BUSINESS PROSPECTS OF RENEWABLE ENERGY ADOPTION IN WEST AFRICA (A CASE STUDY OF NIGERIA)

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ABSTRACT

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ABSTRACT

The West African countries are endowed with significant renewable energy resources and ECOWAS Member states have resolved to improve their access to modern, reliable and affordable energy services, energy security, reduction of energy related GHG emissions and the climatic change impacts on the energy systems in their countries. Nigeria is one of these West African countries and as the most populous African country with the biggest economy it was taken as a case study for the research work here. Nigeria is a huge market for foreign investors in its energy sector considering its enormous renewable energy resources and an adoption of RE to overcome energy poverty.

This thesis project was conducted to establish the business prospects of renewable energy adoption in the West African countries with a major focus on the leading economy there. The goal was to evaluate the current energy situation and demand for electricity in Nigeria, and the prospects for foreign investors into its energy market. Hanlog Oy in Finland was the commissioner of this research work.

A qualitative approach was used to gather relevant information which involved personal observations, interviews with the regulators in the Nigerian energy market, focus groups such as telecommunication companies and relevant associations, and some locals of the country. This thesis project provided information to conclude that Nigeria had great potential for renewable energy businesses and was creating an enabling environment to attract foreign investors like Hanlog Oy to achieve its Millennium Development Goals to be a leading economy in 2020. The major gap between the demand and supply of energy in Nigeria would definitely position any foreign investor to compete for a share in market.

Keywords Renewables, energy crisis, market situation, West Africa and Nigeria.

Pages 34 p. + appendices 7 p.

CONTENTS

1 INTRODUCTION

Renewable energies represent a broad and diverse array of energy resources- biomass, hydro, geothermal, wind, solar and ocean energy- as well as range of conversion processes and application such as combustion, thermal, mechanical, photovoltaic processes, etc. Apart from obvious emission control advantages, renewable energy technologies can also make a significant contribution to domestic energy security and spur economic development (Sawin, Adib & Chawla 2012).

The year 2011 saw the reorientation of future energy policy in many countries in the wake of the tragic nuclear disaster in Fukushima, Japan. Despite the economic uncertainty of the present, global investment in renewable power and fuel has increased by 17% and renewable energy continues to grow strongly in all the end use sectors- power, heating, cooling, and transports.

Renewable energy support policies continue to be a driving force behind the increasing shares of renewable energy. As many as 118 countries, more than half of which are developing countries, have had renewable energy targets in place by early 2012, and 109 countries have had policies to support renewable in the power sector.

A main driver propelling policy forward is the potential of renewable energy to create jobs. Globally, an estimated 5 million people work directly or indirectly with renewable energy industries. More and more governments around the world acknowledge the benefits of renewable energy along with energy efficiency as central elements of any green energy economy strategy (Sawin et al. 2012, 37-39).

Renewable forms of energy are also increasingly viewed as critical for providing access to energy, particularly in rural areas of the developing world. Renewable energy is now seen as a viable option for providing millions of people with a better quality of life. Although there is a long way to go to provide energy for all, today more people than ever before derive energy from renewables as capacity continues to grow, prices continue to fall, and shares of global energy from renewables continue to increase (Sawin et al. 2012, 37-39).

The electrification levels of ECOWAS (Economic Community of West African States) countries are the lowest in the world, especially in rural areas, where tens of millions of people have no access to ‘modern’ energy; a fact behind the rural exodus and overcrowding of large cities. Furthermore, the lack of drinking water constitutes another emerging problem in these countries. ECOWAS needs sustainable solutions for development of these basic sectors. However, these solutions are not the same as those of industrialised regions: they must be adapted to their needs and are different for each area (rural, suburban and urban) (Izquierdo 2012).

West Africa is an asymmetrical group of states that includes big countries such as Nigeria, but also small ones such as Gambia, Guinea-Bissau or Liberia, with quite diverse and complex situations. These states are distributed from the Sahel region in the north to the humid area in the south, which accounts for the diversity of environments found in the region. In addition, the majority of these states are among the least developed countries in the world, with high levels of poverty both in urban and rural areas. In this context, energy plays an essential role in improving living conditions. This is especially true in z region with abundant energy resources, yet that continues to be highly dependent on fossil fuels.
The energy situation in West Africa, specifically in the area of renewable energy and human development, is highly diverse areas complex. Therefore, any initiative in the sector must start with a strong understanding of the region and its dynamics must also take into account different aspects of development, from the local to the regional level (Ferrenbach 2012)

For the ECOWAS region, 19% of the rural population have access, mainly the major rural centres and some localities under the lines. And 81% of their rural population are left without access. Six countries already have a significant national electricity access rate in 2009, greater than 30%. These are Cape Verde (87%), Ghana (66.7%), Nigeria (50%), Cote d'Ivoire (47.3%), and Senegal (42%). For these countries, 25.1 million urban people and 78.8 million rural populations had no access, only 18% of the population in average had access to electricity with most of them in urban areas (83%). 82% of the total population are without access with 80% living in rural areas (Elayo, Lugmayr, Vilar & Kappiah 2012).

1.1 Renewable energy potential in West Africa

There is a huge technically and economically feasible potential for renewable energy development in West Africa. These resources are generous and well distributed among the countries.

Wind potential is concentrated in the costal zones (Cape Verde, Senegal, the Gambia, and possibly Ghana, Mali and Nigeria). The overall assessments provide only general information on the potential. Site specific surveys and measurements are required to verify the seasonal variation of wind regimes and to determine the financial viability of the potential.

Small hydro potential is located particularly but not exclusively, in the southern part of the region (Cote d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Togo and Sierra Leone) while solar resources are abundant in the northern regions (Niger, Burkina Faso, Niger, and the northern part of Ghana and Nigeria).

Except for Cape Verde and the Sahelean areas of Mali, Burkina Faso, and Niger, biomass is well distributed across the region, with a propitious potential in the Southern region. When considering biomass resources, it is important to distinguish: (i) the diffused biomass resources from

agricultural by-products, which are generally costly to collect and transport in large quantities, and are for that reason used locally, and (ii) the concentrated resources at the agro-industry sites such as rice husk, cotton seed shells, groundnuts and cashew shells, sawdust, manure and dung at dairies or slaughterhouses, which can constitute a proper resource for cogeneration of energy. Under the same category comes the urban waste of different forms.

Finally, solar resource is especially favourable in the northern desert areas of the ECOWAS region in Mali and Niger and in the Northern-Eastern part of Nigeria with a potential of 1,700 kWh/installed kWp/year. The coastal areas of Liberia, Cote d'Ivoire, Ghana and Nigeria do not benefit to the same extent from this resource with an average potential of 1200 kWh/installed kWp/year. For the remaining areas, the average potential is about 1500 kWh/kWp/year (Elayo et al. 2012, 87-88).

Table 1 Indicative ranking of RE resources by countries (ECREEE)

INDICATIVE RANKING OF RE RESOURCES BY COUNTRIES

	WIND	PV	SMALL SCALE HYDRO	BIOMASS
Benin	10%	20%	50%	20%
Burkina Faso	0%	60%	30%	10%
Cape Verde	90%	10%	0%	0%
Côte d'Ivoire	0%	10%	50%	40%
The Gambia	60%	30%	0%	10%
Ghana	25%	35%	30%	10%
Guinea	0%	20%	50%	30%
Guinea-Bissau	0%	20%	40%	40%
Liberia	0%	10%	50%	40%
Mali	10%	30%	30%	30%
Niger	30%	50%	0%	20%
Nigeria	10%	30%	30%	30%
Senegal	70%	10%	0%	20%
Sierra Leone	0%	10%	60%	30%
Togo	0%	20%	50%	30%
Mines	0%	30%	70%	0%

As can be seen in Table 1, the sum of the potential per country is 100%. O% indicates that the resource is not available or not economically feasible, as

for instance biomass and small scale hydro for Cape Verde. Three countries have good wind potential (Senegal, The Gambia and Cape Verde), and therefore the wind resources are given a high ranking for these countries.
Countries like Mali and Nigeria, which have an equal distribution of their renewable energy resources, are given an average ranking of 30% for three resources (solar, biomass and hydro) and a 10% ranking for wind, as wind is more intermittent compared to the other resources. Even if there is significant solar resource in Northern Mali, it cannot be fully exploited as it would require long transmission lines to transport the produced energy to the south. However, this resource can be used to supply the large cities in Northern Mali.
The line "Mines" shows that four countries with large mining potentials (Guinea, Liberia, Sierra Leone and Guinea-Bissau) can take advantage of their renewable energy potentials to satisfy the energy demand of their respective mining industries, which are located in remote areas from the national grid. The two main sources are, by order of priority, the small scale hydro power and the solar PV. The energy demand of the mining sector generally ranges from 30 to 150 MW.
Therefore, there is considerable potential to address both grid and off-grid related energy needs of the region (Elayo, et al. 2012, 89-90).

1.2 Problem statement

The purpose of this paper was to examine the current energy situation in West Africa width, a case study of Nigeria and to evaluate the business prospects of renewable energy adoption in this part of the world stressing the economic benefits there when efficiently applied.

1.3 Significance of study

The transition to renewable energy is of utmost importance for the world at the moment as the issue of global warming has arisen. The population of the world has been increasing and developing countries are becoming more and more developed, the standards of living are rising, at the same time energy use and demand are increasing bringing about a climatic change and the inevitability of adopting renewable energy.

Africa has tremendous untapped renewable energy resources, including hydro, wind, biomass, geothermal and solar power which could be used to produce a large share of the electricity that the continent needs.
The total dependence of our society on electricity is obvious and West African countries, especially Nigeria have huge demand for electricity having the largest population and the largest economy in Africa currently.

The government of Nigeria has an ambitious target to generate 40,000 MW of electricity by 2020 even though the current power generation is only 4,000 MW. The government has privatised the power sector, which presents an ample opportunity for foreign investors.

This paper looks deeply into the current energy situation in Nigeria and how renewable energy especially utilization of solar energy has been employed for solving the energy poverty. The findings of this research project will provide useful information for foreign investors to strategically launch into Nigeria's energy market as energy producers.

1.4 Objectives and research questions

The objectives of this study were the following:

- To evaluate the energy situation in Nigeria and the current demand for electricity;
- To identify the renewable energy potential and most especially solar energy and its applications in Nigeria;
- To carry out market research of Nigeria and find out possible business prospect for Renewable Energy especially Solar Energy, clean water technology and its composite advantage for agriculture, waste management and salt production, based on the multifunctional concept of Hanlog Oy, Finland.
- To recommend a market entry plan for Nigeria energy market.

The research questions were based on the operating area of investment and business in the energy sector of Nigeria. The key research questions were the following:

- What are the business prospects of investing in renewable energy in Nigeria?
- What are the Nigeria's electric power sector reforms and regulations?
- What are the solar energy applications in Nigeria?
- What are the economic benefits for Nigeria maximizing the use of RE?

