Proposed Indoor Sport Complex for Lagos State Government
(Assessment Of Energy Efficiency in Public Facilities)

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Certification

This is to certify that Olasunkanmi Ezekiel OLAGUNJU, with matriculation number LCU/PG/002831 carried out this research work titled “Assessment of Energy Efficiency in Public Facilities” in the Department of Architecture, Facult y of Environmental Design and Management, Lead City University, Ibadan, Oyo state, for the award of Master Degree (M.Sc.) in Architecture and that this has not been previously submitted.

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Dedication

This dissertation is dedicated to God Almighty, the source of all knowledge and the world's Savior.

Acknowledgement

I would like to express my sincere gratitude to several individuals who have been instrumental in the completion of my MSc Thesis.

First and foremost, I would like to acknowledge and extend my heartfelt appreciation to my Head of Department, Dr. Funmi Adedire. Her unwavering support, encouragement, and guidance throughout this journey have been invaluable. Dr. Adedire's dedication to fostering growth and excellence in all aspects of life has been a driving force behind my successful conclusion of this research. I am truly grateful for her mentorship and unwavering belief in my abilities.

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Abstract

Energy efficiency is a critical aspect of sustainable development and has gained significant attention in recent years. Public facilities, such as governmental buildings, sports complexes, educational institutions, and healthcare centres, account for a substantial portion of energy consumption. Therefore, assessing and optimizing the energy efficiency of these facilities is of paramount importance in achieving sustainable energy goals. This research aims to assess and evaluate the energy efficiency of public facilities through a comprehensive study. The primary objective is to identify the key factors that impact energy consumption and propose effective strategies for energy optimization. The study explores various aspects, including building design, equipment efficiency, occupant behaviour, and energy management systems. The research employs a mixed-methods approach, combining quantitative data analysis and qualitative assessments. Energy performance indicators, energy audits, and simulation models are utilized to evaluate the energy efficiency levels of selected public facilities. Energy consumption patterns are analysed to identify areas of improvement and potential energy-saving opportunities. Additionally, detailed surveys and interviews are conducted with facility managers and occupants to gain insights into occupant behaviour and preferences related to energy usage. The findings of this research will contribute to a deeper understanding of energy efficiency in public facilities and provide valuable recommendations for stakeholders involved in facility management and policy-making. The proposed strategies aim to enhance energy performance, reduce energy consumption, and mitigate environmental impact while ensuring occupant comfort and productivity. This study serves as a foundation for future research and policy development in the field of energy efficiency in public facilities.

Keywords: Energy efficiency, Energy performance, Occupant behaviour, Public facilities

Word Count: 252

Table of Contents

List of Tables

List of Figures

List of Plates

Chapter One

Introduction

1.1 Background to the Study

In the UK, the term "public facilities" was first introduced. These amenities are provided by the government or other social institutions and encompass various aspects of urban life, including healthcare, education, leisure, transportation, sports, administration, community services, and financial services. Public facilities are essential for a complete urban lifestyle, and their practicality is a primary consideration in their design to ensure they function effectively within the necessary supporting infrastructure. Additionally, these facilities serve as the city's identity, contributing to its aesthetic appeal and cultural character.

Public facilities are indispensable to support government services and functions, as well as those of associated public and private agencies. They play a vital role in fostering community growth and enhancing residents' quality of life.

In response to the growing awareness of climate change, policymakers at all levels of government are placing greater emphasis on energy transition. This transition encompasses the entire energy flow, from primary energy sources to final energy consumption. Throughout this process, including energy transformation, transmission, distribution, and final energy use, there are inherent losses and inefficiencies (Morvaj and Bukaric, 2010). While the initial phases of energy efficiency improvement mainly focus on technological advancements, the fourth and final phase, discussed in this paper, involves a combination of technical and non-technical measures aimed at influencing consumer behaviour and lifestyle.

In recent years, energy efficiency has gained significant importance in national development, particularly in the context of public buildings. Energy not only represents a substantial portion of a building's operational costs but also has a profound impact on the comfort of its occupants, both in terms of thermal and visual aspects.

According to Sambo, A. S. (2010), the public building sector in Nigeria exhibits high energy consumption rates and poses energy efficiency challenges. Energy plays an integral role in various daily tasks and purposes, spanning domestic, agricultural, industrial, commercial, and official needs. The access to energy is a key differentiator between developed and developing or underdeveloped nations. To combat poverty, it is crucial for nations to ensure access to energy, and energy efficiency does not mean abstaining from its use but rather utilizing it in a manner that reduces the energy required to deliver services.

Energy-efficient appliances and practices can significantly reduce the energy needed for services such as lighting, cooling, heating, manufacturing, cooking, transportation, and entertainment. Energy-efficient products enable consumers to achieve more with less energy, exemplified by the transition from a 60W incandescent bulb, which consumes 60W/h, to an 11W/h compact fluorescent bulb that provides the same or even better lighting. This translates to saving 49W or 82% of energy per hour of operation. End-use efficiency encompasses devices, methods, or procedures that enhance energy utilization at the consumer level, extending beyond electrical appliances to measures like improving insulation for better heat retention in winter and cooling efficiency in summer.

Utility companies can also play a role in promoting energy efficiency through demand-side management strategies. This includes practices like load shifting, where consumers are

encouraged to adjust their energy usage away from peak hours. Two primary approaches to energy efficiency exist: the technological approach, which involves adopting more efficient technology, and the behavioural approach, which focuses on changing individual behaviours, such as turning off appliances when not in use.

Furthermore, energy-efficient considerations must be integrated into every stage of the design process to create buildings with low operating and maintenance costs. Achieving energy efficiency results in benefits such as more affordable and straightforward construction for developers, increased rent potential for landlords due to reduced operating costs, lower operating and maintenance expenses for tenants, and healthier and more productive indoor environments for building occupants.

1.2 Statement of the Problem

As per the 2008 ECN report, Nigeria possesses nine electricity generating facilities. These facilities are all government-owned and fall under the umbrella of the Power Holding Company of Nigeria (PHCN). Among these stations, there are three hydroelectric stations and six thermal stations, with a combined installed capacity of 6000MW. Unfortunately, these stations are currently operating well below their installed capacity for various reasons, ranging from a shortage of gas supply to inadequate maintenance practices.

According to a recent estimate reported by Punch on September 11, 2009, Nigeria's current electricity production stands at 2000MW. Some of this electricity is also exported to neighboring Niger Republic. However, given that approximately 60% of Nigerians do not have access to electricity, there is a significant demand for electricity in that country. Despite the commissioning of many gas-powered stations to augment generation by 4000MW, it is evident

that the energy production in Nigeria remains significantly insufficient. This situation underscores the urgent need for the adoption of an energy-efficient culture to address the energy challenges in the country.

1.3 Aim and Objectives of the Study

1.3.1 Aim

Energy efficiency should consider not only the current working environment but also future development, including how it will affect the surrounding population and the fossil fuels used in the process. This study's focus is on electrical energy management through a review of pertinent literatures. In order to increase the sustainability of public buildings as it relates to the use of natural elements, this research will examine the principles in order to better understand the situation as it relates to the design of public facilities in Nigeria., thus suggests the best ways to make public buildings sustainable and adaptable in line with best practices.

1.3.2 Objectives

The objectives are to:

1. To identify commercially and behaviourally low-cost ways of reducing energy consumption in the public sectors in Nigeria.
2. To identify renewable energy potentials in the different regions of Nigeria.
3. To present the different opportunities and measures for reducing energy use in buildings without sacrificing comfort levels.
4. To design a public sport facility taking into consideration energy efficiency measures which will not affect the comfort and use of the building and it occupants.

1.4 Research Questions

1. What are the challenges facing the energy efficiency of public facilities in Nigeria?
2. How can energy efficiency be ensured in public facilities?
3. How can public facilities reduce energy consumption in Nigeria?

1.5 Significance of the Study

In numerous developing countries, including Nigeria, the potential advantages of energy efficiency for both the environment and economic progress have not received sufficient attention within energy policies. This oversight may stem from the underdevelopment of the concept of energy efficiency in these nations. Many developing countries also face a shortage of essential data required for formulating policies that can enhance existing regulations aimed at fostering energy efficiency.

In addition to informing the creation of policies and legislation aimed at bolstering regulatory efforts to promote energy efficiency in Nigeria, this research aims to gather information that highlights the benefits of energy efficiency in public buildings.

1.6 Scope of the Study

This study primarily focuses on the idea of enhancing energy efficiency within public facilities. Furthermore, it will delve into the formulation of strategies to enhance the energy efficiency of sports facilities among public buildings.

1.7 Operational Definition of Terms

Operational definition of terms refers to a detailed explanation of the technical terms and measurements used during data collection. (https://www.google.com/url). The following are the terms used:

i. Energy efficiency: The definition of energy efficiency is the use of less energy to carry out a task or achieve a goal. Homes, buildings, and manufacturing facilities that use less energy to produce goods use less energy to heat, cool, and operate appliances and electronics. One of the simplest and most economical ways to slow climate change, lower consumer energy costs, and boost the competitiveness of American businesses is through energy efficiency. In order to achieve net-zero emissions of carbon dioxide through decarbonization, energy efficiency is also a crucial factor.

ii. Assessment: The systematic gathering, review, and use of data about educational programs and services for planning, decision-making, and quality improvement can be referred to as assessment. Assessment in higher education has many advantages, including:

-Enhanced student learning, development, and engagement
- Stronger programs and services that are self-studied and refined
- Opportunity to make improvements based on accurate evaluations of need

iii. Public facilities: Public facilities include a variety of services provided by the government for the welfare of the nation's residents, such as adequate infrastructure development and sanitary facilities. They significantly contribute to the citizens' ability to maintain a minimal standard of living. The government's main objective is to give the general public and business organizations the necessary facilities to ensure that all activities can be carried out smoothly.

Chapter Two

Literature Review

2.1 Conceptual Review

2.1.1 History of Sport

Sports encompasses leisure activities involving skill and physical exertion, where individuals or teams compete against each other. This definition also encompasses competitive sports and physical games, which, through organized or informal participation, aim to maintain or enhance physical abilities and skills while providing enjoyment for participants and, in some cases, entertainment for spectators (source: Wikipedia). The world of sports includes a vast array of activities, ranging from those requiring just two participants to those involving over a hundred. Typically, sports are governed by established rules or traditions that ensure fair competition and enable the determination of a clear winner. A rich body of literature spanning from ancient times to the present has documented various sports, including running, swimming, bullfighting, wrestling, shot put, long jump, and many more.

In Africa, some of the most popular and widely practiced sports include football, basketball, boxing, wrestling, handball, and numerous others. However, throughout history and even in contemporary times, sports have faced challenges in certain nations and regions due to insufficient infrastructure and policies. As far back as around 1500 B.C., ancient Egyptians engaged in a variety of sports and athletic events, such as horse racing and wrestling. The Olympic Games, which originated in 776 B.C. and were later revived in Athens, Greece, in 1896,

represented highly advanced athletic competitions cherished by the Greeks. Following the Middle Ages, new sports began to emerge, and many more have evolved since, necessitating the construction of new types of buildings and structures, with a noticeable influence on modern architectural works.

The origins of the Olympic Games are thought to date back to around 1270 B.C., nearly a century before the first recorded hurling match in Ireland. However, it is widely agreed that the first official Olympic Games took place in 776 B.C. The Greeks possessed a highly developed competitive spirit, and most ancient sports served as a form of preparation for or a reflection of their prowess in warfare. The Greeks were unwavering in their determination to emerge victorious in sporting events, and chariot races often featured elements of cheating and violence.

Professional Greek wrestlers, boxers, and athletes were open to receiving bribes in exchange for deliberately losing matches, resulting in the tarnishing of the Olympic Games with violent brawls and numerous injuries. Beyond these incidents, the Greeks and Romans engaged in a variety of ball games, dice games, and board games. They also participated in various field and track events. Furthermore, the Olympic Games served as a cultural event where poets and orators showcased their talents. These games occurred every four years, although not all existing sports were represented each time; nevertheless, new sports were introduced with each edition. The Olympic Games take their name from the Greek city where they were first held in 776 B.C. and continued to be hosted there at four-year intervals for an extended period. The primary objectives of these games were to promote excellence in both physical and moral qualities (as they were exclusively for men at the time) and to provide a platform for the nation's finest athletes to compete. Given the frequent small-scale wars of that era, another aim was to maintain peace during the competitions.

In 1896, in Athens, the modern tradition of the Olympic Games was initiated by Pierre de Coubertin. Since then, with the exception of times during world wars, the event has occurred every four years. Additionally, a separate Winter Olympics has been conducted since 1924. The International Olympic Committee currently oversees the games from its headquarters in Lausanne, Switzerland. The iconic logo of the games consists of five interlinked rings of various colors on a white background, symbolizing the five continents.

The Olympiad, or the games, were held every four years until Emperor Theodosius prohibited them in A.D. 393, and they were not reinstated until 1896. Unlike many other regions, there is limited evidence of games and sports in Europe from the 5th to the 14th centuries. However, a wide range of sports and games gained popularity in Europe from the 14th century onwards.

Sports and games saw increased popularity in the late 16th century, as well as during the 17th and 18th centuries, with numerous records available for studying their history. The period of significant development occurred in the latter half of the 19th century, primarily driven by developments in England and Britain. Indeed, the British made substantial contributions to the evolution of sports and games from the late Middle Ages to the 1930s.

Speaking of recreation, it encompasses activities that foster the development and enhancement of skills, talents, abilities, and intellect. Sports are closely linked to and associated with recreation. Sports and recreation serve as a means of entertainment, physical fitness maintenance, and even income generation. Various activities such as soccer, basketball, swimming, yoga, aerobics, tennis, dancing, hockey, golf, cycling, running, listening to music, and many others fall under the umbrella of sports and recreational pursuits (Source: IAC Publishing, 2017).

2.1.2 Administration of Sports in Nigeria

Nigeria is a diverse nation with over 500 distinct languages, encompassing different dialects, religious beliefs, cultural values, and traditions (Adeji, 1972). The need for a collective effort to foster sports development in Nigeria led to the establishment of the Amateur Athletic Association of Nigeria in 1944. Subsequently, the Nigerian National Sports Council (NSC) was formed in 1962. Federal Government Decree 34, published in August 1971, designated the National Sports Commission with the responsibility of promoting sports in Nigeria, among other duties, and it was officially established on September 23, 1971 (Federal Republic of Nigeria Gazette, 1979).

Throughout history, sports and sporting events have wielded a profound influence on the cultures of societies. Evidence of sport as a form of leisure and entertainment dates back as far as 30,000 years, as indicated by prehistoric cave art discovered in France, Africa, and Australia (Masterman, 2009). These depictions often portrayed activities like archery, running, swimming, and wrestling. Even though they do not entirely mirror contemporary sports practices, Mongolian cave paintings from 7000 BC depict wrestling matches with substantial crowds of spectators, highlighting the enduring significance of sports participation and consumption in society. Sporting contests of ancient times often centred around ceremonies honouring religious deities or historical figures. For example, engravings on ancient monuments portrayed individuals engaging in various sports, including swimming, boxing, wrestling, running, and handball, many of which were believed to have been initiated and governed by ancient rulers, princes, and statesmen.

The development of sports facilities, including stadiums, has been a continuous process from the early modern era until the early 1990s to accommodate the growing landscape of sporting events.

However, shifting funding mechanisms for stadiums, the preference for sport-specific venues, and the demand for luxury suites and premium seating have led to approximately 84% of professional sports facilities undergoing substantial renovations or new construction since 1980 (Fried, 2010). A notable example illustrating the various factors driving changes in sports facilities is Levi's Stadium, the home ground of the San Francisco 49ers, recently constructed in Santa Clara, California. This discussion will delve into these aspects.

Energy serves as the driving force behind Nigeria's economic growth and expansion. It plays a significant role in the nation's foreign policy and serves as a tradable commodity that generates the national income necessary to fund government development initiatives. Energy is a tool in politics, security, and diplomacy, as well as a vital input in various sectors, including industry, transportation, agriculture, health, and education, contributing to the production of goods and services (Sambo, 2009). Primary energy sources in Nigeria encompass coal, oil, natural gas, nuclear fuels, biomass, and other resources.

More than 80% of the world's primary energy consumption relies on hydrocarbon compounds, commonly known as fossil fuels (Awwad, 2007). Nigeria possesses abundant resources for primary energy production. The country's crude oil reserves, estimated at 36 billion barrels (or 4.896 billion tonnes of oil equivalent (toe)) in 2006, rank among the world's largest. Natural gas resources surpass those of oil, with an estimated 166 trillion standard cubic feet (5,210 billion cubic meters) in 2006, and are often likened to an island. Nigeria also boasts substantial primary energy resources such as tar sands (approximately 31 billion barrels of oil equivalent or 4.216 billion toe), coal and lignite (with a combined estimated mass of 2.7 billion tonnes or 1.882 billion toe), significant hydropower potential of around 10,000 MW, and smaller hydropower potential estimated at 734 MW. Table 1 offers a concise overview of these resource endowments

in Nigeria, including projections for other renewable energy sources aside from hydropower (Dayo, 2008).

