Study of Energy Savings and Sustainable Practices Adoption in Telecommunication Services

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Abstract: - The concerted efforts of keeping up with the environment and mitigating the consequences of climate change should focus more towards reducing carbon oxides and other greenhouse gases emissions within stipulated regulations. One of the ways to achieve this is through adoption of sustainable practices within industries and organisations by encouraging more of energy saving practices and reduction of carbon footprint within all production, commercial and service related functions. Nigeria, an emerging economy nation, is identified with higher emission of greenhouse gases due to downstream gas flaring combined with rapid industrialisation, urbanisation and commercialisation activities. This research paper examines the potential impacts of energy saving within Nigerian telecommunications industry, and highlights how the cell sites base stations within the industry have great challenges and threats towards the climate change from the amount of energy generated and used within the system. The paper conducts a literature study on general energy overview, usage, impacts and concepts towards the benefits of energy saving practices. The overview, concepts and benefits of energy savings and renewable energy technology were also reviewed. Further investigations within the concept of energy saving towards using sustainable methods for addressing the climate change issues was also carried out. The research used a sustainability ranking procedure with both economic and environmental analysis to conduct a sustainability assessment on some identified renewable energy technologies such as wind, solar, geothermal. The result of the analysis of the research was able to come up with about €16.4Billion of potential energy savings cost within the fifteen years of operation if the recommended alternative energy could be used. This sustainability assessment had been conducted towards providing recommendations for more sustainable, suitable, alternative and affordable strategies for replacing or complementing conventional methods of powering telecoms industries in future.

Key-Words: - Climate Change, Emission, Energy Savings, Environment, Renewable energy, Sustainability, Telecommunications.

1 Introduction

Profit maximization through cost-effective approaches is an economic concept trending globally especially in manufacturing, production, services, and utilities within industries. While reducing the costs, one of the biggest challenges is that of the strategic sustainability plan partly due to their current corporate social responsibility. Previous studies have all demonstrated that a sustainable practice within any industry improves the profit maximisation and provides the company with a better image value. This has led to many industries adopting and designing sustainable chain models and practices that aims to reduce overall cost of operations [1]. Nigerian telecommunication sector is presently the fastest growing market in Africa; and it is among the ten fastest growing telecommunication industries in the world. Recent suggests that Nigerian Telecoms sector manages over 135 million active subscribers as at the end of 2014 and between 2003 – 2015, there has been huge growth within the Nigerian telecoms subscribers' base [2] This has led to the average energy demands by the service provider for the delivery of telecom services increased as well. The competitiveness among existing network providers have led to investigations on how to improve on tariff such that it's affordable for booming subscribers. This drive has led telecommunication companies in Nigeria to start looking for ways of cutting down on their running cost and general expenses. Hence, energy saving measures and reduction in greenhouse gas emissions (GHG) is considered to be one of the safest ways towards sustainable business practices within the telecoms industry.

There have been significant impacts on other economies such as financial sector due to the growth within the telecoms sector in general. For instance, the growth in telecoms industry facilitates better and improved performance levels within banking services through operations and service provision such as ATM services, general banking transactions, money transfers, electronic banking, and other E-commerce based banking transactions. Same is also true for other industries such as advertising, media and service sectors due to the substantial growth within the telecoms industry. The problems associated with cell site base stations in Nigeria telecommunication sector in terms of cost, environmental pollution, security and management. These problems can be solved through this research on energy savings where the best and safest form of energy supply was recommended. Here are some major issues that the research study aims to examine:

- Environmental pollution - the conventional method of power generation in running the cell site base stations in telecommunication industry pollutes the environment.
- High site running cost – The cost incurred in powering the cell site base stations affects both call and data bundle tariffs.
- Management method – The processes and methods of cell site base station management is cumbersome and tedious, and the logistics in powering them are complex.
- Sites vandalism and theft – The theft attempts on the stored diesel due to scarcity of fuel, hike or increase in the price of the fossil fuel.

1.1 Aim, Objectives and Significance

The aim of this research study is to minimise the energy costs by encouraging the use of alternative renewable power sources that are relatively available, economic and environmental friendly within Nigerian Telecoms sector. The study conducts a comprehensive study on the cost of powering telecommunication cell sites, practices on cell sites management and ways of reduction by network providers. The research also aims to analyse and assess better alternative power sources and management practices and providing recommendations based on the findings of research. The study adopted comparative studies of the sustainability indicators for the power generation in running cell sites within Nigerian Telecoms industry. The sustainability indicators considered were adapted from [3] that includes, cost and availability of electricity from government grid, cost of generating set acquired, and maintenance and running cost, including greenhouse emission and social impacts (noise pollution, security, hazards etc.). Further sustainability assessment was carried out on the alternative renewable energy and the key factors considered such as the cost of acquiring the alternative renewable energy, maintenance and running cost and the greenhouse emission and social impacts. The significance of this research project will help in cutting down the overall expenditure of the telecoms industry thereby leading to profit maximisation. It will also reduce the environmental risk through mitigation of carbon emission thereby helping the ecosystem and supporting sustainability. It will increase the call power and internet usage of subscribers while it will also allow easy entrance for new investors in the country's telecoms industry due to reduced initial capital investment. Finally, this will improve the telecoms sector's good image and status through their Corporate Social Responsibility (CRS) commitment and sustainable development.

