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The Cost of Telecommunications Evolution in Nigeria

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Abstract
One of the fastest growing segments of the ICT Sector is the Mobile Telecommunications and in the African Market, Nigeria has witnessed phenomenal growth since the full liberalisation of the Telecommunications Sector. Nigeria is now considered to be the leading Mobile Telecommunications Market in Africa in terms of Subscribers' Base, Tele density and inflow of Foreign Direct Investment according to the Nigerian Communications Commission (NCC), which is the Organisation saddled with the regulatory responsibility of the sector.
However, the rapid growth of Mobile Telecommunications is not without its challenges as the adoption of Mobile Communication Services in Nigeria means the rollout of several Base Transceiver Stations (BTS) operating on diesel fuels because so many parts of the Country lack reliable electricity supply. The costs associated with this form of power supply as stated in this article are:

- environmental – it increases the carbon footprints of the industry through the emission of CO_2 and adds to the effect of climate change;
- economic – as the operating expenditure (OPEX) of telecommunications operators increases due to direct and indirect costs in powering the BTS sites; and
- Security challenges – which mostly involves diesel fuel pilfering and vandalisation of BTS sites.

With the understanding of the effects of the use fossil fuel generators to power BTS sites, it appears to be highly unsustainable if the current gains in the Nigerian telecommunications industry are to be sustained. Hence, it is important to have a comprehensive policy framework that embraces - sustainable renewable energies, as well as hybrid energy systems, enforcement of policy guidelines on security of telecommunications infrastructure, provides different funding options for renewable energies, and supports funding of research into renewable energies. This article attempts to provide an understanding of the effects of fossils fuels usage vis-à-vis telecommunications infrastructure and a roadmap for the regulatory agencies in charge of this Sector in addressing the various challenges.
Keywords: Mobile Telecommunications; Renewable Energy; BTS; Fossil Fuel Power; Policy.

1. Introduction

The overall contribution of the Information and Communications Technology (ICT) Sector to the socioeconomic activities and technological development of a Nation has been enormous. Such ICT Systems appears to be the core of today's knowledge based society as innovations in this sector are readily adapted at stupendous pace and its worldwide use soaring in recent years.

One of the fastest growing segments of the ICT Sector is the Mobile Telecommunications and in the African Market, Nigeria has witnessed phenomenal growth since the full liberalisation of the Telecommunications Sector 2000. Nigeria is now considered to be the leading Mobile Telecommunications Market in Africa in terms of Subscribers' Base, Tele density and inflow of Foreign Direct Investment according to the Nigerian Communications Commission (NCC), which is the Organisation saddled with the regulatory responsibility of the sector.

However, the rapid growth of Mobile Telecommunications is not without its costs as it can create network congestion and poor quality of service delivery particularly, when there is limited capacity (Okundamiya, et al. 2014). Furthermore, the adoption of Mobile Communication Services in Nigeria means the rollout of several Base Transceiver Stations (BTS) operating on diesel fuels because so many parts of the Country lack reliable electricity supply. Due to the fact that the Mobile Telecom Networks require vast amount of energy, Markets such as Nigeria which has unreliable grid power, tend to rely on fossil fuels which act as supplements to the Utility grid or exclusively, in remote rural areas. According to Ike, et al. (2014), Nigeria alone already uses well over 150 million litres of diesel fuel every year to power its Telecom BTS when the grid power is not present or not available.

This article attempts to provide an understanding of the effects of fossil fuels usage vis-à-vis telecommunications infrastructure and a roadmap for the regulatory agencies in charge of this Sector in addressing the various challenges.

2. Growth in Telecommunications sector in Nigeria

Examining the trends in the Nigerian telecommunications market will confirm the huge strides that have been achieved. Key indicators showing the unprecedented growth in the sector include the following - high active voice subscriptions, remarkable teledensity growth, Active internet subscription, contribution to the growth rate of GDP and employment generation according to the Nigerian Communications Commission.

In terms of active subscriptions for voice, figure 1 below indicates that from less than 500,000 lines in 1999, the industry has experienced the highest subscriber growth rates for voice in Africa, standing slightly above one hundred and thirty eight million active lines as at the end of 2014. The trend is very commendable – from slightly above two million in 2002 to over fifty million in 2008 and one hundred and ten million in 2012 (see figure 1).