Despite its ample fossil fuel reserves, Nigeria's energy system remains inadequately structured to promote the development of sustainable energy sources. Nigeria, as a country with limited technological capacity that views industrialization as a critical lever for meaningful development, should adopt prudent management practices for its finite energy resources. Recognizing the need for low-risk, low-cost, yet highly beneficial energy-efficient measures that enhance the bottom line of any enterprise should be acknowledged by Nigerian industrialists, workers, scholars, government officials, and students (Unachukwu, 2003).

Energy efficiency is emerging as a pivotal driver of sustainable development in developed nations. However, the current situation in Nigeria differs significantly, with immense untapped potential for the adoption of energy efficiency and conservation measures across various economic sectors. This untapped potential largely stems from a lack of awareness regarding the social and economic benefits of such measures (Uduma, 2010). A sustainable energy system efficiently utilizes regional networks and resources, delivering reliability, affordability, and environmental sustainability. Unlike traditional energy systems, which tend to be slow and unresponsive, a sustainable energy system adapts to new technological, economic, and political solutions, encouraging the introduction of innovative approaches (Uduma, 2010). This study will explore the diverse energy needs of various sectors and opportunities to maximize them, thereby conserving energy.

Table 1: *Nigeria Energy Reserves and Potential (2005)*

Resources type	Reserves	Reserves (BTOE)[c]
Crude oil	36.0 billion barrels	4.896
Natural gas	166 trillion SCF[a]	4.465
Coal and lignite	2.7 billion tonne	1.882
Tar sands	31 billion barrel of Oil equivalent	4.216
Subtotal fossil		15.459
Hydropower, large scale	10,000 MW	
Hydropower, small scale	734 MW	
Fuelwood	13,071,464 ha[b]	
Animal waste	61 million tonnes/year	
Crop residue	8.3 million tonnes/year	
Solar radiation	3.5 to 7.0 KWh/m^2/day	
Wind	2 to 4 m/s (annual average)	

[a]SCF, standard cubic feet; [b]Forest land estimate for 1981; [c]BTOE, billion tonnes of oil equivalent. Adapted from Dayo [3].

2.1.3 Energy Source in Nigeria

Nigeria is the continent's top oil producer and the fourth-largest exporter of liquid natural gas in 2012 (NESP, 2014). However, the majority of this production is currently exported and only a small portion is imported back into Nigeria in refined form. Nigeria produced 159Mtoe of oil and gas in 2011, but only used 20.5Mtoe of it, making up 17.4% of the country's total raw energy consumption. The production of hydroelectricity makes up about 0.5Mtoe (0.4% of the total energy used). There are coal reserves as well, though they haven't been widely used yet. In Nigeria, biofuel and waste account for the majority of the remaining energy consumption (82%

in 2011), primarily in the form of firewood burned for cooking and water heating. The use of fossil fuels has remained relatively stable over the past twenty years, as shown in Figure 2, presumably as a result of costs and inadequate infrastructure to deliver oil and gas to domestic users. In many parts of Nigeria, the rate at which firewood is consumed far outpaces the rate at which it is replenished, making the situation unsustainable and contributing to desertification.

2.1.4 Energy Efficiency in Nigeria

Reliable information regarding the energy consumption of buildings is scarce due to multiple factors. Firstly, the primary electricity supply is not accurately metered. Secondly, many buildings rely on gasoline and diesel generators for electricity generation, further complicating assessments. Professor Chinedu Nebo, a former minister of power, estimated in late 2014 that 55% of Nigerians using electricity lacked proper metering (Nebo, 2014). This absence of accurate measurement is recognized as a significant barrier to achieving energy efficiency, and efforts are underway to install appropriate meters.

Energy is a driving force behind Nigeria's socioeconomic progress and economic growth, as emphasized by Oyedepo S.O. It plays a vital role in the nation's foreign policy and serves as a tradable commodity that generates national income, funding government development programs (Sambo S.A.). It is a fundamental input in various sectors such as industry, transportation, agriculture, health, education, commerce, and official activities, contributing to the production of goods and services (Community Research Development Centre). These sectors, including industrial, transportation, commercial, agricultural, and residential buildings (households), exhibit varying energy consumption patterns.

Energy efficiency improvements represent the most cost-effective means to enhance Nigeria's present and future energy supply. This is particularly crucial as the grid strives to cope with demand amid a persistent shortage of electrical generation and transmission capacity. Despite Nigeria's abundance of renewable energy resources like wood, solar, hydropower, and wind, as well as sustainable energy sources, the country's energy utilization remains remarkably inefficient (Oyedepo S.O.). Inefficient energy use in Nigeria has far-reaching consequences, with significant investments made in energy supply infrastructure significantly exceeding energy demand. This overconsumption exacerbates environmental issues associated with inefficient energy utilization. Nigerian buildings, for instance, consume more energy than necessary, resulting in substantial energy wastage.

One of the contributing factors to this inefficiency is the use of outdated and ineffective appliances and equipment in buildings. Efficient energy management and utilization could yield substantial benefits for Nigeria across economic, environmental, and security dimensions. Implementing energy efficiency practices through policy measures could reduce energy demand in buildings. Currently, Nigeria lacks mandatory energy efficiency standards and policies for both the building and industrial sectors, as highlighted by Emodi N.V. and Boo K.J. This absence of effective energy efficiency policies represents a significant hurdle, particularly in promoting the widespread adoption of energy-efficient appliances in Nigerian buildings. Numerous obstacles, including low awareness, general ignorance, affordability issues, limited government support, insufficient financial incentives, and an unreliable electricity supply, have hindered energy efficiency policy implementation in Nigeria. To enhance the efficiency of homes and conserve the nation's current energy generation, government policies should incentivize investments in energy-efficient technologies and practices (Umar D.A. and Abubakar M.M.).

2.1.5 Importance of Energy Efficiency

In many economies around the world, energy efficiency has emerged as the primary force behind sustainable development. When energy is used effectively, personal income can be saved because families won't have to spend as much on energy. It will aid in preventing the construction of additional power plants, allowing for the expenditure of funds on other areas of the economy instead. Additionally, more people will have access to energy because it can be distributed throughout the country if energy is saved in one area.

Energy supply in Nigeria is alternated because the utility companies do not have enough energy to meet everyone's needs simultaneously. There won't be a need for a backup electricity supply if both the public and private sectors manage their energy resources well. Fossil fuels (oil and gas) are primarily responsible for the majority of the energy that we produce in Nigeria. We emit an equal amount of greenhouse gases (GHGs) for every kilowatt of electricity we use. Energy efficiency can lessen our reliance on petroleum to power our economy and the emission of greenhouse gases (GHGs). If we use energy wisely, the harmful environmental effects of energy production will also be lessened. During intervention programs, a large number of people can be employed to alter people's behavior to use energy more effectively. Companies that produce electrical appliances will then compete with one another to produce the most effective appliances in an effort to win over customers.

2.1.6 Energy Efficiency Practices in Nigeria

Since energy is a crucial component of production, it should be managed alongside land, labor, and capital. Given that the cost of providing energy can be several times higher than the cost of saving it, energy-efficient production should be considered a quick and less expensive source of new energy supply. Energy efficiency is increasingly thought to include both the overall

economic efficiency of the energy system as well as the physical efficiency of the technical facilities and equipment (Unachukwu, G.O.). Energy efficiency refers to changes made to procedures and goods that lower the amount of energy required to provide services like lighting, cooling, heating, manufacturing, cooking, transportation, and entertainment, among others.

In essence, energy-efficient products enable users to accomplish more work while using less energy (Schutze, E., Worthington, R.). According to Rosen, M.A., another definition of energy efficiency is the practice of using less energy to deliver the same service. Energy efficiency can be considered a supply resource in this sense and is frequently regarded as a significant, financially advantageous near- to midterm supply option. By protecting the resource base and reducing environmental issues, investments in energy efficiency can add economic value. This is especially true when combined with pollution prevention technologies.

In many economies around the world, energy efficiency has emerged as the primary force behind sustainable development (Etiosa, U). Efficiency in energy use will lessen the need to construct additional power plants. The funds used to build the power plants will then be allocated to other areas of the economy. Additionally, more people will have access to energy because we can transfer energy from one region of the country to another by making energy savings in that region. Energy supply in Nigeria is alternated because the utility companies do not have enough energy to meet everyone's needs simultaneously. There won't be a need for a backup electricity supply if residential, public, and private sectors all practice good energy management.

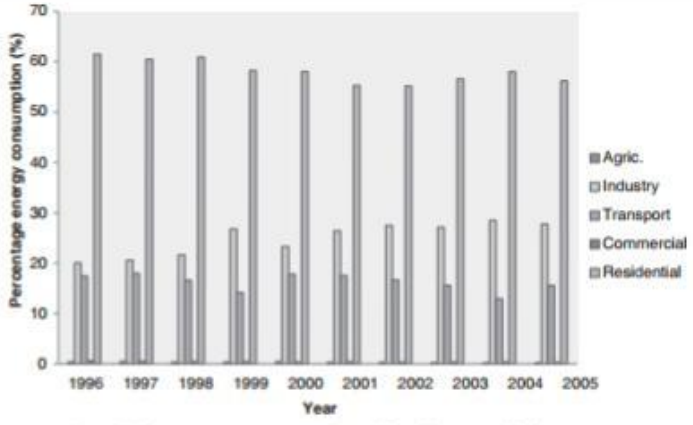

Figure 1 Sectoral energy consumption (PJ) from 1996 to 2005. Adapted from Dayo et al. [14].

Figure 1: *Sectoral Energy Consumption (PJ) from 1996 to 2005. Adapted from Dayo etc Al.*

2.1.7 Challenges Facing Energy Efficiency in Nigeria

SDGG Nigeria is experiencing a population increase, yet the nation's growing energy demands are not receiving adequate consideration. The current energy policy is primarily centered around urban areas, neglecting the energy needs of rural and sub-rural regions. In these rural areas, people typically rely on burning wood and traditional biomass for their energy requirements, leading to deforestation, greenhouse gas emissions, and environmental pollution, which contribute to global warming and other ecological problems.

The central objective has been to provide energy to urban centres and industrial hubs, resulting in an energy imbalance in the country's socioeconomic and political landscapes. Despite the operational capacity of existing power plants, Nigeria is unable to meet the energy demands of its population, particularly in rural areas where electricity remains inaccessible (Ajayi O.O., Ajanaku K.O. 2007).

Two main characteristics characterize Nigeria's energy crises. Firstly, there is a significant issue with the petroleum products market, particularly kerosene and diesel. Despite owning five government-operated domestic refineries with a daily processing capacity of 450,000 barrels of oil, Nigeria imports over 75% of its petroleum product requirements. The state-owned refineries have rarely operated at more than 40% capacity utilization in the past two decades, with gasoline being better supplied due to its higher political significance. The government has resorted to substantial imports to address domestic shortages, with the gasoline import subsidy alone

estimated to be between 700 and 800 billion naira in 2008 (Iwayemi A. 2008). Kerosene and diesel, consumed largely by the less politically influential poor and lower-middle-class populations, face more severe and persistent shortages, primarily due to limitations on large-scale imports (Ibitoye F, Adenikinju A 2007).

The second dimension of Nigeria's energy crisis is reflected in electricity supply issues, including brownouts, blackouts, and widespread reliance on self-generated electricity, despite the country's abundant energy resources. The government-owned Power Holding Company of Nigeria (PHCN), formerly known as NEPA, has been unable to provide the minimum levels of electricity reliability, accessibility, and availability required by international standards over the past three decades (Adenikinju A. 2005). Nigeria's transmission and distribution losses are among the highest globally, exceeding those in well-run power systems by five to six times. Frequent load shedding persists, even though the peak electricity demand has been less than half of the installed capacity in the last decade.

The manufacturing sector also suffers from power outages, with a significant increase in outages between 2006 and 2007. This is attributed to the near-collapse of the generating system, which operated well below 2,000 MW in 2008. As a result, many customers, unable to tolerate unreliable service, resort to more expensive captive supply alternatives to mitigate power interruptions' impact on their production and profitability. Approximately 20% of industrial projects allocate alternative sources of electricity supply.

In summary, Nigeria's energy crisis is rooted in several factors:

- A regime of price control.

- Insufficient economic incentives and a lack of emphasis on cost recovery, leading to inefficiencies in state-owned companies like NNPC and PHCN.
- Pursuit of numerous economic and non-economic objectives without a clear understanding of the trade-offs between them, evident in pricing strategies for petroleum products and electricity.
- Institutional and governance shortcomings resulting in production distortions, inefficiencies, poor investment decisions, high operating costs, low returns on investments, costly delays, and cost overruns in state energy enterprises.

2.1.8 Energy Intensive Behaviours in Nigeria

Changes in behaviour among residents are one strategy for combating inefficient energy use. Energy efficiency does not imply that we shouldn't use energy; rather, it means that we should use it in a way that will reduce the amount of energy required to deliver services. If we make changes to the procedures and products we employ, this is feasible. According to a previous study, a lot of energy is wasted in Nigeria because homes, businesses, and government and private offices use more than is actually required to meet their needs. They employ outdated and ineffective machinery and production methods, which is one of the causes. The other causes are unhealthy behaviors that waste energy. Below is a discussion of them.

2.1.8.1 Dominant Use of Incandescent Light Bulbs

Lighting with incandescent bulbs requires a lot of energy. A typical incandescent bulb uses about 5% of its total energy for light production and 95% for heat production (Lebot 2009). We have incandescent bulbs for 40, 60, 100, and 200 W because the energy ratings of incandescent bulbs on the Nigerian market range from 40 to 200 W. Cost is a significant barrier to the switch from

incandescent to energy-saving bulbs. Energy-saving light bulbs cost a lot more than incandescent ones. On the Nigerian market, energy-saving bulbs can be purchased for between N800 and N1,000. However, for about N200, you could buy some subpar energy-saving bulbs. On the other hand, incandescent bulbs cost between N30 and N100. Nigerians could significantly reduce their country's energy consumption if they switched from incandescent to energy-efficient bulbs.

The phase-out of incandescent bulbs from the Nigerian system and a prohibition on their production and importation are two possible policy options. Energy efficiency will improve with a policy that promotes the production and importation of energy-efficient light bulbs. Government should implement plans to lower the price of energy-efficient bulbs. To change Nigerians' attitudes about the need to conserve energy by using the appropriate technology, awareness-building is also necessary.

2.1.8.2 Putting on Light to Advertise Goods

Many vendors of certain products, such as snacks and electrical supplies, turn on lights during the day to attract customers. Similarly, owners of fast-food restaurants use incandescent bulbs to heat their food while simultaneously drawing customers' attention to their offerings. Because it uses a lot of energy, this practice ought to be avoided. Several incandescent bulbs are turned on simultaneously in some fast-food restaurants for decorative reasons and to provide daylight illumination. These homes might have been constructed to take advantage of natural light during the day.

The policy alternative is for the government to tax energy use by commercial enterprises and privately held businesses. For the designated agency to impose taxes on these private institutions, it should be mandated that they conduct energy audits and make them public. For transparency,

only government-designated organizations or businesses should conduct the energy audit. House plans should go through a thorough screening process by a designated government agency to ensure that they meet the requirements for energy-efficient home construction. Before being registered by the government, medium and large privately owned businesses should be required to have an energy management unit.

2.1.8.3 Switching On Outdoor Lighting During the Day

Many Nigerians leave their outdoor lighting on throughout the day. This is especially prevalent in public buildings that have outdoor lighting turned on during the day. If Nigerians develop the habit of turning off their outdoor lighting during the day, they can save a lot of energy. During the day, using natural light rather than light bulbs can save energy that can be used in workplaces and for industrial processes.

There should be a rule mandating that residents of private, public, and residential buildings turn off their security lights during the day. It might be necessary to pass legislation to penalize defaulters.

2.1.8.4 Proliferation Of Private Water Boreholes

There are now many homes in Nigeria's major cities with boreholes. This is brought on by the government's inability to supply water in many areas of the nation. The use of privately owned boreholes is on the increase. There are frequently two or more boreholes in a single street. The device used to extract water from the aquifer uses a lot of energy and can use up to 2,000 W of power. These devices not only use a lot of energy, but they also put a lot of strain on PHCN facilities. In many parts of the world, pipes are used to transport water from a centralized system

to homes, businesses, and other structures. This approach significantly reduces the energy required to extract water from the earth and make it accessible to people.

People have a right to access clean water, and it is the duty of their government to consistently provide that for them. The most effective way to prevent the use of private boreholes is through this. If the government and approved private businesses provide water from a centralized system, a lot of energy will be saved. A policy should be created to support a centralized water delivery system.

2.1.8.5 Industrial Activities in Residential Areas

In Nigeria, many cities lack sound planning. Residential power supply is harmed by the practice of constructing industries in residential areas. With this type of practice, electricity providers are unable to plan how to distribute energy to different sectors. Additionally, the industrial equipment puts a lot of strain on the PHCN facilities, which were initially built to serve residential areas, due to its high energy consumption. It is challenging to divide the energy between the two sectors in this kind of system so that everyone is as satisfied as possible. Shifting loads is another challenging task for utilities.

Cities should be properly planned, with residential and industrial areas kept apart, according to policy. The government will be able to better plan how to supply electricity to these two sectors as a result of this.