1.5 Research methods

The method used in the thesis project was a qualitative approach. This included in-depth interviews through phone conversations, email, and skype. Information gathered through conversations with people with a good understanding of the energy sector of Nigeria and emails from players in the industry, focus groups, personal observations and self study were formed the result of this research project.. Confidentiality was strictly observed, as the information of the participants were only their names and position in their individual organisation.

2 RENEWABLE ENERGY

Renewable energy is defined by oxforddictionaries.com as energy from a source that is not depleted when used, such as wind or solar power.

Texas renewable energy industries alliance (TREIA) defines it as "Any energy resource that is naturally regenerated over a short time scale and derived directly from the sun 8such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy in biomass, or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources."

Renewable energy includes resources that rely on fuel sources that restore themselves over short periods of time and do not diminish. Such fuel sources include the sun, wind, moving water, organic plant and waste material (eligible biomass), and the earth's heat (geothermal). Although the impacts are small, some renewable energy technologies have an impact on the environment. For example, large hydroelectric resources can have environment trade-offs associated with issues such as fisheries and land use (US Environmental protection agency).

Renewable energy provided an estimated 19% of global final energy consumption in 2012, and continued to grow strongly in 2013. Of this total share in 2012, traditional biomass, which currently is used primarily for cooking and heating in remote and rural areas of developing countries, accounted for about 9%, and modern renewables increased their share to approximately 10%.
The combined modern and traditional renewables energy share remained about level with 2011, even as the share of modern renewables increased. This is because the rapid growth in modern renewable energy is tempered by both a slow migration away from traditional biomass and a continued rise in total global energy demand.
Modern renewable energy is being used increasingly in four distinct markets: power generation, heating and cooling, transport fuels, and rural/off-grid energy services. The breakdown of modern renewables, as a share of final energy use in 2012 was as follows: hydropower generated an estimated 3.8%; other renewable power sources comprised 1.2%; heat energy accounted for approximately 4.2%; and transport biofuels provided about 0.8% (REN21 Renewables 2014 global status report, 21).

Global perceptions of renewable energy have shifted considerably since 2004, when people widely acknowledged the potential of renewable energy, but large-scale deployment still had to be demonstrated. Over the last 10 years, continuing technology advances and rapid deployment of many renewable energy technologies, particularly in the electricity sector, have demonstrated that their potential can be achieved.

Today, renewable energy technologies are not only viewed as tools for improving energy security and mitigating and adapting to climate change, but are also increasingly being recognized as investments that can provide direct and indirect economic advantages by reducing dependence on imported fuels, improving local air quality and safety, advancing energy access and security, propelling economic development, and creating jobs (REN21 Renewables 2014 global status report, 92.)

Thousand of cities and local government around the world also have active policies, plans, or targets for renewable energy and climate mitigation. Almost two-thirds of the world's largest cities had adopted climate change action plans by the end of 2011, with more than half of them planning to increase their uptake of renewable energy. Many of the institutions encouraging co-operation among cities in local renewable energy deployment saw increased membership and activities in 2011, including the *EU Covenant of Mayors* (with over 3000 member cities). Most activity has occurred in the North American and European cities, although 100 demonstration cities exist in China, and cities in Argentina, Australia, Brazil, India, Mexico, South Africa, South Korea, and elsewhere undertook initiative to support renewable energy deployment in 2011 (Sawin et al. 2012, 44-45).

2.1 Energy situation and demand in Nigeria

Nigeria is located in West Africa, bordered by Cameroon to the east, Niger to the north, Benin Republic to the west and the Atlantic Ocean to the south. The terrain varies from coastal swamps and tropical forest in the south, to savannah and semi-desert in the north. Nigeria lies within latitudes 4.32˚N and 14˚N and longitude 2.72˚E and 14.64˚E, with land area of about 924,000km^2 and a population of 165 million (Shaaban & Petinrin 2014).

Nigeria is considered as one of the energy rich country in the world. Nigeria is rated among the top Oil producer in Africa, second in natural gas reserve (with an estimate of 176 trillion cubic feet) and estimated 2 billion metric tonnes of coal. Nigeria is also rich in water, wind and sun energy from which appreciable electricity can be generated. With the abundance of energy resources, Nigeria need not import energy to achieve a sustainable generating capacity suffices the targeted economic growth and also has excess generation to sell to neighbouring countries (Koledoye, Jumah & Philips 2012, 30.)

Nigeria is richly blessed with reasonably high qualities of various energy resources, such as crude oil, tar sands, natural gas and coal. About 90% of the country's economy is dependent on crude oil. In 2006, Nigeria was ranked the 10th largest crude oil producer in the world with a reserve estimated to be about 36 million barrels, which is about 4.9 billion ton of oil equivalent (toe). The country is endowed with more of natural gas than oil, with an estimation of 5210 billion m^3 (187 trillion SCF) as of 2006. Thos includes associated and non associated reserves; placing Nigeria among the top 10 countries with the largest gas reserves globally. Nigeria also

possesses other energy sources including 4.1 trillion toe of tar sands and 1.52 billion toe of coal and lignite. However, it has been estimated that Nigeria's fossil fuels will be depleted to an uneconomically point by the year 2050; going by the present extraction trend. Moreover, Nigeria, surprising, imports over than 70% of it s petroleum product requirements. (Shaaban et al. 2014, 73).

Nigeria is equally blessed with renewable energy (RE) resources like wind, solar, biomass and hydropower. Hydropower has the utmost RE potential, which amounts to 10000 MW for large hydropower and 734MW for small hydropower (SHP). Further RE sources include wind energy with a potential of 150,000 terra joules per year, generated by an average wind speed 0f 2.0-4.0 m/s, solar radiation estimated at 3.5-7.0 kWh/m^2 , and biomass at 144 million ton per year. However, these resources are yet to be explored.

Despite the abundance of energy resources available, Nigeria is only able to generate 1600 MW effectively out of 6000 MW of installed generating capacity (less than 30%). This is because most the power grid facilities are poorly maintained. Nigeria's power sector retains high energy losses, between 30% and 35%, from generation to billing. This is significantly high as compared with US, where power losses across lines usually comes to less than 7%, even across long distances. In addition, there is low collection rate, 75-80%, and low access to electricity by the population. Since there is insufficient cash generation, because of these inefficiencies, the Power Holding Company of Nigeria (PHCN) is consequently reliant on fuel subsidies and state funding of capital projects. Declining electricity generation from a number of domestic power plants has sent the country into an energy crisis during 2000/2001. Currently, the actual electricity generation of the country is considerably below the demand for electrical energy (Shaaban et al. 2014, 73-74).

Power outages are frequent and the power sector operates well below its estimated capacity. A fundamental reason offered is the low generating capacity of the Nigeria power sector relative to installed capacity. Consequently, the sector has to undergo some reforms to increase power generation and distribution. Among the reforms is the setting up of the National Electricity regulatory Commission (NERC), unbundling of PHCN and entry of Independent Power Producers (IPP) among others. These reforms are expected to increase power generation and distribution and also residential electricity demand in Nigeria (Babatunde & Shuaibu n.d).

2.2 Overview of the energy crisis in Nigeria

The Nigerian energy industry is probably one of the inefficient in meeting the need of its people. This is most evident in the persistent disequilibrium in the markets for electricity and petroleum products, especially kerosene and diesel. The energy service provision has adversely affected living standards of the population and exacerbated income and energy poverty in an economy where the majority of the people live on less than 200 Naira a day. This energy crisis has weaken the economic development process, and

significantly undermined the effort to achieve sustainable economic growth, increased competitiveness of domestic industries, regional and global markets, and employment generation (Mbunwe & Muncho 2014).

Nigeria's electricity market, which has been dominated on the supply side by Power Holding Company of Nigeria (PHCN) formerly called the National Electric Power Authority (NEPA), has been incapable of providing minimum acceptable international standards of electricity service reliability, accessibility and availability for the past few decades.
Power outages in the manufacturing sector provide another dimension of the crisis. In 2004, major manufacturing firms experienced 316 outages. This increased by 26% in 2005 followed by an explosive 43% increase between 2006 and 2007. Though no published data exist, near collapse of the generating system to far below 2000MW for prolonged periods of time suggest that the number of outages in 2008 will also be very high. This poor service delivery has rendered public supply a standby source as many consumers who cannot afford irregular and poor quality services substitute more expensive supply alternatives to minimize the negative consequences of power supply interruptions on their production activities and profitability (Mbunwe et al. 2014).

The wide energy gap and poverty in comparative regional terms is apparent in per capita electricity consumption in Nigeria being 140 KWh in 2004 compared to 1337 KWh in Egypt and 4560 KWh in South Africa. The government projects that generating capacity should increase to eliminate current electricity poverty and raise electricity per capita to 111o KWh in 2015 and 5000Kwh in 2030. Even then, Nigeria's per capita consumption in 2030 will be about 20% above the level that obtained in South Africa in 2003! (Iwayemi 2008).

2.3 Structure of the electricity market in Nigeria

In 1988, the National Electric power Authority (NEPA) was partially commercialized, supported by an upward review in tariffs. As part of the restructuring effort of the power sector, the Electric Power Sector Reform Act 2005 was enacted. Consequently, NEPA is now known as Power Holding Company of Nigeria (PHCN). The law paved the way for unbundling of NEPA into the 18 companies – 6 generating companies, 1 transmission company and 11 distributing companies. The generating companies are made up of 2 hydro and 4 thermal (gas based) stations (British journal of arts and social sciences 2012, 233).

The Nigerian power sector has witnessed attempts by successive governments to attain stability. The democratic governments of 1999 undertook rehabilitation of the existing power infrastructure. In 2004, the National Integrated Power Project (NIPP) was initiated to boost power supply by the launch of gas-powered stations. The National Electric Power Policy (NEPP) of 2001 resulted in the Electric Power Sector Reform (EPSRA) Act of 2005 establishing the Nigeria Electricity Regulatory Commission (NERC). The EPSRA provided the statutory basis for the

privatisation of the power sector. A key step in this plan was the setup of the Power Holding Company of Nigeria (PHCN) and subsequent unbundling into 18 successor companies.
The implementation of the Roadmap for Power Sector Reform of August 2010, (the Roadmap) led to the privatization of the power sector on November 1 2013 with the formal handover of the successor companies to private investors as six generation companies (GENCOs) and 11 distribution companies (DISCOs) and the establishment of the Transmission Company of Nigeria (TCN) (Adeniji & Osisiogu 2014).

2.3.1 Regulatory agencies

The Key regulatory agencies are:

– The Federal Ministry of Power

This is the Government administrative arm that deals with policy formulation and provides general direction to other agencies involved in the power sector. The key function of the Ministry is to develop and facilitate the implementation of policies for the provision of adequate and reliable power supply in the country.

