decline to 3.74% per annum in 2030 as a result of the desire for improvements in the quality of living. The assumed evolution of the population growth rate and other demographic parameters which are drivers of energy demand are presented in

Time series data on stock of vehicles in Nigeria is not available. However, based on data obtained from the National Bureau of Statistics on newly registered vehicles in Nigeria, stock of vehicles in 2005 was estimated as 2,508,150 (ECN, 2008). Cars accounted for 42.32%, motorcycles 47.27%, minibuses 2.47%, medium buses 1.24% and luxury buses 0.41%. Freight vehicles (vans, pick-ups, tippers, trailers, tankers) accounted for the balance of 6.3%. In 2005, total freight activity was estimated as 140.88 billion tonne –km, while passenger activity was estimated as 177.72 billion passenger-km. The freight activity is projected to increase to 803.28 billion tonne-km and 2793.53 billion tonne-km by 2020 and 2030 respectively for the optimistic. These and the contributions by various modes of freight transportation are presented in Table 4. In addition, the projections for passenger activity and contributions from cars, buses, train and plane are also presented in

The developments of energy consumption in the household sector up to 2030 are presented Table 5. Electricity penetration is assumed to increase from 55.2% to 93% and 100% in 2020 and 2030 respectively for the Optimistic scenario. Other drivers of energy demand such as electricity

consumption per household, electricity penetration into cooking are also presented. Similarly, the evolution of drivers of energy demand in the services sector is presented in Table 6. Floor area per employee is expected to increase from 16.2 m^2 to 17m^2 and 17.2m^2 in 2020 and 2030 respectively for the Optimistic scenario. Cooling requirement is expected to increase from 135 kWh/m^2/yr to 274 kWh/m^2/yr and 310kWh/m^2/yr in 2020 and 2030 respectively for the Optimistic scenario.

4.0 RESULTS AND DISCUSSIONS

The total final energy demand projections over the period 2005 -2030 for the three scenarios are presented in Table 7. The total final energy demand of 32.5Mtoe in the base year will increase to 224.54Mtoe, 456.96Mtoe and 747.27Mtoe in 2030, for the reference, high growth and optimistic scenarios, respectively. The projected energy consumption values include traditional fuels, and kerosene (fossil fuel) demand for lighting mostly in household and the services sectors. The average annual growth rates of the total final energy demand over the period 2005-2030 are 9.46%, 13.97% and 17.94% for the reference, high growth and optimistic 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 instead of current dependence on importation for virtually everything, increasing access to electricity by all the sectors of the economy, increasing mechanization and automation of the industrial sectors.

Table 8 presents the various forms of the projections of total final energy demand for the three scenarios. In the base year, traditional fuels provided the highest energy demand with 11.66 Mtoe, which constituted a share of 35.88% while modern energy consumption amounted to 20.84Mtoe, representing 64.12% of the total. Petroleum products used for transportation purposes followed fairly closely with 9.98Mtoe or 30.71%. Fossil fuels (petroleum products, natural gas, coal) used for thermal applications constituted 4.57Mtoe (14.06%) while electricity, coking coal and feedstock accounted for 5.93Mtoe, 0.09Mtoe and 0.27Mtoe , that is, 18.25%, 0.28% and 0.83% respectively of the total energy consumption in the base year. Solar thermal and solar photovoltaic applications (that is energy from commercial or engineered solar technologies, excluding the open-to-sun or natural use of solar radiation), made no significant contribution in that year. Solar energy is projected to make some contributions by 2020 due to policy drive by government, to expand access to modern energy and the desire to ameliorate climate change by encouraging the adoption of clean and renewable energy sources. Commercial energy demand will increase by 34.52%, 82.29%, and 139.30% of the base year value of 20.84Mtoe for the reference, high growth and optimistic scenarios respectively.