2 Literature Review

Energy consumptions increase on daily basis especially in the fast growing and non-OECD emerging economies including Brazil, China, and India. The increase in population and economic growth of these countries will further increase their energy consumptions. Meanwhile increase in energy needs and requirements poses threat to the environmental degradation. As energy consumption increases, the greenhouse gas emission to the environment will also increase especially with electricity generation through the extensive use of fossil fuels with generating sets. According to the United States environmental protection agency report, the world generated about 46 billion metric tons of greenhouse gases which is expressed as carbon dioxide (CO_2) through human activities in 2010 and the use of fossil fuel in energy generation increased the greenhouse gas emissions by about 35% from 1990 to 2010 [4]. Renewable energy can be defined as energy flows which are replenished at the same rate as they are used [5]. Green power represents renewable energy resources and technologies that provide the highest environmental benefit [6]. It is said to be the energy obtained from the continuous or repetitive currents of energy recurring in the natural environment. This is an important aspect of energy due to some recent realisable facts which include;

- Degradation: There is a limited access to all non-renewable energy sources like coal, petroleum, natural gas and so on because they do not replenish.
- Consumption increase: The growth in the world

population and technology advancement will surely increase demand for energy which indirectly results to demand in the non-renewable energy resources that are limited.

- Sustainability - the development that meets the needs of the present without compromising the ability of future generations to meet their own needs [7].

2.1 Renewable Energy Sources

The use of renewable energy is needed to keep up with the sustainability pace and the use of the renewable energy will support and have positive impact on the energy supply, it will help build good environment, society and economy. It was confirmed that Effluent from coal mining can degrade local water quality by lowering pH and increasing concentrations of solids and heavy metals; leachate water from overburden dumps can also have high metal concentrations [8]. Renewable energy can be derived from natural resources and processes that replenishes within a short time scale and can be derived directly or indirectly [9]. Some of the types of renewable energy technologies are as discussed below.

- Hydropower – is the generation of electricity through water, and mostly generated through the use of hydroelectric dams in rivers. It is one of the technologies that provide 20% of the global electricity supply [10].
- Solar Energy – relates to generation of electricity through the use of harnessed energy from the sun, and can also be stored for future use.
- Wind Energy: This is another clean energy source. It is the generation of electricity using turbine turned by wind.
- Geothermal Energy: This is the energy generated through the heat stored in the rock by the rock natural heat flow.
- Wave Energy: This is the type of energy generated in relation to ocean waves generated by passing over long stretches of water called fetches [5].
- Bioenergy - is the conversion of biological waste to source of energy. Biomass provides about 40% energy source in the developing countries of the world [10].

There are advantages of using renewable energy technology, these include; relative availability, sourcing and environmental friendliness. There are social impacts of these sources of energy for instance increasing or decreasing employment rates in certain regions, changing political relations internationally as certain nations end their reliance on others for energy etc. The effects of these impacts are insignificant and most importantly pose no danger to the environment, and public health. However, there are other qualitative social impact assessment as summarised in the table (1).

Technology	Impact	Magnitude
Photovoltaic	Toxin Visual	Minor - Major Minor
Geothermal	Noise Pollution Seismic activity Odour	Minor Minor - Major Minor Minor
Wind	Noise Bird Strike Visual	Minor Minor Minor

Table 1, Impact of some Renewable Energy Technologies.

Introduction of the renewable energy technology especially in the developing part of the world is necessary at this period due to some known research facts which include;

Degradation: Limited access to the non-renewable energy sources like coal, natural gas, petroleum etc. will surely finish one day because they are not raw materials that can replenish. Therefore, for this particular reason, the humanity needs to think about potential alternative and also think of what to you to supplement the existing non-renewable energy to manage the ecosystem.

Security of supply: Availability of the non-renewable energy resources is not general. Some part of the world has it as natural resources while some does not have. Most of these non-renewable energy resources are transported or exported to some other places for processing and usage. It also requires some other extra work and technology to refine them for use [11].

Consumption increase: increase in the world energy consumption becoming rapid on daily basis. With the growth of the world population and technology advancement, there is more need for energy to compliment the better living of the world [12]. This population growth is a great factor that will affect the supply of non-renewable energy, i.e. the more the population increases, the more the demand on energy supply and this will finally result to demand of the resources like fossil fuel.

Sustainability: sustainability can be said to be living in a way that or maintaining conditions where human beings and its natural habitats can exist in productive harmony to support the present and future generation [4]. The use of renewable energy is needed to keep

up with the sustainability pace and the use of the renewable energy will support and have positive impact on the energy supply, it will help build good environment, society and economy.

Climate change: The continuous use of non-renewable energy sources especially like fossil fuel that increase the greenhouse gases to the atmosphere is having negative impact on the global climate and this is affecting the general environment negatively causing climate change [13].

