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POWER MANAGEMENT SCHEME FOR WIRELESS TELEPHONY SERVICE PROVIDERS

Aboaba, A. Abdulfattah[1]; Amoo, L. Abdullahi[2] and Yusuf, Ahmad [3]
[1]Computer Engineering Department, University of Maiduguri, Maiduguri, [2]Electrical and Electronic Engineering Programme, Abubakar Tafawa Balewa University, Bauchi, [3]Department of Electrical and Electronics Engineering, Federal Polytechnic, Bauchi

ABSTRACT
The relationship between the mobile phone service providers and their service consumers since the about seven years ago when mobile phone became fully integrated into Nigeria society is to say the least rough. Accusations of poor services coupled with high charges are levied against the service providers and in defense the service providers blame it on high running cost especially fuelling and maintenance of generating sets for power supplies. Hence, for mobile phone service providers to provide satisfactory service to their customers, there is need for efficient power management system. This work finds the average power supply per day, cost of the Base Transceiver Station (BTS) generating set, cost of installing the generating set, fuel consumption of the generating set per certain periods based on BTS equipment data provided by one of the service providers, routine maintenance cost of the generating sets, etc and compare these with Photovoltaic (PV) system. The findings reveal that an environmental friendly renewable energy technology, a photovoltaic system is a potent alternative power source especially when life cycle cost (LCC) analysis is invoked and the site management scheme proposed is adopted. PV system has been found to be cost competitive with the conventional system.

KEYWORDS: Photovoltaic (PV) array, Balance of system, Life cycle cost (LCC), Cost benefit analysis, PV hang-on, & Site management scheme,

INTRODUCTION

Statistics have shown that the wireless mobile telephony is growing tremendously just over one and a half decade of its existence. For instance, in Nigeria there are about 40 million active subscribers to wireless telephony operators by the close of 2007 and Nigerian teledensity stood at 29.98 (NCC, 2008). Nigeria with a population of one hundred and forty million three, thousand five hundred and forty two (140,003,542) in 2006 and at a growth rate of 3.2 percent was about 143,363,627 by the end of 2007. Using the teledensity of about 30 percent, forty three million, nine thousand and eighty eight (43,009,088) people are having access to telephone line as at the stipulated time if we assume one line per person. Thus, it can be projected that with about ten (10) wireless telephony operators in the first quarter of year 2008 and if the rate of penetration remains steady, by the next decade, over 50 individual wireless telephony operators may have emerged. With the BTS radial coverage of about 4.5 kilometers for urban cells and 10 kilometer or higher for rural cells, each wireless telephony operator may have 1000 base transceiver stations (BTS) for adequate and effective coverage, which will aggregate to 50,000 BTS for Nigerian network alone. Moreover, by the present state-of-art owing Nigeria perpetual energy problem, each BTS in most urban areas has at least a dedicated generator while in the rural areas where there is no grid they two dedicated generators approach is usually employed per BTS. Then the fuel consumptions and environmental impact will on the long run become very alarming and prohibitive. Therefore, the call for alternative scheme is inevitable for sustainability of the industry with the view of offering mobile service at reduced cost for the providers and invariably to their customers.

History of Wireless Telephony

The Global System for Mobile Communications (GSM) is a European digital communications standard which provides full duplex data traffic to any device fitted with GSM capability, such as a phone, fax, or pager, at a rate of 9600 bps using Time Division Multiple Access (TDMA) communications scheme. In the l980s GSM began as an analog cellular telephone system in Europe. Initially, there was problem of equipments incompatibility around European countries where the systems were experiencing rapid growth. The mobile equipments were limited to operation within national boundaries, which in a unified Europe, were increasingly unimportant because an economy of scale was absolutely difficult and substantial saving could not be realized. The Europeans realized this early on, and in 1982 the

Conference of European Posts and Telegraphs (CEPT) formed a study group called the "Groupe Special Mobile (GSM)" to study and develop a pan-European public land mobile system. This acronym accidentally coincided with GSM.