2.1.8.6 Setting Appliances on Standby Mode

Many Nigerians are unaware that even when appliances are in standby mode, they continue to use energy. Electrical appliances cannot be switched off or placed in standby mode at the same

time. In standby mode, electrical equipment uses energy. Turning them off when not in use can help save some energy, even though the amount of energy they use is different from when they are switched on. The producers of energy-efficient electrical appliances in standby mode should properly inform the public. This can be accomplished by writing it on labels and attaching them to the appliances.

Government should establish regulations to guarantee that energy labels are thorough enough to give consumers the information they need.

2.1.8.7 Simultaneous Use of Appliances in Public Buildings

In Nigeria, public employees frequently engage in this behaviour, especially senior staff. All offices, including those of junior staff, will have refrigerators and air conditioners in the same department or building. A refrigerator, air conditioner, television, photocopier, desktop computer, fan, electric kettle, and incandescent bulbs are frequently found in government buildings, and many of these appliances are turned on simultaneously. You visit another office in the same division or structure and discover similar items there. The reason for this practice may be that since public employees do not pay for their own electricity, they are not aware of how much they use. The fact that many government buildings lack meters means that officials are not held responsible for the energy they consume while working. Residents of university housing use a wide variety of electrical products, and there are no limitations on the equipment they can use. Students frequently use various types of electrical heating appliances for cooking in dorm rooms. It is best to avoid using a particular heating device known as a "hot plate" in dorm rooms for students because it consumes a lot of energy. Student housing does not have individual rooms

metered, which encourages waste because residents are not held responsible for their energy usage.

It should be policy to hold public servants and users of public facilities responsible for their energy consumption. Institutions in both the public and private sectors should create their own energy management guidelines that limit the use of specific appliances. Public and private buildings should be required to conduct energy audits and make the results available to the general public. There should be legislation and policy changes to tax the use of energy in both public and private institutions. A policy should be created to promote the use of centralized air conditioning systems rather than portable units.

2.1.8.8 Leaving Appliance on When Not in Use

When appliances are not in use, many Nigerians do not turn them off. This practice can result in significant energy loss in private, public, and residential buildings. The fact that many Nigerians do not actually pay for the electricity they use could be the cause of this. The meters that PHCN installed in many homes are no longer working. Officials with PHCN put these homes on an estimated bill. Since they don't really keep track of how much electricity they use, this practice encourages energy waste.

The goal of policy should be to promote the use of prepaid meters while discouraging the use of estimate bills.

2.1.8.9 Multiple Uses of Inefficient Heating Equipment

In residential and private buildings, it should be discouraged from using heating appliances for cooking and water heating. Solar heater use should be promoted by the government.

Approximately 60% of the energy used in homes is used by heating equipment. The use of solar heaters in these buildings will help to significantly reduce the amount of energy used in places like hotels where numerous water heating equipment are installed in numerous rooms, sometimes numbering up to 100 rooms or more.

Government policy should promote the use of solar heaters rather than electricity by hotel operators. This could take the form of tax breaks or money awarded for using less energy. The less energy-efficient ones may be punished and forced to pay a fine in order to motivate the more energy-efficient ones.

2.1.8.10 Purchase Of Second-hand Appliances

There are a wide variety of used appliances on the Nigerian market. Over 90% of Nigerians use some sort of second-hand product. Compared to the new ones, they are less expensive. Many Nigerians believe that used goods outlast new ones in terms of durability. This claim might be supported by the fact that there are many subpar products available and that used products typically last longer than new ones. Many of the pre-owned items are from European and North American nations, and they might have been created decades ago. These products' efficacy is seriously questioned, and it's possible that their previous owners passed them up in favour of more modern, effective appliances. For the purpose of guiding policies that will address the issue, more research into the second-hand market is required.

It is necessary to establish policies to standardize the used goods imported into the nation. Additionally, policies that encourage Nigerians to buy brand-new, contemporary appliances must be made.

2.1.9 Energy Efficiency Policy in Nigeria

Basic policies and strategies for energy efficiency and conservation in Nigeria are included in the national energy policy and the draft energy master plan. The following is specifically covered by the policy:

1. The promotion of energy efficiency and conservation in industrial, residential, and transport sectors,
2. Designing a national program on industrial energy efficiency and conservation in collaboration with MAN and experts in higher institutions and research centers,
3. Introduction of fuel efficiency labeling program in the transportation sector for various vehicle types,
4. Establishing codes and standards for energy efficiency and conservation technologies, and
5. Enforcing the codes and standards.

To encourage the application of energy efficiency and conservation principles across the nation, this policy has only ever existed on paper and has never been put into practice.

2.1.10 Barriers To Energy Efficiency Development in Nigeria

The following were identified as the barriers to the development of energy efficiency in Nigeria

- Lack of policy and legislation

One of the biggest obstacles to the advancement of energy efficiency is the lack of legislation and policy to address the inefficient use of energy. In order to shift behavior toward an energy-efficient economy, policy and legislation will be helpful. According to the Etiosa survey [22], 79% of participants were unaware of any government policies pertaining to energy efficiency.

Additionally, it should be encouraged for both public and private institutions to create their own policies to support energy efficiency. The establishment of an energy management department or unit may be required of public and large- and small-scale private organizations by the government.

- Lack of awareness

The term "energy efficiency" is unfamiliar to many Nigerians, and even those who claim to be familiar with it struggle to define it accurately. Increasing people's awareness will go a long way toward assisting them in understanding the idea and changing their behaviour.

- Lack of trained personnel and energy efficiency professionals

Another factor impeding the advancement of energy efficiency is inadequately trained personnel and professionals. There are not enough energy efficiency specialists in Nigeria to lead the creation of a concept and a policy that will support energy efficiency.

- Importation of used machines

The prevalence of imported second-hand appliances could make it more difficult to use energy-efficient appliances. The reason is that used equipment is inexpensive and easily accessible; new, effective equipment may not be able to compete with them on the market.

- Lack of research materials on energy efficiency

Research information and data are lacking, which makes it difficult to create policies that will improve energy efficiency. Additionally, there is a lack of training materials for energy efficiency.

- Inefficient metering system and low electricity pricing.

Nigeria's energy metering system is incredibly ineffective and does not push customers to pay the right amount for the energy they use. Since many people still use the outdated meters, which are defective, they now estimate. Prepaid meters, which the PHCN recently introduced, will help alter consumer behaviour to use energy more effectively.

-Proliferation of inefficient equipment and desire to minimize initial cost

Many consumers are compelled to buy inexpensive, ineffective appliances because they want to reduce their initial expenditure. For instance, in Nigeria, the price of an energy-saving bulb is about N800 while the price of an incandescent bulb is about N40. Many consumers will choose the less expensive options over efficiency bulbs in the long run.

-Low income

70% of Nigerians live in poverty, defined as earning less than $2 per day. The cost of efficient appliances, which can occasionally be more expensive than the less efficient ones, is beyond the means of many people.

2.1.11 Public Sector Energy Use

Government agencies are in charge of a variety of public services, including the provision of infrastructure like harbours, airports, roads, water supply, power generation, street lighting, waste disposal, and sewage systems. Public administration, social services, and health and education services are additional services. A large number of these state- or city-owned public services are significant energy consumers. In contrast to private sector organizations, public sector organizations are typically accountable to the public through a Council or a Parliament.

The public generally anticipates the public sector to serve as an example of effective use of public resources to the neighbourhood

Energy conservation is a crucial component of this. Supply-side efficiency is just as crucial as demand-side efficiency because the public sector produces electricity frequently. The primary areas of energy use in the public sector are determined by the local environment and its roles within the national system of government, which are typically:

1. Lighting- particularly of public areas

2. Heating and cooling of buildings

3. Public transport

4. Construction of roads and buildings

5. Sewage treatment and waste disposal

6. Management of reserves and public facilities.

2.1.12 Energy Conservation in Various Sectors in Nigeria

In Nigeria, the demand for energy is rising while the supply is not keeping up. Primary energy conservation, rationalization, and efficient use are thus necessary right away given these circumstances. The goal of effective equipment operation is to transfer as much fuel's energy as possible into the working fluid. This not only results in greater productivity and cost savings, but it also influences equipment safety, longevity, and pollution levels (Habib 1999). The right steps can be taken to protect the environment by reducing energy consumption or by using energy more efficiently.

Measures or recommendations for energy conservation are frequently referred to more positively as opportunities. The two main requirements for energy conservation opportunities are that they be simple to implement and have a quick payback period. Energy conservation opportunities have been divided into three broad categories based on their ease of implementation and payback periods: maintenance and operation measures, process improvement projects, and large capital projects (Adeyemo, 2008). Although energy efficiency and conservation are not resources in and of themselves, it is acknowledged that their adoption in the nation can significantly lessen the supply issue. The Federal Government of Nigeria recently authorized the creation of a National Centre for Energy Efficiency and Conservation in recognition of this (Sambo 2008). The Centre is in charge of planning and carrying out research and development in energy conservation and efficiency. The Center is responsible for performing the following duties in this regard:

1. Develop guidelines for energy-efficient end-use products and advise on their implementation;

2. Develop energy efficiency codes, standards, and specifications for domestic, industrial, and commercial facilities;

3. Gather, analyze, and manage energy supply and consumption data and information;

4. Serve as a Center for training of high-level manpower in energy efficiency and conservation;

5. Develop and execute pilot/demonstration project highlighting energy efficiency concepts;

6. Disseminate information on energy efficiency and conservation concepts through public awareness programs such as seminars, workshops, publications, etc.; and

7. Perform any other functions, as may be directed by the Federal Government in relation to energy efficiency and conservation in Nigeria.

2.2 Design Consideration

2.2.1 General Principles Of Sport Facilities Planning Design

Sport facilities design and planning should consider the following principles for excellent and best outcome.

- **Sustainability**

A sustainable building is one that has negligible or no environmental impact. It should strive to use renewable building materials, reduce its negative environmental impact, have little empty space, and be durable.

- **Structure**

For a sport facility to be functional and safe for people to use, it must be strong, secure, earthquake proof, and have good foundations.

- **Community**

All buildings should strive to have as little of an adverse environmental impact as possible. To do this, they should use locally and easily accessible building materials, as much renewable energy as possible, such as solar energy, and either none at all or very little fossil fuel.

- **Aesthetics**

The stadium must have an appealing appearance, and modern building materials must be used to give the building a high-quality finish that satisfies international and recommended standards.

- **Safety**

When designing a sport facility, the safety and security of the facility's users must be taken into account. For the guaranteed safety of people and property, various security measures must be incorporated into the design even at the early stages of development. For instance, fire exits must be strategically placed, and fire and emergency equipment must be available.

- **Accessibility**

Wide entrances, numerous fire exits, and easy movement within the building are all necessary in a stadium. Additionally, there ought to be signs directing people in the right directions at key intersections.

2.2.2 Energy Conservation Measures in Nigeria Public Sectors

Possible energy conservation measures in office and public buildings include the following:

1. Proper building orientation and symmetry.

The majority of the spaces in the building should be able to receive natural light. By using daylighting to replace electric lighting with natural light, energy consumption is reduced. In comparison to conventional buildings, daylighting-designed buildings typically use 40% to 60% less electricity for lighting needs.

2. Provision of enough windows for cross ventilation.

Ventilation is crucial in a climate with high temperatures. This will significantly cut down on the use of air conditioners in public areas. Although free and easily accessible, it can be challenging to use sunlight and daylight without creating glare and overheating. By using window sills, louvers, reflective blinds, and other tools to reflect light deep inside the buildings, glare can be reduced. Windows with selective glazing should therefore be preferred as they transmit the most

visible light while minimizing solar heat. Through cost-effective building design, there are significant energy savings potentials for office and residential buildings in Nigeria.

3. Lighting

The following are potential energy-saving lighting initiatives in Nigerian offices, shopping malls, and public spaces:

1. Relamping: To save energy, it entails switching out one lamp for another. There are new fixtures that outperform incandescent lamps in terms of energy efficiency, dependability, and longevity. In homes, offices, and commercial and industrial establishments, CFLs are typically thought to be the best replacement for lower-wattage incandescent lamps. The efficacy of these lamps ranges from 55 to 65 lm/W. 10,000 hours is the average rated lamp life, which is ten times longer than the average incandescent. They have a very high luminous efficiency in addition to having excellent color rendering qualities. Moreover, they have the potential to save energy.

2. Installing lighting control systems in bathrooms, stores, and bedrooms. Devices used to dim or turn on lights are known as lighting controls. In bathrooms, shops, bedrooms, and other rarely used spaces, lighting control systems like photocells, timers, occupancy sensors, and dimmers are required. This prevents energy waste in these areas.

3. Street light control

More than half of all electricity used in Nigeria is for street lighting. About 50% or more of this amount of energy is lost due to outdated equipment, poor maintenance, or ineffective use. There is a lot of room for cost and energy savings by increasing light efficiency since street lighting may be the most energy-intensive service that local councils offer. According to a 1999 study by

Energy Efficiency Victoria and the Sustainable Energy Development Authority, a combination of the following could significantly improve the quality of street lighting while reducing energy consumption by at least half:

- More efficient lamps e.g. metal halide, compact/tubular fluorescent.

- More efficient luminaries which incorporates reflector design, reduced light loss in the diffuser and more accurate light distribution.

- Efficient ballasts such as ‘low loss’ or electronic ballasts.

- More accurate control of lighting times e.g. by using an electronic photo-switch.

The amount of electricity required to run traffic lights has steadily increased alongside the growth of urban populations and motorized transportation. The older technology typically uses high-intensity, low-efficiency incandescent lamps with colored lenses that further reduce the lamps' efficiency, and traffic signals are typically on 24 hours a day. The proposed specification for traffic signals by ELI is technology-specific, stating that in order for traffic signal systems to be eligible for inclusion in ELI programs, they must use LED-based products at least for the red signal. Traffic signal LEDs emit colored light, are long-lasting, and save energy. This eliminates the need for colored lenses. It is necessary to either cut back on the amount of electricity the light source uses or the amount of time it is on.

4. Water Supply and Sewerage

The infrastructure for traditional water and sewage systems uses a lot of energy and resources. Embodied energy must be taken into account during the planning process. By using techniques like high-efficiency motors and pumping at the bare minimum pressure necessary, water can be

pumped at a lower cost. Managing Energy in Local Government has more advice. Along with the aeration process, pumping is a significant energy consumer in the sewage treatment process. By using dissolved oxygen sensors to control the aeration fan's operation, lowering the pressure drop in air pipes, and using high-efficiency motors, the aeration process can be made to use less energy.

5. Waste management

The majority of local government entities oversee solid waste disposal facilities, and a large portion of this waste is valuable as a source of recyclable materials, energy, and soil conditioners. There are numerous different waste-to-energy plans in place or being considered. This kind of cogeneration has the potential to save a lot of money while also having positive social and environmental effects.

6. Building Design, Insulation and Air Conditioning

Careful building design or retrofitting existing buildings can result in significant energy savings. Buildings with long lives, durability, and adaptability are the single most crucial strategy for reducing the effects of embodied energy, according to the AGO. Many of the previously covered concepts are applicable to public buildings. Usually, building an energy-efficient building from the ground up is less expensive and more difficult than retrofitting an existing structure. All Council buildings should have a high standard of insulation because most of them have relatively long occupancy hours and are intended to provide a high level of comfort. The amount of energy insulation savings increases with building size. The heating, cooling, and ventilation of office buildings account for more than 60% of their energy consumption. For small offices, reverse cycle air conditioners are an energy-efficient heating option, but on a larger scale, this might not

be the case. Savings opportunities include keeping the system well-maintained, such as by checking the thermostat setting and plugging air leaks around doors and windows. The use of blinds can help with insulation. In the winter, lowering the blinds at night or on a chilly winter day reduces heat loss.

7. Interior Lighting

Numerous strategies are available for reducing energy from indoor lighting. These include:

1. Operate lights only when required: Although the majority of Councils adhere to this policy, it is unlikely that "turning off" is always used. When a room is empty, occupancy sensors that are mounted near doorways and are inexpensive turn off the lights.
2. Use of an efficient light source: If artificial lighting is controlled, increasing daylight levels can reduce electrical lighting loads by up to 70%. Skylights increase user satisfaction in the workplace and are cost-effective. Although more expensive, compact fluorescent lights can cut lighting costs by up to 80%. A typical 36-watt fluorescent lamp costs about $2 to purchase, but it costs about 10 times as much to run for just one year in a building. In comparison to a compact fluorescent, it also has a shorter lifespan, lower efficiency, poorer light quality, and a faster rate of performance degradation. A traditional recessed fluorescent lamp fitting with a diffuser made of acrylic plastic distributes about 50% of the light the lamps produce.

- Lighting systems require regular maintenance: fluorescent lamps have a propensity to be kept until they are no longer useful, by which time they may be producing only one-third of what they did when they were brand-new. The following benefits are made possible by routine maintenance programs, which include window cleaning:

- light quality of the built environment is maintained
- tendency to add more light fittings because of falling light levels will be avoided
- bulk lamp replacement facilitates recycling through a special lamp crusher.

When lamps are changed one at a time, the mercury they contain ends up in landfills, contaminating the environment.

Light-colored walls, ceilings, and furniture reflect more light into work areas, requiring less artificial lighting to achieve the desired luminance. For this reason, the walls in many government buildings are painted white.