Population growth: With the increase in the world population, it is going to a period when these existing non-renewable energy resources will no longer be available or will not be enough to satisfy everyone. Potential scarcity of these non-renewable energy sources due to this population might make it to be very expensive and not affordable for many [14].

Global Resource Saving: Introduction of the renewable energy sources is in a way saving the world a lot of resources that would have been depleted to unreasonable level [15]. These introduced renewable energy is serving as a supplement and a complementary option to safeguard the early exhaust of the little existing non-renewable energy resources.

Rural energy supply and electrification: The introduction of renewable energy has really helped in the remote areas of many countries of the world [12]. The villages that did not have access to the main government grid have been able to have supply of electricity through the renewable energy technologies used in rural electrification for the community use.

2.2 Overview of Energy Savings

It has been evident from many research studies that one of the most common research areas in the modern era has been that of Energy Saving and Sustainability [1]. Increase in energy cost and environmental impacts of generating the electricity is really giving reasons for energy savings and making energy saving more important. There is a need to take global environmental protection seriously in the future to ensure companies liabilities; the concept of "Green integration" is a set of solutions for contributing to environmental protection regarding energy system design, architectural & building design, and energy management [16]. Great importance is towards green energy which includes the renewable energy and power generation source like solar power, hydroelectric power, wind power and biogas/biomass power. These are the common environmental friendly and non-polluting energy sources that can be used effectively for energy saving purposes. The Green or renewable energy is considered to be best alternative energy source for many years compared to traditional energy due to higher expenses. Energy saving is a means designed to minimize the use of some forms of energy sources like gas, electricity for environmental, cost and socio economic reasons. Energy savings' means an amount of saved energy determined by measuring and/or estimating consumption before and after implementation of an energy efficiency improvement measure, whilst ensuring normalisation for external conditions that affect energy consumption [17].

Energy savings has been in use in the developed nations of the world years before now, the concept is just spreading to the developing countries with this vast economic growth and rapid industrialisation that comes with additional energy requirements. Energy savings is set as a new approach to maintain a suitable environment and to control the greenhouse gas emission which is being released mostly from power generation through fossil fuel. The cost of running paper industry in China has been on the high side for a while now and the cost is mostly incurred from energy consumption, a research by [18] analysed the methods of cutting energy costs which also triggers reduction of CO_2 emission by encouraging low energy consumption. Some factors like Energy price, industry structure, profile margin and technology were added to analyse energy intensity in paper industry for better result. This research developed a long time energy saving model for paper industry in China. This research is the first that will analyse energy saving potential in paper industry in China. It ascertained that upgrade of technology in paper industry or introduction of new production technology which increases productivity will go a long way in reducing power consumption and thereby enhanced energy saving. It also looked into how energy especially electricity consumption can be saved in the telecommunication industry in China [1]. It critically estimated the amount of electricity being consumed by the technology of the telecommunication industry and looked into how this can be reduced to the barest minimum. A model was generated or developed for the technological energy saving in the telecommunication industry in China. Some parts of Indian experience extreme cold in winter which will always increase energy consumption for heating especially during winter. It was researched into, how energy could be saved and CO_2 emission reduced around this time of the season and beyond in India [19]. The theoretical energy saving analysis of air conditioning system using HPHX for Indian climatic zones was also studied by [20]. They carried out an analysis in twenty-five (25) cities in India representing different Indian climatic zones.

Another research discussed on the ways thermal comfort could be achieved without the use of energy thereby saving energy to also reduce CO_2 emission for better sustainability in Mexico [21]. The research encouraged the use of building materials with high heat capacity to reduce heat in buildings, schedules to control room temperature and control the number of occupants in the building. Taiwan industrial sector was able to use energy saving potential insight through this research [22]. The research highlighted the energy saving potentials of similar countries in Asia and was able to analyse them to work out potential energy savings in the industrial sector in Taiwan. It analysed Taiwan industrial structure, energy use and Greenhouse gas emission in full. Energy saving is a strategic approach which can promote sustainable development. The safe practice in industries and homes has been what the sustainability awareness is all about to achieve the reduction of greenhouse gas release into the atmosphere, energy saving is part of the main method that can be adopted for this to be achieved. Sustainability or Sustainable development has been commonly defined as "Economic and social development that meets the needs of the current generation considering the ability of future generations to meet their own needs" [23]. This definition reflects the three most important aspect of human living which are; economic, social and ecological development. Research also considered solar energy as one of the important aspects for the future of cleaner energy, including many energy experts expected renewable energy revolution to start once solar systems starts extracting more energy from the sun than at the present time [24]. Similar studies focus towards the need for implementation of environmental conservation or energy saving policies that effects the economic growth of the African countries due to being within the current stages of industrialisation [25]. Although there are many studies that have focussed within African continent, however there is a lack of research that focuses on the linkage between energy consumption, carbon emission and economic growth. The concept of sustainability in energy saving relates to things that can be done to achieve a comfortable environment in homes and industries towards economic, environmental and social satisfaction. However, maximizing profit and building very good social responsibility status in any country, every sector or organisation should embrace and encourage the use of sustainable practice in every aspect of their productions and services. Meanwhile, potential energy saving is one of the strong tool for sustainable development. Energy generation and consumption especially through the use of coal, fossil fuels and the rest release a lot of harmful greenhouse gases to the atmosphere, apart from the air pollution, these gases reacts with some other elements in the atmosphere which at the end will cause series of damages to the earth thereby affecting the smooth living of the creatures.

