Embracing the Green Communication Initiative in Powering Telecommunication Networks in Nigeria

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Alenoghena Caroline O,
Dept of TelecommunicationEngr'g ,
Federal University of Tech,
Minna, Nigeria.
alenca2@yahoo.com

Ambafi James G.
Dept of Electrical/ElectronicEngr'g,
Federal University of Tech,
Minna, Nigeria.
ambafi@futminna.edu.ng

Dauda Umar S.
Dept of Electrical/ElectronicEngr'g,
Federal University of Tech,
Minna, Nigeria.

***Abstract*—The threats to global substance necessitated by effects of global warming call for the embrace of green energy initiatives. The powering of telecommunications equipment is an enormous burden for the operators in Nigeria since it has the smallest per capita electricity consumption in the world. In this paper, the challenges faced by telecommunication service providers in powering their infrastructures are reviewed. The green energy options available for powering our telecommunication infrastructure in Nigeria are analyzed. The paper ends with a frame work on modalities to having safer and efficient power source for communication service delivery. It is anticipated that this paper will bring to light the plight of the public and telecommunication operators in sustaining good quality of service. It will also hasten the need to embrace alternative power supply that is clean and reliable in powering telecommunication base stations for better service delivery.**

Keywords- Base Station, Green Energy, Power, Telecommunication, Infrastructure

I. INTRODUCTION

The advent of telecommunications can be traced to 1838 when the first telex system was invented by Samuel Morse, and the subsequent invention of the first wireless communication device by Bell in 1880. The introduction of cellular technology by Bells laboratories in 1947 boosted the communication capacity of wireless systems [1]. The telecommunication industry experienced a great leap in the mobile sector with the release of the first handset in the UK by Vodaphone in 1985. Later the introduction of Global System for Mobile Communication (GSM) Services (operating on cellular technology), has seen mobile phone users grow steadily best described as a revolution. The world mobile cellular subscribers rose from less than 1 million in 1991 to over 6.8 billion subscribers in 2012 [2], with GSM been acclaimed as the most trendy and common personal technology on the planet [3].

In Nigeria, GSM service was introduced in August 2001, following the liberalization of the telecommunication sector and introduction of a new telecommunication policy in the year 2000 [4]. Prior to GSM introduction, telecommunication service was limited only to privileged few. GSM service in Nigeria has led to increase in the number of telecommunication users from about 500,000 in 2001 to over 120 million in 2013 with prospect for more market. As at March 2013, 97.36% of telecommunication users in Nigeria rely on the GSM platform [5]. The contribution of telecommunication sector to the gross domestic product (GDP) of Nigeria rose from 0.62% in 2001 to 8.53% in 2013 [5]. In terms of growth, Nigeria is ranked the largest and fastest growing telecom markets in Africa and among the ten fastest growing telecommunication markets in the world [6].

As the number of mobile subscribers increase, the need for more GSM base stations (BTS) to be able to meet the demand for services becomes a necessity. The growth in the number of GSM subscribers has resulted in the multiplication of the number of base stations in Nigeria. The Base stations erstwhile were very few, seem to have appeared everywhere from residential, commercial centers to highways and bye ways. As more base stations are built, the energy provision to power these facilities and their health effects becomes a cause for concern. Research has shown that mobile operators are among the top energy consumers (Telecom Italia is the second largest energy consumer in Italy). Though ICT consumes only 3% of worldwide energy its power consumption is rising at 16-20% per annum doubling every 4-5 years [7]. Globally there are about 640,000 base station sites primarily powered by diesel generators. In Nigeria 52% of the base station sites are strictly powered by diesel generators [8]. Diesel generators result in the emission of Carbon IV Oxide (CO_2) in the already polluted atmosphere further warming up the climate system. Currently companies believe that the use of green energy options could transform the telecommunications industry for the better.

In this paper, we review the green communication initiative and also the grid power supply situation in Nigeria as it affects the telecommunications industry. The viable green power options are presented with a cost estimate for setting up a 10 kVA solar power plant. The paper is rounded up with a cost analysis for powering a base station with different power options.