– Nigerian Electricity Regulatory Commission

The Nigerian Electricity Regulatory Commission (NERC) was established by the EPSR Act, 2005. It is an independent regulatory agency mandated to regulate and monitor the Nigerian power sector. The functions of the NERC include, but not limited to, the following:

- Promote competition and private sector participation, when and where feasible.
- Establish or approve appropriate operating codes and safety, security, reliability and quality standards.
- License and regulate persons engaged in the generation, transmission, systems operation, distribution and trading of electricity.

Approve amendments to the market rules and monitor the operation of the electricity market.

– Energy Commission of Nigeria
The Energy Commission of Nigeria (ECN) was established in 1988 with the statutory mandate for strategic planning and coordination of national policies in the field of energy. It was established in line with declaration of the Heads of The Economic Community of West African States in 1982 for the establishment of an agency in each member state charged with the responsibility of coordinating and supervising all energy functions and activities. The functions of the ECN include, but are not limited to the following:

- Serve as a centre for gathering and dissemination of information relating to national policy in the field of energy.
- Inquire into and advise the Government of the Federation or the State on adequate funding of the energy sector including research and development, production and distribution.
- Monitor the performance of the energy sector in the execution of government policies on energy.
- Serve as a centre for providing solutions to inter-related technical problems that may arise in the implementation of any policy relating to the field of energy.

– Rural Electrification Agency

The Rural Electrification Agency (REA) is Federal Government Parastatal under the Federal Ministry of Power. It was established by the EPSR Act with the statutory functions of promoting, supporting and providing electricity access to rural and semi-urban areas of the country.

The Agency also administers the Rural Electrification Fund (REF). The purpose of the REF is to promote, support and provide rural electrification programmes through public and private sector participation in order to achieve more equitable regional access to electricity, and promote expansion of the grid and development of off-grid electrification.
Eligible customers and licensees are required to contribute to the fund at rates to be determined by the NERC.

– Presidential Task Force on Power

The Presidential Task Force on Power (PTFP) was established in 2010 to drive the implementation of the reform of Nigeria's power sector.

The role of the PTFP is to coordinate the activities of the various agencies charged with ensuring the removal of legal and regulatory obstacles to private sector investment in the power industry. It also has the mandate to monitor the planning and execution of various short-term projects in generation, transmission, distribution and fuel-to-power that are critical to meeting the stated service delivery targets of the power sector roadmap.

2.3.2 Key institutions

The key institutions include:

– Niger Delta Power Holding Company Limited

The Niger Delta Power Holding Company Limited (NDPHC) is a special purpose vehicle jointly owned by the three tiers of government (Federal, State and Local). It is charged with the responsibility for the implementation of the National Integrated Power Project (NIPP). The Government conceived the NIPP in 2004 as a fast-track government-funded initiative to

stabilize Nigeria's electricity supply system while the private-sector led structure envisaged in the EPSR Act develops.
Wholly-owned subsidiaries of NDPHC own each of the ten (10) power generation stations that have been developed under the NIPP.

– Nigerian Bulk Electricity Trading Plc

The Nigerian Bulk Electricity Trading Plc (NBET) is a government-owned public liability company. The Bureau of Public Enterprises and Ministry of Finance Incorporated are its two shareholders with shareholding of 80% and 20%, respectively.

The NBET, established in line with the provisions of the EPSR Act, is an electricity trading licensee that engages in the purchase of electrical power and ancillary services (from independent power producers and the successor generation companies) and subsequent resale to distribution companies and eligible consumers. It is not envisaged to be the sole authorized or designated electricity buyer, as other entities, such as distribution companies that have attained commercial viability, will also be able to procure power directly from the generation companies.

The role of the NBET is, however, a key success factor during the transitional stage of the Nigerian power sector reforms. Its role in the reform process is to use its legal backing to drive private sector investment in generation activities by executing bankable Power Purchase Agreements (PPAs) with them. These PPAs may subsequently be novated to the distribution to the distribution companies when it becomes economically viable for all parties.

– Operator of the Nigerian Electricity Market

The Operator of the Nigerian Electricity Market (ONEM) is licensed to function as the Market Operator of the wholesale electricity market of the Nigeria electricity supply industry. It is responsible for the operation of the electricity market and settlement arrangements.
A key function of the ONEM is the administration of the metering system among generation, transmission and distribution companies.

– Nigeria System Operator

The Nigeria System Operator (NSO) is licensed to provide system operation services to the Nigeria electricity supply industry.
The NSO is primarily responsible for the planning, dispatch and operation of the transmission system. It is also responsible for the security and reliability of the electricity network grid.

– Gas Aggregation Company Nigeria Limited

The Gas Aggregation Company Nigeria Limited (GACN) was incorporated in 2010 for the purpose of stimulating growth of natural gas utilization in the Nigeria domestic market.

– National Power Training Institute of Nigeria

The National Power Training Institute of Nigeria (NAPTIN) was established in 2009 to serve as a focal point for human resource development and workforce capacity building, and act as a research centre on matters relating to power in Nigeria.
A key objective of the institute is to design, develop and deliver a wide variety of training courses that will enhance the skills and capacity of both technical and non-technical power utility personnel.

– Nigeria Electricity Liability Management Company Limited

The Nigeria Electricity Liability Management Company Limited (MELMCO) was established in 2006 as a company limited by guarantee, to assume and manage the non-core assets, all liabilities and other obligations that would not be taken over by the successor companies. This is to ensure that the successor companies are not encumbered by these liabilities at take off.

The NELMCO is mandated to:

- Assume and administer the stranded liabilities of PHCN pursuant to the provision of EPSR Act,
- Assume and manage pension liabilities of employees of PHCN,
- Hold the non-core assets of PHCN, sell or dispose or deal in any manner for the purpose of financing the repayment of the pension liabilities of employees of PHCN,
- Take over the settlement of stranded PHCN's Power Purchase Agreement obligations and other legacy debts as may be determined by the National Council On Privatization within the Nigeria Electricity Supply Industry, and
- Manage and supervise the management of contractual arrangements arising from the assumption of stranded liabilities of PHCN.

2.4 Electricity production and consumption

Energy generated in 2007 and 2008 amounted to 22,978,128.88 MWh and 20,980,778.96 MWh respectively. 2008 shows a drop of 1,997,349.7 over 2007 generation. This decline in generation might be connected with the inability of the government to adequately fund the sector due to fall in revenue resulted from the global economic crisis of late 2007(Oseni 2012.

The demand of electricity in Nigeria's outreaches the supply. About 60% of the population – over 80 million people are not served electricity with the

rural and semi urban access to the electricity estimated to be 35% (Aliyu, Ramli & Saleh 2013).

Household access to electricity services in Nigeria is low. About 60% of the population – over 80 million people are not served with electricity and rural and semi-urban access to electricity estimated to be about 35%. Per capita consumption of electricity is approximately 125 kWh against 4500 kWh, 1934 kWh and 1379 kWh in South Africa, Brazil and China respectively.
Over the years, more than 40.0% of the households did not have access to electricity in the country, 41.4% in 2007 and 48.0% in 2008. This continuous rise in households without access maybe connected with rising rates of population growth without corresponding improvements in electricity supply.
The households depending on self-diesel generating plants rose from 2.7% to 3.2% over the period. Similarly, households complementing form the national grid with diesel generating plants also rose to 6.3% in 2008 from 5.8% in 2007. It is clearly shown that the rural electrification programme in the country is yet to record a remarkable progress with just 0.9% of household being its beneficiary (Oseni 2012, 993).

3 RENEWABLE ENERGY POTENTIAL IN NIGERIA

The renewable energy resources in Nigeria are as enormous as they are diverse.

Aside non-renewable energy resources such as crude oil, natural gas and coal, Nigeria is endowed with significant renewable energy resources, solar energy, biomass, wind, potential for hydrogen utilization, and development of geothermal and ocean energy.

Table 2 Energy forms and policies

Renewable energy resources.
Source: Renewable Energy Master Plan (2009).

Resource type	Reserves			Production	Domestic utilization (natural units)
	Natural units		Energy units (Btoe)		
Small Hydropower	3500 MW		0.34 (over 40 years)	30 MW	30 MW
Large Hydropower	11,250 MW		0.8 (over 40 years)	1938 MW	1938 MW
Wind	2–4 m/s at 10 m height (main land)		0.0003 (4 m/s @ 12% probability, 70 m height, 20 m rotor, 0.1% land area, 40 years	-	-
Solar Radiation	3.5–7.0 kWh/m^2/day (4.2 million MWh/day using 0.1% land area)		5.2 (40 years and 0.1% land area)	6 MWh/day	6 MWh/day
Biomass					
Fuel wood	11 million hectares of forest and wood land	Excess of 1.2 m ton/day	-	0.120 million ton/day	0.120 million ton/day
Animal waste	211 million assorted animals			0.781 million ton of waste/day	None
Energy crops and agric residue	28.2 million hectares of arable land (=30% of total land)			0.256 million ton of assorted crops/day	None

Source: Energy Commission of Nigeria (ECN)

3.1 Potential energy resources in Nigeria

Hydroelectric energy – Hydropower is conceivably regarded as the major source of electric power generation and supply in Nigeria because the

country is endowed with large rivers, waterfalls and dams. Only large hydropower technology is the prominent commercial RE technology in the electricity supply mix of the country. Due to economy of scale, large hydropower technology takes the lion share of the entire commercial RE resources for electricity generation under any CO_2 emission constraints. Unlike fossil fuel, hydropower is renewable and can supply uninterrupted fuel, except for the question of water levels. The total potential of hydropower in Nigeria is about 14,750 MW. However, only 1930 MW, approximately 14%, of that is currently being generated at Shiroro, Kanji and Jebba representing about 30% of gross installed grid-connected electricity generation capacity of Nigeria.

Figure 1 Waterways in Nigeria (Safety4Sea)

Solar energy can provide a cheap and abundant energy for communities whose connection to the national grid may not be economical due to their remote physical location from the nearest grid connection point. Solar

energy is an alternative source of energy in rural and remote areas of Nigeria. It complements rapid development of small scale industries and reduces the rural-urban drift. The country receives abundant solar radiation and sunshine.

Solar energy is the most promising of the RE resources in Nigeria due to its apparent abundance. Energy radiated from the sun is about 3.8×10^{23} kW, which is 1,082 million ton of oil equivalent (mtoe) per day. This is about 4000 times the current daily crude oil production in Nigeria and about 13000 times the natural gas daily production, based on standard energy units. The total energy demand of the nation could be met if only 0.1% of the total solar energy radiant on Nigeria's land mass is converted at an efficiency of 1%.

