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Environmental and Cost Comparative Analyses between Generator set and Solar as Alternative Energy Sources-NITEL Repeater Stations a Case Study

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Abstract: Energy and development are two things that are closely related; as energy availability increases, the rate of socio-economic development of a nation will equally increase and vice versa. The challenge in most developing nations of the world, including Nigeria, today is non-availability of appropriate electricity supply. In solving this problem, the use of generator sets has become the order of the day. Unfortunately, its uses rather than bringing the desired solution, has been a major source of environmental problem in recent times. To prevent this, a better alternate energy source that is cost effect and environmental hazard free must be encouraged worldwide. This study, therefore, takes a look at the environmental and cost effectiveness of using diesel generator set and solar as alternative energy sources using Nigerian Telecommunications (NITEL) Plc, as a case study. The study revealed the huge amount of Nitrogen Oxides (NO_x), Carbon (IV) Oxide (CO_2), Sulphur (IV) Oxide (SO_2) and particulates being emitted annually into the atmosphere by two repeater stations of this company alone. Also, through the cost comparative analysis carried out in this study, it was found that over 40% of the company's expenditure on diesel and maintenance of the generator would have been saved if solar was being used. Hence, the study established the fact that the use of solar is more economical and environmentally safer than generator set. The paper concludes with suggestion on how to encourage world energy-environmental friendly policy as well as how to avert the adverse effects of total exhaustion of non-renewable energy for socio-economic development.

Key words: Energy, developed and developing nations, air pollutants, renewable and non-renewable energy sources

INTRODUCTION

Energy and its utilization constitute the transforming agent, which has taken mankind from its primitive state to the present level of civilization (Megbowon and Adewunmi, 2002). The role and impact of energy in nations (developed or developing) development can not be over-emphasized. It is the lubricant that lubricates the engines of all sectors of an economy in order to keep it moving toward the desired direction and to achieve the desired goal (Akinbami, 1997). In fact, it is an indispensable commodity for national growth. Thus, it is true to say that energy and energy supplies are the foundations of modern industrial economies (Deijomaoh and Iyoha, 1980) and a central factor for eliminating poverty in the society (Adgoke and Akintunde, 2000).

In developing nations, such as Nigeria, where electricity is unreliable, unavailable and inconsistent due to the problem associated with grid system, financial constrains and other societal problems, alternative energy source is then a must. In view of this, most residential and industrial consumers of electricity have adopted the use of generator sets as an alternative source of power supply. However, with the present dramatic rises in the price of petroleum products over the past decades or so, it has become practically impossible to use generator sets because of its maintenance and running costs. This has resulted in backwardness in economic growth of most nations, mass retrenchment of workers, folding up of both small and medium scale industries, mass rural-urban migration, increase in waves of armed robbery and other societal vices.

However, in the recent times, there has been a considerable surge of interest and activity worldwide in searching for more efficient ways of using existing energy sources that are naturally available including solar, tidal and wind among others. In this regard, solar energy, which exists in much larger quantities than oil in nature, has been discovered as one of the best alternative energy sources for satisfying the world energy demand.

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Solar energy is one of the renewable energy sources. Unlike petroleum products, solar energy can be regenerated with the advantage of being inexhaustible. There are three ways of harnessing solar energy. It may be used directly through passive solar system or active solar system (Botkin and keller, 1998). The third means of harnessing solar energy is by using Photovoltaic (PV) technology. This is the modern technology of harnessing solar energy.

Photovoltaic is the term used for the technology that converts sunlight directly to electricity using a solid semiconductor materials. The system uses solar cells made of silicon or other materials such as gallium arsenide for converting sunlight directly into electricity (Nwaroh, 2000). The cells are connected in standardized modules which can be combined to produce systems of various sizes so that power output can be matched to the intended use. Electricity is produced when sunlight strikes the cells causing electrons to flow out of the cells through electrical wires.

In Nigeria, like many countries of the world, solar powered generating systems have been found to be a well established, reliable and environmental problem free alternative to conventional generator sets as stand-alone source of energy in few homes (Offiong, 2003). The system has equally made great success in rural electrification, water pumping, agriculture and security systems. It has been and will remain the best choice for providing electrical power to satellites in an orbit around the earth. Apart from these applications, photovoltaic solar generators have been discovered as reliable alternative source of electricity for terrestrial remote television and radio receivers, remote weather measuring, rural telephone systems, etc.

