Design Strategies for Energy Efficient Retrofits for School of Engineering Faculty Building in Federal University of Technology Akure

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Abstract: ***Addressing energy efficiency in the existing building has been acknowledged as one of the most critical yet challenging aspects of reducing our environmental footprint on the ecosystem. This research presents a case study of design measures for energy efficiency retrofit in Engineering faculty building in Federal University of Technology Akure. An analysis of energy performance was carried out to access various energy consumption equipment in the building. And most of the components used are not efficient to meet the energy demand in the building. The findings establish significant benefits in establishing a retrofit standard in existing buildings.***

Keywords: Design strategies, Energy efficient building, Energy efficiency, Energy efficiency retrofit, Retrofits in building.

1. Introduction

Most buildings around the world are not energy efficient, buildings and are mostly constructed without taking the energy efficiency the buildings into consideration. In Nigeria, building designs are void of energy efficiency strategies from the design stage and are constructed without taking into consideration the energy efficiency of the building. For a building to be energy efficient, design strategies include the use of well-equipped efficient equipment that is appropriate based on the location and condition of the building. The building should provide necessary amenities and best services appropriate to the intended use of the building and lastly a low energy consumption equipment must be used within the building to reduce carbon emission [(13)].These three criteria define an energy efficient building and must at least be a little above average in all terms of a life cycle cost. Although a possible and a much stricter standard may be used as a criterion.

Retrofitting can be done on existing buildings that are not energy efficient. Based on findings, It is of the opinion that retrofits in existing buildings can be widely categorized into three levels which includes improving the management of a building and energy system required in housekeeping activities, partial retrofits that are cost effective when replacing components and inefficient equipment such as light fixtures, ventilators, air conditioners, pumps and windows within the buildings, while component may be replaced individually, and lastly upgrading building envelop by reducing structure heating and cooling, reducing lighting loads as an approach that addresses the individual components which takes an integrated comprehensive retrofit of a whole building into consideration [(5)] . Hence, there is a need to put in place design strategies or certain measures to design energy efficiency retrofits in existing buildings. This study is adopted to basically to develop design strategies for energy efficient retrofits for faculty of Engineering FUTA. The study is streamlined to energy efficient retrofit of the existing university faculty building. This will be limited to faculty buildings that has the same configuration as the school of environmental technology FUTA.

2. Energy efficiency in buildings

Energy efficiency in both the residential and commercial or tertiary buildings presents itself in a similar manner. On a technical basis the quality of building construction in terms of choice of the most suitable form of energy or technique best for cooling and heating in buildings are connected to the energy-consuming equipment and equipment performance using high energy efficiency. For instance, solar water heater or cost generation equipment.

Energy efficient buildings must contain energy-efficient technologies that, when operating as designed, will effectively reduce energy use. Building must supply the required amenities and features best for that kind of building. Most offices provide around 60 hours/week of suitably conditioned air, lighting, and equipment. Building must also be operated efficiently in such a manner as to be efficient, to promote low energy use relative to other similar buildings [(14)]. However, it is not necessary that efficient building must excel in all the aspects listed above, but the building must possess at least an average quality of an energy efficient buildings.

Newly constructed buildings should use quality standards and best practices in reducing heating, cooling, and lighting loads and also introduce energy efficiency technologies that can pay for themselves over the course of their life cycle. Building Energy efficiency codes (BEECs) is an elaborate process, requiring a variety of data and analyses and requires extensive consultation with active participation of broad set of stakeholders involved in the building designs [(5)] These codes can be adopted in introducing and implementing energy efficiency in buildings.

The best means to achieve efficiency gains in existing structures, is by the replacement of old energy-consuming equipment which is often the best means to achieve efficiency gains. A building envelope, is often unchanged for decades except for basic maintenance, the equipment that are inside an existing building can generally be replaced over a long period of time depending on the energy demand of the particular building. Therefore, reducing the use of energy and emissions of carbon in an existing building is should be a primary component of reducing overall energy consumption and CO2 global emission.

