How Green Building Passive Design Techniques Can Enhance the Lighting and Thermal Indoor Environment in Museums

CHAPTER ONE Introduction

1.1 Background of Situation

There is a need for global environmental sustainable development involving upgrading the built environment with green initiatives to conserve water and energy. It is necessary to make the country economically and environmentally sustainable for the future since they will not be able to rely on oil after a few decades. They also believe that green building energy consumption management and alternative energy partnerships with foreign governments and companies will help improve the green building energy conservation strategies throughout the country. The global built environment is the interrelated management, design and construction of manmade surroundings for community activities, including housing, infrastructure, energy networks and water supplies. Many developing nations require global sustainable development strategies for the future to reduce energy consumption. A solar energy business model using passive cooling and thermal mass can make energy more efficient and decrease consumption for developing nations. Sustainable development strategies can then be made for the future and adopted by the other countries after they have proven energy consumption reduction. Detailed accounts of how passive cooling and thermal mass can reduce energy consumption explain how green building strategies help use less energy (Aghion, 2009, 1-6) (Al-Ateeqi, 2009, 1-4).

1.2 Research Process

Research Question:

“Can green building strategies using passive cooling and thermal mass increase thermal comfort and reduce energy consumption inside museums to help the built environment become environmentally-sustainable for the future?”

Research Objectives

The research objectives for this project include:

- To explain how environmental solar energy strategies like passive cooling and thermal mass increase thermal comfort inside museums and reduce its energy consumption
- To determine if green initiatives like passive cooling techniques will help museums become environmentally-sustainable for the future
- To determine if solar energy museum projects with green building designs will reduce energy consumption and increase environmental sustainability for the future

CHAPTER TWO Literature Review

2.1 Green Building to Reduce Energy Consumption For Sustainable Development

The global built environment can become sustainable for the future with green building designs that reduce energy consumption. Some of the most important characteristics of global sustainable development include:

- Protection of the desert and city areas and the wildlife that lives there
- Protection of the sea, creek and beaches and the marine life that lives there
- Protection of the people living in the city from smog, acid rain, and all forms of land, water and city pollution
- Protection of the drinking water to ensure that it is clean and usable during construction and afterward
- Urban development and urban renewal programs for renovating older areas of the cities so they are safe and retain an aesthetic appeal and retain the value of the surrounding properties
- Urban development infrastructure of the cities for building new construction properties, freeways and public transportation systems (like the Metro) so they conform to new local and global environmental standards (according to and Kyoto Protocol for Greenhouse gas emissions and carbon emissions) (Al-Marashi, H, Salama H 2008, 1-4). (Peterson, 2008, 1-5).

Examples of how green building energy conservation strategies that the global is using to reduce energy consumption for sustainable development include:

- Solar panels to use solar energy from the sun to save energy
- Energy-efficient strategies and supplies for saving electricity and air conditioning, such as Smart technologies and automatic hallway lights
- Water conservation methods for saving clean water for drinking, such as automatic public bathroom faucets and toilet flushers to avoid drips, leaks and people leaving the water on for no reason
- 3R Strategy: Reduce waste, Reuse materials, Recycle items
- Develop better landfills conforming to environmental standards to protect the desert and sea from the increasing garbage that is being dumped there (Peterson, 2008, 1-5) (Bradford et al. 2008, 1-3).

Global Green Building Construction Integration Strategies

Some of the latest global green building construction integration strategies that are being incorporated into future urban planning include:

- Green buildings reduce overhead, operating and capital costs & promote employee productivity through improved sense of well-being (saving energy and protecting the environment)
- Energy efficiency—streamlining building overhead costs with high-tech automatic indoor/outdoor lighting, recycled landscape water systems
- New SMART technologies—auto-lighting, auto-water turnoff systems, security systems, security gates, underground parking

- Sustainability, energy efficiency, water conservation, indoor air quality, and the use of non-toxic, eco-friendly materials within the structure;
- Energy-efficient chillers and environmental-friendly refrigerants;
- Reduction of lights required through architectural designs integrating more direct/indirect sunlight
- Waterless urinals, water-based paints, carbon dioxide detectors;
- Intelligent commercial and industrial automated products and concepts such as building management systems (BMS) and machine-2-machine (M2M) communications;
- Water reduction strategies, wastewater and desalination treatment plans;
- Reduction of unnecessary pollution
- LEED global standards provide a framework for assessing building performance and meeting global environmental sustainability goals
- Local outsourcing of green building supplies
- Bonding green building materials for reducing land erosion
- Construction waste segregated and disposed of according to green building guidelines;
- Recycled wood and eco-friendly sealants, paints and carpets for the interiors;
- Carbon dioxide sensors for maintaining fresh air in all rooms;
- Parking facilities for bicycles and battery-operated cars;
- Ramps and handicapped parking spaces for the disabled;

- SMART state-of-the-art technologies compile Internet Protocol (IP) infrastructure with all the IT systems (including the building maintenance system (BMS), security system, and access controls) all linked to a single IP network
- Increasing added value to projects—customers get more value for their money (innovative architectural solutions; sense of health and well-being in both living & working spaces)
- Corporate sustainability—adopting new governmental initiatives and creating value-added projects that consumers feel are worthwhile investments
- Global environmental laws (Kyoto Protocol)
- Upgraded Facilities Management (FM) services—combination of electricity, plumbing, air conditioning and general maintenance services (managed under one main company and outsourced for cheaper bids)
- Improved building security—video surveillance cameras, burglar/fire/smoke alarms
- Strategic alliances between developers, banks, real estate management and FM companies (often all owned by same parent company to obtain economies of scale and competitive advantage over rivals in the industry)
- New Corporate Social Responsibility (CSR) initiative for environmental regulations;
- Consensus-based national standard for developing high performance, sustainable environmentally-friendly buildings (Kulatilaka, Klosowski, 2011, 1-7) (Salama, 2010, 1-6).

2.2 Passive Design Techniques

Passive Cooling

Passive cooling uses natural building designs to sustain cooler interior temperatures, which reduces the need for mechanical energy sources and decreases overall energy costs. Global experts agree that green building passive cooling strategies can decrease heat gain energy consumption by up to 25%, which means less electricity used for air conditioning and greatly reduced energy costs. Passive cooling can also include green building designs with shading, window and building orientation to allow for specific amounts of sunlight and shade. Massing means combining building heights during urban planning to allow for natural winds to cool areas and reduce heat gains. Passive cooling using wind tunnels to provide natural ventilation is very effective in reducing air conditioning electricity and energy consumption costs (Guy et al, 2010, 1-4).

According to a United Nations survey on construction, global buildings utilize over 40% of the entire world's energy, 25% of timber from forests, and 16% of fresh water for development projects. This huge amount of natural resource consumption can be greatly reduced with green building strategies, especially those using solar energy to decrease energy consumption. Europe's energy consumption rates for commercial building air conditioning and cooling have reached over eight billion euros annually. According to Adnot (2005), over 6% of industry, commercial and office buildings have air conditioning that total 20 million cubic meters (Santamouris, 2005, 1-25).

This total air conditioning usage has been forecasted to increase 400% in the next 10 years without proper green building strategies and regulations in place. The USA shows over 3.5 billion meters squared with air conditioning in commercial buildings, with 250 Twh annually. Summer cooling in the USA requires over 109 gig watts annually for commercial buildings. Passive cooling and hybrid cooling are specific green building solar energy techniques that improve microclimates, provide more efficient solar and heat protection, and allow for distribution and modulation methods for contributing to increasing thermal comfort and reducing building cooling loads, especially during the hottest summer months (Santamouris, 2005, 1-25).

According to Pascool, the European Research Project developed by Santamouris (1997), specific advanced green building engineering design tools and techniques now provide much more effective passive cooling and thermal comfort strategies for improving building interiors and reducing energy consumption costs. Thermal comfort explains how comfortable people are in the environment of their building interiors. According to a study conducted by the International Institute of Refrigeration (IIR), air conditioning and refrigeration consumption is over 15% of global electricity costs. IIR estimates that Europe's commercial building air conditioning consumption will continue to increase to 40 kwh square meters annually. IIR states there are over 856,000 air conditioners that rely on water, 89 million split and duct free systems, 16 million unitary systems for commercial usage, 55 million split systems with ducts, and 79 million air conditioners per room worldwide. The yearly sales for these air conditioning units total over $60 billion.

Almost $21 billion go to room cooling units, over $12.3 billion is spent on housing heating pumps, $6.5 billion goes to rooftop air conditioning units, and almost $16 million for packaged air unit systems. These totals make up over 10% of the entire global car industry. Major developed nations like Japan have 80% of air conditioning in all their buildings, while Europe has 65% and the USA has nearly 100%. By redesigning the overall building using green building strategies like passive cooling techniques and thermal mass, experts agree a huge amount of global energy consumption and related expenses can be decreased over time (Santamouris, 2005, 1-25) (Chiras, 2011, 38-46).

This school classroom in Figure 2.1 shows how green building designs using passive cooling and solar energy are combined to maximize natural sunlight and heat with window placement and concrete floors for exposed thermal mass to reduce air conditioning usage and annual energy consumption costs through natural ventilation (Myhren, 2008, 134-142).

Figure 2.1 Passive Cooling & Thermal Mass Green Building Example (IRR, 2005)

Enhancing Thermal Comfort Through Passive Design

Studies have proven that applying green building alternatives like passive cooling to the architectural design and construction of building envelopes can accomplish and maintain thermal comfort levels for indoor spaces environment. Passive cooling contributes to controlling heat exchange through the building envelope. It also improves the thermal behaviors of the construction components of the building. Technological developments have proved they are very efficient in lowering the use for cooling as it improves indoor environmental surroundings. They have proved successful in maintaining thermal comfort levels and achieving comfortable indoor environment, if well applied. In Tokyo and Singapore, a typical office building is mostly a high rise glazed tower. Passive cooling strategies and elementary design like massing, envelope and orientation are now considered a major concern as to their effect on the building energy performance and how to improve thermal comfort (Chiras, 2011, 1-7).

Thermal Mass

Peterson (2009) states thermal mass is the capability building materials have to store interior heat and then gradually release it into the room again. Thermal mass involves providing natural thermal comfort in passive solar energy green building designs using natural sunlight and shading techniques. Thermal mass is an effective method of upgrading the overall comfort of building spaces during daily temperature changes in all seasons. According to the Environmental Protection Agency (EPA), within passive solar design green building strategies, thermal mass shows major energy consumption reduction (Krause, Sergey, 2011, 1-7).

According to the international cooling experts at the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), thermal comfort is the satisfaction people have in their immediate surrounding environment. The ASHRAE Standard 55 is the main global benchmark for deciphering thermal comfort during green building designs. Passive solar design involves the implementation of thermal mass and thermal comfort approaches to reducing energy using passive cooling strategies that include natural light, shade and ventilation. Thermal mass is situated within green buildings to allow for maximum exposure of natural sunlight to take advantage of solar energy for power storage. Low angle sunlight during summer through windows provides natural shade, which reduces excessive heat and the need for more air conditioning, decreasing energy consumption and costs. High angle sunlight during winter captures sunlight and uses it to heat interiors naturally, reducing heat and energy costs (Anderson, et al .2011, 1-4) (Mays, 2008, 79-83).

Table 2.1 shows the most common building materials for construction and their heat capacity, density and heat per volume. An explanation of the units shows: J=Joules, K=Kelvin; 1 kilowatt hour of electricity totals 3.6MJ of energy. Water has the highest heat capacity at 4.18 J/gk and highest heat per volume at 4.18 mj/m3k, while gypsum has the highest density at 1602 kg/m3 (Hauck, 2009, 1-25).

Table 2.1 Thermal Mass in Building Materials (Build Green, 2008)

Material	**Heat Capacity (J/gK)**	**Density (kg/m^3)**	**Heat per volume (MJ/m^3K)**
Water	4.18	1000	4.18
Gypsum	1.09	1602	1.746
Air	1.0035	1.204	0.0012
Concrete	0.88	2371	2.086
Brick	0.84	2301	2.018
Limestone	0.84	2611	2.193
Basalt	0.84	3011	2.529
Sand (dry)	0.835	1602	1.337
Soil	0.80	1522	1.217
Granite	0.79	2691	2.125
Wood	0.42	550	0.231

Figure 2.2 explains the green building solar energy strategies that help reduce overall energy consumption levels and costs annually by reducing thermal mass and solar radiation. Direct solar radiation increases thermal mass, so green building designs must focus on appropriate placement of windows using horizontal angles of perforation that are altered for different floors. This will facilitate visual contact to the street level. Vertical angles of perforation changes prevent solar radiation during early morning and late afternoon hours when temperatures are hottest, keeping buildings cooler naturally (Fromonot, 2009, 65-72) (Shaw, 2007, 128-147).

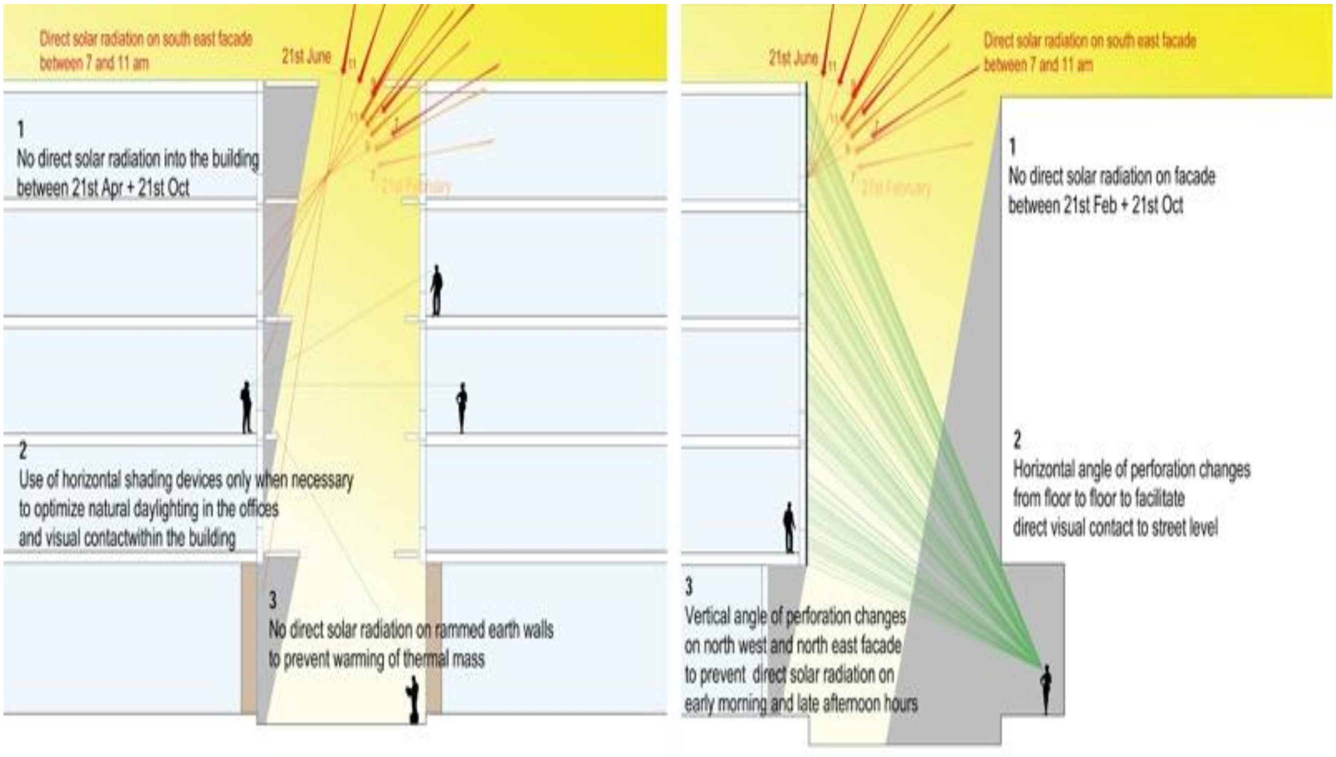


Figure 2.2 Reducing Thermal Mass & Solar Radiation (LEED, 2008)

Building Orientation

Building orientation is considered the most simple and sensible design strategy that can be applied and effectively reduce cooling demand and performance in buildings, climatic data revealed that buildings in the UAE receive the highest amounts of solar gains in the summer on the buildings eastern and western elevations and on winter on the southern elevation, that's why its recommended to orient buildings on the east-west axis with glazing designed to be located on the north and south sides of the building supplemented with suitable shading devices in addition to glare controls. Designers should also study Microclimatic wind patterns because they can help reduce heat gain and increase passive cooling methods (Chynoweth, 2010, 1-25).

Building Massing

Another effective design strategy is massing, it should be seen in the urban contexts, like high rise group of buildings which are having similar heights should be avoided because they limit movement of air and minimize ventilation. . On the other hand gathering buildings that have different heights and have longer facades increase movement of air which will help to better ventilate the buildings and reduce heat gains (Njeri, 2012, 1-8).

Shading Devices

Shading is considered another significant design strategy that effects thermal comfort levels in the UAE since the high heat gains that are received by its buildings. Shading devices can be accomplished through different strategies like self-shading, overhangs on windows, building clustering, planting high trees, and designing shading features. There are the operable shading devices which give the flexibility of adjusting the shading shutters and blades to increase ventilation and day light into the interior spaces as well as minimizing the admittance of direct heat gain (Hancock, 2010, 1-5).

High Performance Envelope and Thermal Insulation

It is recognized that in UAE, in a typical house 30% of heat gains happens through its roof and also 30% through walls, so to providing high thermal insulation on the building envelope.is considered an effective passive cooling technique as it prevent heat from getting into the building. In a typical house in the UAE, 30% of heat gain occurs through its roof and almost 30% through its walls. So another effective passive cooling technique is by preventing heat from entering the building, so any cooling achieved by mechanical or natural conditioning can be reserved. In order to reduce heat gain, higher insulating building materials should be applied and used properly in the building envelope (Khodakarami, 2009, 92-104).

The efficacy of insulation for a certain envelope can be measured according to their U-value (which represents the amount of heat radiation (W) which enters the building per meter square of area at a temperature deferential of one degree). A U-value of 0.35 at most should be there in w insulated walls, roofs and floors. Traditional architecture in the UAE took advantage from high thermal mass materials, which are insulated against increases in outdoor temperatures and reduced solar heat gain. The use of thermal mass is the most difficult in hot climates where night temperatures are also high. Its use is mainly as a temporary heat sink. Yet, it needs to be tactically located to avoid overheating. It should be placed in an place which at is not exposed to direct solar gain as well as allow suitable ventilation at night to move away the stored energy without increasing the internal temperatures any more. And of it will be used it should be used in sensible amount and not in big thicknesses (Khodakarami, 2009, 92-104).

Window Design

Over 40% of heat gain constitutes through windows can be controlled by using less glazing ratio in the building facades and with small Solar Heat Gain Coefficient (SHGC), which represents the ratio of heat which enters the indoor to the heat that reaches the window, and to use a high performance glazing it should be a double glazing yields a SHGC of 0.22 (Omer, Qenssen, 2008, 1-5).

Natural Ventilation

Buildings can apply natural ventilation and create a good level of thermal comfort through many ways; orientation is one important decision that can allow cross ventilation by providing access to major wind directions. Advanced solutions like wind towers and solar chimneys can allow natural ventilation where the situation do not allow cross ventilation. For instance, using solar chimneys in combination with a cooling cavity can cool the outdoor air while entering the space, on the other hand removing the warm air through the solar chimney. In the city of Al Ain in 1998, a similar system was tested and proved successful by Professor Mohsen Aboulnaga, in the study air current rates achieved were adequate to provide thermal comfort to occupants inside the building.

Buildings yearly consume 30% of the total energy as well as 60% of the electricity. The energy needed to run the air conditioning (HVAC) system constitutes about half of a buildings' energy usage. Thus, reducing energy consumption means giving more attention to the HVAC system energy usage. Moreover, the possible annual saving and productivity gain from improved indoor air quality (IAQ) are estimated as $14 billion from reduced breathing disease, $4 billion from allergies and asthma $160 billion from direct improvements in worker performance that are unrelated to health and $30 billion from sick building syndrome. Thus, investments toward improved IAQ can make considerable returns. For decreasing HVAC energy usage and improving the building's

IAQ, Precisely measuring and controlling outdoor air intake flow rates and building pressure are decisions should be considered (Salama, 2010, 1-24).

Table 2.2 shows the ASHRAE and LEED minimum engineering design guidelines for thermal comfort according to the green building parameters that include ventilation, filtration, design temperature, humidity, heat dissipation, lighting, building envelope, insulation, moisture, rooftop, windows, shading and heating degree days (Aaron, 2012, 48-64).

Table 2.2 Minimum Engineering Design Guidelines For Thermal Comfort

(ASHRAE and LEED, 2012)

Parameter	Value	Source	Standard	Design Target
Ventilation	20 cfm/person	ASHRAE 62/89	same	Maximize outdoor air by using displacement ventilation Deliver air low/ exhaust high
Filtration	None		35-80%	65% pre-filter 85% final filter
Indoor Design Temperature	75F summer 72F winter		same	
Humidity Control	NA			50% RH summer 40% RH winter
Equipment Heat Dissipation	NA		3-4W/ sf	1.5W/ sf or 2W/ sf with 75% diversity factor
Toilet Exhaust	50cfm/ fixture	ASHRAE 62/89	same	2 cfm/ sf
Lighting Power Loads	NA		2W/ sf All direct	0.5-0.75W/ sf Total task/ ambient with Occupancy sensors & Daylight sensors
Lighting Loads	100 ft candles		same	20-30 ft candles with Ambient and task lighting
Building Shell Infiltration (Envelope)	6 /100 sf	ASHRAE	3 /100 sf	1.5 /100 sf (Canadian Standard)
Building Shell Infiltration (alternate)	0.80 cfm/ sf		0.30 cfm/ sf	0.10 cfm/ sf
Exterior Wall Insulation	U= 0.28 btu/ sf-hr F	BOCA Energy	U=0.10 btu	U= 0.15 btu/ sf-hr South U=0.05 btu/ sf-hr N,E, W

		Code		
Exterior Wall Moisture Control				A/B-With insulation both sides
Roof Insulation	U= 0.07 btu/ sf-hr	BOCA Energy Code	U=0.05 btu/ sf-hr	U= 0.05 btu/ sf-hr with low surfacing
Windows				
Glazing type	single/ clear		double/ clear	heat reflecting clear
Visible transmittance	0.80	0.78	0.70	
Shading Coefficient	1.00	0.80	0.43	
U value	1.04	0.48	0.30	
Heating Degree Days	6,155 btu	ASHRAE	same	determined by DOE2 analysis of TMY data

2.3 Adapting to Sustainable Development

Sustainable development is one of the most important concepts that has been created to help cities and countries expand, grow and adapt to the changing global society and regulations. Sustainable development helps governments have global guidelines that will allow the new infrastructure to be developed according to higher environmental standards including green building energy conservation strategies to protect the natural ecological systems and the people, animals and plant life that live there. Worldwide is currently attempting to make the economy into a sustainable development society by launching new green building energy conservation regulations for all companies and people to adhere to in order to protect the natural environment.

Sustainable development involves cities meeting special requirements in order to protect the future society from not having the natural resources that are currently available. Some of these resources include clean drinking water, trees, fossil fuels, oil, clean land to live on, and clean air to breathe. Sustainable development is about people and companies in the present not focusing only on current needs and not compromising the future generation's ability to live in a clean and safe natural environment that will meet their needs. According to the World Commission on Environment and Development (WCED), the present global society must ensure that they do not restrict the people of the future by wasting resources. For these reasons, green building energy conservation strategies must be incorporated into the built environment to reduce energy consumption for the entire country (Hui, 2002, 1-3).

Any society requires the basic needs of air, water, food, housing, clothing and employment. There are also secondary needs in developed societies that include improving living standards above the basic minimum required for just survival to have better lives. However, developed societies have become very materialistic and consumer-oriented communities that often exceed their basic or secondary needs to be greedy and wasteful. This has led to a lack of natural resources, declining productivity and decreasing biodiversity worldwide. Each society should not be allowed to exploit too much of the natural environment so that the future generations will not have them to use for themselves. Sustainable development refers to preventing the overexploitation of these natural resources by restricting or prohibiting deforestation, water waste, carbon dioxide emissions in the air and excessive air conditioning use increasing global warming, dangerous landfills, and chemicals in natural waterways (Bradford, 2008, 1).

The chart in Figure 2.3 and Table 2.4 shows the fundamental elements of green building energy conservation sustainable development on a global level as a business model for to integrate into their own green urban planning. The most important aspects include environmental sustainability for the ecosystem, economy and biodiversity of animals by protecting the natural resources. Environmental sustainability requires reduced waste and toxins to protect people. Another significant factor is economic sustainability for societies to continue to survive with growth, development, productivity and financial and other resources for the future generations. Economic sustainability means creating new markets and sales growth opportunities, with cost reduction, energy efficiency, raw material protection and value-added creation in everything.

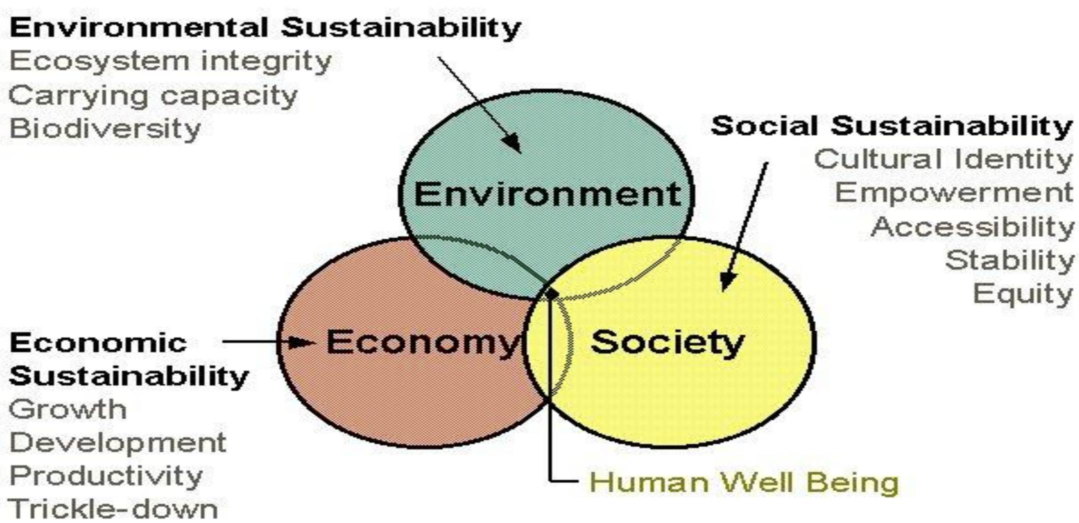


Figure 2.3 Sustainable Development

Table 2.4 Sustainable Development (Reiss, 2008)

Economic dimensions of green building sustainability:	**Environmental dimensions of green building sustainability**	**Social dimensions of green building sustainability**
• Creation of new markets and opportunities for sales growth • Cost reduction through efficiency improvements and reduced energy and raw material inputs • Creation of additional added value	• Reduced waste, effluent generation, emissions to environment • Reduced impact on human health • Use of renewable raw materials • Elimination of toxic substances	• Worker health and safety • Impacts on local communities, quality of life • Benefits to disadvantaged groups e.g. disabled

A new variable to green building sustainable development is the social sustainability of communities, which protects cultural identities, empowerment of individuals, accessibility to resources, stability of cultures, societies, families and households, and equity in homelands and heritages from the past to be preserved for the future. Sustainable development is the responsibility of all people to protect these elements to ensure the future of the global society. Social sustainability involves the protection of employee health and safety, improvement of life quality, and helping less fortunate people. Green building energy conservation strategies help to improve the quality of life for all people and save energy for the future sustainable development of the whole country (Hui, 2008, 1-4) (Peterson, 2008, 1-5).

Significance of Global Sustainable Development

Global sustainable development is necessary because oil will lose value and other industries have to be profitable enough to keep the country wealthy and maintain its current high standard of living. Many nations do not really produce many products and does not grow its own food, so research and development on growing agricultural crops in desert regions is needed for future food security. In a recent governmental report released by the International Council For Economic Development entitled, “Rooted in sustainability”, the main strategies for future sustainability include developing business ventures that will comply with international benchmarking best practices for sustainable development in all areas.

This report explains how global policymakers are attempting to make countries more economically sustainable through growth and development of non-oil sectors. It details how sustainable economic development must take into consideration the quality of life for all people in the community for the present and the future. It also focuses on how is pursuing an integrated approach to economic, social and environmental sustainable development for the future. The International government is especially focused on increasing global competitiveness and developing new investment and business opportunities for Emiratis with and entrepreneurship programs (Hrais, 2011, 1-8).

In a Khaleej Times article called “in the UAE”, the rationale as a part of a larger sustainability strategy is detailed. This newspaper article explains how global involves the private sector providing facilities and services for the public sector to expand the economy. It describes how partnerships are helping transfer many different assets and operations to the public sector that were previously unavailable. It also states how in the global includes joint venture partnerships that will help reduce governmental costs so they can be reallocated to other necessities related to expansion and development of the country.

One of the main reasons green building strategies are acknowledged as having many environmental benefits is stated as requiring managerial, technological and investment expertise for major global research and development projects. Other reasons include governments support and subsidize many green building expansion projects is to increase successfulness in infrastructure, utility and agricultural ventures. The government invests money into various projects that are then controlled and managed by private companies (both local and global) who have the responsibility to ensure its long-term sustainable development. Worldwide governments support provision of subsidies that contribute money in the form of government grants to help enforce green building initiatives for energy and water conservation (Al-Hashimi, 2005, 1-4).

In an article in The National called, “Sustainability the new buzzword in global growth”, the issue of economic diversification in the global to increase future sustainability is shown to be a strategic tactic for the government. This article explains how continued diversification, investment and expansion into non-oil sectors like tourism, hospitality and airlines is continuing to show advantages for the global economy. The article explained how expert economists like Shuaa Capital’s Khatija Haque in Dubai are supporting International’s 2030 Economic Vision for gradual growth and development over time through economic diversification and of the public sector. The article also depicted how the Dubai government’s Strategic Plan 2015 will continue to focus on global tourism and investments with more diversification into non-oil sectors (Arnold, 2010, 1-4).

Green Building: TOD Communities

The global future green building will include creating Transit Oriented Development (TOD) communities within walking distance from the town squares and residential areas. Architectural engineers and landscapers can work together to design the community setting as a pleasant natural environment that is close in proximity and practical for people to get around. This TOD capital facilities buildings should involve developing a neighborhood that has mixed-use green building streetscapes for reducing energy consumption and a diversity of well-designed housing and public transportation systems for all residents. The global will adopt strategies from global TOD town planners Andres Duany and Elizabeth Plater-Zyberk, two of the founders of the Congress for the New Urbanism (Philips, 2006, 1-8).

These experts promote that the most essential criteria for the global green TOD projects should include mainly public transportation modes, such as a train, taxis and buses for getting around town, and pedestrian sidewalks for walking and biking around the community safely. There should be several public parks that are well-lit with walking paths for exercising, refreshment stands with drinks and sandwiches, and benches for resting and relaxing, all surrounding beautifully landscaped gardens and ponds. Some of the most significant green building and energy consumption reduction theories today relate to preparing rapidly developing countries like global for the effects of global warming. Other green building theories include preserving natural resources and raw materials during real estate development (Bradford et al, 2008, 1-5).

Some public transportation theories involve creating more pedestrian-oriented communities that will reduce traffic congestion and pollution, and increase suburban walkways, subways, skyways and metro trains within the new global real estate communities. Some strategies encourage urban planners to plant more trees, grass and flowers to produce more oxygen into the environment and to reduce the amount of carbon dioxide in the air. Some of the current green building strategies relate to how is attempting to reduce energy consumption, protect the natural environment, reduce unnecessary waste by-products, increase energy efficiency, and provide safe, comfortable, relaxing communities for its residents (Peterson, 2008, 1-7) (Philips, 2006, 1-15).

Integrating Environmental Protection into Green Building

When comparing green building strategies, it is essential to realize how important the design and implementation protocols for energy efficiency are to establishing its future communities to be able to cope with the changes of global warming. One of the most prevalent green building theories that is based on governmental and non-governmental interaction to decrease the carbon dioxide emissions worldwide involves adhering to the Kyoto Protocol while developing new communities. According to researcher Lee (2003), within similar theories, are several energy efficiency and conservation strategies that must be integrated into emerging cities like global as a part of the entire infrastructure (Bradford et al, 2008, 1-5).

Through the design and construction of smart growth, technologically-advanced buildings within new communities, and the development of “Green” environmentally-friendly buildings that focus on reduction of energy consumption and natural environmental preservation, many theoretical guidelines can be directly applied to global’s new developments. Some of the latest theories on green building have focusing on upgrading various modes of transportation, including shuttle trains, transit buses, carpooling and pedestrian walkways for biking and walking to work to reduce traffic congestion and carbon emissions. Since the development of new housing and green building projects can also implement a variety of alternative energy sources, including renewable energy, hydrocarbon fuels, biofuels, solar power and wind power, cities of the future like global can help to prevent more adverse effects of global warming. Through the use of geoengineering, there are many new high-tech possibilities that global is currently incorporating into the green building of new projects.

Researcher Harrison (2006) feels creating buildings that adapt to the changing needs of the global society, and that are able to adhere to the conditions of the Kyoto Protocol and other environmental proposals is the key to changing the world. Another theoretical direction that is vital to adjusting global’s current green building strategies so that they are in compliance with new global warming designs is encouraging Multinational Corporations (MNCs) to change the way they conduct business practices and manufacturing processes during globalization. Many modern countries today like the global are creating efficient buildings to reduce energy consumption by 25%. By establishing the proper guidelines for carbon emissions trading, and complying with both non-governmental and governmental approaches to protecting the natural environment during the design or new urban plans, cities like global can begin to establish the energy efficiency benchmarks for the future global societies (Bradford et al, 2008, 1-5).

2.4 Global Energy Consumption Business Models

There are several governments and private corporations currently developing more effective energy consumption monitoring and measurement business models to create more efficient systems for the future. Many of these business models focus on alternative fuel sources being used to increase energy efficiency and save power. Some of the most promising global business models for energy consumption efficiency include these below.

The Informetrica Macroeconomic (TIM) Model Figure 2.4 explains how by the year 2020, the global demand for energy for residential, commercial, industrial and transportation will be too high for the current supply systems and the prices will make energy unaffordable for most consumers. This means that more appropriate energy consumption levels must be shown in the most developed nations where energy is wasted, such as the global, which has the highest consumption levels per capita in the world. There must be changes in the research and development investments for energy usage and consumption to determine new methods of saving electricity, water and power fuel sources (Kulatilaka, Klosowski, 2011, 1-7) (Salama, 2010, 1-6).