8. Office Equipment

Even though computers and related equipment only contribute a small amount to energy use, energy efficiency in this sector will result in significant savings. Energy use can be affected by:

- Specifications established for new equipment.

- The extent to which energy saving features are utilized.

Policies for purchases are crucial. An international standard for energy-efficient equipment called "Energy Star" can cut the energy consumption of specific products by more than 50%. This category of printers and fax machines can reduce electricity consumption by over 65%, saving about $20 per unit annually in electrical costs. For savings to be realized, energy features must be installed and used, though. One of these functions is "sleep mode," whereas "screen savers" do not reduce electricity consumption (Energy Smart Schools Computer Related Equipment). When not in use frequently or overnight, all electrical equipment should be turned

off. When buying equipment, there are a number of additional factors to take into account. To reduce energy waste from idle times, it is worthwhile to compare the photocopier's rated volume with its actual copying volume before buying. Taking into account various "styles" of technology, such as laptop computers that consume a tenth as much energy as desktop PCs. Energy savings can quickly offset the additional cost of the machines.

Chapter Three

Methodology

3.1 Introduction

In this project, a combination of qualitative and quantitative research methods will be employed to gather the required data. Both primary and secondary data sources accessible to researchers will be utilized as part of the data collection techniques.

Primary data for the study includes information from direct sources such as:

- Site visitation for observation and familiarizing one’s self with the on-site existing facilities.

- Taking photographs of such existing facilities and producing diagrams for illustrative purposes of such.
- Direct interviews and enquiries from users of existing outdoor sport complex.
- Case studies which involve the study of existing building types. It helps in the description of information which is specific to a group of objects and their contexts. It focuses on the use of spaces, spatial coordination, general features and characteristics.

Secondary data is generated through the following:

- Internationally recognized and accepted research encyclopaedia.
- Policy documents.
- Use of the internet for further information and data collection.
- Use of existing literatures from textbooks, publications, magazines, and unpublished materials.

3.2 Research Instruments

3.2.1 Field Survey

A field survey was employed to validate information that could not be obtained through any other means due to the research's inherent characteristics. To accomplish this, all selected case studies were physically visited. During these field trips, comprehensive notes were taken and photographs were captured, creating a comprehensive and intricate record of their physical existence and spatial relationships.

3.2.2 Internet sources

The study was supplemented by data received from the internet. The information retrieved were subjected to a carefully planned checklist for the international case studies.

3.2.3 Interview of relevant authorities

On the occasion of the facility visit, oral interviews were conducted with the pertinent authorities in attendance. On the basis of specifics, questions were posed in each of the case studies centers that were chosen. Open-ended and receptive questions were asked, and the topics to be covered were decided upon or prepared in advance. This made it possible for the researcher and interviewers to discuss the history and pertinent information in context.

3.2.4 Checklist

A check list is a type of informative task aid designed to compensate for potential memory and attention deficits in humans in order to reduce failure. It assists in making sure a task is completed accurately and thoroughly. It acts as a checklist of tasks that need to be completed, goals to reach, or considerations to make.

3.2.5 Photographs

Pictures were taken for documentation and to supplement the tour notes. For viewers outside the area, the images provided a crucial source of visual information about the case. Images of the relevant locations were acquired in order to demonstrate the traits of bioclimatic architecture the examples possessed as well as the extent to which they were applied.

3.2.6 Sketches

Sketches were created during the field survey to represent the selected case studies. These sketches were deemed essential for forming an opinion on the precise location and spatial configurations of the case studies in order to explain the research.

3.2.7 Notes.

The information mentioned in the interview and what was observed during the field survey were supported by the data gathered in this manner. In-depth notes were taken as the investigation went on to keep a running log of what was occurring.

3.3 Literature Review

An extensive literature review on sports complexes, energy efficiency, and crucial elements to take into account when designing an outdoor sports complex will be required. For general information about the performance/functional and spatial requirements of the building typology, pertinent textbooks and peer-reviewed journals were consulted. As a result, online research journals were the primary source of the materials used.

1. Text books

2. Journals and Seminar papers

3. Encyclopaedia of thermal comfort, passive design methods, newspaper articles on the study area/ client 4. Case studies of existing senate buildings

5. Personal observations

3.4 Design Criteria

In order to define functional spaces and activities, ascertain the furniture and equipment required, ascertain the circulation patterns, and establish relationships between spaces, this will involve spatial and functional analyses (using words, diagrams, and tables).

3.5 Site and Environmental Analysis

An extensive investigation and analysis of the current site and its surroundings will be required for this. The prevailing micro and macro environmental climatic conditions were determined through analysis of the site; this will greatly influence the form and concept of the design.

3.6 Case Studies

A case study entails an empirical investigation carried out in the real-world context of a contemporary phenomenon, especially when there is some ambiguity in distinguishing between the phenomenon and its context. The primary objective is to provide insights into a decision or a series of decisions, elucidating the reasons behind them, the processes involved in their execution, and the resulting outcomes. To gain a comprehensive understanding of the fundamental principles governing the design of any building typology, an initial assessment of the current building typology is essential. These initial assessments of the documented buildings focused on their layout, functionality, equipment, and operational standards, providing valuable insights for potential future requirements within this building typology.

The research will encompass the examination of sports complexes, both within Nigeria and internationally, including the use of photographs and schematic illustrations. An evaluation of sports complexes will be incorporated into the personal observations. This comprehensive approach is aimed at grasping the design philosophy and methodology, particularly concerning passive design techniques and other functional and performance-related building prerequisites.

List Of Selected Case Studies

1. Indoor Sport Hall University of Lagos

2. Indoor Sport Hall University of Ibadan
3. Mercedes Benz Super dome.
4. Sports Building Erasmus University Rotterdam
5. Jianshang Sports Complex

3.6.1 Case Study 1 (Local)

- **Indoor Sport Hall University of Lagos**
- **Location:** University Of Lagos, Lagos, Nigeria
- **Architect:** Unknown
- **Client:** University of Lagos
- **Date Built:** Unknown

3.6.1.1 Description of the Building

The University of Lagos Indoor sport complex is a standard sport facility with a main bowl of about 800 capacity seats, contains about 3 Football pitches, 2 basketball courts, a Track for field events, a volleyball and tennis court as well as a badminton court. Although the facilities aren't quite the most modern or most appealing, it is functioning. The design is an open space with decked seats arrangement that affords everyone a great view of the courts and properly ventilated. The sports center contains ample space for other sporting events like Football, Athletics, American Football, Volleyball and so much more. The Centre also serves as a hub for the students of the University of Lagos; as students regardless of faculty or department or age or level or course or tribe, find themselves united through sports. The Sports centre has ample car parking, various food vendors and kiosks and has restaurants in the environs. The Sports centre

is also very easily accessible from the front gate of the University of Lagos. It's a much-loved Landmark in the University of Lagos by the students.

3.6.1.2 Facilities Provided

- Football pitches
- Basketball court
- Athletic Track
- Volleyball court
- Tennis court
- Badminton court
- Shops and kiosks for food and snacks
- Restaurant
- Swimming pool
- Gym

3.6.1.3 Appraisal

Merits

- Open and accessible to the public; secure and safe space.
- The complex was properly planned to allow for adequate ventilation.
- Provisions were made for adequate parking spaces.

Demerits

- The sports centre is badly maintained.

- This facility requires more investment to make it truly functional for the physical and health development of staff and students.
- The gym is not fully equipped.

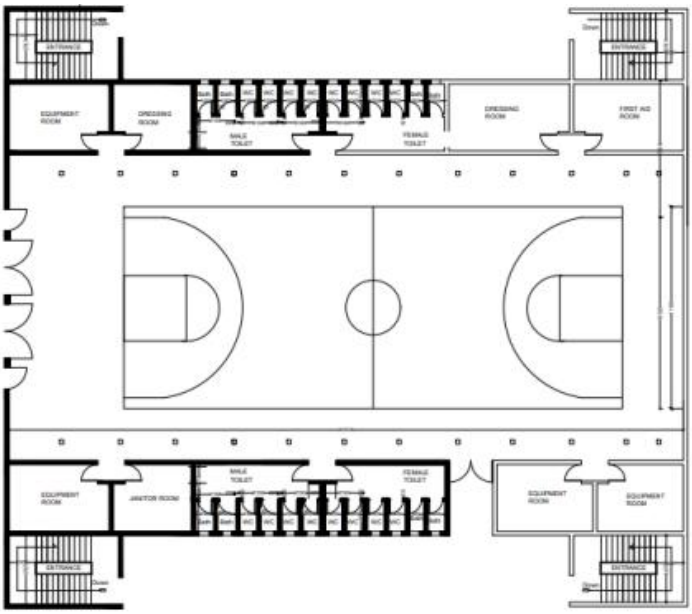

Plate 1: *Ground floor plan of Unilag Sport Hall*

Source: *Google search engine (2023)*

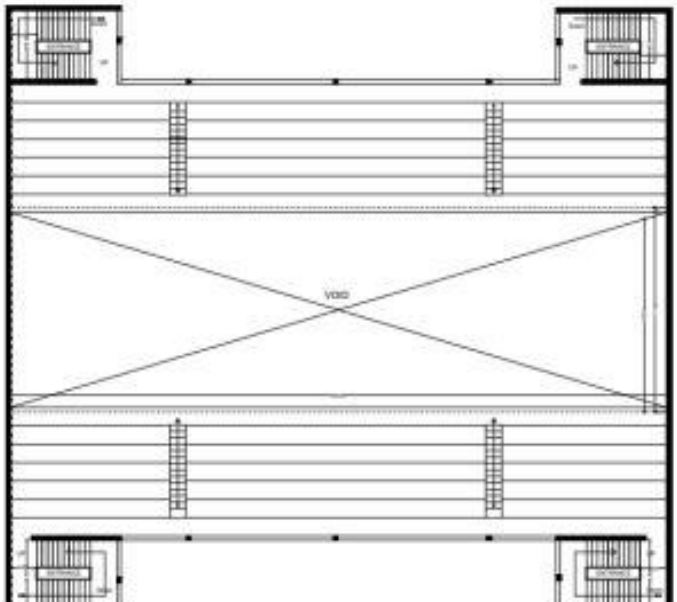

Plate 2: *First floor plan of Unilag Sport Hall*

Source: *Google search engine (2023)*

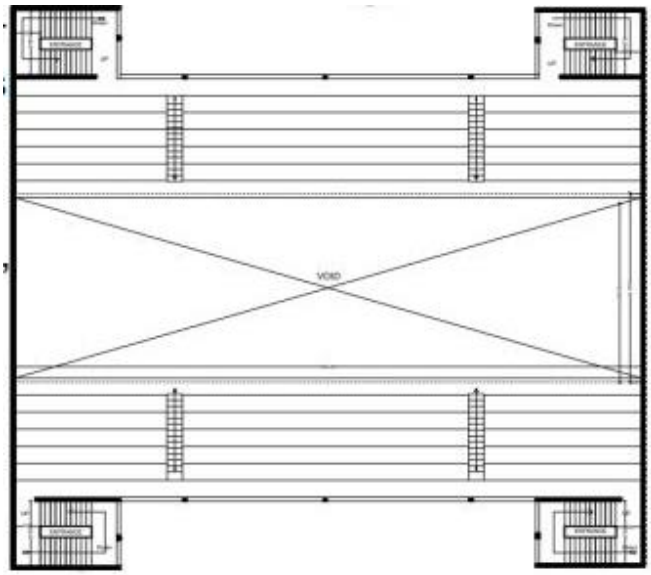

Plate 3: *Second floor plan of Unilag Sport Hall*

Source: *Google search engine (2023)*

Plate 4: *Basketball court of Unilag Sport Hall*

Source: *Researcher's field work (2023)*

Plate 5: *Exterior view of Unilag Sport Hall*

Source: *Researcher's field work (2023)*

Plate 6: *Exterior view of Unilag Sport Hall*

Source: *Researcher's field work (2023)*

Variables	**Adequate (*)**	**In-adequate (X)**	**Not available (0)**
Architectural style	*		
Scope of Facility	*		
Construction technology		X	
Building material	*		
Energy efficiency		X	

3.6.2 Case Study 2 (Local)

- **Indoor Sport Hall University of Ibadan**
- **Location:** University Of Ibadan, Oyo state, Nigeria
- **Architect:** Unknown
- **Client:** University of Ibadan
- **Date Built:** Unknown

3.6.2.1 Description of the Building

There are 2 existing sport complexes in the University of Ibadan and their locations are at

i. Old sport complex is embedded between the Faculty of Education, the Kenneth Dike Library and the Faculty of Social Sciences. The complex accommodates the sport center office wth sports facilities spread between the students' Union building and the Faculty of Social Sciences (Tennis, Volleyball, Handball, basketball courts, Hockey pitch and cricket Pavilion).

ii. The New Sport Complex is located near Obafemi Awolowo Hall and it accommodates three sporting facilities at present which are Football pitch, rubberized 10 lane track, Gamaliel Onosode Gymnasium.

The University of Ibadan Sports Council provides facilities for all the fifteen (15) approved sporting events by Nigeria University Games Association (NUGA).

3.6.2.2 Facilities Provided

- Cricket Pavilion
- Volleyball court
- 10 Lane Athletic Track
- Football pitch
- Tennis court
- Basketball court
- Hockey pitch
- Handball court
- Gymnasium
- Shops

3.6.2.3 Appraisal

Merits

- The sports complex is quite accommodating for both males and females.
- The facility is well equipped.
- Good natural day lighting and ventilation are achieved.
- Swimming pool and multi-purpose hall meet international standards and are well located.
- All columns are square and perfectly aligned in the interior parts.

Demerits

- Some of the facilities are of average standard and needs to be renovated to meet the modern standard.
- There is no provision for future expansion.

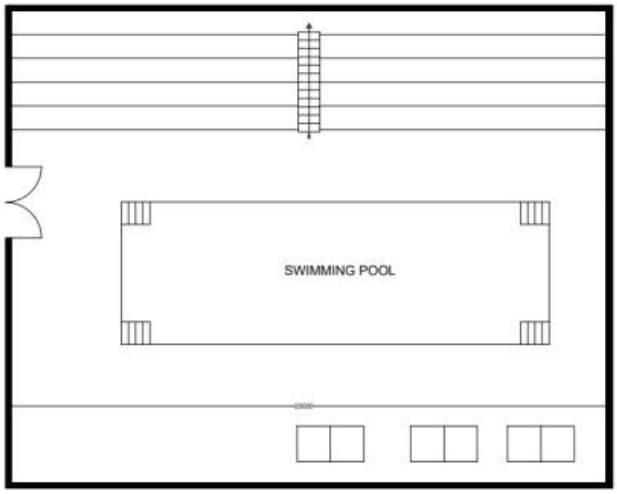

***Plate** 7: Ground floor plan of U.I Sport Hall*

Source: *Google Search*

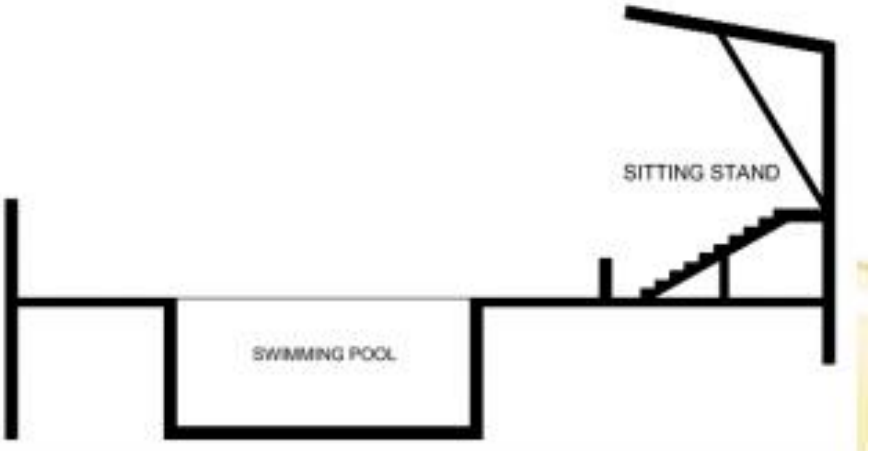

Plate 8: *Section through U.I Sport Hall*

Source: *Google search*

Plate 9: *Interior view of the swimming pool for U.I Sport Hall*

Source: *Researcher's field work (2023)*

Plate 10: *Aerial view of the swimming pool for U.I Sport Hall*

Source: *Researcher's field work (2023)*

Variables	**Adequate (*)**	**In-adequate (X)**	**Not available (0)**
Architectural style	*		
Scope of Facility	*		
Construction technology		X	
Building material	*		
Energy efficiency		X	

3.6.3 Case Study 3 (International)

- **Mercedes Benz Super Dome**
- **Location:** Atlanta Georgia
- **Architect:** HOK with tvdesign, Stanley Beaman & Sears and Goode Van Slyke Architecture, all of Atlanta, GA
- **Client:** ASM Global
- **Date Built:** 1975

3.6.3.1 Description of the Building

Mercedes-Benz Stadium is a multi-purpose stadium located in Atlanta, Georgia, United States (Tucker, T 2015). Opened in August 2017 as a replacement for the Georgia Dome, it serves as the home stadium of the Atlanta Falcons of the National Football League (NFL) and Atlanta United FC of Major League Soccer (MLS). The stadium is owned by the state government of Georgia through the Georgia World Congress Center Authority, and operated by AMB Group, the parent organization of the Falcons and Atlanta United. The stadium officially opened on August 26, 2017, with a Falcons preseason game against the Arizona Cardinals, despite the retractable roof system being incomplete at the time (McQuade, A 2017). Several events formerly held at the Georgia Dome moved to Mercedes-Benz Stadium following its completion, including the SEC football championship game and the Peach Bowl.

