INTEGRATION OF GREEN ENERGY INTO BUILDING DESIGN AND CONSTRUCTION CASE STUDY PROJECT: "WATER CUBE" PROJECT FOR THE BEIJING OLYMPICS IN CHINA

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INTEGRATION OF GREEN ENERGY INTO BUILDING DESIGN AND CONSTRUCTION CASH STUDY PROJECT: "WATER CUBE" PROJECT FOR THE BEIJING OLYMPICS IN CHINA

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ABSTRACT

Green energy is the new drift and prospected to our energy needs and the failing climate with the environment decline since energy use and demand cannot be done without. man must do work and energy is of critical importance on the domestic or commercial front. This necessitates for acknowledging the need for better energy can be lowered where possible, the supply can be increased or sustained but also in the best possible and environmentally safe way whilst improving on the efficiency of energy use itself.

This dissertation uses a reckonable case study to reference the use and application of green energy and technology on a gigantic scale project by ARUP, in Beijing china, the aquatics centre for the Olympics, nick named the *"watercube"* and showing the possibility that it is even much more easily achievable on lower scales in west Africa, especially Nigeria.

It takes us through the specific design and need based processes as reported by engineers and architects that were part of the cross-continental project while highlighting on the practically of green energy structures in Nigeria looking at Oyo state under the microscope of arc-GIS to show viable sites to locate solar passive low cost houses should they be needed to meet the high housing and power demand in the country.

Conclusions hinge on the fact that green energy is practicable and needful in Africa, Nigeria.

Keywords: green energy, climate, *watercube,* solar-passive houses.

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DEDICATION

I dedicate this project to GOD Almighty, I also extend my dedication to, Ogeneochukome Akpodiete, James Ogundiran and family, for the support and understanding you showed me throughout the project.

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I want to thank the faculty and school for the privilege to have been a part for the programme.

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Ogundiran John Omomoluwa

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CERTIFICATION

I certify that this work was carried out by Ogundiran John O. of the Department of Mechanical Engineering, Faculty of Technology, University of Ibadan.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 GENERAL BACKGROUND-

Energy remains the capacity or ability to do useful work! Today the need for the sustainable supply of energy amidst skyrocketing energy demands, due to manifold reasons, has been a strong contention at all levels of energy application or requirement. Also more than ever, is the need to fulfill the common resolve by various countries of the world where energy is manufactured or used, especially in the developed and developing countries, to produce energy at the best possibly affordable price but most importantly in an environment friendly method with little or no ecological or/and climatic consequence, either when the energy is being made or used. Hence the reason for the consistent clamor for GREEN ENERGY at all levels of application.

1.2 PROBLEM STATEMENT

There is the need to gratify the quest for increased efficiency of energy use amidst the nagging inadequacy of energy supply whilst abiding to the new world policy to reduce $C0_2$ emissions via reduced dependence on fossil fuels but an increased reliance and harvesting of renewable energy resources. Thus there is the need to incorporate green energy into building, facilities, utilities design and construction especially in under developed regions of the world like west Africa; Nigeria, Ghana, Benin republic etc. where there is a wild embrace of housing construction, utilities development and construction infrastructure in the face of the power challenge of inadequate supply, transmission and distribution asides other militating factors.

1.3 OBJECTIVES-

There are key objectives which are relevant to this study as guides in research and interpretation (design analysis) of facts through the sample case study (water cube project)

1. To make bare the concepts of green energy design integration in construction
2. To show its feasibility i.e. it is possible to go green with respect to energy on the platform of construction projects
3. To show the benefits and huge prospects of increased efficiency of energy use and deployment.
4. To show the importance of engaging renewable energy in respect of climate and

environmental concerns

5. To show that it is practicable in West Africa and more locally Nigeria.

1.4 SIGNIFICANCE OF STUDY

- AT the end of this project work, it will be vivid the possibilities, processes and design requirements to deploy green energy in architecture and construction

- Also it will be made clear how we can leverage on the massive construction projects going on in the country to make positive strides in the clamor for a safer environment through green energy. Finally, the advantages of increased energy efficiency through renewable energy

1.5 THE SCOPE

This study shall be limited to evaluating the integration of green energy considerations in design and construction of building, facilities, utilities infrastructure, how it can be done? What the requirements are? And finally the benefits to environment and role in increasing energy supply and efficient use

1.6 LIMITATION OF STUDY

The study will be limited to analysis of reference case study to show green energy benefits and use, the process of integration into building design and also attempt to give viable suggestions if it were to be deployed by Oyo state in its low housing building scheme pursuit.

CHAPTER TWO

2.0 WHAT IS A GREEN BUILDING?

- ***Energy****-Thermal and electrical energy are mainly generated by the combination of resources. During the conversion of coal , oil gas and other fossil fuels, the majority of the energy obtained is lost in the form of waste heat, for example around 2/3 is lost in generation of electricity. The use of fossil fuel-based energy systems is increasingly called into question by increasing raw material prices, uncertain availability, as well as the harmful effects on the climate. At the same time , the cost of renewable energy sources is falling , which means that not only do they help safeguard the global environment but in many sectors also represent the best alternative in terms of price.*
- ***Primary energy***

  Primary energy designates potentially available and naturally occurring energy in the form of oil, coal, sun or wind, prior to conversion.
- ***Grey energies***

The energy required for the manufacture, maintenance and disposal of building materials and components is referred to "grey energy". Considered over the whole life cycle, in highly efficient buildings it contributes more to the environmental impact and the energy balance than the heating, cooling and electricity used in operating the building. A careful selection of the construction methods and materials can help considerably with energy savings. A long service life spreads the grey energies over a longer period, thereby reducing the energy budget and the consequent effects on the environment

There are many definitions of what a green building is or does. Definitions may range from a building that is "Not as bad" as the average building in terms of its impact on the environment or one that is "notably better" than the average building, to one that may even represent a regenerative process where there is actually an improvement and restoration of the site and its surrounding environment. The ideal "green" project preserves and restores habitat which is vital for sustaining life and becomes a net producer and exporter of resources, materials, energy and water rather than being a net consumer. A green building is one whose construction and lifetime of operation assure the healthiest possible environment while representing the most efficient and least disruptive use of land, water, energy and resources. The optimum design solution is one that effectively emulates all the natural systems and conditions of the pre-developed site – after development is complete.

While many green materials and technologies do cost more, it has been demonstrated that many green strategies and technologies actually cost the same and some even cost less than traditional "not-so-green" technologies.

By blending the right mix of green technologies that cost less with green technologies that cost the same or slightly more, it is possible to have a very green building project that costs the same as a conventional one. Often the key to a cost effective green building and site design lies within the interrelationships and associated cost and performance trade-offs that exist between different building systems. For example, the use of high performance windows and window frames increases the first cost of the building envelope, however the resulting reduction in the size and cost of the buildings heating and cooling system more than offsets the added cost of the better glazing system. The result is a building that has a comparable or perhaps even a lower first cost, a higher comfort level, lower energy use, and lower energy bills and operating cost for the life of the building. The Commonwealth of Pennsylvania Department of Environmental Protection (PA/DEP) recently completed two green buildings – the DEP South Central Regional Office Building in Harrisburg, PA, (USGBC LEED Bronze certified) and the DEP Southwestern Regional Mining Office in Cambria, PA, (USGBC LEED Gold certified), that are living examples of cost effective green building projects.

2.1 DECISION TO BUILD GREEN

It is critical to make the decision to build a green building early in the design process in order to maximize the green potential, minimize redesign, and assure the overall success and economic viability of the green elements of the building project. Making a commitment to build green and establishing firm environmental objectives for the project must be done as early as possible because opportunities for incorporating green technologies and design solutions become less and less available and increasingly costly to implement as the project design and construction process progresses. Ideally, the decision to build green should be made before the site is selected, as many of the green criteria are affected by site characteristics and some sites are inappropriate for certain green projects.

- **SETTING GREEN GOALS AND OBJECTIVES**

Once the decision to build green has been made, one of the first steps in the green design process is to establish firm environmental goals for the project. This is often done during what is called a goal setting or targeting session. During this session, it is important to set specific measurable goals for things like energy efficiency, water conservation, on-site treatment of rain water and storm water, material and resource management, construction waste management, and to assign responsibility for meeting these goals to specific members of the design team. Each goal needs a champion who will see that objective through to the end. If the building is to be built in accordance with the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) green building rating system, it will be helpful to review the requirements of LEED as part of the green project goal setting session, begin targeting which elements of LEED are going to be pursued, and establish firm criteria for meeting those goals.

❖ BUILDING A GREEN TEAM

Hiring a design team with prior green design experience is highly desirable, but not essential provided that the design team is augmented with architects or engineering consultants who do have experience in green building and site design principles and technologies. The collective knowledge, experience, and dedication of the design team will determine the overall success of the green project. All members of the green team should participate in the project goal setting session. Once the goal setting process has been completed it may become obvious that meeting certain goals may require expertise that lies outside the current design team. Specialized consultants may need to be engaged for specific elements of the design and construction process or to oversee all elements of the green design program. These specialists will be able to bring new ideas and solutions to the table for consideration and should be included in the project as early as possible.

❖ INTEGRATED DESIGN PROCESS

Integrated building design is a process that can be used by building owners and designers to cost-effectively lower building operating costs while improving the comfort and productivity of building occupants. It is a key strategy for meeting and exceeding California's Title 24 energy code, which raises the bar of energy efficiency because it is updated every few years.

Building a green building is not just a matter of assembling a collection of the latest green technologies or materials. Rather, it is a process in which every element of the design is first optimized and then the impact and interrelationship of various different elements and systems within the building and site are re-evaluated, integrated, and optimized as part of a whole building solution. For example, interrelationships between the building site, site features, the path of the sun, and the location and orientation of the building and elements such as windows and external shading devices have a significant impact on the quality and effectiveness of natural day lighting. These elements also affect direct solar loads and overall energy performance for the life of the building. Without considering these issues early in the design process, the design is not fully optimized and the result is likely to be a very inefficient building. This same emphasis on integrated and optimized design is inherent in nearly every aspect of the building from site planning and use of on-site storm water management strategies to envelope design and detailing and provisions for natural ventilation of the building. This integrated design process mandates that all of the design professionals work cooperatively towards common goals from day one.

To make integrated building design work, practitioners typically take these six actions when designing and constructing a building

- They make a commitment to the integrated design process, and they back that commitment up by giving the project team members the time and resources they need to see the process through.
- They identify integrated design strategies that will reduce lifetime costs while also improving occupant comfort.
- They do whole-building analyses that treat a building and the site it sits on as a complete system, taking into account the interactions among all of the building's systems.
- They base design decisions on life-cycle economics, emphasizing the full lifetime value of proposed building improvements.
- They follow through by ensuring that the integrity of the design is maintained throughout the construction process.
- They check their work repeatedly after the project is finished in order to verify that building performance does—and continues to—live up to expectations.

The exemplary buildings produced through the integrated building design process consume less than half the energy of comparable buildings that have been conventionally designed, while providing a comfortable, healthy indoor environment.

2.2 DEPLOYMENT, STRATEGY AND TECHNOLOGICAL APPROACH

In summary below, are the key principles, strategies and technologies which are associated with the five major elements of green building design

2.2.1 ELEMENTS OF A GREEN BUILDING PROJECT

1. Sustainable Site Design;
2. Water Conservation and Quality;
3. Energy and Environment;
4. Indoor Environmental Quality;
5. Conservation of Materials and Resources.

This information supports of the use of the USGBC LEED Green Building Rating System, but focuses on principles and strategies rather than specific solutions or technologies, which are often site-specific and will vary from project to project.

1. **Sustainable Site Design**

Key Principles:

Minimize urban sprawl and needless destruction of valuable land, habitat and green space, which results from inefficient low-density development. Encourage higher density urban development, urban re-development and urban renewal, and Brownfield development as a means to preserve valuable green space.

Preserve key environmental assets through careful examination of each site. Engage in a design and construction process that minimizes site disturbance and which values, preserves and actually restores or regenerates valuable habitat, green space and associated eco-systems that are vital to sustaining life.

Key Strategies and Technologies:

• Make more efficient use of space in existing occupied buildings, renovate and re-use existing vacant buildings, sites, and associated infrastructure and consider re-development of Brownfield sites. Design buildings and renovations to maximize future flexibility and reuse thereby expanding useful life.

• When new development is unavoidable, steer clear of sites that play a key role in the local or regional ecosystem. Identify and protect valuable Greenfield and wetland sites from development.

• Recognize that allowing higher density development in urban areas helps to preserve green space and reduce urban sprawl. Invest time and energy in seeking variances and regulatory reform where needed.

• Evaluate each site in terms of the location and orientation of buildings and improvements in order to optimize the use of passive solar energy, natural day lighting, and natural breezes and ventilation.

• Make best use of existing mass transit systems and make buildings and sites pedestrian and bike friendly, including provisions for safe storage of bicycles. Develop programs and incentives that promote car-pooling including preferred parking for commuters who carpool. Consider making provisions for re-fueling or recharging alternative fuel vehicles.

• Help reduce the urban heat island effect by reducing the building and site development footprint, maximizing the use of pervious surfaces, and using light colored roofs, paving, and walkways. Provide natural shading of buildings and paved areas with trees and other landscape features.

• Reduce impervious areas by carefully evaluating parking and roadway design. Pursue variances or waivers where local ordinances may unintentionally result in the over-design of roadways or parking.

• Optimize the use of on-site storm water treatment and ground water recharge. Minimize the boundaries of the construction area, avoid needless compaction of existing topsoil, and provide effective sedimentation and silt control during all phases of site development and construction.

• Use landscape design to preserve and restore the region's natural habitat and heritage while emphasizing the use of indigenous, hardy, drought resistant trees, shrubs, plants and turf.

• Help reduce night-time light pollution by avoiding over-illumination of the site and use low cut-off exterior lighting fixtures which direct light downward, not upward and outward.

2. Water Quality and Conservation

Key Principles:

Preserve the existing natural water cycle and design site and building improvements such that they closely emulate the site's natural "pre-development" hydrological systems. Emphasis should be placed on retention of storm water and on-site infiltration and ground water recharge using methods that closely emulate natural systems. Minimize the unnecessary and inefficient use of potable water on the site while maximizing the recycling and reuse of water, including harvested rainwater, storm water, and gray water.

Key Strategies and Technologies:

• Recognize that the least costly, least time consuming and most environmentally preferable design for site and storm water management is often the one in which the design of buildings and site improvements respect the existing natural flows and features of the land instead of designing the building and site improvements with total disregard for the site, which results in needless, extensive, disruptive, costly and time consuming excavation and earthmoving.

• Conduct a thorough site assessment and strategically locate buildings and site improvements so as to preserve key natural hydrological features. Special effort should be made to preserve areas of the site that serve as natural storm water retention and ground water infiltration and recharge systems. Preserve existing forest and mature vegetation that play a vital role in the natural water cycle by absorbing and disbursing up to 30% of a site's rainwater through vapor-transpiration.

• Minimize the building's footprint, site improvements and construction area, and minimize excavation, soil disturbance and compaction of existing topsoil as this soil in its natural un-compacted state serves a vital role in absorbing and storing up to 80% of natural rainfall until it can be absorbed by vegetation or enter the site's natural sub-surface ground water system.

• Design and locate buildings and site improvements to optimize use of low-impact storm water technologies such as bio-retention, rain gardens, open grassy swales, pervious bituminous paving, pervious concrete paving and walkways, constructed wetlands, living/vegetated roofs, and other technologies that support on-site retention and ground water recharge or vapor-transpiration. Storm water that leaves the site should be filtered and processed naturally or mechanically to remove trash and debris, oil, grit and suspended solids. Use "hold and release" technologies such as dry retention ponds only as a last resort as these technologies do not preserve the natural water cycle, have little or no benefit in terms of ground water recharge and result in needless additional site disturbance.

• Establish a water budget for the building and implement a design that minimizes the use of potable water by using low-flow plumbing fixtures and toilets and waterless urinals. Harvest, process and recycle rainwater, site storm water, and building gray water and identify appropriate uses within the building and site. Use on-site treatment systems that enable use of rain water for hand washing, gray water for toilet flushing, rain and storm water for site irrigation, cooling tower make-up and other uses.

• Conserve water and preserve site and ground water quality by using only indigenous, drought resistant and hardy trees, shrubs, plants and turf that require no irrigation, fertilizers, pesticides or herbicides.

3. Energy and Environment

Key Principles:

Minimize adverse impacts on the environment (air, water, land, natural resources) through optimized building citing, optimized building design, material selection, and aggressive use of energy conservation measures. Resulting building performance should exceed minimum International Energy Code (IEC) compliance level by 30 to 40% or more. Maximize the use of renewable energy and other low impact energy sources.

Key Strategies and Technologies:

• Optimize passive solar orientation, building massing and use of external shading devices such that the design of the building minimizes undesirable solar gains during the summer months while maximizing desirable solar gains during winter months.

• Optimize building orientation, massing, shape, design, and interior colors and finishes in order to maximize the use of controlled natural day lighting which significantly reduces artificial lighting energy use thereby reducing the buildings internal cooling load and energy use. Consider the use of light shelf technology.

• Use high performance low-e glazing, which can result in significant year round energy savings. Consider insulated double glazing, triple glazing or double pane glazing with a suspended low-e film. Selective coatings offer optimal light transmittance while providing minimal solar gain and minimal heat transmission. Window frames, sashes and curtain wall systems should also be designed for optimum energy performance including the use of multiple thermal breaks to help reduce energy use.

• Optimize the value of exterior insulation and the overall thermal performance of the exterior envelope assembly. Consider advanced/high performance envelope building systems such as structural insulated panel systems (SIPS) and insulated concrete form systems (ICF's) that can be applied to light commercial and institutional buildings. SIPS and ICF's and other thermally "decoupled" envelope systems will offer the highest energy performance.

