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Energy security challenges in developing African mega cities: the Lagos experience

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Abstract: As demand for energy continues to rise, especially in rapidly industrializing and developing cities as Lagos, energy security concerns become ever more important. To maintain high levels of economic performance and provide solid economic growth, energy must be readily available, affordable, and able to provide a reliable source of power without vulnerability to long or short-term disruptions. Interruption of energy supplies can cause major financial losses and create havoc in economic centers, as well as potential damage to the health and well being of the population. Hence, this study analyzes the various energy security drivers and determinants of electricity supply in Nigeria and their impact to Lagos using a combination of exploratory and empirical research methods. Results shows that projected lost GDP growth in Nigeria attributed to power supply constraints will reach $130 billion by 2020. Lagos will account for more than 40% of that. This paper highlights the key drivers governing the secure supply of energy - from a developing economy perspective - and their impact in developing and ensuring a secured energy future.

Keywords: Energy security, Energy demand, Energy barriers, Energy economics, Energy market

1 Introduction

Lagos is located in the south-west coast of Nigeria with an estimated population of 20 million people. Lagos is home to almost 50% of Nigeria's skilled workers [1] and has a large concentration of multinational companies. It is one of Africa's biggest consumer markets and boasts of a higher standard of living than anywhere else in the country. However, rapid population growth and urbanization have introduced significant challenges for its water, sanitation and waste management infrastructures, as well as energy supply, traffic management, and so on. Despite these, officials of the Lagos state government are keen to transform this mega city into a first class business hub by investing heavily in a mass transit plan and establishing a dedicated environmental authority [2]. The Lagos state government established the ministry of energy and mineral resources with the sole aim of developing and implementing a comprehensive energy policy for Lagos State that will support the states' socio-political development plans (which include job creation and revenue generation).

2 Energy demand & supply analysis

Within the past decade, energy demand in its various forms (electricity, oil, gas, etc) has grown rapidly due to increased economic activities and population growth, with Lagos accounting for over 50% of the incremental energy demand in Nigeria [3]. The US Energy Information Administration (EIA) in 2011, estimated the total primary energy consumption in Nigeria to be about 4.3 quadrillion British thermal unit (Btu), with traditional biomass and waste (consisting of wood, and other crop residues accounting for 83% of the energy use [4]. Figure 1 shows the proportion of traditional biomass and waste in relation with oil, natural gas and hydropower.

This section presents a historical overview of the development of the various energy resources in Nigeria and their connection to the Energy Security challenge in Lagos

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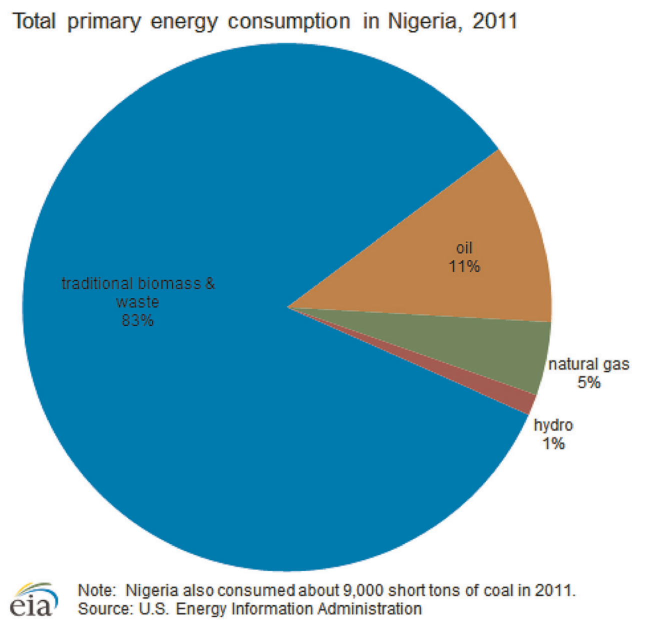

Figure 1 *Total primary energy consumption in Nigeria in 2011*

2.1 The Nigerian electricity supply market

Electricity generation in Nigeria started in 1896. In 1929, the Nigerian Electricity Supply Company (the first Nigerian utility company) was established. In the 1950's, the Electricity Corporation of Nigeria was established to control all diesel and coal fired power plants. In the 1960's, the Niger Dams Authority was established to develop hydroelectric power plants [5]. In 1972, the National Electric Power Authority was formed from the merger of the Electricity Corporation of Nigeria and the Niger Dams Authority. From the late 1990's, Nigerians started feeling the pinch of insufficient electricity supply. It became obvious that the publicly owned and managed electricity systems were not meeting Nigeria's electricity needs. In 2001, the government established a National Electric Power Policy which paved the way for the electrical power reforms.

