American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-1, pp-263-270
www.ajer.org
Research Paper Open Access

Development of Framework on The Performance And Sustainable Use Of Generating Sets in Buildings

Wahab, A.B.[1] Adesanya, D.A[2]
Department Of Building, Obafemi Awolowo University, Ile-Ife, Nigeria
E-Mail: wahabak2002@yahoo.com

ABSTRACT: Poor power supply by service provider has remained a stumbling block to the drive of building occupants to achieve comfort needs and efficient performance of occupational tasks indoor. This is due to the malfunctioning of energy infrastructures and associated components of power sector. This has caused paradigm shift to dependence on various types and brand of generating sets used by the occupants of buildings. The mode of use of generating sets and its operational performance affect its availability and reliability of being used as an alternative power supply by building occupants. The interrelated concepts associated with the dependence and use of generating sets were holistically considered. A framework was therefore developed that depicted how managers of built environment could be strategically positioned with tools that concern institutional base and house-keeping practices guide that the users of generating sets in buildings should adopt in the quest of ensuring sustainability of both users and environment.
Keywords: Buildings, Electricity, Supply, Generators, Availability, Users, Framework.

I. INTRODUCTION

Electricity is used on a large scale for different human activities in administrative, industrial, commercial, and residential buildings. Energy supply has become the next important ingredient for living after air and water (Abayomi, 2012). Different variables like income, price of electricity, degree of urbanization, income and level of population affect quantity of electricity used by each household (Adegbulugbe and Akinbami, 1995; Hickling, 2006; Lin,2003).Limited access to quality and quantity electricity has remained an unresolved scourge in Nigeria and its ravage cuts across buildings in different sectors. This has made significant number of households own and operator their generators (Azodo, 2014).

Electricity infrastructure provides base for commercial activities and technological advancement. The Nigerian energy infrastructure has experienced series of ups and downs (Adewoye, 2007; Sambo, 2008; and Subair and Oke, 2008). Nigeria, before 1999 had energy generating capacity of 5976 MW with 79 generating units. This however declined progressively to 1600 MW and 19 generating units in 1999. As at 2006, the generation level stood at 1500 MW as against the estimated demand of 4500 MW. According to World Bank (2001), it reported that in two decadesô time, Nigerian population is identified to likely double. In the absence of a comprehensive overhaul of energy policy and regulatory framework, more Nigerians will in the future be without electricity (Chidiezie and Igwiro, 2008).

In Nigeria, poor electricity supply is perhaps the greatest infrastructure problem confronting business sector. A typical Nigerian firm experiences power failure or voltage fluctuations about seven times per week, each lasting for about two hours, without the benefit of prior warning(Chidiezie and Igwiro, 2008). Electricity demand is mainly from residential, commercial and industrial sectors. Consumption has increased from less than 2,000 GWh in 1970 to about 11,044 GWh in 1990, representing an annual growth rate of 9% within the period and to 14,325 GWh in 1998 (Subair and Oke, 1998). The electricity consumption correlates very highly with economic activities. For instance, the growth rate was much higher in the 1970s during the period of relatively high economic growth than in the 1980s when there was downturn in the economy.

There is a strong connect between outage costs and outage frequency of electricity supply. Increased dependence of most industrial firms on private generating plants as a result of frequent power outages from the national grid has been observed to be responsible for the decline in electricity consumption by the industrial sector. The power generating plants in the country are not performing at the required output level and this is affecting available power supply to consumers. According to World Bank (2001), the breakdowns of the components of the recently privatized PHCN affect power supply in the country. It shows that power problems in the country, with under-capacity utilization and performance of generating system has resulted in

considerable investment in back-up auto-generation with its own associated huge variable, fixed, operating and maintenance costs.

According to Akinbami (2003), as electricity demand continues to grow, larger blocks of electrical generating capacity must be added to the electrical grid and this constitutes risk to electrical utilities. Many of todayôs vertically integrated utilities have led to changes in the supply system. The transformation has led to advances in energy producing and consuming technologies. Around the world, a new breed of independent power producers are building efficient and innovative power plants that run on cleaner energy sources such as natural gas, solar, wind and geothermal energy (Flavin and Lenssen, 1999).

