Global Scientific JOURNALS

GSJ: Volume 9, Issue 6, June 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

Attributes and Benefits of Energy Efficiency and Conservation in Buildings

CHIORLU, Chibuokem Victor. (B-Tech, MSc Arc.)

Faculty of Environment Sciences.

Department of Architecture, Rivers State University, Port Harcourt.

Email: cchiorlu.v@gmail.com

ABSTRACT

Our planet has been threatened by pollution and climate change as result of carbon (II) oxide and other toxic chemicals emitted from the burning of fossil fuels. Population explosion has made matters worse, as more people crave for energy daily. After the industrial revolution, scientists have innovated some strategies aimed at balancing the scales, but this quest had been found deficient. This has been the case because majority of people in the world are illiterates or not educated enough on the effects/consequences of over-dependence on non-renewable energy sources. Furthermore, there has been little advocation on the benefits of utilizing renewable energy sources. Scientific studies have shown that one major way of attaining a sustainable future is by being energy-efficient. This research focusses on the how energy efficiency and conservation strategies can be applied to building design and construction. Architects and Engineers are professionals who create new buildings and other structures and are to be held accountable for the consequences of their actions on the environment. This research focusses on how energy-efficient design and construction can contribute to a sustainable future. It also digs out the attributes of energy efficiency and conservation that building designers and Engineers can adopt. Furthermore, it discusses the benefits of applying these attributes in the design and construction of buildings.

Keywords: Energy Efficiency, Energy Conservation, Sustainable, Buildings, Design and Construction.

1. INTRODUCTION

As world population is drastically on a high increase especially in this 21st century, there has been concerted effort by scientists to reconcile the high demand and availability of energy. This come into light after the industrial revolution where many innovations begin to flourish. Over the years, these scientific innovations have altered and surmounted natural process in both positive and negative ways; positively in that it has led to a strong economy, increasing employment opportunity, productivity rate and consumption. On the other hand, it has resulted in negative effects popularly known as environmental crisis, such as the ozone depletion, greenhouse effect, heated urban settlement, acid rain and more especially the climate change that is experienced today. Undoubtably, these negative consequences of scientific innovations that are gradually leading to the extinction of natural conservative and efficient processes has raised alert in the mind of man.

The architectural and engineering field of studies should be aware and responsible for the impacts of their processes on the environment as these deal with the design and the erection of buildings. As the environment is altered by design and construction processes, energy conservative and efficient practices must not be forgotten. In spite of the beneficial outcomes of energy efficiency and conservation, it is disheartening to see that some built structures rely

heavily on artificial energy sources especially on the aspect of ventilation, heating and lighting. This is seen in most commercial and residential buildings. Sustainable approaches in the area of energy efficiency and conservation in design and construction have great beneficiary outcome of which can never be overemphasized.

The aim of this research is to bring into light the attributes and benefits of energy efficiency and conservation for a sustainable future.

2. METHODOLOGY

The approach to this study is purely literature review. This will be theoretical studies from academic papers and websites that defines the architectural design strategies/techniques and benefits of energy efficiency and conservation. These include published and unpublished journals of relevant architectures, reports and web pages to achieve the aim of the study.

3. DISCUSSION

In architectural design, the concept of energy efficiency and conservation exploits integrated technology, as well as scientific and local knowledge to minimize energy consumption and to create a comfortable environment for man. According to Givoni; 1994, there are four identified principles of a comfortable environment which include;

i. Ventilated Cooling: This is a principle of cooling a space in which there is inflow of fresh air to cool the occupants of a building.
ii. Radiant Cooling: This principle refers to the transfer of temperature in materials' surfaces. This can be applied with a building envelopment, for the appropriate temperature transfer at an appropriate time and function area.
iii. Evaporative Cooling: Evaporative cooling refers to the cooling by vapour as a result of evaporation from water bodies. Heat energy is drawn from the environment to reduce the temperature. Therefore, there are increases in the spray in the air and evaporation. When the water evaporates, the temperature within is reduced.
iv. Cooled soil as a cooling source for the building*:* The temperature of soil is reduced as the dept increases. At a depth of 2-3 meters from the surface, the soil temperature is lower, which means that the soil can be a cooling source. However, this principle is rarely found.