• Use energy efficient T-8 and T-5 bulbs, high efficiency electronic ballasts, and lighting controls. Consider using indirect ambient lighting with workstation based direct task lighting to improve light quality, reduce glare and improve overall energy performance in general office areas. Incorporate sensors and controls and design circuits so that lighting along perimeter zones and offices can be switched off independently from other interior lights when day lighting is sufficient in perimeter areas.

• Use state-of-the art, high efficiency, heating, ventilation and air conditioning (HVAC) and plumbing equipment, chillers, boilers, and water heaters, etc. Use variable speed drives on fan and pump motors. Use heat recovery ventilators and geothermal heat pump technology for up to 40% energy savings.

• Avoid the use of HCFC and Halon based refrigeration, cooling and fire suppression systems. Optimize the use of natural ventilation and where practical use evaporative cooling, waste heat and/or solar regenerated desiccant dehumidification or absorption cooling. Identify and use sources of waste energy.

• Use Energy Star certified energy efficient appliances, office equipment, lighting and HVAC systems.

• Consider on-site small-scale wind, solar, and/or fuel cell based energy generation and co-generation.

Purchase environmentally preferable "green" power from certified renewable and sustainable sources.

4. **Indoor Environmental Quality**

Key Principles:

Provide a healthy, comfortable and productive indoor environment for building occupants and visitors. Provide a building design, which affords the best possible conditions in terms of indoor air quality, ventilation, and thermal comfort, access to natural ventilation and day lighting, and effective control of the acoustical environment.

Key Strategies and Technologies:

• Use building materials, adhesives, sealants, finishes and furnishings which do not contain, harbor, generate or release any particulate or gaseous contaminants including volatile organic compounds.

• Maximize the use of natural day lighting. Optimize solar orientation and design the building to maximize penetration of natural daylight into interior spaces. Provide shades or daylight controls where needed.

• Maximize the use of operable windows and natural ventilation. Provide dedicated engineered ventilation systems that operate independently of the buildings heating and cooling system. Ventilation systems should be capable of effectively removing or treating indoor contaminants while providing adequate amounts of fresh clean make-up air to all occupants and all regions of the building. Monitor indoor air conditions including temperature, humidity and carbon dioxide levels, so that building ventilation systems can respond when space conditions fall outside the optimum range.

• Provide a smoke free building. When smoking must be accommodated, provide completely dedicated smoking areas are physically isolated, have dedicated HVAC systems, and remain under negative pressure with respect to all adjoining spaces. Assure that air from smoking areas does not get distributed to other areas of the building does not re-enter the building through doors or vestibules, operable windows, or building fresh air intakes.. Locate outdoor smoking areas so that non-smokers do not have to pass through these areas when using primary building entrances or exits.

• Design building envelope and environmental systems that not only treat air temperature and provide adequate ventilation, but which respect all of the environmental conditions which affect human thermal comfort and health, including the mean radiant temperature of interior surfaces, indoor air humidity, indoor air velocity, and indoor air temperature. Following these principles and providing a building that is also responsive to seasonal variations in desirable indoor humidity levels, air velocity, and mean radiant temperatures can also result in significant energy savings as improved occupant comfort results in less energy intensive operation of the buildings air-side heating and cooling system.

• Maximize occupant health, comfort and performance by providing occupants with individual space/zone control of heat, ventilation, cooling, day-lighting and artificial lighting whenever possible.

• Prevent contamination of the building during construction. Take steps to minimize the creation and spreading of construction dust and dirt. Prevent contamination of the building and the buildings heating, cooling and ventilation systems during the construction process. Protect construction materials from the elements so that they do not become damp, moldy or mildewed.

• Provide a clean and healthy building. Use biodegradable and environmentally friendly cleaning agents that do not release VOCs or other harmful agents and residue. Prior to occupancy install new air filters and clean any contaminated ductwork and ventilation equipment. Use fresh outdoor air to naturally or mechanically purge the building of any remaining airborne gaseous or particulate contaminants.

5. Materials and Resources

Key Principles:

Minimize the use of non-renewable construction materials and other resources such as energy and water through efficient engineering, design, planning and construction and effective recycling of construction debris. Maximize the use of recycled content materials, modern resource efficient engineered materials, and resource efficient composite type structural systems wherever possible. Maximize the use of re-usable, renewable, sustainably managed, bio-based materials. Remember that human creativity and our abundant labor force is perhaps our most valuable renewable resource. The best solution is not necessarily the one that requires the least amount of physical work.

Key Strategies and Technologies:

• Optimize the use of engineered materials which make use of proven engineering principles such as engineered trusses, composite materials and structural systems (concrete/steel, other…), structural insulated panels (stress skin panels), insulated concrete forms, and frost protected shallow foundations which have been proven to provide high strength and durability with the least amount of material.

• Identify ways to reduce the amount of materials used and reduce the amount of waste generated through the implementation of a construction waste reduction plan. Adopt a policy of "waste equals food" whereby 75% or more of all construction waste is separated for recycling and used as feedstock for some future product rather than being land filled. Implement an aggressive construction waste recycling program and provide separate, clearly labeled dumpsters for each recycled material. Train all crews and subcontractors on the policy and enforce compliance.

• Identify ways to use high-recycled content materials in the building structure and finishes. Consider everything from blended concrete using fly ash, slag, recycled concrete aggregate, or other admixtures to recycled content materials such as structural steel, ceiling and floor tiles, carpeting, carpet padding, sheathing, and gypsum wallboard. Consider remanufactured office furniture and office partition systems, chairs and furniture with recycled content or parts.

• Explore the use of bio-based materials and finishes such as various types of agro-board (sheathing and or insulation board made from agricultural waste and byproducts, including straw, wheat, barley, soy, sunflower shells, peanut shells, and other materials). Some structural insulated panels are now made from bio-based materials. Use lumber and wood products from certified forests where the forest is managed and lumber is harvested using sustainable practices. Use resource efficient engineered wood products in lieu of full dimension lumber which comes from older growth forests.

• Evaluate all products and systems used for their ability to be recycled when they reach the end of their useful life. Preference should be given to products and systems that facilitate easy, non-energy intensive separation and recycling with minimal contamination by foreign debris.

• Recognize that transportation becomes part of a product or building materials embodied energy. Where practical, specify and use locally harvested, mined and manufactured materials and products to support the regional economy and to reduce transportation, energy use and emissions.

2.3 WHY GREEN ENERGY?

These advantages and inherent benefits give rise to why green energy is being integrated

- The advantage cuts across critical factors that ultimately impact on the following
- Environmental preservation and ecological restoration
- Reduction in long term operational and service cost for facilities and building
- Support for a reversal in the depletion of the ozone hence recovery of drastic climate changes and general global warming concerns
- The economics of building and energy efficiency concerns
- Environmental aesthetics and functionality
- Consequent preservation of wildlife and biodiversity characteristic to certain region
- Reduced material wastage whether in building construction or otherwise
- Reduced pollution in air, noise etc

2.5 ENERGY EFFICIENCY IN BUILDING

"Energy efficient buildings are designed in a way that ensures that energy is used at a reduced cost, and in a sustainable and conserved manner. Energy efficient building is a panacea to attaining a "sustainable city or eco-city". Eco-cities are designed to achieve maximum comfort by occupants with emphasis on reduced energy inputs, water and food, waste output of heat, and reduced air, noise and water pollution (Devuyst, 2011., Eco-city, 2011.,). Energy efficient building is relatively unknown in Nigeria due to certain factors which include: ignorance/illiteracy, poverty, lack of awareness and/or poor Government policies toward achieving such concepts in buildings.

- **Ignorance/illiteracy**

Most developing countries are known for high illiteracy rate. According to the report of the Minister of State for Education in Nigeria, adult illiterates rose from 25 million in 1997 to 35 million in 2013 (Vanguard, 2013). Specifically adult literacy rate is about 56.9% of the total population (National Bureau of Statistics, 2010, Murtala et. al., 2013). This makes the focus of most citizens on buildings to be more on quick gains without consideration on sustainability of the environment and climate. Also with such high degree of illiteracy, majority of the citizens need to be educated on the need for energy efficiency in buildings to enable them understands the merits.

- **Poverty**

Nigeria has a population of 2,176,947 based on 2006 census (National Population Commission, 2006, National Bureau of Statistics, 2010). The poverty rate in Nigeria is still alarming. In Nigeria, an estimated 54 per cent of the population lives below the poverty line (43 per cent urban, 64 per cent rural), and 90 per cent of the poorest people live in the north (Nigeria Country Programme document, 2014-2017, UNICEF). Poverty is a strong limiting factor to energy efficient buildings as money is needed to procure the materials and human resource needed to execute such buildings.

- **Lack of awareness**

Most Nigerians are not aware that buildings can influence our environment and climate. They are more concerned with the aesthetic values and volume of modern technological gadgets in buildings without knowledge of the negative implications of such devices. In some rural areas, seasonal variations and weather changes which are possibly due to climate change are rather attributed to primitive religious beliefs. Thus the need for awareness on the influence of energy efficient buildings on the environment to be created in the minds of the citizenry cannot be overstressed.

Lack of Government policies Lack of Government policies on achieving energy efficient buildings for sustainable environment and development is another contributing factor. The Government (Federal, State and Local) are yet to come up with strong policy that will ensure that buildings are regulated to ensure that energy efficiency is achieved. Currently, the Nigerian government has set a target to increase electricity generation by 40,000MW of power by the year 2020 (Nnaji, 2012) and subsequently, many gas-powered stations have been commissioned to increase generation and many more are expected to be commissioned to meet up with energy demand. These are non-renewable energy source and will result in the emission of GHGs, leading to global warming to consequently increase climate change. Increased urbanization in most States especially in the housing sector will also add its quota of GHGs to the atmosphere. " (P.A. Nwofe, 2014)

2.6 STRATGIES TO ACHIEVING A GREEN ENERGY EFFICIENT BUILDING

There are strategies or measure to achieving energy efficiency, as we discuss on in the proceeding chapters of the study while reviewing the reference case study (the Water cube, Beijing aquatics center, china) we would see how these strategies were adequately demonstrated to execute the design of such a gigantic yet energy efficient building and functional facility amidst the challenge of material choice, aesthetic requirement and general use of the building. Three categories of measures to employ are

1. Architectural design measures

2. Structural measures

3. Technology measures .This measure may be in two ways deployed:

- *Power/energy technology e.g. solar, wind, cells etc.*

- *Materials type used in the construction and finishing*

A combination in consideration of these three strategies will birth a successful energy efficient building. There are other considerations to however examine while executing these strategies

What is important?

When planning the design process it is important that it supports the entire design team and that it provides an overview and clarity about which problems should be treated in which order. The three basic elements in this process are:

- Programming

- The passive qualities of the building

- The active qualities of the building

What to do? The focus areas concerning environmental sustainability are all about

- creating high thermal comfort (experienced temperature, heating and cooling) visual comfort (light and shading),

- High air quality (fresh air, removal of pollution, surplus heat etc.) and

- Architectural quality.

All these circumstances are affected by the passive qualities of the building, which deals with qualities regarding geometry, design and choice of materials and affect the light, temperature and air in the building. The active qualities deal with the technical installations (lighting, heating, ventilation and cooling) which supplement the passive qualities of the building in order to create a comfortable indoor climate.

How is it done?

The process steps in Integrated Energy Design (IED) suggest an examination of six central themes in a specific order. The process is iterative and has to be run through several times to reach an optimal design. The order is set from the following argumentation:

1. Daylight is the first step after programming, since there is no "technical fix" to compensate for the lack of daylight(besides artificial lighting, which increases energy consumption and adds more heat to the building than daylight, which subsequently must be actively cooled). In the analysis phase, the building is mapped and organized according to the possibilities for using daylight and it gives an overview for planning artificial lighting and its adjustments to this.

2. Fire is the next step, as a well-planned fire strategy offers the best opportunities for creating free movement of the air and gives the possibility of co-thinking fire ventilation with natural comfort ventilation which works by the same principles.

3. Thermal Indoor climate & Air quality is the third and often most demanding step, due to the high complexity and many parameters that influence the experienced air quality and thermal comfort in the building. The result of these analyses deals with insulation, heating and cooling needs, heat accumulation, and heat insulation of windows and specifies the dynamic ventilation needs in the building.

4. Ventilation deals with an analysis of the possibilities for firstly natural ventilation, which does not need electricity and secondly analysis of mechanical ventilation. The fire analysis provides parameters offering conditions for free movements of air. Further on, important steps will be the design of openings, adjustments of openings and checking for acoustic requirements and odor from the surroundings. When planning the mechanical ventilation focus should be on supporting the natural ventilation (hybrid ventilation) and on designing in accordance to the maximum demand for fresh air in the building.

5. Cooling is the last step in the IED (integrated energy design) -process. First we examine the possibilities for using free-cooling which is then supplemented with traditional mechanical cooling.

CHAPTER THREE

3.0 INTRODUCTION

This thesis work will proceed to show green energy relations to building and construction using the case study below to demonstrate the feasibility and technical possibilities of green energy considerations and integration into construction of facilities and buildings at almost any scale given that the case study of choice below is on a complex scale that would have been otherwise thought of as unachievable.

3.1 THE CASE STUDY: WATER CUBE PROJECT IN BEIJING AQUATICS CENTER

The need to place china under the microscope of study especially as it bothers on green energy concerns and its integration into building design and general application is of high relevance. It has been said that **cities** produce 75% of the world's carbon dioxide emissions, and the case of china is quite a typical example and concern to the energy world at large. Therefore in the event of the execution of a green project such as the Water cube in Beijing, china, it becomes no challenge at all for Africa (Nigeria) which is still underdeveloped to study the terms and factors of consideration which engineers, architects, builders and the project team as a whole might have taken to achieve this huge success and feat, not just as one of the most remarkable construction project in the entire world but also as a green success on a humungous scale!

A scaled overview of china relation to green energy and challenging factors ,as the Water cube was planned designed and executed will be hinted in the background detailed below.

However full details are available online and in published material reports of the Water cube project. For this study we will concern ourselves with the considerations in design given to energy and general factors that could guide on similar projects that maybe embarked upon in the country, at state level or federal, even domestic scale.

3.2 BACKGROUND BRIEF ON CASE STUDY

According to the last UNEP (United Nations Environment Programme) study, China has the largest construction volume in the world. Over 80% of the nearly two billion square meters of new buildings constructed each year in China are categorized as high-energy buildings, consuming two to three times more energy per unit of floor space than those in developed countries. Trying to stop this uncontrolled growing, the Chinese Ministry of Construction has now established a target that energy consumption in new buildings should be 65% less than in existing buildings, and the government has established a tax and fees rebate system to help meet this goal. In 2006, a new federal building in Beijing became the first in China to pass the stringent Leadership in Energy and Environmental Design (LEED) certification, using 70% less energy and 40% less water than conventional buildings (Christian Science Monitor, 2006).

Beijing is abuzz about the designs of some landmark buildings under construction or to be constructed. Some Chinese architects and critics say foreign architects have turned the capital city into a test field, some say the designs are avant-garde and some others see these designs as ugly10.

As one can see, this exponential growth is practically unsustainable in a country that has almost no prior experience in sustainable construction. Everything is so new, that all the premises are confused and the government is taking big strides to establish new regulations to guide this fast and uncontrolled development and limit the construction in the central city.

A BRIEF ON CHINA ENERGY CASE

There is no doubt that china accounts for about the highest share in the global emission of greenhouse gases due to obvious reasons; a fast growing industrialized economy with vast energy needs to measure up constantly amidst the high demand in a state of timing population even with their stringent policies on birth control. The logic might be looked at quiet simply has the more a vibrant populace the more their basic energy needs, either bio energy or physical energy and chemical energy, if they must grow, solve problems, do work and develop, energy must be available. This necessitates for a quick overview on the current state of china and non-renewable dependence in relation to impact on environment and climate. It has already been discussed in the previous section how the 3 components relate; energy, environment and climate. If the current state of china is presented and with the rate and capacity of energy produced and consumed, it will be easier to appreciate the reason for an urgent shift to renewable especially as it relates to climate.

China is the largest consumer of coal in the world, and is about to become the largest user of coal-derived electricity, generating 1.95 trillion kilowatt-hours per year, or 68.7% of its electricity from coal as of 2006 (compared to 1.99 trillion kilowatt-hours per year or 49% for the US). Hydroelectric power supplied another 20.7% of China's electricity needs in 2006.With approximately 13 percent of the world's proven reserves, there is debate as to how many years these reserves will last at current levels of consumption .Coal production rose 8.1% in 2006 over the previous year, reaching 2.38 billion tons, and the nation's largest coal enterprises saw their profits exceed 67 billion Yuan, or $8.75 billion.

Coal reserves: As of the end of 2006, China had 62 billion tons of anthracite and 52 billion tons of lignite quality coal. China ranks third in the world in terms of total coal reserves behind the United States and Russia. Most reserves are located in the north and north-west of the country, which poses a large logistical problem for supplying electricity to the more heavily populated coastal areas. At current levels of production, China has 48 years' worth of reserves. However, others suggest that China has enough coal to sustain its economic growth for a century or more even though demand is currently outpacing production.

Coal consumption: China is the largest coal producer in the world. Northern China, especially Shanxi Province, contains most of China's easily accessible coal. Coal from southern mines tends to be higher in sulphur and ash, and therefore unsuitable for many applications. Coal production is rising in China, and in 2013, China built approximately one large coal plant every week.