3 Research Methodology

This paper presents the use of comparative research that compares the conventional energy usage for power generation in telecommunications cell sites base stations with the alternative renewable energy sources. The present method of power generation, which is largely dependent on fossil fuel, is harmful to the environment and non-economical. Research shows Nigerian telecommunication use above 150 million litres of diesel every year to power the existing base station which is not environmental friendly [26]. Global demand trends towards maintaining a sustainable environment that entails reducing human footprint and emission of greenhouse gases. This has become imperative to mitigate the challenges of global warming which is the prime factor for climate change. Hence, to better understand the particular aspect, this research study investigates alternative sources of energy that aims to support sustainability through suggestion of renewable energy technology sources that have been identified. Sustainability assessment was then carried out using some sustainability indicators adapted from [3]. These were looked into within the identified renewable energy sources. The sustainability indicators used include;

- *Price of generated electricity;*
- *Greenhouse Gas Emission (GHG);*
- *Efficiency of the energy generation;*
- *Technological limitation and availability;*
- *Socio-economic impacts;*
- *Land use.*

The sustainability assessment was done to rank the identified alternative energy sources to know which one of them will be the best to be considered after considering some other factors. The research then considered the power requirement in a typical telecommunication base station to be sure of selecting the best alternative that could generate enough energy needed to power the cell site base station. The best of all these renewable energy technology is then selected and fully analysed, it was then assessed economically and environmentally with the conventional way of power generation (diesel generator) in the telecommunication base station in Nigeria.

4 Results and Discussions

Identified renewable energy that are clean and sustainable which could be used as alternative to fossil fuel power generation includes: Bio-Energy, Geothermal, Hydro-power, Solar, Wind and Natural gas. Meanwhile, considering some other factors in telecommunication industry, the best three were selected that could fit into this research. The selected three renewable energy technology selected are; Wind, Solar-Photovoltaic and Geothermal. Sustainability assessment carried out on the best three identified renewable energy technology as shown in Fig 1 indicates that the most appropriate alternative source of energy is Solar-photovoltaic energy after considering some other physical factors during further analysis.

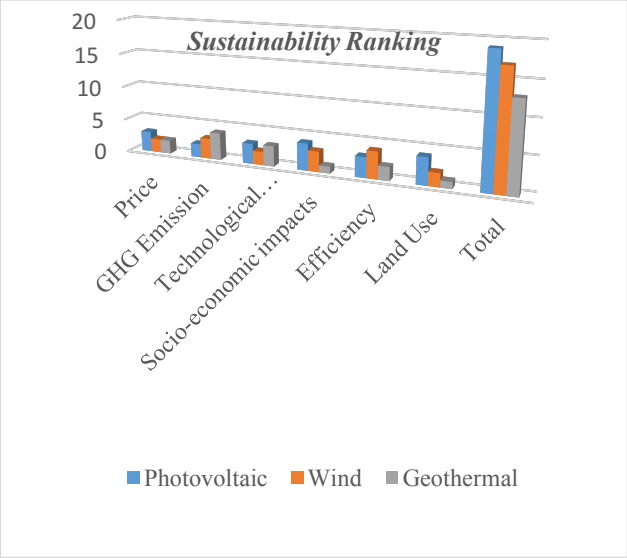

Fig.1, Sustainability Ranking for Renewable Energy Technology in Nigeria

Several studies have shown that telecommunication base station consumes an average of about 12,500kw/h of electricity annually [27]. Every base station requires this amount of power for the equipment to work at the maximum rate and efficiency; therefore, there is a need to be sure that the chosen alternative will be able to meet the power requirement of a typical telecommunication cell site base station. This can be supported by daily solar radiation data (kWh/m^2/d) as well as the highest power required to power a telecommunication base station. The highest power that can be drawn by the fully loaded GS/3G base station is traditionally estimated to be about 3.5kw on the average. This estimation is based on the worst-case scenario after critical analysis of an experimental result summarized in figure.2. A field experiment in Ibadan, southwest Nigeria chosen as the worst-case scenario site shows that solar-photovoltaic can generate enough electricity required to power any cell site base station [27].