At the dawn of the new civilian administration in 1999, after a long era of military rule, the following were challenges at the time [6]

- The Nigerian Electricity Supply market had reached its lowest electricity generation point in 100 years of her history
- Only 19 electricity generating plants were operational out of 79, with a daily electricity generation average of 1750MW
- Between 1989 and 1999, there was no investment in new electricity generation infrastructure
- The newest electricity generation plant was built in 1990
- The last electricity transmission line was built in 1987
- It was estimated that about 90 million people had no access to grid electricity
- There was no reliable information on the actual industry losses due to insufficient electricity supply. However, it is believed that industry losses is in excess of 50%

Installed (public) electricity generation capacity stands at 5900MW while current actual electricity generation stands at 3000–4000MW. Generation capacity required to meet the current electricity demand stands at 16,000MW [7]. Considering a population of 177.2 million (2014 estimate), this invariably means that 75% of the Nigerian population have no access to electricity [8]. Lost GDP growth attributed to power supply constraints will reach $130billion by 2020 [9]. The Nigerian government, in her on-going power reforms, have projected a target electricity generation capacity of 40,000MW by 2020. About $10billion annual investment will be required to reach the target in the coming years. Considering the huge investment required to meeting the ever-growing energy demand, one of the biggest opportunities lies in the effective utilization of available energy. Table 1 shows Nigeria's position on the world stage in terms of electricity generation capacity and the corresponding per capita electrical energy.

A recent Energy Audit conducted by the Lagos State Government in 2012 estimates the total electricity demand requirement for Lagos as 10,251MW [3]. Table 2 highlights the distribution of the energy demand from residential, commercial and industrial users in Lagos with an estimated projection of what the electricity demand in Lagos will look like by 2015.

Table 1 Nigeria on the world stage. Source CIA World Fact book

Country*	Generation Capacity (GW)	Watts per capita
S. Africa	40.498	826
Egypt	20.46	259
Nigeria	5.96	40 (25 available)
Ghana	1.49	62
USA	977.06	3,180
Germany	120.83	1,468
UK	80.42	1,316
Brazil	96.64	486
China	623.56	466
India	143.77	124
Indonesia	24.62	102

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Table 2 Current electricity demand in Lagos with a 2015 projection

Sector	Energy Needs; 2012 (MW)	Energy Needs; 2015 (MW)
Residential	7,241	7,913
Industrial	2,350	2,464
Commercial	660	682
Total	**10,251**	**11,059**

This study shows that residential use of electrical energy in Lagos accounts for over 70% of the incremental energy demand. This is true as it correlates with the rapid population growth rate in Lagos (over 10%) as compared to other major cities in Nigeria

2.2 The Nigerian oil & gas market

Nigeria, the largest oil producer in Africa, started her oil & gas operations in 1956 with the first commercial discovery by Shell D'Arcy. However, since November 1938, a concession was signed with the same company to explore for possible petroleum resources within Nigeria's borders. After the discovery, Shell played a dominant role in the Nigerian oil industry for many years until 1971 when Nigeria joined the Organization of Petroleum Exporting Countries (OPEC), after which the country began to take a firmer control of her oil and gas resources [10]. Nigeria holds the largest natural gas reserves on the African continent, and was the fourth world leading exporter of liquefied natural gas in 2012 [4].

Nigeria has the second largest amount of proven oil reserves in Africa after Libya. In 2005, crude oil production in Nigeria reached its peak of 2.44 million barrels per day, but began to decline significantly as violence from militant groups surged within the Niger Delta region, forcing many companies to withdraw staff and shut in production. Oil production recovered somewhat after 2009-2010 but still remains lower than its peak because of ongoing supply disruptions [4]. Figure 2 shows Nigeria's oil production and consumption from 2003 – 2012.