Nigeria, like most other developing countries, is grappling with the task of providing sufficient amounts of electricity to meet its needs and fuel its development. The electrical power problem can be solved through the regional approach with countries teaming up to have centralized generating system serving them. Nigeria uses regional approach for power generation, and thus generate and distribute its power centrally. With the problems of the regional power generation, microgeneration of power can be used. Microgeneration is the generation of electricity on a very small scale. Microgeneration is used to refer to the generation of power to supply anywhere, from one to few houses. More people are turning to microgeneration, particularly in the third world (Infield and Li, 2008; Melo *et al.*, 2009). Methods of microgeneration that are commonly used include hydro power plants, micro heat and power plants, biogas plants, photovoltaic plants and off-grid generating systems (generating sets). Hence, communities or individuals that embark on microgeneration increase their self-sufficiency in power supply through the use of proper technology (Harrison 2008; Fontes *et al*., 2008).

Electricity Generating Sets As Means Of Power Supply in Buildings

A constant power supply is a critical component of every successful modern business. Where power failure happens more often and takes more time to fix, a reliable standby generator is really essential to power all the equipment and systems (Pabla, 2003; Gross, 1986). Today, the most common form of off-grid electricity supply are generators running on diesel or gasoline. Generators are used not only by rural households, but also by the grid-connected households and industries as a more stable supplement to the grid power. The rural incidence of diesel generator in Nigeria is difficult to estimate, but 96 to 98% of the grid-connected firms are known for the ownership of private generators (Tyler, 2002). An electric generator is a device that converts mechanical energy obtained from an external source into electrical energy as the output through the combustion of the fuel used. It does not actually ócreateô electrical energy. Instead, it uses the mechanical energy supplied to it, to force the movement of electric charges present in the wire of its windings through an external electric circuit. Generators are useful appliances that supply electrical power during a power outage and prevent discontinuity of daily activities or disruptions of business operations (Generator, 2012). This study thus aims at evolving a framework by considering various contiguous theoretical and contextual issues on the performance characteristics and adoption of generators in order to ensure its sustainable use by the occupants of buildings.

The Theoretical Framework

Evaluation of buildings and performance of service items incorporated into its fabric depend on the availability of the conventional and other forms of energy supply so that building occupants can achieve their comfort drive. This has led to the understanding of how functionality of the entire building stock would affect the performance of occupants due to its typology and characteristics. This relates to the context of issues in facilities management depicting the type and nature of buildings occupied by its users. There is problem of supply and availability of energy to the buildings which has been a growing concern and paradigm shift to alternative energy models. The adoption of off-grid power supplies through the use of generating sets encompassing issues on its types and operational characteristics of its sub-components (electrical and mechanical) lies within building services. The mode of use of service items like generating sets in buildings must be able to address how its operational characteristics, failure patterns would not impair indoor and outdoor environment (green building). From the fore-going, the theoretical framework for this research lies at the intersection of interrelated concepts of facilities management, green building and building services. Hence, the underlying concept is how to ensure improved sustainability through reliability performance of generating sets, its mode of use (adoption of effective house-keeping practices) and compliance with existing statues. This shows the body of knowledge in which this research is placed through building performance evaluation. Figure 1 shows graphical illustration of the location of theoretical framework of this research.

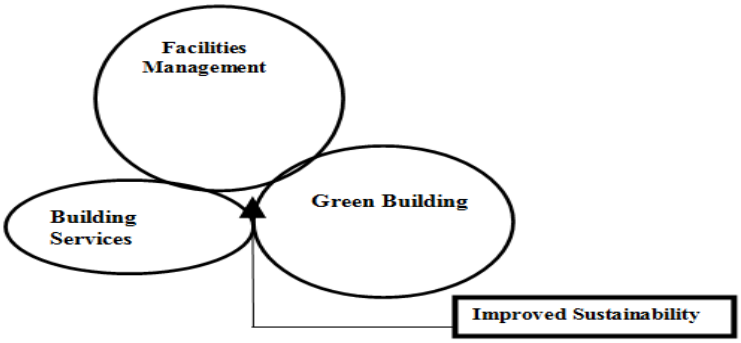

Figure 1: The Place of Theoretical Framework of the Research

The Conceptual Framework

This section is to build upon works of others by identifying gaps in knowledge which would form researcherôs conceptual process of thought on those key variables considered in ensuring the use of generating sets as alternative means of energy supply by the occupants. Particularly, it would help in formulating a framework that will be reliable, quick and accurate in the analyses of the problems associated with the use of generating sets so as to enhance sustainability of its functionality as a core energy component in the built environment.