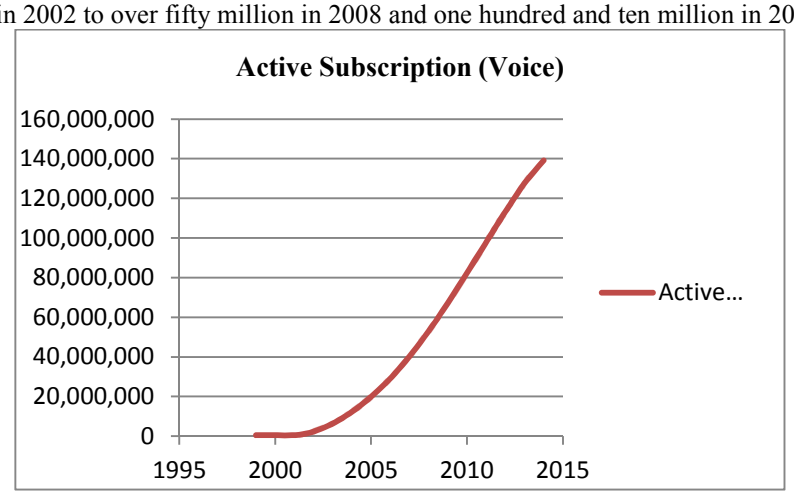

Figure 1 Voice Active Subscription (selected years)[69]

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

Furthermore, the teledensity which according to the International Telecommunications Union (ITU) is the number of lines per 100 inhabitants rose from just 0.45 in 1999 to 1.89 in 2002 and a huge leap to 16.27 in 2005 and 38.08 in 2008. From 2012, 2013 and 2014 the teledensity was 80.85, 91.15, and 99.39 respectively (See figure 2).

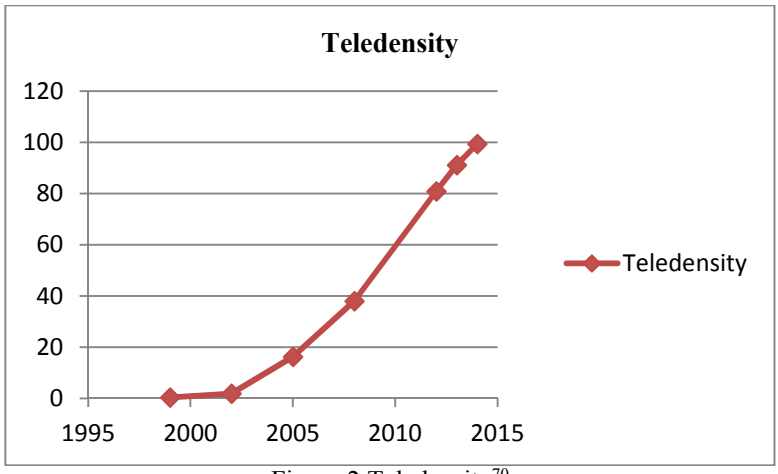

Figure 2 Teledensity[70]

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

Another remarkable milestone recorded in the industry is the gradual increase in the total number of internet subscriptions. Available statistics shows a steady increase on a monthly basis. From slightly above thirty million in December, 2012, it rose to over fifty million six months later. Appreciable growth were further observed in the periods August, November and December, where consistently it added around two million subscribers for each month (see figure 3).

[69] See table 1 in appendix 1 for actual data
[70] See table 2 in appendix 1 for actual data

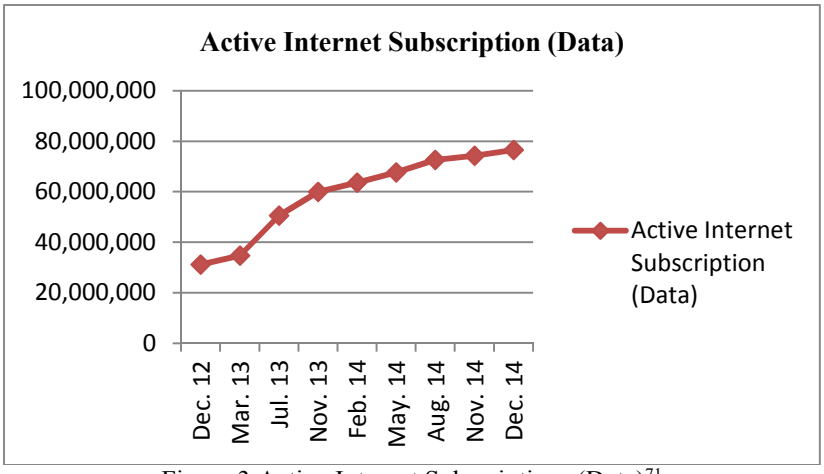

Figure 3 Active Internet Subscriptions (Data)[71]

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

The contribution of the telecommunications sector to the Gross Domestic Product (GDP) of the Nigerian economy has also been impressive. Although its contribution fell from 8.9% in 2010 to 7.4% in 2013, it rose marginally to 7.6% in 2014 (see figure 4). This however is very significant as between 1999 -2006, the contribution of Telecommunications sector the GDP has been less than 2% (see figure 5).