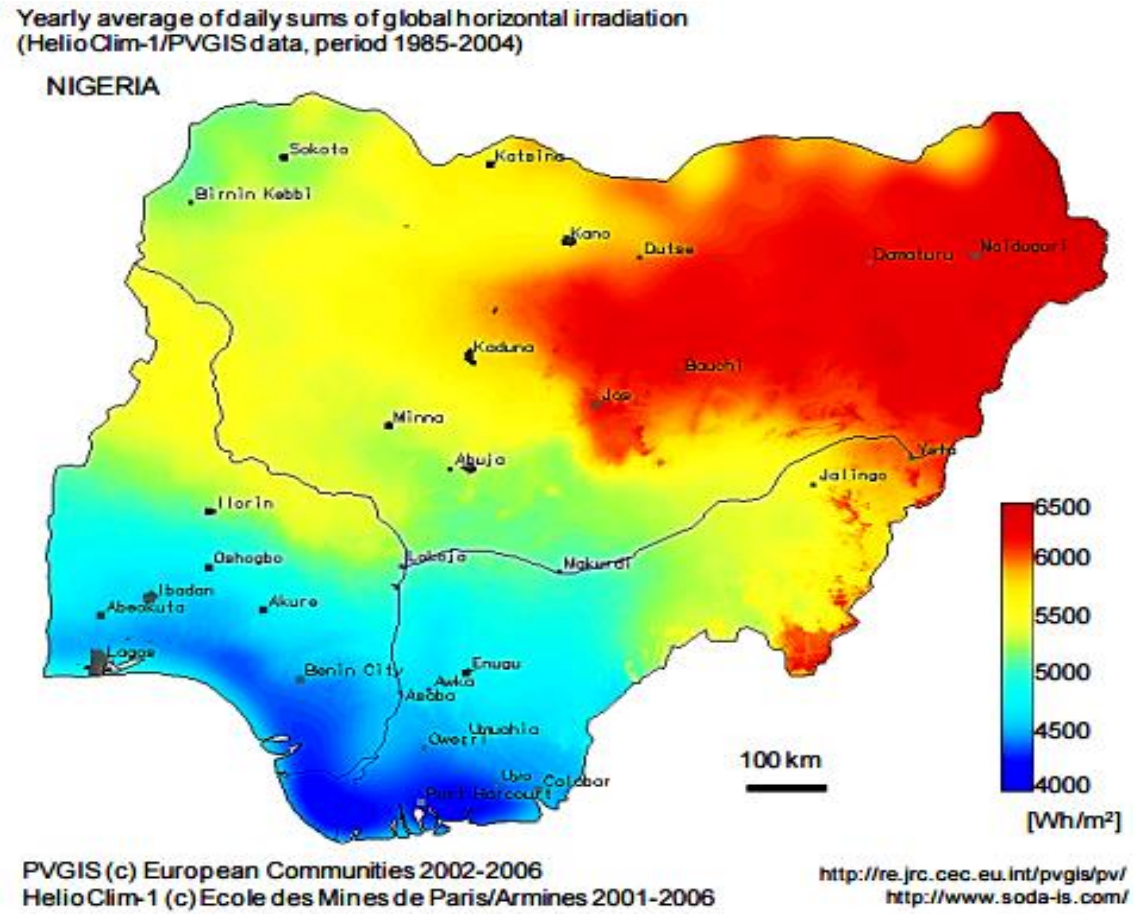

Figure 2 Annual average of daily sunlight in Nigeria

Wind energy – Wind speed in Nigeria ranges from 4.0 to 5.12 m/s in the extreme northern part of the country, while 1.4-3.0 m/s in the southern Nigeria; just like South Africa. The latter has a wind speed that ranges from 4.0 to 5.0 m/s for the majority of coastal regions, but increasing approximately to 8.0 m/s in some mountainous areas. This shows that wind speeds are generally weak in the southern part except at the coastal regions and offshore locations. A study carried out by Energy Commission of Nigeria (ECN) reveals that total exploitable wind energy reserve at 10m

height may vary from 8 MWh/yr in Yola to 51 MWh/yr in the mountainous area of Jos, and could reach as high as 97 MWh/yr in sokoto. A potential estimate of wind speeds for 10 selected sites in Nigeria render the speed between 3.6 and 5.4 m/s.

Figure 3 Wind locations in Nigeria

Biomass - is an indirect form of solar energy because it arises due to photosynthesis. Fuelwood is the most common form of biomass energy. Nigeria is very rich in biomass resources such as wood, forage grasses and shrubs, wastes arising from forestry, agricultural, municipal and industrial activities, as well as aquatic biomass. The Nation biomass resources have been estimated at 8×10^2 MJ.

Biogas – is produced from the bacterial decomposition of organic matter in the absence of air, by the biodegradation of organic material under anaerobic conditions. Some of the biogas raw materials are animal dung, industrial wastes, household wastes and air dry crop residues. The mixture of different types of wastes produces more biogas energy.
Identified feedstock substrate is considered an economically feasible biogas program in Nigeria that includes dung, water hyacinth, cassava leaves, solid (including industrial) waste, water lettuce, urban refuse, agricultural residues and sewage. Nigeria produces about 227,500t of fresh animals

daily and 20kg of municipal solid wastes per capita is produced annually. About 0.03m^3 of gas can be produced from 1kg of fresh animal wastes, thus, Nigeria can produce 6.8 million m^3 of biogas/day. Biogas production will not only increase the energy production but will also lead to a profitable means of reducing, if not eliminating, the menace and nuisance of urban waste (Shaaban et al. 2014, 75-79).

Table 3 Biomass Resources [21]

Biomass resources and estimated quantities in Nigeria.

Resources	Quantity (million ton)	Energy value (000 MJ)
Fuelwood	39.1	531.0
Agro-waste	11.244	147.7
Saw dust	1.8	31.433
Municipal solid waste	4.075	-

3.2 Energy policy

Nigeria had no comprehensive energy policy until recently, when the energy policy in Nigeria was approved by GoM in 2003. The policy was dubbed the National Energy Policy (NEP) with an overall objective of the optimal utilization of the nation's energy resources; both fossil and Res, for sustainable development and with the active participation of the private sectors.

The NEP articulated, amongst other things, that

- Extensive crude oil and natural gas exploration and development shall be pursued with the view to increasing their reserves base, to the highest level possible;
- The country shall continue to engage extensively in the development of electric power with the view to making reliable electricity available to 75% of the population by 2020; as well as to broaden the energy options for generating electricity.

Nigeria Electric Power Authority (NEPA), now the Power Holding Company of Nigeria (PHCN) in the energy policy of 2003, outlined a plan to diversify its energy sector and pursue RE (Shaaban et al. 2014, 79-80).

Table 4 Energy form and policies [21]

Energy form	Policies
Natural Gas (NG)	Utilize the nation's NG reserves into the energy mix More gas exploration Eliminate flaring by 2008 Encourage privatization
Oil	Increase refining capacity Endorse exploration looking for more oil reserves Derive more economic benefit from oil reserves Privatize the oil industry
Goal	Resuscitation of coal industry for export in an environmentally friendly manner
Tar Sands	Encourage tar sands exploration driven by the private sector Extract oil from tar sands
Nuclear	Pursue nuclear as part of energy mix
Hydropower	Fully harness the hydropower potential (in particular small-scale) through environmentally friendly means and through the private sector Promoting rural electrification through SHP
Solar	Help develop the capabilities to utilize solar energy
Wind	Help develop the capabilities to utilize wind energy
Hydrogen	Help develop local production capabilities for hydrogen energy
Biomass	Promote biomass as an alternative energy source
Fuelwood	Promote the use of alternative energy source to fuelwood De-emphasize fuelwood as part of the nation's energy mix
Other REs	Will remain interested in other emerging energy sources.

3.3 Prospects of renewable energy for rural energy provision

There are great opportunities for the use of RE technologies in applications, where electricity, thermal energy or mechanical power, are required. Such applications include non-thermal electricity generation, thermal power plants, industrial and domestic cooking and heating of liquid and gasses, standalone power systems and grid power supply; water purification, irrigation and potable water supply, lighting; drying and processing of agricultural products, etc. However, in view of certain characteristics of the energy sector in Nigeria and the attributes of the RE, in comparison to non-renewable energy and conventional energy, greater prospects for the use of RE exist in the rural sector of the economy.

Widespread adoption of modern RE technologies, with the proper government support, can provide an excellent alternative to conventional firewood based technologies; used predominantly by rural dwellers. Large scale introduction of biogas technology and solar cookers including the use of coal briquettes, natural gas and kerosene can reduce the share of fuel-wood in the energy mix. This has the consequences of not only improving

the living standard of the rural population in Nigeria, as far as the education, economic, and social aspects are concerned, but also decreasing exposure to indoor smoke pollution, associated with fuelwood burning, which pose chronic health problems. This would in turn decrease the mortality rate, in which Nigeria is among the highest in the world, and revamp the wellbeing of rural Nigerians groaning under acute shortage of electricity. It will eventually ameliorate the energy outlook of Africa's most populous nation (Shaaban et al. 2014, 82-83).

3.4 Financing renewable energy in Nigeria

The financing of renewable energy projects is seen by both practitioners and commentators as the single largest barrier to the expansion of improved uptake of renewable energy. Even those close to the small industry have held back on adopting systems because of the high capital cost and the relatively long 'payback' time in a difficult environment.

In Nigeria, the very small size of renewable energy sector appears likel to hold good quality installation costs higher than in other countries, at least in the short term. Yet this also draws attention to another key goal. With labour costs lower in Nigeria than in many of the countries for which installation comparisons are done, it seems vital to develop technician who can provide a professional and affordable services.

In addition to cost- and energy-efficiency, quality is also as important in terms of reliable components. There are several hazards in Nigeria that can easily damage equipment, making renewable energy capital items a markedly more expensive option if difficult repairs or replacement are required. Investment in some additional protection against risks ranging from lightning to accidental damage or abuse have proven to be of very high value to pilot projects, and the same principle seems likely to apply to most consumer situations (Newsom 2012, 24-27).

Table 5 Challenge and Responses (The SUNGAS Project)

Challenge	Response
High initial capital cost of installing renewable energy—whether wind, solar PV, hydro, or solar thermal.	The upfront capital investment cost has some advantages in Nigeria—there are no questions about the ongoing financial and stability issues of fuel and pipelines.
Solar and wind power are clearly better suited to specific parts of Nigeria for the most competitive solutions.	The areas with overwhelming solar potential (northern Nigeria) are very poorly served at present, and seem likely to face very high transmission costs from growing power generation areas in the Niger Delta.
Renewable energy installations have tended to be relatively small compared to conventional grid generation.	Smaller installations near to target communities should mean faster deployment and much lower transmission losses than distant gas-powered options.
Grid-level renewable energy is not an 'always on' generation solution. Both solar and wind require complementary generation.	Nigeria's power shortages are so acute that this may be an acceptable shortcoming initially. As the grid improves, Nigeria has a wide range of sources that should complement renewable sources well.
The feed-in tariffs used as a tool in other countries could prove expensive at a time when Nigeria has difficulties funding infrastructure.	If structured correctly, a green feed-in tariff could prove attractive to agencies such as the World Bank, with a good potential match in the longer term between affordable interest rates and economically sensible green outcomes. The existing cost of power to the private consumer is extremely high, making even the more expensive renewable options competitive.