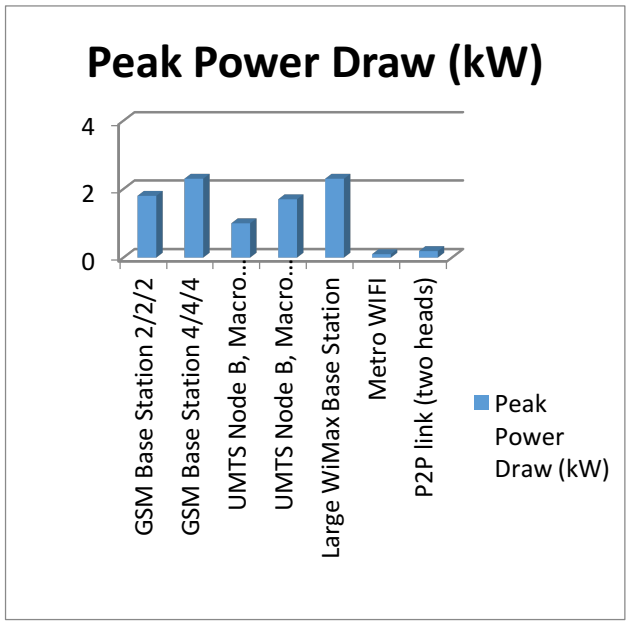

Fig.2, Power Requirement of various Base Stations

However, several solar-powered systems are available and affordable in the market to fulfil this power requirement. The concern about this initially was how the power can be used when there is no sunlight. Meanwhile, the solar-powered system designed has been able to resolve this issue. The solar powered systems available are all designed to have power storage. The system will be able to store power harnessed by the solar panel (PVC) from the sunlight in the day with the aid of deep cycle battery and charger controller that has been assembled and built for this purpose. This charger controller will regulate power to the base station during the day when there is sunlight and sill controls the charging of the battery. Most of these designed solar-powered systems have the solar panel/modules that cam fully charge batteries for just 4-6 hours of sunlight. The charged battery arrays are also able to have a backup compatibility of 2-3 days for the reasons of unforeseen technical issues.

4.1 Economic and Environmental Analysis

The economic and environmental aspect of this research was investigated using typical base station settings and then the overall savings was looked into considering the number of base stations in Nigeria.

Reports ascertain that Nigeria telecommunication sector runs well above 35,000 cell sites by different telecommunication companies [2]. According to data from the Ministry of Communication Technology, between 2013 and December, 2014, 2G-enabled sites have increased from 22, 578 to 28,289 while 3G-enabled sites have increased from less than 10,000 to 15,048 during the same period [2].

Costs	Definition of Term
Purchasing cost	Cost incurred to purchase or to put the power source on site
Maintenance cost	Cost associated with maintaining the energy generation source e.g. repairs, servicing.
Fuelling cost	This is the cost incurred on fuelling if need be.
Emission	Greenhouse gas emitted into the environment.
Life span	This considers how long the power generation set will last or will be due for replacement due to efficiency declination.
Miscellaneous cost	This might be associated with some other little additional cost that might come in over the year. It might be extra fuelling cost due to fuel scarcity, additional cost on maintenance, transportation of materials or equipment to and from sites.

Table 2, Criteria Used in Economic Analysis.

The cost of setting up and running of a conventional diesel generator powered system was first looked into while the chosen alternative which is solar photovoltaic energy was then analysed. The cost analysis over the period of fifteen years was then looked into for the best conclusion to be drawn and best recommendation made. Some of the factors and conditions considered in carrying out the economic and environmental analysis is shown in Table 2.

4.1.1 Base Station with Diesel Generator

The summary cost of a typical base station cost per year and the predicted cost estimated over fifteen years per site is summarized in Fig. 3.

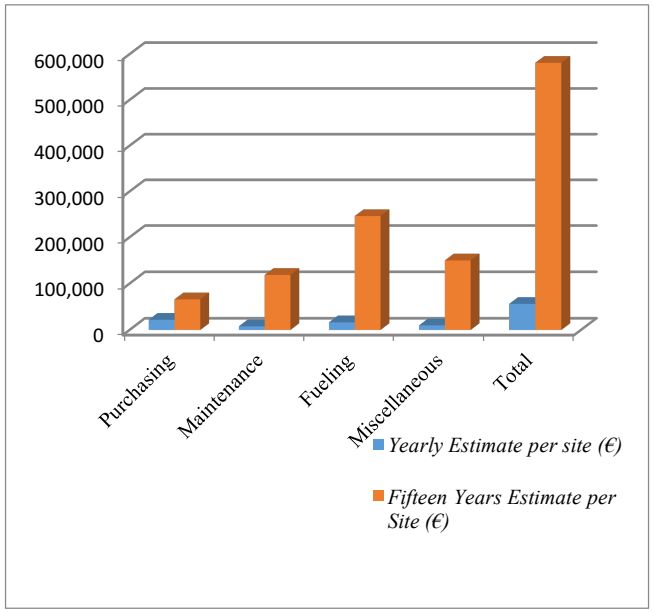

Fig.3, Estimated cost for diesel generator base station per site.

Similarly, the representation of the associated costs for the active 35,000 base stations in Nigeria using diesel generator for a year and fifteen years is shown in fig.4.

