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A PRELIMINARY ASSESSMENT OF THE ENERGY RELATED CARBON EMISSIONS ASSOCIATED WITH HOTELS IN ENUGU METROPOLIS NIGERIA

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ABSTRACT

This study assesses the environmental impacts of energy consumption of 24 hotel buildings in Enugu Metropolis. Structured questionnaire was administered to the hotel managers in order to collect energy consumption pattern. Measurements were carried out to reproduce the floor plans of the hotels in-order to determine the floor areas. The breakdown of energy consumption showed that diesel and petrol generator sets dominated for regular and 24hours electricity supply. The average Building Energy Index (BEI) of 405.73Kwh/m^2/yr was derived based on unit floor area. The result further showed that average CO_2 emissions from consumption of grid electricity to be 2936.06KgCO_2e/Kwh/yr, and 294817.44KgCO_2e/litre/yr and 1546.69KgCO_2e/litre/yr, respectively for diesel and petrol. The study concluded that there is need to reduce

dependence on fossil fuel consumption of the hotels and therefore recommends the encouragement of low energy and energy efficient hotel building designs in the study area.

Key Words: fossil fuel, carbon emission, hotel buildings, building energy Index (BEI), energy efficiency

INTRODUCTION

The Nigerian tourism growth is geared towards the building of hotels. These hotels depend on self-generation of power. These hotels to cater for their numerous customers consume a lot of energy, and therefore need twenty-four hours power unlike most other building types. The findings of the study by (Nnaji et al 2013) shows that Nigeria with a 0.03kw per capita electricity consumption has been incapable of providing minimum acceptable international standards of electricity for its citizens. To compensate for this deficit all sectors, commercial, domestic and industrial continue to use private power generators resulting in the continuous burning of fossil fuels. Nnaji et al (2013), concludes that the use of private generators has resulted in increased CO2 emissions a major culprit of global warming and climate change but also has led to increase in the cost of doing business. Reducing energy consumption of the hotels therefore is a most desirable endeavour.

Emission reduction from buildings can be achieved by reducing emissions from energy supply or by reducing energy consumption through improved building design, increased energy efficiency and conservation, and other mechanisms that reduce energy demand in buildings.

Demand for a better environmental quality in buildings is growing with the rising concern about occupants' health and productivity. At the same time, there is a genuine concern about rising energy consumption in buildings. A significant amount of energy is devoted to heating, ventilation and air conditioning (HVAC) systems in buildings. In Nigeria, HVAC account for about 50% of the energy consumed in commercial buildings as against 15% used for lighting, and much of the energy is in the form of electricity, it therefore contributes much to GHG emission (Ijigah et al 2013). This study carries out a preliminary assessment of emissions from energy consumption of hotel buildings in Enugu Metropolis with a view to understand the consumption patterns and determining the relationship with the building energy index and gross floor area. The data generated will also help to develop a baseline for emissions for hotel buildings.

Global Emissions from Buildings: There has been scientific evidence to prove that the global GHG emission is still on the rise which also contributes to the increasing global temperatures. The primary source of this increase can be attributed to rising fossil-fuel use and other human activities (Malla, 2009). The consumption of fossil-fuel occurs mostly in power generation for electricity and heat production. Many researchers have devoted their time and resources to investigate the decomposition of CO_2 emissions from electricity generation and consumption (Steenhof, 2006; Wang et al., 2010; Malla, 2009, Shrestha et al., 2009, Zhang et al., 2013 and Emodi et al 2015) and all came to the conclusion that the increase in economic activity raised the amount of CO_2 emissions which is as a result of electricity generation and consumption, (fig 1 shows world CO_2 emissions by sector).