2.1 Materials for energy efficiency

Advanced materials are used to achieve energy efficiency and can bring significant energy savings in existing buildings. (2) Such materials include:

a) Reflective indoor coatings which optimize the use of artificial lighting and natural lighting reduces energy use by 20% and increasesperceived light up 20% for the same light perception and can help sustain sunshine radiation heat inside the building in wintertime. The coatings maximize the feeling of space and illumination and are better than normal paints. This in turn allows reducing the amount of energy used for artificial lighting and/or increases the perceived illumination by natural light.
b) High reflectance and durable outdoor coatings are applicable on walls and building roofs in hot climatic regions. It reflects sunlight radiation both in the visible and infrared parts of the spectrum. When applied to roofs and walls, the reflection of the sun's energy reduces roof and wall temperature resulting in reduced heat within the spaces underneath the roof and inside the walls. High reflectance and durable colour coatings have a Life expectancy 12-15 years depending on the climate and can save up to 15% of air conditioning consumption in hotter regions while also allowing for downscaling the size of the air conditioning system and
c) Phase Change Materials (PCM) basically increase the thermal inertia of the wall and ceilings, making them behave like thick stone walls found in buildings of about hundred years of age and are available as an active ingredient ranging from semi-finished materials such as plaster, cement, plasterboard and multifunctional wall and roof modules. PCM enables such walls and ceilings to absorb and store excessive heat during the day when used in (interior) walls and/or ceilings of buildings in order to dissipate that excessive heat during the night when air temperatures decrease. In addition, phase-change material (PCM) effectively increases the thermal mass of the building material when temperature is increase above or below the transitional temperature of PCM. The latent heat needed for initiation of the phase change in a material is relatively bigger than the specific heat of the material, e.g., a conventional wooden wall at the temperature change for 5°C is five times lesser than a latent heat of a wooden wall with around 30% of phase change materials (11) Therefore, organic matter such as paraffin which are considered as a good phase change material
d) Advanced insulation foams with high insulation performances that allows significant energy savings and can be adapted to different building's configurations. It is estimated that these high-performance foams can reduce the energy costs for heating by 30%-80%. Cavity wall insulation fills the space (cavity) between the two layers of the external wall of a building. The insulation could be external or internal.
e) Vacuum insulation panel (VIP) modules can be used in refurbishing glass facade buildings. Their insulation performance is three times higher than conventional insulation materials. VIP were often used in buildings recently due to their nature of being fragile and are exposed to the risk of damaging the vacuum by perforation. VIP is more expensive than conventional insulation materials, among other reasons because they are still in the introduction phase. Recent products make up the vacuum inside a double-glazing package. Buildings that need strong improvement of thermal insulation performance allows the useof glass-intensive facades

Some energy efficient materials that are similar materials such as includes:

a) Thermal insulation of buildings is one of the most effective ways to save energy resources for heating and cooling and providing comfortable temperatures in rooms. Thermal insulation materials or systems which show effective thermal conductivity values far below the conductivity value of still air at ambient conditions are known as so called super insulations. The physical principle is to generate a volume of still air within a porous structure and to avoid convection effects. Thus, the thermal conductivity of still air, i.e., $0.026 Wm^{-1} K^{-1}$ at ambient conditions comes significantly into effect and provides a reasonable thermal insulation.
b) Vacuum insulation glass (VIG) is One active possibilities of insulation glass is to essentially improve the insulation properties to suppress the heat transport due to conduction and convection of the filling gas by evacuating the space between the glass panes (4) This allows walls of modern well insulated buildings to increase its U-values of $< 0.2 Wm^{-2} K^{-1}$. Today, the remaining thermal leaks in the facade of these buildings are glazing with lower U-values of about $1.0 Wm^{-2} K^{-1}$.

2.2 Energy efficiency measures

In the study of examples of deep energy savings in existing buildings, Buildings projects had to apply at least two a list of Energy Conservation Measures (ECMs) associated with each the project. The ECMs have been documented and are identified as follows (3):

Heating Ventilation Air Conditioning (HVAC): Replacement or alteration on mechanical equipment. Includes active and passive heating and cooling methods.

a) Lighting: Replacement and/or alteration to the lighting system, including the incorporation of task lighting, lighting controls and day lighting.

b) Day lighting measures incorporated exterior and interior shading and/or light sensors. It is a sub-set of lighting defined as an energy feature rather than a view or aesthetic feature.
c) Controls: These are means to track energy usage in the building. These include Energy Monitoring System (EMS), Building Automation System (BAS), Building Management System (BMS) and lighting/occupancy controls.
d) Envelope: Upgrade in insulation, including cool roof, addition of high-efficiency windows, including the use of tinting.