Nigeria has a crude oil distillation capacity of 445,000 barrels per day. Despite having a refinery nameplate capacity that exceeds domestic demand, the country still has to import petroleum products since the refinery utilization rates are low.

Nigeria has the largest proven reserves of natural gas in Africa, and the ninth largest proven reserves in the world. Nigeria produced 1.2 Tcf of dry natural gas in 2012, ranking it as the world's 25th largest natural gas producer. Natural gas production is restricted by the lack of infrastructure to monetize natural gas that is currently being flared. Figure 3 gives a picture of dry natural gas production in Nigeria from 2003 to 2012.

The oil and gas industry, primarily located within the Niger Delta region, have been a source of conflict with local groups seeking a share of the wealth via attack of the oil infrastructure, forcing companies to declare force majeure on oil shipment. Loss of production and pollution caused primarily by oil theft (bunkering), leading to pipeline damage that is often severe, is forcing some companies to shut in production.

3 Energy security drivers

This section highlights the major energy drivers that need to be considered to guaranty a secured energy future for Lagos.

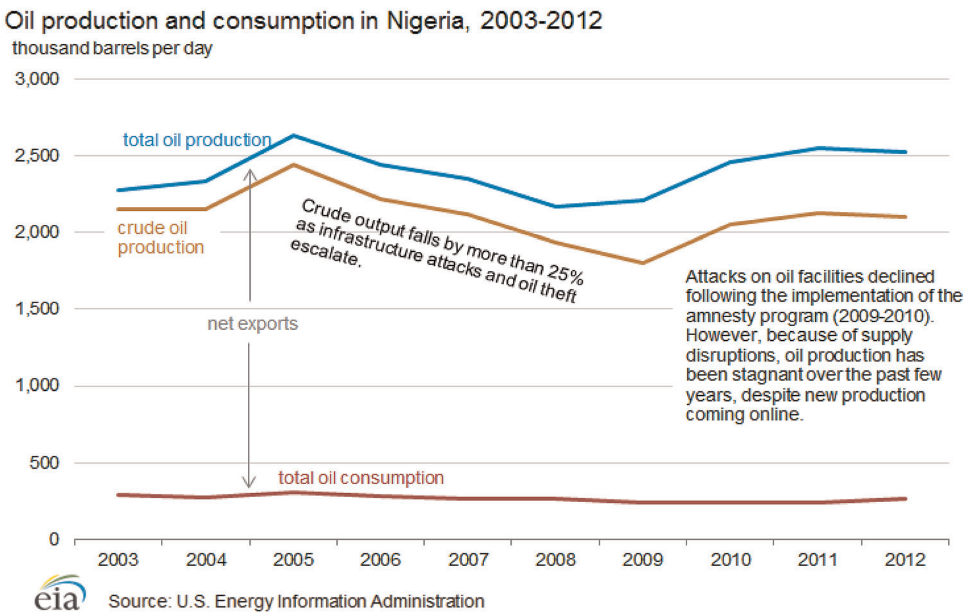

Figure 2 *Nigeria's oil production & consumption. 2003 – 2012*

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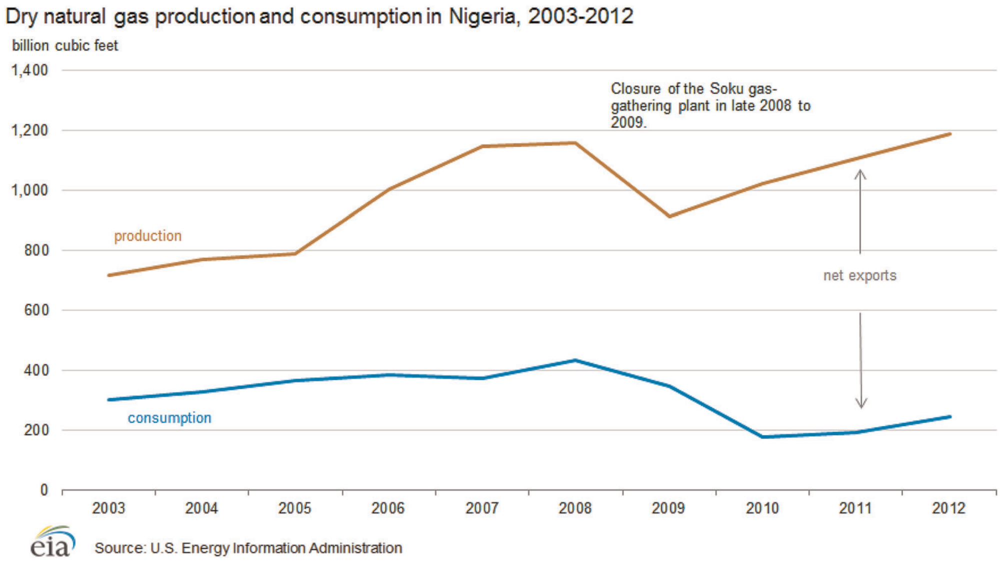