According to Scourias (1995), commercial service was started in mid-1991, and by 1993 there were 36 GSM networks in 22 countries, with 25 additional countries having already selected or considering GSM. In the beginning of 1994, there were 1.3 million subscribers worldwide. In a span of a year, that is, by the beginning of 1995, there were over 5 million subscribers. By the standardization and advances in digital techniques, the GSM is now purely a digital system. It can easily interface with other digital communications systems such as Integrate Switched data network (ISDN), and digital devices, such as Group 3 facsimile machines. Along the line the American standard of wireless communication using Code Division Multiple Access (CDMA) came into being. For most part, mobile phones require the use of either Subscriber Identity Module (SIM) or User Identity Module (UIM) card. These small electronic devices are approximately the size of a credit card and all of the user information is recorded on it. This includes data such as programmed telephone numbers and network security features, which identify the user. Without this module, the mobile equipment (ME) will not function. This allows for greater security and also greater ease of use as this card may be transported from one phone to another, while maintaining the same information available to the user.

Technology Basis of Wireless Telephony

The GSM uses a combination of time division multiple access (TDMA) and frequency division multiple access (FDMA) techniques. GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. The American standard uses the code division multiple access (CDMA) which is the third of the multiplexing techniques. Wireless telephony is presently operating within three band namely: between 850 MHz to 900 MHz called 900 MHz; 1800 MHz to 1900 MHz called 1800 MHz frequency hands; and 450 MHz to 480 MHz called 450 MHz frequency hands (Telecommunications Research Associates, 2007) & (Starcom, 2008).

Architecture of the Wireless Telephony Network

A wireless network is composed of several functional entities whose functions and interfaces are specified. The wireless network can be divided into three broad parts. The subscriber carries the Mobile Station. The Base Station Subsystem controls the radio link with the Mobile Station. The Network Subsystem, the main part of which is the Mobile services Switching Center (MSC), performs the switching of calls between the mobile users, and between mobile and fixed network users. The MSC also handles the mobility management operations. Not shown is the Operations and Maintenance Center, which oversees the proper operation and setup of the network. The Mobile Station and the Base Station Subsystem communicate across the Um interface, also known as the air interface or radio link. The Base Station Subsystem communicates with the Mobile services Switching Center across the A interface.

Of the wireless telephony network architecture, the part of interest to this paper is the base station subsystem because it is the interface between the subscriber unit (mobile station) and the network subsystem and when it malfunctions the subscriber is cutoff and of course one of the most frequent of the base station subsystem problems is power supply.

Base Station Subsystem

The Base Station Subsystem is composed of two parts, the Base Transceiver Station (BTS) and the Base Station Controller (BSC). These communicate across the standardized Abis interface, allowing (as in the rest of the system) operation between components made by different suppliers. The Base Transceiver Station houses the radio transceivers that define a cell and handles the radio-link protocols with the Mobile Station. In a large urban area, there will potentially be a large number of BTS deployed, thus the requirements for a BTS are ruggedness, reliability, portability, and minimum cost.
The Base Station Controller manages the radio resources for one or more BTS. It handles radio-channel setup, frequency hopping, and handovers. The BSC is the connection between the mobile station and the Mobile service Switching Center (MSC).

Powering the Base Station Subsystem

Of the wireless telephony architecture, the base station subsystem (BTS & BSC) formed peoples knowledge of the presence or not of wireless telephony in a particular location with only the exception of operators that uses direct satellite link to their subscribers. Depending on which frequency band a

BTS and BSC is operating on, which mainly determines the coverage area, the number of BTS and BSC deployed in a geographical entity could be enormous and considering the fact that an average BTS consist of electrical and electronics items like transceiver equipment aviation light ,air-conditioners and other lightening all of these consume a total of about 27 KW of electricity, this of course constitute a drain into our already insufficient and epileptic power supply (Aliyu,1998) and (Somolu,2007).

