CARD International Journal of Environmental Studies and Safety Research (IJESSR)
ISSN: 2536-7277 (Print) : 2536-7285 (Online)
Volume 2, Number 2, June 2017
http://www.casirmediapublishing.com

Improving Expo/Exhibition Daylighting in the Tropics by Reducing Energy Consumption

Abdullahi Yusuf & Dr. A. J. Ango
Department of Architecture, Faculty of Environmental Design
Ahmadu Bello University, Zaria, Nigeria
Email: yusufwilsonwakawa@gmail.com, aaronango@gmail.com
Correspondence Author: Abdullahi Yusuf

ABSTRACT

Getting light into the building entity in a clever way is an important stride to designing energy efficient buildings. Learning how to use daylighting, in an efficient way while having control will reduce energy demands in buildings and also and facilitate a good visual comfort for users especially in a developing country like Nigeria where most trade fare take place using artificial lighting which increases operational cost. Most Expo/Exhibition tends to use artificial lighting because proper daylighting design has not integrated into the building. This study identifies different daylighting techniques that will reduce operational cost and at the same time, create a good visual experience. Literatures on daylighting were studied, in which the advantages of daylighting in buildings were identified, different daylighting techniques and system were examined and various ways daylighting can reduce operational cost. Case studies of relevant exhibition Centre buildings were analysed using appropriate variables, a model of the entire building, simulation using Ecotect, Radiance and daysim and data from metrological department and validation of result carried out furthermore changes was made to the various material under observation in terms of their "u-value" "R-value" and Solar Heat Gain Coefficient (SHGC) and it was observed that energy consumption in terms of lighting was reduced by 35% from Daylight Factor (DF) Analysis26% to 75%. An important finding of the research was that a conscious proposition that will fuse daylighting as a major design consideration in term of materials and design considerations is essential for a successful daylighting design for buildings. This finding affects the design process from optimizing building orientation, the perfect size, form and glazing treatment for windows, working with bright interior surface and shading for visual comfort. For the research design, atrium, laminated glass, and light shelves was appropriate for use. The implication of this finding opens a new dimension to the design of Expo/Exhibition centres.

Keywords: Daylighting, Energy Consumption, Energy saving, Sustainability, Expo/Exhibition centres, daylight material, Visibility transmittance, U-value, R-value

INTRODUCTION

The sun is predictable and daylight can be a very reliable source of light. Sunlight, views, and daylight are different though, and need to be carefully managed. Daylighting, or using sunlight to illuminate your building, is an effective way to both decrease your building's energy use and make the interior environment more comfortable for people. In commercial buildings, electric lighting accounts for 35 - 50% of total electrical energy consumption. Strategic use of daylight can reduce this energy demand. Daylight also improves people's comfort and productivity. Even when you can't use daylighting, good lighting design can reduce energy use significantly. Both are important in Net Zero Energy Buildings (Autodesk, 2015). Furthermore various studies agree that lighting is a major factor in determining the way in which people experience the internal environment, how they experience buildings, as well as how they are able to respond to certain tasks. Daylight studies show that day lighting has an important role in health and mental development (Tukur, 2013). Moreover the importance of day light as an integral part of human life cannot be over emphasized, it very essential in shopping mall, exhibitions and market places, of which architects have negated the responsibility of providing good day light to the hands of other professionals who must a times provide artificial lighting of various types that most at times do not provide the needed visual comfort (Vegas, 2008). The understanding and manipulation of light goes to the heart of the architectural enterprise, vision is the primary sense through which we experience architecture and light is the medium that reveals space, form, texture and colour our eyes "more and more" so light is the beautifier of the building (Right, 1952). Therefore it is difficult to overestimate the significance of daylight, and of sunlight, in the character of a building and in the lives of the people who use it. There are, of course, some building types, such as cinemas, theatres or nightclubs, where being cut off from the world outside is an essential part of the experience. In others, department stores or museums for example, daylight may be excluded from large areas of the building so as to give full play to carefully designed display lighting. But most interiors which are to be occupied by people, as opposed to goods or machinery, need plenty of light, and until the middle years of this century the limits of natural lighting were critical determinants in the plan of a building and in the design of its external envelope (Group, 2010).finally artificial lighting of the interior especially in Expo/Exhibition centres where daylighting is very important and due to the large space of such areas which amount to high energy

consumption. This paper tends to address this issue of utilizing daylighting through design approaches that will reduce the energy cost of lighting up the spaces in an Expo/Exhibition Centres in Nigeria.
It is in this light that this study aim to study energy conservation by use of natural means.
The objectives of the study are:
i. To explore the concept of day lighting from literature.
ii. To establish how day lighting features have be incorporated in the design of expo/exhibition centres from case studies.
iii. To demonstrate finding in the design of Expo/Exhibition Centre.

What is Daylighting?

Daylight consists of two words "day" and "light". The word "day" which be defined as that visible light which is emitted via the electromagnetic radiation from the sun (Yohannes, 2011).similarly is a part of a twenty four hour period when it is light, between sunrise and sunset, and, the word 'light' is defined as the energy which produces a sense of brightness that makes seeing possible. Combining the two words, "day light" is the condition of brightness created by the rays of the sun during the day. Therefore, "day lighting" according to (Ander, 2010) is the controlled admission of natural light into a space through openings to reduce or eliminate artificial lighting. Energy savings can be achieved either from the reduced use of artificial (electric) lighting or from passive solar heating or cooling. Artificial lighting energy use can be reduced by simply installing fewer electric lights because daylight is present, or by dimming/switching electric lights automatically in response to the presence of daylight, a process known as daylight harvesting.