When the weather is hot, people often stay in air-conditioned areas. Electricity consumption for air conditioning systems accounts for at least half of the total power consumption of buildings. Therefore, the concept of energy conservation in architectural design should to apply to all processes of a project life cycle from the design stage to the construction stage, occupancy stage and renovation stage. This research will discuss the architectural attributes and benefits of energy efficiency and conservation in buildings.

Attributes of Energy Efficiency and Conservation

A. Building Design (Openings, Overhangs, and orientation)

This is a very important attribute of energy efficient buildings as the orientation of a building significantly affects its degree of energy efficiency. The placement of other building elements in relation to the sun can have an effect. A good oriented building regulates the temperature as much as possible to minimize the excessive use of heating and cooling systems.

Architects who design for warmer climates typically aim to reduce direct solar gain, whereas, in cooler climates, the building is positioned to receive more sunlight. This is a passive design technic, whereby, Architects take advantage of the local climate. This has been an effective attribute of energy efficiency. Passive solar design is a broad term used to encompass a wide range of strategies and options resulting in energy-efficient building design and increased occupant comfort. The concept emphasizes architectural design approaches that minimize building energy consumption by integrating conventional energy-efficient devices, such as mechanical and electrical pumps, fans, lighting fixtures, and other equipment, with passive design elements, such as building siting, an efficient envelope, appropriate amounts of fenestration, increased daylighting design, and thermal mass. Natural ventilation: depends solely on-air movement to cool occupants. Window and openings on opposite sides of the building enhance cross ventilation driven by breezes (Oikos, 2007).

Ventilation requires the building to be open during the day to allow air flow. (Oikos, 2007) as shown in Figure 1.0

Since natural breezes cannot be scheduled, designers often choose to enhance natural ventilation using tall spaces within buildings called stacks. With openings near the top of the stack, warm air can escape, while cooler air enters the building from openings near the ground.

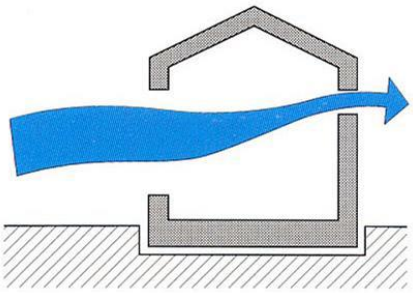

Figure 1.0 Opening to enhance ventilation

Source: Keeffe 2017

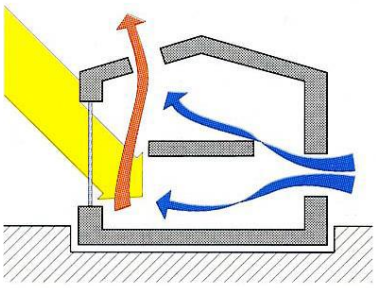

Figure 1.1 Stack effect used to create ventilation

Source: Keeffe 2017

Building orientation is the relationship between the position of the building elevations and its geographical direction. In design, a proper oriented building is important to the quantity of solar gain and also affects the cooling indoor spaces. It is also a determining factor of ventilation. During winter seasons for cold climates, the orientation of a building in such climates will determine the amount of solar heat gained for warming up liveable spaces while for hot, warm and humid climates, orientation will determine the amount of cool breezes

flowing across the building. Also, planting deciduous trees can be used to provide seasonal shading and help to moderate the interior temperature, thereby, saving energy for cooling. In summer months when the trees have its leaves, the amount of solar radiation in homes is limited. On the other hand, in the winter when the trees losses its leaves more sunlight is permitted in to provide warmth as shown in Figure 1.3. Transpiration processes in trees can also be a source of clean air to the environment.

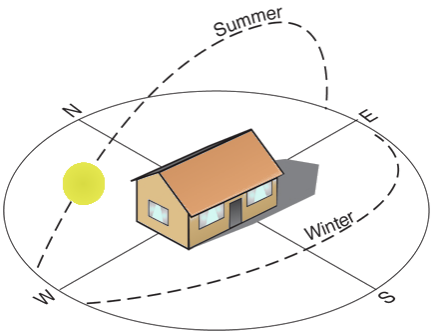

Figure 1.2: Building orientation for optimal energy

Source: (Gromicko & Gromicko, n.d.)