2.3 Energy efficiency retrofits in buildings

Energy improvements in new buildings can be achieved by making use of state-of-the-art technologies and policies to achieve standard practice in our present day. Large energy savings in existing buildings can be realized by energy efficient retrofits, buildings use around two thirds of the total global energy use and represents more than 30% of global energy-related CO2 emissions, existing buildings will account for a major part of this consumption, especially in developed countries[21].The opinion that by 2050, energy use from buildings is expected to double due to a global rise in floor area of around 130% leading to a rise in thermal comfort levels and today's policy trends not being ambitious enough to reduce the increasing energy usage[17]. Also, with a study commissioned by the Global Building Performance Network and prepared by the Central European University (CEU), the 'deep energy efficiency' scenario (from now on called the deep scenario) "denotes how far today's state-of-the-art construction design, retrofit know-how and technologies can help the building sector in lessen energy use and CO2 emissions, while also providing full thermal comfort in buildings [21].

2.3.1 Retrofits for energy efficient in existing buildings

For new buildings, standards that establish a minimum level of performance can be used to ensure maximum building efficiency byadopting ambitious energy efficiency improvements therefore making use of the deep path means as a standard practice for all buildings that are undergoing major renovation and minor renovation within 10 years. The deep path becomes the most challenging when it comes to existing buildings, as there are many varying factors that affects the overall performance and saving potentials of these buildings and the possibilities to adapt to change are very limited. A state-of-the-art energy renovation can, in many cases, reduces the energy consumption far more by 75% in the building [17]. However, a standard renovation or refurbishment will often achieve energy savings in the range of 20% to 30%, sometimes even less. There should bereduction of carbon emissions by 50% on buildings needs in order to meet exacting climate change objectives and to prevent the worst-case scenarios of climate change. This seems challenging unless new and renovated buildings are designed effectively in terms of energy efficiency andit uses much less energy compared to what isbeing used today. Even though highly efficient building technology is readily available, deep retrofits are not in demand and are not yet standard practice.

2.3.2 Design strategies for energy efficiency retrofits of existing buildings

Globally, growing energy use in buildings is majorly due to increased space conditioning load, rapid economic development, increasing urbanization, and improved lifestyles. Energy efficiency can be used as a possible solution to address to all these issues and can also directly connect the dots between health and social benefits, climate change mitigation, energy prices, energy savings, energy security, industrial productivity and improving the asset value. And they also proposed some design strategies for energy-efficient buildings which includes [23]:

1) Reducing loads,
2) Selecting systems that make the best use of ambient energy sources and heat sinks, using efficient equipment and effective control strategies.

In engineering systems and architectural elements, an integrated design approach is required to ensure that they work effectively together. While adopting energy efficiency measures for buildings, the energy consumption in a building can be also be reduced by maintaining or improving various levels of comfort in the building, reducing heating and cooling demand in use of equipment and appliances, lighting, heating water. All these should be carefully planned, when considering electrical component and impact of its energy usage.

There are nine strategic elements and measures for energy efficiency retrofit for existing building which are: Improvement of thermal protection, change in the heating systems, Construction and materials, Implementation of ventilation systems with heat recovery, More efficient electricity use (lighting, cooling, appliances, Implementation of solar thermal panels, Choice of electricity mix, Control and regulation of building systems, Improvement of the sun and overheating protection) [22]

Some energy efficient retrofits measures for existing building suggested the replacement the following: Air condition, furnace, lamps, electric bulbs, refrigerator, water heater, windows, seal ducts, seal and insulate ducts, and whole house air seal. It also includes the use of Air seal and insulate attic floor, close condition, and insulate crawl space, insulate walls (drill-and-fill), and Insulate basement walls. [15]

2.4 Importance of energy efficiency in buildings

High-performance buildings not merely conserve energy costs and natural resources, but also imply a higher-quality indoor environment. The basic principle of building energy efficiency is to apply less energy for air conditioning, heating, and lighting, without affecting the convenience of people that use the building. Advantage of building energy efficiencyin buildings includes:

- Healthier Indoor Environment Quality that makes a building efficient by promoting a healthier indoor environment for users who occupy the space and also operate in them. For instance, using attractive architectural designs to lighten up work areas using natural light instead of electricity, without creating excess glare and ensuring comfortable temperatures for a peaceful work atmosphere are usually characterized as high-performance buildings.