3.5 Country context and prospects

After lurching from one military coup to another, Nigeria now has an elected leadership. But the government faces the growing challenge of preventing Africa's most populous country from breaking apart along ethnic and religious lines.

Political liberalization ushered in by the return to civilian rule in 1999 was followed by militants from religious and ethnic groups pursuing demands through violence. Thousands of people have died over the past few years in communal attacks led by the al-Qaeda ally Boko Haram. Separatist aspirations have also been growing, prompting reminders of the bitter civil war over the breakaway Biafran republic in the late 1960s. The imposition of Islamic law in several northern states has embedded divisions and caused thousands of Christians to flee. Nigeria has formed a military coalition with its neighbours Chad, Cameroun and Niger in response to Boko Haram threat.

2015 presidential election was first in Nigeria's history to be won by an opposition candidate (BBC News 2015).

3.5.1 Political, economic and social context

The country is facing various insurgencies that threaten to distract the Government from its reform agenda. However, the government is making concerted efforts to curtail the spate of attacks. This is reflected in the Government's allocation of about 20% of the 2012 budget and 13.6% of the 2013 budget to address the security challenges. Nonetheless, a lasting solution will be required to tackle the underlying problems of high unemployment, poverty and underdevelopment, which the government is pursuing vigorously under its Transformation Agenda and which the current country strategy paper (CSP) seeks to support (Africa Development Bank Group 2013).

Nigeria rebased its GDP from 1990 to 2010, resulting in an 89% increase in the estimated size of the economy. As a result, the country now boasts of having the largest economy in Africa with an estimated nominal GDP of USD 510 billion, surpassing South Africa's USD 352 billion. The exercise also reveals a more diversified economy than previously thought. Nigeria has maintained its impressive growth over the past decade with a record estimated 7.4% growth of real gross domestic product (GDP) in 2013, up from 6.7% in 2012. This growth rate is higher than the West African sub regional level and far higher than the Sub-Saharan Africa level. The performance of the economy continues to be underpinned by favourable improvements in the non-oil sector, with real GDP growth of 5.4%, 8.3% and 7.8% in 2011, 2012 and 2013, respectively (Barungi 2014).

There is a high degree of social deprivation in Nigeria. GNI per capita was US$1,180 in 2010, but income distribution is highly skewed with a Gini coefficient of 43.70 in 2011. About 63% of the population lives below the poverty line of US$1.00/day; 42% does not have access to safe drinking water; and 69% does not have access to basic sanitation. Nigeria social indicators lag behind the average for Africa. Life expectancy is 51.9 years in 2011, with an adult literacy rate of 61.3%, compared to 57.7 years life expectancy, and an adult literacy rate of 67% for Africa. But, there are huge regional disparities in income and social outcomes in Nigeria, with the north registering the highest levels of poverty and social deprivation compared to the south.

Nigeria economy is dependent on sectors that are either climate sensitive or contribute to climate change such as agriculture, forestry, fisheries, which together employ up to 70% of the workforce, and additionally, oil and gas. The Government is aware of the high vulnerability of the country to climate change. Some efforts are underway to address this in the national development agenda through various climate change policies.

Nigeria has had a gender policy since 2006 which clearly stipulates various actions to ensure gender equality and empowerment. However the excellent policies and intentions have not resulted in the changes required. About 56% of the illiterate population in Nigeria are women. In terms of work, women's participation in the labour force remains low, with only one-third of Nigerians who secure a job in the formal sector being women. In the

private sector, women are chief executives of some large companies but the number remains low relative to men (Africa Development Bank Group 2013, 5-6).

3.5.2 Weaknesses and challenges

The country is facing several challenges to achieve a strong inclusive growth. Turning these challenges into opportunities is critical to setting the country on the path of reaching the Vision 20:2020 objective. The key challenges holding back the country's long-term aspiration are corruption, particularly, in the management of the country's vast oil and gas resources, governance and weak institutional capacity, the infrastructure deficit, lack of long term financing for Small and Medium Enterprises (SMEs), challenging social harmony, and weak business environment. Other daunting challenges include poor policy outcomes resulting from weakness in policy formulation and implementation.

However, Nigeria has the potential to become a major player in the global economy. Nigeria is viewed as a middle income, mixed economy, and an emerging market with expanding financial, service, telecommunication, and entertainment sectors. It is ranked 30th in the World in terms of Purchasing Power Parity-measured GDP, and largest economy in Africa. Its manufacturing sector, though currently underperforming because of the dilapidated state of infrastructure in the country, produces a large proportion of goods and services for the West African region. Furthermore, it is ranked 25th worldwide and 1st in Africa in farm output; and 63rd worldwide and 5th in Africa in service output. Despite the weak business environment, the country remains one of the most preferred investment destinations in Africa. Total Foreign Direct investment (FDI) increased from US5.7 billion in 2009 to US 8.9 billion in 2011, representing 20% of the total FDI to Africa in 2011. However, these are mostly in the oil sector.
Nigeria is endowed with enormous natural resources: about 34 different minerals across Nigeria including gold, iron ore, coal, and limestone. There is also agricultural and manufacturing potential and human capital.

Nigeria is a regional power in West Africa whose economy represents about 55% of West Africa's GDP and its population of about 167 million provides the largest market in Africa. In 2011, Nigeria's export to African countries was 10.7% of the total value of exports, with exports to ECOWAS countries contributing 3%. On imports, 8.2% of the value of imports was from African countries with ECOWAS countries contributing 1.3%. It is a founding member state of the Economic Community of West African States (ECOWAS) and a member of the West African Monetary Zone (WAMZ). Nigeria is major financial contributor to ECOWAS, and hosts the Secretariat, the Parliament and the Court of Justice. Nigeria regarded ECOWAS as an institutional framework for developing, the sub-region and improving the quality of lives of its people. It spearheaded and provided financial support for the establishment of the Economic Community of West African States Monitoring Group (ECOMOG) to unite the region's armies and contain the civil wars in Liberia and Sierra Leone. Nigeria stands

to benefit more from regional integration (Africa Development Bank Group 2013, 7-8).

3.5.3 Doing business in Nigeria

There are different investment vehicles that could be used for carrying on business in Nigeria. These include partnerships, unincorporated joint ventures and limited and unlimited liability companies. However, the authorized mode of investment by foreigners in Nigeria is through limited liability companies.

Under section 54 of the Companies and Allied Matters Act (CAMA), the law that regulates the formation and operation of companies in Nigeria, no foreign company may carry on business in Nigeria unless it incorporates a local subsidiary in the country. However, the Federal executive Council is empowered by section 56 to grant exemption from this mandatory requirement to foreign companies in the following categories:

- Foreign companies invited by or with approval of the Federal Government to execute special projects
- Foreign companies which are in Nigeria for the execution of specific loan projects on behalf of donor countries or international organizations
- Foreign government-owned companies engaged solely in export promotion activities; and
- Engineering consultants and technical experts engaged in specialist projects under contracts with any of the Governments of the Federation or any of their agencies or under contracts with any person where such contracts have been approved by the Federal Government.

The foreign company would have to conduct a name search at the Corporate Affairs Commission (CAC) to ensure that the preferred name has not been issued to an existing company, or is not a prohibited name. The following documents are required to incorporate a company in Nigeria:

- Memorandum of Association
- Articles of Association
- Statement of Share Capital
- Declaration of Compliance with CAMA
- Notice of situation of the Registered Office of the company; and
- Return of allotment of Shares and Particulars of First Directors (KPMG 2013, 22).

Table 6 Ease of doing Business in Nigeria 2015 (World Bank Group)

ECONOMY OVERVIEW

PRINT | EXCEL

REGION	Sub-Saharan Africa
INCOME CATEGORY	Lower middle income
POPULATION	173,615,345
GNI PER CAPITA (US$)	2,760
CITY COVERED	Lagos, Kano

DOING BUSINESS 2015 RANK	DOING BUSINESS 2014 RANK***	CHANGE IN RANK
170	175	↑ 5

DOING BUSINESS 2015 DTF** (% POINTS)	DOING BUSINESS 2014 DTF** (% POINTS)	CHANGE IN DTF** (% POINTS)
47.33	43.72	↑ 3.61

Rankings | Distance to Frontier | Distance to Frontier - Lagos | Distance to Frontier - Kano

TOPICS	DB 2015 Rank	DB 2014 Rank	Change in Rank
Starting a Business	129	138	↑ 9
Dealing with Construction Permits	171	168	↓ -3
Getting Electricity	187	186	↓ -1
Registering Property	185	185	No change
Getting Credit	52	125	↑ 73
Protecting Minority Investors	62	61	↓ -1
Paying Taxes	179	177	↓ -2
Trading Across Borders	159	159	No change
Enforcing Contracts	140	139	↓ -1
Resolving Insolvency	131	129	↓ -2

4 SOLAR ENERGY: TO SOLVE NIGERIA'S ELECTRICITY GENERATION PROBLEM

The sun's power reaching the earth is typically about 1000W/m^2. The total amount of energy that the earth receives daily is 1353W/m^2 . Some 4 million tons of the sun's matter will continue to be changed into energy every second. The sun is the most readily and widely available renewable energy source capable of meeting the energy needs of the whole world. It can provide more power than any fossil fuel on the planet (Oji et al. 2012, 54).

4.1 Role of electricity in Nigeria's economy

In Nigeria, energy serves as the pillar of wealth creation evident by being the nucleus of operations and engine of growth for all sectors of the economy. The output of the energy sector (electricity and the petroleum products) usually consolidate the activities of the other sector which provides essential services to direct the production activities in agriculture, manufacturing, mining, commerce etc (Onakoya et al. 2013).

An evidence of the impact of the poor quality, unreliability and limited availability of power supply on Nigeria's economic development is its debilitating effects on the industrialization process. Nigeria manufacturers have consistently identified poor power supply as the most important constraint to their businesses. The majority of them have to supplement publicly supplied electricity with very expensive auto-generation. Removing the constraint of unreliable power generation will, therefore, enhance the microeconomic response of the real sector to the various government incentives (Adenikinju 2008).

The energy sector is very strategic to the development of the Nigerian economy. In addition to its macroeconomic importance, it has major roles to play in reducing poverty, improving productivity, and enhancing the general quality of life. If Nigeria is to take the path of sustainable energy, it is important to accurately and technically model the energy demand and supply scenarios and their impact on the economy, resources and society along with the environment, for both medium and long terms. From such analyses, we can derive information that is vital for policy construction and investment (Oyedepo, S.O. 2012).

With the increase in electricity to meet fully demand, GDP of the economy in ten years could be in two digits annually. This is because the availability of electricity supply would encourage private investors who have always cited the epileptic power supply, as an excuse to move their businesses to other neighbouring African countries. Furthermore, existing businesses in the country would have lower cost of production. This would result in firms increasing output, which if sustained over time; would yield double digit growth in GDP for the country (Aladejare, 2014, 52).