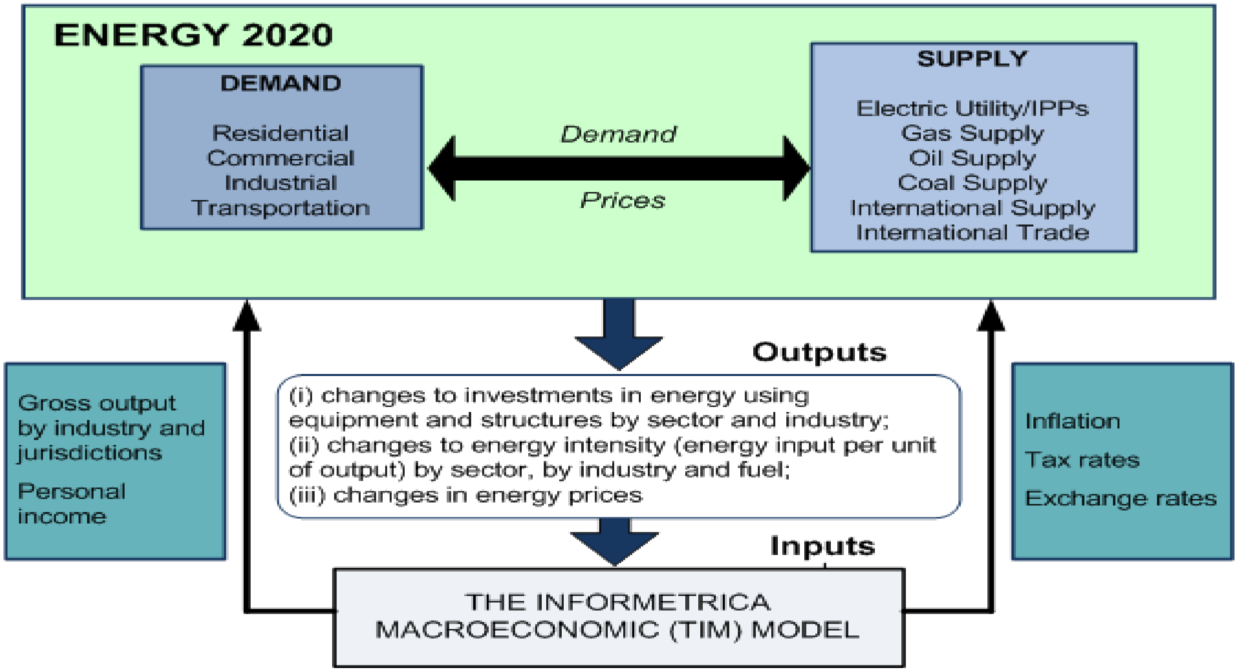


Figure 2.4 Energy Emissions & Economy Model (Environment, 2009)

The chart in Figure 2.5 describes the energy consumption measurement for public buildings according to customer needs and the possible solutions that are presently being proposed worldwide. Most buildings have such large power consumption levels that it is difficult to save energy without making the cost very expensive for consumers and companies. There should be energy-saving equipment modifications that will achieve the anticipated outcomes necessary to show proper efficiency levels and still retain overall costs.

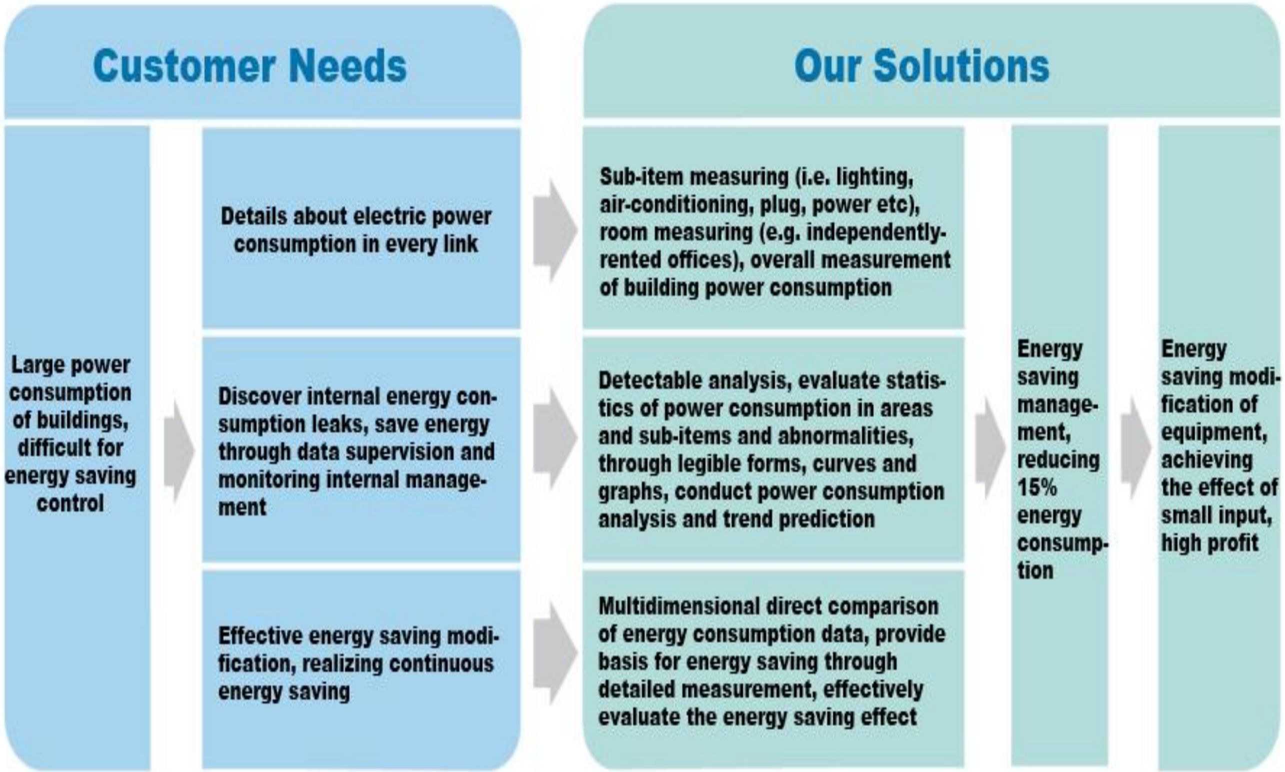


Figure 2.5 Energy Consumption Measurements For Public Buildings

(Energy Smart, 2010)

Figure 2.6 shows how energy consumption business models can be coordinated with optimization policies, automation frameworks and data centers to better monitor their efficiency levels (Kulatilaka, Klosowski, 2011, 1-7) (Salama, 2010, 1-6).

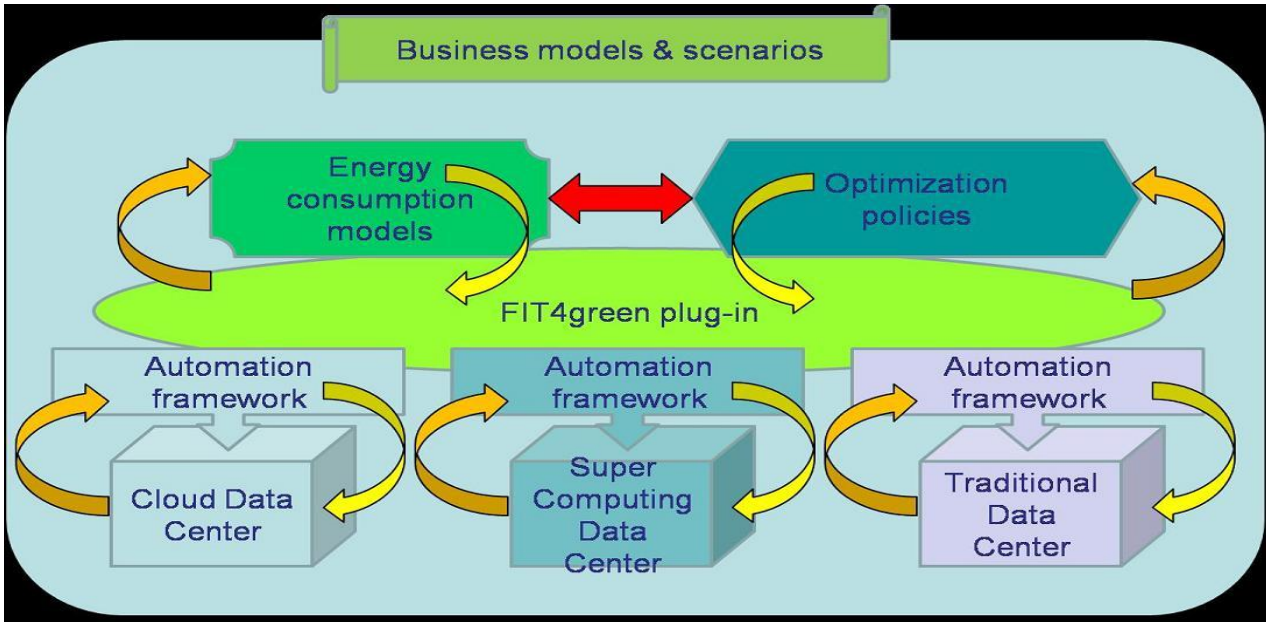


Figure 2.6 Energy Consumption Business Model (Fit4Green, 2008)

The chart in Figure 2.7 shows the alternative energy consumption business model in a SMART grid vision where the bulk of energy generation is transmitted through SMART distribution of loads, storage and generation. The contracts, intermediaries and services are then coordinated to work on higher energy efficiency strategies for consumers and agents (Kulatilaka, Klosowski , 2011, 1-7).

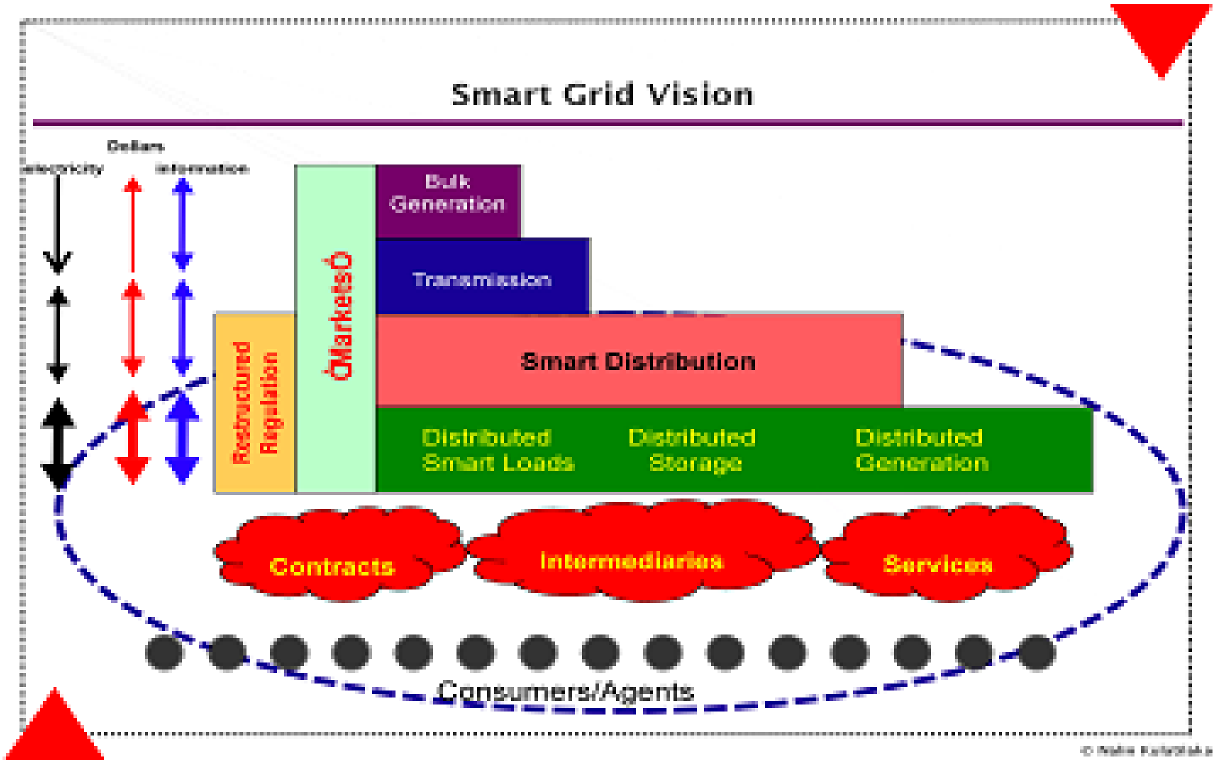


Figure 2.7 Alternative Energy Consumption Business Model

(Gevelber, 2011)

Figure 2.8 shows the energy efficiency levels of alternative fuel sources, with natural gas showing 88% being the most effective at reducing cost, followed by diesel at 84%, CG at 80% and EtOH at 78% (Kulatilaka, Klosowski, 2011, 1-7)

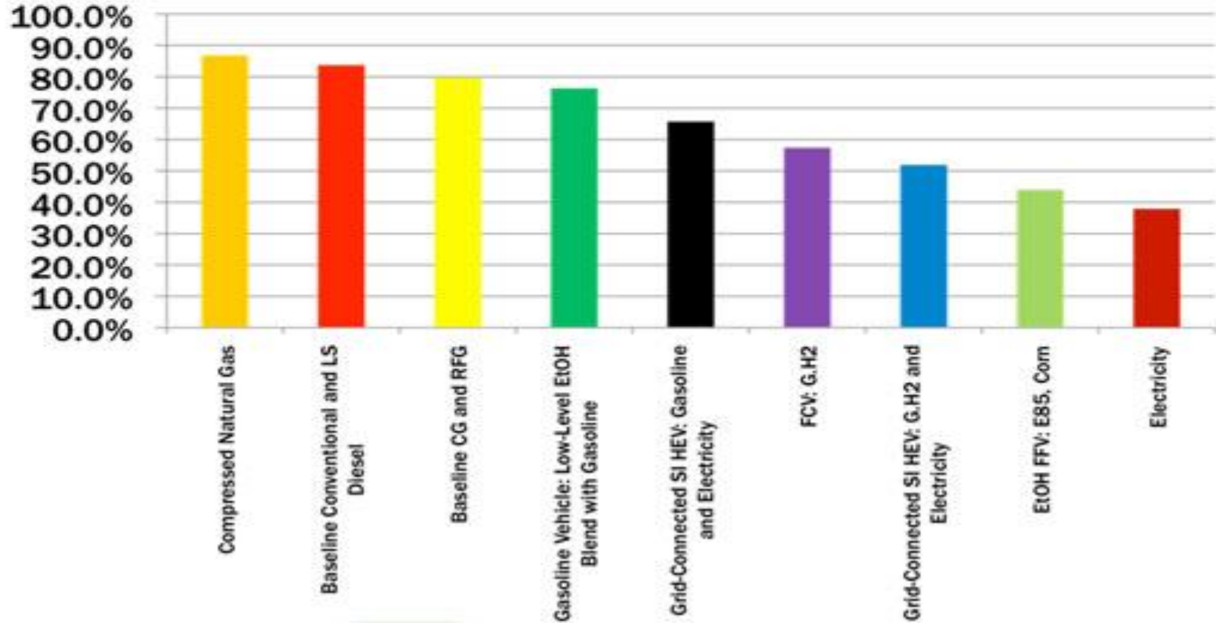


Figure 2.8 Energy Efficiency Of Alternative Fuels

Source: The Greenhouse Gases, Regulated Emissions & Energy Use in Transportation (GREET), 2011.

The model in **Figure 2.9** shows how companies should compare the differences between the energy consumption expected usage and the actual usage by temperature, compressor and condenser to determine if there should be alterations in the machinery and equipment to reduce overall costs and increase efficiency levels. These charts all show how green building designs can reduce energy consumption when properly implemented during environmental sustainability strategies (Yu, 2011, 1-17).

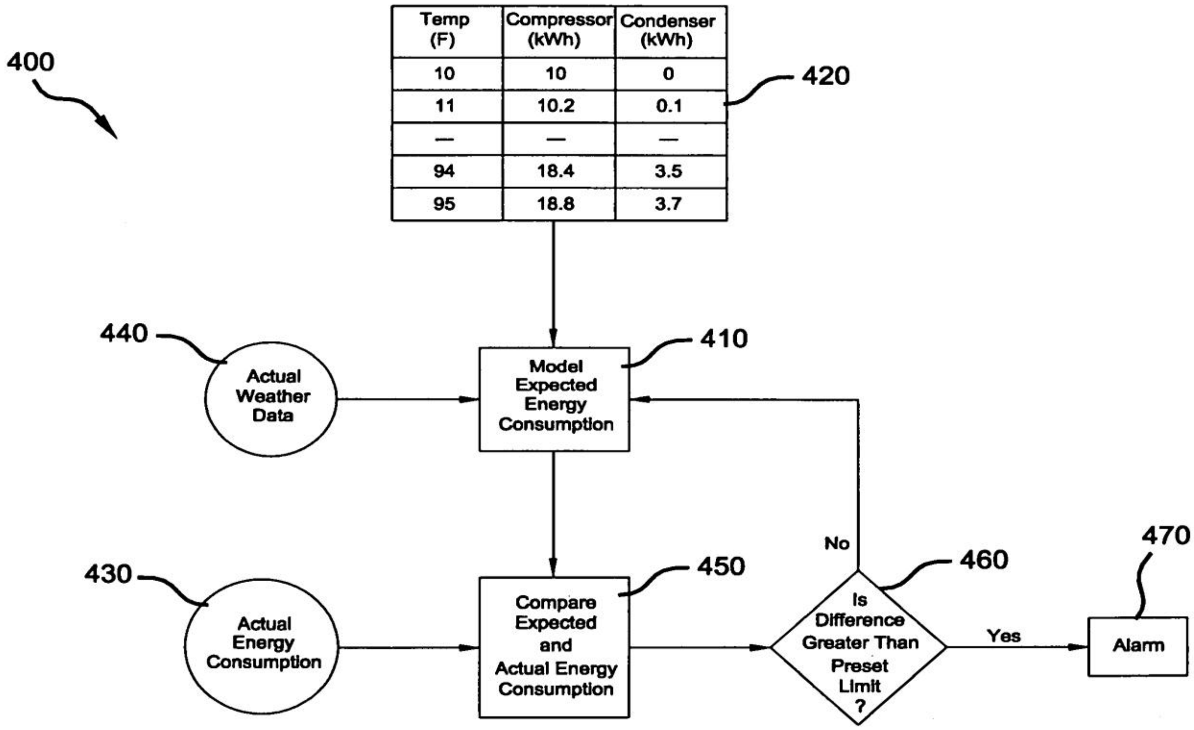


Figure 2.9 Energy Consumption Expected vs. Actual Usage (Singh, 2006)

Figure 2.10 shows the building energy consumption measuring system that includes a collection and remote transmitting hardware system, data storage, computing and release software system, and a data management, retrieval and application system to continuously monitor energy usage. The data collectors track the cold and hot water meters, gas gauges and electricity meters and feel the data into the data collection server so it can be accessed from the company over the Internet. The company can then review and analyze the data on an ongoing basis to apply scientific business models to the energy consumption levels to increase efficiency and reduce costs over time. This helps monitor and improve how green building designs can reduce energy consumption (Yu, 2011, 1-17).

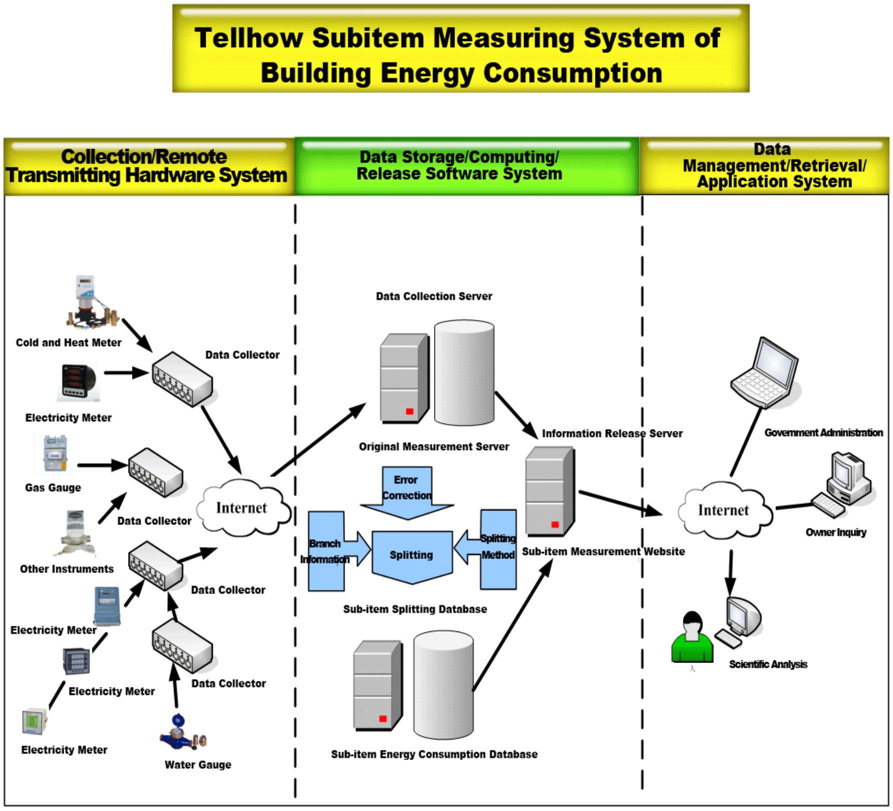


Figure 2.10 Building Energy Consumption Measuring System

(Energy Smart, 2010)

The bellow chart in Figure 2.11 shows the average annual energy consumption per sector in a society, with manufacturing being the highest at 47%, residential next at 35%, then commercial at 11%, municipal at 6% and education at 1% (Shepherd, 2009, 68-74).

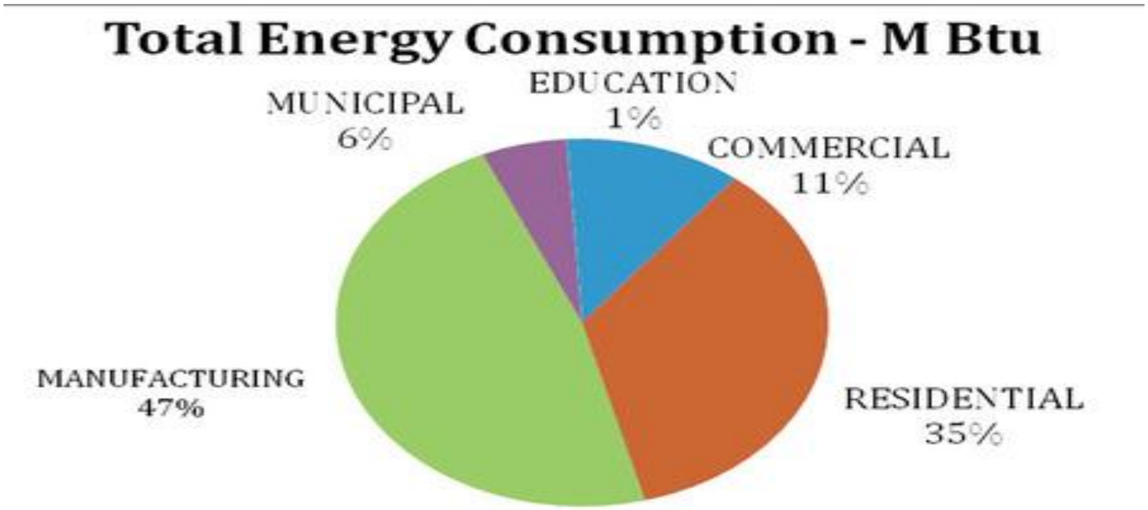


Figure 2.11 Energy Consumption Per Sector (Shepherd Advisors, 2009)

Integrating Transportation Strategies Into Green Building

According to Schwab's Theory (2005), residential buildings, commercial buildings, and the public transportation of people and freight use the majority of the energy consumed in global each year. Specifically, the global industrial sector uses 38% of total energy, closely followed by the transportation sector at 28%, the residential sector at 19%, and the commercial sector at 16%. On a community level, global transportation can account for 40%-50% of total energy use, and residential buildings use another 20%-30%. Green building strategies for energy consumption reduction must now create much more effective public transit designs. In developed nations like global, consumers are totally dependent on abundant supplies of energy for car fuel and air conditioning (Marashi, 2010, 1-6).

According to the TEFMA Space Planning Guidelines (2010), the chart in Figure 2.12 explains the global sustainability strategies and green building and energy consumption reduction for the future. This includes site development plans for taking advantage of natural assets by strategically positioning buildings and encouraging TOD environments. It also includes strategic asset management plans for funding ESD projects to integrate facilities management (FM) into the TOD areas for future sustainability. There are also environmental management plans to comply with global environmental statutes and regulations and operational plans for increasing recycling programs to minimize waste in the global.

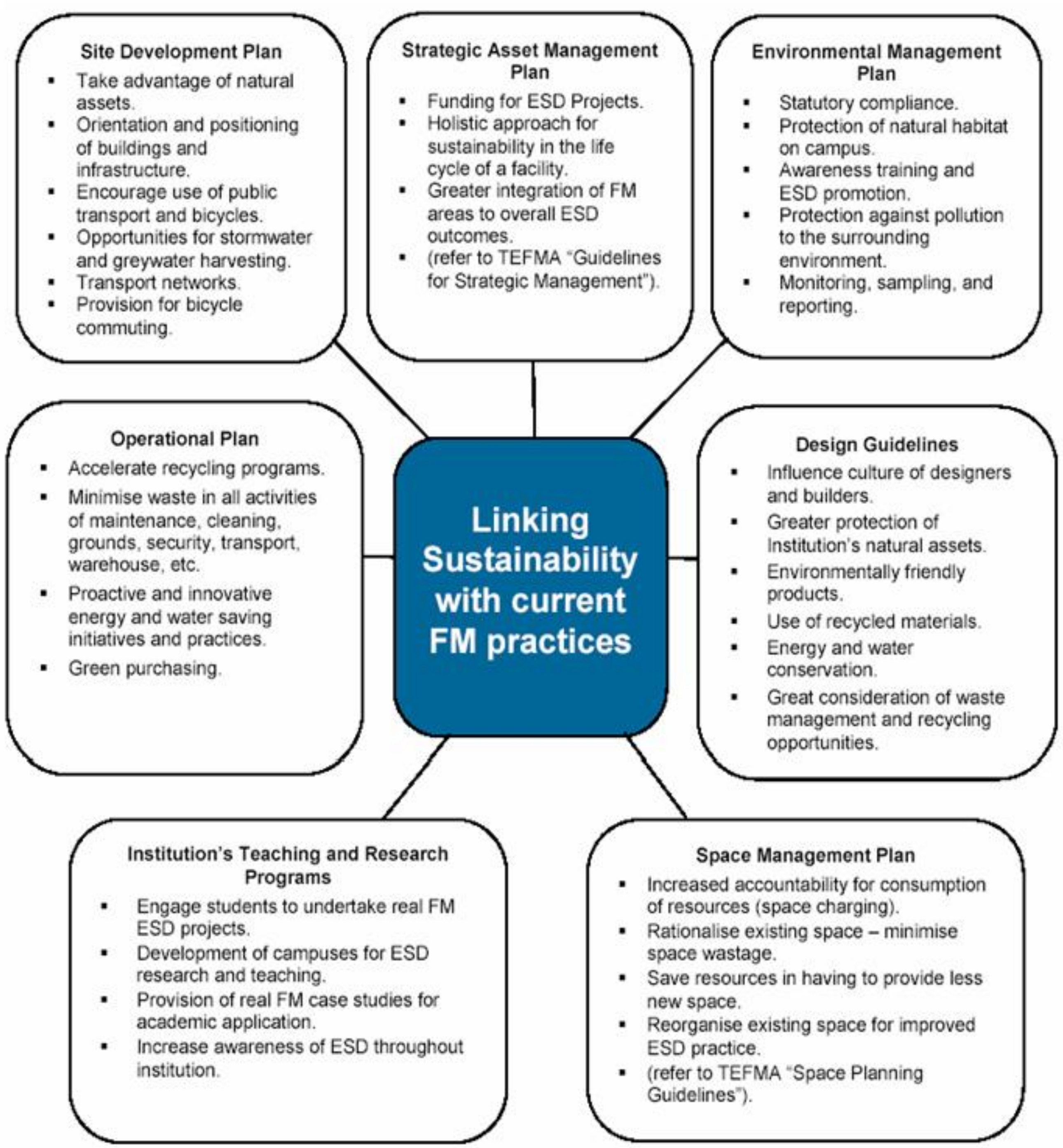


Figure 2.12 Global Sustainability Strategies (Patrick, 2010)

There are design guidelines for influencing the global culture of builders and designers to upgrade the overall built environment with green initiatives to protect the environment. There are also governmental strategies supporting environmentally-friendly products, waste reduction, and water and energy conservation programs. Worldwide is also launching environmental teaching and research programs to engage students in the future sustainable development of the country. There are also space management plans for increasing the overall accountability of resource consumption to minimize space wastage and save resources (Marashi, 2010, 1-12).

Smart Growth Green Building & Energy Conservation Strategies

These global Smart Growth green building and energy conservation strategies include compact community development, multiple transportation choices, mixed land uses, and practices to conserve green space. These programs offer environmental, economic, and quality-of-life benefits, and they also serve to reduce energy usage and greenhouse gas emissions. Smart Growth land use policies have both a direct and indirect effect on energy-consuming behavior. For example, global’s transportation energy usage, the number one user of petroleum fuels, could be significantly reduced through more compact and mixed use land development patterns, which could be served by a greater variety of non-automotive based transportation choices, such as walking, biking, public transport and carpooling (Knight, 2008, 41-66).

As well as designing buildings which are more energy efficient and more adaptable to hotter climates, global urban planners must begin to integrate lighter-colored, more reflective materials into the development of the city. Urban areas can be designed to be more environmentally-efficient by painting roofs white to reflect hot sun rays, and by planting trees to provide more shade areas. This saves energy because it cools buildings and reduces the urban heat island effect, which reduces the use of air conditioning. global's excessive air conditioning is one of the most destructive forces against the environment due to the emissions it releases into the atmosphere. global planners must find new methods of regulating the air conditioning in both public and private facilities so that there is less waste from drastic over-usage. In colder climates where air conditioning accounts for only a small proportion of energy consumption, an increase in average city temperatures can be offset by painting rooftops black, which decreases demand for heating fuel (Klosterman, 1985, 54-62).

Green Building & Energy Consumption Reduction Transportation Strategies

Green building and energy consumption reduction community strategies have had a positive effect on energy usage, and alternative design approaches like New Urbanism and TOD seek to reduce distances traveled by private vehicles. These new global green building strategies encourage public transit and carpooling to reduce traffic and encourage more walking and cycling as possible options for transportation. This global strategy is achieved through medium-density, mixed-use green building and the concentration of housing within walking distance of town centers and transport modes. global's TOD areas are also insistent on protecting the natural ecosystem surrounding the community, as well as providing a safe and secure place for the residents to live.

TODs have proper waste removal systems, recycling programs, environmental educational awareness programs in schools to raise children to respect and protect the natural environment. TODs encourage residents to avoid pollution and to get children involved in conservation. They are urban planned communities that provide peaceful green societies that will aid in protecting the people by protecting the environment. The most essential ingredients of the global TOD include having strategic green building that emphasizes close proximity between residential and commercial buildings, and plenty of parks, recreation areas, and water fountains for a relaxing pace of life. global's "City Within a City" concept has allowed them to develop the first fully-integrated TOD communities incorporating both residential and commercial facilities within walking distance of each other. Some of the newest TOD communities that global has just completed or that are still under construction include: global Sports City, global Festival City, Dubailand, International City, global Internet City, global Media City, global Marina and Jumeirah Village (Klosterman, 1985, 54-62).

2.5 Ecologically-Sustainable Developments (ESD)

Ecologically Sustainable Developments (ESD) include residential, commercial and mixed-use buildings. These sustainability strategies rely on global government, companies and residents using, conserving and enhancing the community's resources so that ecological processes are maintained, and the total quality of life, now and in the future, can be increased for all people. According to the international Development of Environmental Health (DEH), community development must never compromise the ability of future generations to enjoy similar levels of quality of life (Hui, 2002, 1-8).

According to the Al Gore documentary, "An Inconvenient Truth", future urbanization strategies for reducing global warming require governments to develop more effective green building and transportation strategies to reduce CO2 emissions and increase energy efficiency. Different energy consumption reduction green building alternatives must be created by governments for designing more energy efficient city infrastructures. Government-supported energy efficiency green building programs can greatly improve global warming prevention measures. New Smart Growth green building designs can help improve land use policies and energy consuming behavior. More mixed-use land development planning can help reduce transportation energy usage and petroleum fuels by offering different options to driving.

Some of the most recent green building strategies to combat global warming include New Urbanism and Transit-Oriented Development (TOD), which try to reduce the amount of distance cars, buses and taxis have to drive to transport people daily. This would encourage people to walk or ride bicycles instead of drive to work and school, which would greatly reduce fuel emissions that lead to global warming. This type of green building strategy integrates mixed-use developments where housing is within walking distance of transport centers and city centers. Researchers Pacala and Socolow from Princeton University recommend implementing green building energy conservation programs for lessening CO_2 emissions by one billion metric tons annually. The green building plans involve reducing vehicle usage by half, increasing fuel economy to double (60 mpg), reducing energy consumption by 25% with efficiency in green building, stopping deforestation by planting new tree farms, and conserving soil tillage for all crop land (Gore at el, 2007, 1-25).

Global Economic Sustainability

Economic sustainability is the capacity of an economy to retain its present financial state over time for all major industries. Economic diversification is usually necessary since the global economy continuously changes and some markets become unsustainable. In order to achieve sustainable development in the global, the government feels it is essential to focus on economic diversification into non-oil sectors. The governments of all seven Emirates have been investing in various partnerships that will help sustain the country environmentally and develop its social and public welfare systems. Creating partnerships with global countries, companies and governments to privatize vital elements of the global economy, such as education, healthcare and the natural environment will contribute to its overall sustainability.

Worldwide has recently launched several strategic campaigns related to their economic and environmental sustainability plans for the future. The global is currently undergoing major strategic green building transformations that will result in more energy conservation and environmental sustainability over the next two decades. To prepare for the future global market changes, the global is investing in alternative energies and diversifying into non-oil sectors. The global's future sustainable development is dependent upon economic diversification and environmental consciousness (Hamad, 2010, 1-5) (Karim, 2009, 1-6).

According to the United Nations (1987), sustainable development is when a country like the global is able to satisfy its current economic needs without having to compromise any future generations' capability of meeting their needs. The United Nations states that economic diversification refers to the global's ability to reduce its overall risk of recession by investing its oil wealth into non-oil sectors to sustain the economy for the future, despite any reduction in the value of oil revenues. Economic sustainability relates to when an economy like the global can maintain its financial means, trade and industry. According to the World Bank, for developing countries like the global to have sustainability, they must "equip themselves with the highly skilled and flexible human capital needed to compete effectively in today's dynamic global markets" (Al-Ateeqi, 2011, 1-5) (Arnold, 2010, 1-4) (Hraiz, 2011, 1-7).

The United Nations World Summit 2005 explained how there are three specific pillars of a nation's sustainability: economic, social and environmental. Sustainable development refers to how the global must adapt its resource usage patterns to effectively satisfy the needs of the people, yet still preserve the natural environment. Environmental sustainability is when a country like the global must find ways to develop its society and still maintain its natural environment with green building energy conservation strategies, protecting animals, plants, trees, marine life, water, desert and air. Although there are many experts that have varying definitions of these terms, the universal concept is that the global must learn how to adjust its present economic development to integrate environmental green building energy consumption reduction strategies that will allow for growth, expansion and protection of nature and ecosystems for the future (Bradfield, 2009, 1-8) (Hartsig, Nelson, 2007, 1-5) (Martin, Wolf, 2006, 1-3).

This chart in Figure 2.13 explains some of the new global Green Initiatives that are being implemented to increase environmental awareness and protection throughout the country. There are various Green events and activities that include attracting volunteers to help clean up the beaches and deserts. There are also new guidelines for global construction companies that force them to have energy and water conservation strategies. There are also Green Processes for encouraging recycling and waste management strategies and facilities being created to help upgrade the ecological environment (Bradfield, 2009, 1-6).

Figure 2.13 Global Green Initiatives (Green Growth, 2011)

Global Environmental Sustainability

Environmental sustainability is the capability of an ecological system to maintain its existence throughout time without compromising future generations. This requires aggressive educational awareness programs for the society to develop environmental consciousness. Environmental sustainability in the global refers to the protection of the natural environment by all people, companies and governments in all activities. According to the International Urban Planning Council, by 2030 the city's population will increase to 3.1 million, causing major changes to commercial and industrial activities (Mesbah, Enkvist, 2011, 1-12)

The main objectives of all new construction projects, airports, metro trains and freeways will be enforcing new governmental green building energy conservation initiatives for the built environment supporting environmental sustainability to improve public space and travel convenience. The government feels socially responsible to try to preserve the natural environment, as well as the culture in all projects. Many new parks are being created to enhance the city's natural theme. There are also new strategies for protecting the desert and sea from ecological damage from companies, such as new waste management proposals from Municipality. All the coastline projects are being strategically planned to protect the wildlife and avoid urban sprawl (Arnold, 2010, 1-5) (Collett, Graham , 2009, 1-3).