- Minimized Life-cycle Cost strengthens building energy efficiency and lowers the level of energy needed to operate a building by lessens costs for building occupants.
- Reduced Resource Consumption in buildings to promotes energy efficiency as a new energy stock sustainable enough to decreases the need for new power plant in larger investments
- Lower Environmental Impact in buildings lead to the release of four main pollutants harmful to the environment; mono-nitrogen oxides (NOX), Sulphur oxide (SOX), CO2, and particulates. Promoting energy efficiency in buildings minimizes the dependence on fossil fuels and decreases greenhouse gas emissions.
- Improved Employee Productivity enhances comfort of building occupants and lead to greater employee efficiency inwork spaces. Current study has indicated that natural light, better management of temperature, and more intelligent utilization of spaces increases employee productivity [19].

2.5 Setbacks in achieving energy efficiency in buildings

In developing countries, energy efficient retrofit in existing buildings is very difficult to enforce due to some obstacles which may include [19]:

1) Political and Organizational Obstacles which primarily exist in developing nation. These is inadequate administration of policies to ensure energy efficient strategies to enforce structures and establishments comply with building codes, lack of skilled personnel, embezzlement of building funds and corruption. In Nigeria, government involvement in promoting energy efficiency is insufficient

2) Monetary Obstacles

Buying higher costs of energy efficient equipment which many consumers do not want to spend and are not affordable to low-income consumers because they have limited capital. This is the most evident obstacles for energy efficiency in buildings and various sectors in developing nations around the world. In developed nations, consumers usually don’t alternatively pay substantial up-front expenses since they possibly don’t understand energy efficiency opportunities which often reimburse within a few years or perhaps few months.

3) Information Barriers

Developing nation lacks knowledge concerning the opportunities, strategies and possibilities of energy efficiency alternatives and can be a major burden in providing energy services without users recognizing essential benefits of energy efficiency in buildings to reduce electricity needed.

4) Behavioral and Administrative Constrains

Energy efficiency technologies and practices is obstructed through behavioral characteristics of individuals and organizational characteristics of companies. Little opportunities to conserve energy are often overlooked and changing behavior or lifestyle is very difficult. The absence of awareness and information about the prospects and small costs of energy savings and related issues in developing nations is low compared to developed nations. Developed nations strengthens energy-efficiency, thereby restricting significance of energy expenditures in the disposable earnings or financial return of wealthy homeowners and businesses, which leads to very limited interest given to this matter among other things.

5) Market Flops

Consistent translation of specific energy-efficient investments into energy saving benefit are sometimes hindered by market flops. The main drawback within the buildings industry are certainly missing bonuses, Utilities have no direct involvement in measuring their clients’ energy use. While in the public sector, financial constraints arecertainly the main hurdle preventing energy efficiency investments. More so, building tenants pay the energy bill and yet don't have control over the system, whilst building owners are not interested in energy efficiency enhancements.

6) Hidden Prices and Benefits

Hidden costs and benefits for the end-user are not apprehended directly in financial flows, causing higher up-front prices, such as risks associated with the replacement technology and transactional costs related with acquiring the energy efficient solution which are usually high due to the fragmented structure of the buildings sector with numerous small proprietors and agents. New energy efficient technologies might as well not be compatible with current outlets.

The building (School of Engineering and Engineering Technology FUTA) building is located inside the university campus, Federal University of Technology Akure, Ondo state Nigeria, and was established 1995 after the institution came into existence in 1988. The core usage of the faculty building includes lecture rooms, teaching spaces, and office and student amenities. The original building shell is dated from the 90s. The building accommodates over 3000 occupants including staff and students. The building sits 7^0 18’9.13 latitude north and 5^0 08’18.66 longitude east, located within the sub-equatorial climatic belt with tropical rainforest vegetation characterized by densely distribute wide foliage trees. The koppen Gieger climate shows the overall climate is a tropical region and are characterized as hot and humid. The area experiences 8 months of annual rainfall and four months of dry season. The average annual temperature ranges between 28^0C and 30^0C with relative high humidity to enhance precipitation.

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Figure 1: Location map school of engineering and engineering technology FUTA
Source: Google earth

2.6 Approach and methodology

The methodology of this research is divided into two parts.

a) The physical observation of the building energy demand
b) The energy consumption analysis of a single case study that explores at the impact of retrofit strategies on energy consumption.