This section explains and justifies development of research instruments to be used so that the variables, upon which to work with are brought into focus. This is because an appropriate conceptual framework provides logic for integrating existing ideas to enable the study benefit from scientific contributions (Amaratunga and Baldry, 2003; Nieto and Perez, 2000). A concept is an image or symbolic representation of an abstract idea. In this regard, it is the researcherôs position on the research problem and further shows the relationship that exists between different constructs that the study intends to investigate. Conceptualization provides a clear path for the research, through which a holistic view on the problem and influencing factors for the research problems are developed. In a fundamental sense, a conceptual framework provides a guide to the organization of ideas and issues in a study. It acts as a filing cabinet for sorting ideas and issues into neat compartments. As such, a conceptual framework must derive its validity from the objectives of a study, while, it in turn, guides the study towards the achievement of its objectives (Manyong *et al*., 2005).

Conceptualization is often guided by theoretical framework perspective or approach that the researcher is committed to. It involves taking constructs or concepts to be addressed within the research and refining them by giving each of them a conceptual definition. Conceptual definitions are definitions that describe concepts by using other concepts. Concepts allow researchers to classify and generalize related ones. Some of these concepts may be variables like concepts or constructs that can vary or have more than one value. Some variables can be concrete, abstract or constant in nature Nieto and Perez (2000). The main functions of a conceptual framework are to reveal implicit elements in the system being investigated and to explain phenomena involved. It is important to use clear terms like point-form diagram and present the conceptual framework to explain the state of the system being investigated.

The development of a conceptual framework for this research is based on the intersection of the use and mode of operation (performance) of generating sets as an alternative source of energy in buildings. Generally, the concept of performance is used everywhere, and the performance concept covers many topics and criteria which can be categorized as physical, environmental, economical, psychological and social. They are related to a singular context of what is being used (Szigeti and Davis, 2005).The schematic representation of the conceptual framework for this research showing the interrelatedness among the variables that affect sustainability of the environment due to the impact associated with the use of generating sets is shown in Figure 2. It considers the following interrelated parameters:

a. The investigation of the types of generating sets used in the selected buildings via the generator audit. It depicted data on the variation of years of usage, type, output ratings, brand and cost of generating sets used across delineated zones of the study area based on the occupantsô socio-economic status;

b. The collection of data on the downtime, type of failure and failure rate of the components of the generating sets that affected its availability and reliability status;

c. The investigation and gathering of data on the house-keeping practices, type of enclosure characteristics of the generating sets before or during its use and distance limits of its positioning from external walls of the buildings sampled. Its points of locations before and during use were also considered.

d. The determination of the variation of noise levels and carbon monoxide emission before and during use of generating sets at distances from its location across zones of the study area through contributory effects of its

performance to the environment both indoor and outdoor. The values obtained were compared with limits set by statutory bodies. It also involved collection of data on the impact of its usage on soil parameters.

e. The overall framework that enhanced sustainable use of generating sets in buildings through holistic consideration of its use and performance level so as to mitigate its associated impact on the users and environment was developed.