All over the global, the government has been working on upgrading their green building energy conservation processes, knowledge and transfer of green technologies with the Queen of Green. They have chosen 70 different projects throughout the global that will become official green buildings. All seven rulers from the individual Emirate states will work together on this environmental sustainability strategy to accelerate the process of making the global a more green country. Worldwide hopes to imitate other nations' alternative energy programs, such as the Philippines, where 25% of the country runs on geothermal power, and Spain, where they built a solar tower that contributes to their power sources (Salama, 2010, 1-3).

Environmental Strategies For Revitalization

Worldwide environmental green building energy conservation revitalization plans for cities include investing over $1 trillion by 2030 into upgrading the tourist attractions and local society to make it more appealing for visitors, families and businesspeople. One of the major facets of this societal overhaul will involve more partnerships with private sector architectural design, construction and tourism companies for renovating many of the parks and recreational areas to add more green spaces, restaurants, cafes and social areas. This is another strategy aimed at attracting local, regional and international tourists to the city and was proven very effective for global in the past. There will also be many new restaurants, museums, petting zoos, cultural events and children's activities within these parks to encourage families to visit and learn about the global's heritage. One example of these recent expansion projects includes the Mushrif Central Park, which has recently been revamped from being a conservative Ladies Only area into a People's Park for everyone.

This is an illustration of attempting to transform many cities' brand image into a more liberal and open place that encourages global tourists, partnerships and business. The park was designed by ValleyCrest Design Group and the refurbishments were carried out by Seba Properties, a member of the Al Ain Group. "We are honored to be given the opportunity of revitalizing this park. Mushrif Central Park will become a focal point for all of the community to experience and enjoy. It will be seen as a safe and secure destination, but also inviting and inspiring, offering something for everyone to appreciate, experience and enjoy. It will be truly, a People's Park", stated Al Ain Group's Vice Chairman Ahmad Al-Marar (Saleem, 2010, 1-5) (Salama, 2010, 1-4).

According to the article called, "The Current Arab Work Ethic: Antecedents, Implications, and Potential Remedies", by Sidani and Thornberry (2009), the authors state many emerging Arab nations do not have the frameworks in place for managing change. Table 2.5 shows the Global Economic & Environmental Sustainability Objectives & Drivers .

The government has to undergo extensive restructurization that will involve integration of green building energy conservation strategies in order to develop the strategic vision necessary for adapting to the various dynamics of the global workforce. Some of the main issues involved in global government's CSR that have proven they live up to their socially responsible public reputation include natural environmental protection for company green building energy conservation practices to avoid deforestation, toxic waste or chemical dumping on land or water, and any other hazardous actions that could jeopardize the environment (Salama, 2010, 1-4).

Table 2.5 Global Economic & Environmental Sustainability Objectives & Drivers (Sidani, 2009)

	Global Sustainability Objectives	**Drivers Toward Success**
1	Sustainable economic growth on track for global Vision 2021, AD Vision 2030	Government vision, strategies & HRM training programs
2	global national identity must be reinforced due to small percentage of population	Emiratization requires knowledge & skills training with work experience
3	Education and job skills training	Focus on innovation technology, sociocultural tradeoff, needs reorientation HRM training
4	Food security	Need both supply and demand management in food storage and consumer behavior, focus on not wasting or over consuming
5	Green building energy consumption reduction competitiveness and productivity	global should strive for higher global rankings in competitiveness reports, productivity movement begins with value-added efficiency per worker & job creation
6	Legislative and regulatory reform including the green building codes & initiatives for SMART buildings	Integrated approach to upgrade communication process includes including business and social communities
7	World's highest water consumption per capita requires educational awareness campaigns	global is naturally water-deficit, so proper water consumption and utilization is the key to sustainable management of water
8	Reconciling knowledge-based economy and knowledge society	New technologies in business with products and processes needing technology policies for knowledge

		workforce, must be applied in SMEs, regulation for health & safety
9	Tapping nuclear as energy	Nuclear source supply needs to complement other renewable energies, like solar power in Masdar City
10	Integrating environmental green building energy conservation, growth, waste management	Reduce, reuse and recycle must be adopted with green building energy conservation legislation and public educational awareness

Global Alternative Energy Green Building Partnerships

The global alternative energy green building strategies involve development of global partnerships with governments and companies for privatizing industries to upgrade environmental sustainability. Worldwide partnerships with private companies for improving green building energy conservation planning will provide better services to the people. The global public sector is diversifying with private strategic alliances as a major priority for the government since they realize that their oil wealth could be jeopardized in the future as alternative cleaner energies are developed that will replace it as the world's main fuel source. Economic diversification of the non-oil sector with global partnerships can properly sustain the economy for the future.

The significance of to the global's future environmental green building sustainability relates to the governmental Public-Private-Partnerships (PPPs). These partnerships are between public sector industries and various global private sector multinational corporations from the USA, UK, Germany and other nations to increase environmental green building designs to reduce energy consumption and pursue alternative power sources. Worldwide realizes the need for innovation, new technologies and managerial expertise that other governments and countries can provide to train Emiratis. As part of the enforcement of the Emiratization initiative, pursuing many different PPPs to ensure that all major industries in the public sector have the opportunity to diversify with private sector green building energy consumption reduction strategic alliances (Arnold, 2011, 1-6).

Although many developing nations used to provide only state-funded hospitals, schools and oil, the public sectors are now helping expand the service provisions to the public. The government also has many more growth and development projects for the future that require private company partnerships to be successful. Some PPP examples of global that relate to UAE sustainability include numerous governmental public sector services provided to people that involve strategic alliances with private sector companies worldwide:

- Alternative energies—International nuclear power research and solar energy research; USA, England, Germany
- Healthcare facilities—government financial investment company Mubadala; USA and Germany, medical healthcare insurance, clinics and hospitals like Johns Hopkins Cancer Research Institute in Alain
- Education—many new global universities like NYIT; USA, UK, Australia
- Utilities—DEWA power, electricity and water; USA
- Agricultural crops—future food security with genetically-modified crops that grow in desert; Monsanto from USA
- Telecommunications—Etisalat and Du; many European Union (EU) and Asian nations for mobile phones, like Nokia, Ericcson, Samsung

- Oil—International ADNOC; USA Mobile, Total, Shell, Chevron, UK British Petroleum (Arnold, 2011, 1-6).

Global Alternative Energy Green Building Research and Development Partnerships

Some of the recent political issues influencing the global, such as developing the nuclear and solar energy green building energy consumption research and development centers and maintaining peace in the Middle Eastern region, have been instigating factors compelling the government to invest in new energies and partner with foreign governments. There are many international trade partners for importing and exporting goods worldwide and as business associates for commerce within and outside of the country. However, in reaction to the gradual climate changes, reduction of fossil fuels and globalization opportunities, many major oil producers and members of the Organization of the Petroleum Exporting Countries (OPEC) have been taking a proactive approach to retaining its leadership within the global energy industry.

OPEC countries, especially within the GCC) control over 44% of all global oil production and almost 80% of the world's oil reserves, which allows them the wealth that many other nations do not have. As the rest of the world recovers from the global recession and financial crisis of the past few years, many GCC nations are in a unique position to maximize their wealth and become the world's newest alternative energy research and developers. This future-oriented vision provides them with the unique capacity to attract foreign governments that have the technologies and expertise, yet do not have the capital to invest solely in such huge and long-term business ventures. Instead of allowing the Western or Eastern world to capitalize upon the many alternative energy opportunities, the GCC is instead positioning themselves as the most attractive global research and development destination worldwide (Al Lawati, 2009, 1-8).

Global Solar & Nuclear Energy Partnerships

According to the International Monetary Fund (IMF), some of the most important recent global solar and nuclear energy strategic alliances related to preserving the future natural environment and reducing energy consumption worldwide the UAE has developed with other countries include:

- USA—nuclear energy research and development agreements, Shell Oil partnership for alternative clean energy and environmental research
- UK—London Array wind project (largest offshore wind center), 1.5 billion pound DP World partnership project for London Gateway deep-sea logistics park and port (providing 36,000 new UK jobs); new trade agreements for 12 billion pounds by 2015 in finance, aviation, tourism, defense and energy;
- Masdar-British Petroleum--clean energy green building partnership for research on alternative energies, hydrogen power plants with carbon dioxide capture capacity; military, intelligence and knowledge sharing global security projects for promoting worldwide peace, security and political stability; continuous collaboration for ongoing resolutions related to nuclear weapon anti-proliferation and the Middle East Peace Process
- Germany—partners for Masdar City solar energy research, development and advancement project with zero carbon emissions, no cars and all solar powered for 1500 firms and 50,000 residents in International; Mubadala's

International Future Energy Company subsidiary Masdar PV partnership with Germany’s Colexon Energy for large-scale photo-voltic solar energy panel production facilities in Germany by 2009 and International by 2013; Masdar deal with Conenergy for solar powering capacity

- South Korea—contract to build nuclear energy plants by 2020 (Al-Nahyan, 2010, 1-5) (Dominic et al, 2011, 1-4).

This project focuses on detailing the different green building energy consumption reduction strategies and environmental sustainability elements and how they reduce energy.

2.6 UAE Government Developing Solar Energy Business Model

The UAE government has spent the past several years establishing global joint ventures with many nations to create a major solar energy business model. The UAE government’s environmental strategy was launched in 2007 as the beginning of new political, economic and environmental reforms for the country. There have been many updated environmental reform strategies developed since then as well by the UAE government as the leaders of the global. Abu Dhabi is the capital of the UAE, and the source of its oil wealth, and the central force for all major governmental legislation and regulations for both the private and public sectors of the entire country.

The Abu Dhabi government has launched its Abu Dhabi Economic Vision 2030 in collaboration with the United Nations’ Millennium Development Goals in order to upgrade the overall environmental sustainability throughout the nation. This government initiative is significant for integrating green building energy consumption reduction strategies throughout the global to prove how they will reduce the country's carbon footprint for the future. This project includes a comprehensive academic literature review related to of the global's green building initiatives, energy consumption reduction initiatives, sustainable development, environmental awareness and energy conservation strategies. It also depicts how the government recognizes the unsustainable future of the oil sector that has brought the country so much wealth and how is the key to sustaining the non-oil industries for the future (Jassim et al, 2010, 1-16).

The chart in Figure 2.14 shows the UAE electricity demand over the past 30 years from 1980-2008 from 25 million mg to 75 million mg. This amount shows how the UAE has tripled its electricity demand with a continuous increase in energy required to generate power for the city (Ottoman, 2011, 1-5)

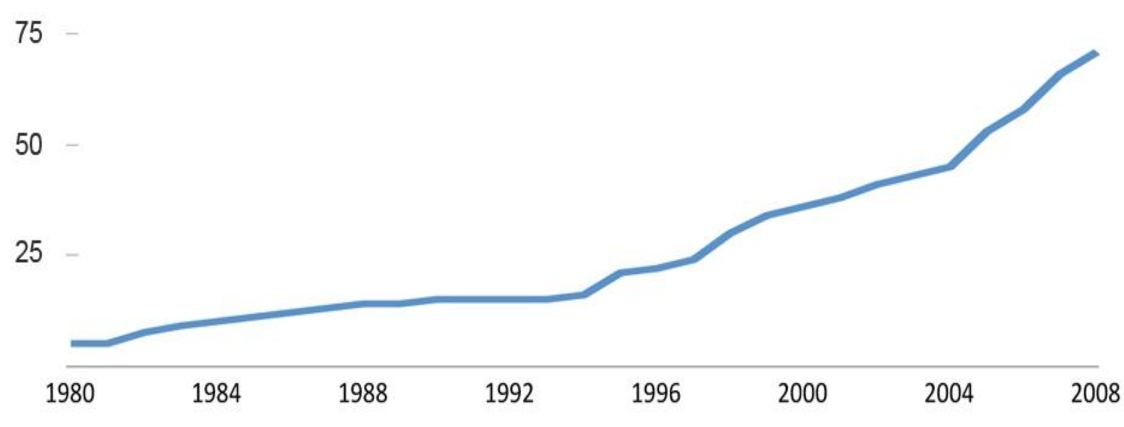


Figure 2.14 UAE's Electricity Usage: 1980-2008

Source: Energy Information Administration (EIA), 2008.

UAE Energy Consumption Reduction

According to the Emirates Green Building Council (EGCB), the UAE has continued to increase its overall energy consumption for water and electricity ever since the real estate boom in Dubai in 2002. Adnan Sharafi, the EGBC Chairman has been focusing on reducing the global energy consumption levels. Over 1200 industrial, commercial and residential construction development projects were finished in 2010. This total is in addition to the 22,000 villas and 11,000 other buildings that have been increasing energy consumption for the past few years by over 11%. By 2009, electricity totals reached six gigawatts, so Sharafi's future goal is to reach a reduction of 20% for the global.

"That kind of savings will benefit the community and the country for many years to come. This is very much achievable and presents a big opportunity for all concerned. To reduce electricity and water consumption, it is important to promote awareness on sustainability. From our experience of working with all industry stakeholders, we have witnessed that they are all willing and ready to undertake positive measures to bring about a tangible change. The key is to increase awareness and constantly engage them. From a material supplies and operational perspective, having energy efficient lighting and air conditioning systems, integrating solar panels and condensate recovery systems, several factors are currently being considered and implemented, which is a truly positive change compared with five or ten years back", stated Sharafi (Landais, 2011, 1-5).

The government's approach to coping with continuous population growth and construction is to integrate new green building designs that will maximize daylight and optimize the insulation and orientation of buildings using alternative power sources to reduce energy consumption. An energy report from Germany's Sesam states the global energy consumption includes 25% of the GCC water for electrical power usage. With estimates of over 12% energy consumption increases required in the next year, experts project over $10 billion is needed to meet the future energy demands in the global over the next decade. A GCC integrated electricity grid is currently being planned by the governments to combine power sources throughout the Gulf region.

The EGBC is the facilitator and oversight committee in charge of enforcing global governmental green initiatives for both the private and public sectors. Their main objectives are to integrate green building policies, practices and regulations from the initial architectural design stages. They also want to adopt more environmentally-sustainable measures for architectural built-up green building projects. Green projects will incorporate optimal usage of daylight and other natural light sources with skylights, as well as insulation and building orientation to take advantage of sunlight to reduce energy consumption and costs. Construction companies can also use concrete that is environmentally-friendly and gives off less pollution (Landais, 2011, 1-5) (Klein, 2012, 1-3).

Two new buildings that will integrate wind and solar power to satisfy all energy requirements are the German Business Park and Dubai Silicon Oasis. These green buildings will take advantage of the prevalent global sunlight for generating cool air by converting heat from the sun for running their climate control systems. Another energy efficient project is the Dubai Energy Tower (Burj Al Taqa), which is a 60-floor tower designed with special ventilation using solar and wind power to make it fully selfsufficient. The Abu Dhabi Islamic Bank (ADIB) headquarters just won the US Green Building Council's LEED Gold Certification for its energy conservation design.

There are many sustainable measures for water conservation and energy reduction from this green building's atrium air conditioning ventilation system, which has proven 50% less energy usage. This green building also has many other energy-efficient systems that have reduced energy consumption by 23% and water usage by 47%. Annual overall energy savings will also show over 50% in waste recycling features when it is finished in 2013. The government is also developing a major green building design called the Dubai Solar Park for diversifying renewable power sources to reduce overall energy consumption. Abu Dhabi government states it will generate 7% of its energy from alternative renewable power sources by the year 2020. Dubai government states it will do the same by 5% by 2030 (Landais, 2011, 1-5) (Klein, 2012, 1-3).

These projects are part of the Integrated Energy Strategy 2030 that will prove how green building designs can reduce energy consumption as a part of their future environmental sustainability strategies. Masdar is also investing $5 billion globally in green buildings of renewable energy research projects and solar power plants in Spain, USA and other Arab countries to prove how committed they are to energy consumption reduction. The USA is also investing $8.2 billion in 39 green building renewable energy projects, and the UK has 20 green building energy projects worth over $8.8 billion to prove how they will help reduce energy consumption for the future (Njeri, 2012, 1-4) (Landais, 2011, 1-5) (Klein, 2012, 1-3).

Incorporating Passive Design Strategies In UAE

Passive cooling basically aims at naturally achieving and sustaining cool indoor environments. It basically decreases the need for energy intensive mechanical cooling which will save the capital expenditure, improve air quality in indoor spaces and reduce energy costs. Abu Dhabi Urban Planning Council have made studies and confirmed that incorporating simple and sensible passive cooling strategies to the built environment design can reduce heat gain by 25% which will translate into great savings in electricity usage. Passive design strategies proved to increase building thermal comfort, passive cooling strategies is in general categorized into two core categories, the first aims at minimization of building's need for cooling and the second category aims at utilizing wind and heat to essentially cool and ventilate indoor spaces (Omer, Qenssen, 2008, 82-94).

Table 2.6 UAE Energy Consumption Overview: 2011 (EIA, 2011)

Energy Overview	
Proven Oil Reserves (January 1, 2011E)	97.8 billion barrels
Oil Production (2010E)	2.81 million barrels per day, of which 2.3 million was crude oil.
Oil Consumption (2009E)	492,000 barrels per day
Crude Oil Distillation Capacity (2011E)	773,000 barrels per day
Proven Natural Gas Reserves (January 1, 2011E)	214.4 trillion cubic feet
Natural Gas Production (2009E)	1.725 trillion cubic feet
Natural Gas Consumption (2009E)	2.1 billion cubic feet
Recoverable Coal Reserves	None

(2009E)	
Coal Production (2009E)	None
Coal Consumption (2009E)	None
Electricity Installed Capacity (2008E)	18.5 gigawatts
Electricity Production (2009E)	80.9 billion kilowatt hours
Electricity Consumption (2008E)	70.6 billion kilowatt hours
Total Energy Consumption (2008E)	3.25 quadrillion Btus*, of which Natural Gas (70%), Oil (30%)
Total Per Capita Energy Consumption (2008E)	703.3 million Btus
Energy Intensity (2008E)	18,401 Btu per $2005-PPP**

Environmental Overview	
Energy-Related Carbon Dioxide Emissions (2008E)	199 million metric tons, of which Natural Gas (60%), Oil (40%)
Per-Capita, Energy-Related Carbon Dioxide Emissions (2008E)	43 metric tons
Carbon Dioxide Intensity (2008E)	1.1 Metric tons per thousand $2005-PPP**

Oil and Gas Industry	
Major Oil/Gas Ports	Abu Dhabi: Das Island, Jebel Dhana, Ruwais, Zirku Island, Umm Nar; Dubai: Jebel Ali, Port Rashid; Fujairah: port
Major Oil Fields	Abu Dhabi: Asab, Bab, Bu Hasa, Murban, Al-Zakum; Dubai: Falah, Fateh, Southwest Fateh; Sharjah: Mubarak
Major Natural Gas Fields	Abu Dhabi: Khuff, Abu -Bukhush, Bab, Bu Hasa, Umm Shaif, Zakum
Total Refining Capacity 2011 and Major Refineries	Abu Dhabi: Ruwais (350,000 bbl/d), Umm -Nar (150,000 bbl/d); Dubai: Jebal Ali (120,000 bbl/d); Fujairah: Metro Oil (82,000 bbl/d); Sharjah: Hamriyah (71,250 bbl/d) = 773,250 bbl/d

* The total energy consumption statistic includes petroleum, dry natural gas, coal, net hydro, nuclear, geothermal, solar, wind, wood and waste electric power.
**GDP figures from Global Insight estimates based on purchasing power parity (PPP) exchange rates.

Commercial energy use	10,174.9	[4th of 119]
Electric generation ability	5,600,000 killowatts	[18th of 32]
Electric power consumption > kWh	48,951,000,000 kWh	[41st of 132]
Electricity > Production by source > Fossil	100%	[19th of 223]

fuel		
Electricity > Production by source > Hydro	0%	[171st of 223]
Electricity > Production by source > Nuclear	0%	[92nd of 223]
Gasoline prices	0.41	[133rd of 141]
Hydroelectricity consumption	0	[199th of 213]
Oil Consumption > Million tonnes	15.6	[35th of 63]
Oil Consumption > Thousand barrels daily	306	[36th of 63]
Oil exports > Net	1,920,000 barrels per day	[4th of 32]
Oil production in 1972	1,300 thousand barrels / day	[11th of 36]
Oil production in 1992	2,510 thousand barrels / day	[8th of 47]
Oil refining ability	514,750 barrels per day	[21st of 51]
Oil reserves	97,800,000,000 barrels	[5th of 97]
Primary Energy Consumption > Million tonnes oil equivalent	51.3	[33rd of 63]
use > kt of oil equivalent	43,813 kt of oil equivalent	[38th of 132]
Wall plugs > Frequency	50 HZ	[137th of 151]
Wall plugs > Plug type UK		
Wall plugs > Voltage	220 V	[161st of 209]
DEFINITION: PowerStream		

According to the US Department of Energy and the US Energy Information Association (EIA), the UAE energy consumption of total primary energy reached 3.257 quadrillion BTUs in 2011. Almost 70% was from natural gas to be used for generating electricity, consuming 2.198 quadrillion BTUs. The UAE consumed 1.06 quadrillion BTUs of petroleum products (Everett, Zweibel, 2011, 1-3).

UAE Alternative Energy Development

The UAE's alternative energy partnerships have been formed to help with both global and domestic challenges, including regaining peace in the Middle East and to help the USA feel more secure in their military and political positioning as a superpower. This decision was also based on the need for renewing faith in the local economy for international investors and businesspeople, and International wanting to be proactive in taking a leading position as a future alternative energy provider. The global still relies on oil revenues for over 90% of their capital, and International has not had to pursue much economic diversification in the past. However, due to the gradual climate change and global warming effects on the natural environment, the global believes establishing a nuclear energy facility will help show their support of non-military nuclear power (Inskeep, 2008, 1-15).

According to the United Nations, the UAE is technologically, financially, politically, economically and geographically the most preferred destination for new nuclear research and development facilities. Worldwide had the most positive criteria matchings of any other foreign nation and was supported by major superpowers wanting to expand their established trade and business investment partnerships. As the first Middle Eastern country to host an international agency of such importance, the global is positioning itself as the latest developing nation to strive to be noticed. One of the main reasons that UAE was considered for hosting the nuclear plant was International's Masdar City capabilities that can be an example for other developing nations.

The UAE is seeking to advance the research and development first-mover advantages of alternative renewable energies so they can replace any future market losses related to the oil sector as it is replaced with cleaner fuels. The UAE promoted that developing nations and oil exporters should participate in the development of renewable technologies to share their own contributions with the more modernized countries. Many new buildings will rely on Smart Grids by Siemens for their energy sources to integrate intelligent energy consumption and electromobility into their green building to become smart buildings that reduce energy usage even more in the future (Greer et al, 2011, 1-8).

Need for Sustainable Building Strategies in UAE

The UAE soon recognized its recent growth trends which are not sustainable, noticing the fast growth in UAE overall electricity consumption and the role of built environment in this development. UAE's electricity demand has doubled from 35 billion kwh to over 70 billion kwh in the last decade, which represents a very big rise in energy usage per capita specially when comparing this rise with the UAE population increase which is about 60% over the same period, the countries built environment plays an important role in this increase in energy consumption per capita .in UAE during the hottest months of the year up to 60% of the energy and electricity consumption is used for cooling buildings, as the increase of the inefficient buildings that joined the existing building stock, this increase presents an undeniable challenge. Policy makers in UAE should start to regulate the building's energy usage and start applying obligatory building codes which integrate passive cooling strategies, in order to regulate the country's high increase usage for energy and electricity (Saleem, 2010, 1-7).

2.7 UAE Green Building Solar Energy Business Model: Masdar City

The International Future Energy Company (referred to as Masdar) was launched in 2006 to accommodate the research and development needs related to solar and nuclear energy research and development. The government then began to position itself as a country that could handle the responsibilities of developing cleaner energies. By 2008, the capital city developed a national nuclear energy policy that has now established them as the first Middle Eastern country to have nuclear plants and host a nuclear energy program. By 2009, UAE won the bid over Germany and other European contenders for becoming the headquarters of the International Renewable Energy Agency (IRENA), which earned them global recognition and attention from foreign governments wanting to partner with them. IRENA's main objectives include promoting alternative renewable energies for both industrialized and developing nations worldwide. Worldwide has set a future target of 7% total alternative energy generation capacity by 2020 using renewable new energy sources. By developing various international strategic alliances throughout the world in new technologies, renewable energy research and utility-scale production facility manufacturing, the global believes it will be able to achieve its goals of becoming the leading global alternative energy producer and provider (Al Lawati, 2009, 1-8) (Dominic et al, 2011, 1-4).

Shown in Figure 2.15 This Masdar chart describes the green building engineering design specifications for conserving energy consumption, including streets laid out at angles for optimizing shading and parks with high treetops for additional shade to capture cool winds and provide natural ventilation for the city. The green building design also has 54 sunshades with automatic open and close features at dawn and dusk to provide natural shade. There is also a solar farm with thousands of PV solar panels capturing and storing natural sunlight used to power the building to reduce electricity. There is a wind tower and wind cones that funnel wind to ventilate cool air into the public square and the air is cooled with intermittent water sprays. There are overhanging trees for shade in the public areas to keep them cool, which solar energy expert Foster (2009) states reduced the area's temperature by 70 degrees in hotter months and decreased over half the electricity and energy consumption and costs. Masdar's innovative usage of geothermal, wind and solar energy allows for the city to be powered by 90% natural sources and all water is recycled and reused with waste materials being converted into other energy (Granger, Marsh, 2009, 1-8).

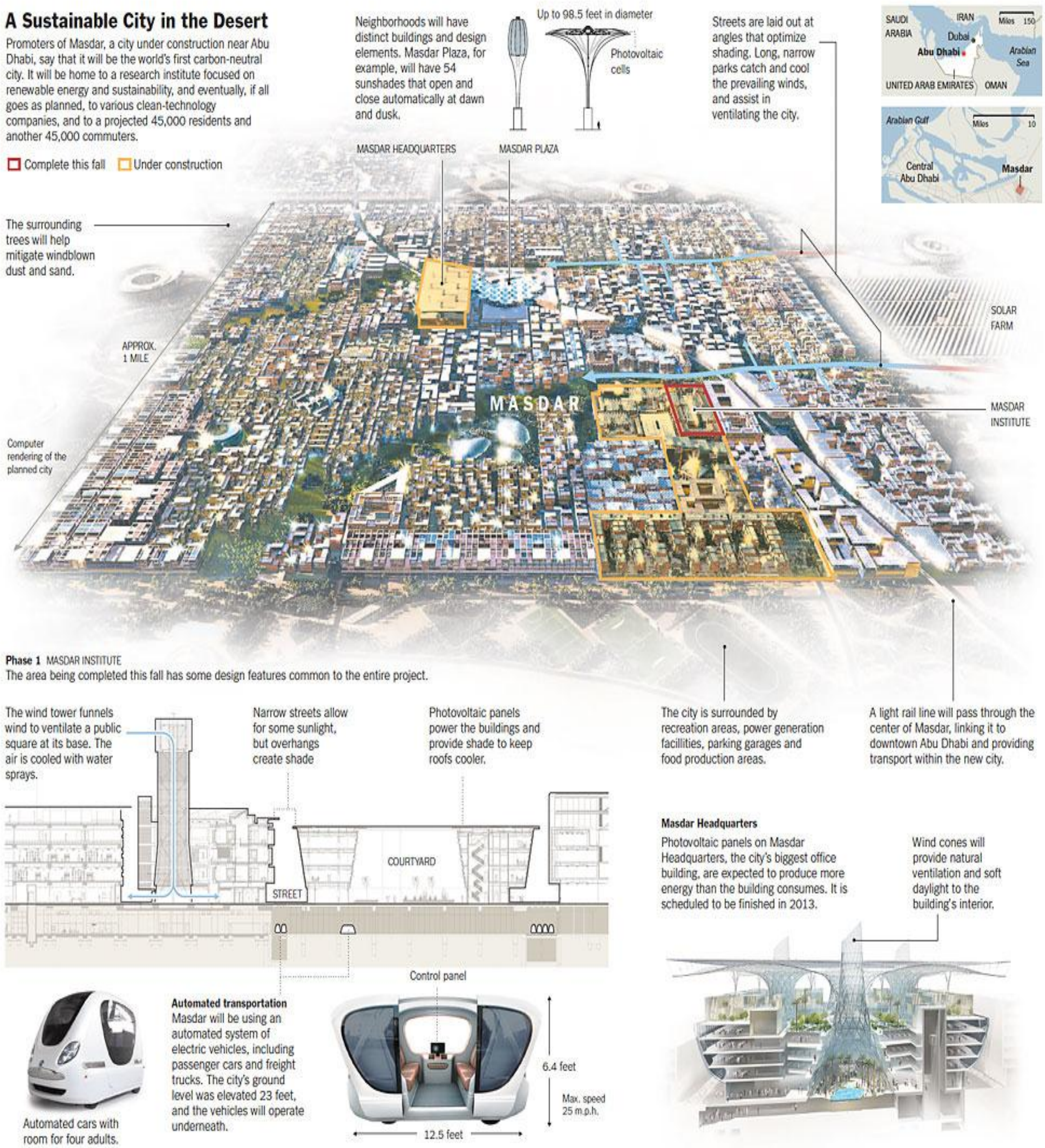


Figure 2.15 Masdar Green Building Energy Consumption Reduction Specification Models (Masdar, 2009)

Masdar City is the UAE's solar energy green building business model for energy consumption reduction that is currently being evaluated globally to prove how it will save energy for the future. Masdar City is the headquarters for the International Renewable Energy Agency (IRENA) and also the center for all future renewable fuel research and development. Masdar City is considered a future-oriented green building energy consumption reduction solution built by the UAE and global partnerships that researches the various environmental consequences of climate change and the loss of natural resources worldwide. Masdar City is the first carbon-neutral all-sustainable city in the world that is the result of decades of global research and development from all over the world.

Masdar (which means the source in Arabic) City was built by the government-owned Abu Dhabi Future Energy Company (ADFEC), which is one of the subsidiary firms of the Mubadala Development Corporation. Credit Suisse, Siemens Venture Capital and the Consensus Business Group have developed partnerships with the ADFEC's Clean Tech Fund financing. Masdar City was designed by Foster & Partners, a British architectural company who worked with ADFEC from 2006 to develop the fundamental design concept of the city. The project cost over $22 billion and is expected to be completed in 2014 after eight years of construction. However, the first phase of construction was managed by CH2M Hill and was intended to be completed this year so the first residents could move in and test the city's capabilities (Hamner, Perez, 2007, 1-4).

Contractor Al Jaber Group is in charge of the construction of the overall infrastructure for Masdar City, which has been designed by Adrian Smith & Gordon Gill Architecture. With over 2.3 square miles within the city limits, the Masdar City project will accommodate 50,000 residents and over 1500 companies, mainly manufacturing and commercial facilities that will specialize in producing environmentally-protected products. With over 60,000 employees commuting into the Masdar City on a daily basis, it will provide many jobs in all industries (Hope, 2009, 1-3).

Within Masdar City, there will be a Masdar Institute of Science and Technology (MIST), which is a joint venture with the American Massachusetts Institute of Technology (MIT). Masdar will have a huge city perimeter wall that is designed to maintain the coolness inside and keep the hot, humid desert winds outside. The streets within the city limits will be shaded and narrow in order to retain cooler breezes and funnel them all throughout the town. Since Masdar City does not allow automobiles due to their carbon dioxide emissions, all travel will be by mass public or personal transit systems that will connect to railways and roads outside the city limits. Masdar City is built upon the concept of the clean energy business model used for constructing Tsukuba Science City in Japan and Novosibirsk in Russia. Masdar City assessments provide evidence that green building reduces energy consumption over time (Jassim et al, 2009, 1-5).

According to the US Green Building Council, and as shown in Figure 2.16 Masdar City meets all of the main components required for a project under construction to be considered a green building (Kulatilaka, Klosowski, 2011, 1-7)

Figure 2.16 Masdar City's Green Building Features

Source: US Green Building Council and EHDD Architecture, 2011.

Masdar City's Innovative Energy-Efficiency Features

Laboratory for Visionary Architecture (LAVA) won the green building design for their innovative energy-saving ideas on how to develop Masdar City. Some of Masdar City's energy-efficiency features that have been incorporated into the green building design to reduce energy consumption include:

• Building façade angles are altered to optimize or offset any solar glare

• Wall surfaces react to changing temperatures since they contain minimal embedded energy

• Movable sunshades shaped like sunflower umbrellas provide shade and natural breezes in the courtyards

• Daytime water features are stored underground and flow at triggered by activity

• Interactive light poles transform the exterior plaza into an interactive 3D media installation

• Heat system is interactive and only activates lighting when pedestrians are around

• Rooftops have gardens for growing crops irrigated with recycled wastewater, reusing organic foods to reduce waste and increase energy generation and water efficiency (to make it a zero-waste city)

• Zero-CO2 Personal Rapid Transit solar-powered vehicles transport visitors around the city (no cars allowed there)

• PE INTERNATIONAL's SoFi CO2 monitoring system to track carbon that is in the buildings

• TVP Solar's MT-Power flat solar thermal panels that are high-vacuum for solar cooling plant

• Monodraught's Sunpipe for natural daylight on the passenger transport system (Jassim et al, 2009, 1-5).

The photo of Figure 2.17 shows the creative architectural design by LAVA for the rooftops of Masdar City. The central design includes rotating umbrellas that provide extensive shade and trap heat for future usage (Jassim et al, 2009, 1-5).

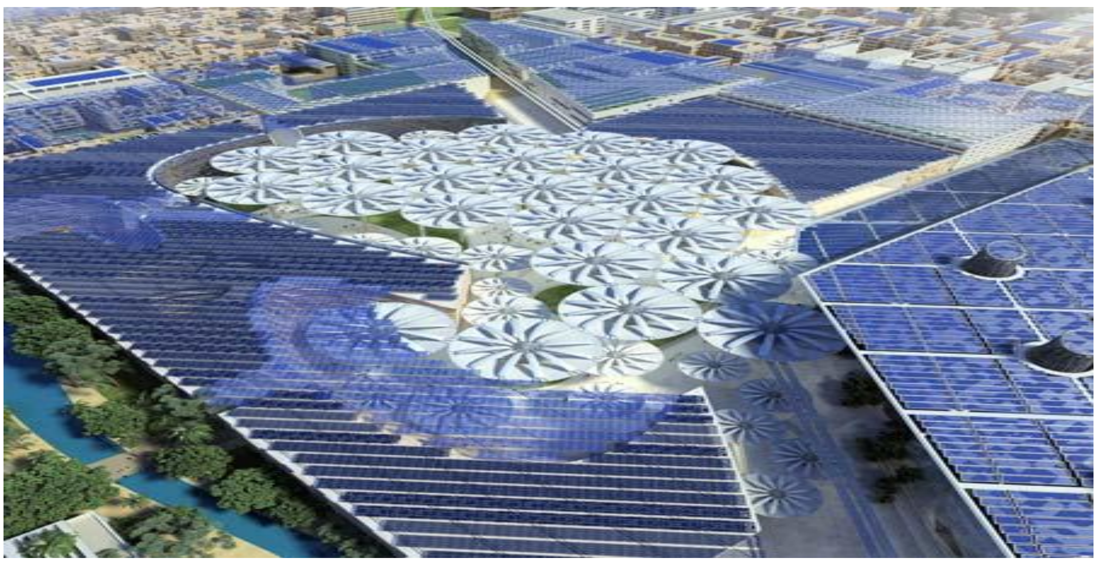


Figure 2.17 Masdar City's Unique Energy-Efficiency Features (Masdar, 2011)

Figure 2.18 shows the Masdar City Geographical Information System (GIS) model with different construction design layers for the PV rooftops, building plots, raised street levels, Abu Dhabi metro system, primary infrastructure and PRT transit system (Jassim et al, 2009, 1-5).