Coal is the major source of energy in China. In 2011 the Chinese coal production was equivalent to 3,576 Mt*0.522 toe/Mt*11.630 TWh/toe = 21,709 TWh. Assuming the same caloric value for the imported coal the net coal energy available would be evaluated as 22,784 TWh. Assuming imported coal equal to domestic one, available coal (IEA) was about 17,000 TWh in 2008 and 22,800 TWh in 2011, with increase of 5,800 TWh in three years. Total renewable energy in China was 3,027 TWh in 2008 and 2,761 TWh in 2005, with increase of

266 TWh in three years. Same period from 2005 to 2008 annual coal use increased 3,341 TWh.

As energy demand in China continues to increase dramatically, with electric demand estimated to roughly double by 2013, demand for coal in China also continues to increase, and it is estimated that it will be around 3.06 billion tons in 2010. Furthermore, it is expected that demand will soon exceed production due to factors such as a government crackdown on mines that are unsafe, polluting, or wasteful. Some were shut down for the 2008 Summer Olympics. On July 6, 2008 in central and northern China, 2.5% of the nation's coal plants (58 units or 14,020 MW of capacity) had to shut down due to coal shortages. This forced local governments to limit electricity consumption and issue blackout warnings. The shortage is somewhat attributed to the closing of small dangerous coal mines. In 2011, seven Chinese coal mining companies produced 100 million metric tons of coal or more. These companies were Shenmue Group, China Coal, Shaanxi Coal and Chemical Industry, Shanxi Coking Coal Group, Datong Coal Mine Group, Jizhong Energy, and Shandong Energy. The largest metallurgical coal producer was Shanxi Coking Coal Group.

China's installed coal-based electrical capacity was 484 GW, or 77% of the total electrical capacity, in 2006. The dominant technology in the country is coal pulverization in lieu of the more advanced and preferred coal gasification. China's move to a more open economy in the 1990s is cited as a reason for this, where the more immediately lucrative pulverization technology was favored by businesses. There are plans in place for an Integrated Gasification Combined Cycle (IGCC) type plant by 2010. Furthermore, less than 15% of plants have desulphurization systems.

China's energy consumption is mostly driven by the industry sector, the majority of which comes from coal consumption. One of the principal users is the steel industry in China. In cities the domestic burning of coal is no longer permitted. In rural areas coal is still permitted to be used by Chinese households, commonly burned raw in unvented stoves. This fills houses with high levels of toxic metals leading to bad Indoor Air Quality (IAQ). In addition, people eat food cooked over coal fires which contains toxic substances. Toxic substances from coal burning include arsenic, fluorine, polycyclic aromatic hydrocarbons, and mercury. Health issues are caused which include severe arsenic poisoning, skeletal fluorosis (over 10 million people afflicted in China), esophageal and lung cancers, and selenium poisoning.

As of September 2014, the People's Republic of China has 21 nuclear power reactors operating on 8 separate sites and 28 under construction. Additional reactors are planned, providing 58GWe of capacity by 2020. China's National Development and Reform Commission have indicated the intention to raise the percentage of China's electricity produced by nuclear power from the current 2% to 6% by 2020 (compared to 20% in the USA and 74% in France). However, rapid nuclear expansion may lead to a shortfall of fuel, equipment, qualified plant workers, and safety inspectors. Due to increasing concerns about air quality, climate change and fossil fuel shortages, nuclear power has been looked into as an alternative to coal power in China. China has two major nuclear power companies, the China National Nuclear Corporation operating mainly in north-east China, and the China Guangdong Nuclear Power Group operating mainly in south-east China. The People's Republic of China is also involved in the development of nuclear fusion reactors through its participation in the ITER project, having constructed an experimental nuclear fusion reactor known as EAST located in Hefei, as well as research and development into the thorium fuel cycle as a potential alternative means of nuclear fission.

Most nuclear power plants in China are located on the coast and generally use seawater for cooling a direct once-through cycle. The *New York Times* has reported that China is placing many of its nuclear plants near large cities, and there is a concern that tens of millions of people could be exposed to radiation in the event of an accident. China's neighboring Guangdong and Lingao nuclear plants have around 28 million people within a 75-kilometre radius that covers Hong Kong.

Coal is emerging as a major topic of conversation at the United Nations climate-change negotiations currently taking place in Warsaw – and rightly so. Indeed, it is a discussion that the world needs to have.

The latest findings of the Intergovernmental Panel on Climate Change conclude that we are quickly using up 'our carbon budget' – the amount of carbon that we can afford to emit while still having a good chance of limiting global warming to 2° Celsius. According to the IPCC, keeping the global temperature increase from pre-industrial levels below this threshold – the recognized tipping point beyond which climate change is likely to get seriously out of control – requires that the world emit only about 1,000 gigatonnes of carbon (GtC). More than half of this amount was already emitted by 2011. Unless we shift away from carbon-intensive behavior, the remaining budget will run out in roughly three decades.

China's plans for 50 coal gasification plants will produce an estimated 1.1 billion tons of carbon dioxide per year and contribute significantly to climate change. The plants, aimed in part at reducing pollution from coal-fired power plants in China's largest cities, will shift that pollution to other regions, mostly in the northwest, and generate enormous amounts of carbon dioxide, the main greenhouse gas produced by fossil fuels. If China builds all 50 plants, the carbon dioxide they produce will equal about an eighth of China's current total carbon dioxide emissions, which come mostly from coal-burning power plants and factories, the organization said. Two of the plants have already been built as pilot projects, three more are under construction, 16 have been given the green light to be built and the rest are in various planning stages, according to a report by Greenpeace East Asia, and organization based in Beijing, September 2013, the government announced a plan to alleviate air pollution in China's notoriously smoggy cities. The plan would reduce coal use in the most populated areas by 2017.Since then; officials have been looking for other ways to provide power for those areas, including the building of scores of coal-to-gas plants, mostly in northwest China. They would take the place of current coal-burning power plants in China's most populated areas, including the heavily polluted northern region that includes the cities of Beijing and Tianjin.

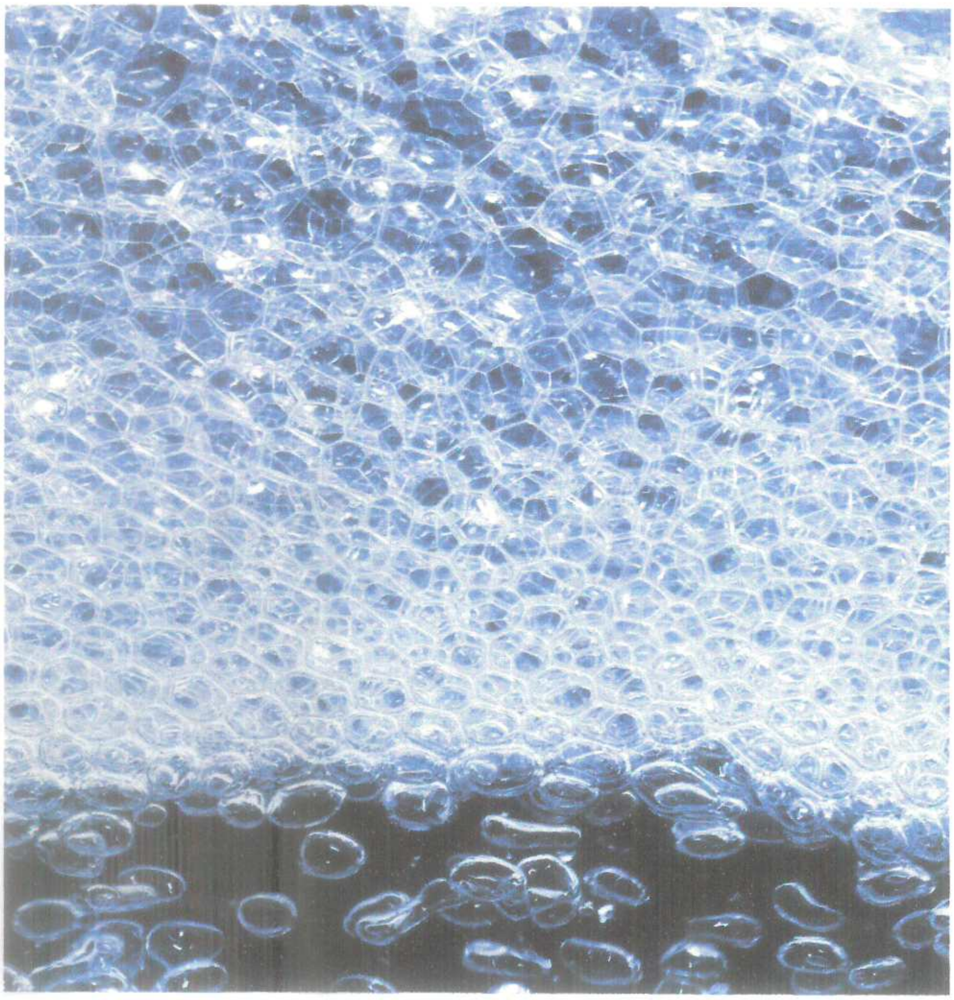
Coal-to-gas, or coal gasification, is a water-intensive process that generates enormous amounts of carbon dioxide, the main greenhouse gas destabilizing the world's climate. Many scientists have criticized the process and said its use would be even worse for global climate conditions than burning coal, which produces carbon dioxide and other pollutants. Chinese state-owned power companies categorize proposed plants as "clean energy" or "new energy." China is responsible for half of the annual global coal consumption and is the world's biggest emitter of greenhouse gases, followed by the United States. Chinese and American officials have been engaged in on-and-off negotiations for years over how each nation can pledge to cap or reduce its coal use to try to avert severe climate change. In October 2013, two Duke University researchers published a commentary in Nature Climate Change that said Chinese policy makers should delay the huge investments in coal-to-gas projects "to avoid a potentially costly and environmentally damaging outcome. An even better decision would be to cancel the program entirely."

Li Shuo, a climate analyst at Greenpeace East Asia, said in a statement that "China risks a boom in a destructive, expensive and outdated technology, which could undermine its efforts on climate change and further damage its environment."

Eighty percent of the 50 plants would be in northwest China, in the provinces or regions of Xinjiang, western Inner Mongolia, Ningxia and Gansu. All these areas suffer from severe water shortages. The Greenpeace report said that besides the surge in carbon dioxide emissions, the plants would also worsen water scarcity, water pollution and air pollution.

One of the two operational plants is in Inner Mongolia, where the city of Hohhot has reached an agreement with Beijing Enterprises Group to provide Beijing with four billion cubic meters of synthetic natural gas per year. The gas from the coal gasification plant there, operated by the China Datang Corporation and would equal half of Beijing's current annual gas demand. The Greenpeace report cited research from Tsinghua University showing that this agreement would reduce coal use by 8.94 million tons per year in Beijing, but increase it by 12 million tons in Inner Mongolia. There would also be a net growth of 3.77 million tons per year in carbon dioxide emissions and an increase of 24 million tons in water consumption, it said.

3.3 THE "WATERCUBE"



Water becomes a profound 'building material' that de-materialises the building in a meaningful way. That is the molecular structure of water in its foam state is magnified into the structure of the building.

The structure of water softens and dissolves all the boundaries, and gives the sophisticated 'micro' details to the monolithic totality. The sophistication of the components and the simplicity and monumentally of the whole gives the building an interesting duality.

John Bilmon, PTW Architects Director, said, "Our "Water cube" concept is a simple and concise square form that ultimately uses the water bubble theory to create the structure and building cladding, and which makes the design so unique.

It appears random and playful like a natural system, yet is mathematically very rigorous and repetitious. The transparency of water, with the mystery of the bubble system, engages those both inside and out of the structure to consider their own experiences with water." The Water cube becomes a striking blue "bubble" aesthetic, which is both eye-catching and indicative of the function it houses.

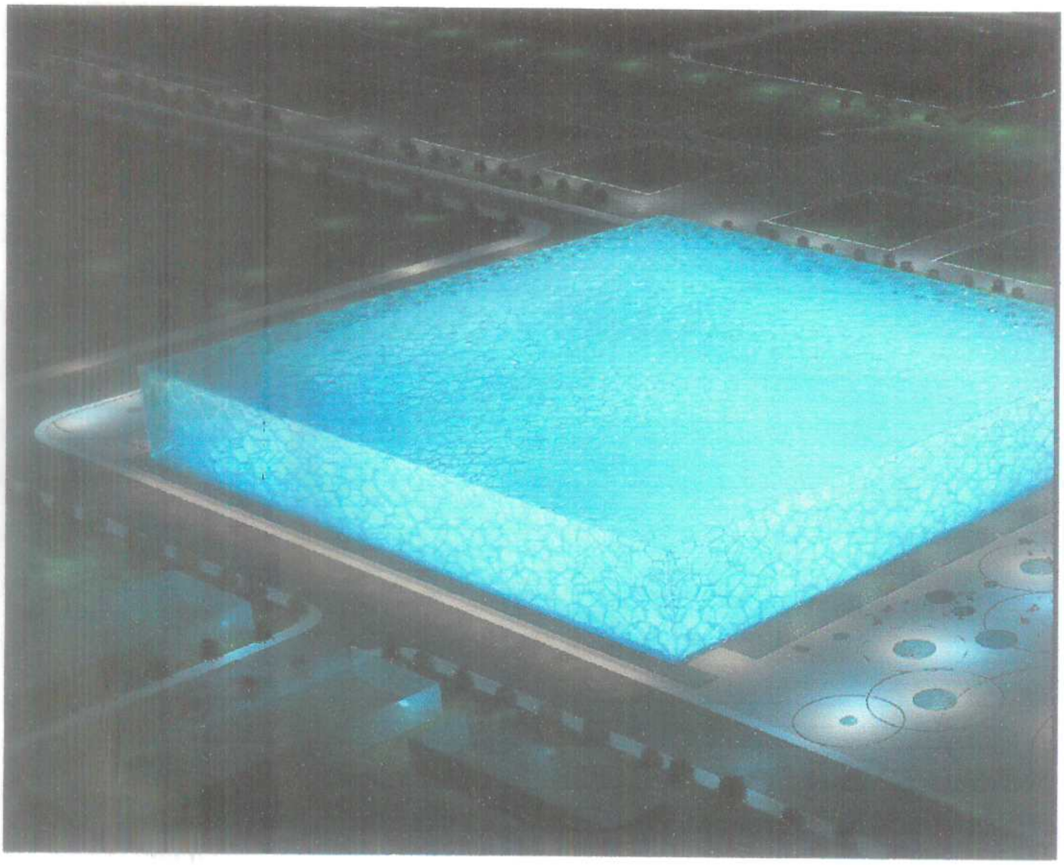
Theory behind the cube

•Inspired by cells and soap bubbles

•Based on a common natural pattern – arrangement of organic cells and natural formation of soap bubbles

•Arup structural engineers realised that a structure based on unique geometry would be highly repetitive and buildable, but would appear random and organic

•This type of pattern is regularly seen in biological cells and mineral crystals



PROJECT BRIEF

- *Project name – National aquatics centre*
- *Project employer- Beijing state- owned Assets management co. Ltd.*
- *Location- Beijing Olympics green*
- *Plot area- about 70,800m²*

- *Project scale- about 50000m^2 floor area ,with 4000 permanent seats and 13000 temporary ones including 13900 for the public, 600 for VIPs , 1000 for journalist and 1500 for athletes*
- *Function demands- swimming, diving, synchronized swimming and water polo during the 2008 Olympics Games, large scale multifunctional aqua-recreational, sports and body building centre after the Olympic game.*

***NB**-The bulk of the new building was centered on the new Olympic green, located on the northern end of the city, on the axis of the Forbidden City at the heart of Beijing. The Olympic green is now a home to 13 sports venues and the athletics village. Two major stadiums are the focus of the park; the national stadium is Beijing aquatics centre.*

Design considerations

Some considerations given to design from the cube shape to the bubble effect and other functionalities were largely as a result of Chinese cultural tones and the blend of eastern influence.

Material choice and execution process- As part of the design process, a comprehensive 3D structural model was created and imported directly into Strand7, the Finite Element Analysis (FEA) software system. The Strand7 model comprised 24,000 beam elements with 12,000 nodes. There were 750,000 beam loads in 55 basic load cases, which were considered in 200 load combinations. The structural model was flown from Melbourne to Beijing, where it was joined to a handmade plastic skin (the team just couldn't draw all the different pillow shapes in time), and the model was complete.

Some Tech detail- The wall cavity is 3.6m deep, and the cavity forming the roof is 7.2m deep, 6.8 hectares surface area of steel

- Budget/ cost – About a 100million us dollars was set aside to execute this project

"When looking at the process from which the National Aquatics Centre has been designed and produced, it is clear that technology and aesthetics have worked together, in order to create a unified whole. This is a good example of performative architecture. The process gives rise to a lifting of architecture to a higher level – a level where the building can both be technically correct and artistically handled. The results from technical analyses are constructively and artistically worked into the design, and they are therefore an important design parameter, rather than an appliqué to a form. The process is hereby a hybrid process, with architects and engineers working closely together in a digital continuum. PTW has used the computer technology to create unconventional architecture, by using nature to find a system that is transformed into a building system with help from the computers. Hereby they redefine and challenge the traditional building elements, walls, columns, window etc. At the same time, they use a system that we humans recognise as porous and stable - foam - that makes the building seem both logic and poetic.

- The team split into four groups to workshop design principles, cultural values, and environmental and structural concepts for the project and quickly identified a range of possible seating bowl arrangements and developed design criteria for the envelope cover: the building should reflect the time and the place, be responsive to the immediate environment and its position as one of two gateway buildings; it should embody the concept of water in one of its forms; it should reflect ideas in traditional Chinese architecture and be culturally appropriate; and it should be a contemporary building – a cathedral for the Twenty-First Century – embodying the values and aspirations of China, testing materials, and expressing form in the most dynamic way".

June 20-28, 2003, the evaluation process of the architecture design competition was held in Boa, Hainan. A panel of well-known 52 Chinese and foreign designers and operation experts, after nine days of closed evaluation, picked three designs (Plan B04, Plan B07, Plan B10) from a total of 10 submissions as the winners of the excellence awards. The International Olympic Committee (IOC) regarded the evaluation process as most sober, scientific, and confidential.