The base year and projected energy demand by sector are presented in Table 9. Industry, comprising agriculture, construction, mining and manufacturing sector accounted for 4.80Mtoe, representing 14.77%. Transport, household and services sectors accounted for 9.90Mtoe (30.46%), 15.82Mtoe (48.68%), and 1.98Mtoe (6.09%), respectively. By 2020 the industrial sector energy consumption would have overtaken all other sectors, being the driving sector in the development scenarios. The dominance of energy consumption by the household sector instead of the usual situation in developed countries in which industrial sector dominates (EIA/USDOE 2010) is due to the following reasons: i) traditional fuel sources are commonly used in households for cooking and hot water production, with the attendant low efficiency of conversion; ii) the industrial sector is inadequately supplied with energy, hence there is low capacity utilization, that is, the energy demand in the sector is suppressed, especially for electricity, natural gas and fuel oil. The suppression of energy demand is assumed to be gradually removed for all the sectors of the economy and that commercial fuels gradually replace traditional fuel sources. Energy demand of the industrial sector is projected to increase by 38.27%, 78.88% and 87.70% per annum between 2005 and 2020 for the reference, high growth and optimistic scenarios respectively. Over the period 2005-2030, the industrial energy demand is projected to

increase by 91.27%, 257.61% and 444.58% of the base year energy consumption in the sector per annum. On the other hand, household energy consumption will increase by 8.72%, 9.84% and 10.90% per annum by 2020 and 13.69%, 15.46% and 16.90% by 2030 for the reference, high growth and optimistic scenarios respectively.

Table 10 shows the electricity consumption in the base year and projections for future years as peak demand. The figure of 5,746MW reported for 2005 represents suppressed demand as only about 55.2% of the entire country was electrified and average household had electricity for only 8hours per day during the year (NBS, 2006). The available capacity should be 8.84, 10.13 and 18.73 times the base year capacity by 2020 and 20.74, 33.41 and 51.84 times the base year capacity in 2030 for the reference, high growth and optimistic scenarios respectively. While generation sources were limited to natural gas and hydro in 2005, the sources of electricity generation would expand to include natural gas, hydro, coal,
nuclear, solar and wind in 2020 and 2030 to be able to meet the projected demand for all the scenarios (Sambo, 2008). This is in line with the World Energy Council's position that all energy types need to be given the chance to provide energy in order to achieve the three objectives of sustainable development in the short, medium and long-term perspectives (WEC, 2010).

It can be seen from Table 10 that for Nigeria to be able to have enough electricity that will enable the attainment of the MDGs and Vision 20:2020, it needs to put in place a generation capacity that will meet the demands of between 51,000MW and 110,000MW and its associated transmission and distribution capabilities by 2020. In other words, a minimum generation capacity of between 9000MW and 21000 MW must be put in place within every 3-year plan between 2005 and 2020.

There is no existing study on the Nigeria energy sector, which the results of this study can be readily compared with because of differences in assumptions. The nearest study, which was titled “National Load Demand Forecast, 2008 -2033” assumed GDP growth rates of 6%, 7.5% and 9% per annum for its low, medium and high growth scenarios, respectively (PHCN/World Bank, 2009). The results of the projections showed peak power demand of 9,096MW, 11,701MW and 15,597MW for the low, medium and high growth scenarios respectively by 2020. The study also showed projections of peak power demand of 16,992MW, 26,752MW and 43,939MW for the low, medium and high growth scenarios respectively by 2030. The differences in the underlying assumptions for the two studies are, most likely, responsible for the differences in projected power demand.