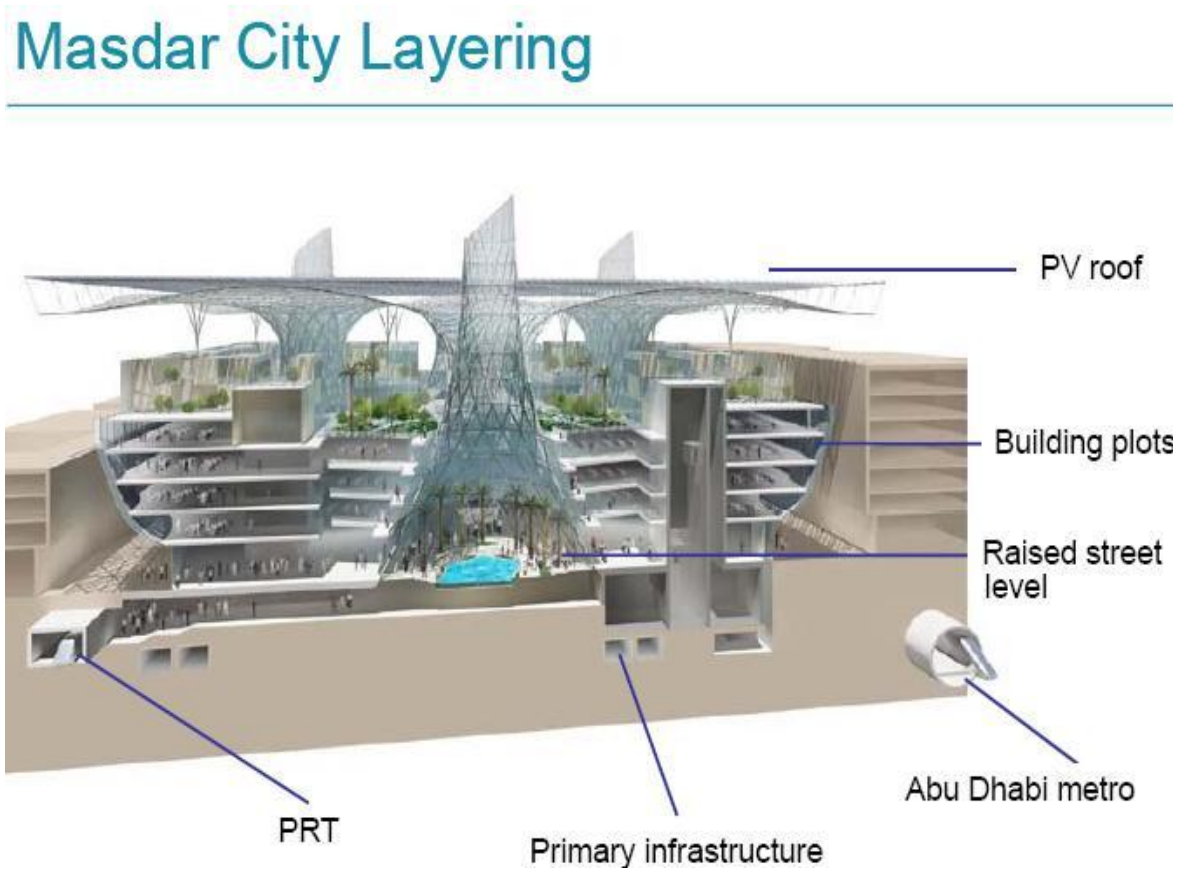


Figure 2.18 Masdar City's GIS Model (Masdar, 2011)

Figure 2.19 shows Masdar City's green building essentials, such as PV generation, rooftop planting, improved insulation, automated ventilation and lighting controls, restricted sunlight, energy-efficient lights and cooling, and motion detection systems with sensors that automatically turn on when needed and off when not needed (Jassim et al, 2009, 1-5).

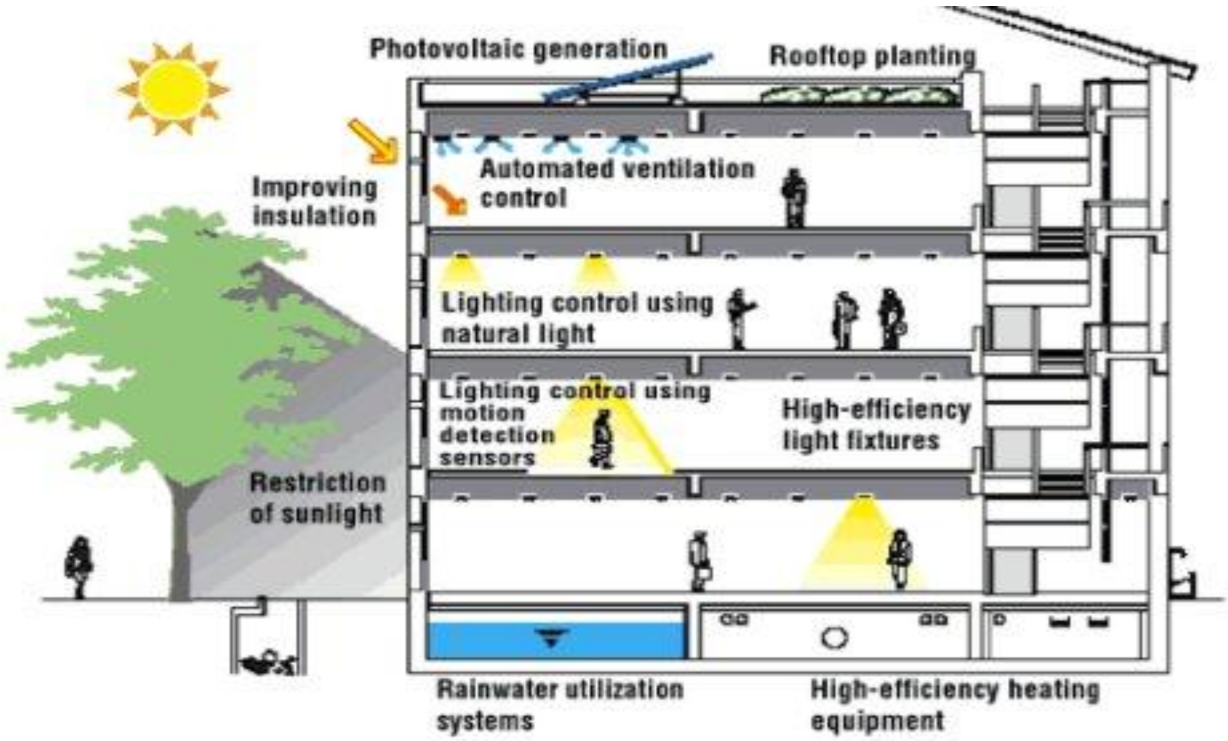


Figure 2.19 Masdar Green Building Essentials (Masdar, 2011)

The chart in Figure 2.20 shows a breakdown of how Masdar City's green building can reduce energy usage by 24%-50%, CO2 emissions by 33%-39%, water usage by 40%, and solid waste by 70%. Other energy consumption reduction strategies include green building features for decreasing cooling and lighting systems since air conditioning accounts for 30% of all energy costs and lighting accounting for about 20%. According to the International Energy Agency, if people spent only $1 more on green building materials that are energy-efficient electrical supplies, appliances and equipment, they would save over $2 in their power bills per unit. Green buildings can generate almost 8% increased added-value to projects, which shows almost 7% higher Return On Investment (ROI), as well as higher occupancy rates than other non-green buildings (Jassim et al, 2009, 1-5).

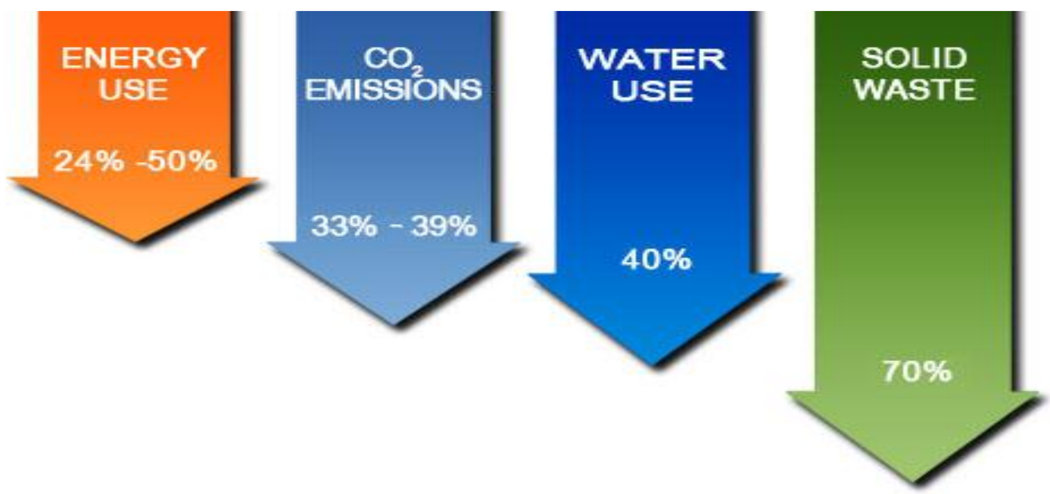


Figure 2.20 Masdar City Green Building Energy Consumption Reduction Breakdown . Source: US Green Building Council, 2011.

Figure 2.21 explains the 100% renewable energy sources for Masdar City, including 53% Photo-Voltaic solar panels, 26% concentrated solar power, 14% evacuated thermal tube collector, and 7% reusable waste to energy. This energy-efficient green building business model will use nine times less energy consumption per capita than in the USA. Masdar City's innovative green building design will reduce overall energy consumption from 800 MW to 200 MW, while desalinated water usage will decline from 20,000 cubic meters daily to 8000 cubic meters daily, and there will be no need for landfills (Jassim et al, 2009, 1-5).

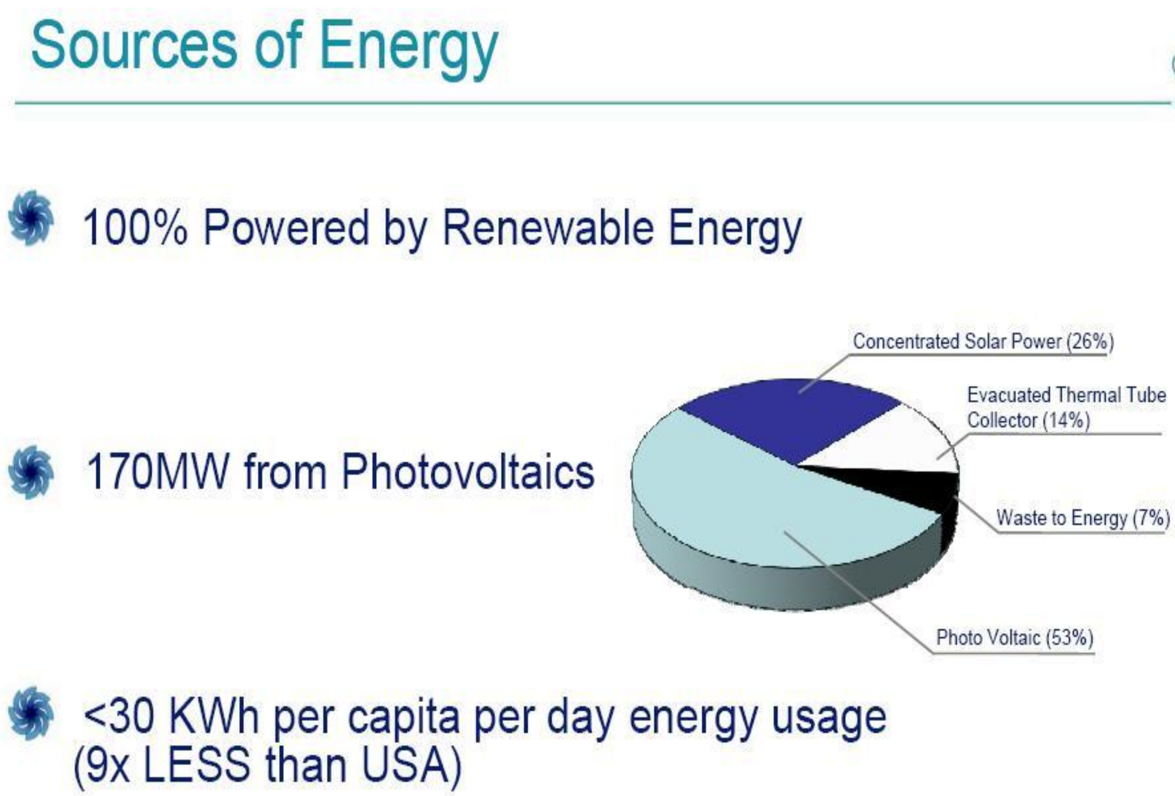


Figure 2.21 Masdar's Energy Sources (Masdar, 2011)

Masdar Solar Energy R&D Global Partnerships

The Masdar solar energy research and development global partnerships are handled by Mubadala, which is investment and project development agency for all major research and development ventures. One of the many Mubadala companies is the Abu Dhabi Future Energy Company (ADFEC) for handling all research and production on alternative energies. ADFEC's subsidiary Masdar is the branch of that launched the famous Masdar City, the world's first carbon-free, no emissions, no vehicles, all transit-oriented development. Masdar Venture Capital originally comes from two different funds, the Masdar Clean TechFund and the DB Masdar CleanTech Fund. The global investors were countries that believe in and support how alternative fuels and cleaner energies are necessary for preserving the future world. These partnerships helped the global because of the mutually-beneficial advantages that will be gained by all parties involved, environmentally, economically and politically, to ensure green building reduces energy consumption (Al Lawati, 2009, 1-8).

The Masdar CleanTech Fund includes a $250 million partnership between global, Credit Suisse, Consensus Business Group and Siemens. Each firm invested between $5-20 million in exchange for the promising future alternative energy technologies. They also receive Intellectual Property (IP) rights and protection under the global laws. The capital investments include Solar Thin-Film to Waste-to-Energy and Water Purification. The investments involve the early stages of the Masdar project before the Initial Public Offering (IPO) until the launch of the IPO. The DB Masdar CleanTech Fund was launched in 2010 to raise between $500-$750 million for the future. The investment partners included global's Masdar, Deutsche Bank, Siemens, Development Bank of Japan, GE, Nippon Oil, Inpex and JBIC (Al Lawati, 2009, 1-8).

Some of the main Masdar solar energy project milestones include:

- 2006—Masdar Initative launch; Masdar Cleantech Fund $250 million partnership with Credit Suisse launch
- 2007—investment into power plan growth platforms and manufacturing
- 2008—Masdar City new construction starts; World Future Energy Summit in Abu Dhabi; Torresol Energy JV partnership with 40% Masdar & 60% Sener
- 2009—first Zayed Future Energy ceremony honoring sustainable energy solutions through global partnerships for the future; Masdar Institute enrolls first students; Masdar investment for London Array wind project; Masdar German PV facility finished
- 2010—Masdar partners with E.ON JV for CDM projects; Shams 1 partnership with Spain's Abengoa Solar and France's Total firms launch in Abu Dhabi; CleanTech Fund II $265 million launch; Masdar Institute completed
- 2011—Masdar City masterplanning completion; Siemens formalizes partnership with Masdar (Davidson et al, 2011, 54-71) (Al Lawati, 2009, 1-8).

Figure 2.22 shows the intended architectural design for the Masdar City in Abu Dhabi with solar energy panels in the ceiling to store and reflect natural sunlight and other innovative environmentally-friendly concepts. Masdar partnered with Phoenix Solar AG, who is a leader in photovoltaic systems worldwide to build the largest and most effective solar energy panels for all types of green building to ensure the reduction of energy consumption levels over time (Badih, 2011, 1-6).

Figure 2.22 Masdar City (Gulf News, 2010)

Masdar's Renewable Resources

Masdar's infrastructure green planning and construction to reduce energy consumption includes incorporating a 40-60 megawatt solar power plant, which was created by Conergy from Germany. Masdar will have the largest and most powerful hydrogen power plant in the world to produce the majority of the energy needed to make the city building's function. Photovoltaic modules will be located on top of all the rooftops of the Masdar buildings to allow for supplemental solar energy that will total 130 megawatts. There will be wind farms located outside Masdar's perimeter to produce another 20 megawatts, and geothermal power for other sources of renewable energy. The water management in Masdar City will be handled through a desalination plant which will be solar-powered and use 60% less water than other communities of the same size, proving green buildings consume less energy than non-green buildings (Al Lawati, 2009, 1-5).

Masdar City has already proven that green building reduces energy consumption levels by showing 51% less energy and 54% less water being used compared to similar-sized buildings in the global. Masdar City buildings are monitored to track continuous energy consumption so the data can be used as a foundation for further research on solar energy and power usage to determine how to reduce energy consumption levels for the future. According to Jorn Jurgens, SunPower Managing Director, "The system will provide a record-breaking efficiency of at least 19.3% in standard conditions" (Perrault, Rambiar ,2011, 1-5).

Some of the other green building energy conservation strategies that Masdar City integrates show over 80% of the water will be recyclable, with multipurpose reusable waste water for landscaping and crop irrigation purposes and other uses. These types of water reduction strategy are just one of the many environmentally-friendly energy conservation approaches to developing alternative resources for the city. Masdar City will also attempt to show a waste reduction down to zero where biological waste products will be utilized as fertilizer and incinerated for other power sources. Industrial waste products like metals and plastics will have multiple recyclable purposes so they are also not wasted.

The BioRegional Sustainability Group and World Wide Fund For Nature charity supports Masdar City as a global conservation model to help countries meet their Kyoto Protocol environmental objectives of CO2 emissions for 2025. These groups have endorsed Masdar City with the official title of being a One Planet Living Community. The divisions under the Masdar company include innovation, human capacity development, clean technology cluster, sustainable green building and development for green building, energy generation and reduction, carbon abatement, carbon sequestration and investment (Lawton, 2009, 1-4).

Masdar City: Green Building & Energy Consumption Reduction

An analysis of Masdar City as a business model explains how it has reduced the energy consumption levels by 51% using solar energy instead of other power sources. Masdar City green building design proves energy conservation within environmental strategies helps countries save energy and become more energy efficient. The main overall energy consumption reduction goal of regarding the green building of the carbon-free Masdar City solar energy project and other alternative power projects is to reduce over five million tons of CO_2 annually from the air. This is estimated to cost the government over $1 billion by 2020.

Examples of how Masdar City green building planning continuously reduces energy consumption levels include how the Masdar Institute’s research laboratories’ exterior is composed of ethylene tetrafluoroethylene (ETFE), which is a high insulation value of plastic similar to Teflon. The interior of the laboratories has an innovative network of sensors for monitoring humidity, CO_2, temperature and other particulate levels. The Masdar Institute air system maintains fresh indoor air quality with minimum air changes so it uses less energy for ventilation than most labs. Masdar has a utility-scale solar power plant covered with rooftop PV panels allowing for 1,800 MWh of electricity annually. It also has evacuated thermal collectors for 75% of the necessary hot water needed for the entire structure. Masdar City buildings have treated climate lobby circulation areas that are transitional zones for keeping warm temperatures (Nambiar, 2011, 1-6).

The Masdar atriums are illuminated from sunlight with ceiling skylights to prevent too much heat or direct sunlight. Masdar City is cooled naturally from night air drawn through vents to lower floors from the rooftop. The walls’ thermal mass modulate temperatures to remain about 86 degrees. Higher temperatures conserve energy by reducing air conditioning and avoiding chilly interiors. Masdar City not only conforms to the latest LEED rating system, but also a new Pearl rating system for alternative power sources to be used as future business models (Nambiar, 2011, 1-6).

Masdar City’s main goals of developing a business prototype renewable energy city that the world can use as a blueprint for future projects will be accomplished, despite the delays in construction. There may be many potential setbacks as the construction begins since no renewable energy project of this size has ever been attempted before. However, global government's main objectives include using up to 60 megawatts of solar polar from Conergy, a German company supplying all power for the project. In the future, a much more powerful 130 megawatt photovoltaic solar energy supply of modules will be put up on the building rooftops for supplementing the solar energy.

There will also be geothermal energy sources and 20 megawatt wind mills and farms set up on the exterior of Masdar City. Masdar will even build the biggest hydrogen power facility in the world and have major water conservation and waste management strategies. There will be a new desalination plant that will be solar powered providing 60% of the city's water needs. Over 80% of the water will be recycled, with waste water being regenerated into the soil for crop irrigation and other landscaping purposes. All biological waste will be utilized for making fertilizer to improve the soil quality and to create landscaping of trees, flowers and grass areas and parks. All industrial waste like metals and plastics will be used for many recyclable purposes as well (Palca, 2008, 1-6).

Masdar's infrastructure planning and construction includes incorporating a 40-60 megawatt solar power plant, which was created by Conergy from Germany. Masdar will have the largest and most powerful hydrogen power plant in the world to produce the majority of the energy needed to make the city building's function. Photovoltaic modules will be located on top of all the rooftops of the Masdar buildings to allow for supplemental solar energy that will total 130 megawatts. There will be wind farms located outside Masdar's perimeter to produce another 20 megawatts, and geothermal power for other sources of renewable energy. The water management in Masdar City will be handled through a desalination plant which will be solar-powered and use 60% less water than other communities of the same size. All of these strategies will help Masdar City become an international business energy efficiency green model to be replicated by other nations for conserving energy during green building using partnerships between the public and private sectors (Al Lawati, 2009, 1-5).

The Use of Passive Design in the Masdar Institute

Masdar Institute for Science and Technology (MIST) in the UAE is considered the biggest project that uses passive strategies, it is the first building constructed in Masdar City, and the institute building is a local example showing how passive design can reduce energy consumptions and help to achieve a city with zero energy targets. The first phase of the project has been totally operational since 2010. It consisted of six buildings that achieved 50% reduction in the cooling demands compared to an average building in the UAE. In order to be able to attain this notable reduction in cooling demand the designers incorporated several passive design strategies that were inspired from elements in the UAE traditional architecture , the most distinguished feature from of those strategies is the 45 m tower structure which provide cool breeze to the courtyard in the center. This traditional wind tower with its contemporary reinterpretation, functions according to the same principle of wind towers that were built in the Bastakia in Dubai and other places around the region, though in a more energetic manner. The wind tower is equipped with several sensors that operate louvers on its top, to open in the direction of the current prevailing wind, the towers is also opened to all four directions, this insures maximum efficiency (Shaw, 2007, 41-59) (Szokolay, 2010, 22-28).

This figure 2.23 shows how Masdar's modern wind tower on the right relates to that of a traditional Bedouin wind tower on the left (which was the type used in my primary research case study museum in the research methodology chapter). The Masdar wind tower shows how the operation mechanism provides passive cooling techniques that naturally cool the interior of all buildings (Yu, 2011, 1-9).

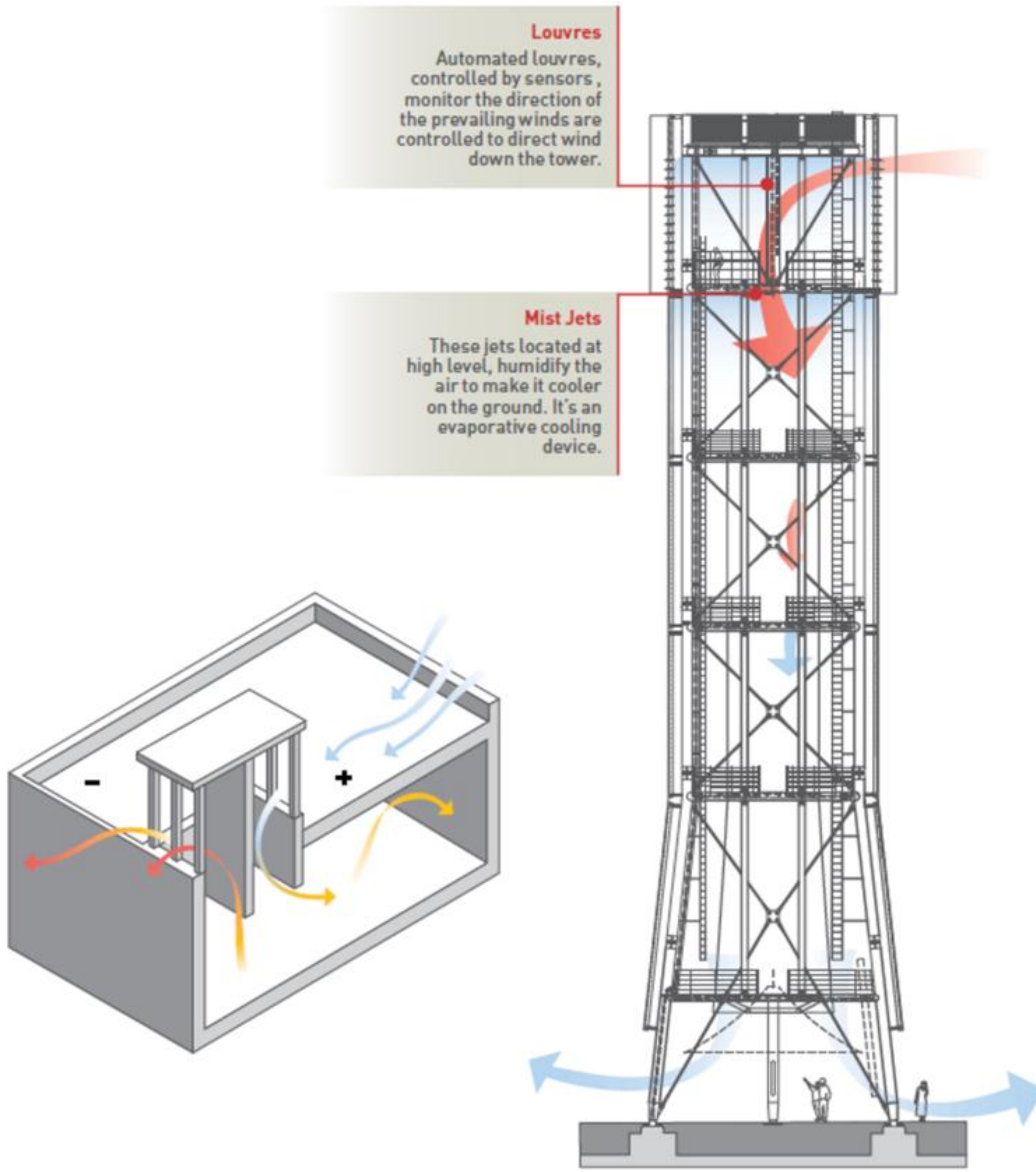


Figure 2.23 Masdar Wind Tower's Passive Cooling Design (Masdar, 2008)

There are other features in the campus design were inspired from passive design concepts taken from then traditional architecture in UAE , These features include its narrow 6 m shaded roads and the high thermal mass used as a storage for "coolth" which is then radiated back to the surroundings when the temperature increases. When visitors enter to Masdar Institute they are drawn to the terracotta colored facades of its residential buildings (Figure), with its wavy envelope design that mimics the forms of desert dunes that surrounds the city , also its multi-layered design that serves many environmental and social purposes. Its outermost layer provides self-shading to the balconies and reduces the solar heat gain in interior spaces. The latticework with its glass-reinforced concrete allows day lighting as well as night purge cooling. The design has cantilevered that provide shading to the narrow pathways below them, the distance between buildings are reduced further to take advantage of this shade. The inner layer of the envelope is highly reflective, highly insulated, highly conductive, as well as highly sealed to complement the outer layer (Hamad, 2010, 1-16).

This figure 2.24 explains how passive cooling design techniques used in Masdar City reduce electricity and energy demand. The main passive cooling methods used in Masdar include orientation, wind towers and shading to provide natural ventilation and air flow for the internal building. The most extraordinary fact about Madder's general approach and about the Masdar Institute particularly in evolving their zero-carbon city, is that it attempts to reach its energy objectives in a very commercially feasible method. This is through selecting features and technologies that are cost effective and disallowing the usage of those which are less scalable. Masdar City can represent a great model for energy efficient project in the region. It gives a great example to the local construction industry that when we incorporate passive design strategies we provide socioeconomic and environmental profits and these approaches are scalable and will become soon a part of majority practice (Hamad, 2010, 1-9).

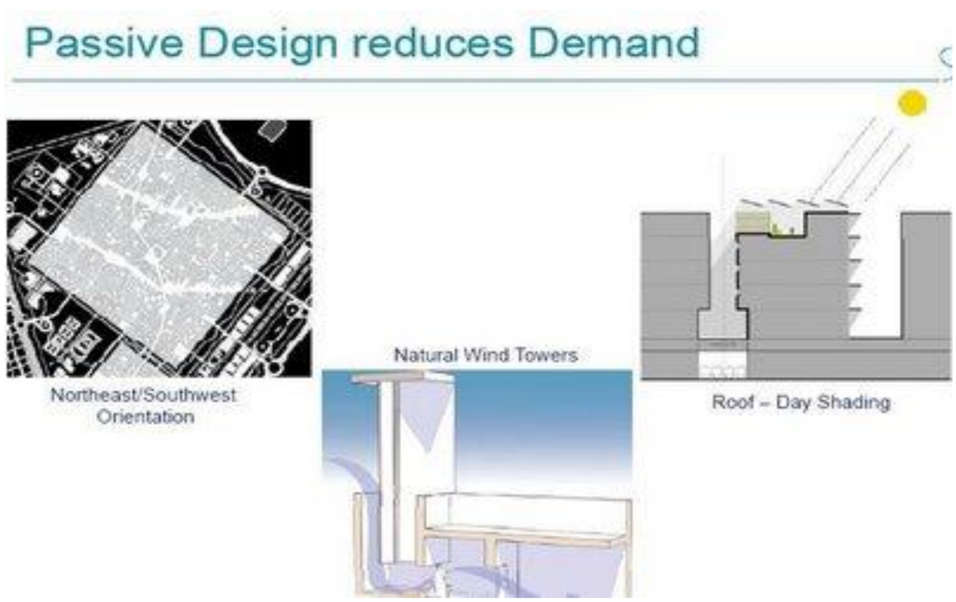


Figure 2.24 How Passive Cooling Design Reduces Electricity & Energy Demand

(Masdar, 2008)

A locally produced sustainable architecture revival in the UAE can be the catalyst it wishes for revitalization especially in our regional building industry which is currently having a lack of innovation. More significantly, it might be a start for developing more sustainable built environment that can have an important role in confronting the global environmental challenges that is facing our earth. Projects with passive technologies like the Masdar Institute present a sample on how this could be done. It is worth noting here that while Masdar is an owned subsidiary of Mubadala, a government venture vehicle; it labels itself as a "commercially ambitious initiative that works to reach the broad boundaries of sustainable technology industry" (Bradfield, 2009, 34-37).

2.8 The museum: a unique building type

Museum buildings characterize a case of engineering typology within society. Their role is to reserve as well as demonstrate the heritage. Museum buildings have superior necessities nowadays that have developed from the desire to attract as several visitors as possible, in the past they were visited mainly by researchers, schools as well as only occasionally by the public.

We associate social wellbeing not only with comfort as well as social security but similarly with access to amenities represented by art, travel, as well as history. In this context, increased as well as entree to cultural events is considered extremely desirable. Furthermore, contemporary Museum buildings must, instead of basically accommodating the visitors, keep their interest without creating a sense of weakness. The engineering of Museum buildings is essential aspects for education of public. If these engineering lessons are joint with a sustainable bioclimatic method to design, then a museum building can be an outstanding resource for the electricity consciousness as well as ecological awareness overall.

Museum historical progress

The Museum buildings designed in the last thirty years are characterized with some specific purposes. However, as all engineering typologies are subject to a process of modernization, Museum buildings similarly evolved over time to come to be extra complex. Museum buildings changed from spaces of permanent exhibition, storage as well as conservation changed to community places with a much wider role, including:

- Exhibition.
- Study.

- Conservation.
- Leisure like restaurants as well as cafes.
- Researches as well as educational centers.
- Storage

Why should museums go sustainable?

museums has relatively extra electricity usages as it needs provide suitable internal environmental conditions twenty four hours a day, during all year. It must retain lighting quality for all displays during its opening hours three hundred sixty three days per year, so if museum buildings were designed in a sustainable manner, they can become electricity efficient as well as conserve electricity.

On the other has well as museum as it is defined according to the International Council of Museum buildings is : “a non-profit making permanent institution in the service of society as well as its development, open to the public, that acquires researches, Communicates as well as exhibits for purposes of study, education as well as enjoyment measure .

Museum buildings characterize our heritage as well as considered buildings of big importance. They are visited by lots of people as well as frequently come to be important of area expansion. Actually, if Museum buildings design as well as construction is sustainable as well as address electricity efficiency, the building can then come to be good aid for electricity consciousness as well as environmental awareness besides saving electricity, as well as that’s why museum buildings have great demonstration potential, Therefore they should become a model of an electricity efficient building that has a sustainable behavior.

2.9 Benefits of efficient museum

Efficient sustainable museum has many advantages like Electricity benefits , Indoor atmosphere benefits as well as Indoor atmosphere benefits

Benefits in the electricity consumption

• Decrease of electricity as well as electricity usage, recently the electricity consumption has increased specially in summer times. So less pollution will happen to the atmosphere.

• Decrease in CO_2 amounts coming from the usage of fossil fuel that is needed for cooling buildings, as well as electricity Therefore will reduce the global generation greenhouses effect.

Benefits in the indoor atmosphere

• Reduced illness frequently reported from people working in closed air conditioned buildings which are recognized as sick building syndromes.

• Improving indoor comfort conditions as well as decreasing in PPD index which is the percentage of people displeased.

• Decreasing the heat which is rejected back to the surrounding environment during the manufacture process as well as minimizing the urban heat islas well as.

• Slowing down the Ozone layer depletion produced by CFC as well as HFC usages in the refrigerant of air conditioning units ,because of the potential for leakage during manufacturing as well as maintenance process.

Museum buildings and the environment

Historically, Museum buildings depended on their environment to a big extent for heating, lighting as well as cooling as mechanical means were at that time simple as well as could not fulfill the required needs. Therefore, the architectural form of buildings was influenced by their electricity needs

Operable windows were designed to provide ventilation, glazed roofs as well as sky lighting as well. Designing small spaces helped the distribute of even lighting, also the usage of thicker masonry walls gave the buildings great thermal inertia , these building skills took great advantages of the surrounding environment.

Andover, the bulk of the artifacts which is exhibited was connected to the nature. The exhibits ranged from daily artifact to statues, engineering elements. Several of these displays worked best in condition of flexible lighting as well as day lighting gave them the necessary diversity. Figure 2.25 bellow shows the usage of day lighting in the Glyptothek in Munich.

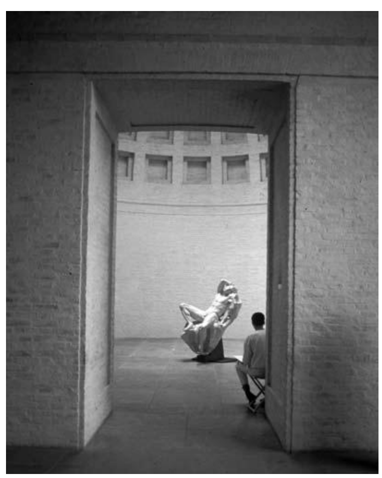


Figure 2.25 usage of day lighting in the Glyptothek in Munich, Architect: Leo von Klenze (N. Vratsanos)

Even though this pragmatic method to design with nature was every so often developed, Modern improvements in knowledge enabled a better understood well using of buildings physics involved.

With the arrival of sophisticated lighting as well as air conditioning methods after the Second World War age, museum establishments started to ask for solutions with neutral artificial indoor environments. Every so every so often suitable from the control opinion such schemes can deny the benefits of the ever changing environment that can better enhance qualities of the displays.

This resulted in Museum buildings very dependent on electro mechanical machines, as well as the available natural potential wasn't well use.

The thermal behavior of museum buildings can be affected by various parameters. Including the main design variables, that can be controlled at the design stage. Other meteorological parameters are the environment variables that are not under the human control. Insufficient attention to these aspects at the design stage, will lead to an uncomfortable indoor environments.

During the summer season, superiorly in climates that have hot weather buildings are exposed to very high amounts of solar radiation as well as heat. This can result in overheating environments that surpass the threshold of the indoor thermal comfort. Under these conditions the protection of the Museum buildings as well as artifacts from the straight environment influence can be of great significance. It was estimated that in extremely hot as well as cold districts, the electricity needs for cooling as well as heating of large Museum buildings could be high. Good environmental design must therefore be measured carefully to control the interior thermal comfort conditions as well as to reduce the need for air conditioning units that can cause environmental indoor air quality hardies as well as additional running costs. The education as well as application of conservation design is a complex as well as multidisciplinary procedure. Heating as well as cooling procedures must not be considered as isolated phenomena, but rather in close relationship to the type of buildings, the building occupancy, as well as the sources of heat gains and losses under diverse climatic conditions.