The three designs were chosen from the 10 submitted for the final competition. The judging panel made the decision based on two criteria. One was whether the project met the needs of the sport itself. The other was whether the design has distinguishing cultural features and how it fits into the surrounding environment.

3.4 WATERCUBE GREEN ENERGY AND EFFICIENCY CONSIDERATIONS

Local environmental conditions

Location: Beijing, China

Latitude: 39°59'26.70"N

Longitude: 116°23'00.10E

Elevation: 167 ft. (Southwest Corner)

Climate: Continental Monsoon Beijing experiences four distinct seasons, with hot, wet summers and cold, dry winters. The spring season is typically characterized by warm and windy conditions.

. **Temps:** July: 71° (avg. low) 81° (avg. high) Jan.: 15° (avg. low) 34° (avg. high)

Precipitation: December: 0.1 in. (low average) July: 8.8 in. (high average)

Annual: 25.35 in.

Citing: The Aquatic Centre is sited at the northern edge of a large plaza. There are no permanent obstructions that interfere with sunlight reaching the building.

A fifth of the world's population lives in cities where the air is not fit to breathe. Burning coal and oil is the main cause. This produces emissions of carbon that contribute to global warming, sulphur dioxide that causes smog, and nitrogen oxide that creates a noxious haze, which covers cities and eats into human lung and plant tissue. According the WHO (World Health Organization) the big cities with the worst air quality are Milan, Tehran, Beijing, Calcutta, Delhi and Jakarta.

There are many reasons to move to the town or city. Some people may no-longer be able to subsist in a rural area, or maybe the opportunities of the city are an incentive to move. Some of the forecasted increase in urban populations between 2002 and 2015 is due to birth rates exceeding death rates within a city.

A total increase of 888 million people living in urban areas is predicted in 186 territories. In the remaining 14 territories, no change or a fall is expected, totaling 6.5 million.

Territory size shows the proportion of all extra people that will start living in urban areas between 2002 and 2015, **in ear**ly November 2000, Financial Times wrote that one of the largest impediments to Beijing's Olympic bid was the city's pollution problem (Financial Times 13.11.2000). At the IOC conference on the legacies of the Olympic Games two years later, environmental concerns were repeatedly cited as a major reason for granting Beijing the right to host the Olympics. How were environmental concerns turned from a weakness to an advantage in Beijing's Olympic bid process?

The city's choking pollution and snarled traffic will be controlled during the 17-day Olympics when at least one-third of 3.3 million vehicles will be banned, and dust-spewing building sites and sooty factories are shuttered. Billions have already been spent moving industry out of town. Through its bid material, Beijing presented itself as a tool for the Olympic movement to reach its environmental goals.

The modern image of Beijing hinges on these mega-avenues aligned by mega-buildings and stepping stone projects. From the air Beijing reads like a belt of modernity that encircles a historic centre (still being eroded), all embedded in a broad zone of dormitory blocks. (These living quarters define the majority of the cityscape and as such are arguably the essence of the 'real' Beijing. Yet this expanse of the capital seems to fall between the cracks of the planning debate.) Beyond the Fifth Ring Beijing extends in thick fingers of suburban high-rise and a puzzling amalgamation of villa-parks and village factories looming in clouds around them. Yet none of these realities seem to tarnish the myth of Beijing. Even though the target audience is very diverse, the city's official image is projected with astonishing effectiveness, attracting foreigners as potential tourists/corporate investors, turning the Chinese middle-class into first time home-owners, and pacifying the Within this framework of urban environment, conditioned by the holding of the Olympic event, the Water cube fully represents the concept of "Green Olympics," in terms of architecture, outside layer engineering, environmental protection in the areas of material, energy and water resources as well as the indoor environmental quality, according to Yu Xiaoxuan from the BOCOG31.

The project is featured by the reasonable and efficient application of clean energies, said Yu Xiaoxuan, deputy director of the Venue and Environment Department of the Beijing Organizing Committee for the Games of the XXIX Olympiad (BOCOG).

The Water cube is designed to act as a greenhouse. Its ETFE cushions allow high levels of natural daylight into the building and, as swimming pools are predominantly heating-driven, they harness the power of the sun to heat the building and pool water passively. This sustainable concept reduces the pool hall's energy consumption by an estimated 30%.

John Bilmon, Managing Director of PTW Architects, said in an interview that perhaps the biggest driver propelling the concept of eco-city design, architectural planning, and urban development are the Equator Principles32, in no small part because they apply to the whole of project lifecycle and in most cases require operational monitoring after project completion and final investment by the firm. This philosophy is clearly recognized in all PTW projects and can be found easily in this project.

"*A foreign firm working abroad carries an exemplar responsibility to demonstrate* *appropriate responses to 'avant-garde 'considerations. Foreign firms really can bring new ideas to projects without the constraints often imposed when one only works locally and falls into a pattern of providing pragmatic solutions often aimed at satisfying local considerations alone. Because of the scale of this project, we must consider their broader urban and cultural impact*" Bilmon said migrant labor force with the persistent dream of progress and urban contentment in the horizon or territory.

The system generates an effective negative U value of thermal conductivity, a net energy gain to the building. Thermal mass heat storage (in both the swimming pool water and heavy surfaces surrounding the pool) ensures that solar heating during the day is offset by overnight cooling.

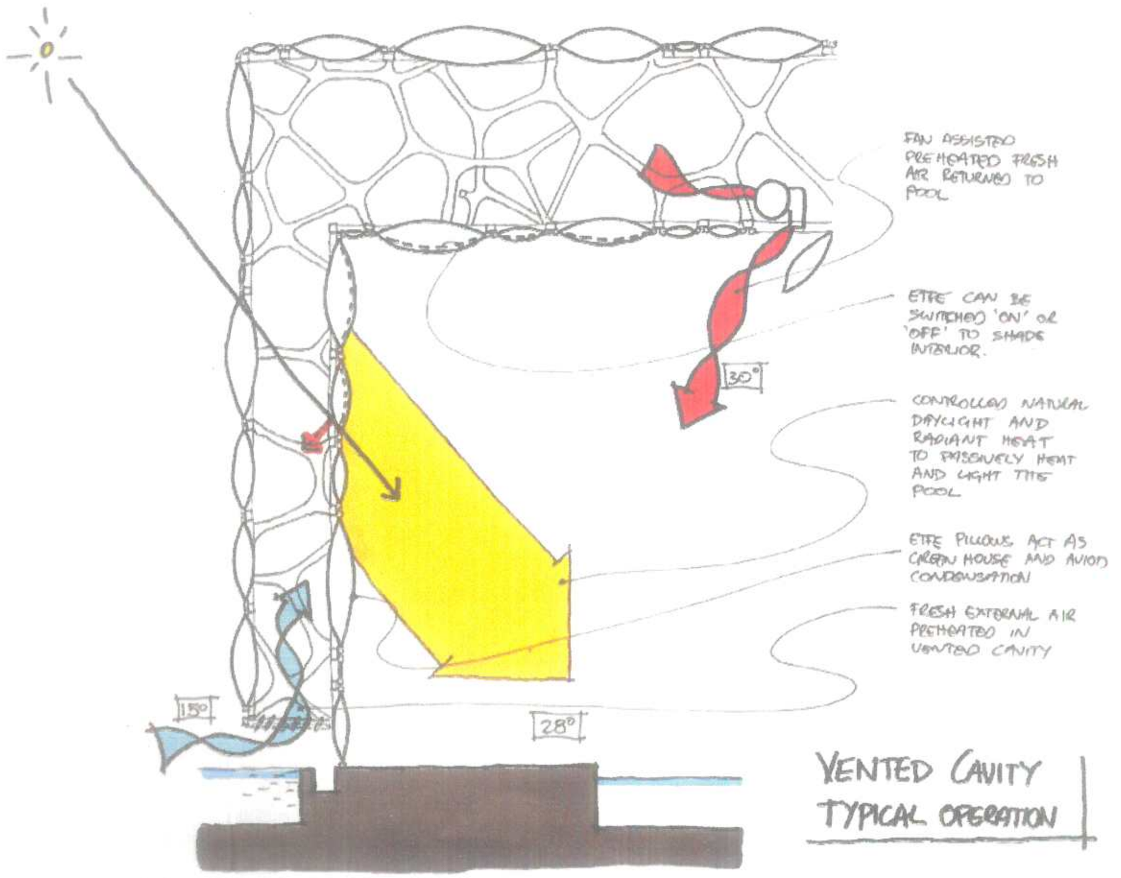
Variation in shading of the facades ensures that fabric heat loads are minimized in summer but maximized in winter, when the solar heat gain is most beneficial. This is achieved by patterning the various layers of the facade with translucent painted frit and by ventilating the heat out of the cavity in summer, and containing it in winter. The location and pattern of these translucent elements respond to the daylight and thermal requirements of the various building uses adjacent to the facade.

The energy consumption of the large pool halls is greatly reduced by using the displacement ventilation principle in the mechanical systems. The concept of stratification is critical to achieving high passive solar heat gains without generating large space cooling loads. Allowing stratification of air in these large spaces, the mechanical system only has to provide cooling to the occupied spaces. This can reduce effective cooling loads by a factor of 10.

In summertime, non-pool and office areas will use air conditioning to be kept around 23°C. The heat rejection of the air conditioning will then be used to heat the pools. The leisure pool must be kept at around 30°C; the competition pool at around 28°C.

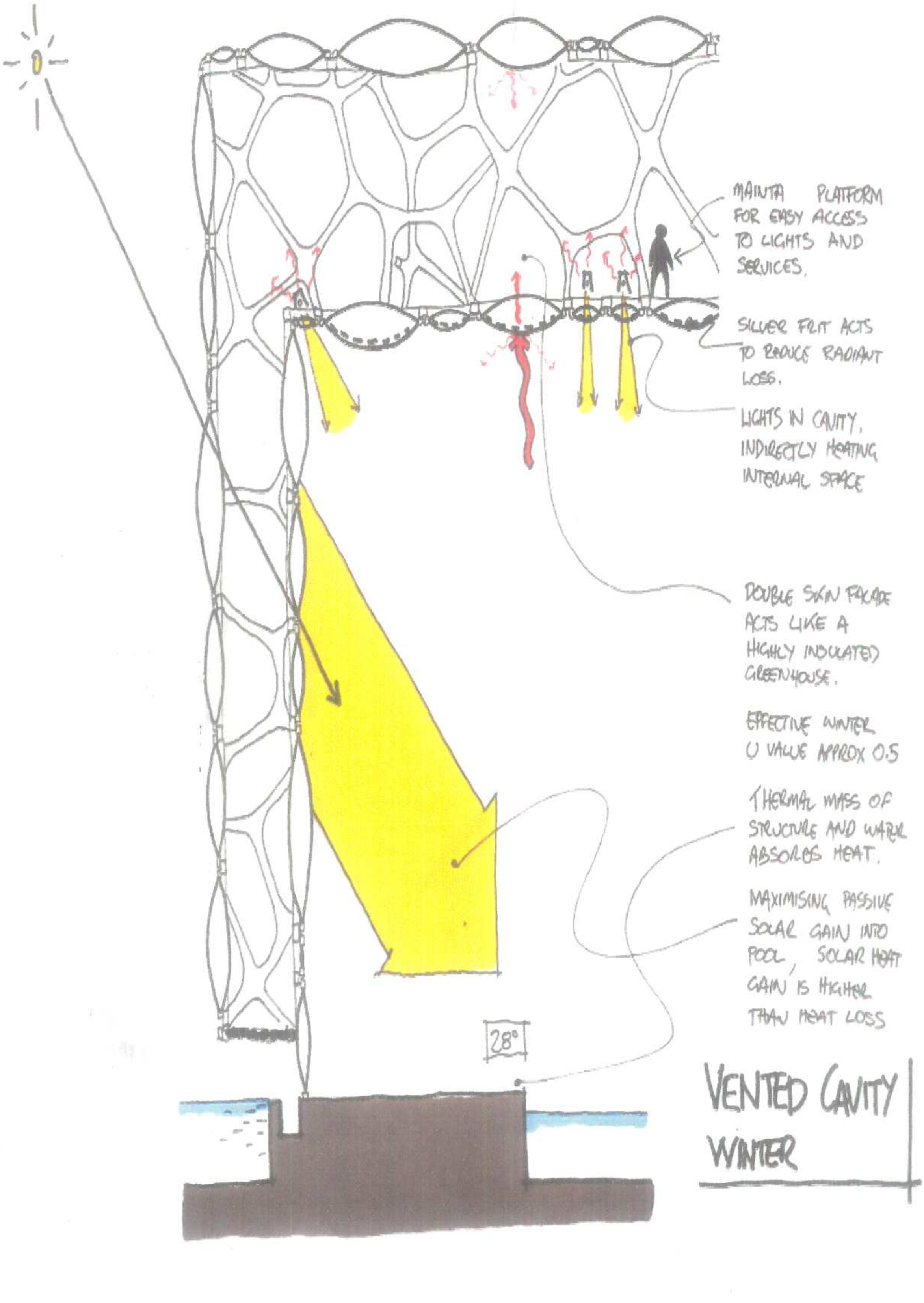
This smart building was designed to have the ability to create a responsive, comfortable environment.

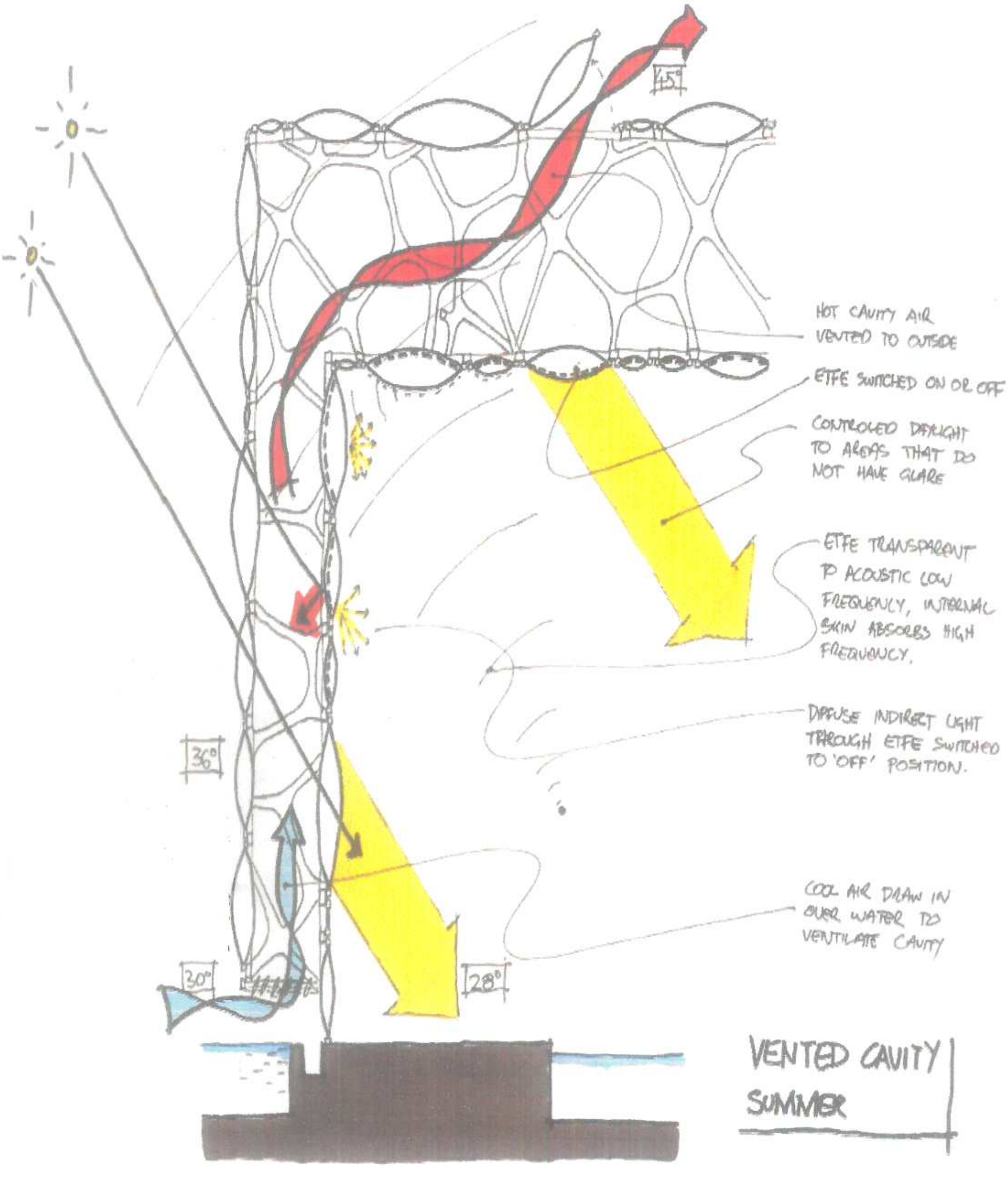
For example, spectator seating areas will be air conditioned separately by an under-seating supply system which will only operate during events, preventing wastage.



Vented Cavity Facade

The insulated greenhouse captures solar energy directly and uses it to heat the pool water and pool hall air.