Advantages of Daylighting

The major advantages of daylighting are the following:
- Practical nature
- Energy conservation
- Cost factor
- Health and well-being
- Aesthetic nature

The Principles of Day lighting Design include for Expo/Exhibition centres:

The first way to begin is by planning the building so that every occupied space has access to a source of natural light, such as a windows or skylights, giving special attention to windows that provide a view. The following principles are to be followed when designing for daylighting:
- Reduce the size of the east and west sides of the building.
- Maximize south and north sides of the building.
- Reduce the size of the east and west sides of the building, the sun rises from the eastern part of any site as that is where the sun is located

therefore there is a tendency that a lot of the direct ray from the sun may affect the building structure only if there is going to a shading device provided.

▪ Maximize south and north sides of the building

▪ North-facing windows present no solar heating problems, South-facing windows are the easiest to protect with overhangs, awnings, and light shelves (Vosko, 2014).

Sustainable Daylighting Strategies for Expo/Exhibition

- Optimize urban design and building orientation.
- The perfect size, form and glazing treatment for windows.
- Shading for visual comfort and cooling.
- Work with bright interior surfaces.
- Move task areas close to windows.
- Consider daylight reflector systems.
- Energize your building with solar radiation.

KEY FEATURES OF DAYLIGHTING DESIGN

There are a few key features of daylighting solutions that maximize overall efficiency. Making sure these features are properly implemented ensures reduced HVAC and lighting costs. Here are the five key elements to look for in a daylighting system;

Exterior Dome or Lens

The exterior dome or lens of the skylight is an essential element because it provides the first barrier between the interior and exterior of the building. It is essential when selecting a system to make sure that the lens or dome that has been tested for both weather and impact resistance. This ensures that your building envelope will be protected and insulated and that you will be less likely to be surprised by costly repairs.

Light Well or Tube

The light well, or in some cases light tube, directs the light of the sun into your building. Because all buildings are not uniform, it is important to find a manufacturer whose system uses light wells compatible with your building or offers the option of custom light wells. In situations where your ceiling space is filled with obstructions, it may be better to incorporate a tubular daylighting solution, which utilizes flexible light tubes to circumvent obstructions.

Internal Blinds

While many manufacturers do not offer these as an option, daylighting solutions with adjustable internal blinds offer an additional level of control over your building's light level. They can also prove useful in minimizing glare and adjusting the level of illumination for different tasks.

Diffuser Lens

Traditional skylights commonly used a second clear lens on the inside of the building, which creates glare and light pooling. Make sure the system you install uses frosted glass or specialized diffuser lenses instead, to filter the light entering your facility. Diffuser lenses come in a variety of designs and help spread light evenly throughout a facility while reducing glare and light pooling as well as heat gain and loss.

Additional Technology

In order to maximize the benefits of your lighting design, it is important to find a system which utilizes additional technologies, such as LEDs, solar power, or GPS. These technologies can lower building energy costs further and provide a more comfortable work environment

What is an Expo/Exhibition Centre?

Expo, or Exposition, is somewhere in the middle between a Trade Show and an Exhibition which may not be sales of product but just display of product. Expo is open to the public, but focuses very much on business networking as well, especially export opportunities. Expositions are very large scale events, usually international and covering many industries; they may have Government support and a lot of Government organisations as exhibitors. When a specific business sector will expose and market their own products. For example, a mobile phones fair. Usually you get to see some of the most popular manufacturer brands of mobile phones, with their displays in booths. They showcase their latest products and services offered. When you engage yourself in a trade fair, you are exposing the new services and products of your business. Nowadays it would be very hard to find a Trade Show which is not open to the public, or a Trade Fair without a "trade day", when only industry professionals and media are allowed to attend. The same can be said about focus on export: although traditionally attributed to Expos, it is hard to imagine any Trade Show or Fair where participants would not be interested in finding clients from abroad (Beier, 2005).

Difference between Expositions and Exhibitions

Exposition and Exhibition have always been combined with the display of goods and products. Exhibitions differed from Exposition in four major ways:

1. Exhibitions were usually one-time events. They did not enjoy a recurring life cycle. However, while fairs ran for a short period of time, many exhibitions ran for months, some for a year or longer.
2. Exhibitions were housed in permanent facilities built specifically for them. Starting in the 18th century, the practice of building a facility for the express purpose of housing an

exhibition was the precursor of the exposition/convention centre industry.
3.Although fairs were held regularly, they were not highly organized events. Over time, religious and later civic leaders did take control of the grounds where fairs were held (usually public lands). Exhibitions, on the other hand, were highly organized events. They were initially created by government departments or committees for the purpose of promoting trade.
4. Finally, exhibitions differed from fairs in the very way in which business was conducted. Goods were bought and sold at fairs. At exhibitions, commercial activity or selling of the displayed goods, was not usually involved. However, inherent in displaying the goods was the hope of stimulating future sales.

Procedure of Data Collection

The data is collected through multiple instrument of data collection. All the selected case studies where visited by the researcher for field survey, interviews were conducted, photographs were taken, notes and sketches were collected. The field survey involved visual survey of all passive daylight design features employ on the case studied buildings. The researcher in this case observed the principles of passive daylight design features qualitatively using checklist. List of variables in the checklist were checked and assessed sequentially. Final notes were also prepared after the interview was carried out. In cases where were no documentation available for the architectural drawings, the buildings were surveyed and the drawings were prepared by the researcher through sketches, photographs and notes. All photographs were taken either by the author or with help of relatives and friends. Photographs of relevant areas of the case studies were taken in order to highlight the observed passive daylight design features. Sketches showed the spatial organization of some of the study cases while notes explained the observed passive design features in each of the selected cases. The table below shows the research method schedule.