2.10 Museum buildings design Parameters

Essential to the engineering perception for Museum buildings are the considerations that must be taken at a very early design stage. Like the role of the museum, as well as its connection with exhibits as well as people.

Despite the big architectural value of several museum buildings, several museum interiors were compact to minimalist spaces in the past, to provide a neutral experience, but every so every so often lost the sense of space as well as the ability to create an friendly environment. Even though this treatment so often facilitated the very big pieces of modern sculpture as well as painting that were produced at that period time, it so often did not enhance other artifacts.

Movement inside the museums

Modern Museum buildings lean towards placing superior emphasis on the movement of its visitors. However, it was just after the building of the Guggenheim Museum in New York City, by Frank Lloyd Wright, that such movement was actually took place as well as become a core parameter of museum design that was combined with three-dimensional design. Museum s Visitors movement results in additional necessities regarding the treatment of lighting , the significance of natural lighting as its differences supplement as well as are necessary for the variety of visitors movement.

Lighting inside museums

Day lighting as well as electrical lighting usually gets special conservation in museum building design. Because lighting is required to recognize artifacts in the museum, but this lighting can also have a negative impact on those artifacts as it can damage the sensitive artifacts that are displayed inside the museum.

When saying lighting we mean ultra violet lighting as well as visible lighting, when controlling lighting, the ultra violet lighting is considered easy to be controlled as it's a un visible lighting as well as does not contribute to our vision , so we can use ultra violet filter to control this lighting. Though, most ultra-violet films use on windows, for example it becomes less operative with time, that's why , where ever there are sensitive objects exhibited , ultra violet lighting control must take place.

The total lightings exposure penetrated on subtle objects is the amount of day lighting as well as electrical lightings. With where sensitive objects it is nearly hard to use day lighting.

In any big museum buildings, spaces must be provided where an out view is conceivable. open areas can display the less sensitivity artifacts and can be used to become seating areas for the

Museum guests, these designing methods can help in minimizing prevalence of what is called , museum fatigue. For Artifacts which has average sensitivity, measured methods can be implemented needing involuntary shutter controllers of the louvers which regulate the received day lighting besides non-natural lighting. Such methods are very costly in their original cost as well as maintenance costs. An extra passive method can be adopted where day lighting can offer around 40 percent as well as 70 percent of the total annual lighting requirement. Such systems would usually have variance louver controllers on the day lighting for summer as well as winter, and be comparatively extra transparent in winter than summer.

Another basic lighting rule is that diffused illumination, anywhere lighting comes similarly from all direction, will let an object to be seen, nonetheless it will do slight reveal the form and texture as of the lack of shadow. The gradations of reflected lighting which is brightness of an object, over the surface of an object reveals its three-dimensional outline, however textures could be shown by providing light in an appropriate angle.

The grade of diffusivity in spaces is expressed as vector /scalar ratio, where values between 1.2 as well as 1.8 give acceptable modeling of surfaces.

Lighting inside museums effects the deterioration of objects in diverse ways. For display reasons lighting cannot be avoided, but it is necessary to minimize the damage that it can cause as much as conceivable. Deterioration because of lighting can be summarized as follows:

• increasing photochemical reactions having several consequences like discoloration.

• increasing materials breakability, especially when meeting high temperatures.

Lighting properties to be controlled are inside the museums are the following:

• IL luminance LUX

• Yearly exposure LUX h/year

• UV radiation W/lm.

Museum displays lighting standards

The description of recommended values for the conservation performance programed involves a classification of the objects typologies which can be displayed in museum by way of every object has its conservation necessities that depend on the material of that the display is composed. Every object must be preserved as a separate case, demanding specific attention.

Museum displays should be divided in three groups depending to its light sensitivity, insensitive, medium sensitive as well as sensitive, as shown in the following table, The figures in the table must be seen in the situation that full appreciation of colors is not accomplished until around 250 LUX. The amounts of lighting suggested for sensitive artifacts prevent the usage of day lighting.

Some controlled day lighting systems like roof lighting happen to retain 200 LUX on

The objects, but the LUX-hour allows passive methods to retaining conservation requirements. necessities some observers have suggested that very sensitive objects that can have to be lit at 10 LUX and below like the Leonardo cartoons in London's National Gallery can be displayed at a higher level but with limited view timing.

Bellow table 2.7 showing the recommended amount of light (lux) depending on the museum’s object sensitivity.

Table 2.7 the suggested amount of light (lux) according to object sensitivity.

	Maximum IL luminance (LUX)		**Maximum accumulated yearly exposure (LUX-hours)**	
	UK	US	UK	US
Sensitive objects (*e.g.* water color)	50	50	150000	50000
Medium Sensitive objects (*e.g.* oil painting)	200	200	600000	480000

Ombazis (2004)

2.11 Improvement of museum energy efficiency

In museum designing, a general problematic issue is the contrasting conservation necessities of exhibiting objects as well as the visitors comfort necessities. Those deviating necessities generally lead to hardies in the designation as well as the enhancement of museum indoor air quality as well as thermal stability. Historical construction methods every so often make it hard to incorporate building services like air ducting and active systems as well as preservation and safety of monuments

Often confines variety of solutions put onward. As of that combined planning as well as the contribution of professional as early as conceivable is essential for the design ,as well as retrofitting of electricity efficient museum buildings. It is essential in electricity efficient buildings to reduce thermal loss. The development of thermal insulation in addition to the airtightness of buildings in combination with controlled air variations will decrease the electricity required. This can allow the usage of electricity enhanced low temperatures cooling as well as high temperature heating systems.

It is essential to describe a agreed of recommended values for every display which can be viewed in relative to human comforts standards. This can be useful when measuring the compatibility of the indoor environment both for visitors as well as displays, and the necessity to adapt the display environment by means of showcases. Poor climate control can have much harm to the displays.

Air temperature can have biochemical reactions in materials and might do the following effects:

• increasing the organic material descent because of chemical reactions.

• Organic materials can have volumetric expansion of the material.

• Increase in physical as well as chemical deteriorations because of evaporation processes which can have a mechanical stress in the material of the artifact.

• increasing photochemical reaction in the material.

• increasing organic activator of microorganisms, especially in organic material.

The precise classification of indoor climate values is very important for museum's visitors comfort, display conservation as well as electricity savings.

The design approach requires a comprehensive, holistic method in order to enhance the use of passive systems as well as active systems. Sometimes an accurate analysis of the displays and a model of museum occupancy which is the number of persons, occupancy pattern, activities, etc. make it conceivable to reduce the heating, cooling loads as well as to design the HVAC system without an oversize.

CHAPTER THREE Research Methodology

3.1 Research Development

According to Lewis, Raton (2006), the research process begins by defining the problem, setting research objectives, and assessing a market as mature or new. There are six steps that explain what is involved in the research process:

- Problem definition—defining the problem to determine the purpose of the study
- Development of Approach to problem—formulating goals, theoretical frameworks, models and hypotheses required
- Research design formulation—framework for conducting research
- Data collection—gathering information and simulation data
- Data preparation and analysis—preparing the information (using data mining and data warehouses to store and evaluate data)
- Report preparation and presentation—written report presented that addresses the research problem (Malhotra, 2006, 10-12) (Moody, 2009, 1-6).

3.2 Estimated Annual Savings From Passive Cooling Techniques

According to the US Northern States Power Company, who created a sophisticated energy performance IT engineering simulation program called the DOE-2, the amount of money saved on annual energy consumption costs in developed nations like the USA who use green building passive cooling techniques can be estimated to show huge savings. According to the DOE-2 Computer Modeling and Payback Analysis, an average office building with a size of 243,000 gross sqft and an annual energy cost of over $1.4 million shows these calculated energy cost savings per year from the integration of passive cooling techniques:

- Heat recovery saved the most with 8.0 kw peak reduction in heating energy, showing $309,933 yearly energy savings
- Chiller efficiency saved 403.4 kw, showing a $46,348 yearly energy savings
- Variable speed drives reduced static from fans, and variable air volume and day lighting reduced energy by 218.4 kw, showing $39,843 yearly energy savings (Tolat, Venkes ,2010, 1-16).

Figure 3.1 shows the average annual energy savings from using passive cooling techniques, including 38% energy consumption costs over time. The main green building solar energy passive cooling methods include photovoltaic solar panels, shade, day lighting controls, operable windows, raised floors, natural light, glazed glass and roof terraces. These methods provide fresh air natural ventilation and reduce solar glare and solar heat gain (Aaron, 2012, 1-6).

Figure 3.1 Energy Savings from Passive Cooling Techniques (LEED, 2011)

Shown is Figure 3.2 the energy consumption calculations for Philippines Ayala Tower One and how passive cooling techniques reduce energy consumption and increase savings. The chart shows how the buildings' energy consumption demand share of air conditioning was 8.67% at 20 degrees F. and by adjusting the interior room temperature to 26 degrees F. and adding fans and chiller pumps, they saved almost 12% in overall energy consumption and costs annually. This 400,000 sqm building's annual energy costs were approximately reduced by $16,300 by using passive cooling and thermal mass methods to reduce energy consumption. These green building strategies were then applied to five Philippines high-rise buildings with each floor being 80,000 sqm, and the overall annual savings totaled $1.1 million (Andamon, 2010, 1-30).

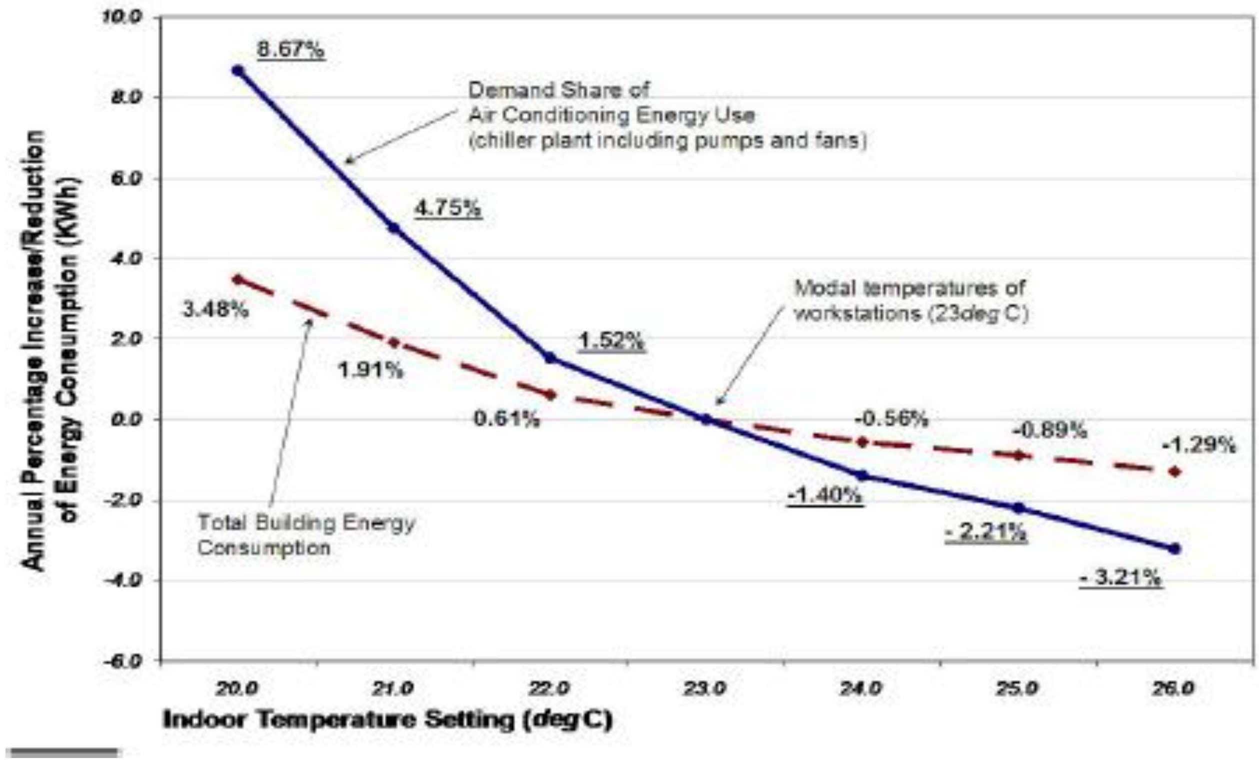


Figure 3.2 Energy Savings in Philippines Using Passive Cooling Techniques

(RMIT, 2010)

3D Thermal CFD Simulations: Increased Thermal Comfort & Energy Reduction

The use of three-dimensional Computational Fluid Dynamics (CFD) simulations to show increased thermal comfort and decreased energy consumption help detail how passive cooling and thermal mass reduce energy consumption costs by providing natural sources of cool air. The main passive design techniques discussed include passive cooling, thermal mass, building orientation, building massing, shading devices, high performance envelope and thermal insulation, window design and natural ventilation since they are the foundation of the green building strategies for energy consumption reduction to improve thermal comfort (Hauck, 2009, 1-25).

This 3D CFD example in Figure 3.3 of an office lobby waiting room shows how the Under floor Air Distribution (UFAD) is an effective natural alternative to air conditioning ventilation systems. This method helps to improve thermal comfort and air quality as it decreases energy consumption. This 3D thermal model displays the natural climate-controlled environment in this building using the different temperatures in the room that impact people's thermal comfort. Blue colors represent the coolest temperatures, while red signifies the hottest temperatures, and yellow and green are in the middle (Hauck, 2009, 1-25).

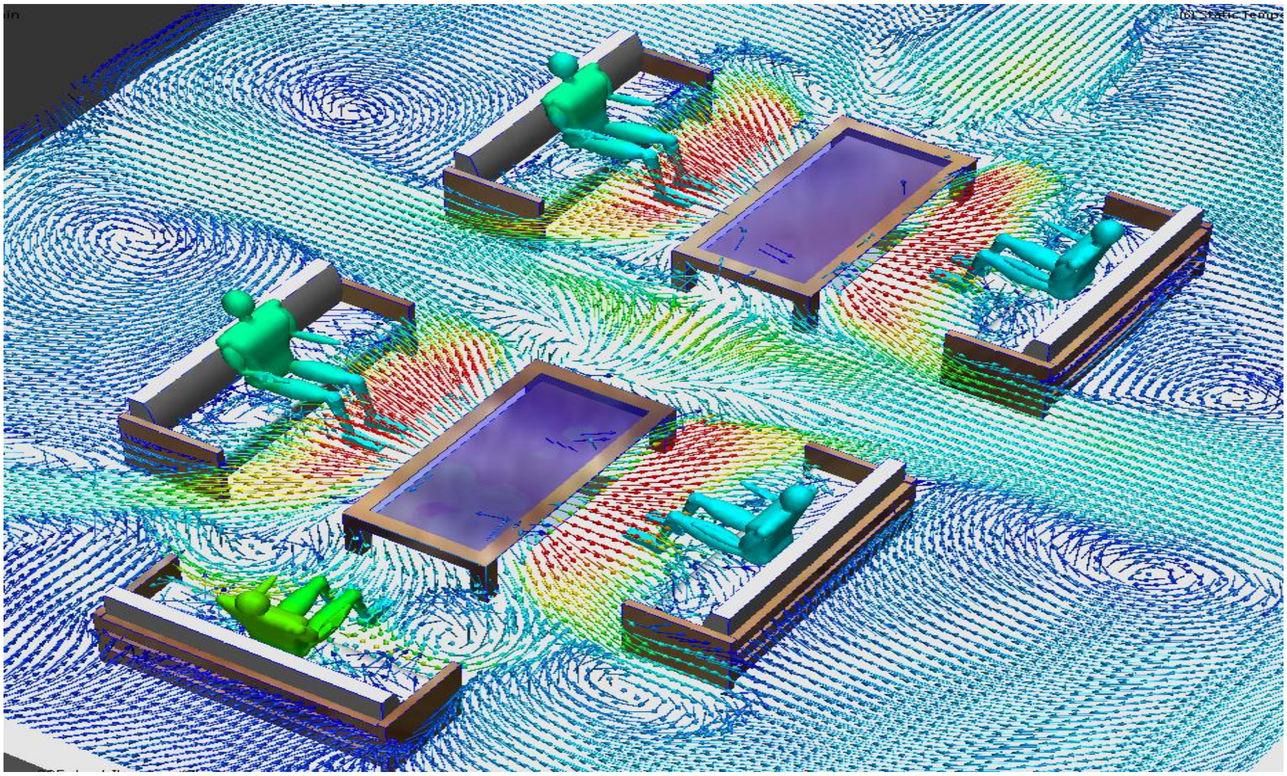


Figure 3.3 Example of 3D CFD Simulation In An Office Lobby Waiting Area (LEED, 2009)

The 3D CFD analysis in Figure 3.4 of thermal imaging for an office work space shows the increasing thermal comfort indoors that can be provided with passive cooling (green represents natural breeze from open windows), and thermal mass (red heat signifies thermal mass stored in corners of room away from people working), as green building strategies to control the internal temperatures naturally (Hauck, 2009, 1-25).

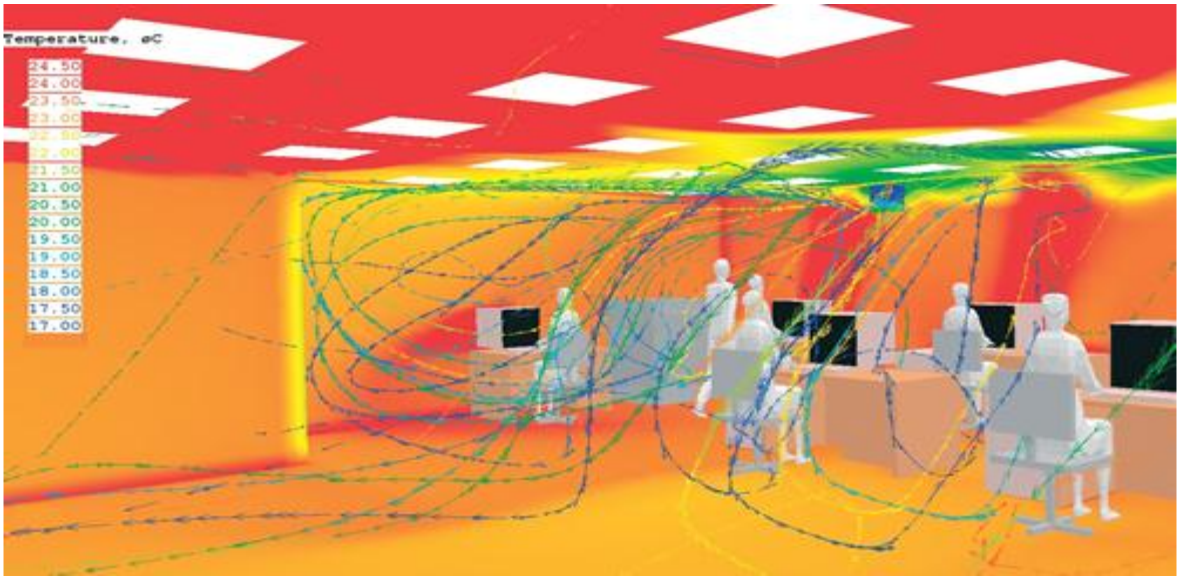


Figure 3.4 ***3D*** **CFD Simulation of Office Work Space** (LEEDS, 2009)

Global Sustainable Development Initiatives

Some of the global sustainable development initiatives include:

- Green initiative—in January 2008, began to enforce the new environmental green building energy conservation urban development initiatives for protecting the natural ecological system for the land and sea; all construction companies have to conform to the new environmental and safety guidelines or pay huge fines and be shut down by the government
- Humanitarian laws—in 2008, also began to enforce new humanitarian regulations to protect laborers, and to ensure their health and safety during green building planning; new wage increases were given to the manual laborers, new safety regulations were passes, and enforcement of health codes and health insurance provision for laborers began

- Desertification—new global government green building regulations are being passed to protect the natural desert and its wildlife and plant life from the waste disposal landfills and construction; new green building laws will provide cultural heritage protection of certain endangered species that originated in the global region, as well as various areas that cannot have any developmental changes made to them (Al-Marashi, H, Salama H, 2008, 1-10) (Peterson, 2008, 1-5) (Bradford et al 2008, 1-3).

Green building energy conservation sustainable development initiatives will be integrated into the mainstream development operations of most countries' future urban construction design. The global infrastructure is now going to be able to sustain itself for the future by following these green building energy conservation initiatives in order to help the next generations create a more environmentally-friendly climate. The government will also be better able to protect the people, animals, water, desert and cultural heritage they are trying to preserve for future generations. Sustainable urban development with green building energy conservation is necessary to protect natural resources for the future. Worldwide is currently working on incorporating various sustainable urban development programs and green building energy conservation strategies into its infrastructure and construction.

Worldwide nations are attempting to integrate environmental urban development sustainability into all new projects to ensure future generations have enough resources. Sustainable urban development is the key to preserving all future global societies. According to the Earth Pledge, "Architecture presents a unique challenge in the field of sustainability. Green building construction projects will help reduce large amounts of materials that produce tons of waste, and often involve weighing the preservation of buildings that have historical significance against the desire for the development of newer, more modern designs" (Al-Marashi, 2008, 1-10).

Global Sustainable Development

Global sustainable development is reliant upon governments' ability to successfully integrate political, economic, social, technological, environmental and legal (PESTEL) strategies into their future long-term planning. Change management strategies and economic diversification into the non-oil sectors are essential to the global since adapting to the development of new cleaner alternative energies will eventually reduce the need and value of oil in approximately 20-30 years, according to leading economists. With solar, nuclear, wind, hydrogen and geothermal power sources being continuously developed to handle global energy responsibilities, any nation totally dependent upon oil must formulate alternative sustainability objectives for the future. The global's Gross Domestic Product (GDP) is stated to be 29% reliant upon oil for the majority of its domestic revenues (yet experts state it is really more like 95%). Worldwide has acknowledged these issues and taken on the responsibility of preparing the country for major changes within the next 20 years (Raghavan, 2006, 1-4).

Worldwide recently published the International Economic Vision 2030, which focuses on how the country will improve its sustainability potential in all areas and sectors over the next two decades. According to the United Nations (1987), sustainable development is when a country like the global is able to satisfy its current economic needs without having to compromise any future generations' capability of meeting their needs. The United Nations states that economic diversification refers to the global's ability to reduce its overall risk of recession by investing its oil wealth into non-oil sectors to sustain the economy for the future, despite any reduction in the value of oil revenues. Economic sustainability relates to when an economy like the global can maintain its financial means, trade and industry. According to the World Bank, for developing countries to have sustainability, they must "equip themselves with the highly skilled and flexible human capital needed to compete effectively in today's dynamic global markets" (Al-Ateeqi, 2011, 1-5) (Hraiz, 2011, 1-7).

The United Nations World Summit 2005 explained how there are three specific pillars of a nation's sustainability: economic, social and environmental. Sustainable development refers to how the global must adapt its resource usage patterns to effectively satisfy the needs of the people, yet still preserve the natural environment. Environmental sustainability is when a country like the global must find ways to develop its society and still maintain its natural environment, protecting animals, plants, trees, marine life, water, desert and air. Although there are many experts that have varying definitions of these terms, the universal concept is that the global must learn how to adjust its present economic development to integrate environmental strategies that will allow for growth, expansion and protection of nature and ecosystems for the future (Bradfield, 2009, 1-8) (Arnold, 2010, 1-4).

3.3 Review of methodologies of previous work

In this part of the paper, a review is conducted of research methodologies used by other scholars a highlighting will be on the explanations for the selection of the several methodologies in order to find the most suitable option for this study.

Experimental studies

Simos Yannas (2007) explored through an experimental study to address the architectural potential of adaptive comfort in the extreme climatic conditions of the Gulf Region. He studied a building in the Gulf Region located in Abu Dhabi in united Arab emirate that is categorized by its strong dependency on mechanical air-conditioning. He focused on design considering improving thermal discontinuities between the heavily air-conditioned building and the high ambient temperatures in this climatic region. The experience of designing and making the structure helped inform a set of parametric studies using a dynamic thermal simulation model. In turn the results of the study guided the development of building design Proposals for sites in Abu Dhabi. He studied the building adaptive measures for thermal comfort , glazed openings size and shape to provide adequate day lighting, he also analyzed Solar control measures to be considered on all orientations focusing on the Internal heat gains as well as ventilation . The experiment took place in Al Lulu Island, a manmade islet with an area of some 15 square kilometers, located a few hundred meters off the coast of Abu Dhabi.

Another experimental study was done by BYOUNGSOO AHN (2005) studying day lighting systems for the Kuwait National Museum (KNM). He examined lighting performance of side shading devices in the Museum. His research covered day lighting methods for two blocks of the Museum Building. Day lighting systems were calculated using a scale model as well as Desktop RADIANCE, a lighting simulation program. His research presents how to make use of daylight in museum buildings while shielding museum objects from the negative portion of daylight. Desktop RADIANCE was used in the study to exam the lighting level in the gallery. Then, to verify the data from Desktop RADIANCE, the data were compared with scale model measurement. Scale model was used to test the sun penetration through the top light and verify the lighting level of Desktop RADIANCE. To simulate sun path of Kuwait City, sundial was used and field observation was done to match the exact reflectance values in the Desktop RADAICE. He explained daylight in museums and effects of Light Exposure on it. Showing the composition of light, highlighting benefits of daylight in museums, and how to make use of daylight taking into accounts design considerations for Museums.

Simulation

A simulation methodology was used by Carl, Simi and Mohammad (2011) to study the design characteristics that impact energy efficiency and conservation.

The study was done on a masterpiece of American residential architecture called Paul Rudolph's Milam Residence, the modernist structure is built primarily of concrete and glass and located in a

Subtropical climate, the building is mainly constructed of poured concrete and concrete blocks and has extensive window glazing, especially on the east façade while this glazing makes up a majority of the eastern most elevation, all other sides of the building contain minimal transparent surfaces.

They examined design strategies such as orientation and shading devices and their effect on day lighting, shading, and heat gain. Their analysis was based on parametric energy modeling analysis using Autodesk's Ecotect, an environmental analysis tool that allows simulation of building thermal performance. The program allows the input of multifaceted geometries and detailed programming for zones, materials and schedules. The program's great analyses of desired parameters are improved by visualizations that make it valuable in communicating results.

Their paper provides a study of the building with respect to its climate responsiveness, concentrating specially on day lighting, shading, heat gain, and cooling loads. The objective was to assess the building design to quantify how it is impacted by solar insolation and to provide visions about design characteristics that impact efficiency and energy conservation. Their paper contained a detailed analysis of the building's solar responsiveness and their finding shows that the building as built and situated on the site, can have great benefit of day lighting and solar shading.

Svetlana Olbina (2005) explored through simulation shading device systems installed in windows, examining shading device performance in the process of selection and design of the shading devices. The shading devices were fitted in an office building located in Roanoke, Virginia. software Autodesk VIZ 4 was used to simulate the building day light and thermal performance.

The paper studied heat transfer, HVAC conditions, Performance parameters for the shading devices and thermal performance of the shading device

The research developed a general decision making framework that can be used by architects and manufacturers of shading devices.

Most of the literature reviewed throughout the preparation of the study used similar methodologies based on experimental field studies and computer simulations , some of the main advantages and disadvantages of both methodologies are summarized in the following table.

Table 3.1 advantages and disadvantages of simulation and field experiment study methodologies

Characteristics	**Field experiments**	**Computer simulation**
Reality	√	×
Validity	√	×
Ability to scale object	×	√
Easy	×	√
Control of variables	×	√
Cost	×	√
Consistency	×	√
Time	×	√

√ **Advantage**

× **Disadvantage**

3.4 Research design and methodologies

the investigations that defined in the previous section shows that is similar studies to this one two methodologies were mostly conducted experimental methodology and simulation methodology the simulation was chosen for this study for several reasons , those reasons are briefed as follows :

- Control of variables and consistency: in simulation there is more control of variables than it in experiments, which made simulation more consistent.
- Time limitations: simulation require less time than experiment which require long tim that is beyond the time available for the study.
- Cost limitations: simulation has no considerable expenses, unlike experiments that usually needed for considerable expenses.

The study has been carried out in two phases, the first one consists of a literature review of passive green building technologies. The second is based on simulation methodology

Method 1: literature review

involves thorough a comprehensive academic literature review developed from analyzing several textbooks, journals, articles, essays and other reading materials from both online and offline sources. The findings of this review will be used to highlight a gap in knowledge in the field of building thermal performance and several passive design strategies that will be used to frame the research problem as well as aim and objectives. Literature review is covered in chapter two of this paper.

Method 2: Simulation

The simulation was achieved via a computer model using software simulation to study the thermal performance of the building evaluate several passive design strategies that has an impact on cooling loads of buildings, and to determine how these building technologies can reduce building cooling demands. The data gathered from the primary research was evaluated and statistically calculated for overall analysis, conclusions and recommendations for future improvement.

Smith (1999) defined simulation as the process of designing a model of a real or imagined system and conducting experiment with that model, the main objective of this process is to understand the behavior of the system or evaluate strategies for the operation of the system through assumptions, mathematical algorithm and relationships.

As discussed previously simulation is less time consuming, accurate and cost effective and if done correctly it can stand for real systems.

Smith (1999) defined proposed a definite process for creating, developing, validating , operation and analyzing the results of simulations, the main steps of his process were as follows:

- Define problem
- Define conceptual model
- Collect input data
- Construct software
- Verify, validate and accredit the model
- Design experiments
- Execute simulation
- Collect output data
- Document result
- Analyzed data
- Expand model

3.5 Selection of the simulation tool

Selecting a simulating tool for the study needs a careful attention, choosing simulation software depends on the parameters that will be studied in the research. For this study a simulation that is capable of analyzing building thermal performance as well as passive design parameters that are related to building orientation, thermal mass, material insulation, glazing and shading parameters. Fundamentals were identified to be satisfied by the simulation software.

- Ability to visualize incident solar radiation on windows and surfaces, over any period.
- Capability to calculate daylight factors and luminance levels at any point in the model.
- Ability to Display the sun's position and path relative to the model at any date, time, and location.
- Capability to Calculate total heat gain of the building model on an annual, monthly, daily, and hourly basis, using a global database of weather information

Finally and after exploring through many available software, Autodesk® Ecotect® Analysis software was selected to be used in this study. a software that is comprehensive and offers a wide range of thermal simulation and building thermal performance analysis. The software Autodesk's Ecotect is a considered a parametric simulation software for simulating building performance which can do analysis in several grounds like the solar exposure, artificial lighting, day lighting, material costs, resources consumption, material usage, building thermal performance and acoustics. it also shows the sun's path (daily or yearly) through the location.

Ecotect is capable to study heat gain , solar exposure as well as daytime lighting.

a comprehensive geometric model is necessary in all features such as the building envelope , shading devices, overhangs, window opening design , also all other aspects that can affect the simulation of temperatures or shadow and lighting simulations like nearby building geometries and landscaping topographies.

Inputs needed for Autodesk Ecotect software are as following

• Three Dimensional model of the building: Specific dimensions can be given to model the Building. Figure bellow is the model of museum Building Construction with approximate dimensions in Autodesk Ecotect Program. The figure displays a three dimensional views of the building in this software.

• Location Data: Figures bellow shows thermal components of Dubai climate zone.

• Hourly Data: Figure bellow shows monthly diurnal average of diverse temperatures throughout the twelve months of year.

• Give information to calculate thermal analysis. Hottest day of July/21 has been chosen for this study.

Research Design

The research design for this paper includes both primary and secondary research methods with quantitative and qualitative research to analyze the data. The secondary research involves a thorough comprehensive academic literature review developed from analyzing hundreds of textbooks, journals, newspapers, articles, essays and other reading materials from both online and offline sources. The primary research involved using a

Dubai Museum as a case study to study the energy consumption of an alternative energy business model.

Museums have a vital role in the sustainability growth as well as management of natural and cultural heritage collections. Museum galleries as well as other historical collections hold an estimated 41 million objects. They are a vital national advantage and a legacy for future generations. Though, they may become a future problem if we fail to conserve them. Museums through their function activities have an essential part in encouraging and implementing sustainability in culture. Museums have a far reaching, rooted connection with their communities there for museums should display case for the public their own energies to work headed for sustainability in all aspects of their effort.

During the last forty years, there has been a marvelous growth in awareness through the world about the need to control museums environment to reservation of collections. Generally, the employment of environmental controls within museum buildings had an enormous positive influence on the maintenance of museum collections. This tendency was given a big increase in 1978 when Garry Thomson issued The Museum Environment (1978). His book provided a detailed and brilliant knowledge to date on this subject.

This study suggests an architectural scheme for the museum building specially in hot climates. It is an effort to emphasize the importance of preserving our environment to all architects involved in the field of conservation and more specifically to the culture sector, expecting that it would motivate new ideas for museum design as a measure of sustainable conservation

The data was fed into the Ecotect software program and the statistical analysis provided the overall results that show how well the museum represents a solar energy business model for reduction of energy consumption. The data was evaluated and calculated for overall analysis.

3.6 Primary Research—Dubai Museum Case Study

In the following Dubai museum case study, the Autodesk Ecotect engineering IT software program was used to analyze the effects of several environmental strategies using passive cooling and thermal mass design elements related to green building. For energy consumption reduction, passive cooling, thermal mass, site and orientation, , windows design and sizes, and external solar shading , information is provided on how green building strategies can reduce overall energy usage. The study was conducted on a proposed museum building design, doing the thermal analysis using environmental software called Ecotect. This software provided a detailed analysis before and after applying the green building strategies on the building. All results are calculated according to its location and the weather typologies of the case study's region which is Dubai city.

The work is carried out with an objective of evaluating the thermal characteristics of building envelope of case study "museum" building in hot climate, studying the impact on sol-air temperatures, heat gain factors and the u-value of envelope and inner spaces of the building. The research discusses thermal comfort for a building in UAE; this building is affected by heat exchange influenced by its orientation, envelope design and constructional components also the specifications and use of materials. In the case study there is an analyze for the effect of several environmental strategies and passive design elements related to green building energy consumption reduction like Site and

Orientation, Windows design and sizes, external Solar Shading, Thermal Mass and energy consumption reduction.

This case study has an analysis of the building with regard to its climate responsiveness, concentrating specifically on cooling loads, heat gain, day lighting and shading. The objective is to assess the museum's design to quantify how it is impacted by solar insolation and heat gain and to provide insights about design features that impact efficiency and energy conservation. The study was done using environmental software Ecotect, this software will provide us with detailed analysis before and after applying the green building strategies on the building, all results are calculated according to its location and the weather typologies of the case study's region which is Dubai city .Computer simulations for building thermal behavior and design modification of building components are covered by the research.

A previously designed museum building was chosen, and a 3D model was created for it to study the effect of the environmental strategies that will be applied on it to make it more green and as a consequence more energy efficient. The study will show how applying environmental strategies will affect the overall thermal environment inside the building, and how is it possible to create human comfort using those strategies which after all will result in less energy consumption.

The thermal properties of the building envelope are determined by the combination of wall mass, thermal resistance, insulation, location, external surface color, texture, and the size and location of glazing. All of these affect the building energy consumption in a different ways according to weather conditions. Based on the highlighted design features and specific climate parameters, the problem of the building case study may be briefed as following:

1. Discounting comfort level requirements for occupants which influenced by construction materials and details used in buildings as well as the suitable architectural conducts in the

Building design

2. Absence of ideal passive design strategies for the building envelope which impacts the comfort levels of the inner spaces environment and effect energy conservation.

a museum building was chosen for the study for some reasons, first the parameters that will be analyzed in this study like building orientation, glazing and external shading devices has a deteriorating effect on the museum designs, as museums are mainly composed of galleries and show rooms orientation , glazing and shading can provide a sufficient effect on the interior spaces ,it determine the amount of natural lighting that can be provided into the interior to create comfort and ease in the interior spaces. Second there are few specific studies on museum thermal performance in hot arid climates like the climate of UAE, several studies were done for museum thermal performance in other climates, few has discussed Dubai hot climate. For this reason a museum building was chosen for the study.

The interest of simulating an internal environment through the use of computer modeling was to find alternative building approaches to museum buildings in which the firmness of the environment required for the preservation of artifacts is accomplished through passive techniques without the extensive use of air conditioning particularly in hot climate

In this chapter the results found from the simulation of the base case as well as for other different configurations and scenarios for the base case after applying some passive building technologies that improved the thermal performance of the building, simulation for the model will be done and analyzed in this chapter.