Having understood the Nigerian terrain in terms of poor electricity supply, all the operators design their BTS and BSC to have both connection to grid and diesel generating set(s) and for those BTS sites that are located off grid and those in locations where there is acute power outage , a two diesel generating sets approach is adopted. Taking into consideration the amount of money in excess of normal operation cost the utilization of diesel generating sets had brought on the operators, it thus becomes inevitable that consumers had to pay more for the same service compared to other place with stable electricity. This was exactly the faith of wireless telephone users in Nigeria right from the onset GSM/ Wireless telephony in 2001. While the consumers cry foul, the operators had been defending the reason why high-call-cost should continue perpetually with bogus claims such as the one debunked by Aluko (2004).

Apart from high-call-cost that is blamed on high running cost, even poor services is also linked with use of diesel generating set and this could be true if no mischief is intended because generating sets have to be periodically maintained besides, even though seldom, breakdown maintenance. Thus a challenge is thrown to the academic community in Nigeria to channel a way of reducing call-cost and improving the services of the wireless telephony from the angle of, but not limited to, powering the Base Station Subsystem.

The Photovoltaic Cell (PVC) Alternative

The sun is a nuclear power plant producing all the heat and light experienced on earth by nuclear fusion reactions in the sun's core .The radiant energy produced by sun is about 3.8×10^{23} kilowatts out of which about 1.8×10^{14}KW is intercepted by the earth. Again about 60% of this penetrates the earth's atmosphere to reach the earth surface. The atmosphere and clouds absorbs or scatter the other 40 percent. However, the total energy receives on earth is fairly constant from year to year with only 0.2% change in 30 years (Microsoft, 2007). Hence, the solar energy alternative to power generation using solar cell or photo voltaic cell (PVC) and balance of systems which has been in use for about 40 years now is instructive. The infamousness of PVC as an alternative energy source to the conventional types was due to some of its odds like cost per watt and space (site size). However, according to renewable energy policy project in the USA (2003), PV module cost has gone down by half from 1991 to 2001 and Foster, *et al* (1998) said: "PV systems cost decrease significantly on a per watt basis as PV system size is increased".

The assertions above have made the use of PV more popular and acceptable as evident in the works of (Foster, *et al* (1998) and (Moore, *et al*, 2003) especially for large projects of the kinds of BTS and BSC. Figure 1 shows in schematic diagram form the PV and the balance of system arrangement.

Cost of PV System

The capital cost (that is the initial cost) of the PV system typically contains four costs viz: PV array; balance of system; transport and installation; and project management, design and engineering.
Generally, the relative contributions of these costs to the total price of an installed system depend on the application, the size of the system and its location. PV technology is on the threshold; costs falling each year invariably make PV commercially mature in many applications where it can compete with higher installation costs of long links to the grid or expensive generation from diesel set (FJC/SIS, 1999). According to Islam (2007) a 125 KW PV installation capacity cost 70 million naira for the PV array at the rate of 4 dollar per watt of PV cell, while its balance of system cost 42 million naira.

Cost of Connection to Grid

By the present state-of-art, PV generation of energy cannot be compared with conventional systems in terms of capital cost except where connection to grid is above 1.25 miles (Moore, *et al*, 2003) as in the case of off-grid areas, and in situations of unstable power supply (too-poor-power-supply) where grid connection is combined with the use of diesel generating set. For instance, according to (Mtel, 2007) it costs only 3.6 million for a contractor to purchase and install a 100 KVA transformer to a site and the operator only pays an average of 27,000 naira as monthly consumption of energy even though it is for