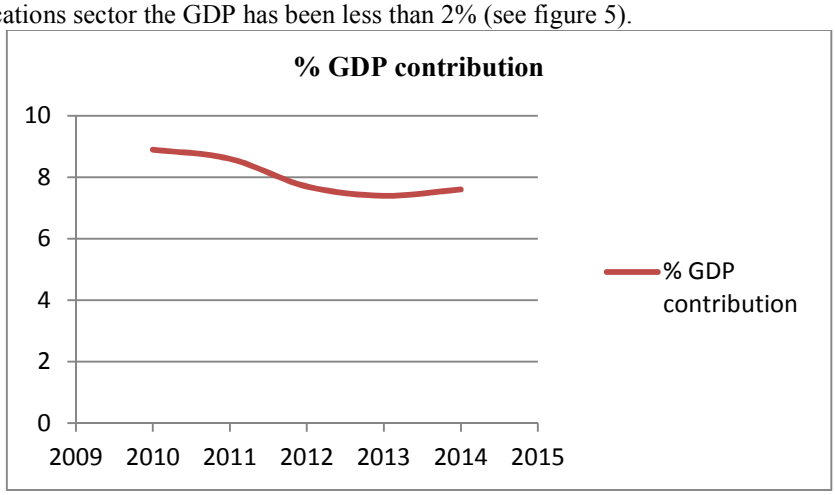

Figure 4 Percentage Contribution of telecoms to GDP (2010-2014)

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

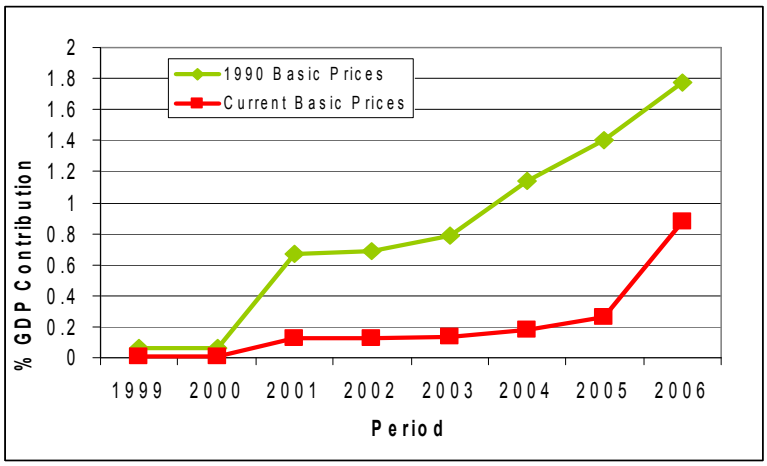

Figure 5 Percentage Contribution of Telecommunications sector to GDP (1999-2006)

Source: NBS National Accounts of Nigeria (1999-2006)

The telecommunications sector has also contributed immensely to generating employment for Nigerians.

[71] See table 3 in appendix 1 for actual data

More than one million jobs have been created in direct and indirect employment according to the NCC. Handset shops, accessories dealers, phone trouble shooters and call centres are found in several corners of the streets and business districts contributing greatly to service accessibility.

However, the remarkable growth in the Nigeria's telecommunications industry over the past decade comes with some challenges which require urgent policy measures. The lack of adequate power supply in the country means that several of the BTS rely on diesel fuelled generating sets to meet up with the remarkable growth rates currently being experienced and this poses a huge challenge environmentally and otherwise. Hence, it is very important to note that as Nigeria strives to grapple with the rapid growth of the telecommunications industry, understanding and appreciating the effects of diesel generating set which provides power to the BTS across the country appears to very critical in sustaining this rapid expansion.

3. Mobile Telecommunications Network

Most Major *telecommunications* operators have installed voice and data mobile *networks* over several parts of the world and this has allowed for the use of mobile phones and other electronic devices to be connected to public switched telephone networks and the internet. The effect of this is very high volume of telecommunication services around the world. Globally, around 3 billion users spend large portions of their income on such services (Ike, et al. 2014). To sustain such growth in telecommunication services, particularly in Nigeria, a robust telecommunications network infrastructure is very crucial.