Petroleum products are used for driving of vehicles of all types, aircraft, trains and boats within the country and for heating purposes in industry, households and services sectors of the economy. The projected petroleum products demands are shown in Table 11 for the reference and optimistic scenarios. Increase in passenger mobility and transport of goods and services are important consequences of the development aspirations. This will bring about increase in the demand for motor fuels, hence the increasing supply of diesel and premium motor spirit and dual purpose kerosene for air travels. Similarly, demand for LPG will increase due to increasing standard of living brought about by high income levels and desire for cleaner energy fuels. Industries that are running at low capacity presently would run at higher capacities and expanding industrial activities necessitated by demand for goods and services will increase demand for fuel oil which is required for industrial heating purposes. Given that over 80% of current domestic consumption of petroleum products consumption is imported, more domestic refineries need to be established to cater for the domestic demand with less disruption in the supply chain.
The supply of petroleum products in the country has been fairly stable. The projected demand was therefore compared with actual supply in 2005 and 2009 (NNPC, 2005). From Tables 12 and 13, it can be observed that projected demands are generally higher than actual consumption of petroleum products. This observation is most likely due to the fact that the anticipated socio-economic developments in the assumptions for the study are not met in reality. For instance, while it was anticipated that the manufacturing sector will contribute between 7% and 15% to the GDP between 2005 and 2010, the actual contribution averaged 3.98% over the period 2005-2009(NBS, CBN, 2008).

5.0 CONCLUSIONS AND RECOMMENDATIONS

The Model for Analysis of Energy Demand to develop an outlook for the energy demand was applied for Nigeria for the period 2005-2030. The results of the energy analysis give the energy implications of the development aspirations of Nigeria and the challenges of supplying the projected energy demand. The structure of energy consumption in the base year demonstrates that current systems of energy supply and use are clearly not sustainable in economic, environmental and social terms, with overdependence on traditional fuels and low modern energy (electricity and petroleum products) consumption and generally low energy and electricity consumption per capita. With more vigorous government action, the trend can be changed to a sustainable path. There should be a strong commitment to increase investment in the provision of adequate modern energy sources in order to power the development aspirations. The aspirations cannot be met with current energy system based mainly on traditional fuels and inadequate and unreliable modern energy (Ojosu et al, 2009). Reliance on importation of motor fuels is not sustainable in the long term. Government needs to create the enabling environment to encourage private sector participation in the establishment and management of refineries in the country.

The energy demand projection study was conducted before the release of the Final Blueprint of the Nigeria Vision 20:2020 (FGN, 2009). Hence, some of the input assumptions for the study are different from the assumptions in the Blueprint. However, except for the projected population, none of the differences in the input parameters may significantly affect the energy demand projections. Although the energy implication of the government's Vision20:2020 is very huge, it is technically feasible to progress towards sustainable supply in meeting the goals. Petroleum products would have to be made available at affordable costs in all parts of the country and efficiency of use improved to discourage the use of traditional fuels. Household access to grid electricity will have to cover the entire country and availability increased to 24hours daily.

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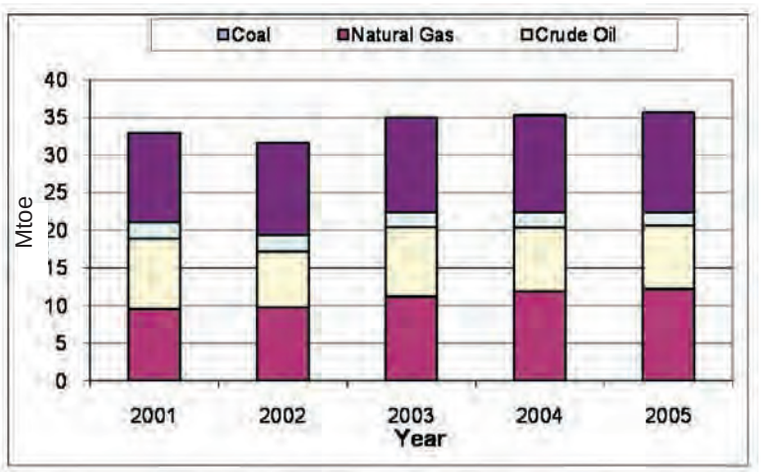