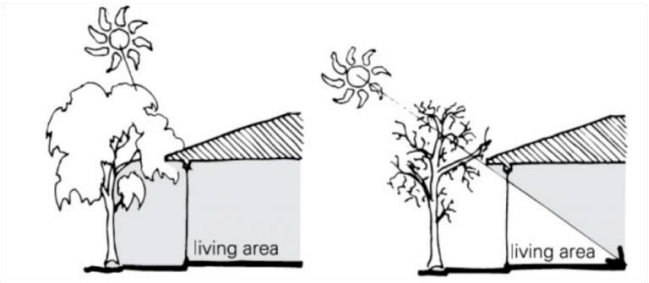

Figure 1.3: Shading using a deciduous tree

Source: www.yourhome.gov.au

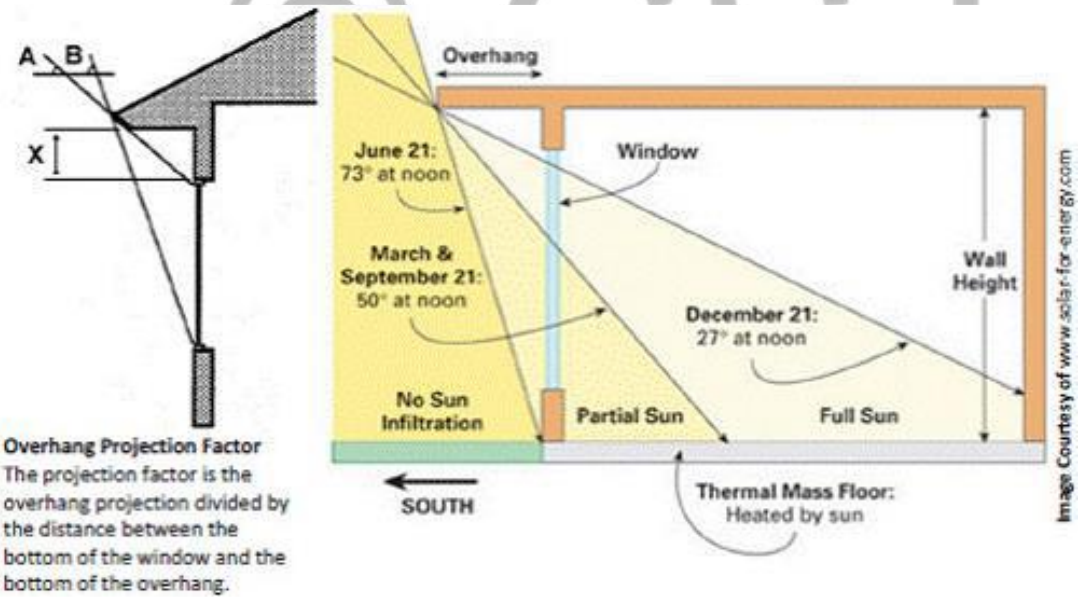

Figure 1.4: Overhangs for shading and regulating temperature

Source: SBIC and the Beyond Green Guidelines for High-Performance Homes

The position of such openings such as doors and windows are also important. Overhangs are great construction techniques that can alter sun exposure to a building. Figure 1.4 above illustrates how strategic placement of overhangs can cast shade and help regulate the temperature throughout the year.

B. Insulation

One other attribute of Energy-efficient building is insulation. Insulated buildings can heat and cool themselves independently. Insulation plays an important role as it helps to regulate the temperature in a building by minimizing the amount of air that escapes it. This technique reduces the load on HVAC system, thereby, reducing the electricity usage. One insulation technique in building is the use of Insulated Concrete Form (ICF) during construction of buildings. This uses blocks of expanded polystyrene foam that perfectly fits into sections of a building. They contribute to the effective insulation of a building by using a seal that prevents air drafts. It is also effective in protecting the building from fire and weather damage. Figure 1.5 illustrates the use of the ICF in walls of buildings.

Figure 1.5: Insulated concrete form for insulation in walls

Source: Natsoulis 2019

Other insulation materials for energy efficiency are fibreglass, mineral wool, cellulose, natural fibres, polystyrene, etc.