Research Method Schedule

	Study	Investigation	Research and Data Analysis
1.	Building structure	1.General information 2.material types 3.building morphology 4.historical background	Field survey Interviews Checklist Photographs sketches
2.	Actual/existing	1. Daylight quality 2.Useful day light Illuminance (average) UDI. 3.Glare Level 4. Daylight level distribution quality	Graphs and tables from field survey.
3.	Validation of actual tool and assessment of models	1. Validation of result by the researcher 2. Assessment of light Light level illuminance 3. Assessment of visual Comfort form recommended lighting requirement.	1. Simulation. 2. Visual Analysis 3. comparative analysis 4. average illuminance Calculations

Simulation

After collection of data and analysis of design, planning the simulation runs and determining the simulation conditions was required. This included the following.

1. Design and building materials: the design information obtained from the survey was used to create a 3D model for a space representing the various expo/exhibitions; this model was used in the simulation runs.

a. Sky conditions Clear sky with sun conditions are used based on Abuja's (location Coordinates (latitude 9.10 degree north and 7.40 degree east). Simulating the entire year would be very costly, and yet it is probably not necessary if one can decide on important dates and hours.

b. model of the case studies in Abuja is simulated for daylighting characteristics of the building as it where to determine the visual comfort under normal circumstance and data analysed using Ecotect with Abuja metrological data inputted, using the same model, but with different materials a simulation test was run to determine the visual comfort in the same expo/exhibition to determine the improvement in visual comfort which will letter be used as the model for the final design.

Ftcd (Foot Candela) /Lux Value for Various Lighting Conditions

Condition	Illumination	
	(ftcd)	*(lux)*
Sunlight	10000	107527
Full Daylight	1000	10752
Overcast Day	100	1075
Very Dark Day	10	107
Twilight	1	10.8
Deep Twilight	0.1	1.08
Full Moon	0.01	0.108
Quarter Moon	0.001	0.0108
Starlight	0.0001	0.0011
Overcast Night	0.00001	0.0001

Source: (lighillumania.com)

Activity and their Lighting Requirement

Activity	Illumination *(lux, lumen/m²)*
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theatres, Archives	150

Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000

Source: windowsfcm.com

Energy Concepts for Insulating Glass

U-factor (U-value)

The measure of the rate of non-solar heat loss or gain through a window system in terms of Btu/ hr-sq ft·°F (W/sq m·C). The lower the U-factor the greater the resistance to heat flow and a better insulator.

R-value

The measure of the resistance of a glazing material or fenestration assembly to heat flow. Basically the inverse of the U-factor or R = 1/U

Solar Heat Gain Coefficient (SGHC)

The fraction of the solar radiation admitted through a window or skylight both transmitted and absorbed and released inward (A William Lingnell, 2011).

Simulation Assumptions

Site Description

The investigated building is located in Abuja (9.10 N/ 7.40 E).

Daylight savings time lasts from April 1st to October 31st.

User Description

The zone is occupied Monday through Friday from 8:00 to 17:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of occupancy at the work place are 1569.0.The occupant performs a task that requires a minimum IL luminance level of 3500 lux.

Lighting and Blind Control

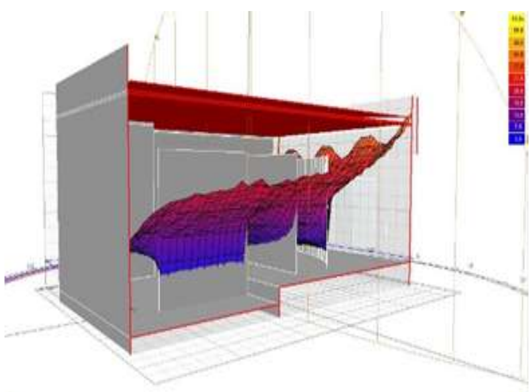
The office has no dynamic shading device system installed

Material sample 1 (*Low-E Glazing)*

U value =0.47

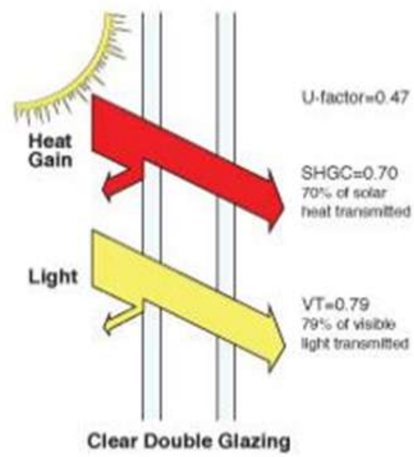
SHGC (solar heat gain coefficient) =0.70

Visible Transmittance (VT) =0.79



Lighting level for Low E-Glazing 1

Source: (Author)



Clear double glazing

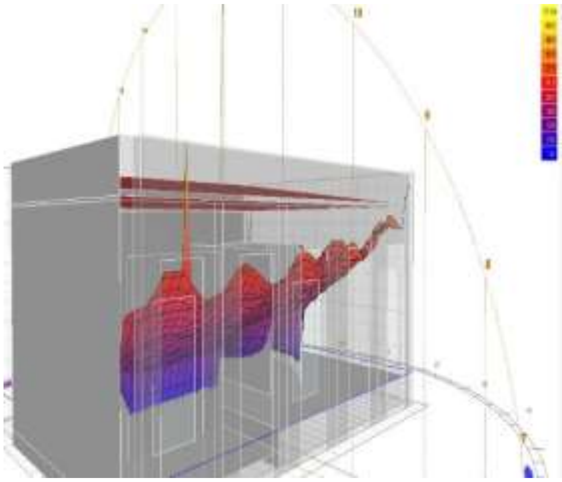
Source: (INC, 2014)