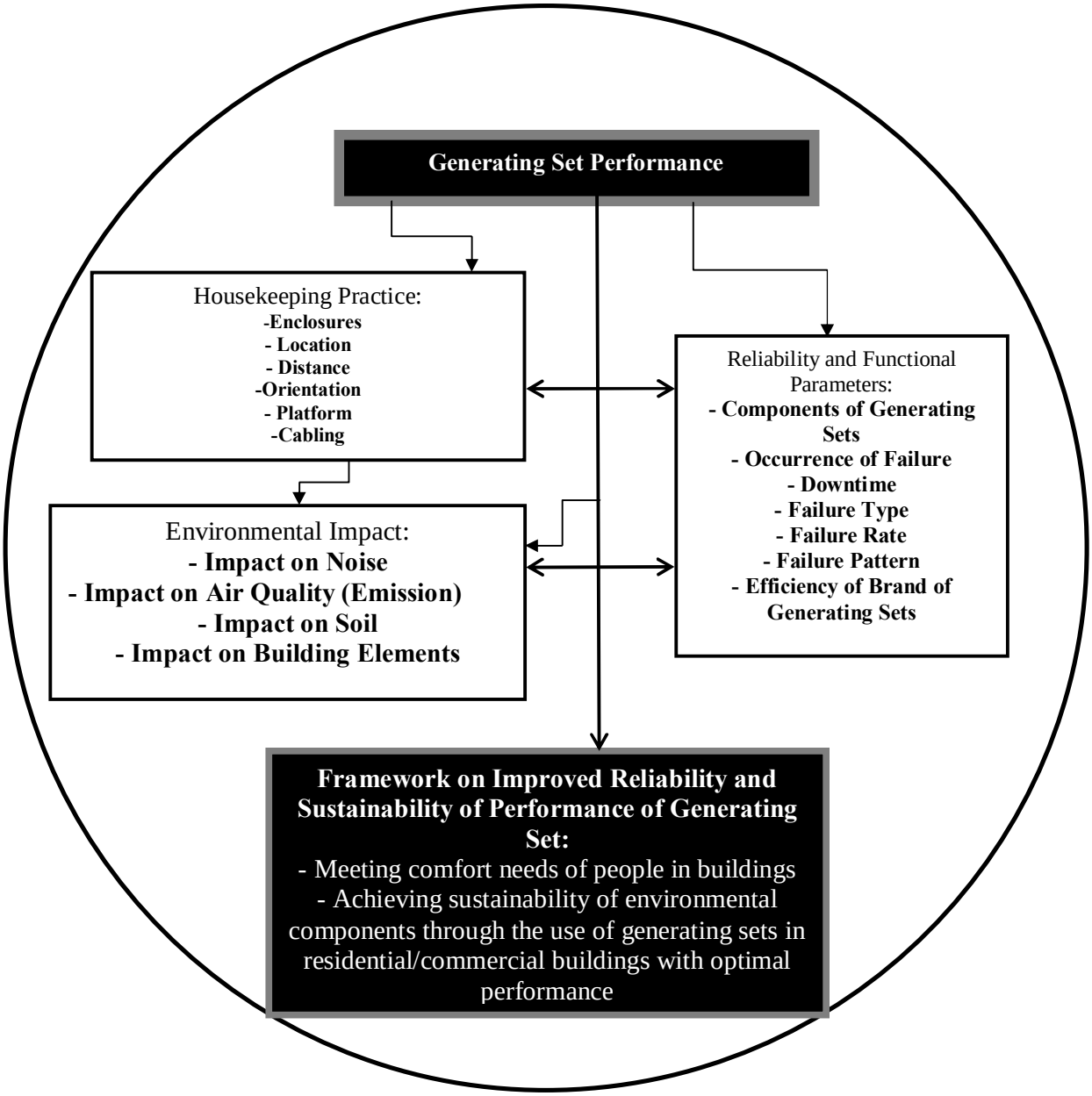

Figure 2: Conceptual Framework on the Performance of Generating Sets

Development of a Framework for the Sustainable Use of Generating Sets in Buildings

The thrust of this section is to develop a framework that will assist policy makers, managers and stakeholders directly involved in the production of power and its associated facilities needed in building stock to further appreciate impact of the use of generating sets as an alternative power supply in the built environment. If the framework is properly captured, building services experts, managers of built environment and other associated professionals particularly in Nigeria, that have been riddled with power outages, will be strategically positioned with tools to capture effects of óforced dependenceô of building occupants on generating sets on the comfort of the users and enhance overall sustainability of the environment.

Decision tree was used at the preliminary stage of the development of the framework to show how the choice of actions would lead to the next in order to achieve improved reliability and sustainable use of generating sets. It considered variables like downtime and failure that would affect service and functional performance of generating sets; the effects of the mode of use of generating sets (house-keeping practices) on the users and environment and the likely actions to be taken to mitigate generating set performance.