Figure 3 *Dry natural gas production in Nigeria. 2003 – 2012*

3.1 Energy affordability

A very important aspect of energy security is energy affordability. A lot of literatures exist that describes and analyzes energy security in strictly economic terms. However, this is understandable since rapid price increases and economic losses are yardsticks for measuring the impact of disruption of energy systems. There is a clear difference between energy affordability and energy security. Energy affordability measures the cost of energy in relation to economic parameters such as income per capita, GDP, etc. It is also influenced by changes (increase or decrease) outside energy systems such as a rise in income levels. Primarily, it is in a situation of economic equilibrium that affordability addresses the relative cost of energy. In contrast, energy security focuses on price disruptions – outside economic equilibrium – induced by changes in energy systems rather than general economic development such as supply disruptions [11].

Central to the issue of household energy affordability is the relationship between energy cost and income. While the majority of existing literature on energy affordability discusses energy required to maintain a suitable indoor environment in terms of heating energy, it is also noteworthy that in some areas energy may also be required to cool homes as is the case in Nigeria. Synott, in a publication, noted that discussions of fuel poverty need to take into account *the impact of both hot and cold on the health of householders, particularly vulnerable households* and *the proportion of income spent on fuel bills (and the proportion which would need to be spent to adequately heat and cool the dwelling) for low income households* [12]. However, it is good to note that:

- Household energy expenditure has a positive correlation with household income.

- Energy cost make up a smaller proportion of the total household expenditure as income increases.

- There are significant variations in low-income households' expenditure on energy (as a proportion of the total) indicating some households spend very little on energy in absolute terms.

The cost of power generation, transmission, and distribution is a major determinant for the provision of affordable energy. Supply interruptions have, over the years, impacted negatively on prices and have created economic difficulties for the country due to exposure and over-reliance on very few energy sources. From experience, inflation and recession has been triggered by sustained rise and short term spike in prices of oil, gas and electricity.

3.2 Energy for transport

Transportation is an essential element which is crucial for every aspect of modern society. Transportation has helped and shaped the way we address varying issues such as; food production, personal mobility, availability of goods and services, trade, military security, and so on. Over 20% of energy use in many developed countries accounts for transport. In as much as there is a rapid growth in energy use in developing countries (including India and China), energy use in developing countries for transportation is less than 15%. In least developed countries, transport account for less that 10% of their energy use. There is a competition for the same energy resources used for both modern transport systems and other applications such as construction, agriculture, and other machinery. Thus, security of fuels for construction, agricultural production, and other related sectors is also applicable in the discussion of energy security for transportation [9].

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Transportation is one of the most vulnerable sectors among all vital services in the country. Its vulnerability is a result of the over-reliance on imported refined petroleum products used as transport fuel. Increasing demand of energy systems for transportation purposes also increases its vulnerability. The rapid growth of energy use in transportation signals a pressure on transport.

In Lagos, there has been massive investment in transportation infrastructures, particularly within the past five years. The Bus Rapid Transit (BRT) scheme, the building of a new rail infrastructure for rail transportation, and the development of the Lagos waterway transport systems are vivid examples. This sudden rise in provision of transport infrastructure has a definite impact on energy demand and the energy security mix.

3.3 Energy for industry

Energy use in industrial applications is mainly in the form of heat and electricity. This varies between countries. In most developed countries, energy use in the industrial sector accounts for about 15% of total energy use. The industrial sector accounts for over 25% of energy use in about 60 countries with a population of 4.5 billion people. In about 12 countries (including Brazil, China, and Ukraine) with a population of about 1.7 billion, the energy use in the industrial sector accounts for over 40% [13]. Emerging and developing economies are dominated by a few industries relying on distinct energy systems which are critical for energy security in those societies.