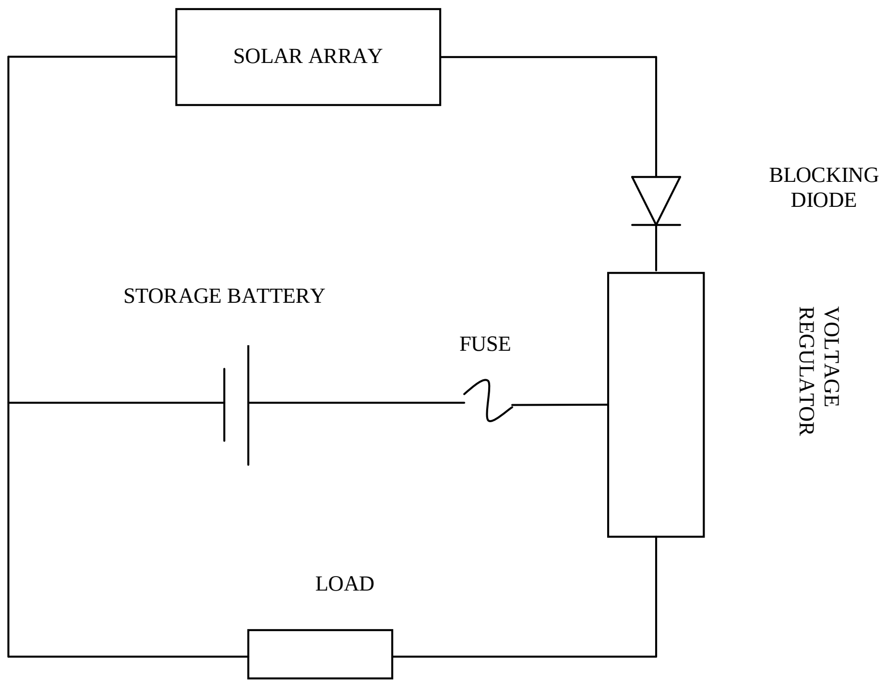

FIG. 1: SCHEMATIC DIAGRAM of PV ARRAY and BALANCE of SYSTEM ARRANGEMENT.

an average of around four (4) hours per day, meaning the operator would have paid only 162,000 naira monthly and 1,944,000 naira annually if supply is for 24 hours. More over, the too-poor-power-supply scenario best describe Nigeria and that is what wireless telephony operators are encountering. Hence, the comparison will be between first; PV versus conventional cum diesel generating set; secondly between PV and diesel generating set as is often the case in off-grid locations. In both cases, varying hours of generator utilization is used to generate many curves.

Cost of Installing, Operating and Maintaining Generating Sets

The analysis of data from (Mtel, 2007) revealed that it cost 3.6 million naira for a contractor to purchase and install a 27 KVA diesel fuel generating set with a fuel storage capacity of 2000 litres, the generating set consumes 3.5 litres of fuel per hour and for efficient and durability the generating set(s) are made to work for 6 hours at a stretch. More over, after every 250 hours of work minor maintenance is done on the generating set. Also major maintenance is carried out after every 7000 hours of work. Electricity supply is said to be at an average of 3 to 4 hours per day within Maiduguri metropolitan, more than that around Biu area of the state and less than that in the northern part of the state. For the minor maintenance, the following items are used: 10 litres of engine oil, 1 number of oil filter, 1 number of fuel filter, and 1 number of air filter. And finally information shows that diesel is supplied at a contract rate of 115 naira per litre.

Data Analysis

From the foregoing, in respect of PV cost, using the $4 per watt of PV cell (Renewable energy Policy Project, 2003), and drawing proportionality from Islam (2007) cost of PV array and balance of load given above, and using exchange rate of 120 naira to American dollar (CBN, 2008), the cost of 27 KVA PV array will be 12, 960,000 naira. Hence balance of load will be 7,760,479 naira. Putting transport and installation cost at 1% of PV array cost for large installation, that component of the bill will be 129,600 naira. The forth component of PV lifecycle cost (LCC), that is, (O&M) will be calculated based on (Moore, *et al* 2003) who said “Operation and Maintenance (O&M) represents the forth component takes 4 percent of the capital cost for small system of 500W and 0.6 percent for a range of PV system providing daily energy of 2 to 10 KWh”. Therefore, O&M will be about 125,000 naira annually, and the PV system would last for 25 years (Renewable energy Policy Project, 2003).