Nigeria power breakthrough provides hope for millions. Electricity enables hospitals to functions more efficiently, eliminates the use of woods and

charcoal for cooking which causes wood-smoke pollution and sickness, students have access to light to read at anytime of the day and performs better academically, small scale businesses would also grow assured of saving cost on self-powered generator, rural areas becomes developed and migration to the urban areas is reduced.

Provision of adequate supply of electricity will transform Nigeria's economic prospects and create more and better jobs for millions of Nigerians.

4.2 Solar energy applications in Nigeria

Nigeria is located within the high sunshine belt, and has according vast potential for solar energy generation. Solar energy potential is especially good in the northern part of the country, but large development projects are planned also for the southern Delta area. The emphasis is on solar PV projects, solar thermal solutions are used mainly at small scale, for example, in agriculture (Nwoke 2014).
Several countries like Germany, United States and Canada are actively supporting solar PV development and investments in Nigeria. For example, in May 2014, SkyPower FAS Energy signed agreements for the development of 3000 MW of utility-scale solar PV projects that should be built in the next five years in the Delta state (SkyPower News 2014). Nigerian-German Energy partnership emerged in 2007 and includes several energy related projects. There are plans, for instance, 420 MW of solar power plants in nine northern states (PV Magazine 2013). In July 2014, the installed capacity for large scale grid connected solar PV was around 30-50 MW (Soremekun 2014).

Besides large scale solar PV, market opportunities exist for off-grid solar PV applications at different market sectors. These include, for example, agricultural applications, solar and hybrid solutions for telecommunications sector, security systems, solar street lights and solar traffic lights. (Soremekun 2014.) For instance, at telecommunications sector thousands of base stations are fuelled by diesel generators. This entails huge cost for maintenance and transportation of fuel. High electricity prices are also an obstacle for many small and medium sized companies, which could well benefit from renewable energy, especially if they can be supported with getting affordable loans for investment (Adaju 2013).

4.3 Costs and challenges

Some of the factors militating against the growth of the Solar-PV and concurrently solar thermal industry in Nigeria includes:

- Financial constraints: a basic barrier to the development of solar technology in Nigeria as developing country lies in high initial costs and log payback times.

- Technological incapability: Though the technologies for harnessing solar energy are being developed in Nigeria, most components have to be imported which further pushes the investment costs higher.
- Absence of a comprehensive National Energy Policy: There was virtually no comprehensive energy policy in Nigeria until very recently. Only sub-sectoral policies relating to energy exist.
- Low level of public awareness: the level of awareness about the immense socio-economic and environmental benefits derivable from solar energy is very low in Nigeria. The current flow of information about the development, various applications, dissemination and diffusion of solar energy resources and technologies is adequate. (Oji et al. 2012, 58).

4.4 Hanlog Oy and its multifunctional concept

Hanlog Oy is a Finnish company located in Valkeakoski and one of its products and services is solar energy and clean water technology. The company produces a cost effective solar power system to produce electricity and simultaneously the system has the capacity for producing clean water for drinking or irrigation irrespective of the location, from one hectare this system can produce 40 m^3 clean water per sunny hour. It can as well extract salt if the water source is from the sea water.

The system is module based and can be scaled based on the needs of the customer; the size of one module is 36 m^2. Solar heat collection is based on Linear Fresnel-technology and the mechanical energy used is a new type of steam motor.

Hanlog's concept uses new effective steam and temperature can be even less than 200 ^{0}C. Therefore, the components are cheaper, more effective and simple to produce compared to the traditional system that uses turbine having temperature as high as 700 ^{0}C and all its components are expensive.

When mounted, this solar power system gives room for growing at partly shadowed condition on the soil under the mirror. Also the surrounding can use for farming. Hanlog's concept uses drip irrigation. Drip irrigation will save water. The water for each plant can be controlled. Also the nutrients can be controlled plants by plants which enable the growth of different plant despite soil type.

This multifunctional system can also be simplified into solar power system only or clean water system or both.
Considering the uniqueness of this multifunctional system, it shows that there is huge market for Hanlog in Nigeria which gives them edge over other companies that may come to country with a system that provides only solar energy.

The government of Nigeria has plans to improve its economy through serious investment in Agriculture industry; this would be one big sector for Hanlog to offer both power supply and drip irrigation. In the housing sector,

there is huge market for provision of power and clean water technology and this applies to all manufacturers.
The telecommunication industry is definitely a huge market for solar power supply and the rural and remotes areas needs electricity and clean water which also assure Hanlog a big market.

There is a big market in Nigeria for Hanlog to explore with its multifunctional concept but this can be easily achieved only by partnering with a local firm or agent that offer RE services in Nigeria.

5 DATA ANALYSIS, CONCLUSION AND RECOMMENDATION

5.1 Method

The method employed in the thesis project was a case study of Nigeria which is the biggest economy and most populous country in Africa. This research work was narrowed down to a case study of Nigeria rather than all the West African countries since it is an exemplary economy for the other West African countries and because a detailed research project could be conducted within a short time (four months) especially for the purpose of this thesis project served.

5.2 Research instrument

The research instruments employed in the thesis project included open-ended interviews, company reports, and the use of informants. Several organizations were contacted such as associations, private organisations and government agencies. These organisations were Nigerian Electricity Regulatory Commission (NERC), Energy Commission of Nigeria (ECN), Manufacturers Association of Nigeria (MAN), Nigerian Association of Small and Medium Enterprises (NASME), Nigeria Alternative Energy Expo (NAEE), and the focus group is the telecommunication companies (MTN Nigeria Communications Ltd, Etisalat Nigeria, Globacom Nigeria, Airtel Nigeria, Multilinks Telecommunications Company, Starcomms Plc., Zoom mobile Nigeria). Others were informants such as family and friends who works with different organisation and chief of a village. These interviews were done through emails and phone conversations.

5.3 Findings and presentation of results

The author gathered the findings through articles, literature in the field, internet, email and phone conversations with organisations and local persons.

Nigeria is blessed with abundant primary energy resources which include non-renewable energy resources such as natural gas, crude oil, coal and tar sands; and renewable energy sources such as hydro, biomass, wind and solar. However, there is a high dependence on the consumption of oil and gas for commercial energy which has reduced the development of renewable energy in Nigeria and the country has found itself in a serious energy crisis which has been affecting the growth and development of every sector of its economy.

The Nigerian vision 20:2020 is to become one of the largest economies in the world and to establish itself as a significant player in the global economic and political arenas. The government has set up an Economic Transformation Agenda. This includes an ambitious target to generate 40,000 MW by 2020 even considering the low power generation currently.

Electrifying Nigeria has been definitely sighted to be an instrument that will facilitate the economic boom and the government are doing everything to make this possible by employing a mix of energy resources especially different forms of renewable energy.

The government concluded the first phase of privatization of the power sector in November 2013. The government-owned Power Holding Company of Nigeria which had responsibility for the generation, transmission and distribution of electricity was sold to the private sector to increase efficiency and profitability.

The second phase of the privatization, which is underway, relates to the sale of ten government-owned independent power projects, called National Integrated Power Projects (NIPPs). This renewed focus on privatization of the Nigerian power sector provides opportunities for international and local investment. Nigerian Bulk Electricity Trading Plc. (NBET) is already able to buy power from all generation companies and sell this competitively in the open market. The government regulatory agencies have provided incentives for investments in renewable energy projects including feed-in tariffs, easy licensing procedures, access to land and import duty waivers.

Another positive aspect is that Nigeria has geographic and climatic conditions which are particularly well suited for solar and hydropower projects.

There are already companies from Germany, the USA, Korea and Japan coming to Nigeria to invest in the power sector. Many of these foreign companies are already conducting major RE projects for the government but there are still opportunities for servicing the telecommunication companies, local communities, manufacturing companies, the housing industry and so on.
There is also a new government coming into power by May 29th in 2015 when the president-elect will be sworn in and the just concluded election in the country showcased the advancement in Nigeria's democracy. The conclusion of the election has boosted the Nigerian stock exchange. All this proves that this Africa's most populous country is offering great opportunities to foreign investors.

In Nigeria, investments in renewable energy have a large potential for growth given the large gap between energy demand and supply and the enormous renewable energy resources available. This gap can only be filled by stakeholders (financial institutions and RE service providers).
The rural areas are starved of power supply and the urban areas are not getting enough of energy. Solar and/or wind powered electricity are cost-effective in areas where electricity cannot be supplied, especially in the rural, riverine and remote areas.

Electrifying Nigeria will be a source of economic and social development that will improve the citizens' quality of life, and bring about developments akin to telecommunications. Electrification will reduce urban immigration,

create employment opportunities and reduce crime, which will translate into providing a conducive political environment in Nigeria.
Electricity generation through renewable forms of energy reduces environmental pollution and fits into the European Union (EU) member state framework for cooperation with Nigeria which will provide an opportunity for technology transfer for foreign companies.

5.4 Conclusion

There is no doubt that Nigeria has abundant renewable energy resources such as high intensity solar energy resources throughout the country; large forests and farmlands that can be used for cultivating plants for biofuels; wind energy potential, and large numbers of dams and other water resources that can be used to generate hydropower. Most of these potential resources are not fully utilized to overcome the energy poverty in the country.

There is a need to develop strong and well integrated steering frameworks which will boost access to renewable energy services and encourage energy efficiency measures. This framework will also ensure the growth of the renewable energy sector and energy efficiency contribution in Nigeria.

An overall national renewable energy and energy efficiency policy is also needed and requested by foreign investors who wish to invest in the nation's economy based on a national strategy program instead of a project based approach. Thus, a viable energy policy will be a game changer for Nigeria's energy crisis.

There were limitations to the outcome of this thesis work due to a time constraint and a low responsiveness of the interviewees (companies that were contacted). There were several phone conversations and multiple emails sent to individual and companies but only four contacts responded out of the fifteen organisations that was contacted by the completion of this research work.

Getting information from a long distance from Finland to Nigeria was a major setback; the best option would have been to visit the location in person, especially since organisations in Nigeria hardly give attention to person(s) unless they have established relationship beforehand with such entity.

5.5 Recommendation

Based on the results, the following recommendations were made by the author. Renewable energy companies, especially a company like Hanlog Oy, that intends to do business in Nigeria, would have to first find a medium to showcase their concept in Nigeria to create an awareness of their existence and to get linked to potential partners and customers. This can be

achieved by attending an energy expo where the stakeholders and foreign investors meet.

The Nigeria market is difficult to penetrate by a foreign investor (Hanlog Oy) without a partnership with a right local RE service provider that can easily help advertise the company's concept to potential customers or contact to any tier of the government that could award contracts.
The staff of Hanlog's potential partner or subcontractor in Nigeria can be trained on the design, construction, maintenance and operation of Hanlog's unique systems to the reduce cost of operations and to achieve mass production and sales.