C. Daylighting

According to Public Technology (1996), daylighting is an important attribute of energy efficiency and conservation. It is the practice of admitting light into a building interior and distributing it evenly in a way that provides more desirable and better-quality brightness than other artificial light sources. This natural lighting strategy reduces the need for artificial sources, thus cutting down on electricity use and its associated costs and pollution. Daylighting requires the correct placement of openings, or apertures, in the building envelope to allow light penetration while providing adequate distribution and diffusion of the light. A well-designed system avoids excessive thermal gains and excessive brightness resulting from direct sunlight, which can impair vision and cause discomfort. To control excessive brightness or contrast, windows are often equipped with additional elements such as shades, blinds, and light shelves. Establish the location, shape, and orientation of the building on the site based on daylighting performance objectives as part of an integrated passive solar heating and cooling strategy.

Traditional Daylighting Strategies

Windows and Side-lighting: Windows are the most common way to admit daylight into a space. Their vertical orientation means that they selectively admit sunlight and diffuse daylight at different times of the day and year. Therefore, windows on multiple orientations must usually

be combined to produce the right mix of light for the building, depending on the climate and latitude. (Public Technology Inc, 1996).

Skylight is any horizontal window, Roof lantern or Oculus, placed at the roof of the building, often used for daylighting. White translucent acrylic is a 'Lambertian Diffuser' meaning transmitted light is perfectly diffused and distributed evenly over affected areas

Another important element in creating daylighting is the use of clerestory windows in residential building and the use of saw-toothed roof in factories. Light shelves are also an effective way to enhance the lighting from windows on the equator-facing side of a structure, this effect being obtained by placing a white or reflective metal light shelf outside the window.

D. Renewable Energy

Renewable energy is one other facet of energy efficient and conservative buildings. This is an energy that is naturally replenishable and obtained from natural sources. It includes; sunlight, rain, tides, waves and geothermal heat. (Ellabban et al, 2014). This energy is a sharp contrast of fossil fuels which are used up quickly than they are replenished. On the other hand, unlike fossil fuels, renewable energy is a sustainable energy as it is readily available, clean and reliable. According to the 2010 Global Status Report on Renewables, there are four major ways that renewable energy provides energy; electricity generation, air and water heating/cooling, transportation and rural (off-grid) energy services.

Photovoltaic (PV) technology is the most used renewable energy today as it is the direct conversion of sunlight into electrical energy by the aid of semiconducting devices usually referred to as “solar cells”. (SunPower, 2011). Photovoltaic are almost maintenance-free and seem to have a long-life span. The conversion process is clean and can make use of free solar energy. Generally, its durability, simplicity, and minimal resources used to produce electricity through Solar PV systems make this a highly sustainable technology. The figures; 1.6, 1.7 and 1.8 below show the other benefits of Photovoltaic elements. Other than providing electrical energy, they replace construction materials, such as building components thus performing an additional function as part of the weatherproofing of the walls or roof. Replacing conventional elements of the building envelope (roof tiles, metal roofs, façade elements, windows, shading devices, thereby reducing the cost of buildings.

Figure 1.6: Solar PVC on roof
Source: www.zmescience.com

Figure 1.7: Solar PV as wall material
Source: www.smartbricks.com

Figure 1.8: Solar PV as shading device
Source: www.pinterest.com

Mechanical system consumes energy, however, some HVAC systems are energy efficient and are commonly used in most commercial and some residential buildings.

HVAC Systems

HVAC means Heating, ventilation, and air conditioning. This system provides heating and cooling to buildings. Thermal regulating systems are common in buildings whether they are residential or commercial. They provide thermal comfort and fresh air to building occupants. Installing energy-efficient HVAC systems can adjust the air intake through measures such as an exhaust hood setting. By using timers, the operation of these systems can be minimized during periods of low activity in a building.

Although, the latest technology in HVAC systems may be costlier, the energy savings in the long run makes it a worthwhile choice.

According to Hensen and Trcka; 2010, integration of building and HVAC system models is accompanied at different levels. The models can be, (i) sequentially coupled (many duct/pipe sizing tools. BLAST, DOE-2, etc.) – without system model feedback to the building model or (ii) fully integrated (ESP-r, EnergyPlus, IDAICE, TRNSY, etc.) – allowing the system deficiencies to be taken into account when calculating the building thermal condition.