In Nigeria, there is a big contrast to this as the biggest manufacturing challenge is inadequate infrastructure, and specifically inadequate electricity supply. The manufacturing industry in Nigeria today generates about 72% of its own electricity needs [14]. The cost of manufacturing goods has increased tremendously due to large operating cost of generators for electricity generation.

Demand-side vulnerabilities should also be noted. Growth in industrial use of energy cannot be considered pressing or permanent as is the case of residential and transport sectors. Industrial growth of energy use may be reversed. Industrial energy intensity is an important factor that can make the industrial sector relatively vulnerable to price volatility and other energy supply disruptions.

3.4 Energy for residential and commercial centres

The residential and commercial sector depends largely on supply of electricity for lighting, cooking, heating, and other applications. Energy use in this sector for heating is of particular importance since it is a matter of national priority in the temperate region.

In many developing countries, this sector significantly relies on traditional biomass. Energy statistics generally designates this source as combustible and renewable without any distinction between traditional (e.g. firewood) or modern (e.g. straw boilers, modern heaters) uses of biomass. Reliance on traditional biomass in this sector is a serious national energy security issue due to its side effects on environment, health, and development. Low access to electricity has been identified as one of the primarily reasons for the massive use of traditional biomass. For modern nation states, this is untenable. In Nigeria, energy systems are under pressure to find new sources of energy in replacement of traditional biomass which invariably can lead to a case of worsening national energy vulnerability.

Energy use pattern in this sector differs between industrialized and developing countries. Countries with lower income typically have high proportion of residential and commercial energy use. This typically explains why Lagos has about 70% of her total electricity demand from residential use.

3.5 Energy for water

There seem to be some relatively very uniform water cycle among developed countries which does not necessarily seem the same among developing countries. This starts from the water source where water is extracted and conveyed, then moved directly to an end use (such as irrigation) or to a treatment plant from where it will be distributed to final consumers. After the water is used by end users, the waste water is collected through a waste water collection system to a treatment plant after which it is discharged to the environment. In some cases, the treated waste water could be used again before finally discharging to the environment. The entire value chain of water extraction, conveyance, treatment, distribution, and discharge all require energy. Figure 4 shows a typical water flowchart, highlighting the various aspects requiring energy for water extraction, conveyance, distribution, and treatment.

A very important factor for consideration in the water-energy mix concerns energy required for treating and supplying water. This involves electricity requirements for pumps used in the extraction (from ground and surface sources), collection, transportation, and distribution of water. The amount of energy required depends on the distance to (or depth of) the water source. The conversion of various water types – saline, fresh, brackish, and waste water – into water that is fit for specific use requires electricity, heat, and other processes involved in desalination of water which can be very expensive and energy intensive. There are other energy requirements associated with end-use application of water - mostly in households - for water heating, cloth washing, etc.