Material sample 2 (*Low-E Glazing)*

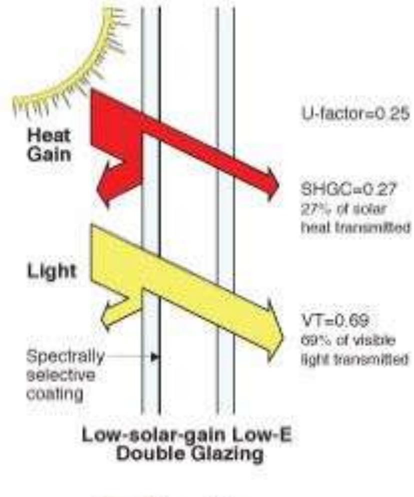
U value =0.25

SHGC (solar heat gain coefficient)=0.27

Visible Transmittance (VT) =0.69



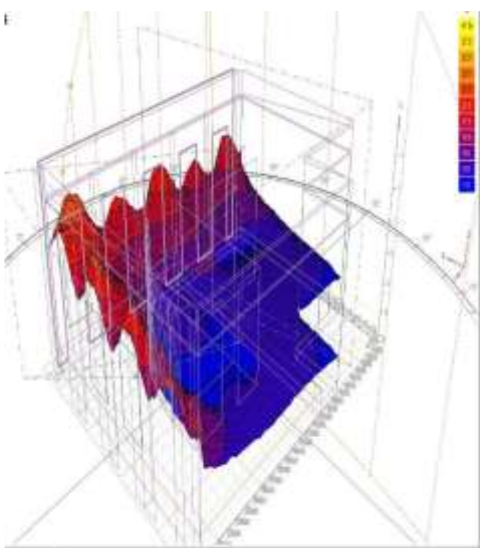
Lighting level for Low E-Glazing 2
Source: (Author)



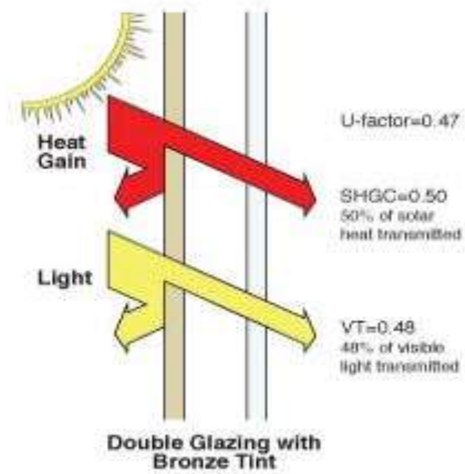
Low solar-gain low-E Double glazing
Source: (INC, 2014)

Material sample 3 (*Low-E Glazing*)

U value =0.47
SHGC (solar heat gain coefficient)=0.50
Visible Transmittance (VT) =0.48

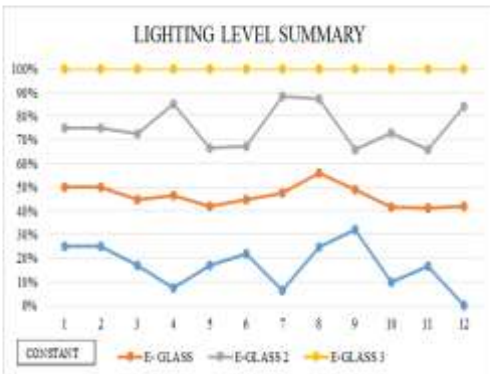


Lighting level for Low E-Glazing 3
Source: (Author)



Double Glazing with Bronze tint
Source: (INC, 2014)

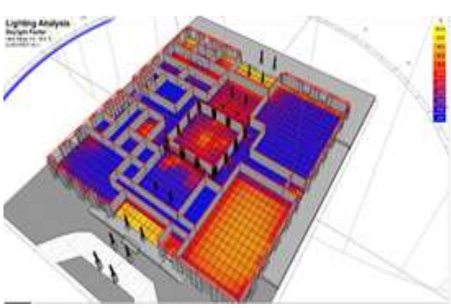
constant	26%	100
material 1	75%	288
material 2	75%	288
material 3	55%	212



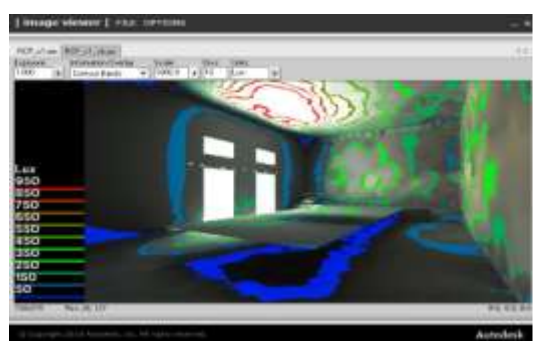
CASE STUDY ONE

Shehu Musa Yar adua Center

Established in honor of one of Nigeria's leaders, the center provides news and information about conference services, the library and exhibition hall. The building was dedicated to Shehu Musa Yar´ Adua a patriot with courage and compassion who sacrificed his freedom and ultimately his life for Nigeria on the 1st of March 2000 by the then president of Nigeria Olusegun Obasanjo, Vice-President Atiku Abubakar and His Excellency Nelson Mandela of South Africa and was letter commissioned by his excellency John Kufor the president Republic of Ghana on the 9th of march 2002.