MAINTN PLATFORM FOR EASY ACCESS TO LIGHTS AND SERVICES.
SILVER FRIT ACTS TO REDUCE RADIANT LOSS.
LIGHTS IN CAVITY, INDIRECTLY HEATING INTERNAL SPACE
DOUBLE SKIN FACADE ACTS LIKE A HIGHLY INSULATED GREENHOUSE.
EFFECTIVE WINTER U VALUE APPROX 0.5
THERMAL MASS OF STRUCTURE AND WATER ABSORBS HEAT.
MAXIMISING PASSIVE SOLAR GAIN INTO POOL, SOLAR HEAT GAIN IS HIGHER THAN HEAT LOSS
28°
VENTED CAVITY
WINTER

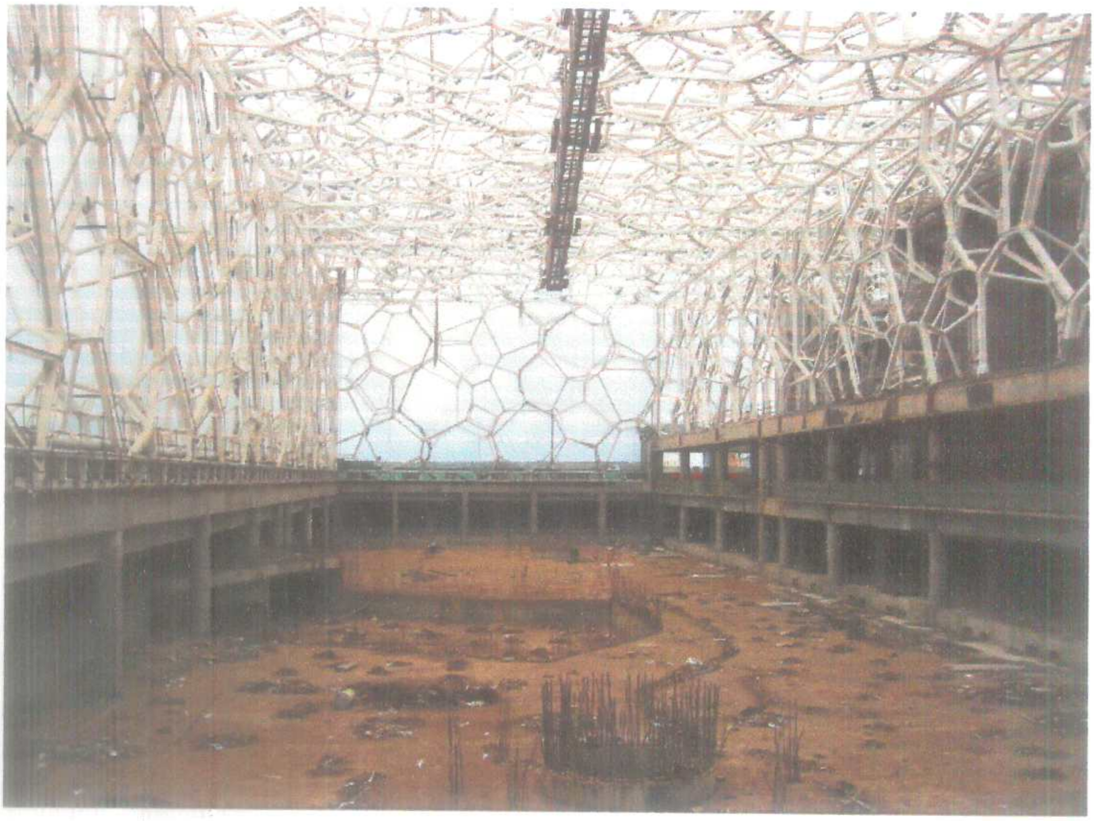


20% of the solar energy trapped within the building will heat the pools and the interior area- the equivalent of covering the roof with photovoltaic cells

To reduce the energy consumption of the Water cube, the design has incorporated many energy recovery systems, including:

- •Heat recovery from warm exhaust air for warming up the cold outside air (fresh air supply)
- •Heat recovery from chillers for space and pool water heating

•Heat recovery from ice making machines (for the ice rink) for air in building and pool water heating



Up to 55 per cent savings on lighting energy use can be achieved in the leisure pool hall, with smaller savings expected in other areas.

In addition to exceptionally low U values, heat losses within the system due to infiltration are reduced to zero as the Texlon cushions form a protective pressurised enclosure around the building.

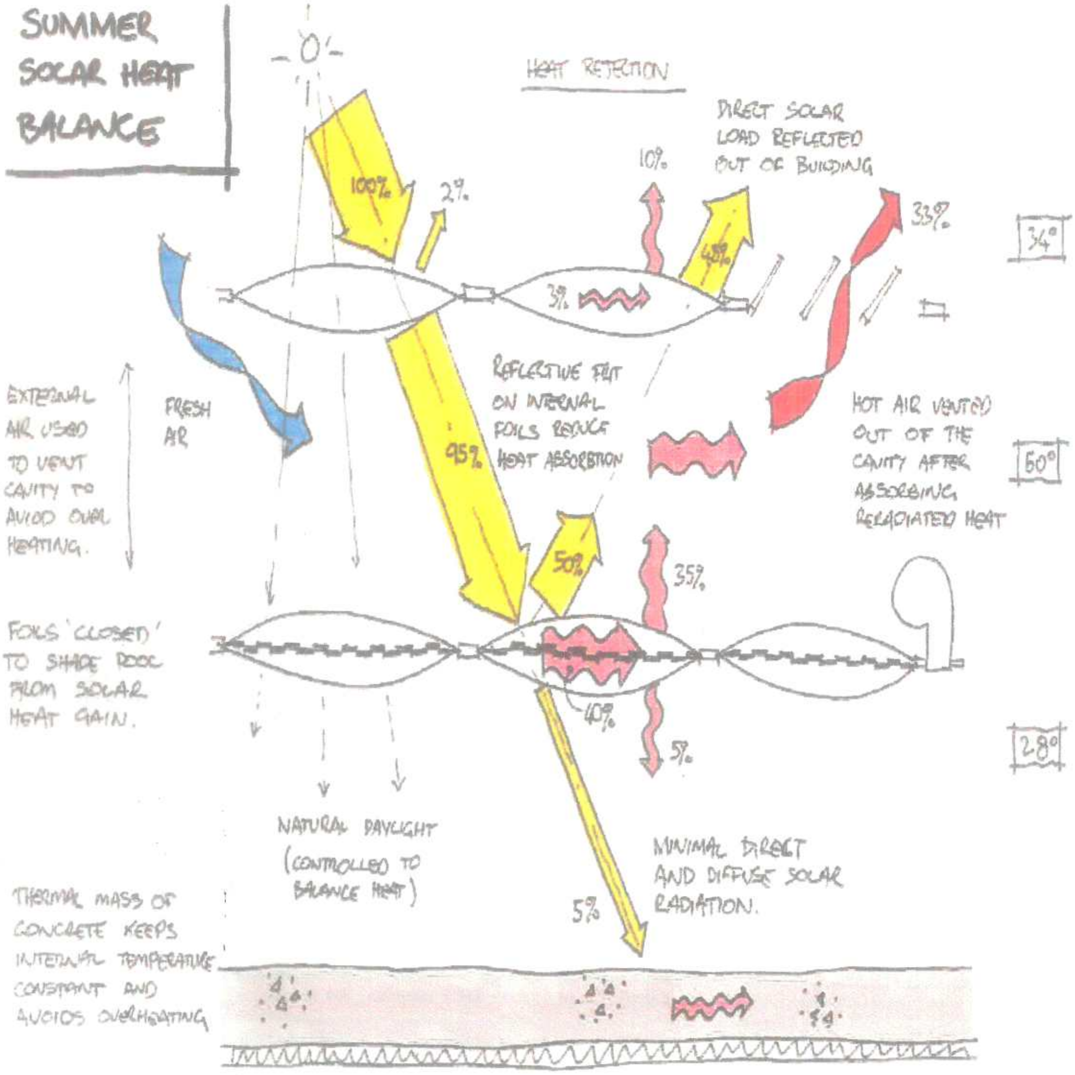
Swimming pools can be problematic because of heating, condensation and corrosion issues. When chlorine from the pool combines with moisture in the air, hydrochloric acid forms. So swimming pool centres are very corrosive environments if not designed properly.

Air distribution is critical. Because of the unique façade, surface temperature and air movement must be maintained to prevent condensation. To achieve this, nozzles will be located around the perimeter of the building to supply air up the walls. During winter, thermal buoyancy will lift warm air to the top. In summer, it will be the reverse, with cooler air being supplied to compensate for heat gain. This cooler air will not have the same buoyancy force, so it won't go all the way to the roof and only condition the lower part of the building. This stratification of the air will reduce the energy consumption of the building.

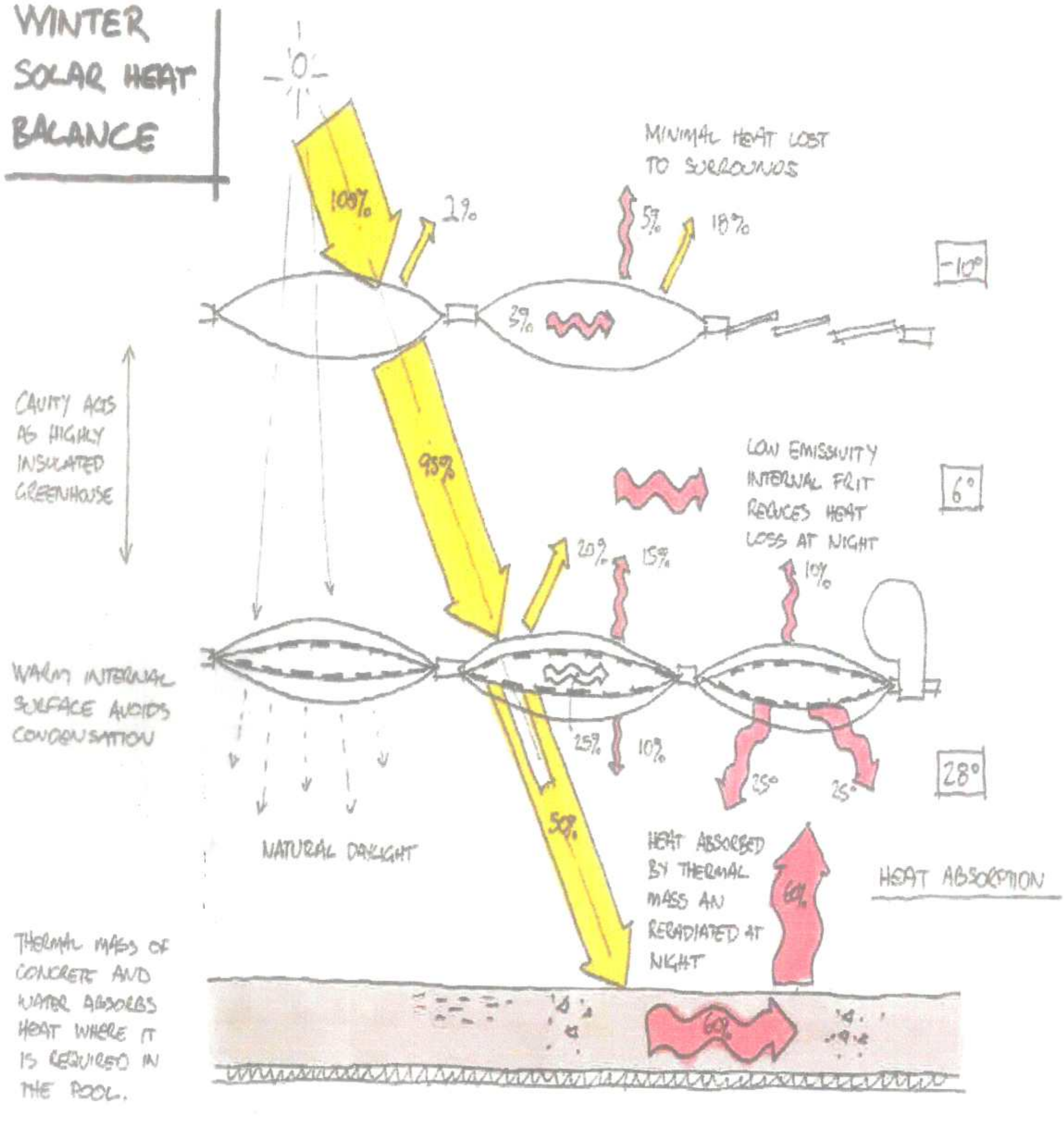
The dual-ETFE cushion envelope allows the Water cube to achieve great thermal efficiency. The envelope is so well insulated that the design may create an annual net heat gain. The concrete structures containing the pools will act as thermal masses, retaining heat during the warm days and releasing it over the course of cool nights.

The envelope has three modes of operation, allowing the building to adjust to winter, summer and mid-season conditions. These changes are achieved by varying the amount of light and solar radiation entering the interior, by varying the translucent and transparent foils. Hence, the level of natural day lighting is also easy to control and alter rapidly. There is no need for artificial illumination during daylight hours. At night, the building is lit from within giving it a soft glow and dominant place in the landscape.

Opening and closing the internal foils by varying their internal pressure is what allows for such flexibility. Dappled lighting effects can be achieved, or light can be directed only to certain areas. Additionally, the entire envelope can be 'turned off' to achieve the lighting situation that works best for televised events.

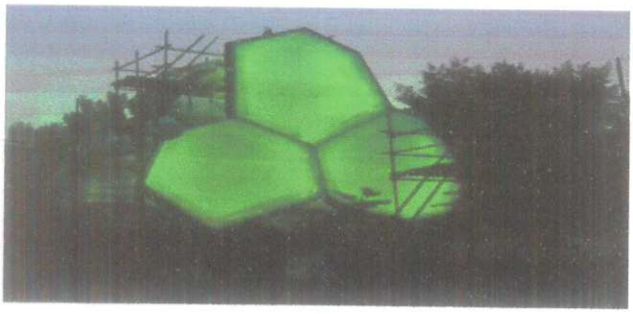


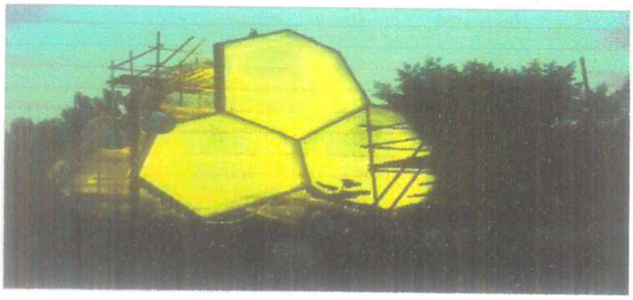
SUMMER SOLAR HEAT BALANCE
HEAT REJECTION
DIRECT SOLAR LOAD REFLECTED OUT OF BUILDING
100%
2%
10%
48%
33%
34°
3%
EXTERNAL AIR USED TO VENT CAVITY TO AVOID OVERHEATING.
FRESH AIR
REFLECTIVE FRIT ON INTERNAL FOILS REDUCE HEAT ABSORBTION
95%
HOT AIR VENTED OUT OF THE CAVITY AFTER ABSORBING REradiATED HEAT
60°
50%
35%
FOILS 'CLOSED' TO SHADE ROOF FROM SOLAR HEAT GAIN.
40%
5%
28°
NATURAL DAYLIGHT (CONTROLLED TO BALANCE HEAT)
MINIMAL DIRECT AND DIFFUSE SOLAR RADIATION.
5%
THERMAL MASS OF CONCRETE KEEPS INTERNAL TEMPERATURE CONSTANT AND AVOIDS OVERHEATING

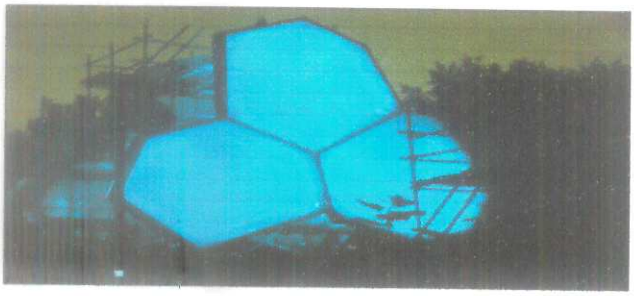


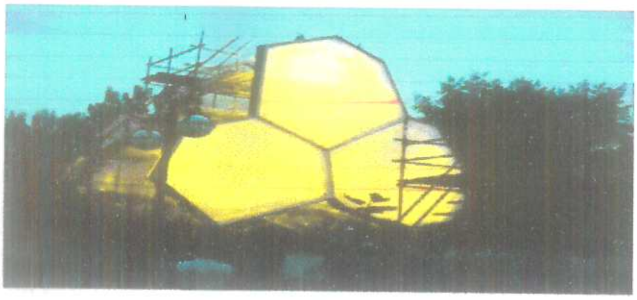
It is clear how this building efficiently and effectively functions energy wise and on such a large scale project it is safe to say that for evn far less intricate and complex construction,designs for buildings , sports facilities, utility buildings or even low cost housing schemes, like the ones proposed by the Nigerian government to develop the housing infrastructure, GREEN ENERGY can be easily integrated, this will trigger economic gains and cut down heavy demand on public power grid in the long run as well ensure environmental preservation or renewal!

❖ **LIGHTENING IN WATERCUBE**









The Water cube includes a lighting design of over 440,000 Cree XLamp LEDs.The LEDs will be used to provide the lighting effects throughout the 80,000 square meter building. The Water cube integrates the visual elements of water bubbles into a rectangular, plastic structure. LED lighting fixtures will light up the bubble designs from inside the structure's translucent walls, allowing the entire building to glow and change color.

"*The scale of the project, combined with unique lighting controls provided to the building, will result in a truly memorable display of changing images and colors,*" said Scott Schwab, managing director with Cree Asia Pacific. "*It's an extraordinary design that relies on LEDs to create dramatic effects while consuming as little energy as possible.*"

The breakthroughs in the LED technology of China's 863 national research program18 has contributed to the successful illumination of the National Aquatics Centre.

Light-emitting diodes (LEDs) are solid-state devices that convert electric energy directly into light. They have a longer lifetime, are easy to be integrated, energy-saving and environment-friendly. Compared with fluorescent lamps, they use up to 60% less energy. Additionally, they do not contain mercury or emit ultraviolet rays. Through custom-made lenses, their light beams can be re-deployed to reach various parts of the luminous flux curve.