Thermal performance of the model will be simulated and calculated to evaluate and estimate the cooling load of the building. The passive technologies are applied on the proposed museum building design, to address the effect of these technologies on the thermal factors in the building like, solar radiation, natural lighting, heat gain and cooling loads.

The case study will show how using building architecture can minimize cooling loads and as a consequence energy use.

Simulation cases configuration

Different configurations for five different parameters were studied after setting out the model with the needed data; following are the parameters which are studied:

- Building orientation
- Wall and roof insulation
- Thermal Mass
- Building glazing
- External shading devices

The simulation configurations were divided into five separated parts for every parameter. Every of the five parameters will be simulated for absorbed solar radiation, heat gain, lighting and cooling load , except for the insulation configuration, which will have simulation of Room temperature, heat gain, lighting and cooling load .at the end of every part there is a configuration result analysis ,containing graphs and tables of the resulted data. Table 3.2 shows a matrix of the simulation cases.

Table 3.2 Matrix of the simulation cases

Matrix od simulation cases																		
	Building Orientation				**Insulation**				**Thermal mass**				**Glazing**			**Shading**		
	Base case	North	East	West	**Base case**	*Wall = U-0.39, roof = U-0.36*	*Wall =U-0.25, roof = 0.21*	*Wall = U-0.18, roof = 0.027*	**Base case**	6 inch (150 mm)	8 inch (200 mm)	10 inch (254 mm)	**Base case**	28.687 m2 (5.3% flr area)	18.452 m2 (3.4% flr area)	**Base case**	Medium shading	big shading
Absorbed solar radiation simulation	√	√	√	√					√	√	√	√	√	√	√	√	√	√
Heat gain simulation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Cooling load simulation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Room temperature simulation					√	√	√	√										

<u>Base case design alignment</u>

- Building orientation : south
- Total area: 445.985 m2
- Total glazing area: 43.479 m2
- Total south facing glazing : 32.10 m2 (6.1 flr area)
- Type of glazing : single glazing panels
- Wall thickness : 2.5 inch (62 mm)
- Insulation : Wall = U- 0.18, roof = U-0.027

<u>Architectural drawings</u>

Below are the architectural drawings of the museum building:

1. Ground floor plan. (Figure 3.5)
2. First floor plan. (Figure 3.6)
3. Section A-A. (Figure 3.7)
4. Section B-B. (Figure 3.8)
5. Section C-C. (Figure 3.9)

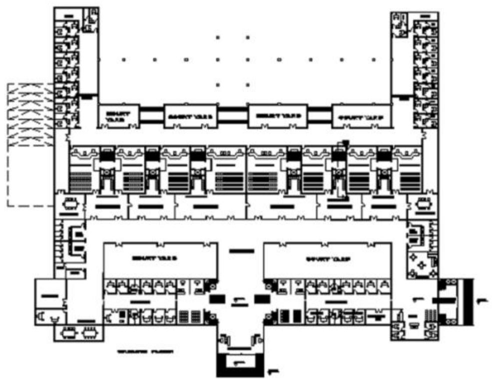


Figure 3.5 Ground Floor plan (Razan .H 2008)

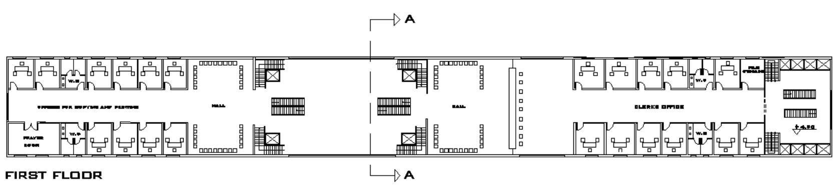


Figure 3.6 First Floor plan (Razan .H 2008)

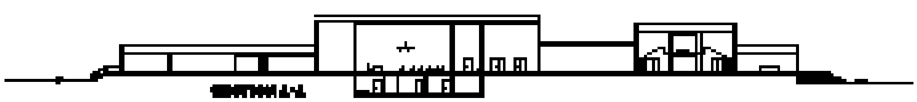


Figure 3.7 Section A-A (Razan .H 2008)

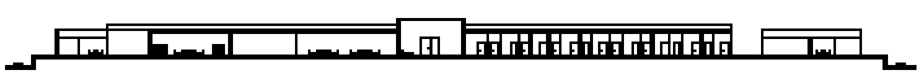


Figure 3.8 Section B-B (Razan .H 2008)

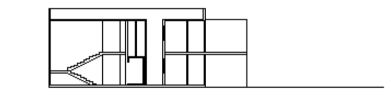


Figure 3.9 Section C-C (Razan .H 2008)

As shown in the architectural drawings of the museum, its design has several halls and galleries as well as two main courtyards, A major factor in the attractiveness of a Museum is the amount to which it is day lit, sunlit or in shade, this means good natural lighting should be provided to the halls and galleries, from an energetic point of view usage of daylight in a Museum space could potentially save energy of its artificial lighting and there for energy consumption. Nevertheless, this will be demanding larger amounts of natural lighting penetrated in to the Museum than would be necessary for a please brightness in the inside of that Museum.

The challenge in this design is to incorporate different technologies and green strategies, to encourage sustainable progress. Several environmental strategies will be applied on the museum model and their effects will be analyzed using the Ecotect software, and since the building is huge and has a symmetrical design, I have chosen part of the building to study it and analyze it; this part of the building is highlighted in figure 4.6 bellow.

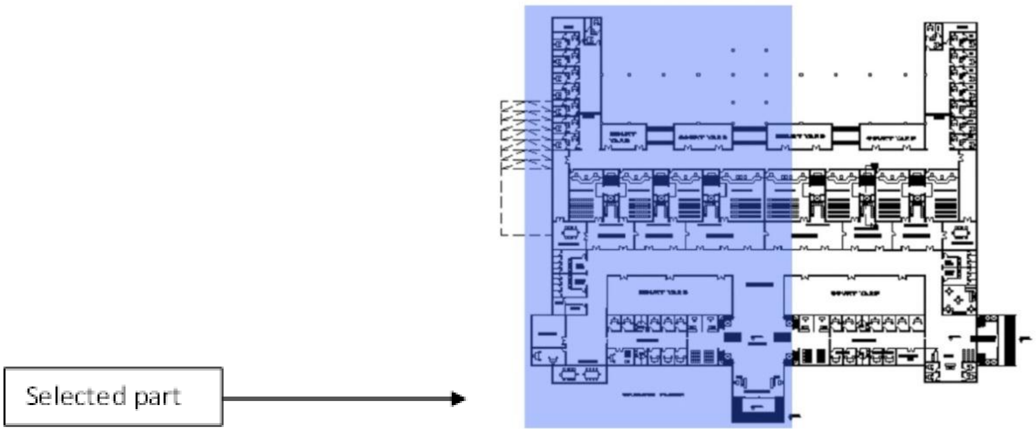


Figure 3.10 Selected part of the building

The studied part of the building as shown in figure 3.11 consists of the main entrance, lobby area as well as exhibition halls. A 3d model was modeled and fed into the Ecotect software for the simulation.

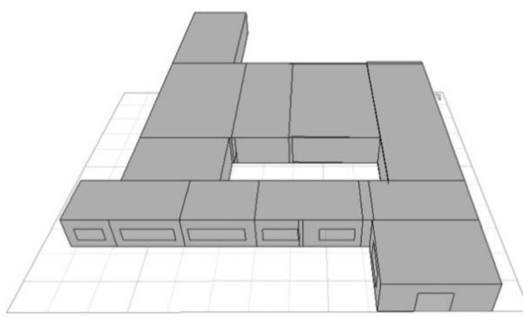


Figure 3.11 3D Model of the studied part

<u>Occupancy, operation and lighting profiles</u>

Before carrying out the simulation, occupancy, operation and lighting data were fed into the Ecotect software.

Barry Lord and Gail Dexter Lord explained in their manual of museum exhibitions (2001), that average occupancy for exhibits spaces should range between 2.8-4.6 m2,so an occupancy of 4 m2 per person was set as an average.

As in exhibits and gallery spaces people walks slow, so the ecotect was set to the activity type of slow walking and that's equals to 115 W, according to the ecotect software setting. Shown in figure 3.8 and figure 3.9 .the data were fed into the software and kept constant for all configurations in the study, and the data are as follows:

-Date of simulation: full day in summer (21 July)

-Museum Hours of operation: 8 am – 6 pm

-Occupancy (m2/person): 4 m2

-Persons type of activity: walking slow (115W)

-Active system: full Air conditioned

-Sky IL luminance: 9146 lux (overcast sky conditions)

-Glass cleanliness: x0.90 (clean)

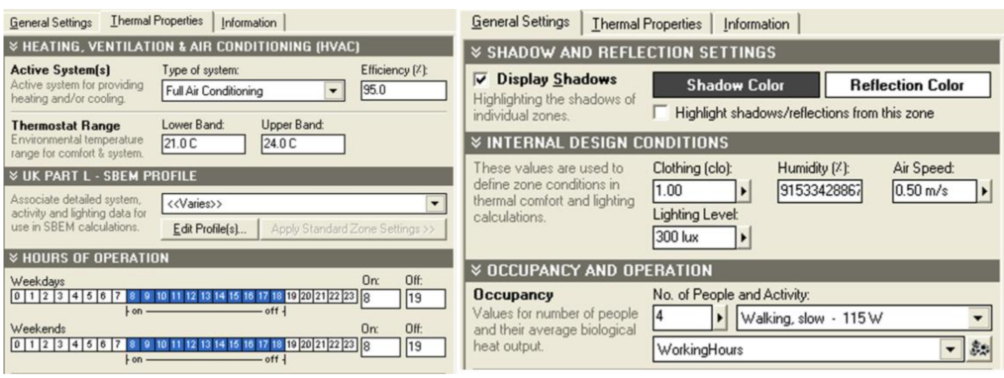


Figure 3.12 Operation, occupancy and active systems ecotect settings

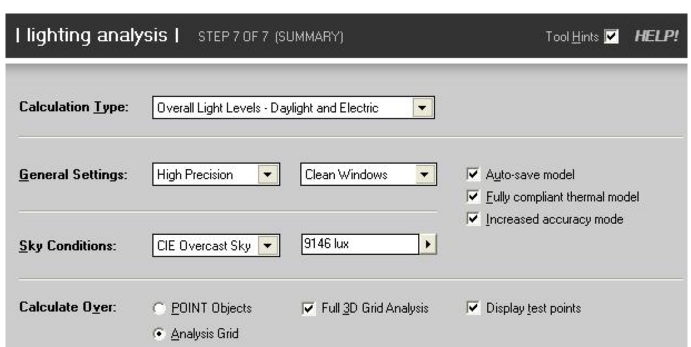


Figure 3.13 lighting profile ecotect settings

3.7 UAE weather analysis

Weather data for Dubai City (24.28oN, 54.25oE) has three different periods: first a four-month period of a the *mild* climate which starts on December and stay up until to March, described by mean daily ambient temperature of 20-23C, second is a the *warm* period begins in November and stay up to April having mean ambient temperatures of 25-26 C and, third is a hot period begins on May and stay up to October having daily mean of 30-36 C. The daytime temperatures range is 10-12K with night time jots under 25 C on most months excluding the three months period from June until August when the night-time temperature can beat 27C. Winds is usually above 4.0m/s through the year having the sturdiest coming from the Gulf direction of which is North and North-west on most months of the year.

In Dubai city the sunshine is sturdy during the year with a yearly average of 8 hours of strong sunshine per day, increasing up to 10 hours/day in hot periods. The daily amounts of solar radiation on the horizontal stays in the range of 3.7 - 7.0 kWh/m2.

In the highest times of the hot periods, the wet bulb temperatures rises to 24-25C which is considered a preventive kind for direct evaporative cooling. The predictions for evaporative

cooling are improved on other parts of the year as soon as the daily values of the wet bulb are around 20 C. Dubai sky temperatures depression is in the range of 10-12K through the hot periods signifying that there might be a beneficial potential for radiate cooling. In Dubai the mean sky luminance has a yearly average of around 25,000 lx, increasing until

100,000 lx. Under the mentioned conditions there is 1-2% of the outdoor luminance can be enough to give the illumination levels of 300-500 lx needed for usual indoor activities. PALENC (2007)

3.7.1 Mean Temperature:

Dubai is located at 25°15′N 55°18′E. The climate of Dubai has a mean day temperature between 17 °C and 37 °C, with mean hour temperatures as high as 43,6°C

according to the location of the building , the weather tools analysis in the Ecotect software , provides us with a weather analysis with the following parameters : passive solar heating, thermal mass effect, exposed mass and night- purge ventilation, natural ventilation, and direct and indirect evaporative cooling. All are done according to the location of the building Dubai -UAE.

3.7.2 Solar radiation:

Dubai is near the equator and the sun there has a higher path in the sky. See bellow Fig. for the sun path diagram of Dubai, There is also the fact that Dubai has less sky coverage by clouds. This means that there is often a clear sky in Dubai. Figure 3.10 and figure 3.14 shows the sun path diagram for Dubai-UAE.

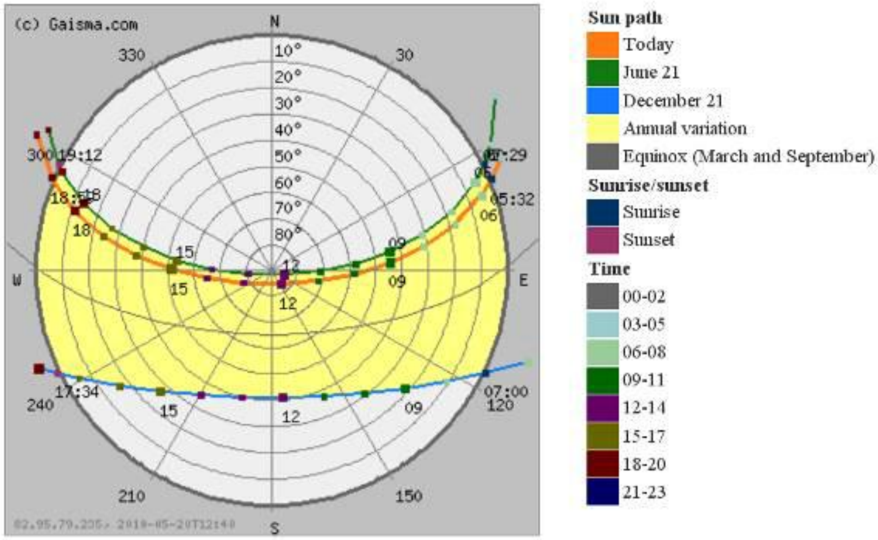
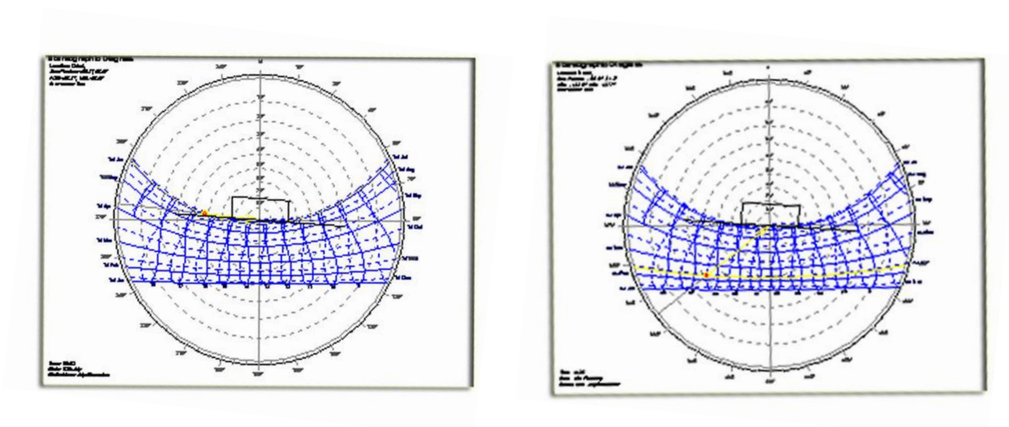


Figure 3.14 Sun path diagram for Dubai-Ecotect



Summer winter

Figure 3.15 sun path diagrams in summer and winter-Ecotect

The sun path diagram shows that the best orientation for a building in Dubai is the North Orientation which helps to maximize the daylight and avoid extensive solar radiation. it also shows the difference of sun radiations angle between summer and winter, it is much higher in summer months than it in winter months. This is a major aspect for designing a passive design

3.7.3 Passive heating

Passive solar heating, is the use of direct solar radiation to heat a space in winter, in which sunlight passes through a transparent building skin directly into the interior space, or indirectly where a separate solar collector is used and the heat transferred to the space via a medium, this technique is helpful in cold weather not for hot climates. Shown in Figure 3.16 This technique can be used in summer time between 28 – 29 Co, while in winter it should be applied between 23- 24 C

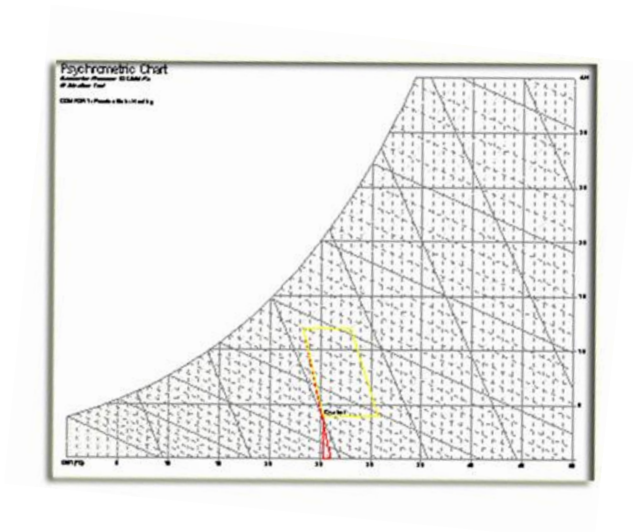


Figure 3.16 passive heating range- All year-Ecotect

3.7.4 Thermal mass effect

This technique is for the use of high thermal mass materials within the building structure or exterior layers and is the main idea of my building concept. This has a good effect which tends to cool out internal diurnal and seasonal internal temperature fluctuations.

As shown in Figure 3.17 Thermal mass effect can be applied between 22- 40 Co in summer and between 17- 34 Co in winter.

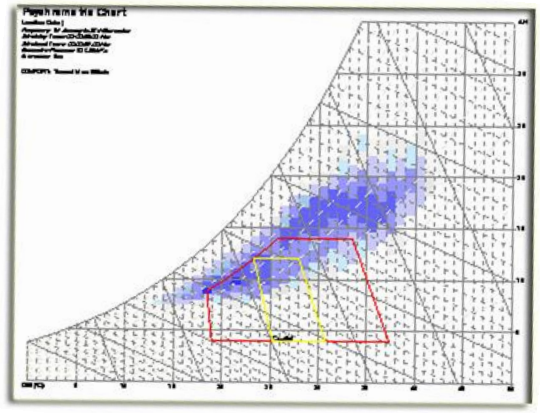


Figure 3.17 the thermal range- All year-Ecotect

3.7.5 Exposed mass & night ventilation

This technique requires high levels of exposed thermal mass within the building. Overnight in summer, when external air temperature is relatively cool, the building is opened up and high-volume air flow is there. This cools the internal mass down to night-time temperatures. The building is then closed up completely during the day. And this has the effect of reducing internal air and radiant temperatures, significantly increasing comfort levels within the space. For it to work properly, the thermal mass must be exposed, not covered over with carpet or ceiling tiles. And to have a comfortable thermal condition, as shown in Figure 3.18 night purge ventilation should be applied between 21-44 Co in summer and from 17- 37 Co in winter.

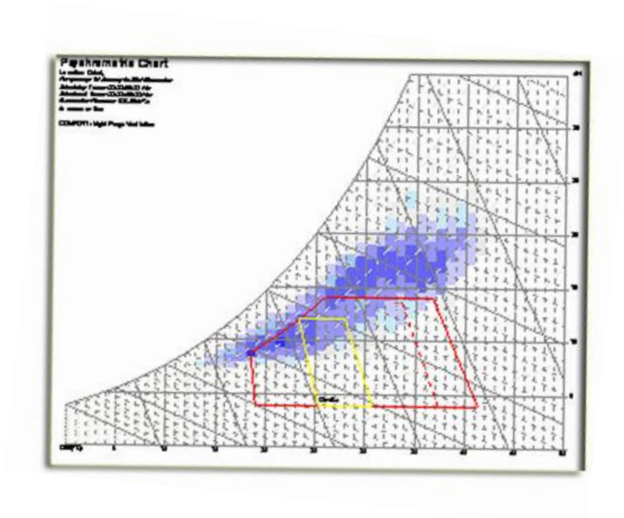
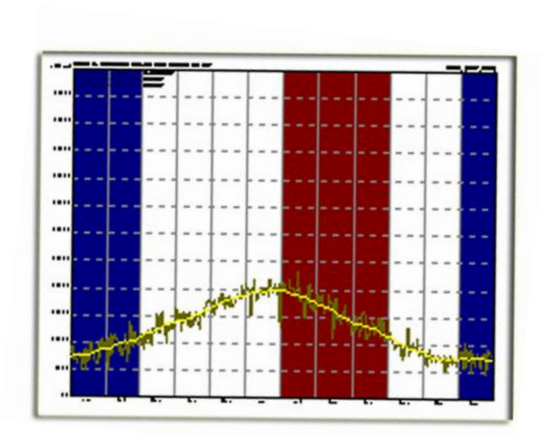


Figure 3.18 Exposed mass & night ventilation range- All year-Ecotect

3.7.6 Best orientation

As the weather tool shows in Figure 3.20 , the best orientation of the building is to be toward north, this is to minimize heat gain & solar radiation as shown in Figure 3.19, which is less to the north at the chosen location .



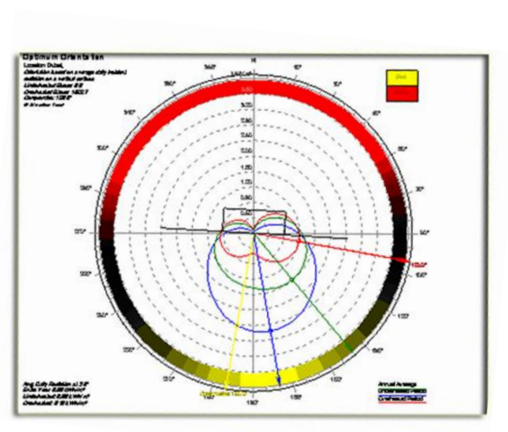
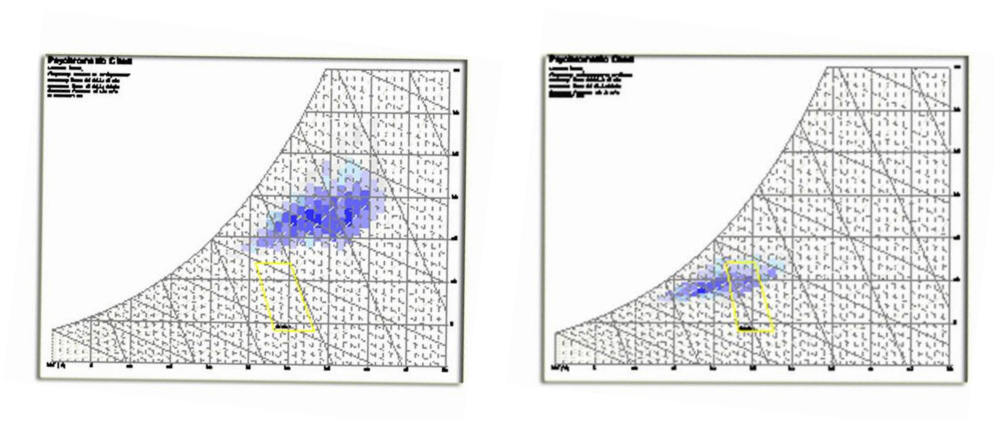


Figure 3.19 Solar Gain –All year **Figure 3.20 Best orientation**

As shown the psychometric chart in Figure 3.21 from weather tool shows that the comfort zone in the summer for such building with medium activity is approximately between 22o – 26o, it is far from the normal temperature in this season, which varies between 22o – 45o as shown on the chart. Unlike summer season, the comfort zone in winter locates within the normal temperature, the comfort zone is between 16o- 22o and the normal temperature varies between 10o – 32o



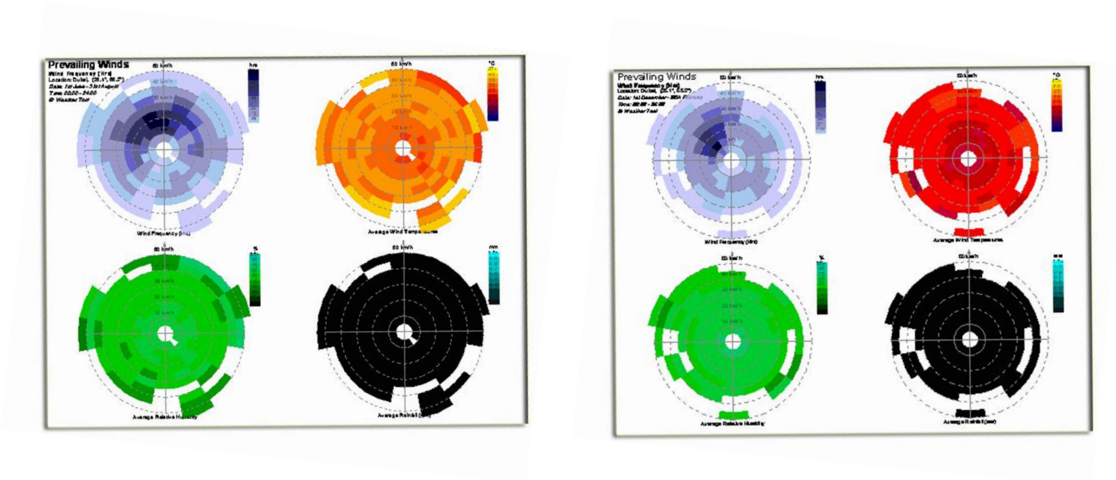
Summer winter

Figure 3.21 the comfort zone in summer and winter

3.7.7 Wind Analysis

Wind analysis is critical when designing building that has a function of museum. It can help in preventing the indoor spaces from undesirable climate conditions such as high temperature .For this project it is necessary to do many type of wind analysis, which are wind frequency, average wind temperature and average relative humidity in the proposed location . The weather tool figures presented different measurements of wind analysis in both summer and winter for the proposed location.

Figure 3.22 displays first, maximum winds frequency in summer is mostly comes from north- west direction, and the highest wind frequency passes 69+ hrs with a velocity of 25 km/h between 330o – 340o and the least wind frequency passes 6+ hrs with a velocity of 50 km/h between 255o- 315o. in winter , wind comes also from the north west direction, with highest wind frequency passes for 107 hrs with 10 km/h velocity from 300o – 320o , and least wind frequency passes for 10 hrs with a velocity of 50 km/h exactly from 280o- 300o. The weather tool show Figure 3.9 that in winter the average wind temperature ranges between 15-30 C, it is 25Co in the direction between 280o – 300 with a velocity of 35 km/h and decrease to 15 C, coming from different directions with varies velocity amounts. But In summer wind with maximum average relative humidity reaches 90% coming from east direction ,ranges between 78o – 102o and 12o – 56o with 50 km/h velocity ,also wind of a minimum value of average relative humidity reaches 25% with a velocity of 50 km/h coming from 260o- 285o. In cold seasons, wind with highest average relative humidity reaches 90% coming from varies direction with low- medium velocity, and the wind with smallest value is 70% comes from 280o – 300o direction. On the other hand the average wind temperature in summer ranges between (30 – 45 C), and the highest wind temperature is 45 C, coming mostly from North West direction with a velocity of 45 km/h, and the minimum value is 15 C, coming from different directions with different velocities



Summer winter

Figure 3.22 Wind Analysis in summer and winter-Ecotect

CHAPTER FOUR. Results and Discussion

4.1 Building Orientation

The main objective of this part is to Apply and test deferent orientation configuration to address the effect of different orientation on the overall cooling and heating demands as well as the overall lighting.

It's known that the most favorable orientation takes place where the amount of incident radiation in winter is greater than that incident in summer, and according to the weather tool data, in the chosen location, in Dubai-UAE the best orientation for the building is toward the north, this is to minimize heat gain and solar radiation and cooling loads.

The building was oriented toward four directions, toward north, south, east and west directions, and then the amount of absorbed solar radiation , heat gain , the overall lighting and the cooling and heating loads was calculated in four scenarios, then the effect of building orientation on the thermal gain in building was revealed.

The four orientations configurations will analyze the following four outputs:

A. The absorbed solar radiation (W/m2).
B. The amount of heat gain (W).
C. The overall lighting simulation (Lux).
D. The amount of cooling and heating loads (W).

Note: results to be described for absorbed solar radiation as well as cooling loads were for all months in one full year. And results to be described for heat gain and lighting were for one day in summer (21 July).

Simulations are done for the four different orientations as follows:

- South orientation (Base case).
- North orientation.
- East orientation.
- West orientation.
- Four configurations results.

South Configuration (Base case):

This is the base case scenario of the building, the building is oriented toward south, So the 3d model was oriented in the Ecotect toward south and then the simulation was carried out . According to the weather tool data south orientation is considered the worse orientation on the chosen, location; it's highlighted in red in the following Figure 4.1 the figure shows the building 3D model oriented toward south, displaying the sun path diagram and the red curve line representing the worse orientation on the site location.

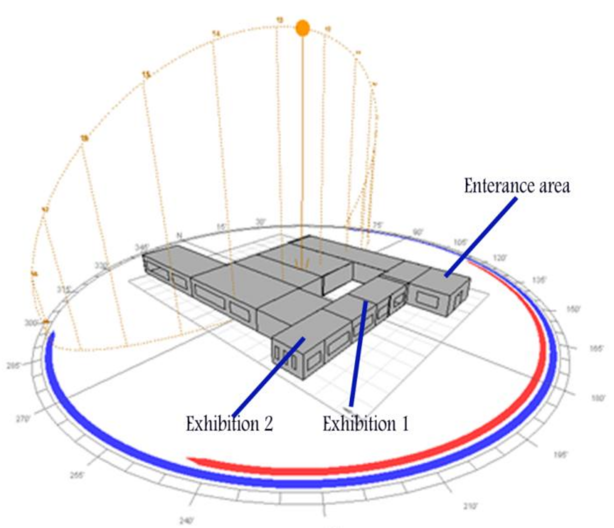


Figure 4.1 Building oriented toward south –Base case

A- The absorbed solar radiation simulation:

Heat flows means gains and losses in buildings are affected by the solar radiation , the greater the amount of solar radiation the greater is the cooling loads needed to cool the building to reach the comfort zone, Shown in Figure 4.2 The graph shows the average daily values to be expected on any day during all months. The absorbed solar radiation amounts on the south orientation, ranging between 20-70 W/m2 and reaching its highest level which is 70 W/m2 during January, October, November and December, these amounts of direct solar radiations absorption can be minimized by changing the orientation of the building.

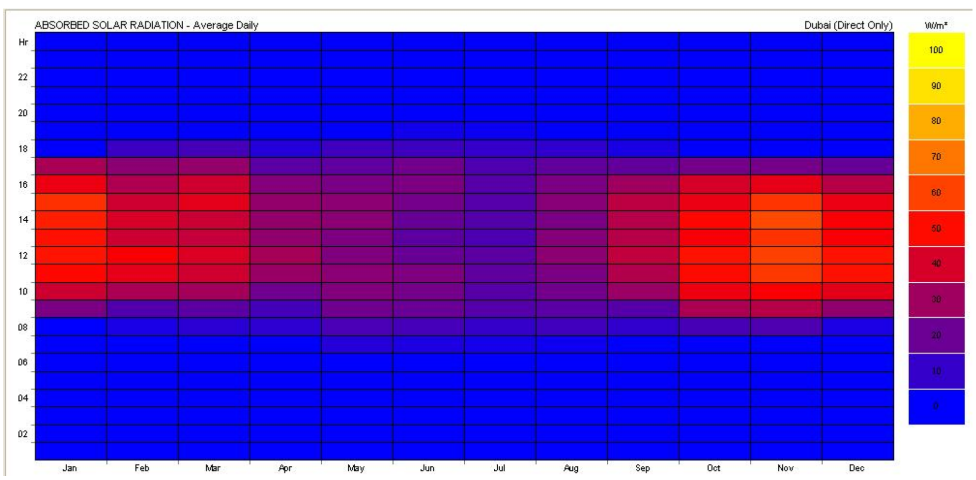


Figure 4.2 Average daily absorbed solar radiation graph–Base case (south)

B. Calculating Heat gain amounts:

In Figure 4.3 shows the amounts of Heat Gain and loss that is taking place through the building envelope, The solid red line represents conduction – gain / loss that happen through the fabric of the building itself, as shown in this case when the building is oriented toward south the red line which is representing the heat gain via conduction range is 240-400 W, that is considered a big amount of heat entering the building and this means there will be an extensive use for energy for air conditioning for cooling the building in order to reach to the required temperature of museums which is 24 ±1°C.

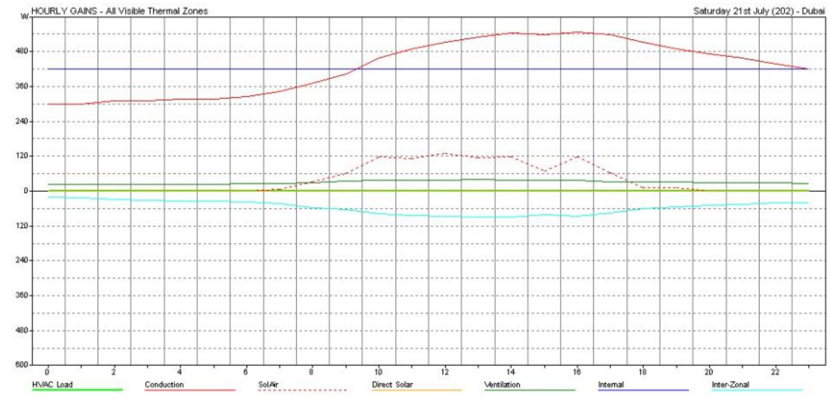


Figure 4.3 Heat Gain Loss graph- Base cases (south)

C. lighting simulation

Light intensity is measured in lux (lumen/square meter). The more intense the light is, the higher the lux level. Lux levels are reduced as the light source moves away from the item being lit. In items of museum displays, it is recommended that light levels are kept around 200 to 300 lux

In museum lighting full appreciation of color is not achieved until about 200-300 lux. And to achieve IL luminance level control lighting amount shouldn’t exceed 300 Lux. (Alexandros N. Tombazis “2004”)

Overall Lighting simulation were carried out for Both daylight and electrical light simulation, after orienting it toward south, this is to address the amount of natural light that is penetrating into the building and then to estimate the amount of artificial lighting that will be needed to fulfill the required lighting demand for museums and exhibitions.

Figure 4.4 shows the Part of the museum model that was selected for the lighting simulation , this part consist of two exhibition areas as well as the entrance and lobby area of the museum .

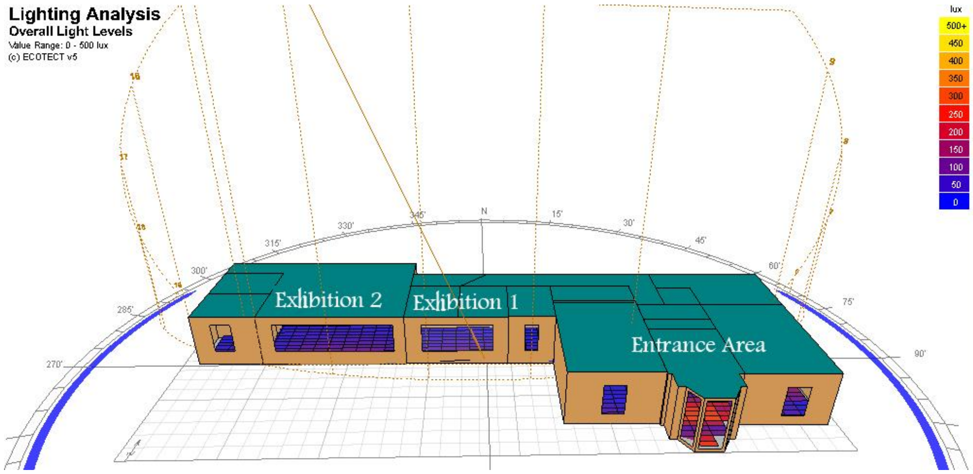


Figure 4.4 shows 3D model of the entrance and two exhibitions.

