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Energy Efficient Housing as a Mitigating Option for Climate Change in Nigeria

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ABSTRACT*: This paper discusses the capacity of energy efficiency in housing to serve as a panacea to climate change. Drawing from secondary sources, the study revealed that energy is required in houses for optimum performance. However, in Nigeria, the energy required is mostly generated from fossil fuel which emits greenhouse gasses into the atmosphere. These greenhouse gasses result in the depletion of ozone layer which causes global warming and by extension, climate change. It recommends among other things, proper landscaping, north and south orientation of houses, natural vegetation, natural lighting, the use of energy efficient electrical and mechanical appliances and the use of green power. The paper concluded that energy efficient housing environment that employs these parameters will experience reduced global warming and climate change associated challenges.*

KEYWORDS: energy, energy efficiency, housing, mitigating option, climate change, Nigeria.

INTRODUCTION

For centuries, the energy supply has been dominated by wood, coal, petroleum and natural gas (Hussaini *et al*., 2007). As the use of one decline, the use of the others increases accordingly. Other aspects like solar energy and nuclear fusion energy are promising but yet to make very significant mark on the energy-use graph (Priest, 1991). Petroleum consumption accounted for the lion share of Nigeria's total energy consumption in 2001, making up to 61.4% of the total. Natural gas (31.7%), with hydropower (6.8%) and coal (0.2%) (Nigeria Economic Issues; in Country Analysis Briefs of July, 2003).

More than one-third of the world energy is used in houses. According to Horsley (2003), one of the most significant environmental impacts of houses occurs through the consumption of energy during their operational lives. Houses use mechanical equipment powered by electricity or fossil fuels for lighting, heating, cooling and maintaining air quality. This in turn brings about the emission of carbon dioxide and other greenhouse gases into the atmosphere. Consequently, new developments are unfolding the world over in the uptake of the climate-sensitive, energy efficient design to reduce excessive energy demands on the economy and also to counter the increasing adverse effects of this development by maximizing the use of renewable energy sources and reducing energy dependence on fossil fuel, thereby minimizing carbon dioxide emission into the environment.

However, there is a common misconception that energy efficient houses need to be technologically advanced, expensive and distinct in appearance. Research has demonstrated that simply by getting the basics right at the inception; very significant environmental and economic savings can be accrued (Horsley, 2003).

Climate change has reached alarming proportions and it is estimated that global temperature had increased by $1^{o}C$ during the last century and that the level of temperature increase may

rise between 1^{o}C and 3.5^{o}C during the next century. Such a modest increase in temperature will result in a rise of sea level and the disappearance of many species of plants and animals.

The problem

Most modern houses in the country have been designed and built with often imported materials and construction techniques to satisfy the ego and aspirations of the modern Nigerians. However, Beredugo (2001) observed that because little consideration is given to the location, climate, culture, availability of local resources and expertise amongst others, modern houses have failed to satisfy their fundamental function which is the protection of man from the vagaries of inclement weather. In other to satisfy this vital need, modern houses have had to rely heavily on artificial or mechanical means of indoor cooling especially in the tropics, thus making the houses energy inefficient. Consequently, in Nigeria, where there is much dependence on fossil fuel for energy generation, greenhouse gases such as carbon dioxide, methane and others are being emitted into the atmosphere. These are responsible for global warming and climate change. The main design task in the tropics is to reduce the impact of solar radiation on houses, adequate control of the ingress of hot, dust and sand laden air into houses interior.

Aim and objectives

This paper aims at reduction in energy usage in housing as a panacea to climate change and the specific objectives are:

i) To identify strategies that can bring about low energy requirement while houses still perform optimally.
ii) To highlight other environmentally friendly sources of energy.
iii) To make recommendations on how energy efficiency can be achieved in houses.