The stadium's signature feature is its retractable roof, which features a “pinwheel” consisting of eight translucent, triangular panels. Each of the eight panels operates on two straight, parallel rails; one rail is responsible for moving the panel while the other rail stabilizes the panel (Newcomb, T 2014). Closing the roof takes slightly less time than opening the roof, since the roof has to disengage the seals at the start of the opening procedure and slow down towards the end to prevent the panels from getting derailed. When opened, the panels are designed to create the illusion of a bird’s wings extended.

3.6.3.2 Facilities Provided

- Football pitch
- Neighbourhood bars
- Games room
- Tailgating area

- Tiers, dual-level shaded pavilion
- Restaurant
- Club

3.6.3.3 Appraisal

Merits

- The stadium incorporated contemporary art into its interior.
- Ample locker rooms were provided.
- Proper drainage system was provided for the field.
- Adequate circulation was provided by circular openings in the roof.

Demerits

- No staircases connecting the seats making it difficult to access the field.

Plate 11: *Location Layout of Mercedes Benz Superdome*

Source: *Google Search*

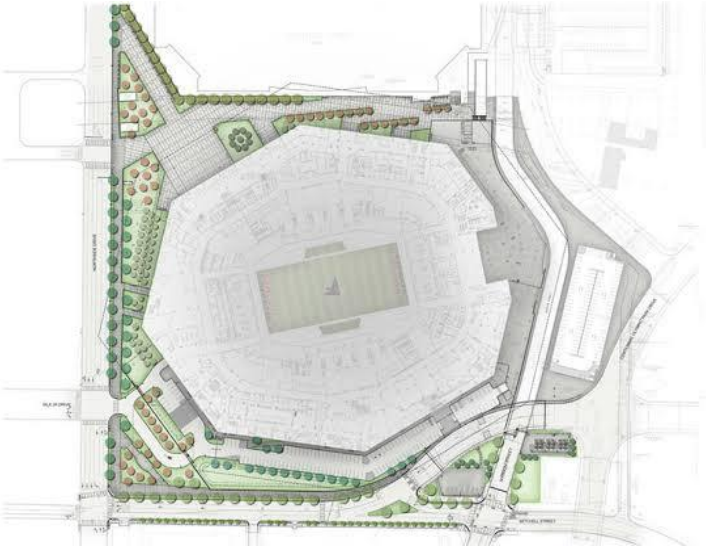

Plate 12: *Site Layout of Mercedes Benz Superdome*

Source: *Google Search*

Plate 13: *Floor Plan layout of Mercedes Benz Superdome*

Source: *Google Search*

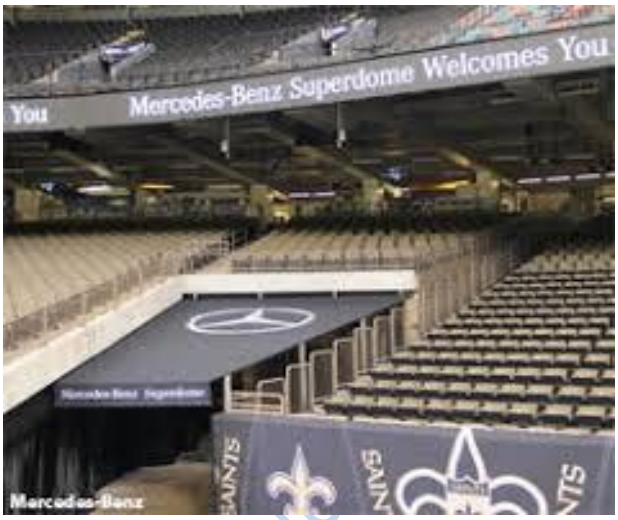

Plate 14: *Interior view of Mercedes Benz Superdome*

Source: *Google Search*

Plate 15: *Floor plan layout of Mercedes Benz Superdome*

Source: *Google Search*

Variables	**Adequate** **(*)**	**In-adequate** **(X)**	**Not available** **(0)**
Architectural style	*		
Scope of Facility	*		
Construction technology	*		
Building material	*		
Energy efficiency	*		

3.6.4 Case Study 4 (International)

Sports Building Erasmus University, Rotterdam

- **Location:** Rotterdam, Netherlands
- **Architect:** VenhoevenCS
- **Client:** Erasmus University
- **Date Built:** 2022

3.6.4.1 Description of the Building

VenhoevenCS architecture+urbanism designed this sports complex to accommodate over fifty sports by stacking the sports hall on a compact plot. The complex functions are energy-neutral and the lively public interior is fashioned from circularly harvested, re-used materials. The central axis through the building functions as destination and transit at the same time and is a true physical and social connector.

In view of sustainability and energy consumption, the building functions as energy neutral, an increasingly urgent condition. Its full facilities are built in to capture, retain, exchange and reuse water and solar energy; and to minimize its use. These are leading principles in its design consideration. The facility serves as a true physical and social connector by using light, high, with stairs and walkways, lots of greenery, and of course a bar. It has a unique Transparency and rhythm. Sports Building is enveloped by a glass and aluminum skin with an interplay of horizontal articulation and vertical fins in multiple rhythms.

The slightly curved eastern façade of the complex opens with a full height glass corner. Also, both end ends of the central passage are glass-only. Of course, the transparency maximizes views, enables a smooth indoor-outdoor transition, and allows for daylight to enter; it also marks the lively spots: the public functions, on street level and above, plus the sports activities that do not require a closed hall.

3.6.4.2 Facilities Provided

- Sport Halls
- 2 Gyms
- Shops
- Fitness centre

- Bar/Restaurant

3.6.4.3 Appraisal

Merits

- The use of glass-only along the central passage enables a smooth indoor-outdoor transition.
- Adequate daylight was provided as well through the use of glass-only.
- Full facilities are built in to capture, retain, exchange and reuse water and solar energy.
- Building materials used were harvested from circular demolition which is a good sustainable practice.

Demerits

- The central axis through the building functions as both destination and transit.

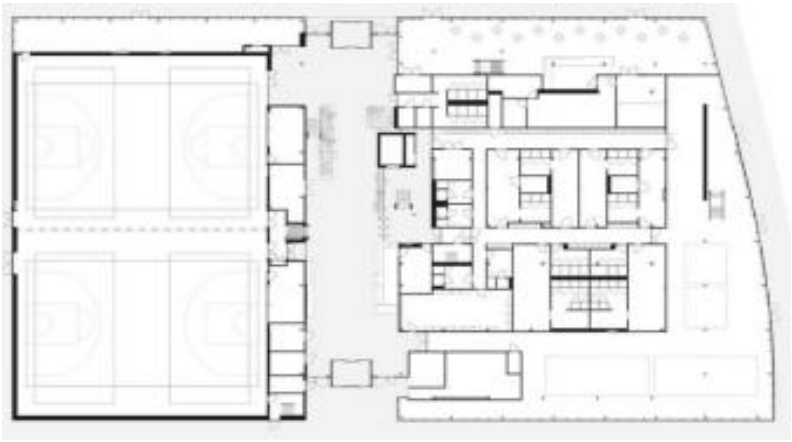

Plate 16: *Ground Floor plan layout of Erasmus University Sport Hall*

Source: *Google Search*

Plate 17: *First Floor plan layout of Erasmus University Sport Hall*

Source: *Google Search*

Plate 18: *Second Floor plan layout of Erasmus University Sport Hall*

Source: *Google Search*

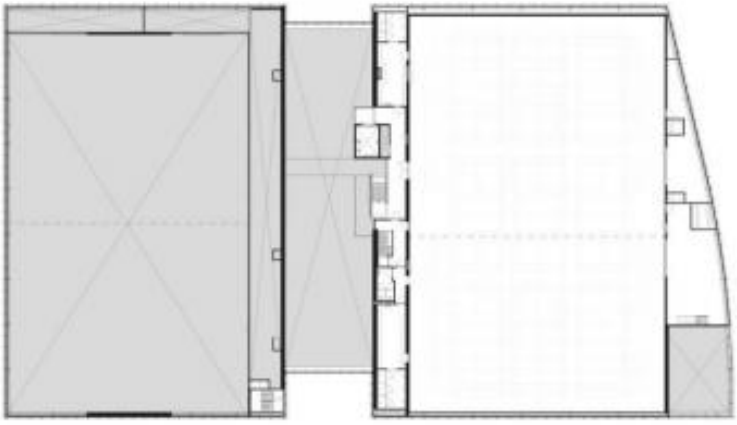

Plate 19: *First Floor plan layout of Erasmus University Sport Hall*

Source: *Google Search*

Plate 20: *Interior view of basketball court for Erasmus University Sport Hall*

Source: *Google Search*

Plate 21: *Exterior view of Erasmus University Sport Hall*

Source: *Google Search*

Variables	**Adequate** **(*)**	**In-adequate** **(X)**	**Not available** **(0)**
Architectural style	*		
Scope of Facility	*		
Construction technology	*		
Building material	*		
Energy efficiency	*		

3.6.5 Case Study 5 (International)

- **Jianshang Sports Complex**
- **Location:** Shenzhen, China
- **Architect:** CCDI
- **Client:** Government of Longhua District Bureau of Culture

- **Date Built:** 2022

3.6.5.1 Description of the Building

This is an energy-saving stadium that makes full use of natural lighting and ventilation, therefore effectively reducing the energy consumption of lighting and air conditioning during operation. The structure faithfully expresses the architectural space, and the dislocated boxes in the architectural form can also be interpreted as a structure that is dislocated up and down. The main structure is mainly supported by six reinforced concrete cores, each layer is jointly stressed by the inter-layer steel truss and the waist truss, up and down dislocation, to achieve an ultra-large span and ultra-long cantilever. The structural module is controlled by the reasonable joint spacing of the steel structure members, and this modular system also runs through the scale division of buildings, such as curtain walls, landscapes, and indoor spaces as well. It is undeniable that this is a behemoth that uses more than 9,000 tons of steel.

The building façade and structure are connected geometrically, constructively, and materially in a clear and affirmative way. The façade of the building adopts a double layer skin, the outer layer is aluminum mesh, and the inner layer is Low-E low iron glazed glass. The outer layer of aluminum mesh extends from the wall to the outdoor ceiling, underlining a simple and complete sense of wholeness. Due to the translucency and directionality of the aluminum mesh, there are subtle changes in light and darkness under different viewing angles, time periods, and weather conditions.

Taking advantage of the terrain, the main gymnasium and swimming pool are embedded in the ground, occupying the first basement to second-floor space. The badminton hall and tennis hall are large and concentrated, placed on the top four and fifth floors respectively, and on the third

floor between the upper and lower large venues, some small venues are set up, such as taekwondo, fencing, table tennis, dance, and fitness. From a macro point of view, the sports complex integrates into the city without losing its personality. On the one hand, the dislocated volumes of the building weaken the sense of heaviness and harmonize with the surrounding urban fabric. On the other hand, the minimal form establishes a distinctive visual identity that is easily detached from the chaotic urban background.

3.6.5.2 Facilities Provided

- Sport Halls
- 2 Gyms
- Shops
- Fitness center
- Bar/Restaurant

3.6.5.3 Appraisal

Merits

- All columns are square and perfectly aligned in the interior parts.
- Adequate daylight was provided as well through the use of glass-only.
- Full facilities are built in to capture, retain, exchange and reuse water and solar energy.
- Building materials used were harvested from circular demolition which is a good sustainable practice.

Demerits

- The central axis through the building functions as both destination and transit.

Plate 22: *Exterior view of Jianshang Sports Complex*

Source: *Google Search*

Plate 23: *Interior view of Jianshang Sports Complex*

Source: *Google Search*

Plate 24: *Interior view swimming pool for Jianshang Sports Complex*

Source: *Google Search*

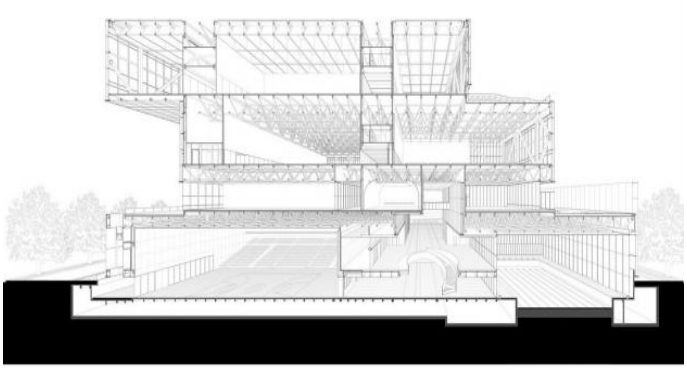

Plate 25: *Section through Jianshang Sports Complex*

Source: *Google Search*

Variables	**Adequate** **(*)**	**In-adequate** **(X)**	**Not available** **(0)**
Architectural style	*		
Scope of Facility	*		
Construction technology	*		
Building material	*		
Energy efficiency	*		

Chapter Four

Site Analysis and Design Synthesis

4.1 Study Area

4.1.1 Site Location

Lagos State, situated in the southwestern region of Nigeria and known as Ipinle Ekó in the Yoruba language, is one of the country's states. It holds the distinction of being the most populous among the 36 states, while also being the smallest in terms of land area. Lagos State

shares its borders exclusively to the south, where it is bounded by the Bight of Benin, and to the west, where it shares an international border with the Benin Republic. To the east and north, Lagos State is bordered by Ogun State. This state was officially established on May 27, 1967, and it derives its name from Lagos, which happens to be the most populous city in Africa.

Geographically, Lagos State's landscape is dominated by water, covering nearly a quarter of its land area. Among the prominent water bodies are the Lagos and Lekki lagoons, which receive water from the Ogun and Osun rivers, making them the largest water bodies within the state. These lagoons are situated inland. Additionally, Lagos State is traversed by numerous other rivers and creeks, playing a crucial role in the transportation of people and goods. On land, undeveloped areas can be found within Nigeria's tropical lowland forests, which serve as a habitat for endangered species like the mona monkey, tree pangolin, and hooded vulture, coexisting with transient populations of African bush elephants. The state also boasts biodiversity in its offshore regions.

Since its establishment in 1967, Lagos State has experienced governance under various regimes. It has been governed either by civilian administrations, featuring a governor and a house of assembly, or quasi-civilian federal administrations, as seen during Ibrahim Badamasi Babangida's tenure. Alternatively, it has been administered by sole administrators or military administrators during military dispensations.

4.1.2 Site Selection Criteria

(i) Location: The location of the site in relation to other facilities that collaborate with the building is the most crucial consideration when selecting a location for any building. The site must be centralized because it is meant to serve as a hub for the community's crisis and emergency management. It must be reachable in terms of travel time between locations. This emergency center's location is centralized to meet a key requirement for site location.

(ii) Accessibility: After site location, accessibility is a crucial factor. This is so because accessibility depends on location. A site must be strategically placed within the area from which access is required in order to be sufficiently accessible. Routes for vehicular or pedestrian traffic are another crucial aspect of accessibility. The sport center should be located in a place where there are routes for both vehicular and foot traffic around the building because it is a public structure.

(iii) Size: The size of the site is an important factor that needs to be taken into account. The site needs to be big enough to allow for equal distribution of functions. This improves worker productivity, coordination, and work-flow continuity. A site that is too small could result in excessive design restrictions. The Lagos State master plan includes a site that is big enough to house the emergency center and leave room for landscaping.

(iv) Services: If the chosen site increases the viability of the proposed project by being close to some basic social amenities like lodging, health care, telecommunication, electricity, water supply, and good motorable roads connected to interurban highways, then it will be more deserving of consideration.

(v) Scenic beauty: Ensuring a beautiful outdoor environment in addition to cozy interior settings can help employees relax and work more effectively. Because of this, employees are not exposed to unpleasant surroundings through the office windows, which could have a negative psychological impact and make them unhappy while they work.

4.2 Project Analysis and Design Synthesis

4.2.1 Brief Analysis

Indoor games and sports are a variety of structured games or competitive physical exercises, typically carried out either at home, in a well-sheltered building, or in a specially constructed sport venue such as a gym, a natatorium, an arena or a roofed stadium.

The aim of this project is to design a functional and aesthetically pleasing sport complex. This complex will provide a Turf Field that allows a wide variety of typically outdoor sports to be played indoors. These turf fields are large and has a grassy texture to it without the maintenance

required to keep it green and plush. Many sports are being played on this type of service, such as soccer, baseball, flag football, shooting softball, lacrosse, rugby, and many others.

- Promoting the best possible use of the topography of the land for construction as well as the best possible use of the facilities and infrastructure on the property.
- Encouraging higher environmental performance and durability standards for buildings in an effort to give users a comfortable, healthy, accessible, and visually appealing environment.
- Offering a manageable and upkeep-friendly design.
- Understand, interpret, and develop the brief's ideas into a compelling design concept.