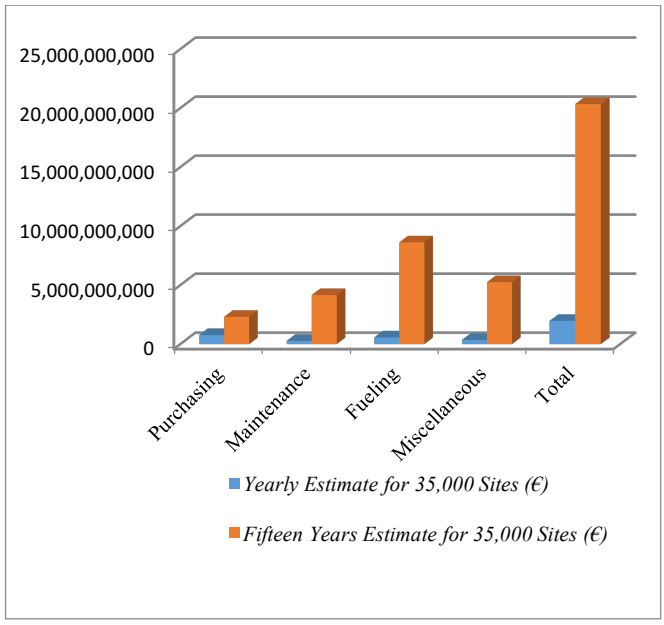

Fig.4, Estimated cost for diesel generator base station for 35,000 sites.

4.1.2 Base Station with Solar Power Generation

The cost associated with solar photovoltaic power generation in any telecommunication base station is just the purchasing cost of the system and the little miscellaneous cost of running the site. Looking into the future for about fifteen years running, the cost on the site will still remain the same except for the little

increase associated with miscellaneous which might entail payment of labour cost for occasional cleaning of the solar panel surface, replacement of damaged or less performing battery if any, occasional cleaning of the power storage equipment boxes etc. Fig.5 summarises the cost per year and over the span of fifteen years.

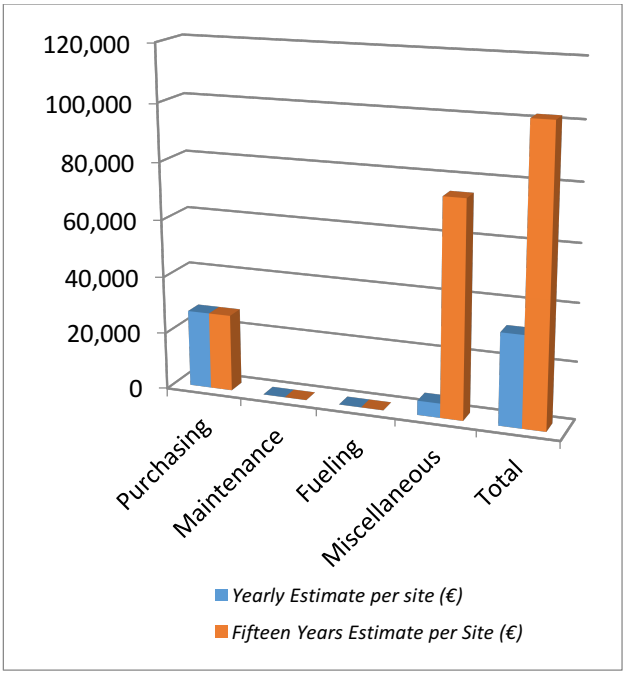

Fig.5, Estimated cost for solar photovoltaic power system base station per site.

Meanwhile fig.6 highlights the cost yearly estimates for the 35,000 as well as the period of fifteen years.

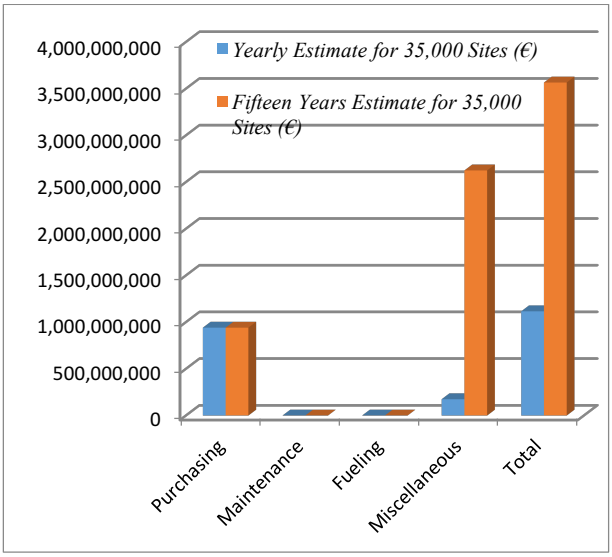

Fig.6, Estimated cost for solar photovoltaic power system base station for 35,000 sites.

4.2 Key Results and Economic Difference

Total yearly cost estimated for diesel generator base station per site is about €56,345, meanwhile it is about €32,000 for solar-photovoltaic. It shows that a total sum of €24,345 can be saved yearly. However, the long term of fifteen years site running on diesel generator will cost €581,175 but it will cost €102,000 if the sites are on solar-photovoltaic which means potential energy savings worth €479,175 within the fifteen years on just one site if photovoltaic energy system is used as alternative power source. However, the difference on the total number of cell sites base stations in Nigeria will tend to save more because of the long term full cost that will be off. The purchasing cost will also be cut down as well because the average life span of a solar energy system will be up to 20 years or more. Total yearly estimate for diesel generator for 35,000 sites is about €2Billion while for solar-photovoltaic is about €1.2Billion which gives a difference of about €800Million. However, for fifteen years long term estimate of diesel generator powered site will cost €20Billion while the solar-photovoltaic power generation will cost just €3.6Billion. This means that the cost of potential energy savings within the fifteen years of operation if the alternative energy is used will be €16.4Billion.