Fig. 1. Consumption of Primary Energy Sources

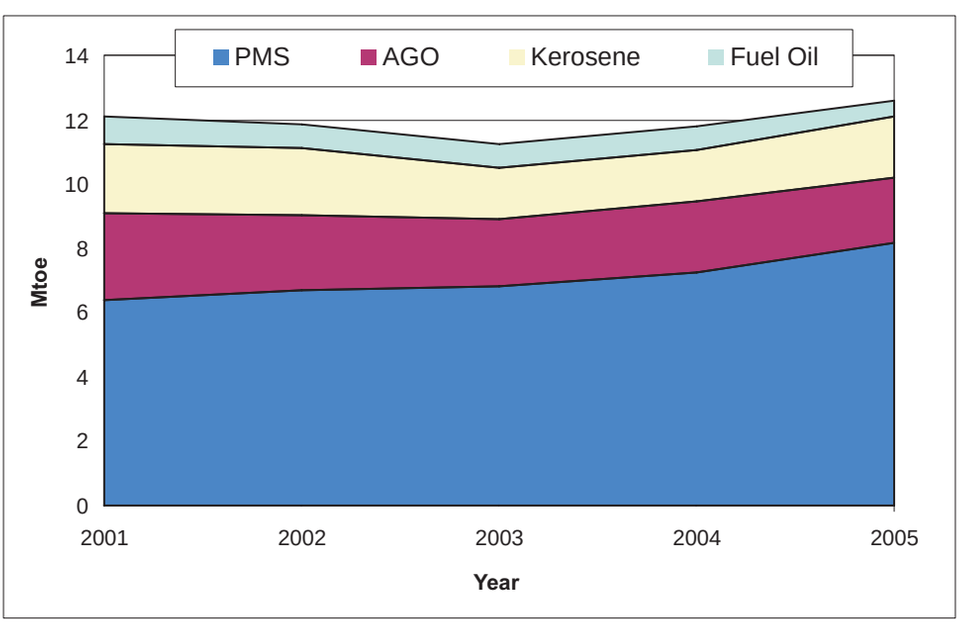

Fig. 2 Consumption of Petroleum Products in Nigeria.

Table 1. Final Energy Consumption in 2005 by Sector and by Energy Form, (000toe)

Economic Sector	Fossil fuels (thermal use)	Fossil Fuels (transportation)	Coal Coke	Feed stocks	Electricity	Traditional fuels	Total	Percentage of total (%)
Manufacturing	774.30	0.00	40.84	278.03	989.24	8.12	2090.53	6.43
Agriculture	0.27	9.50	-	-	0.67	0.00	10.44	0.03
Construction	2.07	66.15	-	-	50.64	0.00	118.87	0.37
Mining	3.04	2.08	-	-	1.54	0.00	6.66	0.02
Transportation	0.00	9168.75		-	0.00	0.00	9168.75	28.43
Household	1520.00	0.00	-	-	2158.08	14794.28	18472.36	56.86
Services	49.81	0.00	-	-	1522.71	1046.94	2619.46	8.06
Total	2349.49	9246.48	40.84	278.03	4722.89	15849.34	32487.07	
Percentage of total (%)	6.56	28.67	0.13	0.86	14.64	49.14	100	

Table 2: Evolution of the Economy for the Three Scenarios, %

	2005	2020			2030		
Sector\Year		Reference	High Growth	Optimistic	Reference	High Growth	Optimistic
Agriculture	41.19	33.75	27.32	29.00	27.90	19.20	15.00
Construction	1.52	5.40	5.35	3.90	7.00	7.00	6.30
Mining	0.27	0.49	0.48	0.42	0.55	0.56	0.56
Manufacturing	3.79	11.00	18.40	15.00	15.00	24.00	25.00
Energy	27.85	8.36	20.00	20.00	4.35	9.00	9.00
Services	25.38	41.00	28.45	31.68	45.20	40.24	44.14
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3: Evolution of the Demographic Parameters for the Three Scenarios