4.2.2 Brief Development

Here's a list of spaces required for the proper functioning of the proposed sport complex design.

- Foyer and reception
- Admin offices
- Food court
- Changing and toilet area facilities for the disabled offices
- Equipment storage
- Services and maintenance
- Open games floor
- First aid and emergency room
- Janitor/ cleaner

- Gym
- Sport gallery
- Swimming
- Netball
- Volley ball
- Tennis
- Bowls
- Trampolining
- Archery
- Apparatus room
- Instructors' room
- Medal room

4.2.3 Design Criteria

Regardless of the site's shape or topography, it is a design principle that the building be created as a seamless part of it. Therefore, such language as bad-site seems like an easy way for the designers to get out of a difficult situation. The need for a site and environmental analysis arises from the fact that every site, regardless of its form, size, terrain, topography, etc., presents an opportunity to be utilized in the design process.

Orientation – The location of the site is crucial in relation to a few nearby factors, which can be expressed in one of two ways: either with respect to the sunrise and sunset, or with alignment with the road. When it comes to sunrise, the shorter side of the building will be oriented east-west, and sun shading devices will be used if this cannot be done. Lagos predominant winds are

trade winds from the southwest and northeast, so placing a building's orientation in an east-west direction will prevent it from having good airflow. The wind will be coming at the building at a 45-degree angle, forcing some of it to travel parallel to it while the rest will pass through it.

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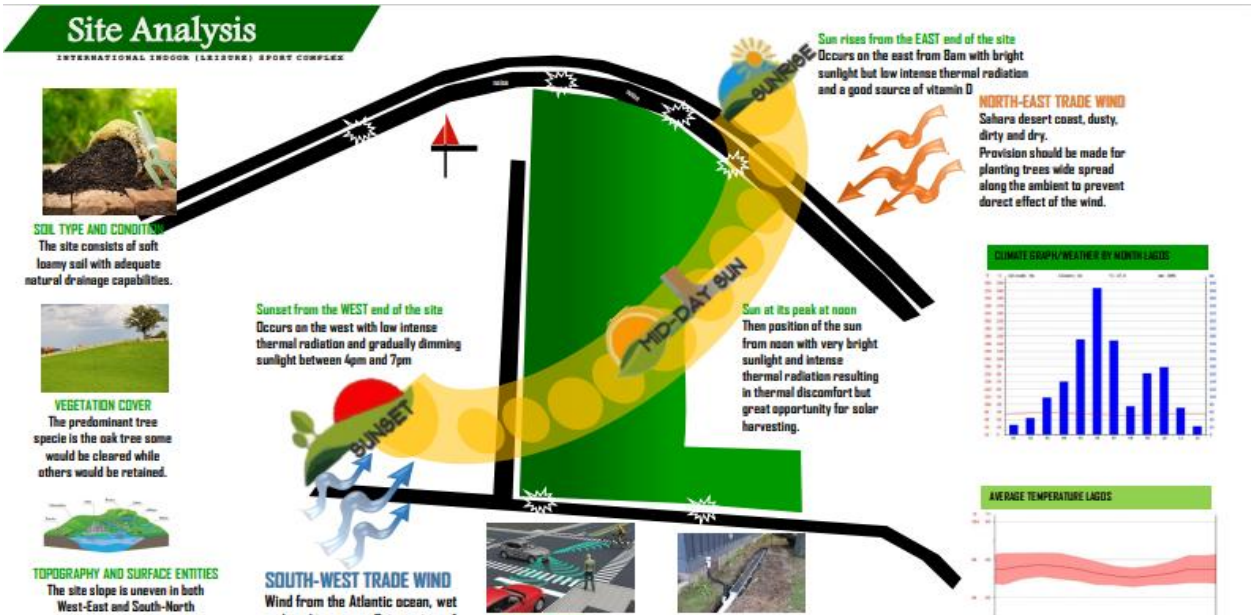
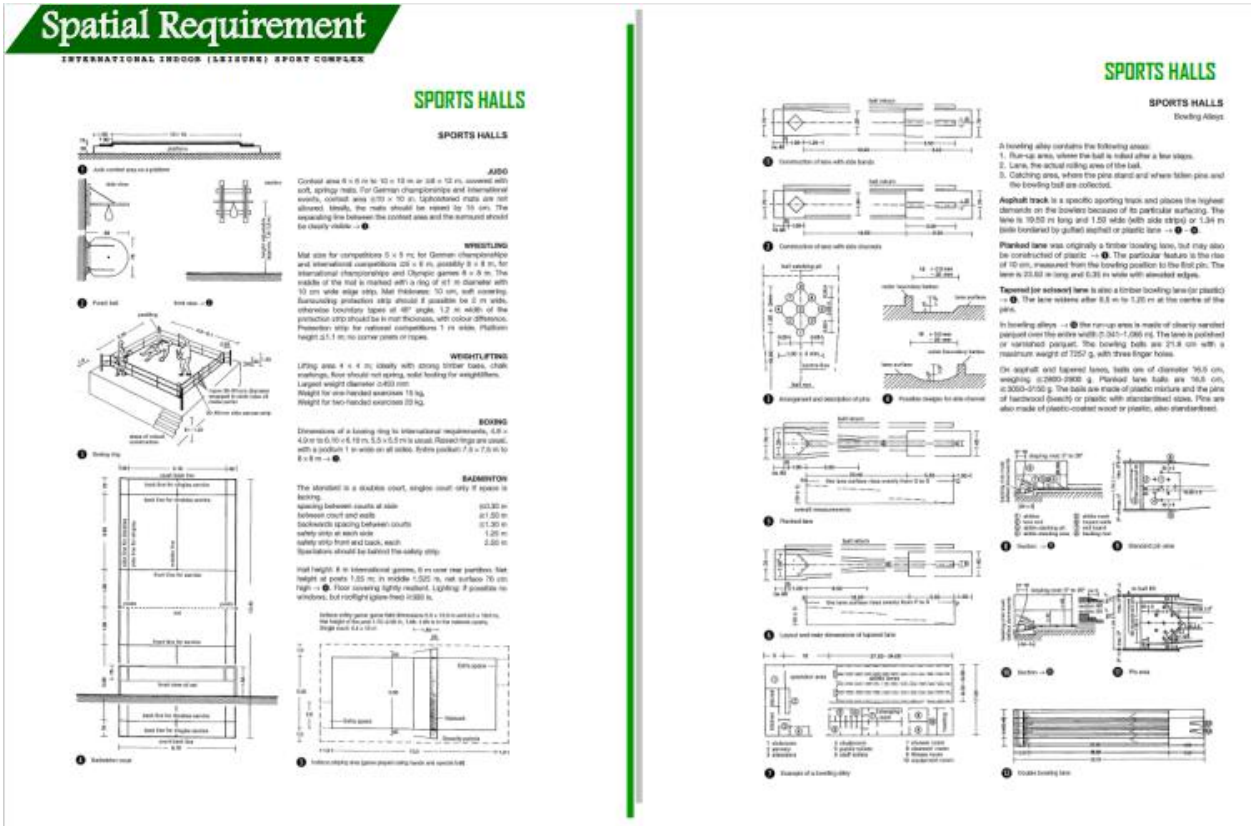


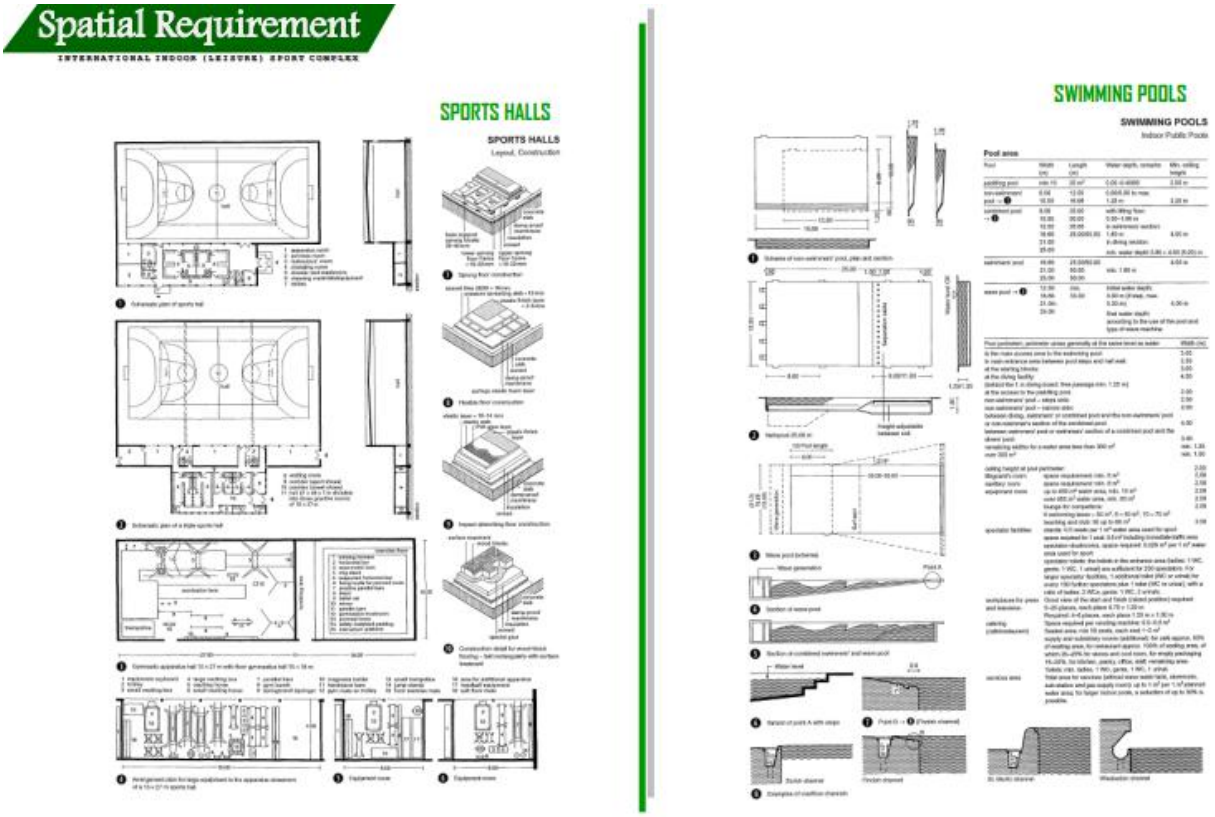
Site Analysis

4.2.4 Functional Relationship

The ideal references, in terms of size, quality, standard, and characteristics, for determining how the required spaces and other building components can be used, are the functional/spatial criteria. The primary goal of having a space-functional relationship is to comprehend how various spaces within a development interact with one another as well as to achieve some consistency in the flow of functions within each area, thereby achieving a sense of unity among the various functions and also increasing efficiency within the building.



Spatial Requirement Source: Architect's data



Spatial requirement Source: Architect's data

4.2.5 Space Allocation/Schedule Of Accommodation

According to the specific activity that was anticipated for each space, due consideration was given when allocating spaces for the various functions present in the sport complex. Maximum space standards from reference data books were used to determine the space requirement. Consequently, the table below shows the amount of space needed for this project.

4.2.5.1 Space Program for General Area

GROUND FLOOR		
S/N	**SPACE**	**AREA (sqm)**
1.	FOYER	750.998
2.	GRAND RECEPTION	1,897
3.	GRAND RECEPTION MALE TOILET	72
4.	GRAND RECEPTION FEMALE TOILET	72

5.	GENERAL GAMES AREA	2,725
6.	GENERAL GAMES MALE TOILET	72
7.	GENERAL GAMES FEMALE TOILET	72
8.	COURT GAMES A	1,492
9.	COURT GAMES A MALE TOILET	70
10.	COURT GAMES A FEMALE TOILET	70
11.	BASKETBALL GAMES AREA	1,214
12.	BASKETBALL GAMES MALE TOILET	45
13.	BASKETBALL GAMES FEMALE TOILET	45
14.	COURT GAMES B	2,497
15.	COURT GAMES B MALE TOILET	70
16.	COURT GAMES B FEMALE TOILET	70

17.	CLUB OFFICES	309
18.	FOOD COURT	735
19.	GENERAL TOILET	135
20.	ADMIN OFFICE	794
21.	SWIMMING POOL	4,062
22.	MAINTANANCE AREA	445
23.	SWIMMING POOL AREA MALE TOILET	70
24.	SWIMMING PPOL AREA FEMALE TOILET	70

MEZZANINE FLOOR		
S/N	**SPACE**	**AREA (sqm)**
1.	GENERAL GAMES AREA	2,725

2.	GENERAL GAMES MALE TOILET	72
3.	GENERAL GAMES FEMALE TOILET	72
4.	FOOD COURT	445
5.	GENERAL TOILET	135
6.	ADMIN OFFICE	340

FIRST FLOOR		
S/N	**SPACE**	**AREA (sqm)**
1.	GENERAL GAMES AREA	2,725
2.	GENERAL GAMES MALE TOILET	72
3.	GENERAL GAMES FEMALE TOILET	72
4.	GYM	1,586

5.	UTILITY	56
6.	GENERAL TOILET	135

4.2.6 Construction Methods and Materials

The choice of building materials for sport complex should be cautious because they could have an impact on the users' health, safety, and security. Generally speaking, when choosing building materials, one should take into account the material's nature, structural properties, functional characteristics, fire resistance, compatibility with other materials, cost of installation, maintenance requirements, climate, and aesthetics. The building, its surroundings, the climate, and the design of its facilities will all have an impact on the design and material selection. However, the chosen materials for the ceiling, floor, walls, and roof must satisfy the following requirements:

i. The components must have a high tensile strength.

ii. They must be strong and durable.

iii. The materials should be easy to install, particularly in the workshops.

iv. The floor covering should be able to withstand vibration caused by heavy machinery being used in the workshops, such as in a generator room.

v. The substance should have a low combustibility.

vi. Materials, particularly those used with metal, should have low expansion properties.

vii. The content needs to be of a high caliber. Building with eco-friendly and non-toxic materials is also encouraged.

4.2.6.1 Criteria For Selection of Materials and Finishes

a) Functional Criteria

i. Primary purpose: Suitability to basic purpose.

ii. Secondary purpose: What are some probable but perhaps unanticipated users? For the particular element? Health and safety issues may play a major part.

b) Aesthetic Spatial Criteria

i. Truth in Materials: a basic philosophy in design since the crafts movement not imitate one another but be used in accordance with their own natural properties. At one level this philosophy insists on clarity when using structural or surface materials i.e. one should not imitate the other for instance surface tiles should not pretend to be brick and imitation structure should not be created with non-structural elements.

ii. Appropriateness to design concept.

iii. Spatial implication (how will material influence the perceive size/shape of space).

c) Economic Criteria

i. Initial cost: this might tend to be high for natural materials such as stone, lower for synthetic such as vinyl.

ii. Life-cycle cost: how long does the installation need to last-short or long term planning.

iii. Cost to maintain: is maintenance an issue in commercial carpet.

d) Environmental criteria

i. Healthy Environments

ii. Sustainability

iii. Upstream impact

4.2.7 Building Services

High standard engineering services with advanced controls are required to guarantee environmental quality, adaptability to meet changing requirements, and energy management. In order to divide the space, the engineering system and apparatus must be designed for both the individual areas and the entire structure. Acoustic treatment, lift services, ducting, communication systems, sewage and drainage, waste removal, ventilation and air conditioning, electrical distribution and lighting, fire safety, and other services should all be taken into account

Chapter Five

Conclusion.

5.1 Conclusion

Energy management should be done in tandem with managing land, labor, and capital because it is a key production factor. Given that the cost of providing energy can be several times higher than the cost of saving it, energy-efficient production methods should be viewed as a quick and less expensive source of new energy supply. Energy efficiency is increasingly understood to include both the overall economic efficiency of the energy system as well as the physical efficiency of the technical facilities and equipment. As a result, Nigeria's major economic sectors (housing, industry, and transportation) will profit more from adopting energy-saving measures, which will also help to curb greenhouse gas emissions, advance sustainable development, and strengthen corporate social responsibility. The Nigerian economy chain needs to launch aggressive campaigns for energy efficiency measures.

This work includes a presentation of the opportunities for energy conservation in the public sectors as well as the production and distribution of electricity. These include energy use in the cooling system of public buildings, lighting, transportation, office appliances, electrically operated industrial machines, and heat engines like pumps, motors, fans, boilers, etc. The various areas where energy can be saved have been identified in this study. To conserve energy in these areas, a number of guidelines and measures have been put forth. If the guidelines and measures are strictly followed, significant energy savings will be realized.

The government must step up the further implementation of renewable energy and energy efficiency programs in order to guarantee the sustainability of the energy supply and, in turn, the sustainable economic development of the nation.

5.2 Recommendation

It is concluded in this study that energy efficiency and renewable energy are two factors that should be combined to achieve sustainable development in Nigeria. For sustainable development, it is crucial to use energy-efficient products and the right procedures to conserve the current energy generated in the nation. As a result, it is advised that the nation take the following actions:

- Create energy-efficiency policies and incorporate them into the current energy regulations. In order to direct the populace toward an effective use of the country's energy resources, a comprehensive and coherent energy policy is necessary.
- Encourage end users, energy producers, and appropriate practices to use energy-efficient products and procedures.
- Increase public awareness of energy efficiency and renewable sources.