4.3 Benefits of Solar Photovoltaic Energy System

In all, this proposed change is to the benefit of the Nigeria telecommunication industry, the environment and the world at large. These overall benefits include;

- Profit maximisation - the telecommunication industry in Nigeria will be opportune to increase their profit margin due to the reduction in the running cost of the base stations
- Better network coverage – this encourages more base stations roll out for better [27] coverage especially in the rural areas. The base station roll out will be of advantage to the people, the country and the operators.
- High social responsibility status - improves the social responsibility status, through an environmental conscious and friendly industry that supports the green campaign.
- Longer life span - solar photovoltaic is more durable than conventional diesel generators used.
- Improved logistics - stress of logistics and procurement process on generators maintenance and transportation of fossil fuel to base stations will be eliminated, thus improving employee efficiency for other aspects of the business
- Keeping on with trend - the telecommunication industry in Nigeria will be able to follow the present trend in sustainable energy movement in the world.

4 Conclusion

The research study presents an understanding towards the energy saving concepts, sustainability and efficiency within the Telecoms industries in Nigeria. This awareness allows further strengthening Nigeria's industrial sector at large and allows the wider knowledge of sustainable management and energy saving towards improving business and productivity. The research also serves to provide early insights for any major telecoms operators in the method of cell site base station management. The research has been able to simplify the cumbersome and tedious management methods of the base stations, and towards reducing the overhead costs of running cell site base stations. The vandalism and theft incidents in the base stations are aimed to be reduced to the minimum levels. The main reason for the theft is towards the stored fossil fuel whenever there is scarcity or increase of petroleum produce within the country. The newly recommended renewable energy technology to power the base stations according to the analysis in this research study is for an environmental friendly energy source. The power saving measures which was carefully and critically analyzed in this research has shown that the cell site base stations in Nigeria telecommunication industry could be well powered by renewable energy technology specifically using solar photovoltaic source. This will bring an end to the high cost of powering base station and will also eliminate the environmental pollution accosted with these base stations power supply in Nigeria telecommunication industry. This research illustrates that the solar photovoltaic energy system will be more efficient and cost effective than the present or conventional ways of powering telecommunication base stations in Nigeria. The sustainability and energy saving is the latest and one of the common research areas within developing countries due to the revolution of the sustainable practices within domestic and commercial usage. This research explores on better utilization of energy saving methods within telecoms industry by focusing towards cell site base stations as the reference. Further research is required towards better energy saving approaches on other business activities within the telecoms industries, specifically for the equipment requiring higher energy consumption such as air conditioners, computer sets and data equipment.

The potential energy saving has been focused in the academic literature in the recent years and this is due to the keen interest of conducive environment in order to secure the future of the unborn generations. It is also been considered by the world manufacturing industries as it provides a great opportunity for profit maximization. However, the telecommunication industry in Nigeria is still at the primary stages of practicing the energy source aspects. The source of energy or energy technology adopted in Nigeria telecommunication sector is not still powerful both economically and environmentally. The country's telecommunication sector still runs its cell sites base station on fossil fuel using diesel generating sets. This method is very expensive and thereby causing high tariffs in both calls and data services. This research sought to investigate more beneficial practices that could help the telecommunication sector in Nigeria to take advantage of the energy saving initiative. Apart from the outrageous running cost of the telecommunication cell site base stations in Nigeria, the negative environmental impacts of this approach cannot be denied. This can be due to the generation of public concerns and posing threat to immediate environment. Hence, the harmful emissions of the greenhouse gases lead to the global warming. According to this paper, the solar photovoltaic energy system would be the best renewable energy that can be used as an alternative by the telecommunication operators in Nigeria in order to help them enhance the cost effectiveness and profit maximization. By analyzing the latest sustainability assessment procedures, the environmental management advantages and its cost advantages were pointed out. In some non-EOCD countries such as china, India, Taiwan; several industries have been able to research and enhance the potential energy savings within different industries such as paper industry, food and beverages manufacturing and cement industries. However, Nigeria as a country with fast growing economy gradually moves towards attaining high industrialization and hence, requires focusing on energy saving practices in the next few years. Future research could be more focused on enhancing the awareness of residential energy savings involving all the people to provide them with the know-how on energy savings that could be the most efficient and long-term sustainability practice within this field.

References

[1] Q. Zhang, N. Shah, J. Wassick, R. Helling and P. van Egerschot, "Sustainable supply chain optimisation: An industrial case study," Computers & Industrial Engineering, vol. 74, pp. 68-83, 2014.

[2] AllAfrica Global Media, "Nigeria: Telecommunication Revolution - 14 Years After, the Journey So Far," AllAfrica Global Media, 2015. [Online]. Available: http://allafrica.com/stories/201501191303.html. [Accessed 17 July 2015].