Arial section view of the modelled centre



Lux value at work plane Musa yaradua center

Types of Materials used for each Building Component (Case Study 1)

Building Component	Type of Materials
Walls	Hollow Block Render
Windows	Double Glaze Aluminium Frame
Roof	Roof decking
Floors	Terrazzor

Dailly Lighting Energy Consumption of Case Study 1

Compact Florescent lamp type (watts /hr)	Number	Working hours (Average) Hr	TOTAL (Watts)
17 (watts) CFL	60	8	8160 *W*
30 (watts) CFL	65	8	15600 *W*
			23760*W*

Monthly Lighting Energy Consumption of Case Study Artificial Lighting

Month	Number of Days	Monthly Lighting Energy Consumption (*W*)
January	31	736560
February	28	665280
March	31	736560
April	30	712800
May	31	736560
June	30	712800
July	31	736560
August	31	736560
September	30	712800
October	31	736560
November	30	712800
December	31	736560
Total	365	**8672400*W***

Natural Lighting

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour.

53.75*8 = 430watts every day * 365= **156950 *W*.**

Total energy = 8672400 + 156950= <u>8829350*W*</u>

Lumens to watts calculation formula

Energy saving lamps have high

luminous efficacy (more lumens per watt).

The power P in watts (W) is equal to the luminous flux ΦV in lumens (lm), divided by the luminous efficacy η in lumens per watt (lm/W):

$P (W) = \Phi V (lm) / \eta (lm/W)$.

Source: (Rapid table)

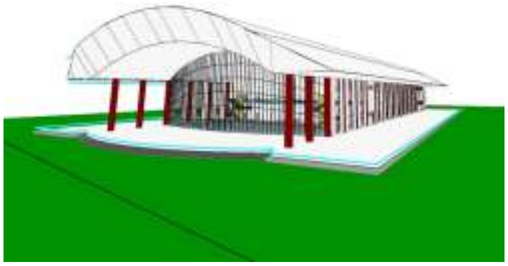
Result Findings from Daysim Simulation

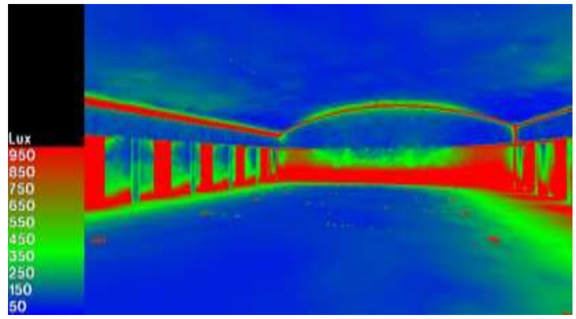
1. Daylight Factor (DF) Analysis: 26% of all IL luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone would not qualify for the LEED-NC2.1 day lighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher.
2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 100%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=100%, UDI100-2000=0%, UDI>2000=0%.
4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 55% of all IL luminance sensors have a DAcon above 40%. 16% of all IL luminance sensors have a Damax above 5%.

CASE STUDY TWO

International Conference Center Abuja

The Abuja International Conference Centre (AICC) provides an ideal location for exciting themed and large events. Ideal for, concerts, consumer and trade shows, large receptions or galas and other special events, the AICC can accommodate up to 3,000 guests. In the last decade and a half the Centre has played host to several International, Regional and National political, social, cultural, economic and religious conferences, summits, meetings, seminars, ceremonies and programmes. A magnificent edifice overlooking the Radio House, 'moulded' and lying in its own lovely garden filled with historic shady pine trees and well paved driveway. Options that the interior of this architectural masterpiece maybe put to are endless function.





View of Modeled of ICC Abuja luminance and lighting levels.

Types of Materials used for each Building Component (Case Study 2)

Building Component	Type of Materials
Walls	Alluminium sheets
Windows	Single Glaze Aluminium Frame
Roof	Curved Alluminium roofing sheets
Floors	Terrazzor

Daily Lighting Energy consumption of Case Study 2

Compact Florescent lamp type watts /hr	Number	Working hours (Average) hr.	TOTAL (Watts)
30 (watts) CFL	60	8	14400 W
60 (watts) CFL	100	8	48000 W
			62400 W

Monthly Lighting Energy Consumption of Case Study 2

Artificial Lighting

Months	Number of Days	Monthly Lighting Energy Consumption (W)
January	31	1934400
February	28	1747200
March	31	1934400
April	30	1872000
May	31	1934400
June	30	1872000
July	31	1934400
August	31	1934400

September	30	1872000
October	31	1934400
November	30	1872000
December	31	1934400
Total	365	22776000W

Natural Lighting

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour

53.75*8 = 430watts every day * 365= **156950W.**

Total energy = 22776000 + 156950= 22932950W

Result Findings from Daysim Simulation

1.Daylight Factor (DF) Analysis: 15% of all luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone would not qualify for the LEED-NC 2.1 day lighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher.

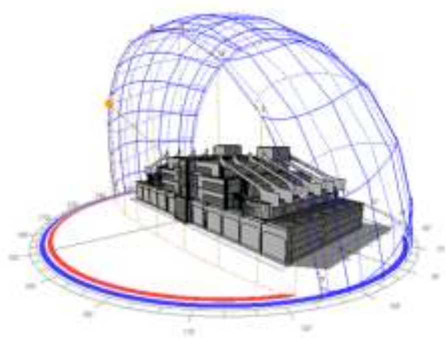
2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 87%.

3.Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=100%, UDI100-2000=0%, UDI>2000=0%.