- Create a body to encourage the use of energy-efficient products and guarantee the right procedures.
- Create and adopt energy-efficient technology.
- To determine the country's overall potential for renewable energy and to identify the local conditions and priorities in the various ecological zones, conduct a resource survey and assessment.
- Create a lab for testing and evaluating renewable energy technologies.
- Create effective motivators for putting energy efficiency policies into action.
- The various sectors of the Nigerian economy should embrace clean energy facilities.
- A partial list of possible clean energy opportunities in Nigeria is given below:
- Utilization of solar technologies in the public building sectors that is more effective and complete.
- Use of lighting that is energy-efficient.
- Use of solar and wind energy for irrigation water pumping and electricity supply.
- Utilization of agricultural residues for electricity generation.
- Generation of biogas from wastes produced by the livestock and animal husbandry.

In addition to these, the current institutions for technology development and research and development should be adequately strengthened to support the transition to a greater use of renewable energy sources. The focus of project development, project management, monitoring, and evaluation should be on human resource development, the transfer of critical knowledge, and know-how. It should be a top priority to create standards and codes of conduct, maintenance manuals, life cycle costing, and cost-benefit analysis tools.

References

Adegbulugbe, A.O, Akinbami, J-FK (1995): Urban household energy use patterns in Nigeria. Natural Resources Forum 19(2), 125–133.

Adeyemo, S.B, Odukwe, A.O (2008): Energy conservation as a viable pathway towards energy stability. J. Eng. Appl. Sci. 3(3), 233–238.

Aliu, I.R (2020). "Energy efficiency in postpaid-prepaid metered homes: analyzing the effects of socioeconomic, housing, and metering factors in Lagos, Nigeria." Energy Efficiency, pp. 1-17, 20.

Awwad, A.A, Mohammed, A.A (2007): World energy roadmap - a perspective. WEC2007 Energy Future in an interdependent world.

Baker, N. (1992). Low Energy Strategies for Non-domestic Buildings in Roaf, S. & Hancock, M. (1992). (Eds).

Chao Li, Yongxi Yi, Aoxiang Zhang, Biao Chen (2023). Fuel consumption-reduction investment decisions and coordination contracts in fuel vehicle supply chains: A dynamic analysis.

Chengchao Lv, Changhua Shao, Chien-Chiang Lee (2021). Green technology innovation and financial development: Do environmental regulation and innovation output matter?

Chunmei Guo, Chenhang Bian, Qinghua Liu, Yuwen You,Shengying Li, Leilei Wang (2022). A new method of evaluating energy efficiency of public buildings in China, Journal of Building Engineering, Volume 46.

Community Research Development Centre (2009), "Energy Efficiency Survey in Nigeria,"2009.[Online]. Available: https://www.osti.gov/etdeweb/servlets/purl/21328691.

Davis L.W, Martinez S. and Taboad B. (2020). "How effective is energy-efficient housing? Evidence from a field trial in Mexic." Journal of Dvelopment Economics, volume 143.

Dear R. de, Xiong J, Kim J, Cao B (2020). A review of adaptive thermal comfort research since 1998.

Domenico Mazzeo PhD, Nicoletta Matera, Cristina Cornaro PhD, Giuseppe Oliveti, Piercarlo Romagnoni, Livio De Santoli (2020). EnergyPlus, IDA ICE and TRNSYS predictive simulation accuracy for building thermal behaviour evaluation by using an experimental campaign in solar test boxes with and without a PCM module.

ECN-UNDP (2005). Federal Republic of Nigeria Renewable Energy Master Plan. Published by the Energy Commission of Nigeria and the United Nations Development Programme.

Economidou M, Todeschi [v], Bertoldi P, D'Agostino D, Zangheri P, Castellazzi L (2020). Review of 50 years of EU energy efficiency policies for buildings.

Emodi, N. V and Boo, K.J (2015):"Sustainable energy development in Nigeria: Current status and policy options. Renewable and Sustainable Energy Reviews." Elsevier, Vol. 51(C), pp. 356–381, 2015. https://doi.org/10.1016/j.rser.2015.06.016.

Energy Commission of Nigeria (2008). Assessment of Energy Options and Strategies for Nigeria: Energy Demand, Supply and Environmental Analysis for Sustainable Energy Development (2000-2030). Report No. ECN/EPA/2008/01.

Etiosa, U (2009): A Guide for Developing Policy and Legislation. International Rivers. Community Research and Development Centre.

Harrington L. and Damnics M. (2004). Energy Labeling and Standards Programme Throughout the World. A publication of the National Appliance and Equipment Energy Efficiency Committee, Australia. NAEEEC Report 2004/04.

Hao Wei, Yaru Zhou (2023). The impact of international talent on environmental pllutio: Firm-level evidence from China.

Hussaini, I. U. (2012). Household Energy Efficiency Practice in Bauchi, Nigeria. Unpublished PhD Thesis. Department of Architecture, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia.

International Rivers (2009). Energy Efficiency: The Greenest Electricity Source. Publication of the International Rivers. www.internationalrivers.org

IPCC (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Junqi Wang, Jingjing Huang, Zhuangbo Feng, Shi-Jie Cao, Fariborz Haghighat (2021). Occupant-density-detection based energy efficient ventilation system: Prevention of infection transmission.

Kwag B.C., Adamu B.M., and Krarti M. (2019). "Analysis of high-energy performance residences in Nigeria." Energy Efficiency, volume 12.

Lebot, B. (2009). Energy Efficiency and Market Transformation: A Short Overview of Best Practices. A paper presented during the Inception Workshop of the UNDP-GEF Project to Promote Energy Efficiency in Residential and Public Building in Nigeria, 14th July 2009.

Maryam Sadat Mirnaghi, Fariborz Haghighat (2020). Fault detection and diagnosis of large-scale HVAC systems in buildings using data-driven methods: A comprehensive review.

Microsoft Encarta Encyclopedia Deluxe, 1999 7.

Niamir L., Ivanova O., Filatova T., Voinov A., and Bressers H. (2020)."Demand-side solutions for climate mitigation: Bottom-up drivers of household energy behavior change in The Netherlands and Spain." Energy research & Social Science, Volume 62.

Newcomb, Tim (2014). "MLS in Atlanta: The $2.1Billion Stadium Blank's New Team Will Share with Falcons".

Nigerian Electricity Regulation Commission, “Energy Efficiency Survey in Nigeria,” 2013. [Online], Available: https://pubs.naruc.org/pub.cfm?id=5384FA06-2354-D714-5117-4BD1D7E58CAA.

Oyedepo S.O (2013): “Energy and sustainable development in Nigeria: the way forward”, International Journal of Energy, Sustainability and Society, vol. 2, pp. 1-17.

Punch News Paper 2009: September 11th.

Pushpendra Kumar Singh Rathore, Shailendra Kumar Shukla (2021). Enhanced thermophysical properties of organic PCM through shape stabilization for thermal energy storage in buildings: A state of the art review.

Rau H, Moran P, Manto R, and Goggins J (2020). “Changing energy cultures? Household energy use before and after a building energy efficiency retrofit.” SustainableCities and Society, Volume 54.

Ravi Anant Kishore, Marcus V.A. Bianchi, Chuck Booten, Judith Vidal, Roderick Jackson (2020). Optimizing PCM-integrated walls for potential energy savings in U.S. Buildings.

Rosen, M.A (2008): Towards energy sustainability: a quest of global proportion. Forum of Public Policy online: A Journal of the Oxford Round Table, Summer.

Sambo, A.S (2007): Strategic developments in renewable energy in Nigeria. International Association of Energy Economics. Third quarter, pp. 15–19.

Sambo, A. S. (2010). Renewable Energy Development in Nigeria. A paper presented at the World Future Council/Strategy Workshop on Renewable Energy, Accra, Ghana, 21-24 June, 2010.

Santamouris, M. (2005). Energy Performance of Residential Buildings; A practical guide for energy rating and efficiency. Uk: James & James/Earthscan.

Schutze E.,Worthington,R (2020): Getting to Grips with Sustainable Energy. Publication of the Sustainable Energy and Climate Change Partnership.

Shaobin Zhang, Baofeng Shi, Hao Ji (2023). How to decouple income growth from household carbon emissions: A perspective based on urban-rural differences in China.

Siyu Ren, Yu Hao , Lu Xu, Haitao Wu, Ning Ba (2021). Digitalization and energy: How does internet development affect China's energy consumption?

Tao Liu, Zehan Tan, Chengliang Xu, Huanxin Chen, Zhengfei Li (2020). Study on deep reinforcement learning techniques for building energy consumption forecasting.

Thomas Parkinson, Richard de Dear, Gail Brager (2020). Nudging the adaptive thermal comfort model.

Umar D.A, and Abubakar M.M (2014): Effects of Energy Utilization on the Environment, Discovery, vol. 25, pp. 93-99.

Unachukwu, G.O (2003): Energy Efficiency measures investigation in cement Company: BCC case study. Nigerian Journal of Renewable Energy 10(1–2), 85–92.

Yohanna, A. H. Iortyer and I. A. Ierve (2013): “Assessment of energy use pattern in residential buildings of Kano and Kaduna Northern Nigeria.” American Journal of Engineering Research (AJER), vol. 2, pp. 271-275.

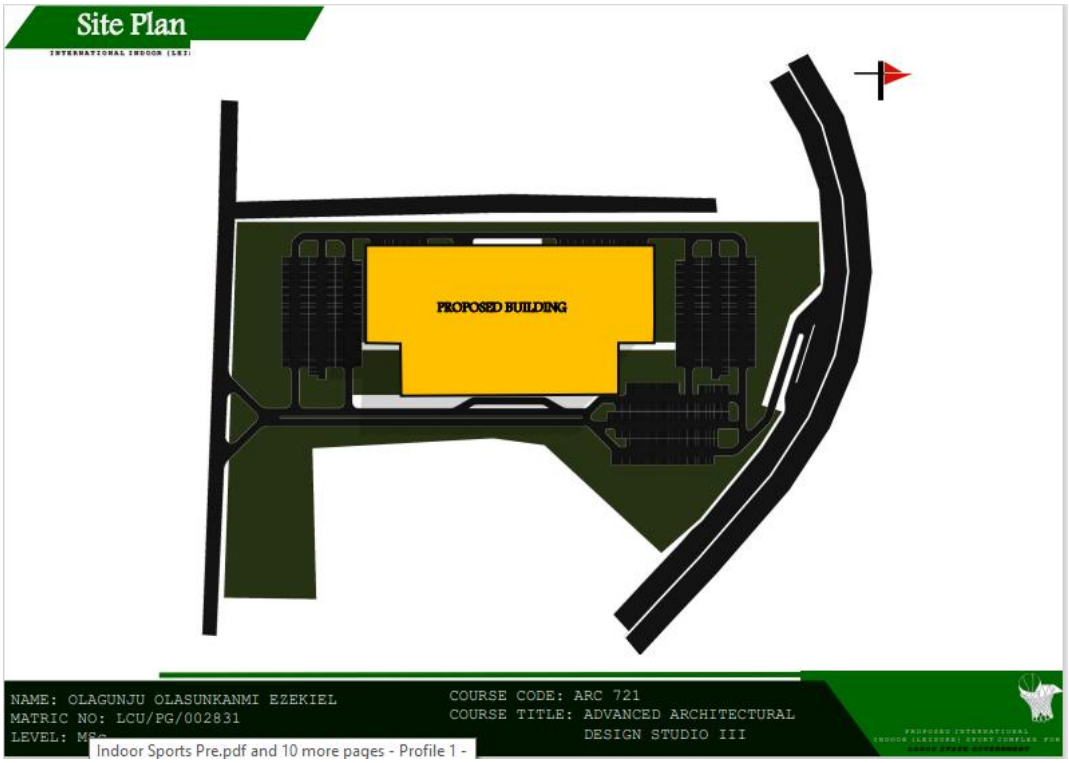
http://www.builldup.eu/cs/node/43328, BUILD –UP The European Portal For Energy Efficiency in Buildings – "The new MINERGIE 2020 strategy for energy efficient buildings".

Yantuan Yu, Ning Zhang (2021). Low-carbon city pilot and carbon emission efficiency: Quasi-experimental evidence from China.

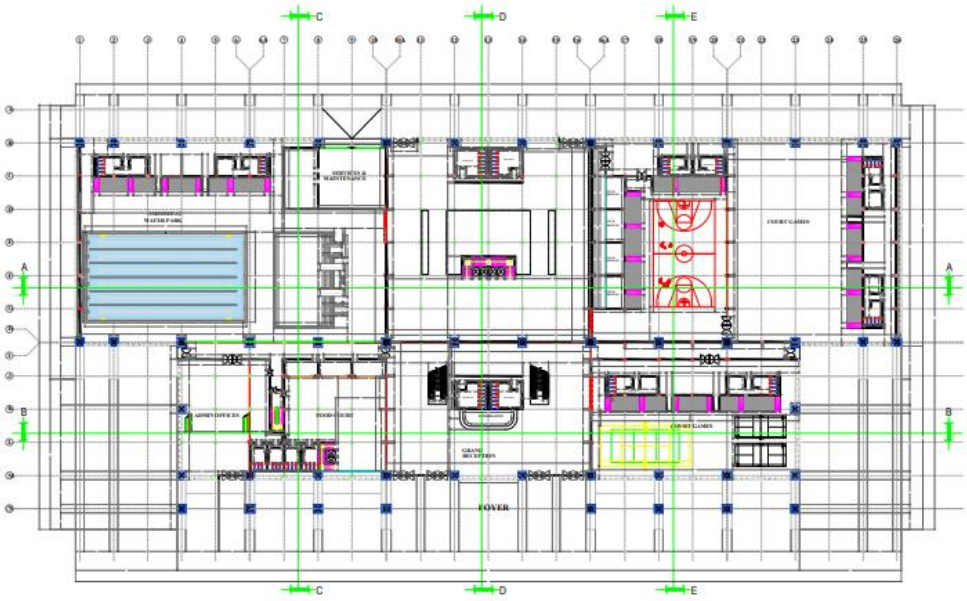
Ying Sun, Fariborz Haghighat, Benjamin C.M. Fung (2020). A review of the-state-of-the-art in data-driven approaches for building energy prediction.

Zeeshan Khan, Muhsin Ali, Liu Jinyu, Muhammad Shahbaz, Yang Siqun (2020). Consumption-based carbon emissions and trade nexus: Evidence from nine oil exporting countries.

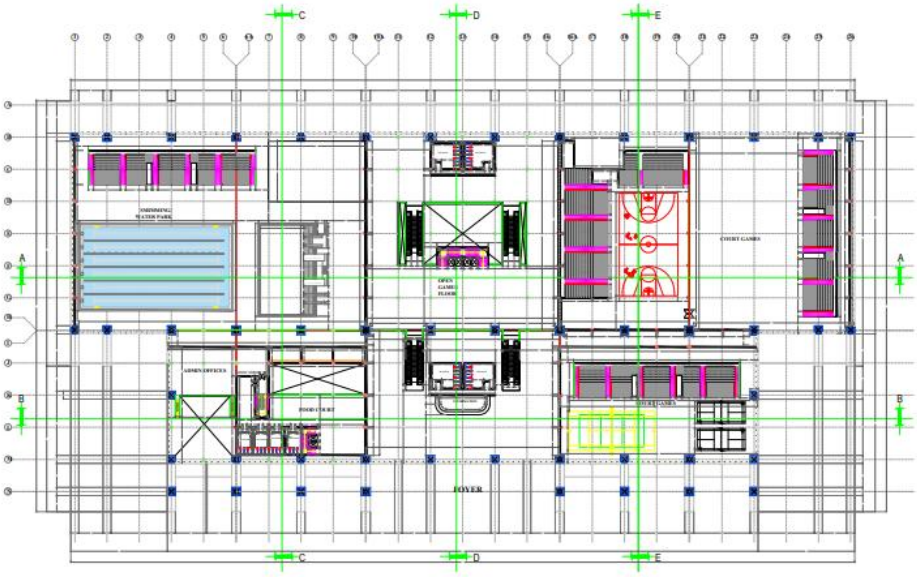
Appendix



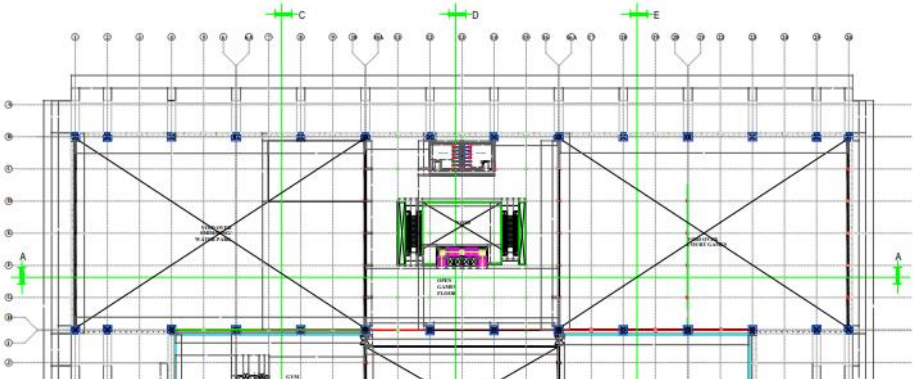
APPENDIX A –SITE PLAN OF PROPOSED SPORT COMPLEX