Year/ Demographic parameter	2005	2010	2015	2020	2025	2030
Total Population (million)	137.49	163.4	196.96	239.63	291.55	352.67
Population Growth rate (%)	3.16	3.52	3.80	4.00	4.00	3.88
Urban Population (million)	55.00	75.19	96.51	127.00	166.18	211.60
Urban population share (%)	40	46	49	53	57	60
Potential labour force (million)	92.94	110.82	134.33	164.72	202.77	248.28
Actual labour force (million)	74.35	88.86	107.86	132.54	163.86	201.75
Number of persons per household	5.8	5.6	5.4	5.2	5.0	4.8

Table 4: Development of Freight and Passenger Transportation

			2020			2030		
		2005	Reference Scenario	High Growth Scenario	Optimistic Scenario 2	Reference Scenario	High Growth Scenario	Optimistic Scenario 2
Freight, billion tkm		140.88	380.25	427.38	803.28	737.66	1735.54	2793.53
Modal split of freight transportation, %	Truck	50.56	50.56	50.56	49.25	50.56	50.56	48.88
	Train	0.01	0.12	0.12	17.40	0.3000	0.2	27.00
	Pipeline	49.43	49.32	49.32	33.35	49.2	49.2	24.12
Passenger intracity, billion pkm		177.72	440.39	449.66	514.56	964.48	1018.76	1273.45
Modal split of passenger intracity transportation, %	Cars	65.3	53.0	53	53	47.3	47	47.3
	Mass transit	34.7	47	47	47	52.7	53	52.7

Table 5: Development of Energy Consumption in the Household Sector

	2005	2020			2030		
		Reference Scenario	High Growth Scenario	Optimistic Scenario	Reference Scenario	High Growth Scenario	Optimistic Scenario
Electricity penetration	47	80	93	93	95	100	100
Electricity consumption per household, kWh/dw/yr	1374.91	3940	4550	5730	4400	5300	6500
Electricity penetration into cooking, %	3.9	5.9	7	10.3	7.0	10	13
Traditional Energy Penetration into Cooking, %	72.12	52	40	17	12	5	0
Fossil Penetration into Cooking, %	23.975	42.04	52.72	71.82	80.40	83.90	84.95
Hot Water per capita, kWh/cap/yr	66.90	90	110	156	177	203	272
Fossil Fuels (FF) for lighting, kWh/dw/yr	508.98	600	600	600	600	0	0
Dwellings Using Fossil Fuels (FF) for lighting, %	78	56.6	56.6	56.6	56.6	0	0

Table 6: Development of Energy Consumption in the Services Sector

	2005	2020			2030		
		Reference Scenario	High Growth Scenario	Optimistic Scenario	Reference Scenario	High Growth Scenario	Optimistic Scenario
Floor area /employee, sqm	16.2	16.42	16.61	17	16.55	16.8	17.2
Electricity requirements of old floor space, kWh/sqm/yr	22.9	38.8	44.8	56.4	45	50.4	63.5
Electricity requirements of new floor space, kWh/sqm/yr	24	40	47.3	60	49.2	55.3	70
Cooling requirement, kWh/sqm/yr	135	212	237	274	230	260	310

Table 7: Total Final Energy Demand, Million toe

	2005	2010	2015	2020	2025	2030
Reference	32.50	49.92	76.45	112.67	158.95	224.54
High Growth	32.50	59.45	104.22	173.62	283.01	456.96
Optimistic	32.50	80.00	130.00	202.74	387.52	747.27