By linking up findings of the study based on the effects of generators, the authorôs concept was modified in order to meet the tripod variables of sustainability. The framework cover associated issues of the periodic determination of the variations in noise levels and carbon monoxide emission in different residential zones. This made it possible to factor contributory roles of the type and condition-based assessment (failure pattern) of generating sets on how they will impart on the comfort of the users either indoor or outdoor and on other environmental components. The framework developed to foster sustainability of the environment based on the use of generating sets by building occupants is shown in Figure 3.

The mode of use; the house-keeping practices of service items used by the occupants lend weight to the occurrence of sustainable building. The use of generating sets as alternative mean of power supply in buildings is characterized by downtime due to the failures patterns of its electro-mechanical components. The need for improved reliability of generator would let it perform at an optimal rate so as to mitigate hazards that it could expose the users and environment to. The mission of performance of an item used in buildings is in being able to satisfy its designed technical, functional and behavioural purposes. The overall performances of physical condition, functional stability, space utilization, health and safety statutory requirements, and energy requirements of the buildings would affect sustainability of buildings and its service items.

In adopting the framework developed in order to foster sustainability in the built environment, users and managers of buildings need to maintain the tripod of environmental, social and economic considerations so as to ensure preconditions of development for future generations. Decision to maintain sustainability can be best achieved through an holistic reform of the power supply to buildings whereby environmentally friendly energy that will not pose hazards to the safety and comfort of the users and environment will be sustained. With this, the supply of power into the building stock would enhance reliability and sustainability.