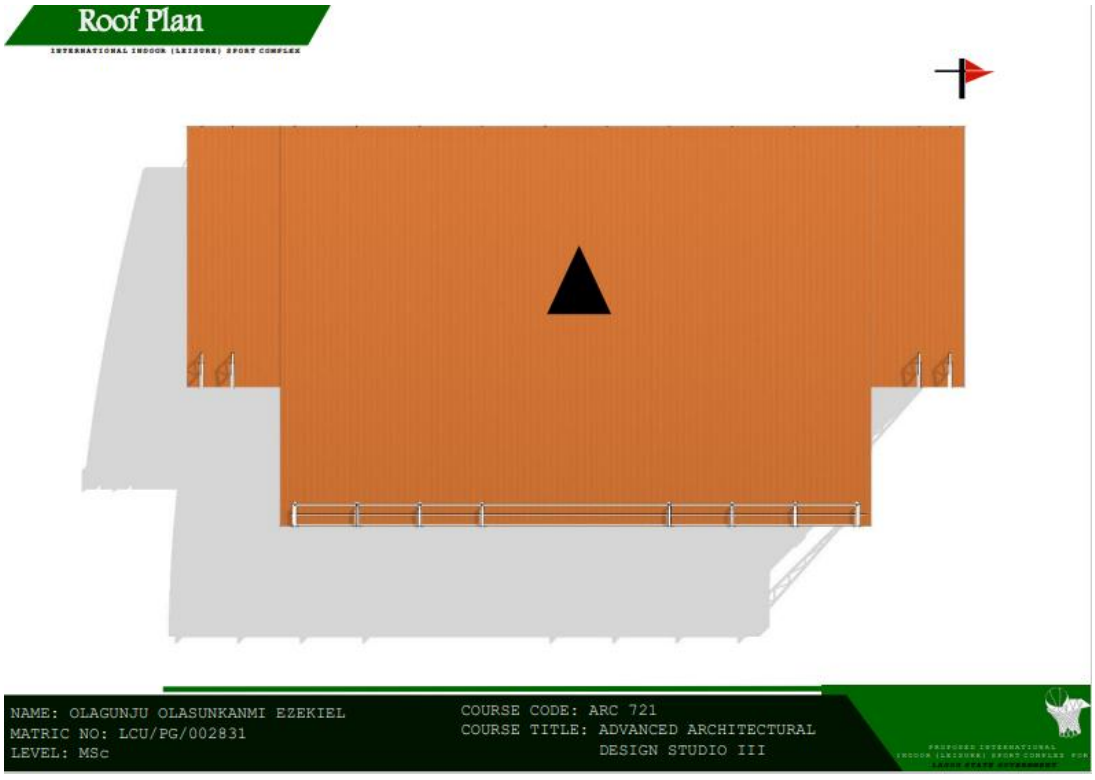
APPENDIX B – GROUND FLOOR PLAN OF PROPOSED SPORT COMPLEX



APPENDIX C – MEZZAINE FLOOR PLAN OF PROPOSED SPORT COMPLEX



APPENDIX D – FIRST FLOOR PLAN OF PROPOSED SPORT COMPLEX



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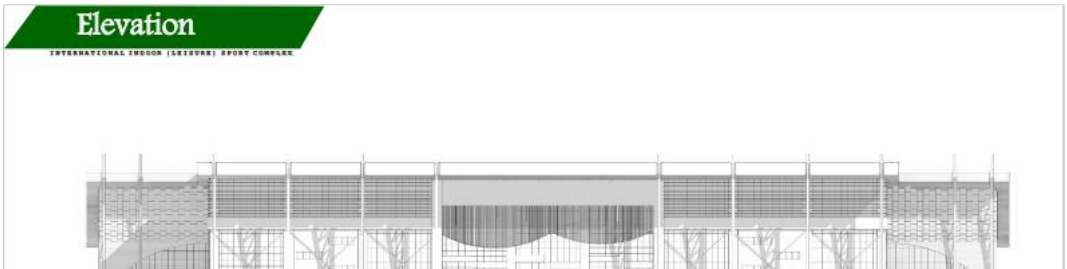
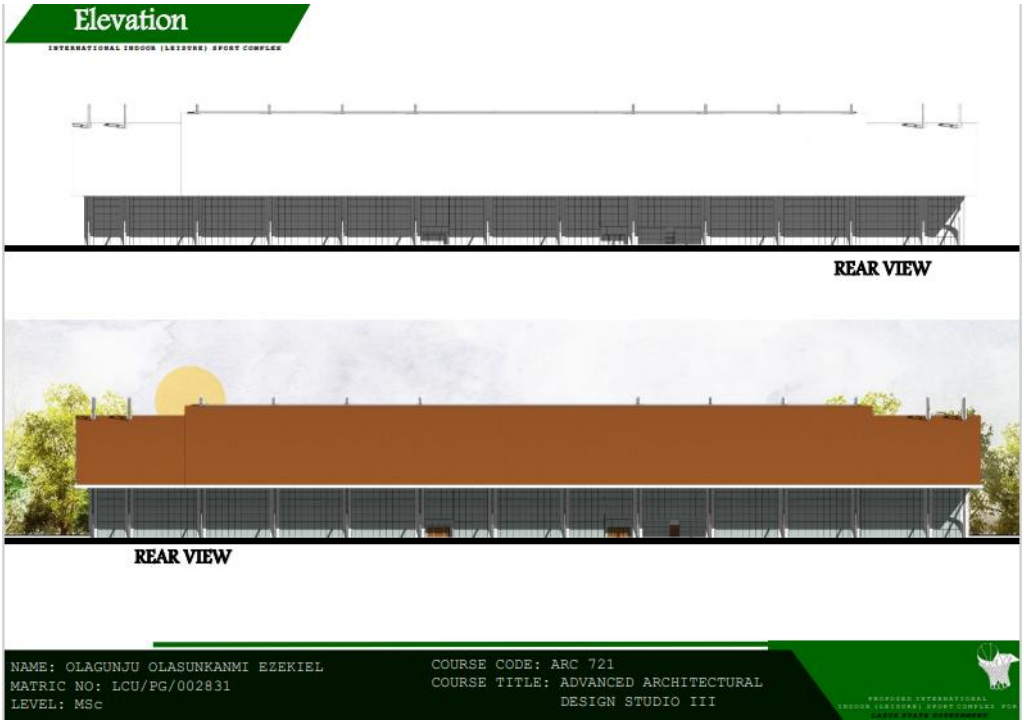


APPENDIX F - ELEVATION OF PROPOSED SPORT COMPLEX



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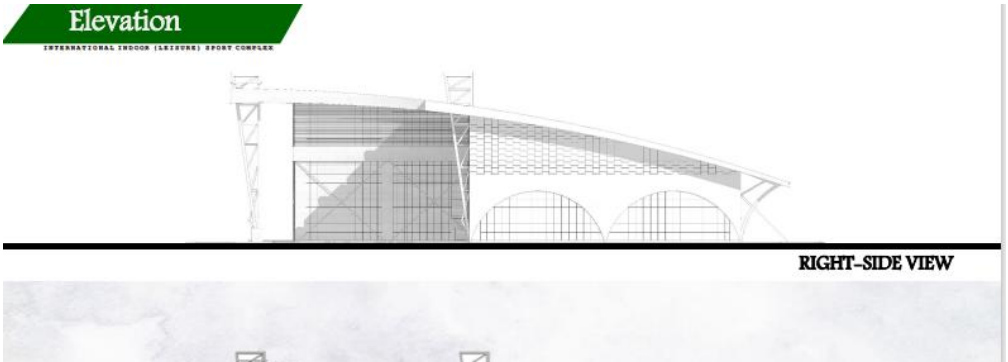
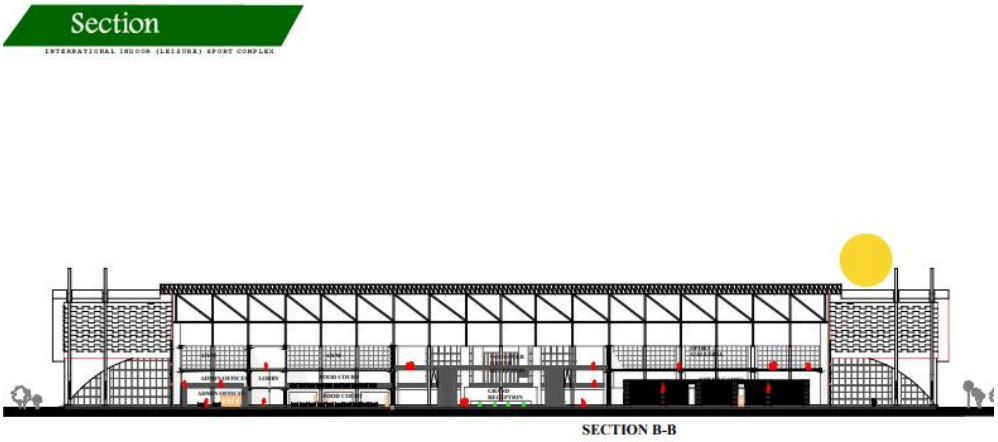


APPENDIX H - ELEVATION OF PROPOSED SPORT COMPLEX

APPENDIX I - ELEVATION OF PROPOSED SPORT COMPLEX

APPENDIX J - SECTION OF PROPOSED SPORT COMPLEX



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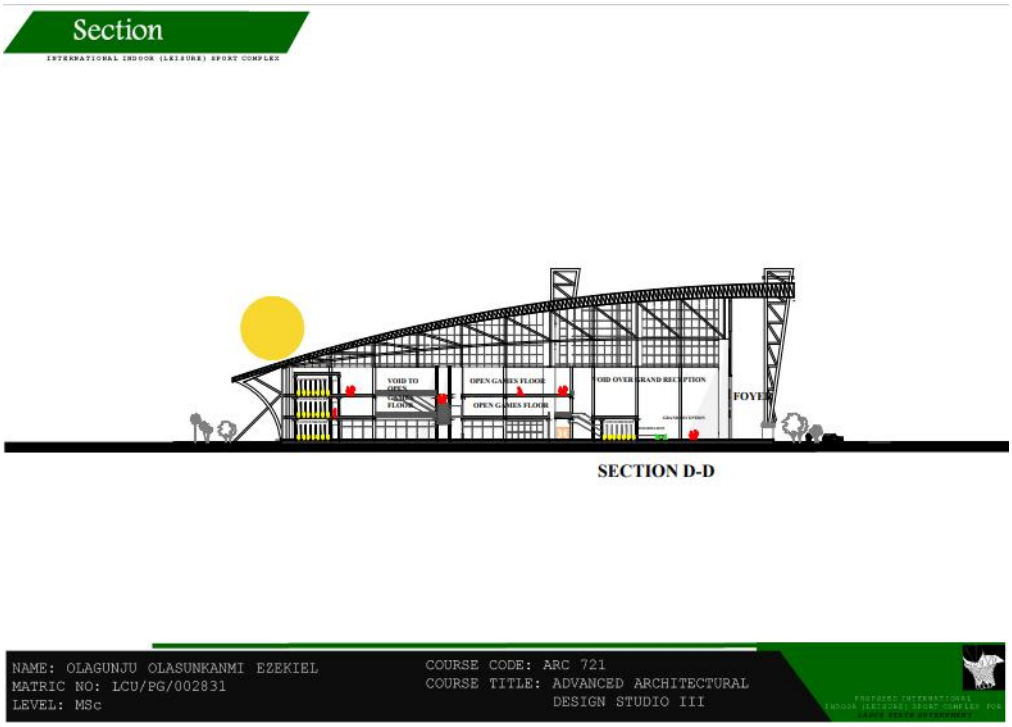
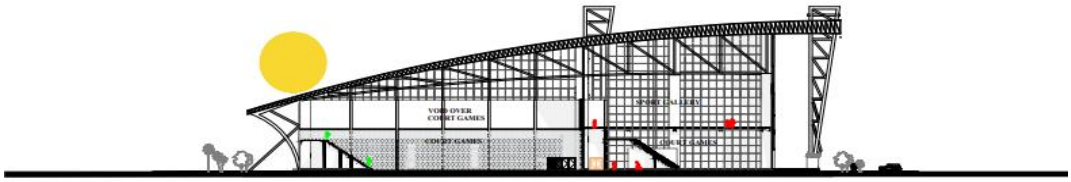
APPENDIX L - SECTION OF PROPOSED SPORT COMPLEX



APPENDIX M - SECTION OF PROPOSED SPORT COMPLEX

Section

INTERNATIONAL INDOOR (LEISURE) SPORT COMPLEX



SECTION E-E

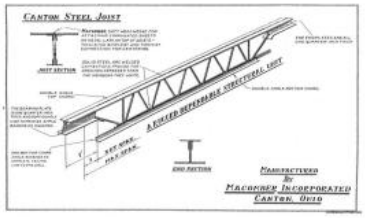
NAME: OLAGUNJU OLASUNKANMI EZEKIEL
MATRIC NO: LCU/PG/002831
LEVEL: MSc

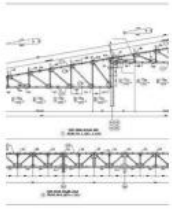
COURSE CODE: ARC 721
COURSE TITLE: ADVANCED ARCHITECTURAL DESIGN STUDIO III

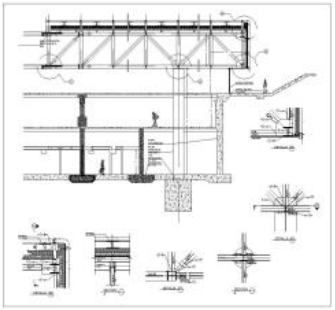
APPENDIX N - SECTION OF PROPOSED SPORT COMPLEX

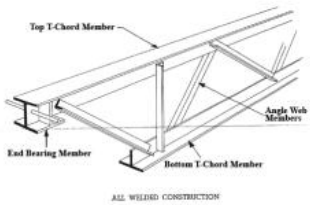
Details

INTERNATIONAL INDOOR (LEISURE) SPORT COMPLEX









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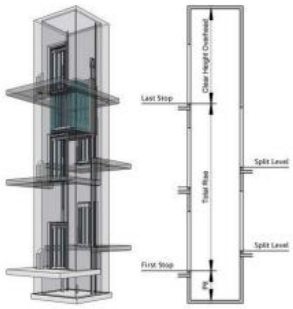

ELEVATOR DETAILS

NAME: OLAGUNJU OLASUNKANMI EZEKIEL
MATRIC NO: LCU/PG/002831
LEVEL: MSc

COURSE CODE: ARC 721
COURSE TITLE: ADVANCED ARCHITECTURAL DESIGN STUDIO III

APPENDIX O - DETAILS OF PROPOSED SPORT COMPLEX

\

Biodata

A. Personal Data

1. Full Name:	OLAGUNJU, Olasunkanmi Ezekiel
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3. Email Adress:	olasunkanmi.olagunju09@gmail.com, ezekiel.o@megascope.co.uk
4. Phone Number:	+2348108440066
5. Date of Birth:	7th July, 1983
6. Place of Birth:	IBADAN, OYO STATE

7. Nationality: NIGERIAN

8. Marital Status: MARRIED

9. Name and Address of Next of Kin: OLAGUNJU, Abimbola Loveth

+447818932550

B. Educational Background

1. Educational Institutions Attended with Dates and Qualification:

Qualifications	Institution	Date
MSc Architecture	Lead City University, Ibadan, Oyo State.	2021 - Date (Ongoing)
BSc. Architecture (First Class Degree Honour)	Lead City University, Ibadan, Oyo State.	2019-2021
HND. Architecture (Upper Credit)	Moshood Abiola Polytechnic, Abeokuta, Ogun State.	2006 - 2008
OND.	The Polytechnic Ibadan, Saki Campus, Oyo State	2001-2003
Secondary School Certificate	Federal Government College, Ogbomoso, Oyo State.	1995-2001

Primary School leaving Certificate	Moyosore International Nursery and Primary School, Ibadan, Oyo State.	1989-1995

C. Awards and Fellowships:

i. Certificate of Participation; Who wants to be an Architect? 2018

D. Work Experience: With Dates

Company	Description	Date
Decent Design and Construction Limited, Abeokuta, Ogun state	• Project Manager • Lead Consulting and Program Management	2011– 2020
Desired Choice Step Limited, Ring road, Ibadan, Oyo State.	• Architectural Technician • Office Manager	2009-2011
AB.DT Partnership, Dugbe, Ibadan, Oyo	• Internship and Architectural Training	2003-2006

State.

E. Publications

"An Investigation into Energy in Nigeria Public Buildings"

…… ……

Signature Date

The University Compliance Certification

This is to certify that the Thesis by Olasunkanmi Ezekiel, OLAGUNJU, with matriculation number LCU/PG//002831 in the Department of Architecture, Faculty of Environmental Design and Management Lead City University, Ibadan, is in full compliance with the University format and style of Thesis.

…… ……

Signature Date

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