II. THE GREEN COMMUNICATION INITIATIVE

The presence of telecommunication infrastructures in our environment has become a subject of debate, litigation and

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apprehension. The question being asked is on the safety of base stations as it concerns radiation. Everyone, championed by the World Health Organization is concerned for the safety of our environment and populace. The green communication initiatives are moves initiated by stakeholders in the telecommunication industry joining the global campaign for a safer environment.

The warming of the climate system being experienced worldwide has been linked directly to human activities referred to as the greenhouse gas emissions. The amount of greenhouse gas in the atmosphere is increasing daily by activities such as burning fossil fuels for energy, land clearing and agriculture. Stakeholders in the industry have intensified efforts to providing cheap and environmentally friendly communication services. Efforts towards energy saving are directed to issues on protocol stack and system architectures [9]. The International Telecommunication Union (ITU) and the Three Generation Partnership Project (3GPP) have been addressing the energy efficiency trend due to the rising cost and carbon trail of operating cellular network. The green communication initiative is the major means the bodies are trying to tackle energy dart in telecommunication service delivery as well slowing down global warming. Telecommunication researches have always been centered on improving network protocols while energy efficiency efforts have been directed mostly to mobile phones and large load scenarios. The need to address energy challenge holistically is now.

The green communication initiative research areas include;

- Green Cellular Networks,
- Green Radio, and
- Energy Aware Radio and NeTworkTecHnologies (EARTH)".

The Green cellular networks covers issues on energy saving in base stations through improvement of power amplifiers, power saving protocols and cell zoning techniques [10]. The Green radio effort involves the adoption of Time Reversal (TR) technique in signal processing of radio technology. EARTH is an international project aimed at reducing the power consumption of cellular networks through the use of different approaches on the components, nodes, and links.

III. POWERING TELECOMMUNICATION BASE STATION IN NIGERIA

As a nation, Nigeria has been facing the power challenge that is yet to be resolved. Though the country has huge potentials for energy generation, these are yet to be fully utilized. A nation of over 150 million people has only about 55.2 % of the total population electrified. Those who have electricity experience it for as low as 5 hours per day. The nation still duels in darkness with many small scale businesses grounded and large production plants like the textile industry shut down for lack of grid power. Electricity consumption in Nigeria is put at 121kWh which is the lowest globally [11]. The Telecommunication sector has been worst hit, as provision has to be made for the radio equipment to be always on. Operators spend as much as 3.5 million naira for diesel generators in other to keep one base station running annually. The huge cost of powering telecommunications facilities, accounts for the high cost of services and poor services quality been experienced in the country [12].

The Base Transceiver Station (BTS) most times generally referred to as the base station is one of the major hardware components of a wireless network. The BTS is the equipment provided at a cell site by which means network coverage is provided over a given region. The BTS facilitates wireless communication between a mobile subscriber and the network. An appropriate site is selected for the installation of the BTS which is usually at the center of the cell close to the users. The hardware components of a typical BTS consist of the BTS Interface Equipment (BIE), Frame Processing Unit (FPU), Carrier Unit, Antenna Feeder System, the clock Unit and Operations/Maintenance Unit (OMU). These units are encased in a cabinet compartment. The BTS equipment is usually housed in a shelter this is to protect the telecoms equipment from external conditions such as dust, corrosion, rust, etc that may hinder its proper operation. Air conditioners are also provided in the tropics for cooling the electronic equipment which generate a lot heat during operation. Other facilities found in the base station include an integrated power unitconsisting of a site transformer for the public utility service, an Automatic Mains Failure panel (AMF), a battery bank, generator unit with a 200-400 litres diesel holding tank and in a very few cases green energy source like solar panels and wind mills.