Lighting design was a complete challenge. It is not ideal to have lighting in the middle of a pool as it creates glare for the spectators. Arup designed two structures for either side of the pool that direct light at ideal angles. The structures can be lowered onto the floor for maintenance, and they are also flexible enough for lights to be added or removed at will.

The Watercube, which doesn't have a tangible lightning protector, has received the same treatment as the National Stadium: it relies on its own steel structure to conduct lightning. Its concrete basement and the steel skeleton on the ground are integrated into a cubic steel mass through the welding process, and it serves as a conductor to bring the lightning underground.

Furthermore, the Watercube has a unique feature to endure an earthquake measuring eight on the Richter scale owing to its welded structure and its 12,000 joints which bear the weight of the project evenly.

CHAPTER FOUR

4.0 IMPACT OF GREEN ENERGY EFFICIENT BUILDING ON THE ENVIRONMENT AND ECOSYSTEM

Even from the definition of the concept of green energy or green building, it would be safe to highlight certain prospected benefits, should green energy efficient buildings be built in any place, in the following categories.

The impact of green energy efficient building on the economic scale will be better discussed as we must not advantages without looking at the economics of green energy on the overall.

4.1 THE POSITIVE IMPACTS

Energy efficient buildings are designed in a way that ensures that energy is used at a reduced cost, and in a sustainable and conserved manner. Energy efficient building is a panacea to attaining a "sustainable city or eco-city" (Nwofe, 2014.) Eco-cities are designed to achieve maximum comfort by occupants with emphasis on reduced energy inputs, water and food, waste output of heat, and reduced air, noise and water pollution (Devuyst, 2011., Eco-city, 2011.,)

1. Conservation and preservation of the ecosystem support for biodiversity sustainability and energy.
2. Minimization of pollution in air, land and water e.g. GH gasses, Carbon and other major pollutants. Reduced dependence on fossils and oils will also mean reduced vandalism, spillage crises and damage to aquatic habitat; when it becomes clear that these sources of energy (coal, crude, natural gas) are not the only favorable ones.

3. Renewability of energy and efficient use
4. Reduction in the overall energy demand and over burdening of public grid supply because incorporating green energy into buildings will amount to designs material wise and structurally to ensure that energy recycling in feasible, losses are minimized and nature is conserved. This consequently impacts well on the overall demand from such facility that is designed to be energy friendly
5. Reduced pollution will without doubt impact well on health. Risks will be lowered and the safer the environment the more viable the conditions for sustainable health. Looking at china, the air pollution crisis in the urban areas bear witness to the consequences associated with non-renewable such as crude, coal and natural gas
6. Aesthetic benefits- in a bid to make a building green or energy friendly and efficient, great considerations have always been giving to general aesthetic contribution of such

buildings, facilities or structures as the case may be to the environment, as already discussed, the water cube stadium, remains a veritable example asides a host of other green structures already existing

7. There are economic benefits of reduced long term cost, maintenance cost reduction and very likely service cost. However, the economics is best viewed in comparative overview to the existing alternative where dependence and design center around fossil fuels

4.3 FEASIBILITY AND CURRENT CHALLENGES IN THE GREEN ENERGY BUILDING SPHERE

As an urban leader you know that investments in the built infrastructure, whether through new construction or refurbishment, can have some of the most long term impacts on the competitiveness of your city. An upfront investment of only 2 per cent in green building design, on average, can result in life cycle savings of 20 per cent of the total construction costs – more than ten times the initial investment. In comparison to the average commercial building, 4 the cost benefits of green buildings5 are appreciable and include 8-9 per cent decreased operating costs, 7.5 per cent increase in building value, 6.6 per cent improvement on return on investment, a 3.5 per cent increase in occupancy ratio, and a 3 per cent increase in rent ratio that green building occupants are more productive. Improvements in indoor environments are estimated to save $17-48 billion in total health related gains and $20-160 billion in worker performance. So from this perspective, city leaders should strive to build green infrastructure just to obtain the significant productivity benefits. Yet it should also be noted that zero net energy buildings are technologically feasible. Moreover through proper design, energy efficient features, and with integrated renewable energy applications, buildings can be net energy producers. Finally cities challenged by water scarcity, either now or in the future, should strive for buildings with reduced water footprint.

4.4 URBAN MANAGEMENT ISSUES

Political will and strong leadership at the top levels of city government are needed if we are to transform the built sector. To encourage such leadership we may sometimes need to educate city leaders to strengthen their conceptual understanding about sustainability and its long-term, systemic benefits to the economic vitality of a city. Strong executive leadership has been the key driver for the successful transition to green building and sustainable development in cities like New York, Curitiba and Sydney. City operating budgets are always tight and allow little tolerance for investing in building upgrades, even when they have a good payback and return on investment. A city's limited capital budget generally skews decisions based on first cost rather than life cycle cost. Lack of interdepartmental communication often prevents collaborative decision-making that would justify the investment in green building for the best long-term interests of the city.

4.5 ISSUES IN THE BUILDING SECTOR

Another important measure to promote development of more green buildings is to increase incentives for builders and developers to build green. The benefits of green buildings, especially in energy savings and worker productivity, accrue over the long term. While green buildings are more cost-effective, the benefits accrue to the final owners and users of the building, and not to the builder. Additional construction costs for green buildings, generally 2-5 per cent, cannot be easily passed on to owners and therefore are often a financial disincentive to builders. The challenge is to create a mechanism that allows some of the value of the long-term benefits to be transferred to the builder to offset first time costs

Another barrier is lack of information and sourcing for green building products. Architects and builders lament the scarce and poorly accessible information available on green products and high performance building systems. The lack of information about performance and cost attributes of building elements can force projects to depend on specialized consultants. Alternatively, builders and contractors risk costly call-backs to remedy green products that don't perform well. Another consequence of limited product information is skepticism from municipal building and safety departments. Green products can only deliver their air quality and energy conservation benefits if regulators allow them to be used. The challenge is to get the information and to educate the marketplace.

As the regulation of building design and construction becomes increasingly complex, developers and clients have difficulty assessing the costs and requirements of complying with regulations. Improved communication of local building codes and their implications for green process and product choices would allow developers and clients to make choices among efficiency, aesthetics, product choice, and cost that would satisfy regulators without costly delays and changes.

This leads us to characterize the general objectives for green buildings. High performance and sustainable buildings should:

- Maximize natural resource efficiency and human health benefits throughout the life-cycle of a building – from sitting through design, specification, construction, operation, maintenance, renovation, and demolition
- Employ integrated design
- Optimize energy performance
- Protect and conserve water
- Enhance indoor environmental quality
- Reduce environmental impact of materials

4.6 POLICY OPTIONS TO PROMOTE GREEN BUILDINGS

4.4.1 EXECUTIVE LEADERSHIP

As Mayor, you might consider establishing, empowering, and staffing a cabinet level position focused on Sustainability. City employees should be empowered through a value system that rewards decisions which make the city green and sustainable. City officials can lead by example, implementing green strategies and proven technologies on city facilities before asking the private sector to make the necessary investments. They may consider:

1. Auditing city facilities for energy and water performance;

2. Using the audits as benchmarks to develop an environmental "accounting" and set goals for improvement; and

3. Holding the departments accountable for achievement of their goals.

A validation and rewards programmed could be launched for city employees who take initiative in advancing green building and sustainable development initiatives. Instituting a course of professional development focused on sustainability for the city's engineers, architects, and code officials could also be useful, engaging the NGO community as educational providers.

As Mayor, you may consider implementing policies and requiring training for departments in the use of life cycle evaluation, consideration of long term operating costs, and assessment of environmental impacts as criteria for their decision-making. The leadership of all departments associated with the City's built environment, including those responsible for operations and the funding of operations, must collaborate to develop policies that are both fiscally and environmentally sound. An example would be Finance and Water working together to establish a requirement for permeable parking lots and sidewalks that absorb rain water as a step to help avoid the need for massive storm water infrastructure investment. The city budgeting process could be changed so that every city facility and department is responsible for paying its own utilities from their respective operating budgets. Savings (or some portion thereof) should accrue to the facility or department rather than to the general fund, to reward responsible behavior.

4.4.2 MEASURES TO CATALYZE INVESTMENTS IN GREEN BUILDINGS

City leaders may wish to establish green building labeling schemes as these can provide more information to potential buyers on the benefits of green buildings and at the same time it provides builders with new marketing tool.Favourable tax policies can incentivize construction of new green buildings. The difference in cost for green construction is 2-5 per cent more than business as usual. 7 Fiscal measures can help reduce that difference. The same is true for favorable interest rate financing policy, which when combined with favorable tax policies can further encourage green building construction. Special funding for financing energy-efficient retrofits of existing buildings is important. Such retrofits often pay for themselves in relatively short period of time, but without special funding they may not occur. Energy price reform can accelerate the realization of energy savings by making the case for renewable energy applications and energy efficiency measures more economically feasible.

Transforming the marketplace requires overcoming the barriers to widespread adoption of renewable energy technologies. In addition to the high—though declining—up-front cost of installing renewable energy systems, obstacles include confusing rules about permitting an connecting systems to the grid, a lack of consumer understanding of technologies and financing options, and a dearth of trained installers and inspectors. Mayors and other local government officials are in a unique position to remove many of these barriers, clearing the way for the renewable energy industry to flourish. Local governments, residents, business owners, advocacy groups, and other stakeholders can take a multifaceted approach to promoting renewable energy by purchasing renewable energy systems directly, streamlining local regulations, and developing programmer that make clean energy options more accessible and affordable for consumers. By investing in renewable energy, local governments can boost the local economy in addition to enhancing national energy security and improving the environment.

Many in the real estate finance and investment community are finding their efforts hobbled by anecdotal data, lack of precedents, perception of higher costs, and inadequate underwriting, valuation and risk management protocols. More awareness-raising is needed to help overcome these barriers and facilitate the flow of debt and equity investment among all stakeholders (investors, lenders, developers, technology experts, building owners and managers, and risk managers) to share experiences, best practices, and new paradigms and to confront novel challenges. Cities can overcome these challenges by undertaking some mix of the following policy options and incentive programmers.

Create Direct Incentives: Up-front cash incentives encourage customers to install renewable energy technologies by helping reduce high equipment costs. Although production-based incentivesdon't reduces up-front costs, they do generate revenue that can help secure financing and offset financing costs. Direct incentives are useful to a broad range of consumers, especially those who can't take full advantage of other incentives such as tax credits. With direct cash incentives, programme administrators can track programme participation and installed capacity, along with any problems encountered and their solutions

- **Adopt Feed-In Tariffs**: Feed-in tariffs are intended to increase the adoption of renewable energy and encourage the development of the renewable energy industry, but they also bring significant ancillary benefits to the table, including enhanced economic development and environmental improvements. For cities that want to assure investors about future revenue, drive more capital to the market, and get more renewable energy applications integrated into new green buildings, a feed-in tariff can be a useful policy.
- **Offer Loans and Fiscal Measures for Energy Efficiency and Renewable Energy Systems:**

State, utility, and local government loan programmes encourage customers to implement energy efficiency measures or to install renewable energy systems by allowing consumers to spread up-front equipment costs over the life of a loan. These loan programmes offer lower interest rates, better terms, and lower transaction costs relative to private lenders. Loan programmes may be more politically viable than cash incentives, and they can even become self-sustaining through a revolving fund mechanism. Governments can also provide tax write-offs for energy efficiency and renewable energy investments to encourage their uptake.

- **Create a Property Assessed Clean Energy Financing Programme:** This approach to financing offers a number of benefits to renewable energy system owners including a long-term, fixed cost financing option; a loan tied to the property (instead of the system owner's credit standing); are payment obligation that transfers with the sale of the property; and the potential to deduct the loan interest from federal taxable income as part of the local property tax deduction. For local governments the benefits are also clear. This financial model can help local governments meet climate and energy goals with little to no liability or exposure to a municipality's general fund. These programmes do have administrative costs, but those costs can be included in the bond issuance and be repaid by programme participants. Because the programme can be structured to fully leverage private investment, a municipality or county can implement a property assessed clean energy programme with almost zero budget impact. Develop or Improve Renewable Energy Access Laws: Solar access laws encourage more widespread adoption of solar energy by increasing the likelihood that properties will receive sunlight suitable for solar energy production, protecting the rights of property owners to install solar systems and reducing the risk that systems will be shaded and compromised once installed. Streamline and Improve Renewable Energy Permitting Processes: Simplifying permitting requirements and processes can increase the likelihood of successful renewable energy installations and save a significant amount of time and money. Creating consistent permitting processes across a state or region benefits renewable energy installers by providing a standard set of operating procedures, reducing uncertainty, and allowing them to produce more accurate estimates.
- **Promote Installer Licensing and Certification:** Consumers, local governments, and the industry should all benefit from an energy efficiency and renewable energy market that encourages high-quality installations through licensing and certification. Consumers benefit when contractors are essentially "pre-screened" according to government standards. The expectation is that encouraging licensing and certification will result in baseline standards being met, which will in turn lead to higher consumer confidence and satisfaction (and therefore fewer contract disagreements). Licensed and certified installers

benefit from possessing credentials that demonstrate their proficiency and experience with installing clean energy technologies. Licensing and certification benefits local governments by promoting high-quality installations and building a skilled workforce. Using nationally recognized programmes relieves municipalities of the need to create their own certification standards.

- **Improve Building Energy Efficiency Codes:** Improving building energy codes for public and private buildings helps achieve community-wide energy-reduction, environmental, and sustainability goals, and results in significant near- and long-term energy cost-savings. Building codes that mandate certain levels of energy efficiency help ensure that renewable energy systems will be used most cost effectively.
- **Engage the Utility:** Work with the electrical utility to promote energy efficiency. Many utilities will cover the costs of basic energy audits and even some efficiency measures, such as replacing incandescent light bulbs with CFLs. Government can lead the way by requiring energy audits of all government buildings and investing in energy efficiency improvements. Improve net-metering rules. Net metering encourages customer investment in renewable energy by allowing customers who install such systems to receive credit for excess electricity generation, which improves their return on investment. Utilities benefit from net metering if customer-sited generation is located in an area that allows a utility to avoid distribution and transmission system upgrades. Utilities also benefit when they own renewable energy credits associated with net-metered generation and can use those credits to meet national renewable energy requirements.

Optimize rate structures for renewable energies. Working with your utility to create rate structures optimized for renewable energy technologies will improve the economics of renewable energy in your community.

4.4.3 POLICY MEASURES FOR REDUCED WATER USE

- **Use Low Impact Development**. Capturing and reusing storm water runoff can greatly reduce the consumption of imported, potable water, as well as the energy usage and CO2 emissions associated with importing water. When runoff is diverted and captured before it flows into surface waters, it can be used onsite either to replenish groundwater supplies through infiltration or for gray water uses, like landscape irrigation and toilet flushing. These techniques are known as low-impact development, the central objective of which is to maintain individual sites' pre-development hydrology.
- **Low impact development uses common sense and simple technology**—landscaping with native plants, rain barrels, "green roofs," porous surfaces for sidewalks, parking lots and roads, and other measures—to retain rainfall onsite or to help rainfall soak into the ground, rather than flowing into and perhaps polluting the nearest body of water. In effect, low impact development mimics nature's own filtration systems.

In addition to reducing water and energy use, the result is less water pollution from contaminated runoff, less flooding, replenished water supplies, and often more natural-looking, aesthetically pleasing cityscapes.

- **Recycle and Reuse Wastewater**. Because water suitable for reuse is often a by-product of existing wastewater treatment processes, this type of water recycling is a low-energy source of water supply. This is especially true in areas where enormous amounts of energy may be required to import water. Recycled water can be delivered to users, usually at less cost than non-recycled water, for anything from irrigating golf courses, parks, and crops, to mixing concrete, to firefighting.
- **Promote and expand water regulations in building codes**. A number of countries now label products that meet water-efficiency performance criteria. Typical labeling programmes set specifications for the labeling of products that are at least 20 per cent more efficient than the current standards while performing as well or better than their less-efficient counterparts. All water

savings realized through the use of labeled products and services also often have a corresponding reduction in energy consumption. The US Environmental Protection Agency estimates that if just one out of every100 American homes were retrofitted with water-efficient fixtures, about 100 million kilowatt-hours of electricity per year would be saved each year. Local governments can expand and promote such programmes by:

1. Offering rebates for the purchase of labeled water-efficient products;
2. Offering tax credits for purchasing such labeled products;
3. Requiring labeled water-efficient products in new construction and in government buildings through appropriate building codes.

4.4.4 POLICIES FOR IMPROVED INTERNAL ENVIRONMENT AND AIR QUALITY

Strengthen building codes and planning requirements. Building codes can mandate that the construction industry choose only better building materials and interior finish products with zero or low emissions to improve indoor air quality. Building codes can also require more day lighting, better quality lighting products, as well as enhanced ventilation and air filtration

N.B For the purpose of this thesis work, further reference on policies in relation to green energy efficient buildings, maybe made at the various links indicated in our reference index. However it would be pertinent to give a brief on the US green business council's LEED programme as described below. Also it should be noted that in policy measures, measures are particularly tailored to meet world standards while paying attention to characteristic features of such country's or state's political terrain and level of technological development especially in the area of construction processes, design approval and available energy resources to such areas. This would account for the peculiarity in execution of such policies in the long run.

- ***US GREEN BUSINESS COUNCIL'S LEED PROGRAMME***

LEED is an internationally recognized green building certification system It provides third-party verification that a building or community was designed and built using strategies aimed at improving performance across a number of important metrics. Those metrics include: energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. Developed by the U.S. Green Building Council, LEED provides building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

LEED is a flexible framework that can be applied to all building types – commercial as well as residential. It works throughout the building lifecycle – design and construction, operations and maintenance, and significant retrofit.

LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings' performance. Architects, real estate professionals, facility managers, engineers, interior designers, landscape architects, construction managers, lenders and government officials all use LEED to help transform the built environment to sustainability. State and local governments across the country are adopting LEED for public-owned and public-funded buildings.

Apart from the U.S., the LEED scheme is being applied to projects in Canada, Brazil, Mexico and India. LEED rating systems are developed through an open, consensus-based process led by LEED committees. Each volunteer committee is composed of a diverse group of practitioners and experts representing a cross-section of the building and construction industry. The key elements of the consensus process include a balanced and transparent committee structure, technical advisory groups that ensure scientific consistency and rigor, opportunities for stakeholder comment and review, and a fair and open appeals process.

LEED points are awarded on a 100-point scale, and credits are weighted to reflect their potential environmental impacts. A project must satisfy all prerequisites and earn a minimum number of points to be certified. Basic certification requires 40-49 points, Silver requires 50-59 points, Gold requires 60-79 points, and Platinum requires 80 or more points

CHAPTER FIVE

5.1 OYOSTATE AND GREEN BUILDING PROSPECT

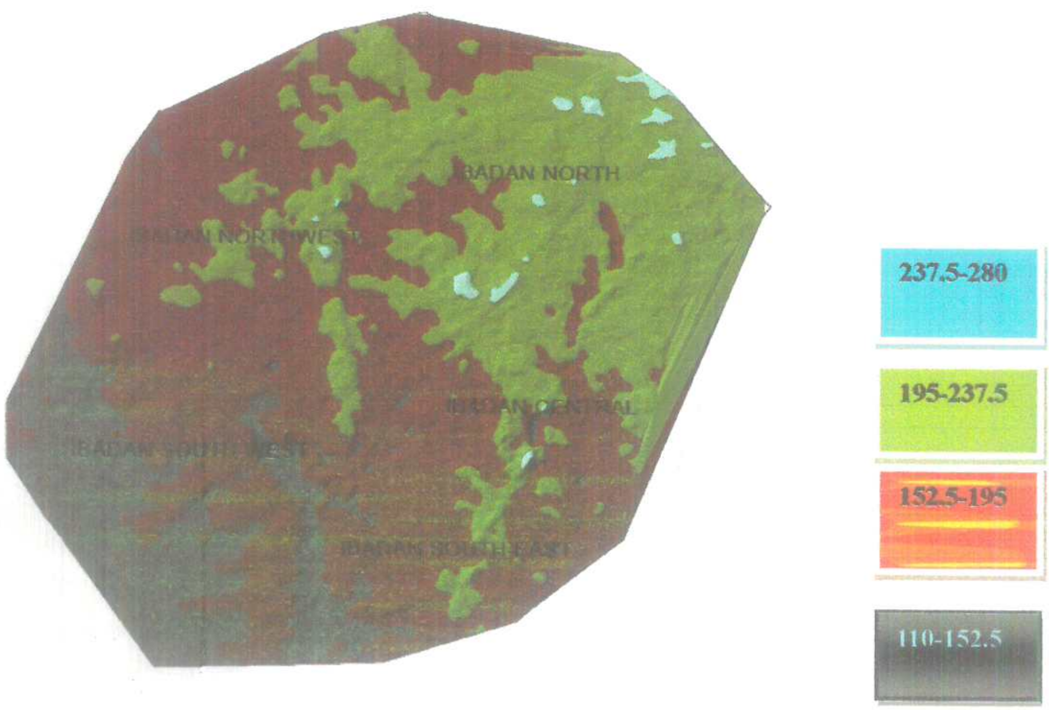


Figure 5A. ELEVATION DATA MAP OF IBADAN CITY, OYO STATE, NIGERIA, APRIL, 2015; USING THE ARCGIS SURVEY &MAPPING TOOL.

NB. *THE COLOUR CHAT INDICATES TO THE CORRESSPONDING ELEVATION STATISTICS ON THE SURVEY MAP PRESENTED ABOVE AND BELOW; SHOWING THE ELEVATION HEIGHTS SCALED BY 1: 100,000 METERS*

- IT IS OBSERVABLE THAT THE HEIGHEST POINTS, ESPECIALLY WITHIN THE IBADAN NORTH EAST LOCATION HAVE THE HIGHEST ELEVATION AND ARE LIKELY MOUNTANEOUS PATCHES
- THERE IS THE VAST CUT ACCROSS OF THE AVERAGE ELEVATION OVER 152.5-195 THOUSAND METERS IN HIEGHT OVER THE IBADAN METROPOLIS

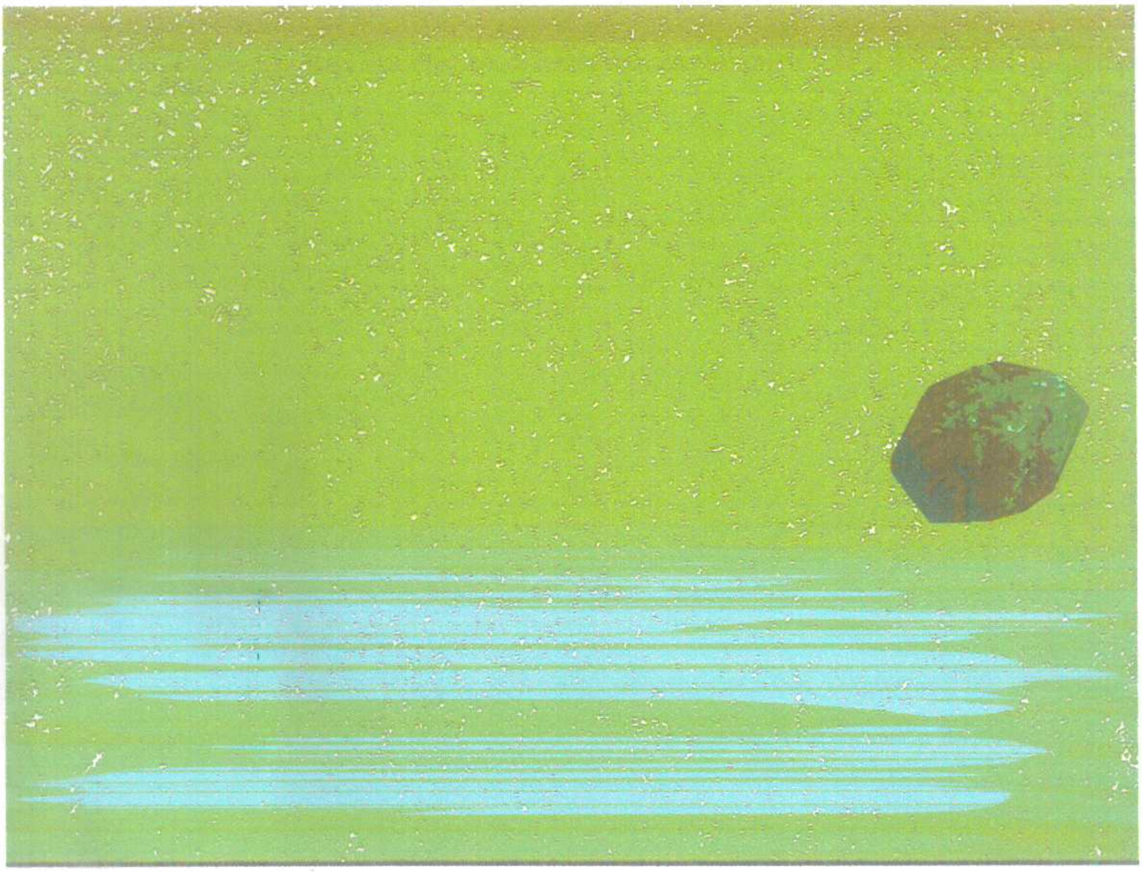


Figure 5b. showing

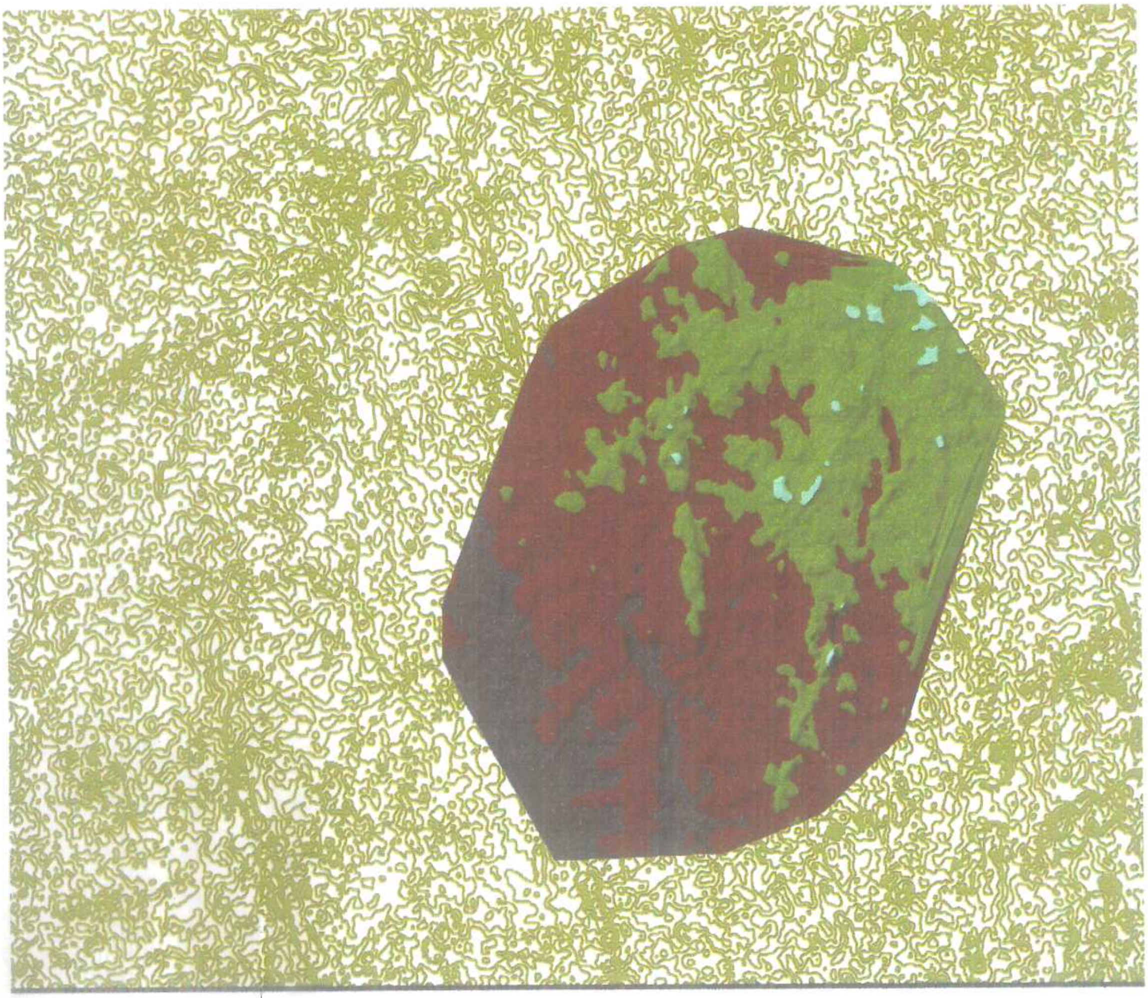


Figure 5c Detailing elevations

The above maps were obtain via the use of ARCGIS mapping and survey tools to determine the elevations of the city of Ibadan, in Oyo state, Nigeria. The essence is to show the favourable locations to site green buildings especially leveraging on elevations above sea level within the state. For the purpose of this discussion, only Ibadan was mapped to exemplify the relations and considerations that will ensue.

No doubt that this data will guide for us to site passive buildings and facilities since favourable locations are known. Further on in this section, the relations will be brought to bear, challenges and the impacts of green buildings will be highlighted in prospect.

❖ **QUICK BRIEF**

"In Nigeria, most buildings hardly take solar architecture and energy efficiency into consideration due to ignorance, poverty, lack of awareness and/or improper policy on building regulations by Government. Use of mechanical devices to achieve thermal comfort in buildings is not only capital intensive but also generate greenhouse gases, air and noise pollution amongst others" (Nwofe, 2014).

Solar passive building is a technology aimed at using natural concepts to achieve comfort in buildings without use of artificial devices. Solar architecture combines solar panels with modern building techniques to achieve an eco-friendly building. Energy efficient building mostly incorporates solar architecture with modern technologies such as BIPV (building integrated photovoltaic), use of solar fridges, solar water heating, and energy efficient building materials to ensure that maximum comfort is attained with reduced energy cost without harm to the environment/climate. Currently, most buildings in Nigeria lay more emphasis on the aesthetic values with little or no consideration for energy efficiency. Recent studies by Malgwi and Musa (2014), and Oyedepo (2012), reveals that building materials should be carefully selected to enhance thermal comfort in buildings in hot-dry climatic conditions. Nigeria is located in the tropical region with latitude 10.0N and longitude 8.00E (Menakaya and Floyd, 1980) with a mean total solar radiation of 500W/m2 (DanShehu and Sambo, 2006).

The need to alleviate the power and energy epilepsy cannot be over clamoured for because of rising energy demand amidst crunch in supply and instability of fossil fuel prices and depleting reserves. This is enough argument to justify the need for green energy integration into building (private or public property). This behoves on the government (public development board for infrastructure) to take the bold initiative and create the ambience for this green initiative to thrive as well as formulate realistic policies to fester the involvement of the private sector.

In reference to chapter four, the economic benefits of green building go a long way to impact the standard of living and also trigger economic boost. When there is energy, work can be done in literal sense and even beyond!

'Low cost housing estate' that is green compliant is a panacea to portable and affordable, serviceable and mortgage worthy scheme. The world is going green in energy and the awareness of efficiency in energy use is the clamour.

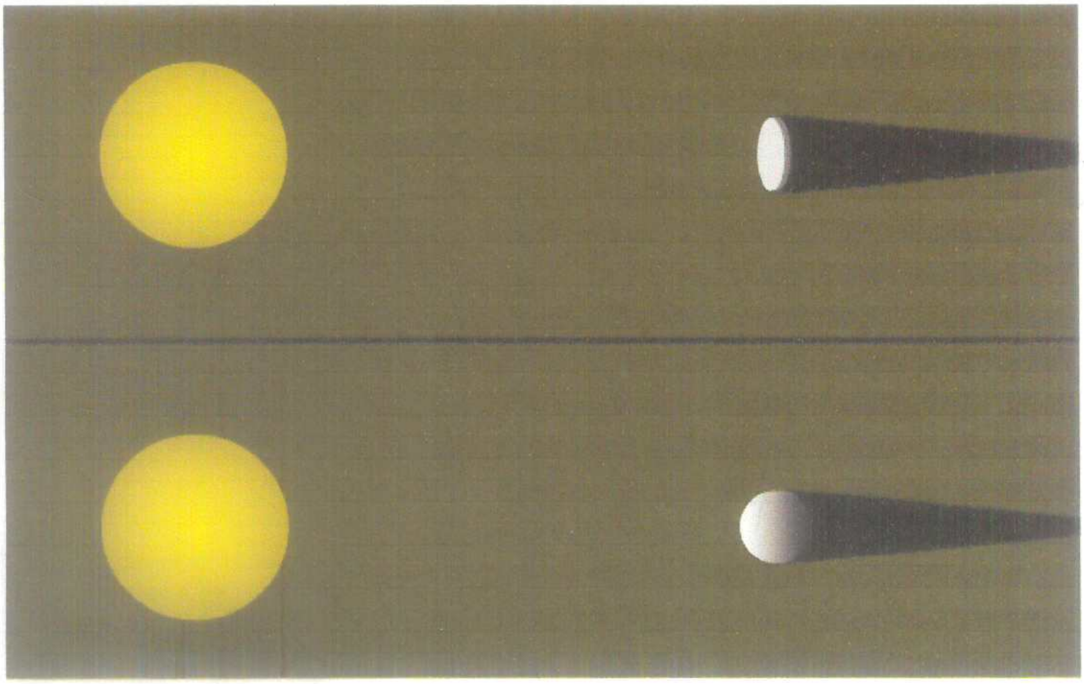
Militated against by certain key factors according to a seminar paper by (Nwoke P.A, September, 2014)

5.1.1 HOW SOLAR IRRADIATION WORKS

The Sun emits a tremendous amount of energy, in the form of electromagnetic radiation, into space. If we could somehow build a gigantic ball around the Sun that completely enclosed it, and lined that ball with perfectly efficient photovoltaic solar panels, we could capture all of that energy and convert it to electricity... and be set in terms of Earth's energy needs for a very long time. Lacking such a fanciful sphere, most of the Sun's energy flows out of our solar system into interstellar space without ever colliding with anything. However, a very small fraction of that energy collides with planets, including our humble Earth, before it can escape into the interstellar void. The fraction of a fraction that Earth intercepts is sufficient to warm our planet and drive its climate system.

At Earth's distance from the Sun, about 1,368 watts of energy in the form of EM radiation from the Sun fall on an area of one square meter. Yes, these are the same watts we use to describe the energy usage of light bulbs and other household appliances. If Earth were closer to the Sun, as, for example, the planet Mercury is, the number of watts per square meter (W/m^2) would be greater. If Earth were further from the Sun, the W/m^2 value would be lower. Recall our hypothetical gigantic ball surrounding the Sun. Whatever its size, it would capture all of the Sun's energy; but a larger ball would have that energy spread over a larger inside surface area, and would thus have a lower W/m^2 value; whereas a smaller ball would have a smaller surface and thus a greater W/m^2value. The surface area of a sphere varies as the square of the radius of the sphere; so the energy per unit area received varies inversely as the square of the distance from the Sun. A planet situated 1/2 as far from the Sun as is Earth would be scorched by 4 times as much energy from the Sun (5,472 W/m^2). A planet twice as far from the Sun as is Earth would be feebly warmed by just 1/4th as much radiation (342 W/m^2). So our planet's distance from the Sun is the first key factor influencing the energy we receive, and thus the behaviour of our climate.