LITERATURE REVIEW

Housing and climate change

Recent estimates of the United Nations Environmental programme (UNEP) sustainable construction and Building Initiative (SCBI) assigns 30-40% of the global energy use to housing sector. Thus the housing sector is the key source of demand for energy and materials that produce by product greenhouse gases. Moreover, there are the greenhouse gases emissions from deforestation when vegetation is cleared to make way for houses. Almost 90% of the word's energy is supplied through the combustion of fossils and every time we burn this fuel to make energy we release other greenhouse gases such as methane, nitrous oxide, carbon dioxide etc into the atmosphere. Carbon dioxide, in turn, is the principal component of the greenhouse gases that are responsible for warming the planet, rising sea levels, extreme weather effect and drought with associated human insecurity. Energy use and climate change are two sides of the coin. Thus, the high-energy requirement of the building sector translates into global warming. According to Obot (2010), Collective evidence presented at the last global climate negotiation (Copenhagen, Decemger,2009) tells us that in order to avoid dangerous climate change, we must keep global warming under 2^{o}C above pre-industrial levels (we are currently at 0.7^{o}C above pre-industrial levels).

Causes of climate change

The intergovernmental panel on climate change (IPCC) concludes that most of the observed temperature increases since the middle of the 20th century was likely caused by increasing concentration of greenhouse gases resulting from human activity such as fossil fuel burning.

Greenhouse gases are gases in the atmosphere that absorb and emit radiation. This process is the fundamental cause of the greenhouse effect. The main greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide and ozone (IPCC, 2007).Greenhouse gases trap heat within the Earth's surface, causing heating of the Earth. This mechanism is fundamentally different from that of actual greenhouse, which works by isolating warm air inside the structures so that heat is not lost by convention. The basic mechanism is that the Earth receives energy from the sun mostly in the form of visible light. About 50% of the sun's energy is absorbed at the Earth's surface; the rest is reflected or absorbed by the atmosphere. The absorbed energy warms the surface. Thus as the atmosphere thickens with more and more greenhouse gases resulting from human activities listed above, more and more infrared radiation is retained and thus the earth warms up.
However, it should be understood that greenhouse gases are necessary to life because they keep the planet's surface warmer than it otherwise would be and make the earth liveable. Nevertheless, as the concentrations of these gases continue to increase in the atmosphere, the Earth's temperature is climbing above tolerance level.

Status of electricity generation in Nigeria

According to Energy Commission of Nigeria (2008), there are nine electricity generating stations in Nigeria. Three of these stations are hydro based while six are thermal based and they are all owned by the government under the Power Holding Company of Nigeria (PHCN). All of them have an installed capacity of 6000 MW. However, for many reasons ranging from shortage of gas supply to lack of maintenance, these stations are performing far below the installed capacity. From the recent figure, Nigeria is generating 2000 MW of electricity (Punch, September 11 2009). Part of the electricity generated is exported to neighbouring Niger Republic. Electricity demand in Nigeria is very high as about 60% of Nigerians do not have access to electricity. Although many gas-powered stations have been commissioned to increase generation by 4000 MW, this will still not be enough. We can see that the energy generated in Nigeria is grossly inadequate, hence the need to imbibe energy efficiency culture.

Types of energy resources

According to Okereke and Anyakoha (1989) energy can be defined as the capacity to perform work. Thus the unit of energy is the same as that of work, i.e., the S.I. unit of energy is the joule, J. The world energy resources are of two types, that is renewable and non-renewable energy. Examples of the renewable resources are:

a) Solar energy: when if falls on solar cells, electricity is produced.
b) Wind: This turns the wind mill, which produces electricity.
c) Hydroelectricity: In dams, water turns generator and produces electricity e.g. Kainji Dam. Other examples are tides and oceans. Examples of non-renewable resources are:

i) Petroleum: The gas is used in power station to produce electricity e.g. gas and kerosene used as fuel for cooking, petrol and diesel are used to drive vehicles. Chemical energy is transformed to mechanical energy.
ii) Coal: Burning of coal produces much heat to boil water in turbines for production of electricity, and also for driving of trains and ships. Coal is used as fuel for cooking also.
iii) Nuclear energy: This produces enormous heat to operate turbines and drive ships and aircrafts. With time, it will be put into more uses.