The poor power situation in Nigeria has made operators to rely fully on diesel generators to power their base stations. The chart in Fig 1.shows the power outages experienced in 11,692 base station sites connected to the national grid [8]. The chart reveals 80 % of sites connected to the grid experience power outages for over 12 hours daily. While only 9% have relative stable power with outages of 6 hours and less daily. This simply means that 81% of these sites have to rely on alternate energy source for more than 12 hours daily. There is a huge potential therefore for putting in place alternate energy sources for powering the telecommunication facilities in Nigeria.

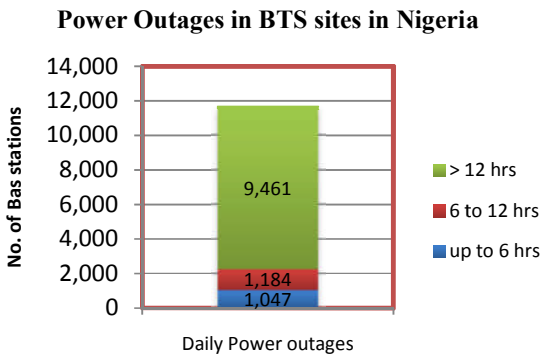

Fig. 1. Daily power outage situation in Nigerian Base station sites

An analysis of the direct cost for powering telecommunication sites in Nigeria reveal that main cost is incurred by the diesel consumed to run the site with an off-grid site consuming on an average 1,765 liters of diesel monthly. The total cost of powering a base station with diesel generator stands at 3.4 million naira (□3.4M) annually for a non-grid site and 2.5 million naira (□2.5M) for a site connected to the grid. Telecommunication operators in Nigeria spent over 178 billion naira (□178B) on diesel fuel only in 2012 to power about 25,000 base stations [12]. With the amount of CO_2 gas emission and potential health hazards of these generating sets, an emergency state should be declared for the deployment of green sources of energy for the sector.

IV. VIABLE GREEN POWER OPTIONS FOR TELECOMMUNICATION

There have been researched and piloted viable Green energy options in use. These green energy sources include hydro plants, fuel cells, solar, wind and bio-mass plants. In Nigeria, the Energy commission (ECN) has put in place poly frameworks for solar, wind and bio-mass energy sources. These options could be adopted for powering telecommunication infrastructures especially the base station, as 90% of energy requirements of telecommunication is used to power the radio site or base station [13]. We shall discuss briefly the potentials of these green energy options in Nigeria;

A. Solar Energy

Solar energy is the process of converting the energy from the sun into electricity. The generation of electricity using solar energy is done using photovoltaic technology. The sun is a source of clean energy that is readily available in Nigeria for energy generation. The scalability of solar dues to its modular technology makes is suitable for use in the telecommunication industries. The different parts of the world have different solar energy incident which is dependent on the amount of sun available and its duration. The radiation intensity for any part of the globe can be determined from the solar energy map, where the world is classified into different regions depending on annual average solar irradiance kWh/square meter with the tropical regions having more [14]. A major challenge in the deployment of solar technology is the high upfront capital expenditure and high space requirements for deploying the plant. There is also an operational challenge due to the theft and breaking of solar panels and weather variations. These challenges however do not over shadow its enormous advantages of being affordable, reliable, long lasting, low cost running maintenance and above all GREEN.

Nigeria is gifted with abundant solar resource for power generation. Nigeria has an average solar insolation of 5.75 kWh/sq. m/day with an average daily sunshine of 4 to 7.5 hours. The northern region of Nigeria has a high solar potential with an average insolation as high as 7 kWh/sq. m/day [ECN]. The Energy Commission of Nigeria (ECN) has a clear policy frame work for the deployment of solar energy in the country, through the setting up of a solar panel production plant in the country. Very few telecommunication companies are beginning to adopt solar power for powering their base stations but more still have to be done.

Solar energy plants can be deployed as standalone, grid connected or hybrid systems. Standalone units are those that depend solely on the solar energy. They utilize battery banks for storing energy. Grid connected solar plants system supply the load and has the opportunity of feeding surplus energy to the grid. In the hybrid system, the solar plant is used alongside other power sources like a wind plant, bio-mass and even the grid to power the load. With adequate batteries, solar plants can be used as standalone to power telecommunication base station, as it requires minimal running cost.