Succinctly, the telecommunications network consists of three basic components according to Saxena and Jadon (2013); Adeyinka (2001). These are:

1. The Mobile Switching Centre (MSC) – this according to Adeyinka (2001) represents the technological heart of the telecommunications system as it performs the central operating function of connecting calls within and between networks;
2. Radio Base Station (RBS) or Base Transceiver System (BTS) – this works between the network and mobile terminal and acting to provide the frequency interface between user and the network (Saxena and Jadon, 2013); and
3. Mobile Terminals or Mobile Stations – it is responsible for sending and receiving signals (Adeyinka, 2001). This represents the subscriber's part and it involves the mobile handsets and the Subscriber's Identity Module (SIM) (Saxena and Jadon, 2013).

Following the understanding that over 85% of the total energy consumption of telecommunications infrastructure is on operating operations, the BTS is very critical particularly as they are deployed in large numbers (Saxena and Jadon, 2013). This is even of more concern to a developing country like Nigeria that relies on the use of fossil fuelled generators to power most base stations, of which this article is restricted to.

A Standard Mobile base Station according to Gross (2012) consist of a tower or mast mounted with telecommunication equipment (antenna, radio receiver and transmitter at the top of the mast that enables the transmission of mobile signals (voice and data). See figure 6.

Figure 6 A Typical BTS

Source: http://newngrguardiannewscom.c.presscdn.com/wp-content/uploads/2015/02/Telecoms-Mast.jpg

Furthermore at the bottom of the tower or mast as the case may be is a shelter with additional transmission equipment, air conditioning, battery racks and for those that are off-grid or unreliable electricity (like most developing countries such as Nigeria), is a diesel generating Set – usually a set of two (Gross, 2012).

The growth rate of BTS deployment in Nigeria has been relatively slow (Okonji, 2013**)** and this is as a result of expensive and complex civil works, high installation and commissioning costs, expensive or not available

electricity due to poor power infrastructure, security challenges, multiple taxation fees and levies, multiple regulation, un-standardised application and approval processes (Okonji, 2013; Infinite Focus Group)

At the inception of the deregulation of the telecommunications industry in Nigeria, there were less than 200 BTS in the whole country which has a land mass of over 900, 000sqms. By 2003, the total BTS had risen above 1,800. However, by 2007, it was approaching the 10,000 figure mark. It further increased to 25,374 in 2011 and then to 26,500, 30411 and 31133 in the years, 2012, 2013 and 2014 respectively. See figure 7 and table 5 in appendix 1

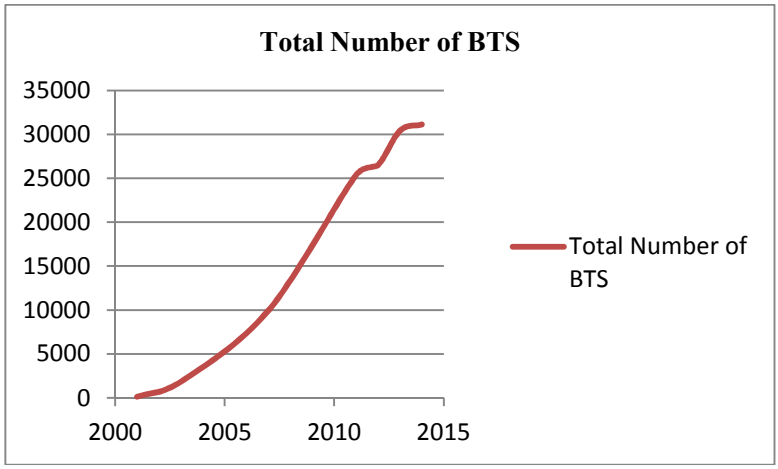

Figure 7 Total BTS in Nigeria (selected years)

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC; Okonji (2013)

Nigeria has one of the lowest per capita electricity consumption in the world at 121kWh which is mainly attributed to extremely low power generation capacity (GSMA, 2013) and the epileptic nature of the power supply in Nigeria means that the telecommunications towers/masts consume about 1.4 million litres[1] of diesel to power the BTS[2] which makes it possible for subscribers to make and receive calls in a day (Onwuegbuchi, 2015). This is is because as further observed by Onwuegbuchi (2015), that telecommunications towers run on fossil fueled generating sets for an average of 20 hours in Nigeria.