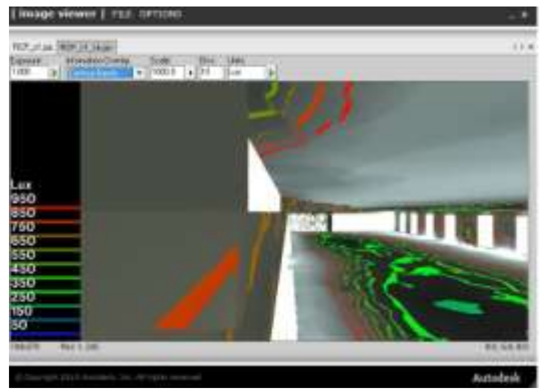
4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 55% of all IL luminance sensors have a DAcon above 40%. 14% of all IL luminance sensors have a DAmax above 5%

CASE STUDY THREE: Ceddi Plaza Abuja

Ceddi Plaza is owned by Ceddi Corporation and is located in the Central Business Area of Abuja. The Plaza consists of 10,000 square meters of retail and office space. The Nigerian owned and designed, the mixed use facility is managed by Broll Property Services Nigeria. Opened officially in November 2005, the Plaza is celebrated as the premiere Centre for Shopping & Entertainment in the City of Abuja Ceddi Plaza is made up of 55 specialty shops, offices & service providers consisting of movie theaters, a bookstore, champagne lounge, the Atrium at Ceddi Plaza, restaurants, cafes, fashion boutiques, shoes, accessories, home interior design stores, furnishings, health & beauty salons, gift shops, telephones, banking and automated teller machine (ATMs), dry cleaning services, a dental office, pharmacy, photo studio, children's entertainment, events hall. The tenant mix is made up of three floors of retail (eateries, fashion boutiques, entertainment and services) and three floors of corporate office space and much more.



View of Modelled of Ceddi Plaza Abuja



luminance and lighting levels of ceddi plaza

Types of materials used for each building component (Case Study 3)

Building Component	**Type of Materials**
Walls	Alluminium sheets
Windows	Single Glaze Aluminium Frame
Roof	Curved Alluminium roofing sheets
Floors	Terrazzor

Daily Lighting Energy Consumption of Case Study 3

Compact Florescent lamp type watts /hr	**Number**	**Working hours (Average) hr.**	**TOTAL (Watts)**
30 (watts) CFL	80	8	19200 *W*
60 (watts) CFL	100	8	48000 *W*
			67200 *W*

Monthly Lighting Energy Consumption of Case Study 3

Artificial Lighting

Month	Number of Days	Monthly Lighting Energy Consumption (W)
January	31	2083200
February	28	1747200
March	31	2083200
April	30	2016000
May	31	2083200
June	30	2016000
July	31	2083200
August	31	2083200
September	30	2016000
October	31	2083200
November	30	2016000
December	31	2083200
Total	365	24528000W

Natural Lighting

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour.

53.75*8 = 430watts every day * 365= **156950W.**

TOTAL ENERGY = 24528000 + 156950= <u>24684950W</u>

Result Findings from Daysim Simulation

1. Daylight Factor (DF) Analysis: 13% of all luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone would not qualify for the LEED-NC 2.1 day lighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher.

2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 87%.

3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=100%, UDI100-2000=0%, UDI>2000=0%.

4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 55% of all IL luminance sensors have a DAcon above 40%. 14% of all IL luminance sensors have a DAmax above 5%

Summary Table of Case Study Variables

	case study 1	case study 2	case study 3
The envelope Shape of building	29	32	31
The geometry, location and orientation of aperture	35	29	30
Surface characteristics	23	24	25
Spatial distribution of light	18	19	22
IL luminance ratio	21	20	17
Shape from shadows	15	13	16
colour rendition	15	14	14
Glare	12	12	13
visual noise	7	9	8
TOTAL	175	172	176

Case Study Validation

More efficient - LED light bulbs use only 12-17 watts of electricity (1/3rd to 1/30th of Incandescent or CFL). LED bulbs used in fixtures inside the home save electricity, remain cool and save money on replacement costs since LED bulbs last so long. Small LED flashlight bulbs will extend battery life 10 to 15 times longer than with incandescent bulbs (Eartheasy, 2014).

Incandesant(watts)	CFLs(watts)	LED (watts)	Lumen (brightness)
20	8-12	6-9	400-500
40	13-18	8-12.5	650-900
75-100	18-22	13+	1000-1750
100	23-30	16-20	1800+
150	30-35	25-28	2750

Source: Eartheasy2014

SUMMARY OF FINDINGS FROM CASE STUDIES

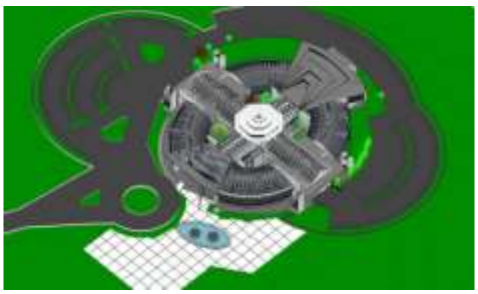
CASE STUDIES SUMMARY					
	Major Facility	Dominant Building Materials	Daylighting Element	Use of Artificial Light	Architectural Features and Characteristics

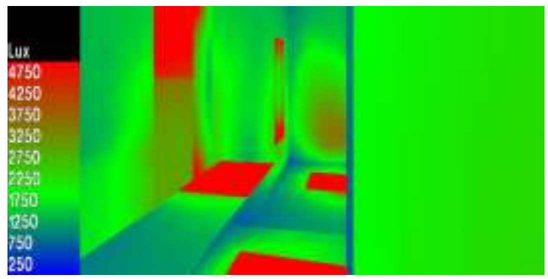
Musa Yar Adua centre Abuja.					
1	The centre has the necessary facility for exhibition.	Dominant building materials include concrete, steel and glass.	This include sky light doors and windows and glassed partition	Incandescing and florescent lighting tubes.	Contemporary architecture with the use of decorative walls and claddings.
International conference center Abuja.					
2	The centre has a vast area space for exhibition and circulation which can be muti-used for different functions	steel, concrete, wood and glass	Large open space windows, partitioned glazing.	Florescent lighting tubes. And halogen tubes.	The building consist of self-supporting columns spaced at 10m apart with steel portioning and a curved steel roofing
Ceddi plaza Abuja					
3	The plaza has a vast floor space that can be portioned for various activities like for commercial and recreation.	Concrete blocks. Precast concrete steel aluminum	Atrium glazed windows and doors	Florescent tube and low energy consumption bulbs.	Framed structure that is easily partitioned for various purposes and the collections of over hangs as shedding device