Sources of energy

These world energy resources come from different sources. Solar energy comes from the sun. Wind comes from air and it is in rapid natural motion. Water comes from rivers and oceans. Petroleum and coal are fossil fuels which were locked up in the soil millions of years ago. More than one third of the world's energy is used in houses. One can help humanity and save a lot of money by designing super-efficient houses which use only 10% to 30% as much energy as a house of similar size that is built to contemporary standards (Wulfinghoff, 2003 and Good Repair Guide part 1).

Today's houses typically use mechanical equipment powered by electricity or fossil fuels for lighting, heating, cooling and maintaining air quality. Creating houses that use less energy not only reduces and stabilizes cost, but also reduces environmental impact (Torcellini, 2001). However, it is apparent that we have the knowledge and technologies to reduce energy use in our houses and workplaces without compromising comfort and aesthetics. Unfortunately, we are not taking full advantage of these advances; houses are typically designed and operated without considering all the environmental impacts. If this trend is reversed, these houses can improve the health, comfort and productivity of occupants, in measurable ways.

Environmental and economic benefits in the delivery of energy efficiency

The cumulative (environmental and economic) benefit in delivering energy efficient buildings is in the accomplishment of the following:

a) Reduced running costs,
b) Reduced environmental impacts
c) Improve ambient condition and
d) Increased equipment life

ENHANCING FEATURES OF ENERGY EFFICIENCY

It is critical that the entire houses be regarded as a system in which passive and active features or technologies interact to make them energy efficient. According to U.S. Environmental Protection Agency, EPA (2012), passive features that enhance energy efficiency of houses include the following:

Passive Measures

a) Roofing

Many of the roofing materials are not brightly coloured. These low-reflectance surfaces reach temperatures of 150 to 190^0F (66 to 88^0C) during hot weather which contribute to increased cooling energy use and higher utility bills. In contrast, lighter-coloured ''cool roofs'' with high reflective and emissivity can stay up to 70^oF (39^oC).

The benefits of cool roofs include reduced building heat-gains and saving air conditioning expenditures. By minimizing energy use, cool roof do more than save money, they reduce the demand for electric power and resulting air pollution and greenhouse gas emissions.

b) Cross ventilation

This is achieved through appropriate positioning of fenestration in houses. Effort should be made to have two windows at different sides of each room to enhance air flow. Inadequate window opening will necessitate the use of artificial means of cooling the interior of houses thus reducing energy efficiency of the houses. In developing country like Nigeria where majority of people depend on fossil fuel for power generation; this will lead to the emission of greenhouse gasses which will cause global warming and by extension, climate change.

c) Natural lighting

Natural lighting is a function of the transparency of the material used for the window, the positioning and adequacy of the window as well. Adequate natural lighting is an essential contributor to energy efficiency of houses as this will reduce the use of artificial lighting in the day time. Inadequate natural lighting more often than not results in increase in energy requirement of houses, hence making it energy inefficient**.**

d) Window material

Windows admit daylight and exclude heat should be specified. The solar characteristics of the glass, such as transmittance, absorption and reflectance, should be carefully considered.
The thermal transfer properties of the window frame and glazing systems should be verified. For instance, aluminium framing fitted with thermal bridging can assist in reducing heat transfer.

e) Building orientation

The impact of orientation on energy consumption needs to be considered. The building's optimum orientation is often overlooked due to competing design considerations such as the orientation of the land, the street frontage, topography or gradient of the site, views etc. In the tropics rectangular buildings with long elevations facing north and south are preferred so as to minimise solar heat gain.

f) Building shape

There is a dynamic relationship between shape and orientation. The most efficient plan shape to enclose the maximum floor area is a square, whereas a rectangle is preferred for solar control.