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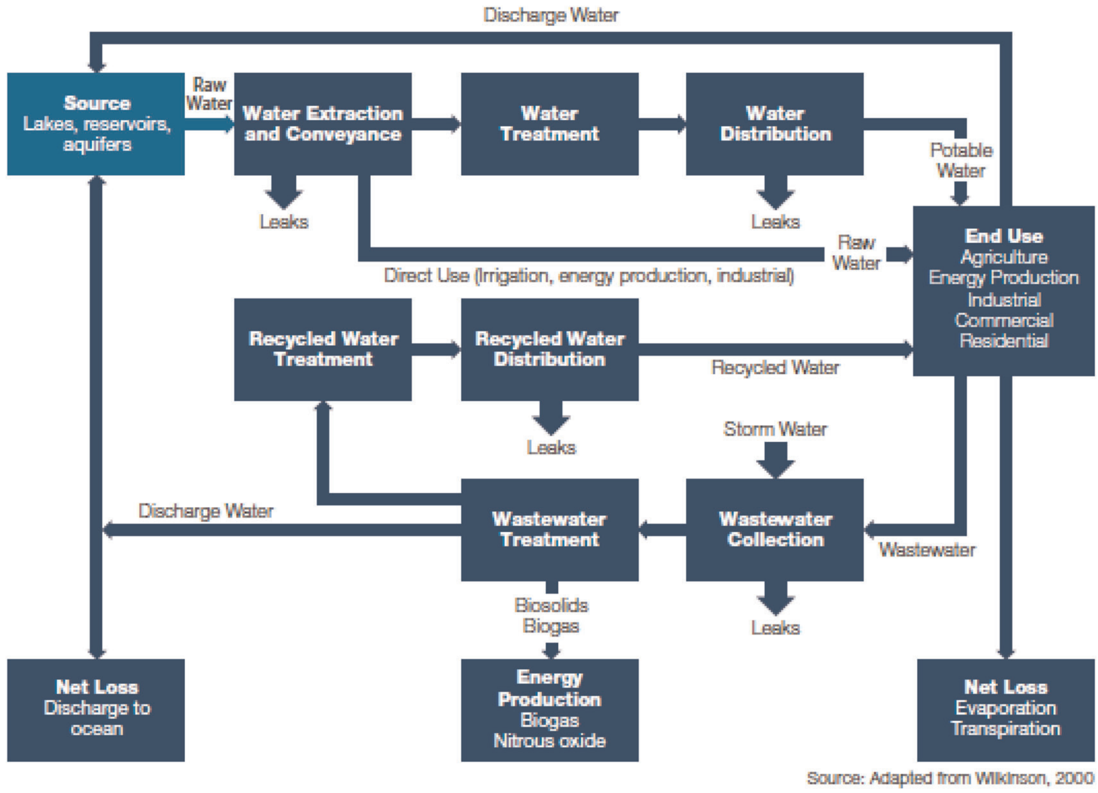

Figure 4 *Water flowchart*

Growing population, improved standards of living, and scarcer freshwater supplies in the proximity of population centres will contribute to the rising demand for energy for the water sector in Lagos, looking ahead. The implication is that water might need to be pumped from greater depth, undergo additional treatment, and transported over long distances. A shift from the traditional surface/flood irrigation method to pumped method puts further pressure on energy requirement for water. Although this method is more water efficient.

A major factor to be considered is the urgent need to identify and optimize the existing policies, perceptions, and practices associated with lowering energy consumption in the entire water value chain (extraction, conveyance, treatment, distribution, use, and recovery of water and waste water.

3.6 Water for energy

The extraction, mining, exploration, and production of nearly all forms of energy require water. In connection with primary fuels, water is used for resource extraction, fuel processing and refining, transport, and irrigation of biofuels feedstock crops. In electrical power generation, water is used for cooling and other related processes in thermal power plants, as well as in hydropower facilities where movement of water is harnessed for electricity generation [15].

Water required for the extraction, processing, and transportation of fossil fuel varies. Minimal water is used for drilling and processing of conventional natural gas as compared with other fossil fuels or biofuels. The development and extraction of shale gas uses a technique that pumps fluids (water and sand, with chemical additives that aid the process) into shale formations at high pressure to crack the rock and release gas. In Nigeria, the availability of huge natural gas reserves will limit activities in the extraction and production of shale gas for some time. However, with existing concerns over the already contaminated water bodies in the Niger Delta region owing to oil exploration activities, there is likely to be a huge public outcry over water contamination risks associated with shale gas production.

In coal production, water is used mainly for mining activities such as dust suppression and coal cutting. The amount of water required is dependent on the characteristics of the coal mine such as the transportation and processing requirements, as well as whether it is underground or surface mine. Increasing the grade and quality of coal requires coal washing which invariably involves additional water. Some quality concern issues associated with coal production include the runoff water from coal mine operations that can pollute surface and ground water.

In oil extraction and production, the recovery technology applied, as well as the geology of the oil field, and its

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production history are major determinants of the amount of water required. The refining of crude oil into end-use products requires chemical processes and further water for cooling with water amount varying widely according to the process configuration, and technologies employed.

In thermal electrical power plants (which includes nuclear and fossil fuel based power plants) water is used primarily for cooling. Thermal power plants are the energy sector's most intensive users of water per unit of energy produced. Cooling systems employed, access to alternative heat sinks and power plant efficiency are major determinants of water needs for thermal power plants. For a given type of thermal power generation plant, the choice of cooling has the greatest impact on water requirements.