<u>-Daylight simulation-south</u>

For daylight simulation the Light source selected is the direct Sun (low altitude) = 90 lm/w (lumens/ watt). Normally sun light has high light output and contains very big concentrations of Ultraviolet rays. These UV rays are known to damage artifacts. Furthermore, light exposure will affect artifacts, so the amount of natural light entering the galleries should be moderated.

In this south orientation the total south facing glazing is 32.10 m2 (6.1 flr area), this is a big area of un shaded glazing facing south that permitted high amount of unwanted direct rays .

As shown in the analysis grid the daylight is penetrating the museum through side windows. The daylight simulation in figure 4.5 shows an amount of 100-200 lux light penetration into the exhibition areas, through windows as well as an amount of 150-240 lux light penetration into the lobby area, through the main entrance glazing and side windows. It is considered a big amount of direct light penetration that should be moderated by shading devices to block the unwanted direct light. Taking into consideration that the exhibitions are deep rooms having glazing on one wall only, and so, it received very high daylight levels near the windows and very low daylight levels at the rear, this is considered un uniform type of lighting, that can be moderated by using shading devices. As well as electrical lights should be fixed at the rear of the room to create a uniform pattern of light that allows for good vision for the visitors of the museum.

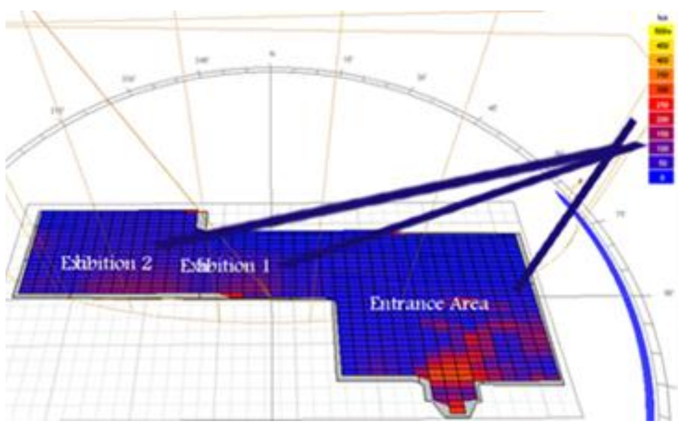


Figure 4.5 day light penetration to entrance and the exhibitions.

This received amount of direct light (100-240 lux) is not satisfactory for the need of the museum; the direct rays are received around the glazing area while it gets darker further from the glazing. south-facing windows allows for unwanted direct rays and its recommended to block these direct rays with a roof overhang or any type of shading device, to minimize the southern exposure on glazing.

Again the light distribution should be equal all over the building and should range 200 - 300 lux (museum requirement), as a consequence there will be an addition of electrical lights to provide the required lighting.

-Electrical light simulation-south

Electrical light sources must be with a wide flood fixture to widely disperse the light without direct aim on the glass (Lingren, 2009).

Incandescent lamps are generally used for ambient as well as accent light. In museums, incandescent optic is the most common light sources. That's why it was used in the lighting study model.

As was seen in the previous natural light grid, there is a need of more lighting so there was an addition of electrical lights to improve the lighting inside the model, usually light and heat comes together, though the amount of heat produced by different lights for the same lighting strength can vary significantly. a number of normal incandescent globes were fixed on the ceiling of the model and the distribution of the electrical lights was changed several times in order to reach the best scenario of light orientation to provides an even amount of lighting throughout the entrance space and exhibitions and this amount of light should range 200-300 lux. For the preservation of the museum objects it is recommended that UV levels are kept below 75 μw/lumen .Halogen and fluorescent lights have an extensive UV module however incandescent lights have virtually no UV (M&G NSW 2011). Therefore a number of normal incandescent globes were fixed all over the model ceiling. The lighting analysis grid shows that the provided electrical lights did provide a uniform pattern of light all over the inner space in the museum. On the other hand, dark areas close to the glazing are shown because daylight penetration was turned off, so the amount of daylight is not displayed on the grid when doing electrical stimulation.

-Overall light simulation (Daylight +Electrical) -south:

This simulation was carried out to calculate the total amount and uniformity of light for both daylight and electrical light. As shown in figure 4.6 the overall light distribution on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

As noticed there are brighter areas in front of the entrance door, this is due to the big glazing of the entrance that allowed for more light penetration which is considered acceptable for entrance spaces. Note that there are darker areas on the middle of the analysis grid; this is due to interior walls of the model.

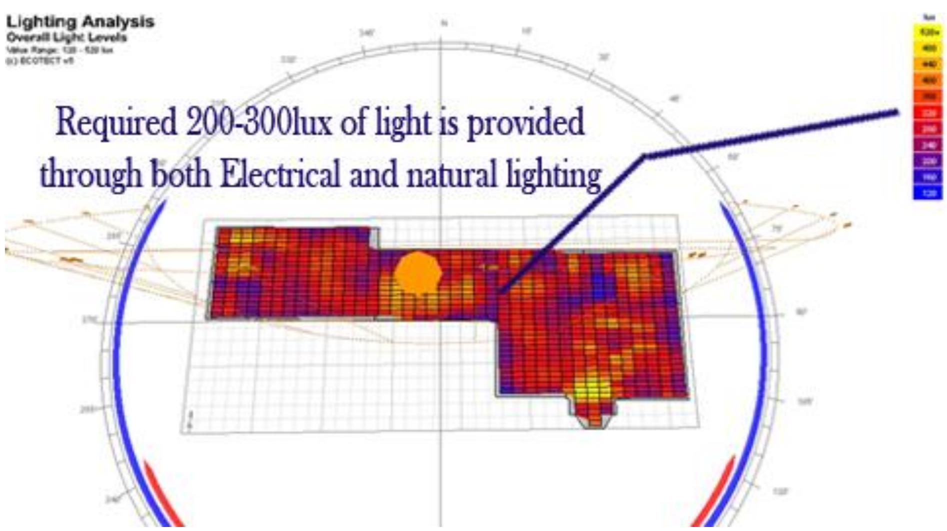


Figure 4.6 the distribution of overall light (electrical + natural) -south

D . The cooling loads simulation -south:

After designing the electrical light amount and distribution, the cooling and heating loads were calculated for this south configuration.

The monthly loads graph in figure 4.7 is calculated and shows the cooling loads for all zones of the model, measured in Watts (W). The blue bars represent when cooling is required, and are plotted in the negative axis of the graph and shows that cooling load reaches 37055W.

The graph colors show the relative overall contribution each zone does to the heating and cooling loads. Every color as shown in figure 4.8 corresponds with the zone color used in the model. And reveals that more cooling loads appear in the lobby area and exhibition, this is due to the electrical lights and the big glazing that allows more heat gain in these zones.

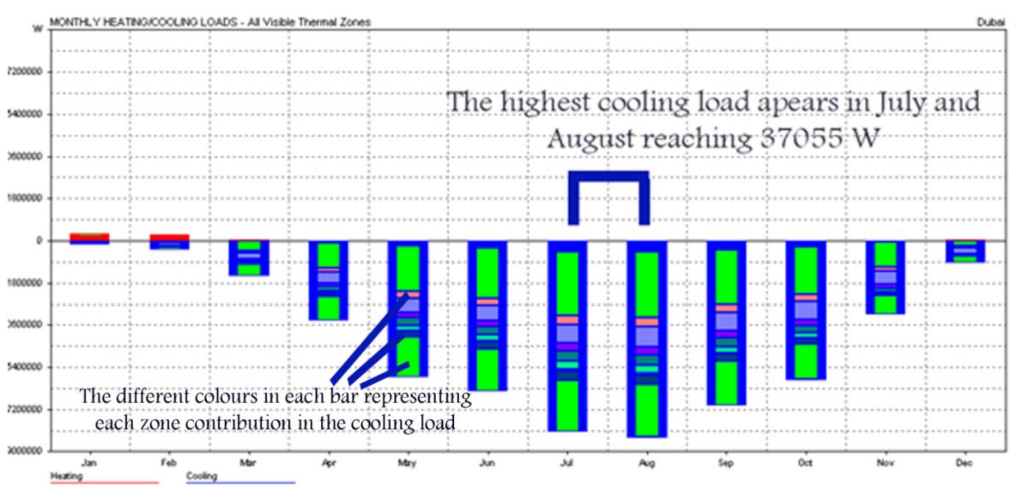


Figure 4.7 cooling loads measured in Watts-Blue bars represent cooling loads

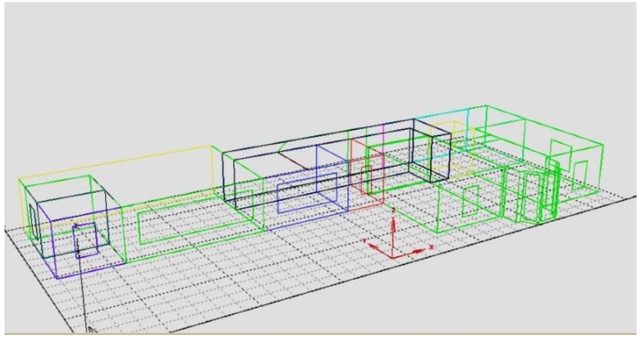


Figure 4.8 zones of the model highlighted in different color

<u>North Configuration:</u>

As shown in Figure 4.9 the 3d model was oriented toward North then simulation was carried out. According to the weather tool data north is considered the best orientation for the selected site.

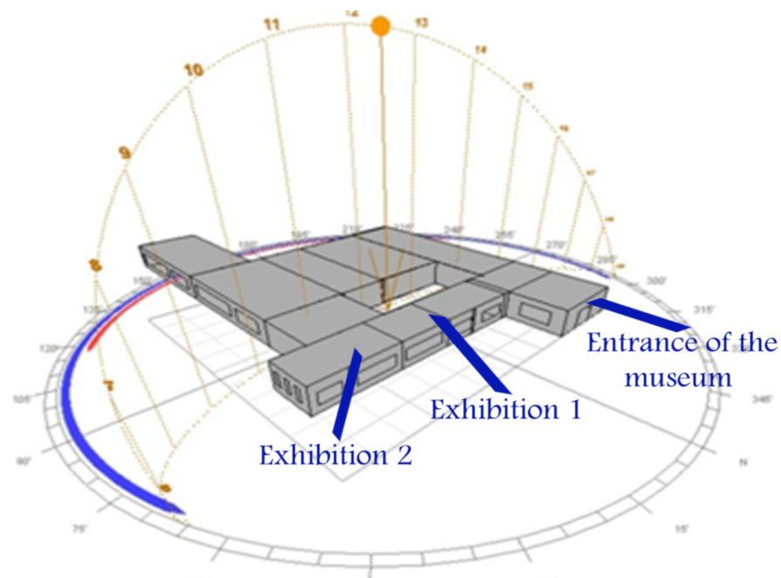


Figure 4.9 Building oriented toward north

A. Calculating the absorbed solar radiation:

The solar radiation which will determine heat gains and losses in buildings is shown below in figure 4.10, the amounts of absorbed solar radiation have decreased and ranged between 10 -40 W/m2. Reaching its highest level which is 50 W/m2 during January, October, November and December these amounts of direct solar radiations absorption were reduced by changing the orientation of the building.

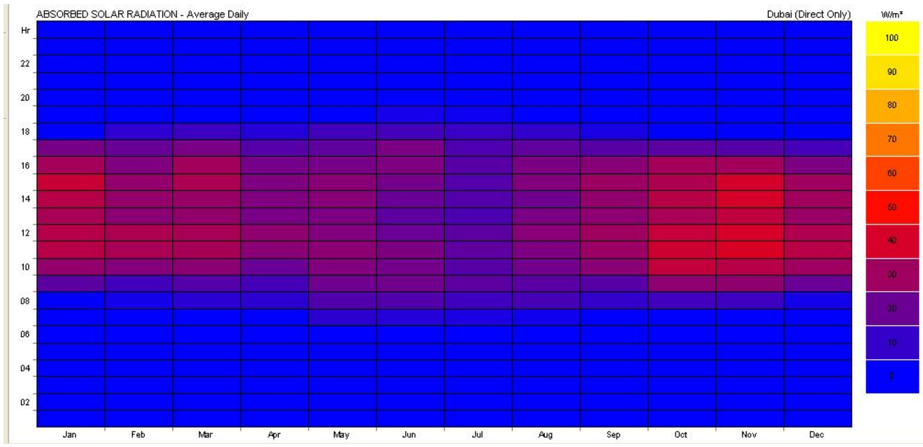


Figure 4.10 Average daily absorbed solar radiation graphs- north

B .Calculating heat gains:

Figure 4.11 shows the amounts of Heat Gain and loss that is happening through the building envelope, as shown in the graph the red line which is representing the heat gain via conduction, in this case when the building is oriented toward north the range of heat gain is 190-280 W, notice the reduction in building heat gain that took place in this case, when orienting the building from south to north, this reduction in heat gain means less usage of cooling loads will be needed in order to cool the building in order and reach to the required temperature of museums which is 24 ±1°C.

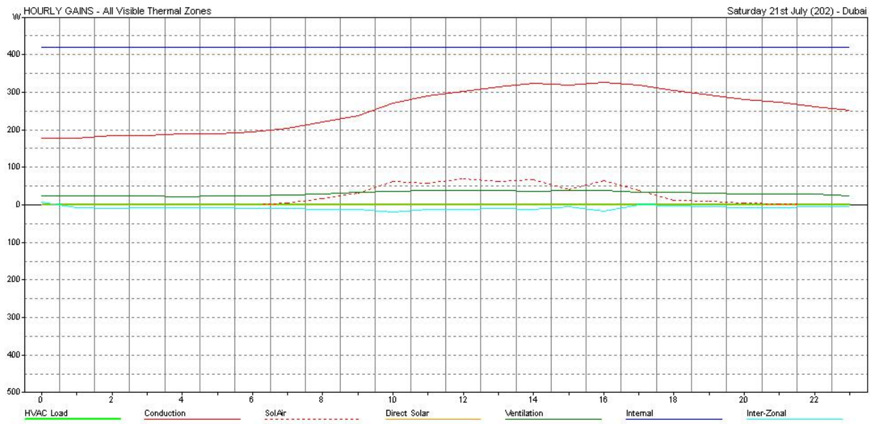


Figure 4.11 Heat Gain Loss graphs- north

C. lighting simulation

Overall Lighting simulation were carried out again after orienting it toward north , this is to address the amount of natural light that is penetrating into the building and then to estimate the amount of artificial lighting that will be needed to fulfill the required lighting demand for museums and exhibitions.

<u>-Daylight simulation</u>

As shown in Figure 4.12 model the daylight is penetrating the museum through side windows and main entrance glazing. The daylight simulation shows an amount of 100-150 lux light penetration into the exhibition areas through windows, as well as an amount of 100-200 lux light penetration into the lobby area though main entrance glazing and side windows.

In this north orientation the daylight is in better uniformity, as seen in the analysis grid, the light has higher levels near the windows and lower levels at the rear, but more uniform than it was on the south orientation, which has a so un uniform type of light. The amount of light received is around 100 to150 lux is received into the exhibition through windows, as well as an The amount of 200 to 300 lux light received into the lobby area , this is not enough as this amount of light is good only for the areas near the glazing and when going deep inside the space it gets darker ,therefore electrical lights should be added more at the rear of the room to create a uniform pattern of light that allows for good vision for the visitors of the museum.

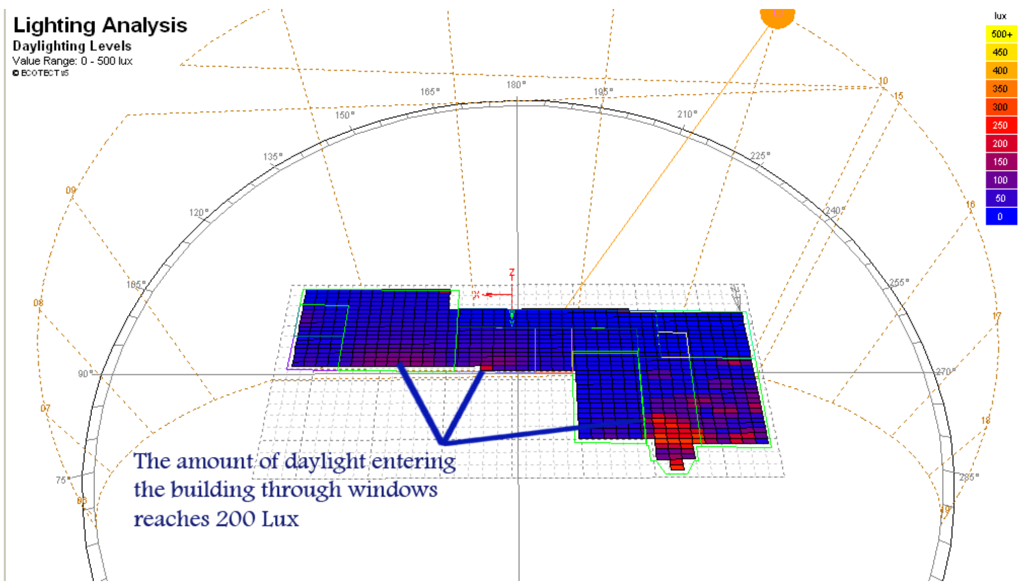


Figure 4.12 the day light penetration to the entrance and exhibitions-north

-Electrical light simulation-north

To improve the lighting inside the model there was an addition of electrical lights, a number of normal incandescent globes were used again on the ceiling of the model as shown in figure 4.13, and figure 4.14 to reach the best distribution of light that is uniform all over the indoor space..

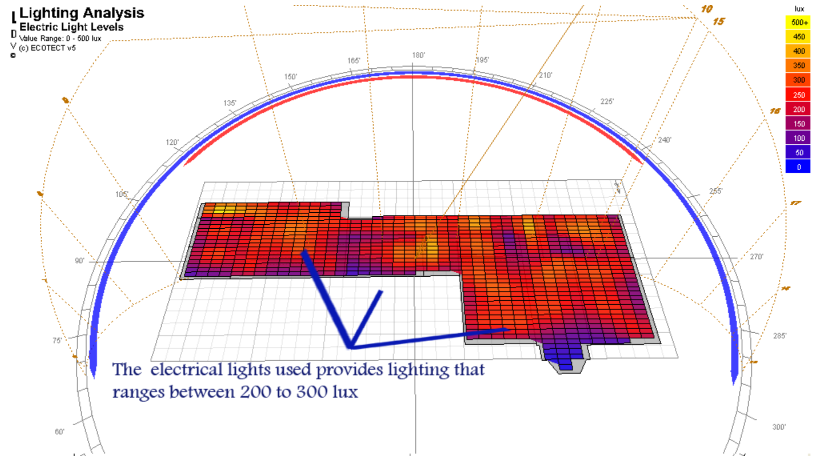


Figure 4.13 the distribution of electrical light excluding natural light

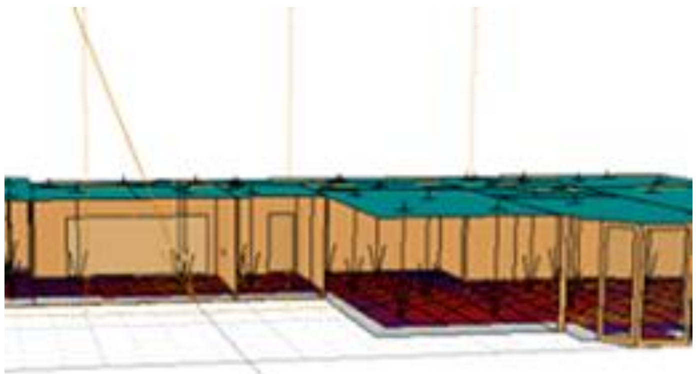


Figure 4.14 position and direction of electrical lights-north

<u>-Overall light simulation (Daylight +Electrical) -north:</u>

This simulation was carried out to calculate the total amount light for both daylight and electrical light. Figure 4.15 shows the overall light distribution that has reached the required amount of light (200-300) lux. As seen the overall lighting created is in good distribution, as seen on the analysis grid, it is uniform and provided through both electrical and natural lighting. And reached the required amount of light needed for good vision in the museum.

Note: dark areas on the analysis grid are due to interior walls of the 3D model.

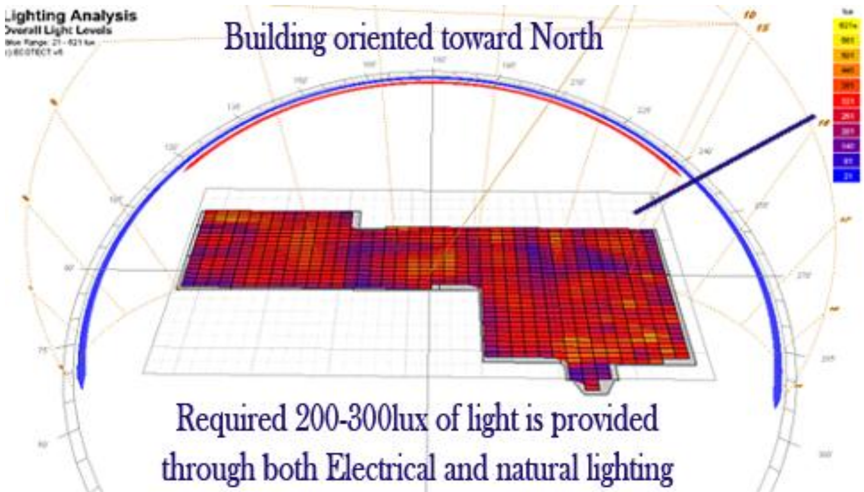


Figure 4.15 the distribution of overall light (electrical + natural)-north

D . The cooling and heating loads simulation -north:

After designing the electrical light distribution, the cooling loads were calculated for this north configuration. The monthly loads graph in figure 4.16 shows the heating and cooling loads for all zones of the model as shown in figure 4.17, measured in Watts (W). The graph shows the relative overall contribution each zone does to the heating and cooling loads. Which reaches 35017 W in July , Note the decrease in the cooling and heating loads from the previous scenario , the cooling and heating loads has slightly decreased from 37055 W (south orientation) to 35017 W (north orientation), this is a 5.49% decrease in the cooling loads of the building, this decrease took place after minimizing of southern exposure, as the most amount of glazing in the model is on the front elevation and by reorienting this big amount of glazing areas toward north the building cooling load decreased

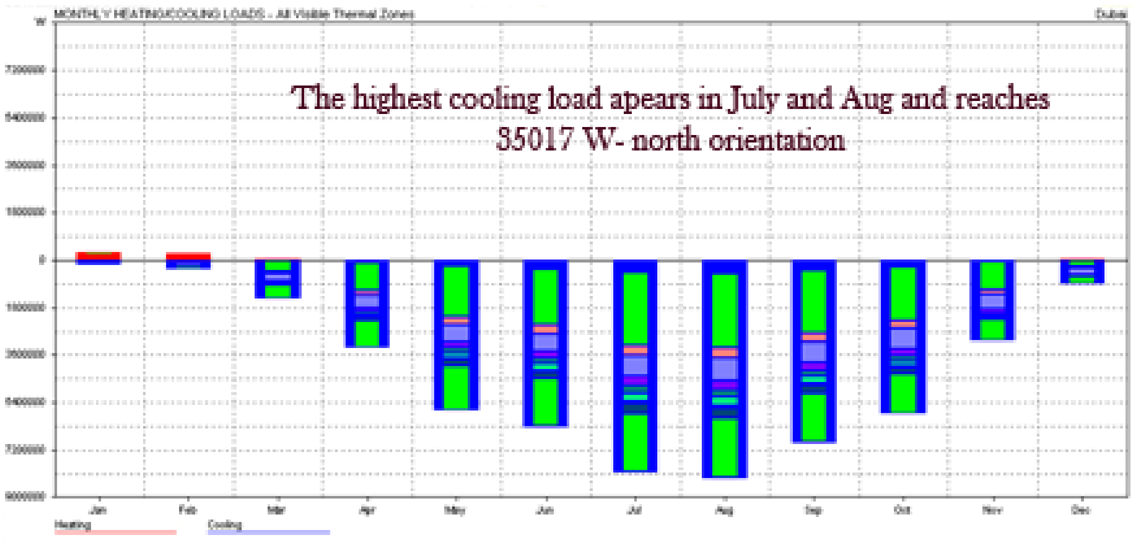


Figure 4.16 cooling loads measured in Watts- north

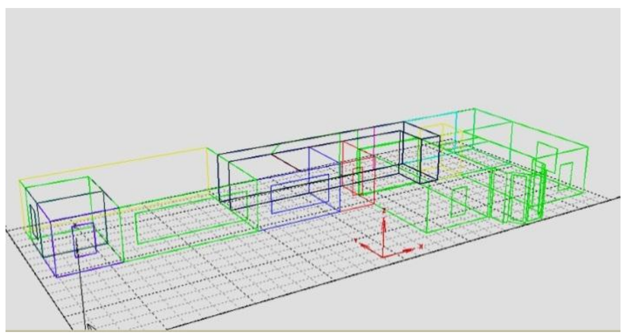


Figure 4.17 zones of the model highlighted in different colors

<u>East configuration</u>

The building 3D model was reoriented toward east and simulation was carried out as follows.

A. Calculating the absorbed solar radiation:

Figure 4.18 shows the amounts of absorbed solar radiation on East orientation. On the east orientation the building amounts of absorbed solar radiation ranges is 20-50 w/m2, which is less than it on south orientations, but more than it on north.

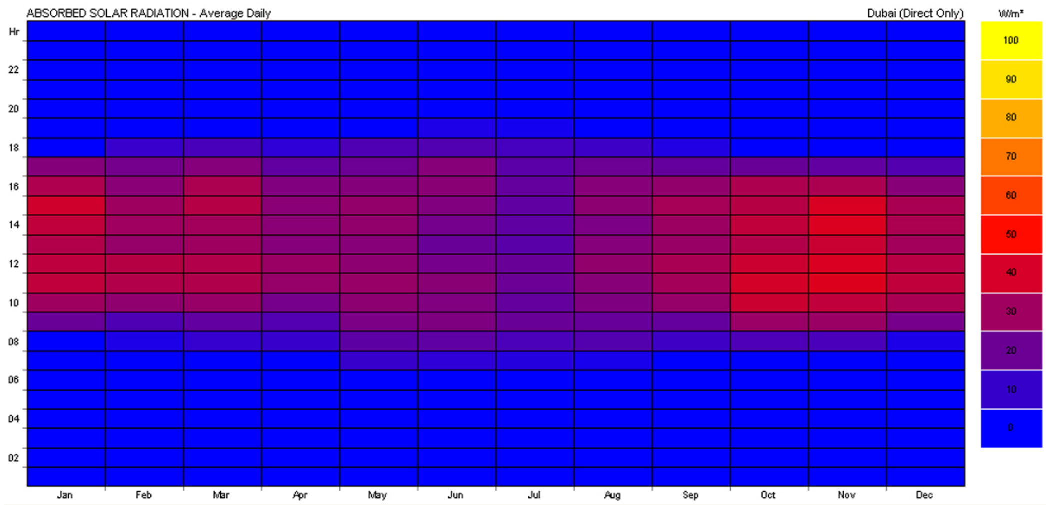


Figure 4.18 absorbed solar radiation -East

B- Calculating Heat gains amount:

Figure 4.19 shows the amounts of Heat Gain and loss that is taking place through the building envelope, as shown in the graph the red line which is representing the heat gain via conduction, in this case when the building is oriented toward east the range of heat gain is 200-350.more reduction in heat gain happen when orienting the building from south to east. This reduction in heat gain means less need of cooling loads that is needed to cool the building in order and reach to the required temperature of museums which is 19 to 24 ±1°C.

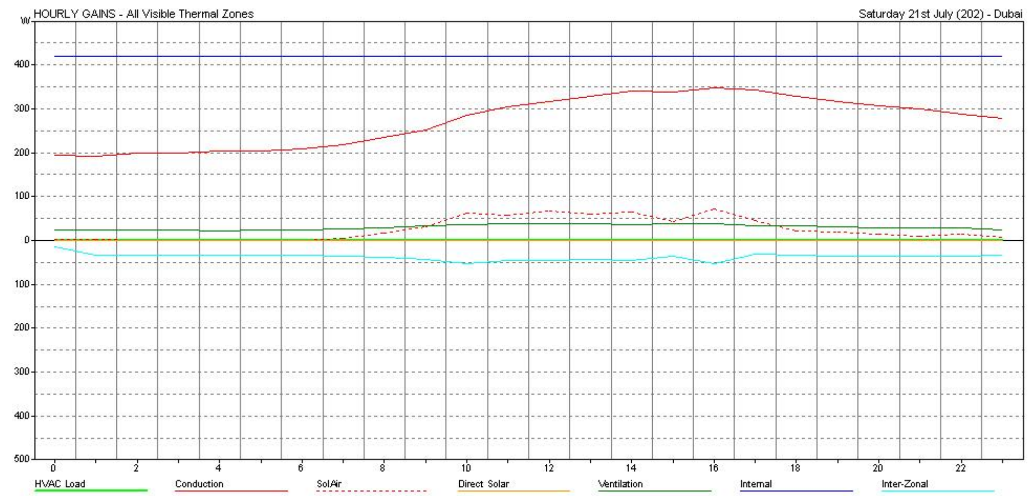


Figure 4.19 Heat Gain Loss graph-East

C. lighting simulation

Overall Lighting simulation were carried out (Both daylight and electrical light) after orienting it toward east, this is to address the amount of natural light that is penetrating into the building and then to estimate the amount of artificial lighting that will be needed to fulfill the required lighting demand for museums and exhibitions when the building is oriented toward east as shown in the following figure 4.20.

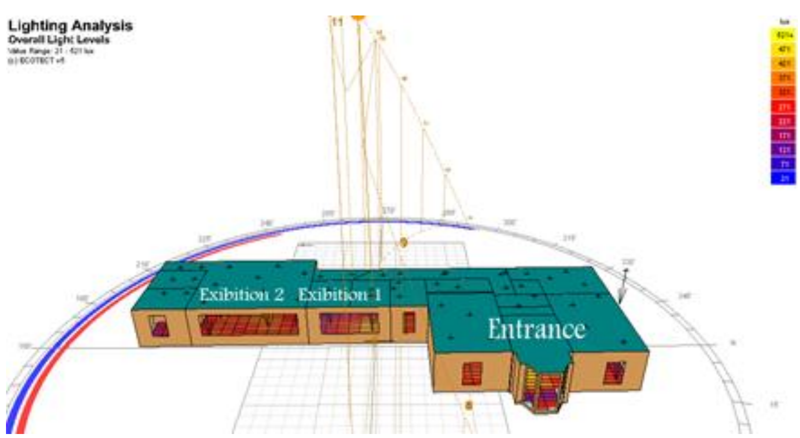


Figure 4.20 shows 3D model oriented toward east

-Daylight simulation - east

Daylight simulation in figure 4.21 shows 100-200 lux light penetration into the exhibition areas through windows, as well as an amount of 150-200 lux, daylight penetration into the lobby area through the main entrance glazing and side windows, According to the ISENA museum lighting standard requirement this amount of direct light is considered high and not appropriate for the museum function, so it should be moderated using a shading device to block the unwanted direct rays.

. As seen in the analysis grid, the light is in high levels near the windows and low levels at the rear, and un uniform.

Electrical lights should be added more at the rear of the room to create a uniform pattern of light that allows for good vision for the visitors of the museum

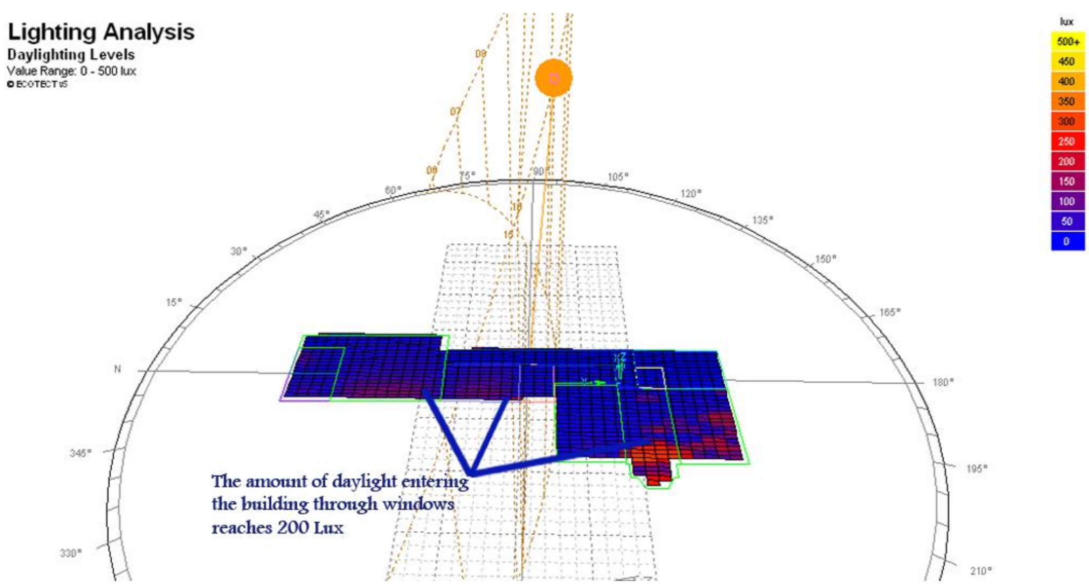


Figure 4.21 shows daylight penetration through glazing – east

-Electrical light simulation - east

An amount of electrical light was fixed on the ceiling of the model in order to provide a lighting range that is acceptable and uniform. Figure 4.22 shows the distribution of electrical lighting that is produced.

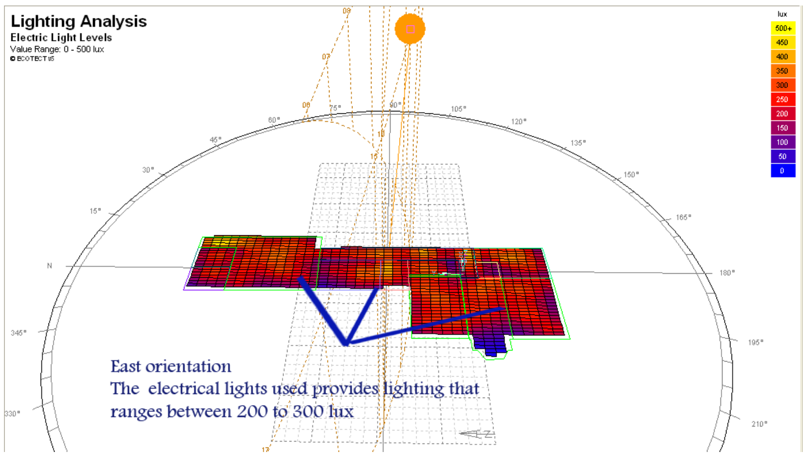


Figure 4.22 shows the distribution of electrical lighting -east

<u>-Overall light simulation (Daylight +Electrical) - east:</u>

This simulation was done to show the total amount light for both daylight and electrical light , as seen in Figure 4.23 using the received amount of natural light and combining it with electrical lighting have created an overall light amount of 200-300 lux, which is the required amount of light for museum functions. Overall lighting on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

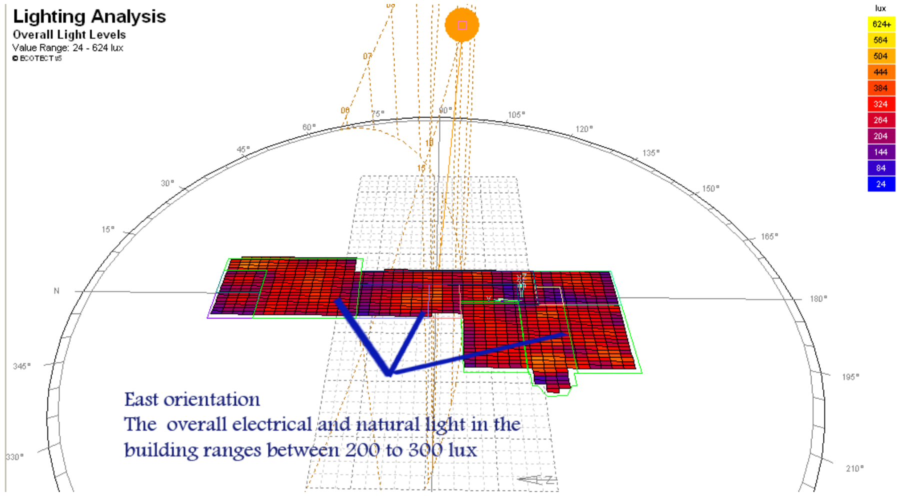


Figure 4.23 the distribution of overall light (electrical + natural) - east orientation

D . The cooling and heating loads simulation- east:

The cooling and heating loads were calculated for the east orientation. The monthly loads graph in figure 4.24 shows cooling loads for all zones of the model, measured in Watts (W).