Table 8: Final Energy Demand by Energy Form, Mtoe

	2005	**2020**			**2030**		
Sector \ Scenario		Reference	High Growth	Optimistic	Reference	High Growth	Optimistic
Non-commercial	11.66	14.72	13.34	10.27	10.04	7.39	0.70
Electricity	5.93	31.19	50.25	60.19	67.78	129.29	196.32
Soft solar	0.00	0.04	0.05	0.08	0.18	0.23	0.34
Fossil fuels (thermal)	4.57	8.93	60.44	63.70	71.83	199.58	316.97
Fossil fuels (transportation)	9.98	37.27	45.85	59.46	52.26	107.48	182.40
Coking Coal	0.09	0.95	2.20	2.23	2.61	8.16	12.36
Feedstock	0.27	0.47	1.48	6.81	0.84	4.83	38.18
Total	32.50	112.67	173.62	202.74	224.54	456.96	747.27

Table 9: Final Energy Demand by Economy Sector, Mtoe

Sector/Year	2005	2020			2030		
		Reference	High Growth	Optimistic	Reference	High Growth	Optimistic
Industry	4.80	45.92	94.66	105.24	109.52	309.13	533.49
Transport	9.90	25.82	31.88	42.29	48.54	70.70	123.37
Household	15.82	34.50	38.92	43.11	54.16	61.16	66.85
Services	1.98	6.43	8.16	12.10	12.32	15.97	23.57
Total	32.50	112.67	173.62	202.74	224.54	456.96	747.27

Table 10: Electricity Demand Projection, MW

Scenario / Year	2005	2010	2015	2020	2025	2030	
Reference	5746	15,730	28,360	50,820	77,450	119,200	
High growth	5746	15,920	30,210	58,180	107,220	192,000	
Optimistic	5746	33,250	64,200	107,600	172,900	297,900	

Table 11: Petroleum Products Demand Projections

		2005	2010	2015	2020	2025	2030
Reference Scenario	LPG, thousand tonnes	15	41	123	332	742	1319
	PMS, billion litres	12.28	15.07	21.22	29.83	41.91	58.83
	DPK, billion litres	2.60	3.29	4.11	5.29	6.93	9.23
	AGO, billion litres	2.69	6.04	8.52	11.99	16.88	23.72
	Fuel Oil, million litres	580	1,469	2,839	4,604	7,216	16,029
Optimistic Scenario	LPG, thousand tonnes	15	81	286	682	1341	2312
	PMS, billion litres	12.28	18.23	35.88	61.09	107.55	196.96
	DPK, billion litres	2.60	3.78	6.45	9.95	16.43	28.83
	AGO, billion litres	2.69	7.31	14.43	24.61	43.38	79.51
	Fuel Oil, million litres	580	2,664	5,641	11,909	26,147	58,873

Table 12: Actual consumption of petroleum products, million litres

Year\ Petroleum Product	PMS	DPK	AGO	Fuel Oil
2005	9,826	2,167	2,329	580
2009	8,544	698	1,361	113