4. Impacts of Fossil Fueled powered BTS

The unreliable grid power supply in Nigeria has forced mobile telecommunications operators to rely heavily on diesel power as either back up for the frequently interrupted on-grid power supply or total power source for off-grid (which include remote sites in rural areas with very poor road infrastructure) to run their networks. This however comes with some consequences which are enumerated in this article.

A typical BTS with a 4.8kW site load as illustrated by Gross (2012) will consume 34 litres of diesel per day and over 12,000 litres in a year. A litre of diesel produces 2.68kg of CO_2[3] and this equates to an annual carbon footprint of 33.2 tonnes of CO_2. In Nigeria, an on-grid BTS site consumes on the average, 1500 litres of diesel per month while an off-grid BTS site consumes over 1700 litres of diesel per month (GSMA, 2013). This translates to a minimum addition of 48.2 tonnes of CO_2 annual carbon footprint for on-grid BTS site and a minimum addition of 54.7 tonnes of CO_2 annual carbon footprint for off-grid BTS site. With a minimum total of 1.4 million litres of diesel consumed by the total BTS sites in Nigeria per day (Onwuegbuchi, 2015), it means that there is a minimum addition of over a million metric tonnes of CO_2 carbon footprints being added to the environment every year from the operations of BTS sites in Nigeria.

The implication of this is that whilst the telecommunications industry in Nigeria has witnessed an appreciable growth as evidenced in the statistical data provided in this article, its impact on the environment

[1] This means that 20,000 of co-located towers in the country that uses 27KVA generator consumes some 1.2 million litres of diesel a day, while towers that house single base station which are 5,000 consume 200,000 litres of diesel a day bringing the total consumption of generators deployed in towers around the country to 1.4 million litres per day (Onwuegbuchi, 2015). Furthermore, a co-located tower houses 3-5 BTS and uses 27 KVA generator while a single tower houses a single BTS and uses a 15KVA generator (Onwuegbuchi, 2015).

[2] In terms of the electricity consumption by the BTS, Gross (2012) provides this as follows: transmitters - 54%; air conditioning – 35%; and other equipment – 11%.

[3] http://people.exeter.ac.uk/TWDavies/energy_conversion/Calculation%20of%20CO2%20emissions%20from%20fuels.htm

through CO_2 emissions[1] considered as the primary Greenhouse Gas (GHG)[2] according to the United States Environmental Protection Agency (USEPA) and the International Panel on Climate Change (IPCC) has been on the increase. As the number of BTS sites built increases in the various years (see table 5 in appendix 1), the CO_2 emissions will appear to increase because of the reliance on diesel to power these sites. The resultant effect is that the Nigerian Telecommunications industry is contributing to the destructive environmental impact of climate change of which some of the effects according to USEPA are (see also IPCC):

- Warmer temperatures increase the frequency, intensity, and duration of heat waves (most Northern States in Nigeria appears to be at risk), which can pose health risks, particularly for young children and the elderly;
- Rising sea levels threaten coastal communities and ecosystems. This is particularly dangerous coastal areas Niger Delta Area where hydrocarbons are explored and exploited and Lagos, the commercial nerve centre of Nigeria;
- Changes in the patterns and amount of rainfall, as well as changes in the timing and amount of stream flow, can affect water supplies and water quality and the production of hydroelectricity;
- Changing ecosystems influence geographic ranges of many plant and animal species and the timing of their lifecycle events, such as migration and reproduction; and
- Increases in the frequency and intensity of extreme weather events, such as heat waves, droughts, and floods, can increase losses to property, cause costly disruptions to society, and reduce the availability and affordability of insurance.

In addition to the poor grid power supply, Nigerian telecoms operators face huge Operating Expenditure (OPEX). These according to GSMA (2013), can be divided into two broad categories – Direct costs and Indirect Costs (see table 6)

Table 6 – Powering Cost of BTS Site of a Telecoms Operator

	Direct Costs	**Indirect Costs**
On-grid	Grid Power costs, cost of grid power outage (diesel back up power costs)	Power equipment maintenance including diesel generators and other power systems components, and overheads
Off-grid	Diesel power costs	Equipment maintenance including diesel generators, battery maintenance, overheads, and cost of transporting diesel to sites

Source: GSMA (2013); modified by the author

More than half of the BTS sites in Nigeria are off-grid and are usually powered by diesel generators only; although the remaining sites are grid-connected, they suffer frequent outages lasting long hours and has invariably led to heavy dependence on diesel generators as well (GSMA, 2013). From the table above, it can be observed that diesel cost gulps a huge amount of the OPEX of the Telecommunications Operators.