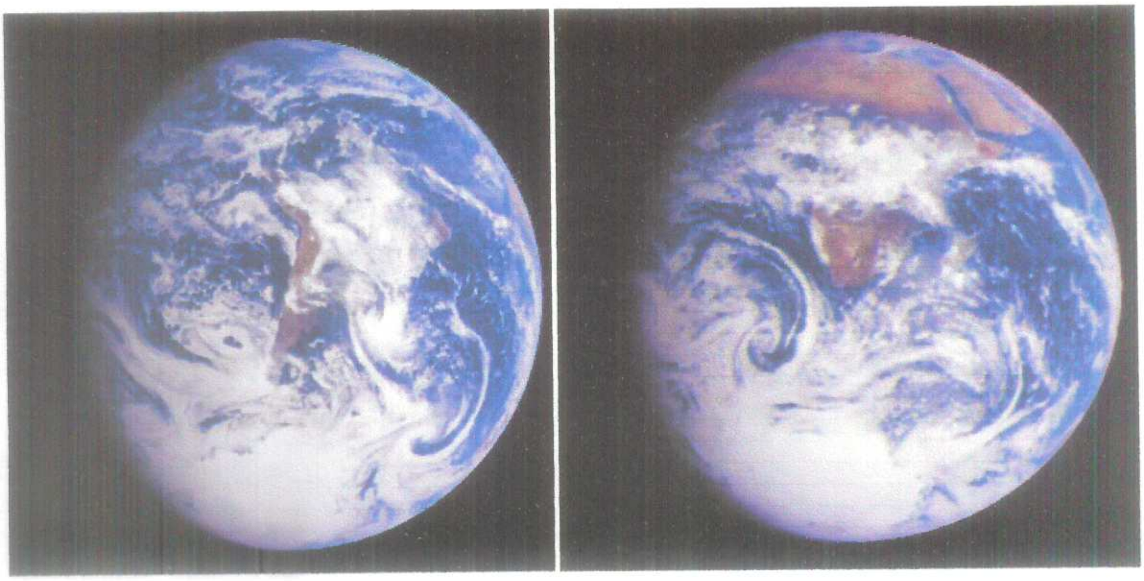
If Earth were a flat, one-sided disk facing the Sun and if it had no atmosphere... every square meter of Earth's surface would receive 1,368 watts of energy from the Sun. Although Earth does intercept the same total amount of solar EM radiation as would a flat disk of the Earth's radius (see figure below), that energy is spread out over a larger area. The surface of a sphere has an area four times as great as the area of a disk of the same radius. So the 1,368 W/m^2 is reduced to an average of 342 W/m^2 over the entire surface of our spherical planet. Another way to think of this reduction is to realize that half of Earth's surface (the night side) is in the dark and thus receiving no solar energy at a given moment, while areas near the edges of the planet (near the poles and around dusk and dawn) are receiving reduced amounts of energy per unit area.



The spherical Earth actually "intercepts" the same amount of incoming solar EM radiation as would a flat disk of the same radius, as shown here. However, the average energy per unit area of Earth's surface is one quarter of that which would strike a flat disk, once we factor in our spherical planet's larger surface area and the fact that half of it is in the dark at a given time.
Credit: Original art work by Windows to the Universe staff (Randy Russell).

Note that, the values for average **solar insolation** (the term scientists use for the solar EM energy delivered to an area) reaching Earth that have been discussed so far are at the top of the atmosphere. As you can imagine, as sunlight passes through our atmosphere, some of it is scattered and absorbed, reducing the amount that actually reaches the ground. We'll take up that issue in a bit, but for now we'll continue to simplify our discussion by assuming an airless Earth.

Whenever you glance up at the full moon, you get an eyeful of the subject of our next topic. Unlike the Sun which generates light itself, the Moon does **NOT** produce light. The moonlight we see on Earth is reflected sunlight. So, not all of the energy in the form of sunlight that reaches the Moon stays there; some is reflected back into space. Likewise, not all of the energy from the Sun that reaches Earth sticks around here to warm our planet; some is reflected back into space. Take a look at these two images of our planet that were captured by the Galileo spacecraft in December 1990:



Earth as viewed from space in December 1990. South America is near the center of the left-hand picture, while Africa is near the top of the right-hand image. Antarctica is visible near the bottom of both images. Note how much sunlight is reflected back into space by clouds and by snow and ice. Note also how light the deserts of northern Africa appear as compared to the Amazon forests of South America and the jungles of central Africa. **Credit:** Images courtesy of NASA/JPL and the Galileo spacecraft.

Obviously, quite a bit of the sunlight that reaches Earth is reflected back into space. The white clouds that cover much of both images, and the white ice of Antarctica, both reflect most of the sunlight that falls upon them. You can also see how the oceans, the deserts of northern Africa, and the jungles of central Africa and of South America reflect or absorb varying amounts of sunlight.

5.1.2 Albedo

Astronomers use a quantity called "albedo" to describe the degree to which a surface reflects light that strikes it. An extremely reflective surface that doesn't absorb any of the light that hits it would have an albedo of 1, while a surface that reflects none of the light that hits it (and that would thus appear pitch black under any illumination) would have an albedo of 0. Fresh snow has an albedo somewhere around 0.8 or 0.9. Forests have albedos near 0.15, while the albedo of desert sands is roughly 0.4. Climate scientists also employ the concept of albedo, though they often express it as a percent; thus they would say that snow has an albedo of 80% to 90%, while the albedo of a forest would be around 15%.

The albedo of a planet (or a locale on it!) clearly affects the ability of that planet to absorb sunlight, thus converting it to heat that can warm the planet and drive its climate. Earth's overall average albedo is about 0.31. Oceans and forests are quite dark, while deserts are lighter, and clouds, snow, and ice are very bright. Without clouds our planet's albedo would be around 0.15, so clouds roughly double Earth's albedo.

5.1.3Earth's "Theoretical" Temperature

We now have nearly all of the tools in hand to estimate what the surface temperature of a simplified (that is, lacking an atmosphere and averaging the albedo over the whole planet) Earth "should be". Here's how that calculation goes. We assume Earth is in a steady state, neither warming nor cooling rapidly. Our planet is obviously receiving an influx of energy (the 342 W/m^2 of solar EM radiation); so, to stay in balance, it must be getting rid of just as much energy (otherwise it would heat up rapidly). So how is Earth shedding energy? Any object that has a temperature above absolute zero emits electromagnetic radiation. Wave your hand above a burner atop an electric stove; even if it isn't hot enough to glow red with visible light, you'll clearly feel the heat from its infrared emanations. Objects much less warm than a stovetop, including our planet, also emit EM radiation, generally in the infrared range. It turns out that there is a mathematical relationship between the temperature of an object and the amount of energy it radiates (the Stefan-Boltzmann law). We'll use that relationship to balance the energy input from the Sun, and thus to calculate the "expected" surface temperature for Earth.

This simplified model of Earth yields an average global temperature for our home world of 254 K (or -19° Celsius or -3° Fahrenheit). Such a planet would be a chilly place indeed; most or all of the water on Earth would be frozen if this were indeed the temperature of our world. In reality, Earth's overall average temperature is roughly +15° C (or +59°F or 288 K). As we'll see in a bit, our atmosphere makes this planet a much more comfortable place to live!

The mathematical calculation

<table>
<tr><td colspan="2">We need to balance: Total power absorbed = Total power emitted</td></tr>
<tr><td>Total power absorbed

Power per unit area x Area of planet facing Sun x Fraction of sunlight absorbed by planet's surface

$1,368\ \text{W/m}^2$ x □ x $(R_{Earth})^2$ x (1 - albedo)

[Note: we use the "Earth as a disk" assumption mentioned earlier to calculate the "area of planet facing Sun".]</td><td>Total power emitted

Power emitted per unit area x Total surface area of planet

□ x T^4 x □□ x $(R_{Earth})^2$

Where □ is the Stefan-Boltzmann constant, with a value of
5.7×10^{-8} watt / (m^2 x K^4)</td></tr>
<tr><td colspan="2">When we set the power absorbed and the power emitted equations equal to each other, □ and the Earth's radius term cancel out, so we are left with:

$1,368\ \text{W/m}^2$ x (1 - albedo) = 4 x □ x T^4

Or, using Earth's average albedo of 0.31 and solving for T:

T^4 = [$1,368\ \text{W/m}^2$ x (0.69)] / 4□

Which yields T = 254 K (= -19° Celsius = -3° Fahrenheit)</td></tr>
</table>

5.2 ELEVATION AND IRRADIATION RELATION

Hill slopes and mountains Topographic variation in slope of terrain can produce local differences in solar radiation equivalent to tens of degrees of latitude. This is most evident in mountains, but also occurs along hill slopes. In addition, changes in elevation alter temperature, precipitation, and winds. As a result, mountain climates are quite different from low elevations (Barry 1992; Whiteman 2000).

Under the right conditions, temperatures increase with elevation rather than decrease. Mountains and hill slopes develop local wind circulations in response to spatial variation in surface heating. Under calm conditions and clear sky, light winds often blow upslope during the day and down slope at night. During the day, mountain slopes absorb solar radiation. Air is heated by these warm surfaces, becomes less dense, and rises. Air flows upslope from low-lying valleys, ravines, or plains to replace the ascending mountain air. These upslope circulations depend on a temperature contrast and develop most strongly on slopes receiving the greatest amount of solar radiation. For example, an east facing slope heats up from early morning solar radiation and may develop upslope winds before a west facing slope. At night, the slopes cool, and cold air near the surface flows downhill and collects in low-lying areas, often forming frost pockets.. Warmest night-time temperatures are often found at mid-slope. Ridge tops are colder due to their high elevation; valleys are cold because of cold air drainage. When a particular mountain was studied, daytime temperatures decreased with elevation as expected. Night-time temperatures increased with elevation up to 800 m; thereafter temperatures decreased with elevation. The warm region at 800 m is the mid-slope thermal belt. Many meteorological factors influence the location of this belt. The thermal belt is best developed during clear, calm nights. With high winds or rain, the normal lapse rate occurs. As a result, the elevation with warmest temperature is not constant but varies over time.

It is clear that proximity to the equator favors the strength of solar irradiation and given that we are in the tropics, it is laudable to depend on the adaption of green building designs to be solar passive architecture. The elevation map above justifies that certain within the Ibadan city would be best to situate such green housing schemes as prospected by the government in other to optimize the power installations in these estates.

At the above sea altitudes especially in the green areas as shown on the map, it would be recommendable to make such regions as choice locations to site these prospected green developments.

The choice to use one natural parameter is due to the scope of the thesis work. Other environmental parameters will play significantly as well and in combination inform critically the choice locations should there be need to site such facilities.

With adequate meteorological data, relating to wind and geothermal presence, it would also determine to a large extent, what locations may be chosen if these green energy resources were to be deployed either in hybrid functionality or as sole energy sources.

The impact of going green in Oyo state using Ibadan as a start being a major city will be enormous. This will be challenged by factors illiteracy, ignorance, poor awareness on the need to save the environment, poverty, lack of competent expertise and bad political terrain.

The simple analogy is that good elevation will favor green energy integration in building in terms of locating the building in contrast to a valley location, with the suggested areas on the map, it would be mindful for the government to focus on areas within such axis. Please note that an array of pertinent factors will still come to play in these decisions to site a green estate.

In reference to the chapter discussions on policy measures to fester green energy use and efficiency of energy in building and other spheres, government must be well informed, proactive and willing to embrace the new frontiers of energy development and the clamor to conserve and preserve the environment.

Also the use of local building materials will play a great deal in reducing the cost of construction, e.g. use of bamboos, rocks and other local materials.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

It is therefore clearly evident from the discussions on green energy, the case review of the water cube energy considerations and design, the green energy application dynamics in solar passive buildings, that it is possible to integrate green energy at any level of sophistication into any size of building or facility for whatever purposes such facilities or buildings will be harnessed. Green energy buildings must be deployed to sustain energy efficiency, increased comfort and affordability. Also, the practice of green energy integration into building and facility design will accelerate and increase the application of energy efficiency techniques and measures which ultimately supports the reduction of domestic and industrial green house gas emissions, lower consumption demand and improve supply quality and quantity.

This is especially needed in a country challenged by increased energy demand, poor development in building infrastructure, a growing energy economy, and favorable climate condition to consider intimately the values and applications of green energy in the regard of building low cost houses, general social amenities facilities projects, and redesigning of sub-urban settlement cities, again in the face of inadequate power generation and distribution challenges.

If at the level of such a dynamic and intricate building and swimming pool centre development for Beijing Olympics, green energy was well considered and integrated , then much easily and possible it is on our (NIGERIA) simpler housing schemes and architectural designs or facility developments.

Finally, NIGERIA, has all it takes (given even the simple overview on the identification of the areas favorable to cite solar passives, using GIS MAPPING, on the basis of elevation parameter) to embrace this so long as it becomes a priority to us at every energy stakeholder level in the country and specifically in the building construction industry.

RECOMMENDATION

In other to take a major stride forward, the issue of environmental degradation, global warming concerns, climate change and the dicey balance between energy supply and demand must be brought forward through campaigns by energy stakeholders, to all levels of the community, schools, citizens because it is only a collective effort, that will create the consciousness, hence stir up the need to proffer green solutions at all levels necessary.

The myth and perception that green energy integration is for the rich and wealthy must be addressed by public sensitization and critical role of government intervention schemes.

When the society has been duly informed on the demerits of continued use of fossils and the merit of renewable energy resources, the need to preserve our environment and also contribute positively to climate change challenges, then we can begin to talk about the possibility of solutions, one of which is as it concerns the subject already discussed, bothering on deploying green architecture and construction.

Policy formation and implementation continues to challenge development in all sectors of our government, and in relation to the subject at hand, energy policies must be well reviewed and formulated, implemented and seen through even in the construction and building industry.

The government must create enabling business environment for green building real estate developers to thrive. They must also inculcate the ideals and standards, setting examples with government building and facility infrastructure projects, so that the private sector can emulate the same.

Energy and power regulatory bodies must function with other organizations or bodies that are concerned with building, architecture and general construction, from design to implementation level. In the academic world, especially for science and technical studies, environmental and green energy awareness courses must be integrated to further increase early awareness and learning on why and how we can fix the world climate, environment and energy challenges, whilst also encouraging collaborations and exchanges with other energy developed and advanced nations.

Finally, Oyo state should simply focus more on solar passive buildings, farms and facilities, whereas, the northern Nigeria will leverage on hybrid green energy buildings of solar and wind where possible.

REFERENCES

Architecture 2030. "Meeting the 2030 Challenge Through Building Codes." June 20, 2008

Ashok, B., Cynthia, A. K. 2012, Green Buildings in Green Cities: Integrating Energy Efficiency into the Real Estate Industry. Haas School of Business, University of California Berkeley

Eastman, C.M. 2008, BIM Handbook: a Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors, Wiley, Hoboken, N.J.

Ekholm, A. & Fridqvist, S. 1996, "A conceptual framework for classification of construction works", Electronic Journal of Information Technology in Construction, 11-25.

en.beijing2008.cn/

Ethel Baraona Pohl. 2008, The watercube. Beijing National Aquatics Centre, People's Republic of China

Feist, W., Schnieders, J., Dorer, V. & Haas, A. 2005, "Re-inventing air heating: Convenient and comfortable within the frame of the Passive House concept", Energy and Buildings, 37(11), 1186-1203.

Feist, W., Schnieders, J., Dorer, V. & Haas, A. 2005, "Re-inventing air heating: Convenient and comfortable within the frame of the Passive House concept", Energy and Buildings, 37(11), 1186-1203.

Fiksel, J. & Dunkle, M. 1992, "Principles of requirement management automation", Combined Proceedings of the 1990 and 1991 Leesburg Workshops on Reliability and Maintainability Computer-Aided Engineering in Concurrent Engineering, 1990 and 1991, 231.

Gosling, J. & Naim, M.M. 2009, "Engineer-to-order supply chain management: A literature review and research agenda", International Journal of Production Economics, 122(2), 741-754.

Haymaker, J.R., Chachere, J.M. & Senescu, R.R. 2011, "Measuring and improving rationale clarity in a university office building design process", Journal of Architectural Engineering, 17(3), 97-111.

Kats, Gregory. 2003, The Costs and Benefits of Green Buildings. Massachusetts: Massachusetts Technology Collaborative.

Magent, C.S., Korkmaz, S., Klotz, L.E. & Riley, D.R. 2009, "A design process evaluation method for sustainable buildings", Architectural Engineering and Design

Management.

Nwofe, P.A. 2013, Deposition and characterisation of SnS Thin Films for Applications in Photovoltaic Solar Cell Devices. Ph.D Thesis, Northumbria University, United Kingdom

P.A Nwofe. 2014, International Journal of Energy and Environmental Research Vol.2, No.3, pp.1-9

Productivity and Green Buildings" Environmental Building News,

Russ,Thomas. 2002, Site Planning and Design Handbook. New York: McGraw-Hill.

Sustainable Building Practices for Low Cost Housing, UN Habitat, 2010

Web links:

www.arup.com/

www.bsd.com.sg

www.buildinggreen.com

www.buildup.eu/home: energy solutions for better buildings.

www.dynamiccity.org/

www.ecoarchwiki.net: Building case studies, good energy-oriented work

www.eren.doe.gov

www.esprojects.net/en/energyefficiency/

www.intendesign.com

www.itcon.org

www.ptw.com.au/

www.usgbc.org