Some knowledge in advanced retrofitting for energy efficient buildingshas been earlier studied which use the first version of Green Star rating tool that was released for benchmarking new and existing university buildings. It lays out the criteria against which all projects seeking a rating under this tool is assessed against green building council of Australia, [6] the energy consumption intensity by space type is a principal benchmark under this tool, which is relevant in assessing the case studies.

The selected building, will be critically studied to identify commonalities in terms of use, age, structure and their retrofit strategies. Retrofits will involve specialist spaces such as laboratories, lecture room, offices, and scientific spaces. The building is bounded by the 750 capacity Education Trust Fund Lecture Theater by the west, at the north is the school library, at the east is the Center for Continuous Education building and at the south is an existing road bounded by an undeveloped thick forest.

Building Typology: Faculty building, offices, lecture rooms, laboratories, and student amenities Construction: Hollow sand Crete blocks plaster with mortar.
Typology of plan: Cluster
Number of floors: 3
Orientation: North

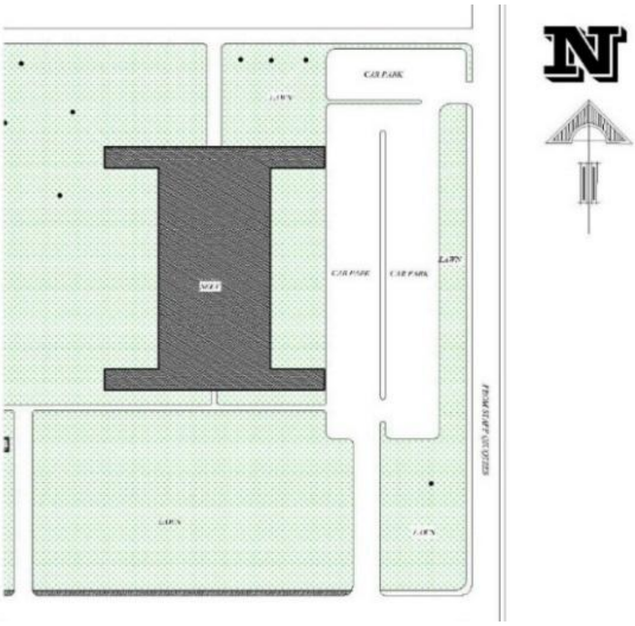

Figure 2: Site plan of the School of Engineering and Engineering Technology.
(Source: Authors field work)

a) Energy exchange variables in the studied building

Energy efficient building are characterized with efficient equipment and materials appropriate for the location and conditions of such building and are seen as technical factors. It should possess amenities and services that are adequately appropriate to the building's intended use; and lastly, it must be operated in such a manner as to have a low energy use compared to other, similar, buildings which are non-technical factors [10, 12] The building selected is subjected to energy exchange variables and was observed to be relatively below average following energy efficiency principles.

b) Consumption analysis in the studied building

A breakdown of energy consumption categories is not presented; as such data is not obtainable in the case study building, which does not have a sub-meter system. This is a typical retrofit building for which there is no clear energy audit data available. Therefore, the lack of detailed energy data has presented its challenges in working out the cause and effect of the retrofit works on energy consumption. However, this represents a significant number of university faculty buildings with the same configuration, where there are no energy consumption breakdowns, nor previous energy audit records. While specific variables cannot be isolated in their cause and effect, due to the complexity of variables and the limitation of the existing monitoring system.

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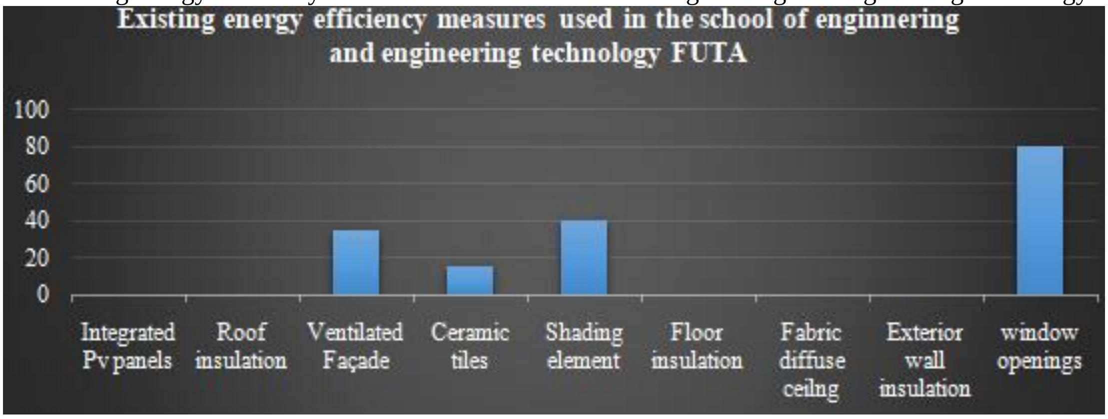
Table 1: Existing energy efficiency measures used in the school of engineering and engineering technology FUTA