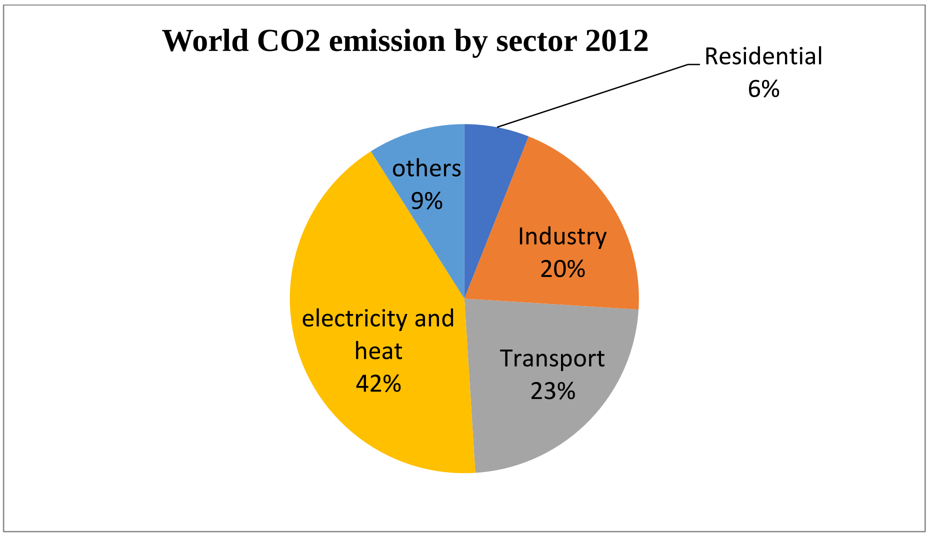

Fig 1: World CO_2 emissions by sector

Source: IEA 2014

Studies reveal that the building sector, which consume more than one third of the world's energy, are the single major or largest contributor to global warming (Odebiyi et al 2010). This implies that the building sector uses more energy than other sectors. According to Lee and Yik, (2004), buildings are the dominant energy consumers in modern cities but their consumption can be largely cut back through improving efficiency, which is an effective means to lessen greenhouse gas emissions and slow down depletion of non-renewable energy sources. Between 1980 and 1990, CO_2 emissions from buildings have grown by 1.7 percent per year with rates of growth noted to be four times greater in developing countries (Wiel et al, 1998). Between 1971 and 1992, studies by Levine et al 1996 show that annual growth in CO_2 emissions from buildings varied widely by regions: 0.9% for industrialized countries, 0.7% for Eastern Europe/former Soviet Union and 5.9% for developing countries. The building sector emitted more than the industrial or transportation sectors with 36 percent of total emission attributed to it in 1998 (Energy Information Administration (EIA), 2000).

However balanced data and literature on carbon emission from developing countries are scarce (Intergovernmental Policy on Climate Change (IPCC, 2007: 31). Especially in Africa, there are remarkably few studies available that examine the impacts of climate change on energy use (Boko et al., 2007). However, in South Africa, about 23% of total emissions come from buildings. Africa has an estimated average annual growth of 3.6% energy-related carbon emission and it is believed that substantial contribution comes from buildings (Odebiyi et al 2010). All building types consume energy with varying degrees of emission representing approximately 40% of the global primary energy use (WBCSD).

With the growth of technology and the introduction of sustainable energy and a continuous reduction of non-renewable energies as well as adequate sources of sustainable energies (solar, water, wind, biogas, etc.), architects can take advantage of appropriate methods to use sustainable energies in architectural design and create suitable environment and provide desirable thermal welfare considering new technology and science (Panahi et al 2013).

Efforts in limiting CO_2 emissions from buildings concentrate on energy demand reduction. As fossil fuels still represent the bulk of energy sources used, reducing energy demand reduces carbon emissions. Another approach is to provide energy from renewable sources like sun, wind and biomass. Efforts to limit CO_2 emissions from buildings in the tropics either focus on reducing energy demand, i.e., air-conditioning, or on replacing fossil with renewable sources (Bruelisaur et al 2013). Building related activities operation, construction processes and materials, account for more than 50% of anthropogenic CO_2 emissions worldwide, the major driver for climate change (Meggers et al, 2012).

Carbon Emissions in Nigeria: Persistent and prolonged public power outages have made Nigerians to be one of the most users of private power generators in the world. As a result of the major shortfall in capacity, most businesses resort to private fossil fuel powered generating sets to supplement power supply. These private power generating sets (an essential part of the Nigerian landscape) are major sources of anthropogenic greenhouse gas emissions. Given the average utilization factor of these generators, there is a huge amount of environmental pollution caused by GHG emissions released into the atmosphere continuously. Moreover, there is no data on the number of power generators in Nigeria, making it almost impossible to calculate the greenhouse gas emissions from the country.