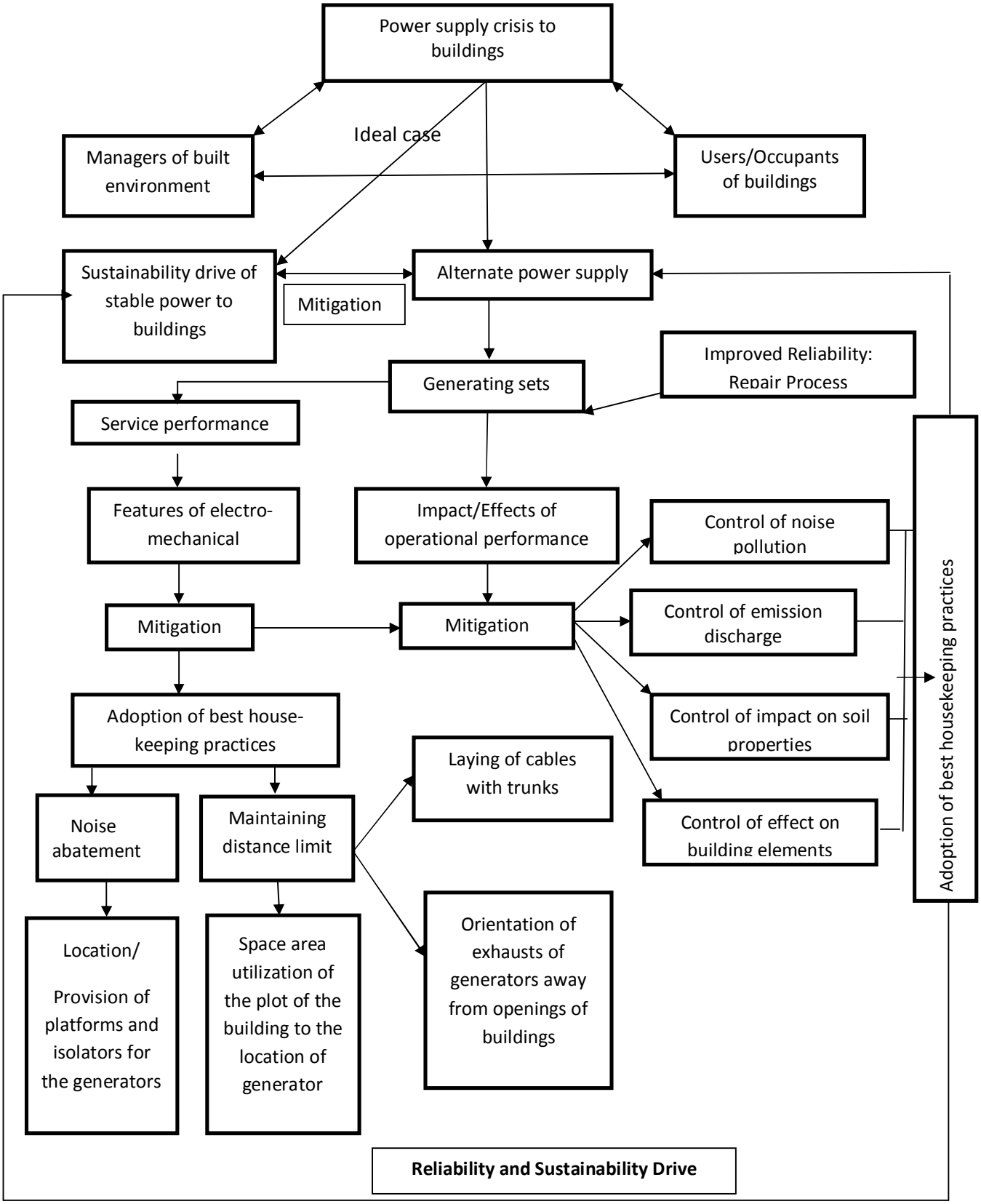

Figure 3: A Framework for the Sustainable Use of Generating Sets in Buildings
Source: Authorôs Concept

The assessment of the performance of generating sets through the generator audit carried out revealed the use of varying brand and types of generating sets based on the socio-economic status of the users. The generators exhibited failure patterns, which affected its performance standard, reliability level and sustainability of the environment. House-keeping practices which involve mode, type and nature of enclosure characteristics of the generating sets and other associated variables/parameters like cabling arrangement, platform provision and optimal distance limit of its positioning are variables that should be considered holistically in order to guarantee sustainable use of generating sets in buildings.

Typically, building occupants would want to adopt house-keeping practices in line with their socio-economic status. However, their socio-economic status notwithstanding, there should be adequate land area in every zone where buildings used for either residential or commercial purposes are situated. This will make it possible to maintain an average and optimal distance limit in the positioning of their generating sets. With this, the performance of generating sets as an alternative to electricity during power outage would drastically reduce negative impacts associated with its usage.

The framework has its core application in providing avenue through which sustainability of generating sets can be maintained in such a way that its impacts, noise pollution and the emissions of carbon monoxide which have suffocating potentials can be mitigated through cognizance given to its orientation and positioning relative to the effective area of land/plot(s) occupied by the building. This will be a rubicon for building occupants and built environment managers on sustainability drive of the environment. With this, it will be an ample piece that the policy makers involved in the management of built environment sector could use as a guide in evolving framework that service items used in buildings must maintain optimal performance so that that their usage would not pose threat to sustainability of the present and future users of the environment.

Conclusion And Recommendations

The availability and dependence of electricity in building stock that will allow the occupants to perform their tasks comfortably and efficiently cannot be over underestimated. The apparent inadequate supply of electricity has inevitably forced households to procure and use generating sets in order to meet their daily needs. The mode of operation and use of generating sets in buildings have untold effects and impact on buildings, environment and its users. This is due to generation of noise and emissions that pose threat to the environment both indoor and outdoor. In a bid to holistically address the impact associated with the dependence on generating sets in buildings, a framework was developed that encompassed supply of quantitative and qualitative power and adoption of best house-keeping practices by its users so as to entrench sustainability of the environment.

REFERENCES

[1]. Abayomi, W. (2012): Nigeriaôs Power Supply Security: Retrieved fromhttp://www.myndff.com/PolicyDialogue.aspx?Edition56

[2]. Adegbulugbe, A.O., and Akinbami, J.F.K. (1995): Urban Household Energy Use Patterns in Nigeria. In National Resources Forum, Vol. 19, No.2, Blackwell Publishing Ltd., pp.125-132.

[3]. Adewoye, O.O. (2007): Human Capacity Building in Engineering Infrastructure: A Paper Presented at the International Conference and Annual General Meeting of The Nigerian Society of Engineers, International Conference Center, Abuja, 4th December, 2007.

[4]. Akinbami, J.F.K. (2003): An Analysis of the Demand and Supply of Electricity and the Green House Gas Emissions of the Nigerian Electrical Power Industry. An Unpublished Ph.D. Thesis Submitted to Technology Planning and Development Unit, Obafemi Awolowo University, Ile-Ife, Nigeria.