There are six main components of the HVAC system, they are;

(i) Heat Exchanger: This is responsible for absorbing warmth and heating colder air. To do this, the thermostat will activate the furnace to allow combustion to occur. The resultant heat will then rise. The heat exchanger is made of durable materials like stainless steel and strong alloys that will reduce or prevent damage from temperature changes.

(ii) Blower Motor: Once the air has been heated up by the heat exchanger and reached the desired temperature set by the user, the blower motor sends electricity to a fan, which then pushes the heated air through the ducts in the home or building. The duct lead throughout the area, and the air will be released from the vents into the open space. Once all of the hot air has been released into the home, the heat exchanger will start up again to heat up the new, cooler air in the system.

(iii) Combustion chamber: This is where air is added by the furnace and a combustible material combine with a source of igniting to heat up.

(iv) Condenser Coil/Compressor: This path of the air conditioning or heating system is usually located outside the home or building and is essential for cooling the air already present, the condenser actually removes the hot air inside the building into the outdoor.

(v) Evaporator Coil: Once the condensed refrigerant liquid is passed to the evaporator coil, it is then sent through a series of valves and nozzles, from which it is sprayed out. This action allows the cooled refrigerant in liquid form to evaporate again into a gas, dispersing the coolness into the home. The evaporation process absorbs heat, so the air indoors lowers gradually.

(vi) Thermostat: This is the most common path of the HVAC system that most people are familiar with, it is the sensor that indicates when the system will be turned on or off.

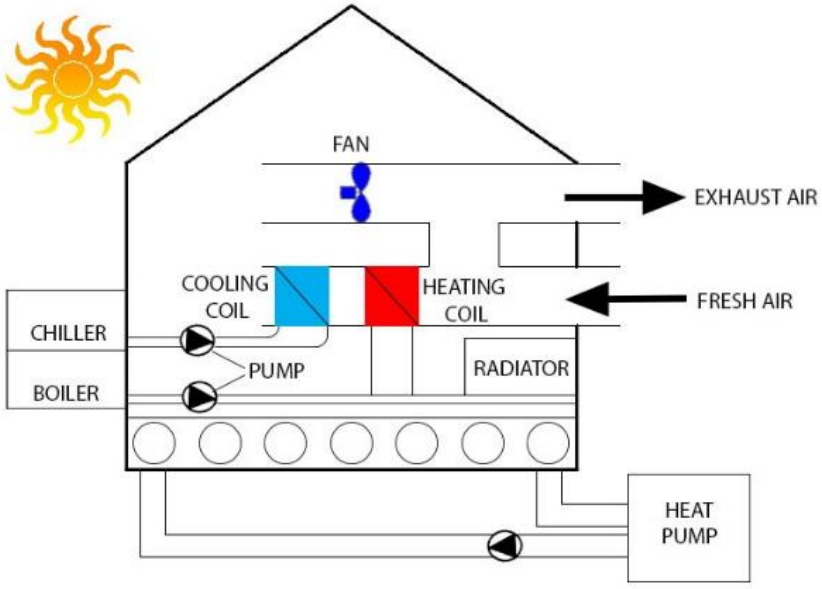

Figure 1.0 Overview of the main components of the HVAC system
Source: Baldi and Satyavada 2016. http://www.researchgate.com

Energy Efficiency and Conservation is Beneficial

- *Minimizes the Effects of Greenhouse Gases*

Over the years, Greenhouse gases has posed more threat to our environment, affecting natural habitats and man himself. There have been majors adopted to reduce this effect on the environment. One way to do this is to reduce the amount of carbon output and the pollution resulting from burning fossil fuels. However, energy efficient building and conservation appliances can go a long way in reducing this threat. Deploying the attributes leads to sustainable future.

- *It saves cost*

Building especially commercial buildings utilize a lot of energy to operate. They need steady electricity for heating and cooling, as well as other daily activities within the complex. This utilization makes these buildings very expensive to keep open and open for operation. Residential homes too need energy for heating in the winter and cooling in the summer. A significant amount of energy is required also.

By applying the above discuss attributes of energy efficiency and conservation in designing and constructing buildings, many of these costs of operation can be reduced drastically. This leaves more energy available for other areas of the business because building owners will be spending less on utility and building maintenance.