(Source: Authors field work)

Plate 1: Atypical view of School of Engineering and Engineering Technology
(Source: Authors field work)

Plate 2: Approach view of the School of Engineering and Engineering Technology
(Source: Authors field work)

3. Results and Discussions

The study discussed suitable measures with specific tools that can be adopted as retrofit strategies to promote energy efficiency in school of Engineering and engineering technology FUTA. This will be a model for faculty buildings within the same configuration to allow designers in built environment, building owners, contractors to identify various retrofitting measures for upgrading existing buildings in order to improve thermal comfort and improve energy efficiency within the building.

3.1 Thermal performance

Windows with low emissive coatings or more glazing surfaces and framing materials (such as extruded fiber glass) with very low conductivity of multiple glazing layers and low-conductivity gases (argon in particular) between glazing layers, has generally improved the thermal performance of windows greatly.

Heat flows in operable windows (open able) have only 25–35% of the heat loss of standard non-coated double-glazed (15 to 20% of single glazed) windows. Cooling loads are best reduced using glazing that reflects or absorbs a large fraction of the incident solar radiation reduces solar heat gain by up to 75%. The costs of glazing and windows has remained constant or even dropped in real terms, in spite of these technical improvements.

The table below shows various types of windows which include louvered and aluminum sliding windows used in the building which only gives room for ventilation.

Table 1: Thermal performance of windows used in the building

S/N	Type	Sizes(mm)	Allowable ventilation%	Number	Location	Material
1	Louvered window	1800 x 1200	100	108	Laboratories, lecture room, workshops and offices	Glass
2	Louvered window	1800 x 450	100	108	Laboratories, lecture room, library, conference room and offices	Glass
3	Louvered window	900 x 1200	100	79	Offices	Glass
4	Louvered window	900 x 450	100	105	Offices	Glass
5	Louvered window	2100 x 1200	100	10	Lecture rooms	Glass
6	Louvered window	3000 x 1200	100	15	Lecture rooms, and conference room	Glass
7	Louvered window	3000 x 450	100	15	Lecture rooms and conference room	Glass
8	Louvered window	1200 x 450	100	40	Lecture rooms, offices	Glass
9	Louvered window	1500 x 450	100	36	Lecture rooms, offices	Glass
10	Aluminum fixed window	700 x 450	0	5	Lecture rooms	Glass
11	Aluminum Sliding window	750 x 600	50	3	Lecture rooms	Glass

(Source: Authors field work)

Plate 3: A typical laboratory in the faculty of engineering FUTA, cooling system employed include fans, lamps, louvered windows and high-level head room
(Source: Authors field work)

3.2 Cooling system

Houses, apartments and small commercial buildings have a nominal COP (cooling power divided by fan and compressor power, a direct measure of efficiency) ranging from 2.2 to 3.8 in North America country and European country, depending on operating conditions. More efficient mini-split systems are available in Japan, ranging from 4.5 to 6.2 COP for a 2.8 kW cooling capacity unit. Chillers are larger cooling devices that produce chilled water (rather than cooled air) for use in larger commercial buildings. Cooling power generally increases with size, with the largest and most efficient centrifugal chillers having a cooling power of up to 7.9 higher under part-load operation and even under full-load operation. Although additional energy is used in chiller-based systems for ventilation, circulating chilled water and operating a cooling tower, significant energy savings are possible through the choice of the most efficient cooling equipment in combination with efficient auxiliary systems. The table below shows the cooling systems in the building.