Regarding diesel generating set, assuming an average power supply of 6 hours per day based on Mtel (2007), the generating set would work for 18 hours in a day which give the number of generator at two per BTS to guarantee uninterrupted telephone service. Thence, each will work for 9 hours per day, and each will be due for minor maintenance 27.7 days (approximately one month) and major maintenance every 778 days (approximately two years). More so, each generator will consume 31.5 litres per day making a total of 63 litres daily. To make the determination of lifecycle cost (LCC) easy, we estimate N10,000.00 per minor maintenance and 100,000.00 for major maintenance. And finally according to (Moore, *et al* 2003).

Lifecycle Cost (LCC) Analysis of PV, Grid and Generating Set

From information regarding cost of PV, grid and generating set, table 1 is drawn for easy comparison for 27 KVA of PV and Generating set and 100 KVA distribution transformer.

TABLE 1: SUMMARY OF LIFECYCLE COST (LCC) OF PV, GRID & DIESEL GENERATOR

Photovoltaic	Grid	Generating Set
PV array: N12,960,000	Installation of Distribution Xformer: N3,600,00	Installation of generator: N3,600,000
Balance of System: N7,760,479	Monthly Bill in 1 year: N324,000	Cost of monthly fuel consumption: N108,675
Transport and installation: N129,600	Cost of annual maintenance: N10,000	Cost of annual maintenance: N120,000
Total: N20,850,079		Cost of biennial maintenance: N100,000
Operation and Maintenance per annum: N125,100		

DISCUSSION OF RESULTS

Based on data from table 1 four LCC curves were plotted each depicting different combination of PV, grid and generator. The plot of figure 2 is the best situation in which PV is compared with the combination of grid and generator supplies with grid supplying for 18 hours and generator for 6 hours. Figure 3 represent the next best situation where both grid and generator supply for 12 hours each, and only one generator is used. This is followed by the most common situation in Nigeria where grid only supplies for 6 hours and generator for 18 hours and of course, two generators are used. Lastly is the off-grid situation in which two generators are employed.

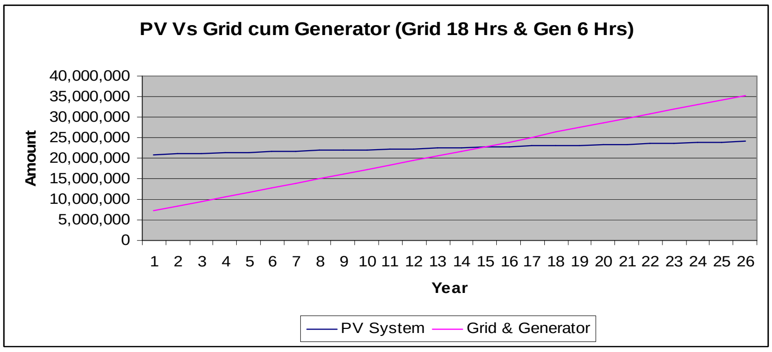

FIG. 2: LCC CURVE FOR PV VERSUS GRID CUM DIESEL GENERATOR (GRID 18 HRS. & GENERATOR 6 HRS.)

Both numerical and graphical results show that even in the best possible situation in Nigeria, PV system is still better in the long run as PV system balance up with grid cum generating set before the fifteenth year.