Since every means of generating energy has impacts on the society. There are two approaches of looking at the value of electricity generating system. The first approach is its environmental impact on the society. For sometimes now, the environmental damage by energy production has been known. Hence, the assessment of this damage has become an important issue. It is therefore essential that environmental aspects of photovoltaic (solar) power generation relative to diesel generator set as alternative sources of electricity generation be considered in full detail. The second approach is through the economic benefits of the system, which can either be money that has been saved, or revenue that has been collected by operating the system. Similarly, therefore, a comparative cost analysis comparing photovoltaic (solar) system and diesel generating set as alternaive energy sources shall be considered.

In view of this, this study takes a look at two Nigerian Telecommunications Limited (NITEL) Plc, repeater stations (Ode-Aye and Odutola) both under the Ijebu-Ode Maintenance Control Paint (MCP) with the objective of seeing how their energy requirements are met. The study also makes a comparative analysis on the environmental impacts of diesel generator sets and solar energy generator as alternative power sources to public electricity supply. In addition, the study explores a comparative analysis on cost consideration of these two forms of alternative energy sources. These comparative analysis were made with the aim of providing information to the nations energy planners and decision maker of each country of the world; most especially the developing nations to shift their focus, resources and decisions on the pathway to sustainable energy development not only for now but also for the future generations to come.

MATERIALS AND METHODS

In carrying out this study, two repeater stations under the Ijebu-Ode maintenance control paint were visited several times. Useful information about the repeater stations was obtained from authoritative personnel of the stations. For instance, it was discovered that the energy requirements of the stations are met through different means. In fact, there are three repeater stations under this maintenance control paint but only two were considered because of their relevance to the study. They are namely; Ode-Aye, Likosi and Odutola repeater stations. The total energy requirement at Ode-Aye repeater station, which is one of the two repeater stations considered, is partially provided using two 35 kVA diesel generator sets and solar generator. Likosi repeater station, though not considered in the analysis, is being powered by two 35kVA generator sets and public power supply. Similarly, the total energy requirement of Odutola repeater station, which is the second repeater station considered, on the other hand, is provided using three 35 kVA diesel generator sets. The data on the capital, maintenance and operating costs of the stations are presented in Table 1.

Furthermore, short questionnaires were prepared to obtain information on workers and general public responses about the environmental impacts of the two alternative energy sources considered in this study. Also, the data obtained are presented in Fig. 1.

COMPARATIVE ANALYSES

Environmental evaluation: The modern civilization has made our environment more livable in many ways. At the same time, we recognized that modern civilization has had many negative effects on the environment. One of such negative effects is increase in air pollution. One of the sources of air pollutant today in our society is exhaust gasses release in using generator set. Air pollutant has

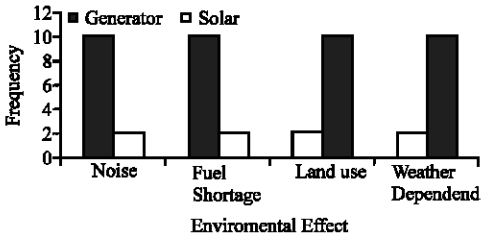

Fig. 1: Comparative analysis on generator set and solar environmental effects. For each category of environmental hazard, the responses are rated relatively to one another in a scale of 2 = best free and 10 = worst involved

Table 1: Summary of the cost comparative Analysis

	Odutola diesel powered station			Ode-aye diesel and cost solar powered station		
Capital cost	₦	:	K	₦	:	K
Cost of diesel Generator sets.	7,650,000	:	00	5,100,000	:	00
Cost of diesel Generator sets installation.	1,147,500	:	00	765,000	:	00
Cost of solar panels	-			4,320,000	:	00
Cost of solar panels installation	-			648,000	:	00
Sub-total	8,797,500	:	00	10,833,000	:	00
Operational cost	₦	:	K	₦	:	K
Annual cost of Diesel	2,336,000	:	00	934,400	:	00
Annual cost of fuelling solar panel	N/A			-		
Sub-total	2,336,000	:	00	934,400	:	00
Maintenance cost	₦	:	K	₦	:	K
Annual maintenance Cost of generator sets	765,000	:	00	204,000	:	00
Annual maintenance Cost of solar panel	N/A*			-		
Sub-total	765,000	:	00	204,000	:	00
	₦	:	K	₦	:	K
Total cost	11,898,500	:	00	11,971,400	:	00

*N/A - Not-Applicable

considerable effects on many aspects of our environment. These effects were once limited to our urban areas, but they are now extending to even the rural areas.