The study by Anomoharan (2011) asserted that 518.84 million metric tons (mt) of CO_2 was released into the atmosphere by Nigeria between 1990 and 2009. This represents 0.26% of the global 202.640mmt emissions. The results of the study further showed an average yearly increase in CO_2 emission of 4.7% for the same period as against the global average of 1.9%.

According to IEA (2014), 2012 data on carbon emissions in Nigeria; i/ total carbon dioxide emissions from the consumption of fuel is 64.6million tons(mt) and per capita carbon dioxide emissions from consumption of energy is 0.38mt.

Emissions from Stationary Combustion Sources: There are large variations in CO2 emissions per MWh of electricity generated by fossil fuels due to differences in generation efficiency, fuel selection, and plant age. The combustion process is defined by the rapid oxidation of substances with the release of thermal energy. Stationary combustion activities emit direct greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as well as ambient air pollutions. Emission of these gases from stationary combustion sources depend upon fuel characteristics, size along with combustion technology. Emissions also vary with operation and maintenance practices. A fuel-based approach will be applied to calculate GHG emissions in this study. This approach requires the collection of activity data, in the form of the type and quantity of fuel consumed for combustion purposes. In order to calculate CO_2 emissions using fuel type, fuel consumption and emission factor data, the UNEP equation below will be applied:

$$\text{Emission } (CO_2) = \Sigma \text{ Amount of fuel consumed x Emission factor of } CO_2$$

Carbon Emission of the Hotel Buildings: A hotel operation requires and uses energy on a daily basis for 24 hours, irrespective of seasonality, number of guests and its location (Kasim, 2007). The energy consumed by hotels is used for space heating, cooling, ventilation, hot water, lighting, laundry, kitchen, recreation and miscellaneous uses (Dascalaki, 2007). Bohndanowicz (2008) reveals that the use and consumption of different forms of energy by hotels lead to the release of harmful gases into the atmosphere and leads to air pollution. The harmful gases said to be emitted due to consumption of different energy resources by hotels is estimated at 160 and 200 kg of carbon dioxide per square meter of room floor area, depending on the type of fuel used to generate electricity (Bohdanowicz, 2008; Kirk, 2008; Bohdanowicz and Martinac, 2008). The emission of such harmful gases results in the alteration of biogeochemical cycles and also release of carbon dioxide leading into global warming (Gossling, 2006, Mungai et al 2013).

The study by Liu et al (2013) identified factors that influence CO_2 emissions in buildings as, urban population, per capita floor space, building structure, building energy intensity and carbon emissions coefficients. According to the Intergovernmental Panel on Climate Change (IPCC), there are 18 greenhouse gases with different global warming potentials. But under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, only Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6) are considered for the purposes of carbon accounting, with others being regulated elsewhere (Ologun et al 2014).

METHODOLOGY

24 hotel buildings located in Enugu Metropolis was evaluated to consider building energy index and CO_2 emissions. Data collection was through questionnaires, oral interview and direct measurements.

Due to the incessant power outage in Nigeria, a preliminary survey was conducted on all 165 hotels registered with the national tourism Development Cooperation (NTDC) in Enugu. The study thereafter adopted the use of constant and steady power supply to categorise the hotels, in-order to identify the hotels that provided 24 hours constant power notwithstanding the energy source. This was used as a major criterion in determining the sample population.

A pilot survey of the 165 hotels revealed that only 42 hotels had constant and steady power 24 hours daily. This established a common basis for energy evaluation. The data for four years (2014 – 2017) was collected from the hotels.

Questionnaire was used to collect primary data on energy mix and consumption pattern of the hotels. A total of 42 questionnaires were distributed and only 24 were completely filled showing a response rate of 57%. The reason for this was mainly due to reluctance of the hotel managers to give out information on energy consumption and in some cases refusal to grant access for the reproduction of the sketches for the hotel buildings.