B. Wind energy

Wind energy plants have become very viable source of renewable energy which is being explored more fully as the desire for a clean environment intensifies. The peculiar feature of this energy source is that it is only feasible in regions with wind speeds of about 3m/s and above. Wind power is currently the fastest-growing source of electricity production in the world. In the USA 5.7 % of the installed generating capacity is from wind power with 46,000 operating wind turbines while in Denmark 28.1% of electricity is generated from wind power plants [15]. The key benefit for wind energy is that it is cost efficient and Green and it can be used to generate huge amount of energy in the mega watt (MW) range. The drawback in the use of wind energy is its huge cost of initial installation and operation. Over the years, the price of installation has dropped and more efficient turbines with higher production capacity are been built. Wind plants are expensive to run as they require regular maintenance. The presence of winds speeds of 4 to 6m/s

in the extreme North of Nigeria makes wind power a viable option for energy generation which could be used to power small scale telecom application. Fig 2.shows the potentials for wind plants available in Nigeria.

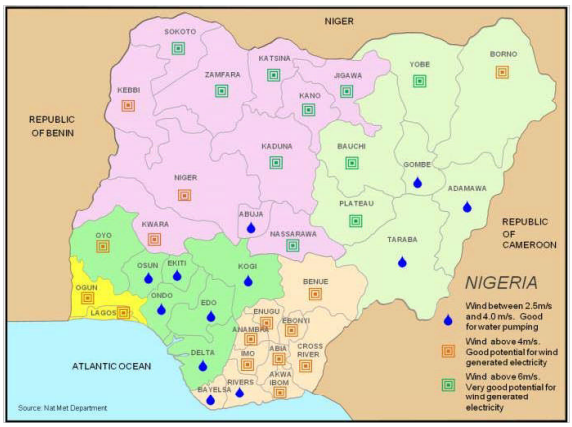

Fig. 2. Map of Nigeria showing the wind speeds in the regions

C. *Bio-mass Plants*

Bio-mass are biological materials used to produce renewable electricity. These biological materials are converted into bio-fuel that must undergo various forms of energy conversion process to generate electricity. Some Bio-mass sources include Agricultural crops and residues, forestry crop and residues, solid waste, animal residues, sewages, and industrial residues. Nigeria has a moderate potential for using biomass as a source of electricity. The Energy Commission of Nigeria has put forth plans to produce bio-fuel (bio-ethanol) from sugarcane and cassava plantations with a potential production of 120-140 million liters every year [8]. The option for using saw dust generated annually is also been considered as biomass input.

V. FRAME WORK FOR POWERING TELECOMMUNICATION BASE STATION USING SOLAR ENERGY

In Nigeria, over 12,560 sites are deployed in off-grid locations with same number with access to grid power only have it for a few hours daily [8]. The choice of using alternative power source for powering telecommunication facilities is one which the operators need to make. In this paper we propose the use of solar energy either as standalone or hybrid for powering telecommunication base stations. The estimate power requirement for a single cabinet macro base station is 3.2 kW, with more required for cooling facility which is usually a 2 no. 1 horse power air conditioner. With a solar plant of I0 kVA capacity, the base station will be fully powered and running clean. A cost estimate is given for the deployment of a 10 kVA solar plant.

A. *Cost Estimate for a Stand Alone 10 kVA Solar Power Plant*

The solar plant is made up of three main sectors; the solar PV array, the power conditioning unit and the load, Fig 3.0 shows the different units of the solar plant.

The Solar PV Array: Solar panels comes in different wattages; 30W, 60W, 100W, 120W, 150W etc. So we can make our choice of the Wattage panel to use, but note that the lesser the wattage the more number of panel one will use.

$$For\ a\ 150\ Watts panel, \quad P_n = \frac{3600\ Watts}{150\ Watts} = 24 \qquad (1)$$

Where $P_n$is the number of panels

Power Conditioning Unit: This unit consists of the Inverters, batteries, load voltage conditioning and monitoring system. Other required accessories include cables, fittings and hangers for the panels as well as racks for the batteries.