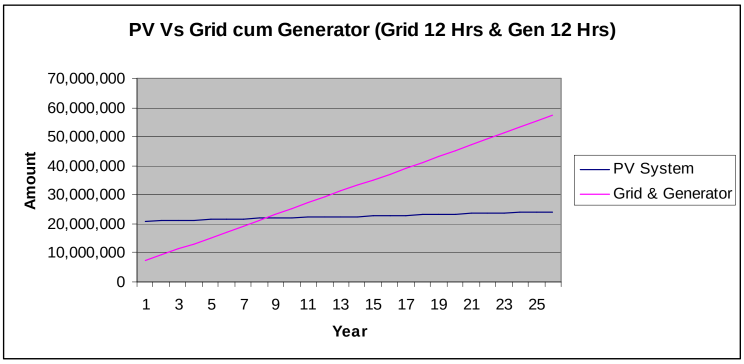

FIG. 3: LCC CURVE FOR PV VERSUS GRID CUM DIESEL GENERATOR (GRID 12 HRS. & GENERATOR 12 HRS.)

In this situation where one generator is used to generate for 12 hours and grid supply is also 12 hours PV system was able to catch only within eight years.

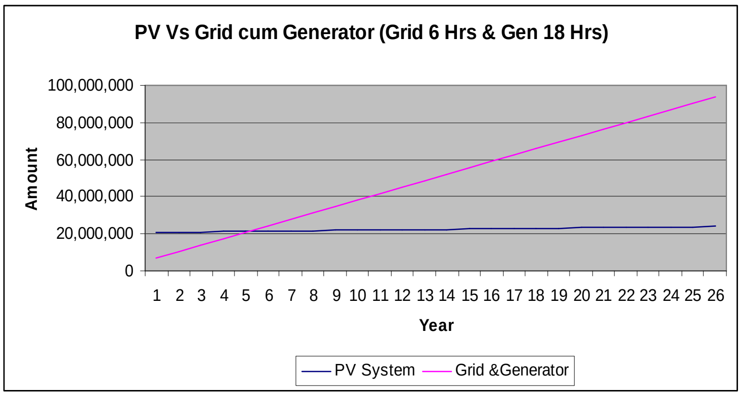

FIG. 4: LCC CURVE FOR PV VERSUS GRID CUM DIESEL GENERATOR (GRID 6 HRS. & GENERATOR 18 HRS.)

The LCC curve of figure 4 is the ideal situation for Nigeria and as can be seen PV system is proved better just before five years.

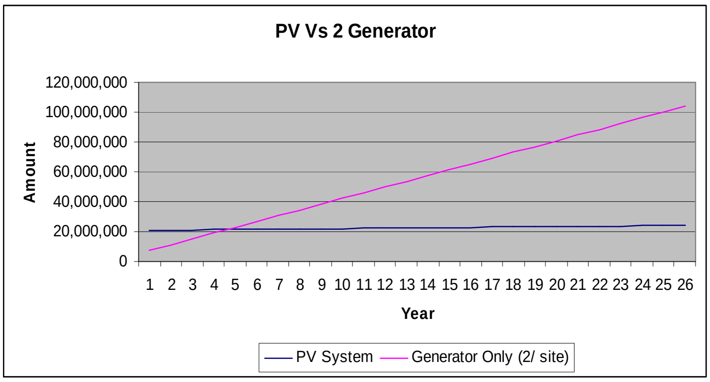

FIG. 5: LCC CURVE FOR PV VERSUS 2 SET OF DIESEL GENERATORS

The last scenario is the rural or off-grid situation where two generators work for 12 hours each per day, again PV system demonstrates it economic advantage.

Tackling Site Size

At this juncture, the only problem that may militate against the use of PV system especially for BTS and BSC sites located in urban areas is the space requirement of PV array. This problem could be solved if PV cells could be arranged on the station's mast as shown in figure 6, and using ideas from "Life Cycle Design Research" the whole mast structure could be examined to see if it could be made of PV material.