[5]. Amarantunga, D. and Baldry, D. (2003): A Conceptual Framework to Measure Facilities Management Performance. Property Management, Vol. 21, No. 2, pp. 171-189.

[6]. Azodo, A.A. (2014): Electric Power Supply, Main Source and Backing: A Survey of Residential Utilization Features, International Journal of Research Studies in Management, Vol. 3, No. 2, pp.87-102.

[7]. Chidiezie, C.T., and Igwiro, E.C. (2008): Urban and Rural Electrification: Enhancing the Energy Sector in Nigeria Using Photovoltaic Technology. African Journal of Science and Technology, Science and Engineering Series, Vol. 9, No. 1, pp. 102-108.

[8]. Flavin, C. and Lenssen, N. (1999): Reshaping the Electric Power Industry. Energy Policy, 22 (12), Buttersworth- Heinemann Ltd., U.k., pp. 102901044.

[9]. Fontes, N., Roque, A. and Maia, J. (2008): Micro-Generated Solar and Wind Hybrid System. In Electricity Market EEM, 5th International Conference on European, Lisbon, pp. 1-5.

[10]. Generator, J. (2012): Generator Sizes and Types for Home or Business. http: //ww.generatorjoe.net/html/ home owners.html. Accessed on 4/25/15.

[11]. Gross, C.A. (1986): Power System Analysis, Second Edition, John Wiley and Sons, New York, pp. 64-65.

[12]. Infield, D. and Li, F. (2008): Integrating Micro-Generation Distribution Systems. A Review of Recent Research: In Power and Energy Society General Meeting Conversion and Delivery of Electrical Energy in the 21st Century, Pittsburgh, PA, pp. 1-4.

[13]. Harrison, J. (2008): MicrogenerationinTechnologies.http://www.microgeneration-oracle.com /microgenerationtechnologies.html

[14]. Hickling, R. (2006): Electricity Consumption in New South Wales: An Application of Co-Integration Techniques to Energy Modelling and Forecasting, TransGrid Economics Information Paper 4.

[15]. Lin, B.Q. (2003): Electricity Demand in the Peopleôs Republic of China: Investment Requirement and Environmental Impact, Economics and Research Development Working Paper, Series No. 37, Asian Development Bank.

[16]. Manyong, V.M., Ikpi, A., Olayemi, J.K. and Yusuf, S.A. (2005): Agriculture in Nigeria: Identifying Opportunities for Increased Commercialization and Investment. IITA, Ibadan, Nigeria, 15qp [Online]. Available at www.iita.org/c/document_library/get_file!.
[17]. Melo, N., Prata, R., Goncalves, R. and Francisco, M. (2009): Micro-Generation in Portugal- EDP Experience and Future Perspectives. In the 20th International Conference and Exhibition on Electricity Distribution, Part2, Vol. CIRE 2009, Session 4, Prague, Paper No. 0569.
[18]. Nieto, M. and Perez, W. (2000): The Development of the Theories from the Analysis of the Organisation: Case Studies by the Patterns of Behaviour, Management Decision, Vol. 38, No. 10, pp. 723-733.
[19]. Pabla, A.S. (2003): Electric Power Distribution, Fourth Edition, Sixth Reprint, Tata McGrawHill Publication Ltd., New Delhi, pp. 35-37.
[20]. Sambo, A.S. (2008): Electricity Demand from Customers of INGA Hydropower Projects: The Case of Nigeria. Paper Presented at the WEC Workshop on Financing INGA Hydropower Projects, 21-22 April, 2008, London, U.K.
[21]. Subair, K. and Oke, D.M. (2008): Privatization and Trends of Aggregate Consumption of Electricity in Nigeria: An Empirical Analysis. African Journal of Accounting, Economics, Finance and Banking Research, Vol. 3, No. 3, 2008.
[22]. Szigeti, F. and David, G. (2005): Performance Based Buildings: Conceptual Framework. PeBBu Final Report, Rotterdam: CIBdf.
[23]. Tyler, G. (2002): Public and Private Electricity Provision as a Barrier to Manufacturing Competitiveness: Africa Region Findings, World Bank, March ,http://www.worldbank.org//afr/findings/english/find221.pdf
[24]. World Bank Report (2001): World Development Report, Washington D.C., USA.