Air pollutants affect both vegetation and human health in several ways. The effects of air pollutant on vegetation include damage to leaf tissues and fruits, reduction in growth rates or suppression of growth, increased susceptibility to a variety of diseases or pest and disruption of reproductive process in plants (Botkin and Keller, 2003). On the other hand, the effects on an individual depend on the dose or concentration of

Table 2: Air pollutants emission factor of diesel

Emission	Pollutant in kilograms			
	NO_X	CO_2	SO_2	Particulates
*Emission factors for diesel (1000 kWh)	1.5	1062.5	19.4	1.0
Emission per day of the pollutants by a Diesel generator set	0.00525	3.71875	0.0679	0.0035
Emission per annual of the pollutants by a Diesel generator set	1.91625	1357.3438	24.7835	1.2775*

Source: Haralambopoulos and Spilanis, 1997

exposure and other factors, including individual susceptibility. Some of the primary effects of air pollutants are toxic poisoning, cancer, birth defects, eye irritation and irritation of the respiration systems, increased susceptibility to heart disease; and aggravation of chronic diseases such as asthma (Botkin and Keller, 2003).

There are two main groups of air pollutants: primary and secondary. Primary pollutants are those emitted directly into the air, they include particulates, sulphur oxides, carbon oxides, nitrogen oxides and hydrocarbon. The secondary pollutants are pollutants produced through atmospheric compounds. For example, ozone is a secondary pollutant that is produced on bright, sunny days in areas where there is much primary pollutant.

The air pollutants are not uniformly distributed in the atmosphere, but tend to be released, produced and concentrated locally or regionally (Botkin and Keller, 2003). For example, in highly populated and industrial areas in Nigeria, the use of diesel generator sets has become the order of the day as a result of epileptic electricity supply from the sole power utility body. Hence, the concentration of air pollutants in such areas is relatively higher than where few people are using generator sets.

The environmental benefits associated with the substitution of diesel generator set with the solar powered system can easily be estimated by determining the reduction in the production of air pollutants associated with this substitution (Offiong, 2003). Table 1 row 1 (Haralambopoulos and Spilanis, 1997) gives the pollutant emission factors used in calculation of the emissions from the electricity production using generator sets.

For instance, in this study, it was discovered that the load estimation of each of the two stations considered is 3.5 kWh. Therefore, for a system requiring this amount of energy; the emission per day of the pollutants by a diesel plant, shown in row 2, will be obtained by multiplying the values in row 1 of Table 2 by a factor of 0.0035. Similarly, the corresponding emission per annum of these diesel generator sets will be obtained by multiplying the values in row 1 of Table 2 by 365, the number of days in a year.

Hence, it means that an average of 9.58125 million kilogram of Nitrogen Oxides (NO_x), 6786.719 million kilogram of carbon (IV) oxide (CO_2), 123.9175 million kilogram of sulphur (IV) oxide (SO_2) and 6.3875 million kilogram of particulates per annum is released into the atmosphere by these two repeater stations alone. These values do not include the amount of emission from other industries, residential buildings, government establishments, ministries and parastatals and automobiles.

In addition, for loads of higher values, it is obvious that the air pollutant releases by using generator sets will be greater than the obtained values. In the same way, for loads of lower values, the air pollutant emitted will be less than the obtained values. But the fact still remains; there will be emission of these air pollutants into the environment. Hence, an alternative energy source such as solar, which is air pollutant free, will be a better substitute.

Apart from the air pollution effect so far considered, there are other discomfort of diesel generator sets considered in this study that makes solar system more preferable to generator set. Although these disadvantages are hard to quantify; they still make diesel generator sets inferior to solar system. These include noise and vulnerability to fuel shortages. The responses obtained from the personnel and general public are presented graphically in Fig. 1.

From Fig. 1, it is obvious that diesel generator sets have more pronounced environmental effects compared with solar energy. Against these, the study equally revealed the greater land area required by the photovoltaic (solar) system which has to be paid for as well as the fact that the effective performance of solar depends on weather conditions. Similarly, because of the greater reliability and non-negative environmental effects of solar energy compared with diesel generator, solar energy will be preferred alternative source of energy as well as best option for electricity supply.