PROPOSED DESIGN REPORT

Proposed Abuja Expo/Exhibition Center

The site will be located in Abuja the capital city of Nigeria located in the centre of the country within the Federal Capital Territory (FCT). It is a planned city and was built mainly in the 1980.At the 2006 census, the city of Abuja had a population of 776,298.making it one of the ten most populous cities in Nigeria. According to the United Nations, Abuja grew by 139.7% between 2000 and 2010, making it the fastest growing city in the world. Abuja has witnessed a huge influx of people into the city; the growth has led to the emergence of satellite towns, such as Karu Urban Area, Suleja, Gwagwalada, Lugbe, Kuje and smaller settlements towards which the planned city is sprawling. The site will be served by the Nnamdi Azikiwe International Airport.





Arial view of proposed design **Lux value at work plane of proposed design**

Result Findings from Daysim Simulation

1. **Daylight Factor (DF) Analysis:** 95% of all illuminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1 (see www.usgbc.org/LEED/).

2. **Daylight Autonomy (DA) Analysis:** The daylight autonomies for all core work plane sensors lie between 20% and 100% .

3. **Useful Daylight Index (UDI) Analysis:** The Useful Daylight Indices for the Lighting Zone are $UDI_{<100}$=63%, $UDI_{100\text{-}2000}$=0%, $UDI_{>2000}$=37% .

4. **Continuous Daylight Autonomy (DA_{con})and DA_{max} Analysis:** 95% of all illuminance sensors have a DA_{con} above 80% . 90% of all illuminance sensors have a DA_{max} above 5.

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E).

2. User Description: The zone is occupied Monday through Friday from 9:00 to 19:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of

occupancy at the work place are 2077.0.The occupant performs a task that requires a minimum IL luminance level of 500 lux.

3. Lighting and Blind Control: The building has no dynamic shading device system installed.

Types of Materials used for each Building Component (Proposed Design)

Building Component	Type of Materials
Walls	Hollow Block Render
Windows	Double Glaze Aluminium Frame
Roof	Double layed polystyrene membrane roof with sky light
Floors	Floor tile

Daily Lighting Energy Consumption for Proposed design

Compact Florescent lamp type watts /hr	Number	Working hours (Average) hr.	TOTAL (Watts)
30 (watts) CFL	30	8	7200W
60 (watts) CFL	15	8	7200W
			14400 W

Monthly Lighting Energy Consumption (Proposed Design)
Artificial Lighting

Month	Number of Days	Monthly Lighting Energy Consumption (W)
January	31	446400
February	28	403200
March	31	446400
April	30	432000
May	31	446400
June	30	432000
July	31	446400
August	31	446400
September	30	432000
October	31	446400
November	30	432000

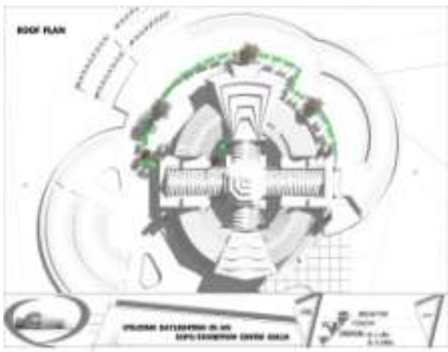
December	31	446400
TOTAL	365	5256000W

Natural Lighting

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour

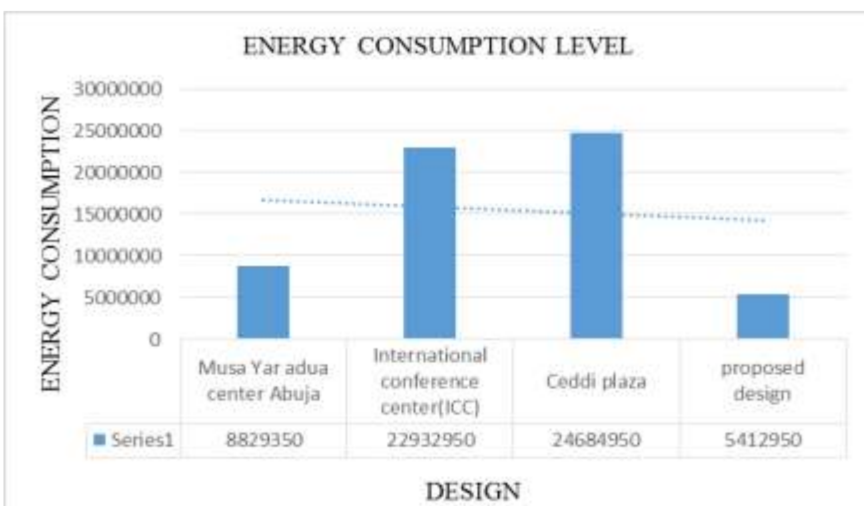
53.75*8 = 430watts every day * 365= **156950W.**