Utility billing information of monthly energy consumption (grid electricity, diesel and petrol) for 2011 to 2014 was collected for each of the hotels. Gross floor area of the hotels was from on-site measurements or direct from the architectural drawings of the buildings where they were available.

RESULTS

All the hotel buildings where fully air-conditioned. The sampled hotels comprise a total of gross floor area of 68,594.18m^2 and have the following attributes; gross floor area between 569.10m^2 and 6372m; year of construction between 1956 and 2007 and total number of guest rooms between 30 and 62 rooms.

The data collected shows three energy sources, power from the national grid, petrol and diesel power generating sets. Diesel is the primary energy source. Most of the hotels provided energy through the use of the power generating sets for close to about eighteen hours daily, in-order to ensure efficiency and comfort of the guests. All the hotels had about two or three power generating sets with capacities ranging from 50kva to 250kva. Fig 1 shows that energy consumption pattern, the energy mix and the energy output from both the national grid and the power generating sets indicating that 22.32% energy is supplied by the national grid, 74.23% from diesel power generating sets and only 3.44% from petrol generating sets. This fuel mix is very common in Nigeria in commercial buildings.

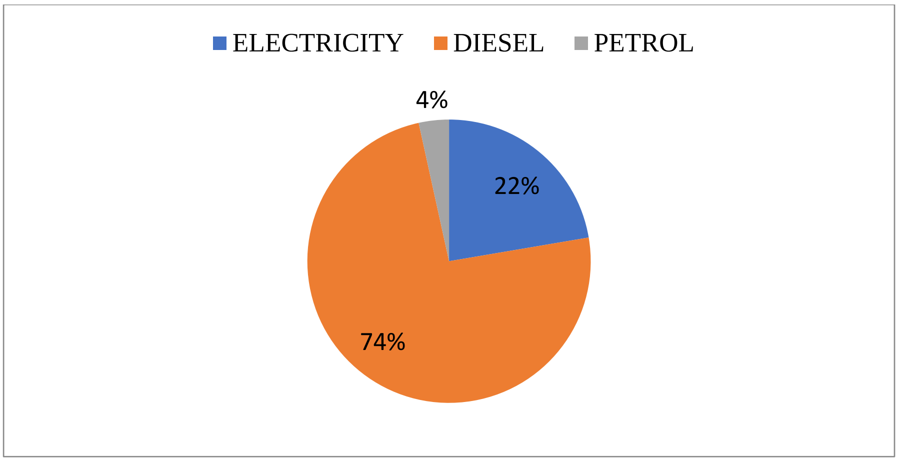

Fig 1: Energy Mix and consumption

Estimating Greenhouse Gas Emission for the Hotel Buildings

The study adopted the UNEP formula for CO2 emission calculations.

1. CO2 emissions from grid electricity

   Amount of electricity (Kwh) x Country specific emission factor

   = CO2e emissions (1)

2. CO2 emissions from fossil fuel

   Amount of fuel used (litres) x fuel specific CO2 emission factor

   = CO2e emissions (2)

Recommended emission factors by DEFRA/DECC (2012) are used for calculations of carbon emission in the study.

i/ Nigerian specific carbon emission factor for grid electricity = 0.439kgCO2/Kwh is used for these calculations of carbon emissions in this study.

ii/ Emission factor for Diesel = 2.602 per litre

iii/ Emission factor for Petrol = 2.19 per litre

Table 1: Summary of CO2e emissions from the sampled hotels

CO2e	Min	Max	Mean	Std. Dev
Grid Electricity ($KgCO_2e/Kwh/yr$)	138.77	12496.91	2936.06	3480.43
Diesel ($KgCO_2e/litre/yr$)	196451.00	430631.00	294817.44	53024.34
Petrol ($KgCO_2e/litre/yr$)	766.50	3055.05	1546.69	1030.13
Total	197223.03	432782.92	298011.29	57534.90

Table 1 above shows the yearly average CO2 emissions from the 24 hotels studied. The result shows that the use of grid electricity by the hotels will grossly reduce the carbon emissions caused by energy consumption of the hotels. Over 98% of the emissions is due to the use of diesel. It should be noted that the non-carbon dioxide greenhouse gases generated in fuel combustion, mainly methane (CH_4) and nitrous oxide (NO_2), are not calculated in this study.