- *Yields better Return on Investment*

The aim of every commercial and business firms is to get a better investment or Return On investment ROI. By designing and constructing energy efficient buildings, building owners ensures a long life-span building that requires less serious repairs and maintenance.

- *Qualifies for special Programmes and Incentives*

With a new advocation for energy efficiency, the government has established many programmes to encourage everyone including building owners to invest in green energy and building. There is a database detailing the various energy efficiency tax credits, rebates, and savings available to commercial establishments and some government agencies created by the U.S Department of Energy (DOE). There are incentives virtually every aspect of energy efficiency, from installing solar panels to installing a more energy efficient HVAC system.

4. CONCLUSION AND RECOMMENDATIONS

This research has discussed how the increased in world population has led to a high demand of energy. It has also saw how scientific innovations in the quest to reconcile population growth and energy usage have altered and surmounted natural process in both positive and negative ways. It has also shown how the burning of fossil fuel through machines for generating electricity has contributed to environmental threat more especially pollution and climate change. The architectural and engineering field has been seen to be accountable for the impacts of their activities in creating new buildings on the planet. Design and construction strategies can alter the environment for good or for bad depending on the approaches taken by these professionals. This study has also unveiled the appreciate designing and construction techniques that are sustainable, by utilizing energy efficient strategies and materials in both commercial and residential buildings. Applying these attributes has been seen to be beneficial, as they reduce the effects of Greenhouse gases by reducing pollution, saving costs, bringing better output on investment and incentives to building owners.

Therefore, to contribute to the betterment of our environment, a sustainable future and the growth of the economy, there should be concerted efforts by all especially Architects and Engineering who design and construct buildings. Energy efficient and conservative measures should be a priority. Government also has to play their roles in establishing programmes that preaches energy efficiency, they should also provide incentives for commercial establishments and local government agencies that are energy-efficient in their operation.

REFERENCES

Aeroseal. (n.d.). *23 Key features of an Energy Efficient Building*. Retrieved June 16, 2021, from Aeroseal: http://www.aeroseal.com

Architecture Revived. (2015, October 17). *Architecture: Passive Solar Heating and Cooling*. Retrieved June 17, 2021, from http://www.architecturerevived.blogspot.ca/2013/10/designing-passive-solar-heating-and-html

Australian Government. (2015, October 17). *Shading*. Retrieved June 17, 2021, from http://www.yourhome.gov.au/passive-design/shading

Baldi, S., & Satyavada, H. (2016). An integrated control-oriented modelling for HVAC performance benchmarking. *Journal of Building Engineering, 6*. doi:10.1016/j.jobe.2016.04.005

Ellabban, Omar, Abu-Rub, Haitham, Blaabjerb, & Frede. (2014). Renewable Energy Resources: Current status, future prospects and their Enablig Technology. *Renewable and Sustainable Energy Reviews*, 39: 748-764 [749]. Retrieved June 17, 2021

Givoni, & Baruch. (1994). Passive and low energy cooling of building. Retrieved June 16, 2021

Gromicko, N., & Gromicko, B. (n.d.). *Building Orientation for Optimum Energy*. Retrieved June 18, 2021, from InterNACHI's Green Resources: http://www.nachi.org

Hensen, J., & Trcka, M. (n.d.). Overview of HVAC systems simulation Automation in Construction. 93-99. Retrieved June 16, 2021, from http://www.researchgate.com

Inc., P. T. (1996). Sustainable Building: Technical Manual, Green Building Design, Construction and Operations. *Public Technology*, PP 3-27, 89-99.

Keeffe. (2017). The Passive House: Issues of Cooling: Form, Shading, Ventilation.

Luvera, N. (2020, December 18). *5 Construction Techiques for Energy Efficient Buildings*. Retrieved June 17, 2021, from ChadFisher: http://www.cfisherconstruction.com

Natsoulis, N. (2019, september). *Improving Energy Efficiency with Insulated Concrete Forms*. Retrieved from Newyork Engineers: http://www.ny-engineers.com

Oikos. (2010). *Green Building Library.* (Oikos, Producer) Retrieved June 16, 2021, from http://oikos.com/library/index.html

REN21's. (2010). *Global Status Report on Renewables.* Retrieved June 17, 2021