The Government needs to further educate the public on the need to embrace renewable energy, to introduce training for RE in tertiary institutes and the government at all levels should create an enabling environment for businesses to strive with a guarantee for full cost recovery and reasonable returns on investment.

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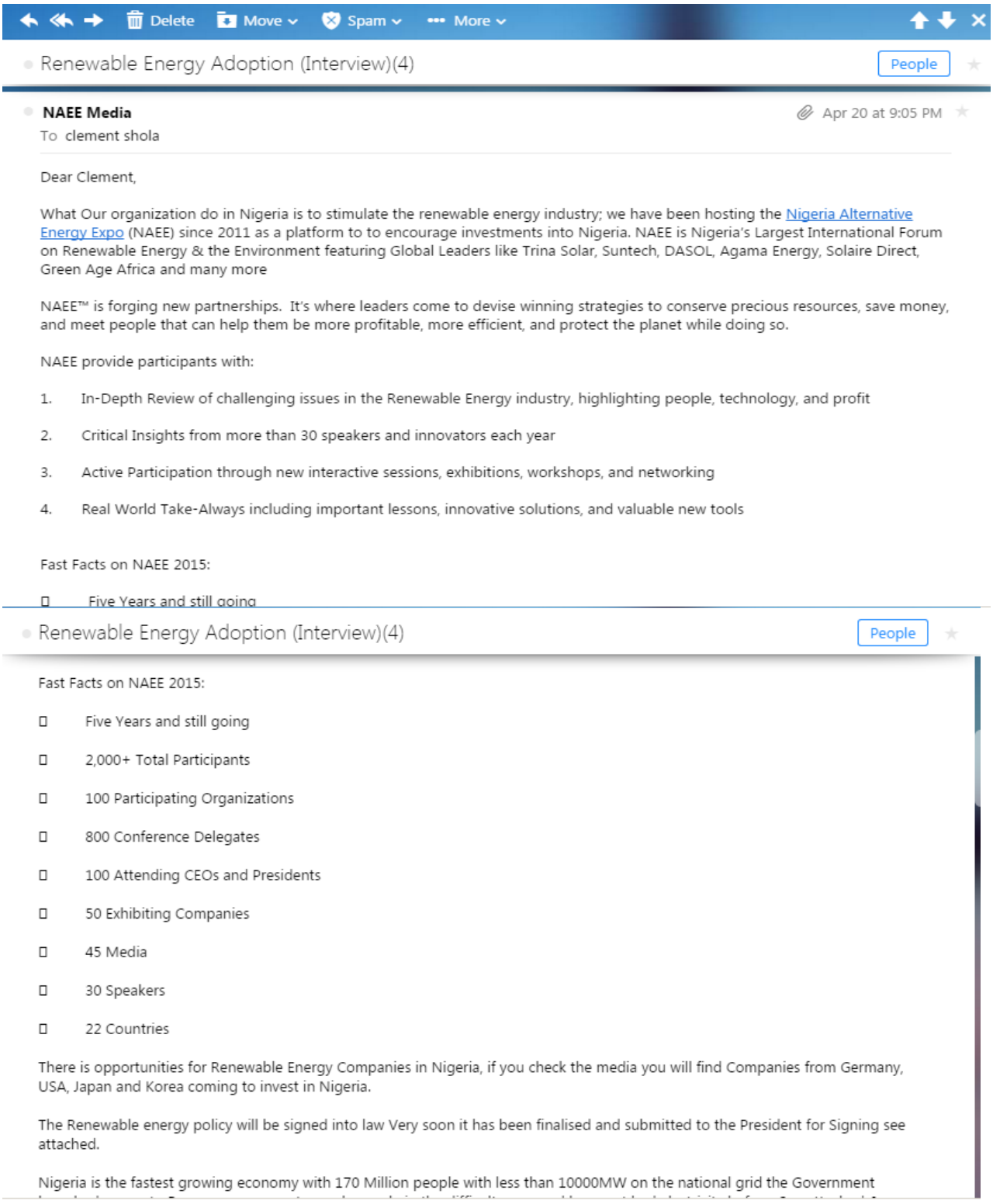
BUSINESS PROSPECTS OF RENEWABLE ENERGY ADOPTION IN WEST AFRICA (A CASE STUDY OF NIGERIA)

Appendix 1

EMAIL CONVERSATIONS



Delete Move Spam More

Renewable Energy Adoption (Interview)(4) People

NAEE Media Apr 20 at 9:05 PM

To clement shola

Dear Clement,

What Our organization do in Nigeria is to stimulate the renewable energy industry; we have been hosting the Nigeria Alternative Energy Expo (NAEE) since 2011 as a platform to to encourage investments into Nigeria. NAEE is Nigeria's Largest International Forum on Renewable Energy & the Environment featuring Global Leaders like Trina Solar, Suntech, DASOL, Agama Energy, Solaire Direct, Green Age Africa and many more

NAEE™ is forging new partnerships. It's where leaders come to devise winning strategies to conserve precious resources, save money, and meet people that can help them be more profitable, more efficient, and protect the planet while doing so.

NAEE provide participants with:

1. In-Depth Review of challenging issues in the Renewable Energy industry, highlighting people, technology, and profit
2. Critical Insights from more than 30 speakers and innovators each year
3. Active Participation through new interactive sessions, exhibitions, workshops, and networking
4. Real World Take-Always including important lessons, innovative solutions, and valuable new tools

Fast Facts on NAEE 2015:

- Five Years and still going

Renewable Energy Adoption (Interview)(4) People

Fast Facts on NAEE 2015:

- Five Years and still going
- 2,000+ Total Participants
- 100 Participating Organizations
- 800 Conference Delegates
- 100 Attending CEOs and Presidents
- 50 Exhibiting Companies
- 45 Media
- 30 Speakers
- 22 Countries

There is opportunities for Renewable Energy Companies in Nigeria, if you check the media you will find Companies from Germany, USA, Japan and Korea coming to invest in Nigeria.

The Renewable energy policy will be signed into law Very soon it has been finalised and submitted to the President for Signing see attached.

Nigeria is the fastest growing economy with 170 Million people with less than 10000MW on the national grid the Government

BUSINESS PROSPECTS OF RENEWABLE ENERGY ADOPTION IN WEST AFRICA (A CASE STUDY OF NIGERIA)

Renewable Energy Adoption (Interview)(4) People

Nigeria is the fastest growing economy with 170 Million people with less than 10000MW on the national grid the Government launched access to Power programme to reach people in the difficult areas and have not had electricity before, See attached. I strongly believe RE is the only way to get the Power need to grow the economy.ye

Some useful Links

http://www.slideshare.net/Mathesisslides/national-renewable-energy-and-energy-efficiency-policy-nreeep-for-the-electricity-sectorfinal-re-ee-policy-draft-viii-17062014

http://www.slideshare.net/Mathesisslides/naee-2013-bank-of-industry-presentation

http://www.slideshare.net/Mathesisslides/overview-of-renewable-energy-and-energy-efficiency-project-by-segun-adaju

http://www.slideshare.net/Mathesisslides/lightup-nigeria-programme

Hope this helps; You can still call me if you want to +27 73 443 8850, we look forward to seeing in Nigeria in October, If you can bring and finish company we normally offer 20% commission.

Regards,

Chris Edeh
Director

RENEWABLE ENERGY ADOPTION (INTERVIEW REQUEST) People

To care@etisalat.com.ng

Dear Sir/Ma,

I am a student of Häme University of Applied Science in Valkeakoski, Finland and at the moment i am doing a thesis project for the completion of my Bachelor of Engineering in Industrial management. The thesis topic is 'Business prospects of renewable energy in West Africa. A case study of Nigeria' and the commissioner of my thesis project is a renewable energy (RE) company in Finland (Hanlog Oy (with a multi-functional concept comprising solar energy, clean water technology, drip irrigation and salt production)) that have strong interest in coming to do business in Nigeria. I would be glad to have your contribution to the success of this research work.

I write to schedule an interview time with any of your personnel who would be able to give me the required information that will aid my research. My question will be focusing on the followings:

1. What are the plans of your organisation towards utilizing renewable energy to power your offices, stations and the mast?
2. Will your organisation be willing to pay to get power supply from small power producers like (Hanlog Oy, Finland) ?
3. Do you welcome the idea of a foreign investor on RE especially solar Power doing business with your organisation?
4. Hanlog concept generates 10 times more power than fresnel traditional system and a lot cheaper, do you see your company a potential customer for Hanlog Oy?
5. Is there an enabling environment for an RE firm like this (Hanlog Oy Finland) in Nigeria ?
6. What are the plans of the government to enable RE firms do business successfully?

Interview!(2) People

clement shola Mar 23

To info@nercng.org

Dear Sir/Ma,

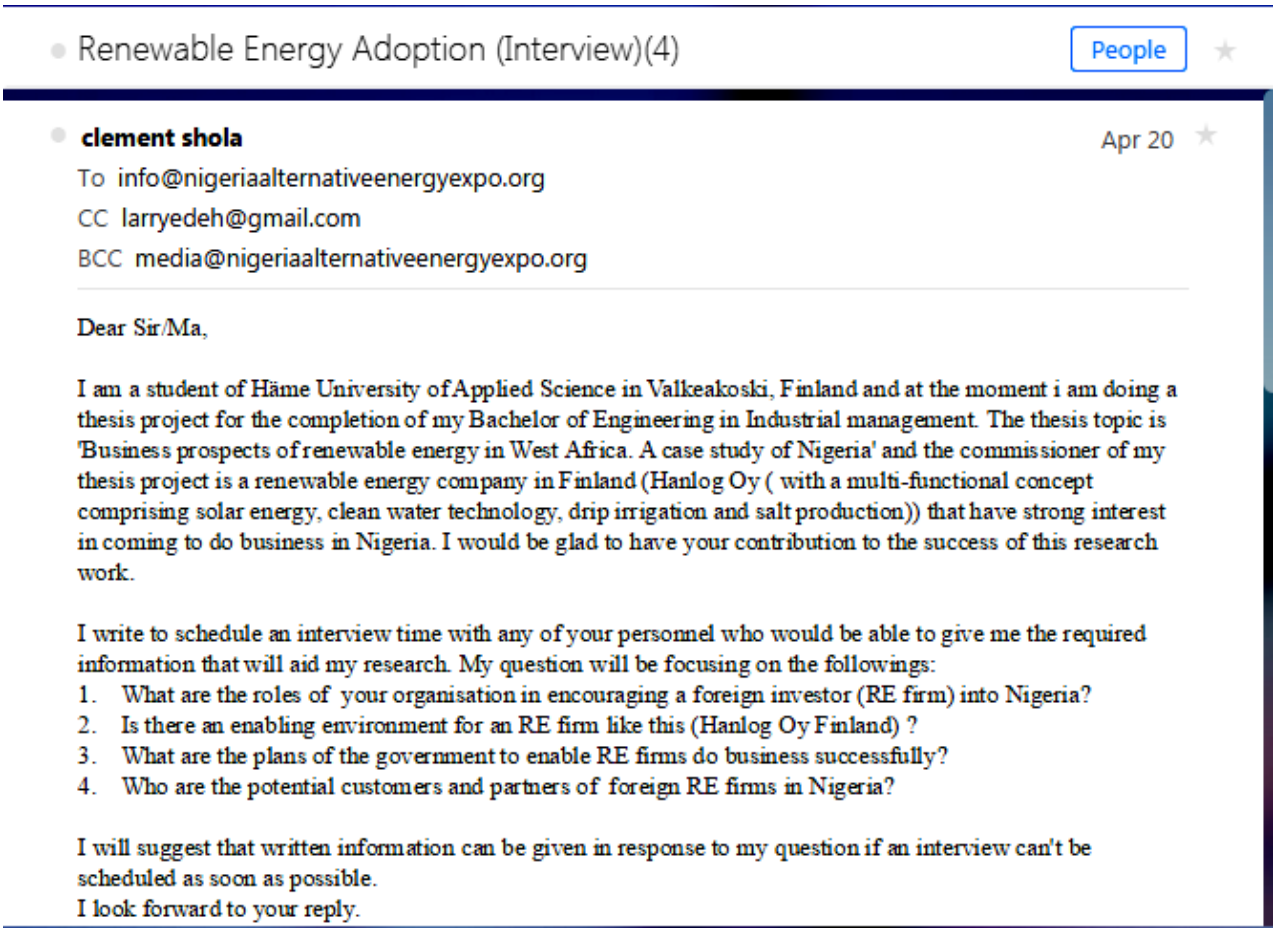
I am a student of Häme University of Applied Science in Valkeakoski, Finland and at the moment i am doing a thesis project for the completion of my Bachelor of Engineering in Industrial management. The thesis topic is 'Business prospects of renewable energy in West Africa. A case study of Nigeria' and the commissioner of my thesis project is a renewable energy company in Finland (Hanlog Oy (with a multi-functional concept comprising solar energy, clean water technology, drip irrigation and salt production)) that have strong interest in coming to do business in Nigeria. I would be glad to have your contribution to the success of this research work.