REFERENCES

1. Adegbulugbe A. O., Felix Dayo, Thomas Gurtler, 1989, 'Optimal Structure of the Nigerian Energy Mix', The Energy Journal, Volume 10, Number 2, pp165-176
2. Central Bank of Nigeria, 2008,
3. Annual Report and Financial Statements
4. George Kowalski, 1992, 'World Oil
5. and Energy Demand Outlook to 2005", Special Issue of Energy Policy Vol. 20, Number 10, pp 920 - 930
6. Energy Commission of Nigeria (2004) "Energy Master Plan Development: Nigerian Energy Demand and Power Planning Study for the Period 2000 - 2030, Part 1, Energy Demand Projections." ECN/EPA/04/01, Abuja
7. Energy Commission of Nigeria (ECN, 2008): Assessment of the Energy Options and Strategies for Nigeria: *Energy Demand, Supply and Environmental Analysis for Sustainable Energy Development (2005-2030).*
8. Eric Martinet, Lee Schipper and Marta Khsuchch, 1995, 'Energy Demand and Efficiency in Estonia: Structure, Potential and Policies' Energy Policy Vol. 23 No. 3, pp 217-233
9. Federal Government of Nigeria, 1992, Presidential Working Group on the Development of Alternatives to Firewood: "Report on the National Fuelwood Substitution Programme," The Presidency: National Resources Conservation Council.
10. Federal Republic of Nigeria, National Population Commission (FGN-NPC, 2007), "*2006 Population and Housing Census – Population Distribution by States and Local Governments*".
11. Federal Republic of Nigeria (FRN, 2007):*http://www.nv2020. org /* accessed 13/03/2010
12. Federal Government of Nigeria, 2009, Nigeria Vision 20: 2020, Economic Transformation Blueprint.
13. Food and Agriculture Organization (provided data for various countries for 1995 and 1996, Source: http://www.fao.org/docrep/x2240e/x2740e32.pdf accessed 10/092008
14. Government of Pakistan (GOP) Planning Commission, Demand Forecasting for Electricity, http://www.regulationbodyofknowledge.org/documents/044.pdf accessed 18/08/10
15. Iloeje O. C., Olayande J. S. and Yusuf A. O. (2004) "Report on an Indicative Survey of Sectoral Energy Consumption in Nigeria" *Energy Commission of Nigeria, Abuja*
16. International Atomic Energy Agency (1998) "Energy and Nuclear Power Planning Study for Pakistan (covering the period 1993 – 2023*), IAEA, Vienna, July.*
17. International Atomic Energy Agency (IAEA, 2006): Model for Analysis of Energy Demand (MAED-2) Users' Manual, Vienna, Austria.
18. National Bureau of Statistics, NBS 2006, Core Welfare Indicator Questionnaire Survey, Nigeria.
19. National Bureau of Statistics, Annual Abstract of Statistics, (Various Issues)
20. Nigerian National Petroleum Corporation (NNPC), 2005, Annual Statistical Bulletin
21. National Population Commission (NPC 2010), http://www.population.gov.ng/ last accessed 19/08/2010
22. Ojosu, J.O., Olayande, J. S., Rogo, A.T., Sambo, A. S., 2009, Sustainable Energy Supply to Meet the Development Aspirations of Nigeria, paper presented at the Regional Conference on Considerations for Embarking on a Nuclear Power Programme: Energy Planning and Infrastructure Milestones, 7-8 June, Cairo, Egypt.
23. Olayande, J. S., Rogo, A.T., Ojosu, J. O., Sambo, A. S., 2008, A Crystal Ball on the Future: How Might Nigeria's Power Structure Look in the Year 2030, Paper presented at the International Conference on Energy, Power and Technology (ICEPT), October 14-16, Abuja, Nigeria.
24. Power Holding Company of Nigeria /World Bank, 2009, National Load Demand Forecast, Omega Systems /

Tractebel Engineering Suez

25. Sambo, A.S., Iloeje, O. C., Ojosu, J.O., Olayande, J.S., Yusuf, A.O., 2006, Nigeria's Experience on the Application of IAEA's Energy Models (MAED & WASP) for National Energy Planning, paper presented at Training Meeting / Workshop on Exchange of Experience Use of IAEA's Models, Korea Atomic Energy Research Institute, 24-28, April, Daejon, Republic of Korea.
26. Sambo, A. S., 2008, Matching Electricity Supply with Demand in Nigeria, International Association for Energy Economics Newsletter, Fourth Quarter, pg 32 – 36.
27. Sambo, A. S., 2009, Strategic Developments in Renewable Energy in Nigeria, International Association for Energy Economics Newsletter, Third Quarter, pg 32 – 36.
28. US EIA/DOE, 2010, International Energy Outlook 2010
29. World Bank, (2008): http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP_PPP.pdf
30. World Bank, 2009, Energy Demand Models for Policy Formulation: A Comparative Study of Energy Demand Models, Policy Research Working Paper 4866.
31. World Energy Council (WEC), http://www.worldenergy.org/documents/euccr_executivesummary.pdf