The cost of diesel[3] on the average in Nigeria is 150 Nigerian Naira per litre[4] (0.75 US$). As observed earlier in this article, the daily consumption of diesel for BTS site is 1.4 million litres (Onwuegbuchi, 2015). This means a minimum of 210,000,000 Nigerian Naira (1,055,011.30 US$) is spent per day to provide power to the BTS Sites in Nigeria. These expenditures have impacted negatively on the operational capacities and increase in the overall OPEX of telecommunication firms in Nigeria with the end result of poor quality of service delivery (Ajayi, 2012).

Despite the above costs associated with the operations of the BTS sites by telecommunications firms, Site Security has been a major issue. These could be in the form of willful destruction or damage to BTS sites or diesel fuel pilferage (GSMA, 2013). In terms of damage to BTS sites, in 2012 alone, telecoms operators lost around 150 due to bombings and flooding, with many dependent BTS sites being affected as a result of these disasters (GSMA,

[1] Carbon dioxide is the primary greenhouse gas that is contributing to recent climate change. CO_2 is absorbed and emitted naturally as part of the carbon cycle, through animal and plant respiration, volcanic eruptions, and ocean-atmosphere exchange. Human activities, such as the burning of fossil fuels (of which diesel used in powering BTS sites in Nigeria is part of) and changes in land use, release large amounts of carbon to the atmosphere, causing CO_2 concentrations in the atmosphere to rise (see USEPA; modified by the author)

[2] Gases that trap heat in the atmosphere are called greenhouse gases (see http://www.epa.gov/climatechange/ghgemissions/gases.html) most common are CO_2, Methane (CH_4), Nitrous Oxide (N_2O), Fluorinated gases.

[3] The cost of diesel in Nigeria depends on oil prices in the global market as this has been fully deregulated (Ayankola, 2015)

[4] Survey conducted by the author. The exchange rate is 1 US $ is equivalent to 199.05 Nigerian Naira.

2013; Okonji, 2013).

For diesel fuel pilferage, it usually occurs in the following areas as noted by Saxena and Jadon (2013):

- The vehicles that distribute diesel are attractive targets for thefts – with operators estimating the average, 10% of fuel costs are a result of theft, which in certain cases could rise 40%-50%;
- By external distributors (tampering of fuel or incorrect book-keeping);
- Outright theft of Generating Sets (two per site);
- Loss during transit; and
- From the BTS site after diesel fuel has been supplied.

Because of the importance the BTS sites in the telecommunications value chain, security, particularly in remote areas is very significant as failure to provide such could lead to the inability of subscribers from either making calls/ browsing data or receiving calls/data.

5. Policy Framework for Creating Sustainable Energy in Mobile Telecommunications in Nigeria

Climate Change is now considered to be a major threat to sustainable growth and development in the world. The African Continent, of which Nigeria is the most populous country, contributes the least to global emissions of GHG of any continent (Yuen and Kumssa, 2010) and yet is considered to be the most vulnerable to the effects of these emissions particularly due to its high dependence on rain-fed agriculture and widespread poverty (UNFCCC, 2006). The impacts of climate change in Africa are already apparent including reduced agricultural production, rise in temperatures, threats to food security, increased flooding and drought, and so on.

Although the ICT sector contributes only about 2% of global GHG, one of the fastest growing segments of the ICT is the telecommunications and this makes up one third of the ICT's global carbon footprint (ITU, 2010). Hence, the use of fossil fuel to power a mobile telecommunications sites such as the BTS, presents huge challenges such as environmental, economic and security. This is in addition to the fact that the earth's climatic change appears to be the result of increasing concentrations of GHGs resulting primarily from fossil fuel combustion into the atmosphere (see USEPA; IPCC), yet because of the unreliable national power grid in Nigeria, such sites are either fully powered by diesel fuel or acts as back up for the frequently interrupted on-grid power supply. This appears to be highly unmaintainable if the current impressive growth in the Nigerian telecommunications industry is to be sustained.

In order to address these challenges, a policy framework which **e**ntails the following is advised. These are:

5.1 Encouraging the Use of Full Sustainable Alternative Sources of Energy to Power BTS sites in phases. Such alternative sources of energy could be Renewable Energy Sources. Renewable energy sources are derived from resources which are continuously replenished – it involves natural resources and does not cause pollution hence they are usually termed green energy sources (Boyle, 2012). Examples of renewable energy sources according to Boyle (2012) are direct solar (solar thermal and photovoltaics), indirect solar (biomass, hydro, wind and wave) and non-solar (tidal and geothermal) energy sources.