In renewable electrical energy generation, water requirements range from negligible levels to that comparable with thermal power plants using wet tower cooling. Cleaning and washing of the panels are typical applications where water is used in non-thermal renewables such as solar photovoltaic (PV) and wind technologies. Renewables is seen in Lagos as the main energy source for the near future, not only because of the lower water use at the electricity generation site, but also because renewable technologies have little or no water use associated with the production of fuel inputs and minimal impact on water quality compared to alternatives that discharge large volumes of heated cooling water or contaminants into the environment.

3.7 Energy generation diversification

There is a need to have a well balanced energy system in Lagos, made up of a variety of generation technologies with suitable capacities that enables the advantage of each technology to be maximized. This helps in ensuring a continuity of supply to the customers at fairly reasonable and stable prices. Studies by the EIA shows that wind energy can better be harnessed in places of higher altitude and geographies closer to the (north and south) poles. The same study shows that solar energy can be better harnessed around the equator, which is where Nigeria (and Lagos) falls. Some generation technologies that could be harnessed include

- Small wind generation plants on high rise buildings and sky scrapers to generate power for elevators and office lighting systems

- Harnessing solar generation technology as backup power source in the dry season for powering some important public infrastructures such as primary health centres, street lighting, and emergency care units, among others.

Policy formulation and incentives to help encourage the private use of some of these new technologies on a smaller scale can help reduce, more rapidly, the residential energy demand in the state. These new generation technologies, deployed on a smaller scale can take care of some domestic energy needs like lighting, electronics and refrigeration systems.

4 The future of energy security in Lagos

In the global energy security scheme, the role of oil will likely be more important in the short and medium term. The dynamics in global oil and gas production is likely to have a consequent shift away from these sources. This is already being vigorously pursued by many countries.

The increasing role of electricity in energy systems is another imminent development affecting energy security. The continuing spread of information and communications technology, other consumer technologies requiring electricity, increasing use of electricity by the rising middle class in emerging economies like Nigeria, and the advent of plug-in electric propulsion vehicles will make electricity play a very important role in the energy security mix.

Reliability issues regarding production and distribution of electricity will come to the forefront of energy security concerns in the future as a result of increasing reliance on electricity. Electricity systems complexity in Nigeria in the near future is likely to increase to include the following:

- New technologies for electricity storage.

- Devices for smart grids including active load.

- Transferring with minimal losses (over long distances) large quantities of electricity using super grids. This can be achieved through the use of high voltage DC lines when localized distribution systems are not sufficient or feasible.

- Increasing reliability of distributed generation and power generation with the use of hybrid systems. This will be in the form of modular small scale systems with improved energy storage capacity.

Some of the aforementioned approaches may help reduce the inherent risk of cascading failures in modern complex centralized grids. The combination of information technologies with electricity, together with a combination of other approaches is likely to increase reliability. As the role of electricity in energy systems increases, institutional structures and capacities will form part of the increasing factors affecting energy security, much more than traditional issues of access to natural resources.

4.1 Proposed policy priorities

This section highlights some proposed energy policy priorities that Lagos can adopt to ensure a secured energy future.

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4.1.1 Energy efficiency standard: There is an urgent need to set some standards regarding energy efficiency which must be adhered to by both utility and non-utility administrators. Specific long term energy savings target must be set which must be met by utility and non-utility administrators through programs focused on customer energy efficiency. There is also a need for a workable federal energy efficiency standard to help compliment the efforts at the state level in order to reach the desired targets [16].

4.1.2 Air emission regulations: There is an urgent need for clear regulations on emissions. The impact of pollution as a result of emissions from the burning and usage of our energy resources has very serious health implications. Coal fired power plants must have facilities for carbon capture to limit the impact on the environment. There should be limits set on vehicles emissions, among others.

4.1.3 Climate change policy: Studies show that energy efficiency measures are the surest, fastest, and most cost effective route to addressing issues of climate change. Reducing energy usage and widening the use of affordable renewable energy resource are other very important means. Energy efficiency standards for utility, standards for vehicles and appliances, land use planning, and energy codes for buildings, should be a part of the climate change policy/bill both at state and federal levels.