TOTAL ENERGY = **5256000 + 156950= <u>5412950W</u>**

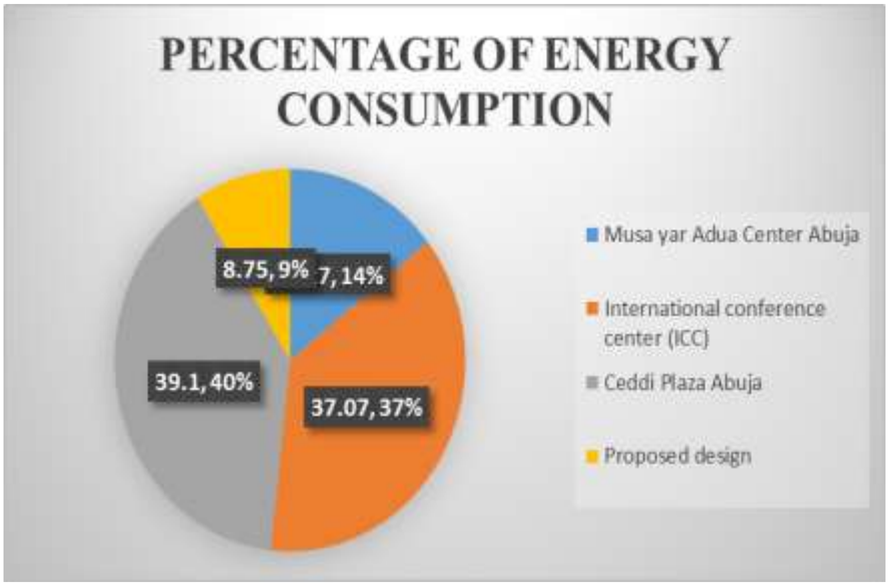


Site plan

floor plan



Energy Consumption Level



Percentage of Energy Consumption

DISCUSSION

It have been noticed from the various cases studied that there has been a deliberate attempt to provide daylight through top lighting and side lighting in exhibition centers in Nigeria. The use of materials that enhances daylight visualization in the interior space have been utilized. Moreover architectural forms from the case studies shows that those form where meant to deliver maximum day lighting to the interior of the building envelop. Exhibition Centre from the case studies display a brilliant showcase of exhibits. Furthermore, in case of power outage, the interior of exhibition becomes dark and it becomes difficult to see due to power failure. A good day lighting design, requires day lighting to be an integral part and not just an addition via windows or glazing. Use of reflected light in the exhibition spaces and galleries will to a great extend illuminate the interior space especially where light cannot extent to those spaces. A careful selection of building materials can enhance day light in the interior environment of buildings such as paint and color. From the simulation result top lighting is more efficient than the side lighting. A good selection of building materials should not affect the comfort of the interior environment. A combination of day lighting elements and artificial lighting will ensure well day lit spaces during the day and a smooth transition to artificial lighting during the night. Good and careful use of top lighting and side lighting is recommended for the design of Expo/Exhibition centers.

CONCLUSION

This research is mainly about the utilizing of daylighting in an Expo/Exhibition center to enhance visual comfort and at the same the needed lighting for exhibit so that visitors can appreciate the creativity they carry. A major disadvantage of day light in the tropics is how to use light efficiently, but this can be taken care of by proper building orientation, bi-directional lighting and careful choice of building finishes and glazing. Computer simulation using lighting design software, such as Radiance can help detect potential areas where glare can occur in buildings. These simulations can also aid in choice of day light elements to be used based on the quantitative and qualitative performance of the element. Ultimately the chief guiding principle in harnessing daylight in buildings is to consider natural light as a primary design consideration which affects all stages of the design, from site selection and preliminary design sketches to the choice of buildings finishes. As such the building form, building openings and finishes made use of in the design were dictated by their daylighting potential as well as their appropriateness for use in expo centers. From the analysis of case studies carried out, specifically the indigenous case studies and research conducted it can be seen that it is possible to make use of day lighting in Nigeria, as the illumination from natural light is adequate for the purpose. As the global search for environmentally friendly, cheap and renewable energy sources continues, the role played by natural light and energy from the sun in architecture will increase in relevance. Thus a country such as Nigeria that has an abundance of natural light which is relatively constant all year round has an immense gold mine which needs to be explored. Spatial requirements for the various spaces within the Expo centers have been given utmost Priority to form a concretized basis for allocation of space. Finally it is important that the choice of material for day light be considered when giving specification as an architect because they serve to maximize daylighting in the building and at the same time maximizing effectively as just material used can reduce energy consumption drastically.

REFERENCES

A William Lingnell, P. E. (2011). An Introduction to Glass Insulation. *IGMA*, 6.

Ander, G. (2010). *Daylighting design and performance.* new york: van nostrand reinhold.

Autodesk. (2015, may 5). *Autodesk education community.* Retrieved from Autodesk sustainability workshop: http://sustainabilityworkshop.autodesk.com/buildings/lighting-and-daylighting-design

Beier, j. (2005). *Role of Exhibition in marketing mix.* Revenbourg: UFI.

Eartheasy. (2014, September 24). *Solutuon For Sustainable Living*. Retrieved from Efficient Lighting Bulbs: http://eartheasy.com/live_energyeff_lighting.htm

Group, E. R. (2010). Day Lighting in Buildings. *The Thermie programme action*, 1.

Reinhart.c, B. (2006). daylight performance metric for sustainble building. *science direct*, 3.

Right, F. L. (1952). Daylighting principle of architectural design.*suatainable interiorlighting* ,8.

Tukur, R. B. (2013). *Harnessing Daylighting Potentials as a tool For Visual Comfort in Residential Buildings.* Nottlugham: University of Nortlugham.

Vegas, m. (2008). *Lighting in architecture.* Newyork: CRC Publishers.

Vosko, B. (2014). Lighting and Daylighting. *Interior design*, 6.

Yohannes, I. (2011). *Characterising the performance of light-pipes in UK Climate.* London: Nottingham.