Estimation for Battery requirement;

Each battery charging current is

$$I = 200ah\left(\frac{1}{10}\right) = 20A \qquad (2)$$

$$P = IV \qquad (3)$$

$$V = 12Vbattery * 15\ No. \qquad (4)$$

$$V = 180Volts$$

$$\therefore P = 20 * 180 = 3{,}600\ Watts$$

Load: The expected load in this case is a radio base station with power requirement of 53 V DC and 3.6 kW AC

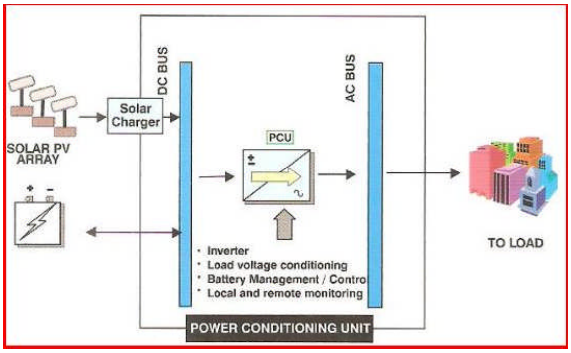

Fig. 3. Solar plant units

TABLE 1. COST ESTIMATE FOR A 10KVA SOLAR POWER PLANT

S/N	Description	Qnty	Unit Price(₦)	Total Price(₦)	Life Span
1	Genus or Luminous 10KVA Inverter	1	400,000.00	400,000.00	10 years
2	12V/200AH Inverter Battery	15	50,000.00	750,000.00	5years
3	Battery Rack (for 15No. battery)	1	80,000.00	80,000.00	10 years
4	150 Watts Solar Panel	24	60,000.000	1,440,000.00	20 years
5	Solar Panel Mount	1	50,000.00	50,000.00	10 years
6	Battery Cable + Accessories	1	20,000.00	20,000.00	10 years
TOTAL COST				**2,740,000.00**	

B Cost Comparison for powering a base station site

The radio base station has to be powered 100% of the time to ensure quality service. A cost comparison is carried for a base station running on three different power option, solar, diesel and hybrid. The hybrid system is a combination of the solar plant and a diesel plant that runs for 9 hours daily. Fig 4.shows the cumulative cost analysis over a ten year period.

The use of diesel results in a cumulative cost with a geometric rise. This means over a period of 10 years the company spends about 35 million to keep one base station powered. The cost for hybrid is less while the cost of using solar plants is extremely low. The slight increase in the cost of solar plant after 5 years is the envisage cost for changing the batteries. The life span of solar panels is 20 years while the batteries have a minimum life span of 3-5 years. With the low maintenance cost of solar plants the company spends very little in subsequent years leading to a saving of over 25 million naira over a period of 10 years.

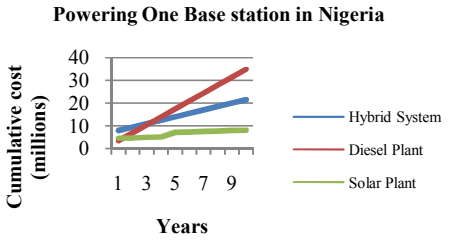

Fig. 4. Analysis on the Cost of powering one Base Station in Nigeria

VI. CONCLUSION

The growth and sustenance of telecommunication service depends on key support infrastructure such as power to maintain a reliable and quality service. The unpredictable and poor power supply to the telecommunication tower sites in Nigeria has hindered the efficient running of mobile telecom networks operations. The choice for green energy option should be considered as a corporate social responsibility which the operators owe the Nigerian populace. The driving force should be the need for a cleaner environment with less emission of CO_2. The inclusion of street lightings to neighbours of the base station will minimize the threat to theft and vandalization of the plant infrastructure.

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