4.1.4 Utility policy/regulation: With the deregulation of the electrical generation sector in Nigeria, there is need for effective implementation of regulations to ensure energy security. Some aspects of utility regulations are very critical in ensuring and enabling utility energy efficiency programs. Regulation also ensures there is investor confidence that they can recover their cost of investment, as well as ensuring they can surmount the barriers to investment in energy efficiency. Regulators and policy makers can help give clear directions to utilities on the importance of energy efficiency.

4.1.5 Standards for appliances: There is an urgent need to set some minimum efficiency standards for domestic appliances. As highlighted in section 2, the residential; use of energy accounts for about 70% of electrical energy demand in Lagos. Setting energy efficiency standards for appliances will help change consumer attitudes in ensuring the prohibition of energy-consuming appliances, as well as prohibiting the production, sale, and importation of such appliances.

4.1.6 Building codes: There is need for the implementation of building construction standards that helps in ensuring energy efficiency in buildings. Ensuring the implementation of energy efficiency standards in buildings is one of the sure ways to help consumers save money and energy, reduce air pollution, as well as ensuring affordable housing.

5 Conclusions

In Nigeria, and particularly in Lagos, one of the most prominent concerns in relation with energy is adequate protection of vital energy systems from disruption. Energy systems disruption may result from short term shocks such as technical failures, natural events, deliberate sabotage, or malfunctioning markets. Some more permanent threats which are slowly unfolding include: ageing of infrastructure, unsustainable demand growth, and resource scarcity. Disruptions in these forms may affect other broader security issues ranging from the viability of national economies and stability of political systems, to the danger of armed conflicts. This invariably means that the driving force in the transformation of energy systems will likely remain as policies developed in the quest for higher energy security.

6 References

[1] www.safri.com. Accessed May 2014

[2] Lagos, Nigeria, "African Green City Index" http://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/lagos.pdf. Accessed May 2014

[3] TIJANI T.: 'Energy Policy as it affects climate change in Lagos', 5th Lagos Climate Change Summit 2013. Lagos, Nigeria, March 2013

[4] US, Energy Information Administration (EIA), http://www.eia.gov/countries/cab.cfm?fips=NI

[5] SAMBO, *ET AL.*: 'Electricity Generation and the Present Challenges in the Nigerian Power Sector', *Journal of Energy & Power Engineering*, 2012

[6] DIKKI B.: 'Status of PHCN Transaction and implications for NIPP Transactions' (The Presidency, Bureau for Public Enterprises, Abuja Nigeria, 2013)

[7] National Integrated Power Project (NIPP) Transaction (2014), 'Nigerian Electricity Market' (Online). Available at http://www.nipptransactions.com/background/electricity-market/, accessed March 2014

[8] OYEDEPO, SUNDAY OLAYINKA: 'Energy and sustainable development in Nigeria: the way forward', *Energy Sustainability and Society*, 2012

[9] BELLO M.: 'Incentives to promote private sector participation in the Nigerian Power Sector'. Nigerian Investment Promotion Council (NIPC), Abuja, Nigeria, 2013

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[10] Petroleum and Natural Gas Senior Staff Association of Nigeria (PENGASSON), 'History of Oil and Gas in Nigeria' http://pengassan.org/pdf/History%20of%20Nigerian%20Oil%20and%20Gas%20Industry.pdf, Accessed May 2014

[11] ALEH CHERP *ET AL.*: 'Energy and Security' Central European University, Hungary. http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=3410975&fileOId=4239056. Accessed May 2014

[12] SYNOTT E.: 'Fuel poverty: Do we have fuel poverty in Australia and New Zealand and what are the implications for social housing?', *Housing Works*, 2004, pp. 7–12

[13] LU, SHYI-MIN, *ET AL.*: 'Energy saving potential of the industrial sector of Taiwan', *Renewable and Sustainable Energy Reviews*, 2013

[14] Corporate Nigeria, 'The Business, Trade and Investment Guide'. Corporate Guides International Publication, 2010-11. p. 190

[15] International Energy Agency, 'Water for Energy: Is energy becoming a thirstier resource?' excerpt from the World Energy Outlook 2012

[16] American Council for an Energy Efficient Economy (ACEEE), 'National Energy Policy', http://www.aceee.org/portal/national-policy. Accessed July 2014

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