Table 4.2: Cooling Systems used the building
(Source: Authors field work)

S/N	Type	Location	Number
1	Ceiling fan	Laboratories, offices and lecture rooms.	87
2	Air condition	Offices, library, and conference room.	65
3	Shading devices (horizontal fins)	Building exterior	32
4	Shading devices (vertical fins)	Building exterior	144

Plate 4: Use of vertical and horizontal fins on the building exterior as a shading device to improve cooling within the faculty building
(Source: Authors field work)

3.3 Day lighting systems

Opportunities for day lighting are strongly influenced by architectural decisions early in the design process, such as building form; the provision of inner atria, skylights,the size, shape and position of windows and clerestories(glazed vertical steps in the roof). IEA (International energy agency) provides a comprehensive sourcebook of conventional and less conventional techniques and technologies for day lighting [7]

A number of recent studies indicate savings in lighting energy use of 40 to 80% in the day lighted perimeter zones of office buildings [1, 8, 14] while a measured savings for an automated Venetian blind system integrated with office lighting controls, finds that lighting energy savings averaged 35% in winter and ranged from 40 to 75% in summer [9] [16]. The table shows various lighting fixtures used.

Table 4.3: Types of lighting fixtures used the building
(Source: Authors field work)

S/N	Type	Location	Number
1	Florescent	Laboratories, lobby, offices, conference room, library, and lecture room.	233
2	Bulb (florescent)	Laboratories, lobby, offices, conference room, library, and lecture room.	180

Table 4.3: lamps, bulb and high-level windows as lighting fixtures used the building
(Source: Authors field work)

3.4 Applicability of energy efficiency retrofit

Retrofit strategies for energy efficient buildings include reducing loads, selecting systems that make the most effective use of ambient energy sources and heat sinks and using efficient equipment and effective control strategies to ensure that the architectural elements and the engineering systems work effectively together in an integrated approach. The school of Engineering and engineering technology FUTA was subjected to Standard retrofit strategies used in upgrading existing building's energy performance in terms of daylight, cooling and lighting system to reduce energy consumption while maintaining thermal comfort.

3.5 Proposed retrofit strategies for the faculty building

Below are some of the retrofit's strategies suggested
1) Replacing existing lighting fixtures to high efficiency.

It included replacing high-energy lighting such as high-pressure sodium in the laboratories, which runs 24/7, with new energy efficient LED lights. Installation of compact fluorescent lamps throughout building and replaced inefficient office-area fixtures with T8 and T5 ballasts and lamps.
1) Installed BMS control for air conditioners and condenser water system.

The installation of amodern building management system (BMS) to effectively control and monitor the Air Condition system, using energy smart control strategies and monitoring features.
1) Alter the economy cycle to maximize outside air cooling.

The reinstatement of the economy cycle to air handling systems to provide free cooling when favorable (cool) ambient conditions prevail. The common cause of poor energy efficiency is the lack of or inefficient operation of the economy cycle
1) Operate the air condition system within the manufacturer's recommended temperature limits.
2) Incorporate optimum start/stop in conjunction with night purge and set the Building Maintenance System time of day schedule to core occupancy hours and utilize the after-hours push buttons at all times.
3) The standard insulation of opaque walls and windows replacement.

4. Conclusion

This research work and the selected case study demonstrates the potential of improving energy efficiency through retrofit strategies. For faculty buildings in federal university of technology, school of engineering and engineering technology was used as reference for faculty buildings with the same configuration. The selected building was chosen according to its relevance for building stock of the university and also to easily exemplify the constraints faced by professionals when retrofitting buildings designed with different priorities and requirements than one used today. Energy efficiency measures in building envelope reduce particularly primary energy use. Resulting reduction of carbon emission in the building is dependent on the energy system and the energy carrier residual heat or electricity demand.

5. Recommendation

In other to achieve a reasonable level of energy efficiency in existing faculty buildings, the following design measures for energy efficiency retrofits are recommended. The lighting retrofit should be carried out throughout the building in various locations starting with all exit lamps as well as the replacement of high-wattage lamps with lower-wattage lamps and fixtures. Also building management system control should be install for air conditioners and replacement of the existing air conditioners, and these air conditioners should be operated within the manufacturer's recommended temperature limits. The standard insulation of opaque walls and windows replacement with windows that are energy efficient such as casement windows where there are 100% air entering the space and therefore creating room for little use of air condition and also aiding effective lighting and much reliance on artificial lighting.