Building Energy Index

Among Architects the normalizing factor for comparing buildings is the gross floor area. The most commonly used index for comparing energy use in buildings is therefore the Energy Utilization Index – EUI or the Building Energy Index (BEI). This is usually expressed as kWh/m2/year and it measures the total energy used in a building for one year in kilowatts hours divided by the gross floor area of the building in square meters.

$$BEI = \frac{\text{total annual electricity consumed (Kwh/yr)}}{\text{gross floor area } (m^2)} \qquad (3)$$

i/ total annual energy consumption for the hotels = 27830919.62Kwh/yr

ii/ total floor area of the hotels = $68594.18m^2$

$$BEI = \frac{27830919.62}{8594.18} = 405.73 Kwh/m^2/yr \qquad (4)$$

Table 2: Summary Statistics of Building Energy Index (BEI)

BEI ($Kwh/m^2/yr$)	Min	Max	Mean	Standard Deviation
Total	171.97	2367.40	405.73	465.73

Tables 2 shows that the average total energy per unit floor area from the survey and collected data is 405.73Kwh/sqm.

DISCUSSION

Reducing the climatic impact of hotel energy consumption should be the major target of the hotel industry in Nigeria. The hotels therefore need to adopt strategies that can help minimize the carbon emissions. However, transitioning to a lower carbon future will require significant investment in a variety of clean technologies especially renewable energy. Reducing fossil fuel consumption in energy generation will provide considerable contribution in the reduction of greenhouse gas emissions. Other measures include energy efficient building designs for new construction and retrofits for existing buildings.

Most of the hotel buildings studied is on very small plot sizes. Introducing trees and greens within the premises will help reduce CO_2 naturally. Trees absorb CO_2 therefore will help offset some of the CO_2 emissions. Integrating renewable energy into the hotel buildings will impact on the architectural form and space planning, façade design, and materials. In Nigeria introducing solar water heaters to the hotels will reduce appreciable energy. However, the bulky nature of the solar water heaters will require that it be taken into consideration at the schematic and conceptual stage of the designs.

There is need for improvement in energy efficiency practice and implementation of energy efficiency policies in building design. Interest in the design of low energy buildings however can only be facilitated by government incentives.

The total carbon emission from the hotel buildings is estimated to be an annual average of 299,300.19 kg of CO_2. This value may be an underestimation because of unavailability of some of the data, it however gives a good idea of the size of the hotel annual carbon emissions, and the impact it is having environmentally. The result of the study agrees with the conclusion of the study by Ede et al 2013 in Port Harcourt City in Nigeria that gasoline and diesel generators have significant emission of pollutants which were in some instances above accepted safe limits. The use of diesel- and petrol-powered generators by buildings is not restricted to the study area, the scenario cuts across Nigeria. This clearly indicates a major set-back and difficulty in assessing the full environmental implications of energy consumption of buildings in Nigeria.

CONCLUSION

The breakdown of energy consumption of the hotel buildings showed that diesel generators dominated the energy consumption for all the sampled hotels. There are over 9million generators in use in Nigeria.

The environmental impact of the sampled hotel buildings can be significantly reduced when reliance on fossil fuel for power generation is reduced (see Table 1.0). This can be achieved with improved access to power in Nigeria, design of energy efficient buildings and application of renewable energy technologies to buildings in general.

Solving the energy crisis therefore is vital to our future welfare and the architectural profession must take ownership and leadership of it. If architects in Nigeria are to join in the efforts to mitigate climate change and secure future energy supplies with the minimum environmental, social and economic impacts, there has to be fundamentally change in public perception of the use and sources of energy.

The increasing demand for energy in Nigeria however often far outweighs the energy savings that can be made by energy efficient building design only. However significant advances in energy efficient design can only be achieved by close collaboration between architects and engineers from the onset of a building project. Major opportunities for energy conservation can only be captured at the conceptual stage of building projects.

To better understand the carbon implications of the hotel energy consumption, a more detailed study needs to be done. The study can be carried out in categories using key performance indicators such as emissions per guest room, ground floor area, number of workers, number of events, will be necessary.

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