Cost evaluation: The second approach to looking at the value of an electricity generating system is its cost evaluation. The financial assessment is an evaluation from the buyer's point of view. Therefore, when comparing the economic value of a photovoltaic system with other methods of power generation, for example diesel generator set, the capital cost, operational cost and maintenance cost as shown in Table 1 need to be considered.

From Table 1, the cost of procuring and installing solar panels is initially greater when compared with that of diesel generator sets. The study revealed that the cost of procuring and installing solar panels is 10.36% higher than the generator sets for the same load. However, in the long run, it is obvious that it is cost effective because the fuelling cost is free. This indeed has justified the high cost of procuring solar panels when compared it with one diesel generator set which is the difference in the two repeater stations.

Similarly, from section B of Table 2, the total cost of diesel (fuel) per annum at the rate of N80.000 per litre for the two repeater stations was ₦3, 270, 400.00. From this study, 71.43% of this amount was spent to fuel the generator sets at Odutola repeater station that is being powered only with diesel generator sets. However, for Ode-Aye repeater station, which is being powered jointly by diesel generator sets and solar panels or photovoltaic, 28.57% of the total amount spent on fuelling was spent on the generator sets here per annum. This indicates that 42.86% of the total fuelling cost was saved by the solar panel at Ode-Aye repeater station per annum.

With dramatic increases in fuel price worldwide, it is obvious that annual operational cost of Odutola repeater station will definitely be increasing at alarming rate. For instance in year 2002, the price of diesel per litre was ₦21.00, while the current price now in year 2006 is N80.00 per litre. Therefore, in 2002, the total amount spent on fuel per annum at Odutola and Ode-Aye repeater stations were ₦613, 200.00 and ₦245, 280.00, respectively. However, by the end of this year, the total amount that will be spent on fuel at Odutola and Ode-Aye repeater stations will be ₦2, 336, 000.00 and ₦934, 400.00, respectively provided in the production of air pollutants associated with this that there is no increase in fuel price before the end of the year. This shows that within almost four years, the amount to be spent on fuel only will be over 380% higher than the total amount spent in 2002. For the next ten years, provided that the price of diesel remains constant, which is practically impossible, the cost of running the Odutola and Ode-Aye repeater stations will be ₦23, 360, 000.00 and ₦9, 344, 000.00, respectively.

Considering this huge amount of money involved in running generator sets in these two repeater stations alone, it is obvious that the profit margin of NITEL will be minimal. Hence, a number of things are bound to happen. It is possible that the company will either lay off some workers or be unable to pay workers salary as and when due. In a situation where the company does not want to do either of this two options, such a company will rely only on public power supply utility body, with its characteristic low reliability. Hence, there service as the case may be will unreliable too and epileptic.

Furthermore, from Table 1 section C, the total annual maintenance cost of the generator sets for the two repeater stations will be ₦969, 000.00. From the cost analysis carried out, it was discovered that 78.95% of this amount will be used to maintain the generator sets at Odutola repeater stations while only 21.05% of the amount will be spent on Ode-Aye repeater station. This indicates that 57.90% of the maintenance cost would have

been saved; peradventure the two stations are solar powered. Finally, the study shows that the overall cost of Ode-Aye repeater station is 0.30% higher than that of Odutola repeater station. The variation can not be seen as a better advantage since the period of analysis is only one year. With no fuel and maintenance free advantages that solar system has over generator set it is obvious that the payback period of solar panel will be shorter compared with that of generator set. Also, the fact that solar system is much more environmentally friendly than generator set makes it a preferable energy source to generator set.

CONCLUSION

This study has established clearly that renewable (non-conventional) energy sources such as solar should be encouraged instead of non-renewable (conventional) energy sources such as diesel base on their environmental hazard free. This study has equally shown clearly that over 40% of the revenue that NITEL is spending on fuelling and maintaining generator sets will be saved by using solar energy sources instead of generator set as an alternate source of electricity. Similarly, this cost analysis has shown clearly that it is advisable to use solar energy source rather than generator sets where small amounts of energy are required. From these two analyses, it is believed that various categories of electricity customers in both developing and developed nations of the world will now agree that solar energy is both environmental friendly and cost effective compare with generator sets.

In line with the result of this study, it will be recommended that governments all over the world should encourage means of achieving energy-environmental friendly policy, which will lead to reduction if not total elimination in the production of air pollutants. In addition, it will be recommended that more efforts should be made worldwide in area of renewable energy sources so as to avert the adverse effects of total exhaustion of non-renewable energy source that is head of the this generation.

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