I write to schedule an interview time with any of your personnel who would be able to give me the required information that will aid my research. My question will be focusing on the followings:

1. How easy is it to procure operation licence for a foreign investor?
2. What are the factors that your organisation have in place that could attract a foreign investor (RE firm)?
3. Is there an enabling environment for an RE firm like this?
4. What are the plans of the government to enable RE firms do business successfully?

I will suggest that written information can be given in response to my question if an interview can't be scheduled as soon as possible.
I look forward to your reply.

Best Regards,
Clement Ogundipe



Renewable Energy Adoption (Interview)(4) People

clement shola Apr 20

To info@nigeriaalternativeenergyexpo.org
CC larryedeh@gmail.com
BCC media@nigeriaalternativeenergyexpo.org

Dear Sir/Ma,

I am a student of Häme University of Applied Science in Valkeakoski, Finland and at the moment i am doing a thesis project for the completion of my Bachelor of Engineering in Industrial management. The thesis topic is 'Business prospects of renewable energy in West Africa. A case study of Nigeria' and the commissioner of my thesis project is a renewable energy company in Finland (Hanlog Oy (with a multi-functional concept comprising solar energy, clean water technology, drip irrigation and salt production)) that have strong interest in coming to do business in Nigeria. I would be glad to have your contribution to the success of this research work.

I write to schedule an interview time with any of your personnel who would be able to give me the required information that will aid my research. My question will be focusing on the followings:

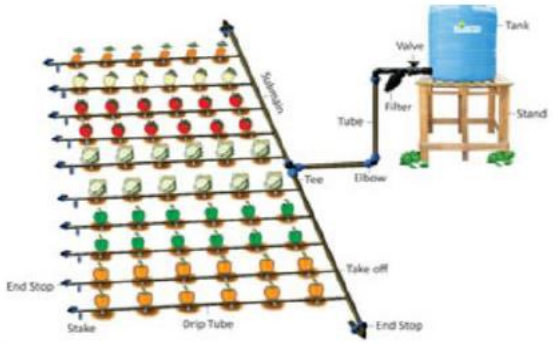
1. What are the roles of your organisation in encouraging a foreign investor (RE firm) into Nigeria?
2. Is there an enabling environment for an RE firm like this (Hanlog Oy Finland) ?
3. What are the plans of the government to enable RE firms do business successfully?
4. Who are the potential customers and partners of foreign RE firms in Nigeria?

I will suggest that written information can be given in response to my question if an interview can't be scheduled as soon as possible.
I look forward to your reply.

Appendix 2

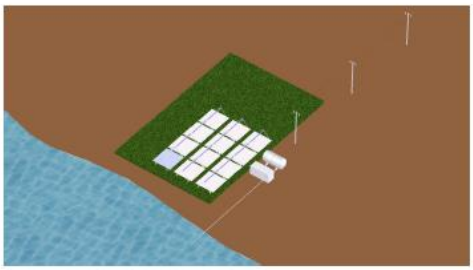
HANLOG'S PRESENTATION

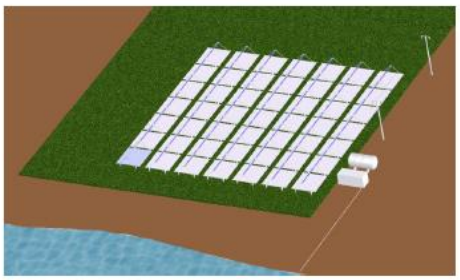
Drip irrigation makes sence



Drip irrigation will save water. The water for each plant can be controlled. Also nutrients can be controlled plant by plant. That enables grow of different plants despite of the soil type.

System is scalable based on modules



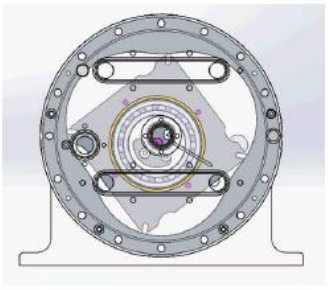


System is module based and is freely scalable by the needs of a customer. The size of one base module is 36 m^2.

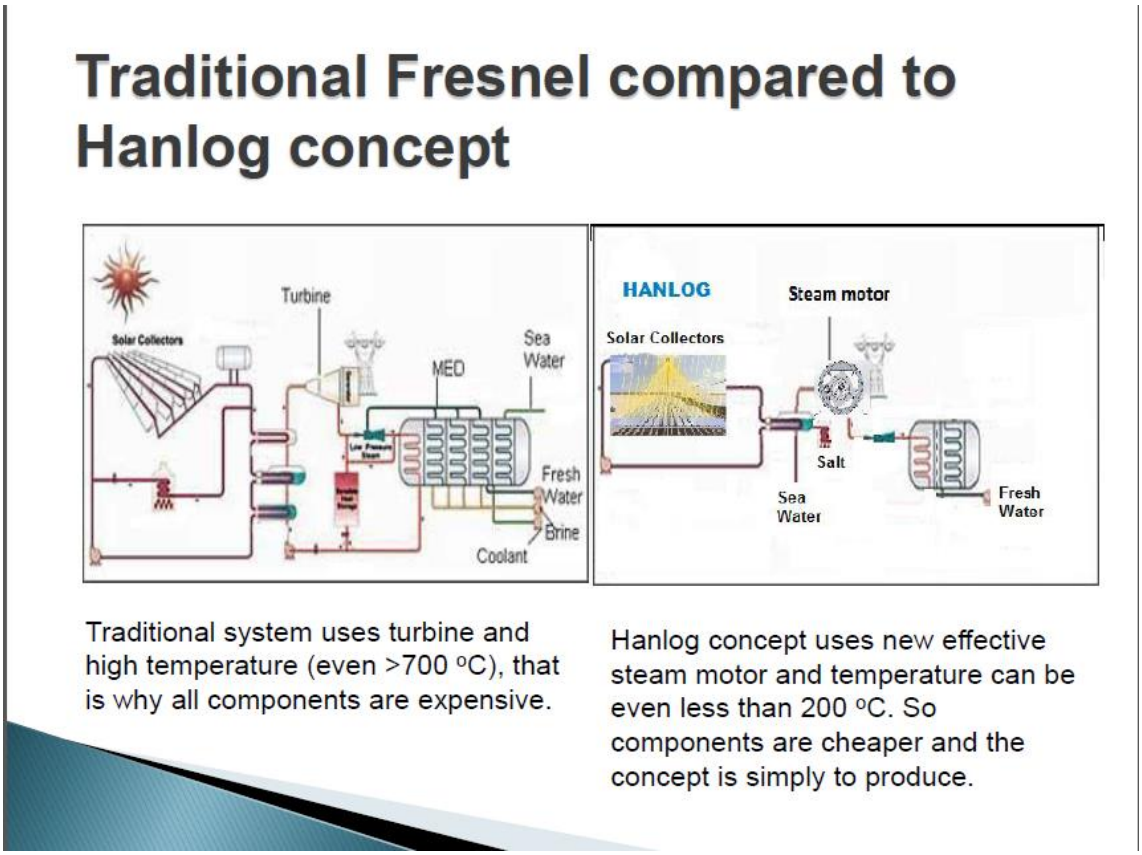
	Mirrors	Electricity	Fresh Water
1 module	36 m2	1,44 kWh	0,144 m3/h
28 mod	1008 m2	40 kWh	4 m3/h
500 mod	18000 m2	720 kWh	72 m3/h
100000 mod	3,6 km2	144 MWh	14400 m3/h

Solar heat collection is based on Linear Fresnel – technology and for mechanical energy we use new type of steam motor

Collector



Steam motor



Appendix 3

NAMES OF ORGANIZATION AND INFORMANTS

Energy Commission of Nigeria (ECN)	http://www.energy.gov.ng/
Nigerian Electricity Regulation Commission	http://www.nercng.org/
Nigeria Alternative Energy Expo	http://www.nigeriaalternativeenergyexpo.org/
Manufacturers Association of Nigeria	http://www.manufacturersnigeria.org/
National Association of Small and	http://nasmelagos.org/

Medium Enterprises	
Etisalat Nigeria	www.etisalat.com.ng
Zoom Nigeria	www.zoomnigeria.com
Starcomms	www.starcomms.com
MTN Nigeria	http://www.mtnonline.com
Globacom	www.gloworld.com
Airtel Nigeria	http://africa.airtel.com/wps/wcm/connect/africarevamp/nigeria/home
Mr. Gbolagade S. Morakinyo	EMEL Hospital, Festac Lagos, Nigeria Electrical /System Engineer
Mr. Stephen O. Olutayo	Office of Surveyor-General, Secretariat Ibadan, Nigeria Asst. Head of Department
Chief David A. Ogundipe	Palace of Onisenlu, Odo Isenlu Town, Ogun state , Nigeria Otunba Ademuyewo of Onisenlu of Odo Isenlu