[3] Evans, V. Strezov and T. J. Evans, "Assessment of sustainability indicators for renewable energy technologies," Renewable and Sustainable Energy Reviews, vol. 13, no. 5, pp. 1082-1088, 2009.

[4] EPA US, "Climate Change Indicators: Global Greenhouse Gas Emissions," US EPA, 2015. [Online]. Available: http://www3.epa.gov/climatechange/science/indicators/ghg/global-ghg-emissions.html. [Accessed 17 May 2015].

[5] G. Boyle, Renewable energy, Oxford: Oxford University Press, 2004.

[6] Z. A. Elum and A. S. Momodu, "Climate change mitigation and renewable energy for sustainable development in Nigeria: A discourse approach," Renewable and Sustainable Energy Reviews, vol. 76, pp. 72-80, 2017.

[7] World Commission on Environment and Development, "Our Common Future," Oxford, 1989.

[8] R. K. Tiwary, "Environmental impact of coal mining on water regime and its management," Water, Air & Soil Pollution, vol. 132, pp. 185-199, 2001.

[9] "Renewable Energy Defined," 2015. [Online]. Available: http://www.treia.org/renewable-energy-defined. [Accessed 17 May 2015].

[10] V. Nelson and K. Starcher, Introduction to renewable energy, Boca Raton, FL: CRC, 2011, pp. 15-70.

[11] S. R. Shakeel, J. Takala and L.-D. Zhu, "Commercialization of renewable energy technologies: A ladder building approach," Renewable and Sustainable Energy Reviews, vol. 78, pp. 855-867, 2017.

[12] P. He and M. Veronesi, "Personality traits and renewable energy technology adoption: A policy case study from China," Energy Policy, vol. 107, pp. 472-479, 2017.

[13] R. Kardooni, S. B. Yusoff and F. B. Kari, "Renewable energy technology acceptance in Peninsular Malaysia," Energy Policy, vol. 88, pp. 1-10, 2016.

[14] C. Taliotis, E. Taibi, M. Howells, H. Rogner, M. Bazilian and M. Welsch, "Renewable energy technology integration for the island of Cyprus: A cost-optimization approach," Energy, vol. 137, pp. 31-41, 2017.

[15] B. Ali and A. Kumar, "Development of water demand coefficients for power generation from renewable energy technologies," Energy Conversion and Management, vol. 143, pp. 470-481, 2017.

[16] "INTELEC: International Telecomunications Energy Conference," 1st ed., N.J, Piscataway, N.J: IEEE, 2007, 2007, pp. 750-755.

[17] Y. Dutil and D. Rousse, "Energy Costs of Energy Savings in Buildings: A Review," Sustainability, vol. 4, no. 12, pp. 1711-1732, 2012.

[18] B. Lin and M. Moubarak, "Estimation of energy saving potential in China's paper industry," Energy, vol. 65, pp. 182-189, 2014.

[19] T. Sivasakthivel, K. Murugesan and P. K. Sahoo, "A study on energy and CO2 saving potential of ground source heat pump system in India," Renewable and Sustainable Energy Reviews, 32, pp. 278-293, 2014.

[20] T. S. Jadhav and M. M. Lele, "Theoretical energy saving analysis of air conditioning system using heat pipe heat exchanger for Indian climatic zones," Engineering Science and Technology, an International Journal, vol. 18 (4), pp. 669-673, 2015.

[21] Oropeza-Perez and P. A. A. Østergaard, "Energy saving potential of utilizing natural ventilation under warm conditions – A case study of Mexico," Applied Energy, vol. 130, pp. 20-32, 2014.

[22] S.-M. Lu, C. Lu, K.-T. Tseng, F. Chen and C.-L. Chen, "Energy-saving potential of the industrial sector of Taiwan," Renewable and Sustainable Energy Reviews, vol. 21, pp. 674-683, 2013.

[23] P. McManus, "Defining sustainable development for our common future: a history of the World Commission on Environment and Development (Brundtland Commission)," Australian Geographer, vol. 45, no. 4, pp. 559-561, 2014.

[24] U. Stritih, H. Paksoy, B. Turgut, E. Osterman, H. Evliya and V. Butala, "Sustainable energy management," Management of Environmental Quality: Int. Journal, vol. 26(5), pp. 764-790, 2015.

[25] M. A. Masoud, N. S. Najat and O. B. Hamad, "The relationship between energy consumption, CO2 emissions and economic growth in Tanzania," International Journal of Energy Sector Management, vol. 9, no. 3, pp. 361-375, 2015.

[26] D. U. Ike, A. U. Adoghe and A. Abdulkareem, "Analysis of Telecom Base Stations Powered By Sola Energy," I. J. of Scientific and Technology Research, vol. 3, no. 4, pp. 369-374, 2014.

[27] M. M. Albiman, N. N. Suleiman and H. O. Baka, "The relationship between energy consumption, CO2 emissions and economic growth in Tanzania.," International Journal of Energy Sector Management, vol. 9, no. 3, pp. 361-375, 2015.