g) Reflectivity and colour

As a general principle highly reflective and light coloured materials for facades and roofs are more effective than darker colours in terms of reduction in interior heat gain which is an important consideration in the tropics. Specialist coatings are available to improve the thermal performance of the base materials and these should be considered.
Using light-coloured wall paints can also help brighten up a room and reflect more daylight throughout the space.

h) Trees and shrub

Another simple strategy is to plant trees and shrubs around houses. These will provide shades and have cooling effect on the houses. In addition, plants absorb carbon dioxide and release oxygen into the atmosphere during photosynthesis thereby purifying the atmosphere.

Active Technology Measures

a) Energy efficient appliances

Energy efficiency does not mean that we should not use energy, but we should use energy in a manner that will minimize the amount of energy needed to provide services (htt://www.energystar.gov, 2012). This is possible if we improve in practices and products that we use. If we use energy efficient appliances, it will help to reduce the energy necessary to provide services like lighting, cooling, heating, cooking etc. Hence, energy efficient products essentially help to do more work with less energy. For instance, to light a room with an incandescent light bulb of 60 W for one hour requires 60 W/h (that is 60 watts per hour). A compact fluorescent light bulb would provide the same or better light at 11W and only use 11 W/h. This means that 49 W (82% of energy) is saved for each of the hours the light is turned on.
Appliances with relatively high operating efficiencies are usually more expensive to purchase. However, higher efficiency appliances provide a measure of insurance against increase in energy prices, emit less air pollution.

Effort should be made to purchase high-efficiency appliances-such as water heaters, energy lighting bulbs, clothes washers and dryers, dishwashers, refrigerators etc. The energy efficiency of these appliances can be discerned with the energy star label on them.

b) Green power

The type of power used in houses can be a significant source of air pollution and greenhouse gases emission. Using green power, a subset of renewable energy, can help reduce environmental impact of energy used in houses while also provide a number of other valuable benefits. Green power is electricity resources such as solar, wind, geothermal, biomass and low-impact hydropower.

The objectives of green power in houses are;

i) Use energy efficiently in houses.
ii) Protect occupant's health.
iii) Reduce waste, pollution and environmental degradation.

The international Energy Agency released a publication that existing houses are responsible for more than 40% of the world's total primary energy consumption and for 24% of global carbon emissions.

RECCOMENDATIONS AND CONCLUSION

To achieve energy efficient houses, necessary recommendations include:

- Some factors have to be put into consideration at the design, construction and post construction stages. These include proper orientation of the houses in relation to wind and sun direction, cross ventilation, planting of trees or proper landscaping and using reflective building materials.
- Architects should design simple and functional houses as complex design will require more energy to function.
- Energy efficient houses can be achieved in new houses by using Energy Star Labelled products or appliances as this indicates their energy efficiency level. Old electrical and mechanical energy inefficient appliances in old buildings should be removed and replace energy efficient ones.
- Electrical and mechanical appliances should be properly installed as improper installation can reduce system efficiency up to 30%. This, to some extent defeats the aim of using energy efficient appliances.
- Cooling and lighting only those portions of the house that is in use at a particular point in time will enhance the energy efficiency of our houses. For instance, if store and kitchen are not being put to use at night, it does not make sense in terms of energy efficiency to leave the light in these functional spaces on as energy will be unnecessarily consumed.
- Green power such as photovoltaic cell, solar energy, etc should be used in houses to reduce the energy generation through fossil fuels and this will result in the reduction of greenhouse gasses that will be emitted into the atmosphere.

  It may not be possible to stop climate change. Bushes must be cleared; trees may be fell where necessary to build houses. Energy is required for these houses to operate optimally. Unfortunately, in Nigeria, most of the energy is generated from fossil fuel. This releases greenhouse gasses that are responsible for climate change into the atmosphere. This trend can checked to a reasonable extent by adopting energy efficiency measures in houses.

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