Because of the epileptic nature of power supply from the national grid of Nigeria which has led to the use of diesel fuel being used to power the BTS sites, it might be appropriate to suggest to the regulatory body, the NCC, in this case to develop a framework with legislative support, for a phased replacement of the diesel generating sets as a source of power with only renewable energy sources within a specified timeline. This framework should include the installation of sustainable renewable energy- efficient infrastructure for every new BTS sites to be built and the gradual replacement of energy inefficient BTS sites which in this case are mainly diesel fuelled.

This initiative becomes even more far reaching with the telecommunication industry striving to reduce its OPEX and to attain negligible anthropogenic emissions of CO_2, which constitutes by far the largest part of the emissions of GHGs, thereby making the environment much more responsive (Okundamiya and Nzeako, 2013). An example of the benefit of using a sustainable renewable energy source to power BTS site is offered by Ike, et al. (2014) where one 15KWp Photovoltaic installation can replace 12 diesel generator installations and save 203,000 litres of diesel in 20 years;

5.2 Closely linked to the above is the Hybrid Energy System[1] which the regulator, may also consider as an option. Recent research and development into renewable energy sources have shown excellent potential as a form of contribution to conventional power generation systems (Nema, et al. 2010). Furthermore, in order to meet sustained load demands of BTS during varying conditions, different energy sources and converters need to be integrated with each other for extended usage of alternative energy (Nema, et al. 2010). Accordingly, the hybrid system if optimally designed can be more cost effective and reliable than a single renewable energy system (Okundamiya, et al. 2014). In Nigeria, the hybrid energy system is still

[1] A **hybrid energy system**, or **hybrid** power, usually consists of two or more renewable **energy** sources used together to provide increased **system** efficiency as well as greater balance in **energy** supply (see https://en.wikipedia.org/wiki/Hybrid_renewable_energy_system; Seeling-Hochmuth, 1997)

in its infancy with some operators combining both solar and diesel fuel. However this option should be seen as a progression towards full conversion into sustainable renewable energy sources within a specific timeline if one or two of the energy sources is inefficient;

5.3 The government through the NCC and other relevant agencies should also support the enforcement and implementation of policy guidelines on Security of telecoms infrastructure which appears to add to the operational complexity and costs of running a telecom network.

Nigeria's **National Broadband Plan 2013-2018,** clearly states that –

> *"It shall be a priority for government to classify all public ICT/broadband infrastructure deployed under a national licence as a critical national security and economic resource that must be, protected from vandalisation, theft, unauthorised tampering and from enforcement action by any authority without a valid order from a high court. The enactment of an ICT Critical Infrastructure Act shall be pursued and in the interim a Federal Executive Directive shall be issued to security agencies for the administrative protection of this security sensitive and economically important infrastructure."*

Furthermore, the enactment of the 'ICT Critical Infrastructure Act' should be given priority in the policy framework as this protects BTS sites and other relevant Telecom infrastructure from vandalisation, theft, and unauthorised tampering. Modalities for addressing the 'would be' vandals should be clearly stated and enforced to deter such behaviours;

5.4 It is also important to articulate different funding options for green BTS sites in the policy framework - These funding sources should be devoid of bottlenecks that can stifle the whole process. Telecoms companies in Nigeria can tap into broader initiatives such as was suggested by Gross (2012) where a South Africa's Nedbank Capital launched a carbon-credit-related [1] initiative for African telecoms operators. This allowed the operators to access global carbon credit markets (without having to understand the complexities of those markets and regulations), and thus additional income from providing renewable power sources for their BTS sites (Gross, 2012).

Also to be included in the policy framework for funding is the provision of subsidies by government for the installation of new green BTS sites by telecoms operators around the country with specific reference to remote sites that are off-grid. This can be done through the Universal Service Provision Fund (USPF) established by the Federal Government of Nigeria to facilitate achievement of national policy goals for universal access and universal service to ICTs in rural, un-served and underserved in Nigeria (see http://www.uspf.gov.ng/); and finally

5.5 The policy framework should encourage research and development into sustainable renewable energy for the telecommunications industry through collaboration between tertiary/research institutes and telecom firms. This is because of the importance of these technologies for the future survival of the industry in Nigeria. In line with this, the policy should support adequate research funding for such schemes. Such research funds can be provided by the Tertiary Education Trust Fund (TETFUND)[2]

In summary, it would appear that for Nigeria to sustain the enormous benefits of the liberalisation the telecommunications industry, a comprehensive policy framework which addresses the following areas might be worth considering:

- Using sustainable renewable energy sources only to provide power to BTS Renewable with specified timelines. This however should be done in phases;
- Considering the use of hybrid energy system with the proviso that there is a progression towards the full conversion into sustainable renewable energy sources within a specific timeline if one or two of the energy sources is inefficient;
- Support the enforcement and implementation of policy guidelines on Security of telecoms infrastructure;
- Consider the different funding options for the installation of BTS sites available; and
- Support for the funding of Sustainable Renewable Energy Research.