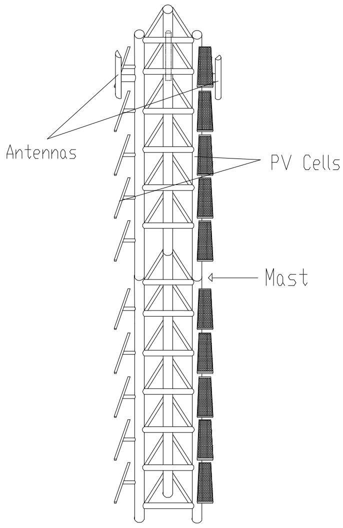

FIG. 6: PROPOSED MODEL OF THE MAST WITH PV CELL HANG-ON

SUMMARY

The LCC curves of figures 2 to 5 have shown that PV alternative is better for BTS and BSC supply at all times. First, it catches up with the best of situation in Nigeria within fifteen years, the second best situation within eight years, Nigerian ideal situation within six years, and the off-grid situation within five years. More so, the proposed site plan makes it unnecessary to expand the present BTS/ BSC sites size for arrangement of PV array.

CONCLUSION

From the foregoing, LCC results have shown that the used of PV cell as a sole alternative power supply to BTS and BSC is economically viable over a period of time than diesel generating set or combination of generator and conventional supply. The only exception is when conventional method can deliver electricity supply for 24 hours uninterrupted, effectively and for a long period of time. More so, when the "Cost Benefit Analysis" is done, the use of PV and indeed renewable energy will be seen to be far superior to conventional methods. In addition to that, the use of mast to hang PV cells makes the idea plausible.

RECOMMENDATIONS

Having seen the results above, it is recommended that the managements of wireless telephony firms should quickly embrace the PV alternative proposed in this paper.
Furthermore, the Nigerian government should sponsor more research into non-conventional methods of electricity generation to address the country's acute power supply problems.

REFERENCES

Aliyu, U.O. (1998). Some though on Nigerian energy demeand outlook into the next century: Prospects, problem and R & D directions. 8th inaugural lecture series, Abubakar Tafawa Balewa University, Bauchi.

Aluko, M. (2004). GSM: Cutting cost of power generation, The Punch, Tuesday 13 January, 2004. P. 16

Central Bank of Nigeria, (2008). www.cenbank. Org. ng/

FJC/SIS, (1999). Photovoltaics: Cost and economics, FJC/SIS www.fjc/sis.org

Foster, R., Cisneros, G., & Hanley, C. (1998). Lifecycle cost analysis for photovoltaic water pumping systems in Mexico, 2nd World conference on photovoltaic solar energy conversion, 6 – 10 July, Vienna, Austria.

Islam, M. S. (2007). Assessment of electricity supply for critical load, Ph D seminar, Abubakar Tafawa Balewa University, Bauchi.

Microsoft, (2007). Microsoft Inc, Microsoft Encarta. GSM

Moore, L. M., Malczynski, L. A., Strachan, J. W., & Post, H. N. (2003). Lifecycle cost assessment of fielded photovoltaic systems, Sandia National Laboratories, NCPV and Solar Program Review Meeting, USA

Mtel PLC Maiduguri Office, (2007). Title, place of publication etc

National Communication Commission (NCC), (2008). www.ncc.org.ng/

Renewable Energy Policy Project in the USA (2003). Cost benefit analysis for photovoltaic program: A case study of Arizona, USA. www.repol.org/arizona

Scourias, J. (1995). Overview of global system for mobile communications, waterloo, University of waterloo. USA.

Somolu, F.A. (2006). The yesterday, today and the future of power system engineering in Nigeria….so that Nigeria may have electricity. The Nigerian Society of Engineers' October lecture, 6th October 2006, National Engineering Centre, Victoria Island, Lagos Nigeria.

Starcom Nig. Ltd. Maiduguri Office, (2008). Title, place of publication etc

Telecommunications Research Associates. (2007). *Understanding the basics of wireless communications*. Kansas (USA). Telecommunications Research Associates (TRA) LLC. http://www.tra.com

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Corresponding Author:
Aboaba, A. Abdulfattah
Computer Engineering Department, University of Maiduguri, Maiduguri, Bornu State.
adeabdul2002@yahoo.co.uk