An incorporated optimum start/stop in conjunction with night purge to set the Building Maintenance System time of day schedule to core occupancy hours and utilize the after-hours push buttons at all times.

References

[1] Atif, M.R and A.D Galasiu. (2003). Energy performance of daylight-linked auomatic lighting control system in large atrium space: report on two feild-monitored case studies. *Energu and buildings*, 35, 442-461.

[2] Bax L, CruxenJ, and Komornicki L. (2013). Materials for energy efficiency buildings (Innovative chemistry for energy efficiency buildings). *Smart cities stake holder platform*.

[3] Carthy H. (2011). Exsmples of deep energy savings in existing buildings. Vancouver: New building institute NBI.

[4] Ebert H.P. (2015). Functional materials for enery efficiency buildings. *EJP Web of conferences* (p. 98). W'urzburg EPD Sciences.
[5] Energy Sector Management Assistance Program, (2014). *Improving energy efficiency in buildings.* Retrieved from ESMAP: www.esmap.org/improving energy efficiency in buildings
[6] Green Building Council of Australia. (2009) Green star Education VI. Standard practice benchmark Summary. Green star (1st ed) Green building council of Australia
[7] Hyde R. Yeang K, Greonhout N, Barram F, Webster-Mannison M, Healey K and Halawa E. (2008). Exploring snergies with innovative green technologies for advanced renovation using a bioclamatic approach. *42nd Annual Conference of the Australian and New Zealand Architectural Science Association.* Newcastle: ANZAScA.
[8] International Energy Agency, (2000). Day lighting in buildings: A source book on day lighting system and components. *IEA.* Lawrence Berkeley National Laboratory (eetd.lbl.gov) as LBNL-47493.
[9] Lee E.S, DiBartolomeo D.L, Selkowitz S.E. (1998). Thermsl and Daylighting performance of an automated venetian blind and lighting system in a full scale privae office. *Energy and Buildings*, 29, 47-63.
[10] Li, D.H.W and J.C Lam. (2003). An investigation of day lighting performance and energy saving in a day light corridor. *Energy and buildings*, 35. 365-373.
[11] Liu M and Hyde R., (2012). retrofits to improve energy efficiency of existing builings in the tetiary education sector: An investigation of current practice and implications. *Building and Energ Conference, University of Sydney.* Sydney.
[12] Lukic p, Tamburic J and Stojic D. (2012). Energy efficiency of buildings with phase change material,. *FACTA UNIVERSITATIS (architecture annd engineering).*
[13] Mier A, Olofsson T and Lamberts T. (2002). What is an efficientbuilding?*Natonal de technologia do ambiente contruido, foz do iguacu-parana.* Brazil: IX Encontro.
[14] Noak L. and Wheelock C. (2010) *Energy efficiency retrofits for commercial and public buildings (Energy saving potential, Retrofit business cases, Financing Structures, Policy and regulatory factors, demand drivers and market forecast)* Boulder: Pike research
[15] Polly M, Gestwick M, Bianchi M, Anderson R, Horowitz S, Christensen C, and Judkoff R. (2011). A method of determining optimal residentialenergy efficiency retroffit packages Oak ridge. *US department of energy*.
[16] Rubinstien F and Johnsons S. (1998). *Advanced ighting program development (BG9702800) Final report.* Berkeley Califonia pp28: Lawrence Berkeley National Laboratory.
[17] Shnapp S, Sitja R. and Lausten J. (2013). *What is deep renovation definition?* Paris: Global building performance network.
[18] Ullah, M.B and G. Lefebvre. (2000). Estimation of annual energy-saving contribution of an automated blinding sysyetm.
[19] Umar U, Khamidi M, Shika S and Musa U. (2013). Towads building Energy efficiency for Developing Countries. *Bonfring International Journal of Industrial Engineering and Management Sciences*, 7.
[20] United Nations Environment Programme, (2012). *Theemission gap report.* Retrieved from UNEP: www.unep.org/publicationebooks/emmissiongap2012
[21] Urge-Vorstaz et al, (2012). Best practices for low carbon and energy buildings. GPBN.
[22] Viorel Ungureanu, et al. (2013). Intergrated science for retroffiting buildings to reduce primary GHG emmission and cost. *Central Europe towards sustainable Buildings*, 3.