6. Conclusion

This article examined the cost of telecommunications evolution in Nigeria. In examining this, the study provided an overview of the tremendous growth that has occurred in the telecommunications sector in Nigeria. However, it was observed that because of the epileptic National Power Grid System, the telecommunications firms rely heavily

[1] A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the mass of another greenhouse gas with a carbon dioxide equivalent (tCO_2e) equivalent to one tonne of carbon dioxide(see https://en.wikipedia.org/wiki/Carbon_credit).

[2] It was established as an intervention agency charged with the responsibility for managing, disbursing and monitoring the education tax to public tertiary institutions in Nigeria (see http://www.tetfund.gov.ng/index.php/interventions/types/curriculum-programme-contents-development).

on diesel generators to power their BTS sites either as back up for frequently interrupted on-grid power supply or fully powered diesel fuel for off-grid sites.

Unfortunately, there are consequences associated with this form of power supply which are: environmental – as it increases the carbon footprints of the industry through the emission of CO_2 and adds to the effect of climate change; economic – the OPEX of telecommunications operators increases due to both direct and indirect costs in powering their BTS sites; and Security challenges – which mostly involves diesel fuel pilfering and vandalisation of BTS sites.

With the understanding of the effects of the use fossil fuel generators to power BTS sites, it appears to be highly unsustainable if the current gains in the Nigerian telecommunications industry are to be sustained. Hence, it is important to have a comprehensive policy framework that embraces - sustainable renewable energies, as well as hybrid energy systems, enforcement of policy guidelines on security of telecoms infrastructure, provides different funding options for renewable energies, and supports funding of research into renewable energies. It is hoped that having such comprehensive policy framework will greatly assist in sustaining growth of the telecommunications sector in Nigeria.

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Dr. Ebinimi Tebepah's principle research interests lie in the field of Knowledge Management, Technological innovation and Spin offs with specific reference to the Petroleum and Telecommunications Sectors. During his doctoral Programme at the Manchester Business School, University of Manchester, United Kingdom, he examined Technological Innovation within the Upstream Sector of the Petroleum Industry with the application of the N-T Model of Knowledge Creation to Innovative, Value Adding Activities with Petroleum Firms.

Through practical industrial experience as a Telecommunications Regulator in Nigeria, he has tried to understand the dynamics of Knowledge Creation in this Telecommunications Industry vis-à-vis the Petroleum Sector and proffer workable solutions as policies to the Nigerian Government.

Dr. Tebepah currently works with the Bayelsa State Government of Nigeria (a state endowed with huge deposits of hydrocarbon) as an adviser of Science and Technology.

Appendix 1

Table 1 Voice Active Subscription (selected years)

Year	1999	2002	2005	2008	2012	2013	2014
Active Subscription (Voice)	**450,000**	**2,296,719**	**19,810,258**	**52,949,838**	**113,195,951**	**127,606,629**	**139,143,610**

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

Table 2 Teledensity (selected years)

Year	1999	2002	2005	2008	2012	2013	2014
Teledensity	**0.45**	**1.89**	**16.27**	**38.08**	**80.85**	**91.15**	**99.39**

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

Table 3 Active Internet Subscriptions (Data) (selected months)

	Dec. 12	Mar. 13	Jul. 13	Nov. 13	Feb. 14	May. 14	Aug. 14	Nov. 14	Dec. 14
Active Internet Subscription (Data)	31,143,861	34,637,158	50,593,576	59,894,564	63,640,926	67,629,469	72,580,325	74,241,805	76,492,866

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

Table 4 Percentage contribution of telecoms to GDP

Year	2010	2011	2012	2013	2014
% GDP contribution	**8.9**	**8.6**	**7.7**	**7.4**	**7.6**

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC

Table 5 Total BTS in Nigeria (selected years)

Year	2001	2003	2007	2011	2012	2013	2014
Total Number of BTS	**116**	**1837**	**9957**	**25374**	**26500**	**30411**	**31133**

Source: 2013 and 2014 Year end Subscriber/ Network Data Report, NCC; Okonji (2013)