As seen there is a small decrease in the cooling and heating loads from the previous north scenario, the cooling and heating loads has slightly increased from 35017 W (north orientation) to 35019 W (east orientation), the cooling and heating loads almost remains the same as this is considered a small increase of 0.006 % in the cooling loads of the building.

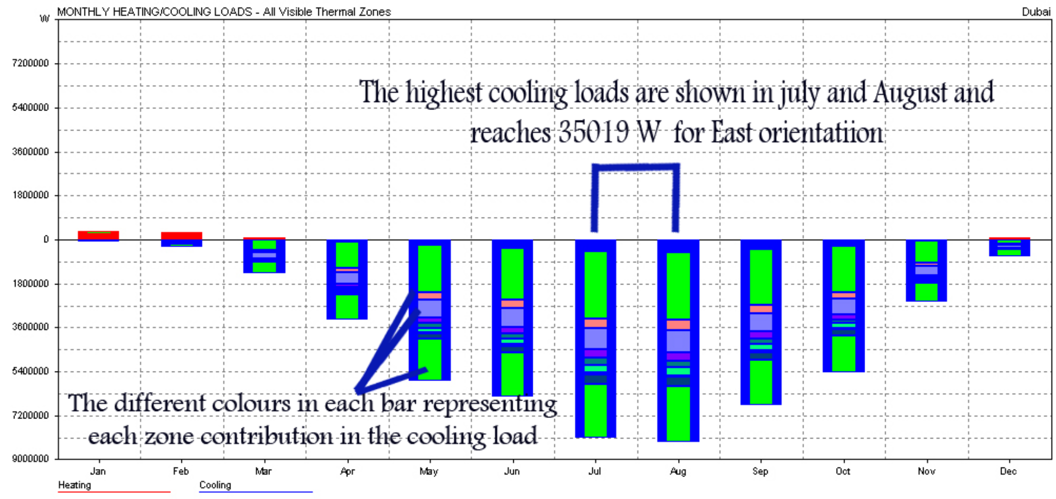


Figure 4.24 the cooling loads measured in Watts - east

<u>West configuration</u>

The 3d model was oriented last of all toward west and simulation was done again to get the needed outputs.

A. Absorbed solar radiation -west :

Shown in figure 4.25, the amount of absorbed solar radiation is 20-50 W/m2, that is more than absorbed solar radiation on north and less than south, but around the same almost the same amount of solar radiation on east orientation.

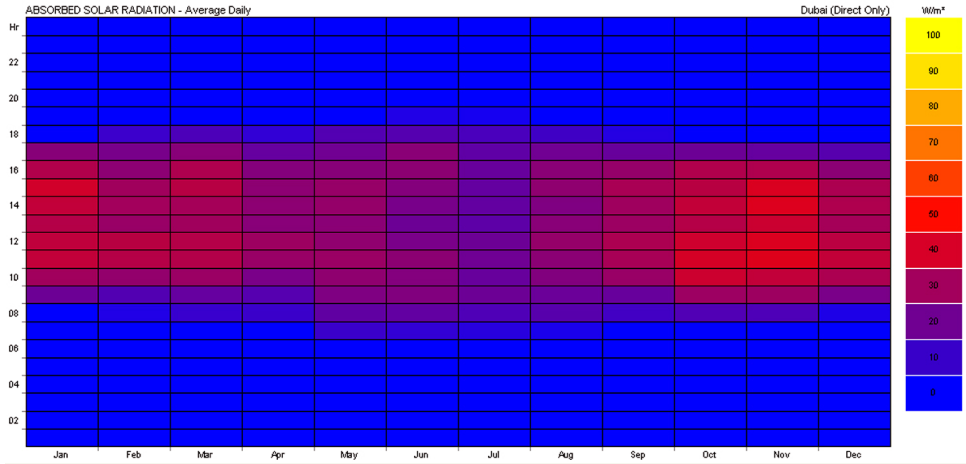


Figure 4.25 average daily absorbed solar radiation -west

B. Calculating Heat gains amount - west:

Figure 4.26 shows the amounts of Heat Gain that is taking place through the building envelope, as shown in the graph the red line which is representing the heat gain via conduction, in this case when the building is oriented toward east the range of heat gain is 200-400 W. According to the amounts of heat gains for each of the four orientations, West orientation is considered the third best orientation after the best orientation which is north and the second best orientation which is east.

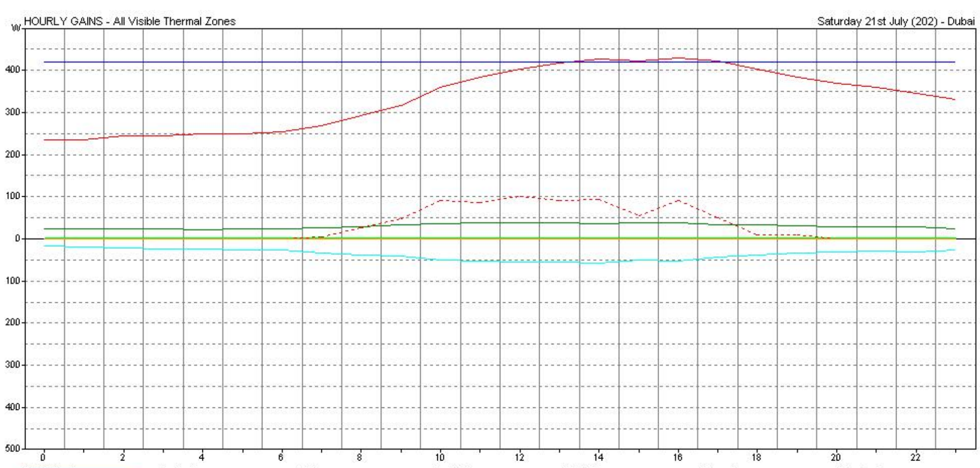


Figure 4.26 Heat Gain Loss graph-West

C. lighting simulation

Overall Lighting simulation were carried out (Both daylight and electrical light) after orienting it toward west figure 4.27, this is to address the amount of natural light that is penetrating into the building on west orientation.

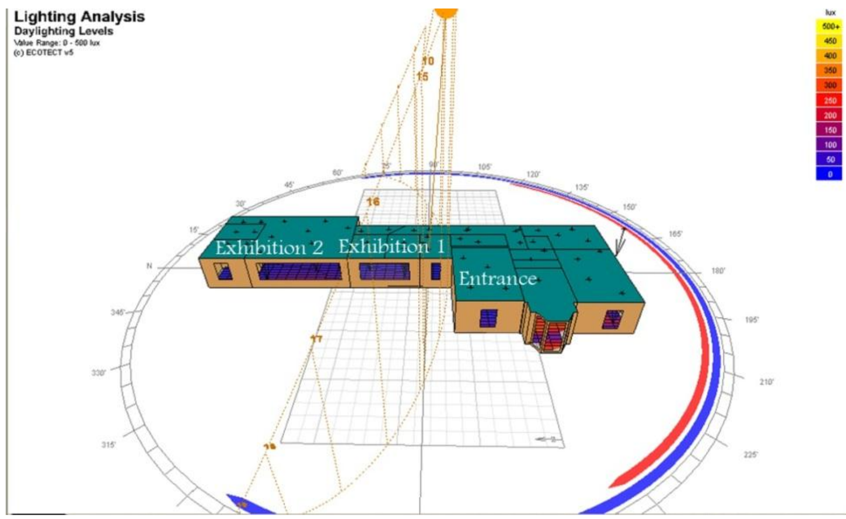


Figure 4.27 model orientated toward west

-Daylight simulation –west:

figure 4.28 shows an amount of 150 lux light penetrated into the exhibition areas through windows, as well as an amount of 200 lux of light penetrated into the lobby area though main entrance glazing and windows According to the ISENA museum lighting standard requirement this amount of direct light is considered high and not appropriate for the museum function, so it should be moderated using a shading device to block the unwanted direct rays.

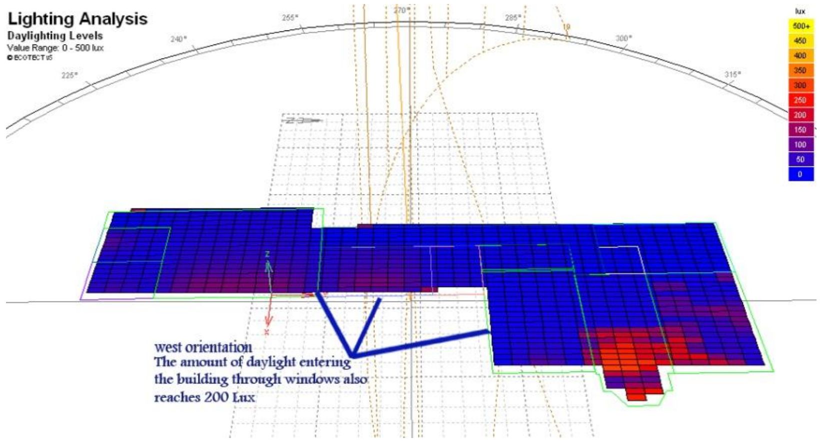


Figure 4.28 shows daylight penetration through glazing - west

-Electrical light simulation -west

As shown on the previous daylight analysis, the amount of day light was received on areas near glazing while it gets darker when going further from the window, this means electrical lights should be added in order to provide an even distribution an enough amount of light.

a number of normal incandescent globes of the previous scenario was fixed on the ceiling of the model to provides an even amount of lighting throughout the entrance space and exhibitions, as mentioned previously the amount of light inside the museum should range 200-300 lux, that is necessary for museum functions, in figure 4.29 shows the distribution of electrical light disregard the natural light.

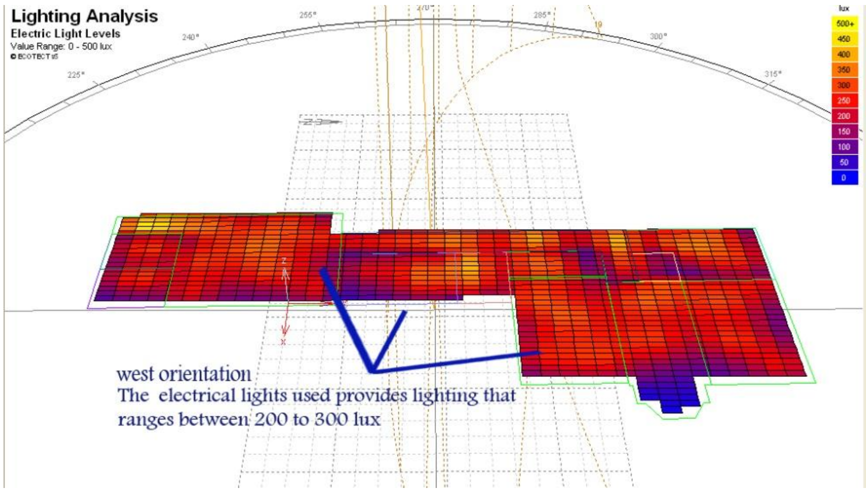


Figure 4.29 the distribution of electrical light excluding natural light

<u>-Overall light simulation (Daylight +Electrical) -west:</u>

This simulation was carried out to calculate the total amount light for both daylight and electrical light on west orientation.as shown in the Overall light grid figure 4.30, the lighting through the museum ranges is satisfactory for the museum need, Overall lighting on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

There are dark areas shown in figure 4.31 on the grid, this is due to some interior partitions in the model.

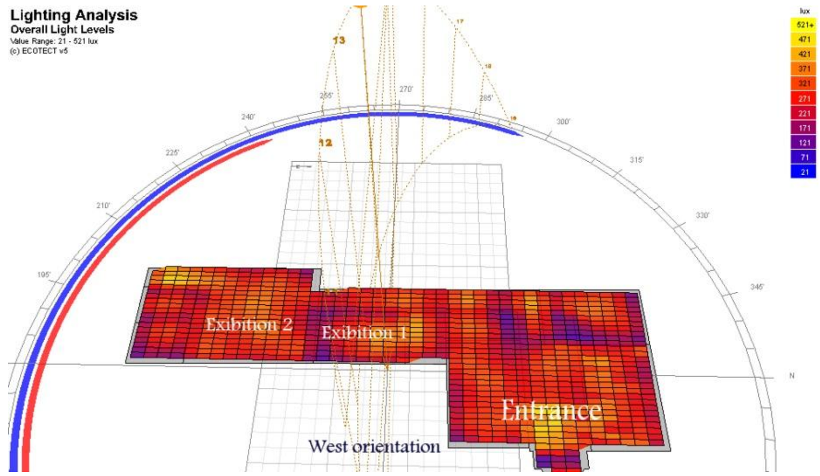


Figure 4.30 the distribution of overall light (electrical + natural) -west

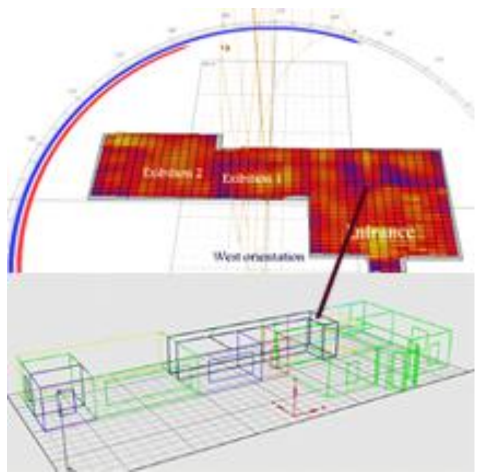


Figure 4.31 3D showing the interior partitions of the model -west

D .The cooling loads simulation:

The cooling and heating loads were calculated for this west orientation. The blue bars which represent when cooling is required are plotted in the negative axis of the graph and states that the max amount of cooling loads appears July the hottest month and reaches 35060 figure 4.32, so west comes in the second worse orientation after south that has a heating load of 37055 W.

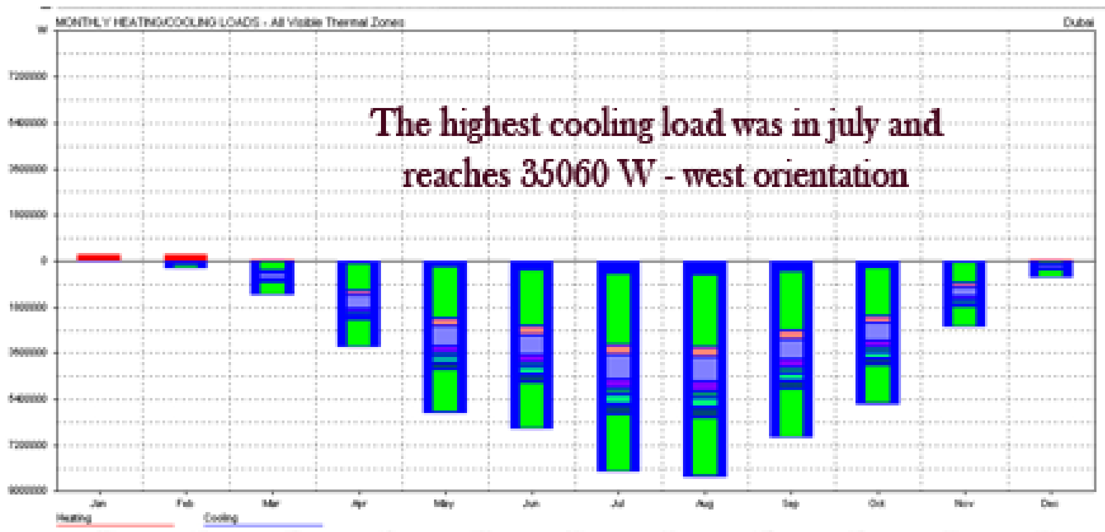


Figure 4.32 the cooling loads simulation –west

<u>Four configurations result (south-north-east-west):</u>

-Solar radiation conclusion:

As shown in table 4.1, the solar radiation, when building was oriented toward South simulations generated an amount of absorbed solar radiation equals to 65 W/m2, then when the building was re-oriented toward north the best orientation (according to Dubai weather file), simulations generated an amount of absorbed solar radiation equals to 32.5 W/m2, this is a 35.0% reduction in absorbed solar radiation, reflected in a chart in figure 4.45.

Table 4.1 Absorbed Solar Radiation for four Orientations in four months (Dec-Jan)

Absorbed solar radiation amount				
	2nd – North Configuration	**1st – South Configuration**	**3rd –East Configuration**	**4rth-West Configuration**
January	30 W/m2	65 W/m2	35 W/m2	40 W/m2
October	35 W/m2	65 W/m2	40 W/m2	45 W/m2
November	35 W/m2	65 W/m2	40 W/m2	45 W/m2
December	30 W/m2	65 W/m2	35 W/m2	40 W/m2
Average	32.5 W/m2	65 W/m2	37.5 W/m2	42.5 W/m2

() Best orientation () worst orientation

Figure 4.33 shows the amounts of absorbed solar radiation in each orientation during the months Jan, Oct, Nov and Dec. a 35.0% reduction in absorbed solar radiation took place when changing the orientation of the building from the worst(south) to best orientation (north).

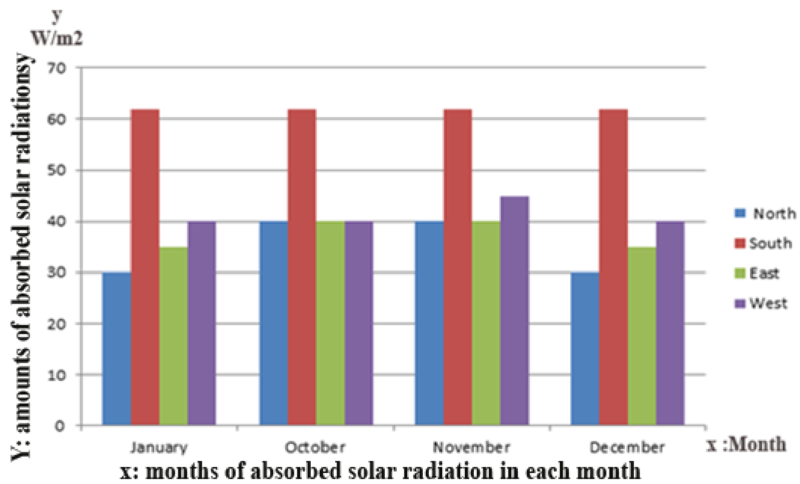


Figure 4.33 Chart showing the amount of absorbed solar radiation in each orientation during the months Jan, Oct, Nov and Dec.

-Heat gain conclusions:

in the heat gain simulations, when building was oriented toward South simulations generated an amount of heat gain average equals to 320 W, then when the building was re-oriented toward north the best orientation (according to Dubai weather file), simulations generated an amount of heat gain equals to 235 W, this is a 28.1 % reduction in Heat gain. As shown below table 4.2 and figure 4.34 showing the Heat gain via conduction in each of the four orientations. It summarizes the reduction in heat gain that took place in each of the four orientations

Table 4.2 Heat gain range in each of the four orientations.

Heat gain via conduction in each of the four orientation				
	2nd – North Configuration	**1st – South Configuration**	**3rd –East Configuration**	**4rth-West Configuration**
Heat gain range- Via-conduction	190-280 W	240 -500 W	200-350	240-400 W

() Best orientation () worst orientation

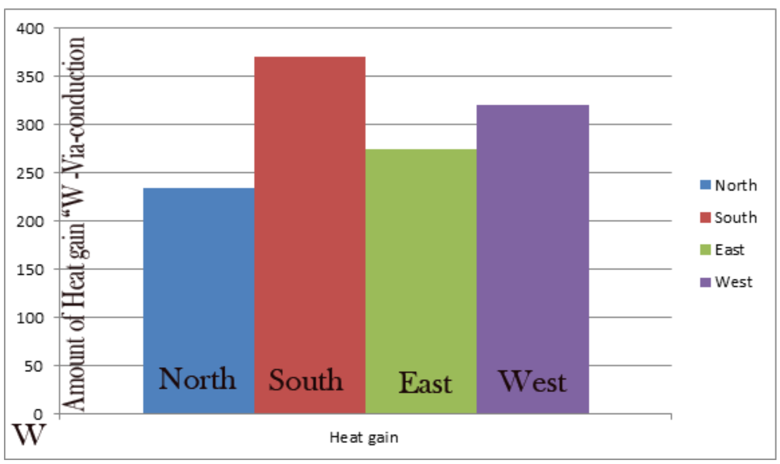


Figure 4.34 Chart showing the amount of heat in each of the four orientations

-Lighting conclusions:

In lighting simulations, different amount of daylight was received in the building in every orientation. The highest amount of direct light was received when the building was oriented toward south, the amount of direct light on south reached 240 lux on areas near the windows and the entrance glazing this is a big amount of sun rays have a negative impact on the museum displays, and has to be moderated through using a shading device to block the excess amount of sunrays that is received.

Later on, on other east and west orientations, the lighting simulation showed that daylight received on the north orientation was less, the maximum amount of light was 200 lux on areas near the windows and the entrance glazing which is still a big amount of direct light penetrated into the exhibitions.

On the other hand, the amount of light on north orientations reached 150 lux which is, which is considered the best scenario as it has less direct sun light penetration, so north orientation is considered the best orientation as the sun rays received was less on this orientation, bellow in table 4.4 representing the amount of received daylight in each of the four Orientations.

Table 4.4 the received daylight amount in each of the four Orientations.

Day light in each of the four orientations				
	1st – South Configuration	**2nd – North Configuration**	**3rd –East Configuration**	**4rth-West Configuration**
Day light	150-240 lux	100-200 lux	150-200 lux	150-200 lux
Average daylight	195 lux	150 lux	175 lux	175 lux

() Best orientation () worst orientation

-Cooling loads conclusions:

In cooling loads simulations, the highest amount of cooling loads appeared when building was oriented toward south, cooling load reached 37055 W, and this is because of the solar gain received into the building through the southern windows. Afterword when the building was reoriented to north the cooling loads decreased by 5.3%, this decrease happened mainly because of minimizing the southern glazing exposure. On the other hand the other two orientations east and west, the cooling loads were almost the same. Bellow table 4.5 and figure 4.35 showing the cooling loads in each of the four orientations. Note the reduction in heat gain that took place on the north orientation.

Table 4.5cooling loads for each of the four Orientations.

Cooling load in each of the four orientations				
	1st – South Configuration	**2nd – North Configuration**	**3rd –East Configuration**	**4rth-West Configuration**
Cooling load	37055 W	35017 W	35019 W	35060W

() Best orientation () worst orientation

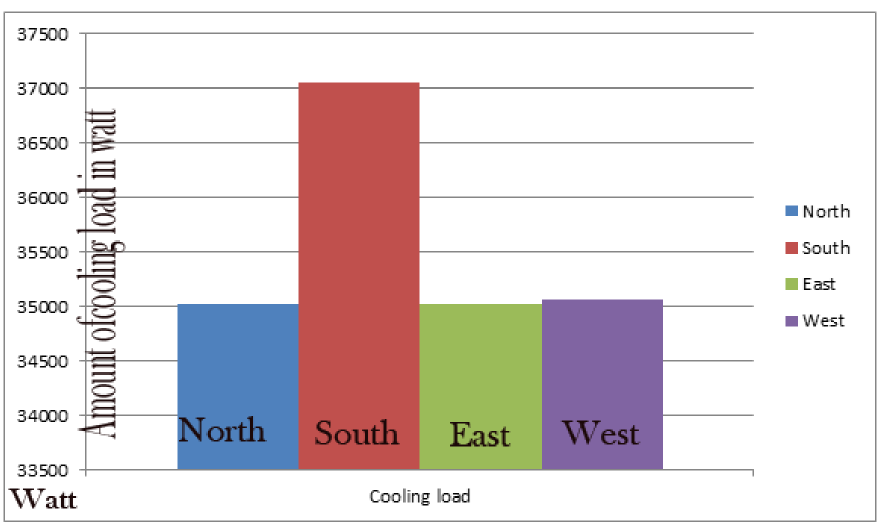


Figure 4.35 chart showing the cooling loads in each of the four Orientations.

4.2 Thermal Insulation:

Building's envelope constantly relates with the outside environment, and its performance has a great impact on the indoor environment and comfort conditions. Wall and roof insulation is recommended in hot humid climates like the climate if the UAE, this is because the sun is high so a thermal insulated material with a U-value of approximate 0.5 W/m2K can effectively minimize heat gains in building. Using materials with high resistance such as glass fiber, expanded clay, mineral wool and cellulose can reduce heat gains and losses indoor and minimize daily climate fluctuations (BAKER and LUGANO.1999).

As known The U-value or U-factor is the overall heat transfer coefficient , it has great effect on the rate of heat transfer through the building envelope. Thus using materials with greater U-value have sufficient effect on the overall heat transfer, in this study deferent materials with unlike thermal insulation were used; using different material for walls and roof with different U-value and then Hourly Temperatures, Heat gain amounts as well as cooling loads were calculated

Simulations are done for four different scenarios then the results of the four configurations are compared, the simulations are done as follows:

- First configuration: (*Walls: Poured concrete U- 0.99, roof: reverse brick veneer U-0.68)*
- Second configuration :(*Walls:* block *U- 0.39, roof: Clay roof U- 0.36*
- Third configuration: *Walls: (brick U- 0.25, roof: Wood – Roof U-0.21)*

- forth configuration: *Walls: (Fiberglass Insulation U- 0.18, roof:* Fiberglass *insulation 0.027)*
- Four configurations results.

The simulation shows three main outputs for one day in summer 21 July. as follows:

A. The Hourly temperatures.
B. The heat gain.
C. The cooling and heating loads simulation

In these three different configurations of wall and roof insulation, the lighting simulation is not required because insulation of walls and roof has no important effect on the overall lighting inside the building; insulation is expected to have an impact on the heat gain and cooling loads of the building, that's why lighting will not be tested in this configuration. Note that the only building feature that will be changed and tested is the insulation while all other base case features of the building will remain the same in all of the four different insulation configurations. The building orientation is kept toward the south as it's the base case. Glazing of the model has a total area of to 42.5 m2 and south facing windows have a total area of 32.1 m2 and single glazing was used for windows of the model.

First configuration (Base case):

(Wall =U- 0.99, roof =U-0.68)

In the base case scenario, *Poured concrete U- 0.99* is used for all the walls of the model, and *reverse brick veneer U-0.68* for the roof. For buildings with a large amount of roof area relative to floor area, such as the model museum facility, reducing heat gain through the roof can be an important consideration, that’s why the material of the roof was also changed. The simulation is done, on the hottest day of the year which is 21 first of July.

A. Calculating Hourly temperatures :

 Outer temperature records 35-42 dig C before 8 a.m., After 8 a.m. the temperature rises up and has a peak at 2p.m. (41 deg. C). Temperature increases by 6:30 a.m. and maintains over 36 dig Wind speeds during the day are represented by the green dotted line, and ranges between 0.2 k -0.5 k (w/m2). (Figure 4.113 appendix)

 The most important factor is zone temperatures, zones temperature are high and ranges between 46-47 c, this high temperature is due to the higher U-value material that is been used in this configuration .

B. Calculating Amount of heat gains:

Heat gain via conduction ranges in this case between *200W and 400W.* (Figure 4.114 appendix)

C. Calculating the cooling and heating loads

The monthly loads graph as shown in figure 4.36 is calculated after setting the software model to be fully air conditioned, the graph shows the cooling loads for all zones of the model , measured in Watts (W). The blue bars represent when cooling is required, and are plotted in the negative axis of the graph. The graph a relative overall contribution each zone gave to the heating and cooling loads. The colors correspond with the zone color used in the model. It reveals that more cooling loads appear in the lobby area and exhibition (green color) reaching 37055 W, this load is immense due to the low insulated walls and roof.

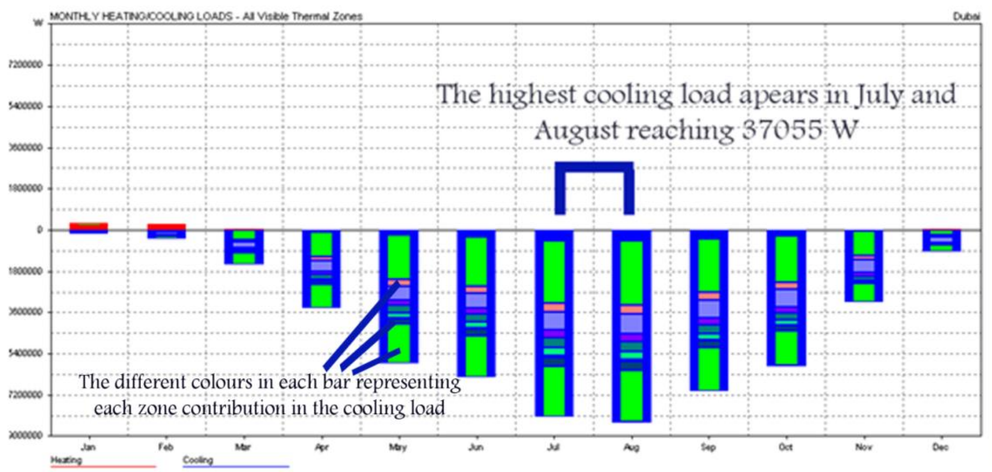


Figure 4.36 the cooling and heating loads measured in Watts - low insulating

<u>Second configuration:</u>

(Wall = U- 0.39, roof = U- 0.36)

In this scenario building material was changed to Wall masonry block *U- 0.39* for all walls of the model, and Clay roof U- 0.36, and then simulation were done again in the hottest day in the year 21 first of July.

A. Calculating Hourly temperatures :

The temperature rises up and has a peak at 2p.m (42 deg. C). Wind speeds during the day are represented by the green dotted line, and ranges between 0.2 k -0.5 k (w/m2).

As represented by the green line, a noticeable reduction happen to internal temperatures which ranges in this case ranges between 40- 45 c, by changing model materials to materials with less u-value gave a noticeable reduction on internal temperatures of the inside spaces..(Figure 4.115 in appendix)

B. Calculating the amount of heat gains:

The heat gain amounts in the first base case scenario, the red line representing the heat gain via conduction ranges in this scenario between *220 and 350 W*. (figure 4.116 in appendix)

C .Calculating the cooling and heating loads

The monthly loads graph as shown in figure 4.37 was calculated, the graph shows the heating and cooling loads for all zones of the model, measured in Watts (W), and are plotted. The graph a relative overall contribution each zone gave to the cooling loads. The simulation shows that cooling loads reaches 24186 W, notes the decrease in the cooling load from 37055W in the last scenario (low insulation) to 24186 W, this is a 34.72 % decrease in cooling load of the building, this sufficient decrease it took place only by changing the walls and roof material to better insulated materials.

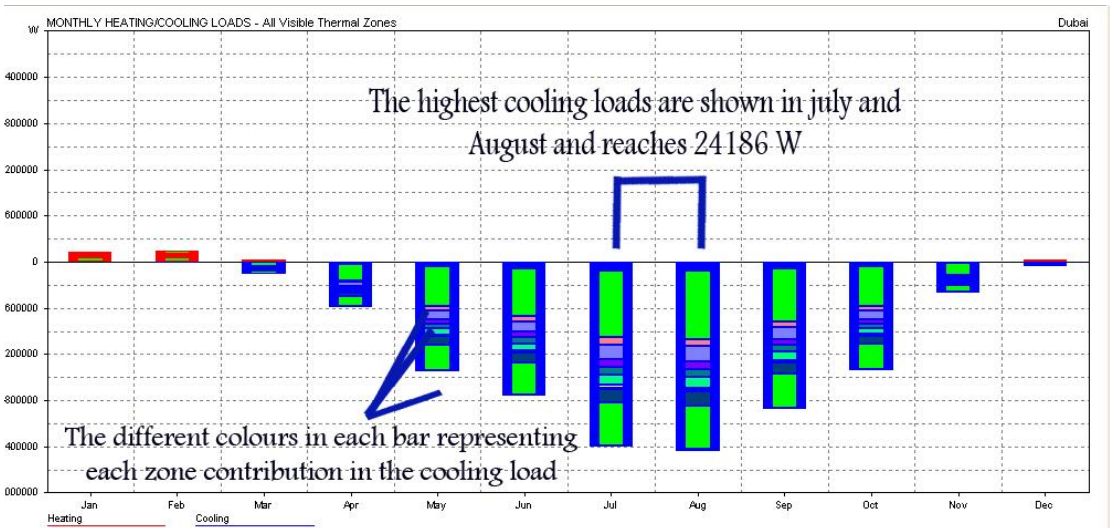


Figure 4.37 the cooling and heating loads measured in Watts– medium insulation

<u>Third configuration:</u>

(Wall =U- 0.25, roof = 0.21)

In this case building material was changed to masonry *brick U- 0.25* for walls of the model, and *Wood – Roof U-0.21*.

A. Calculating Hourly temperatures :

The dashed blue line which is the outside temperature. records have a peak of 41 deg. C at 2p.m. Wind speeds during the day are represented by the green dotted line, and ranges between 0.2 k -0.5 k (w/m2). zone temperatures which are shown in dark green line in the graph, ranges between *35-42 c*, this decrease in inside temperatures is due to using materials with lower U-value . (Figure 4.117 in appendix)

B. Calculating Amount of heat gains:

The red line representing the heat gain via conduction ranges in this scenario between *150 W and 320 W* (figure 4.118 in appendix)

C . Calculating the cooling and heating loads

Figure 4.38 Shows the amount of cooling load for this configuration, one can notice the sufficient decrease in the cooling load of the building to become 18397 W in this scenario, this decrease in cooling load from 37055W (base case) to 18397 W means 50.35% reduction in cooling loads which means half of the cooling load of the base case is removed.

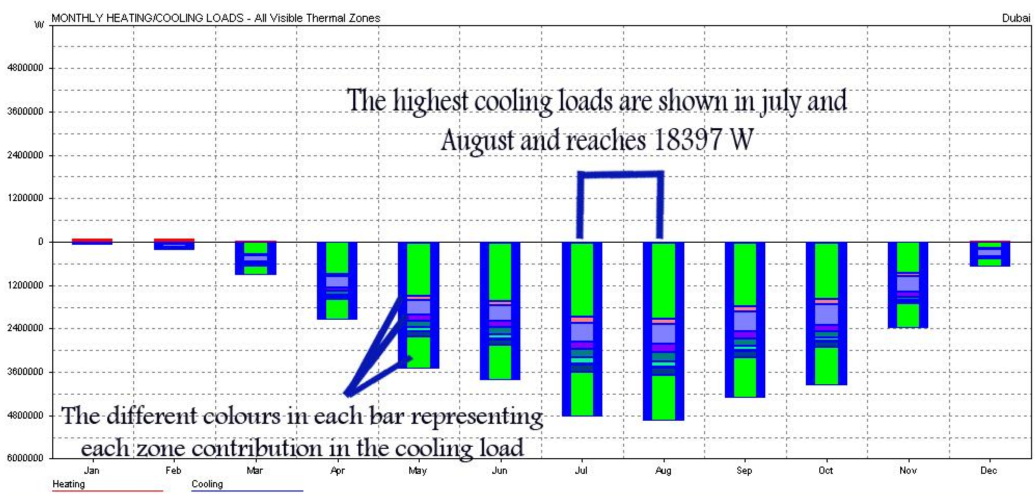


Figure 4.38 heating and cooling loads – high insulation

<u>Forth configuration:</u>

(Wall = U- 0.18, roof = 0.027)

In this case building material was changed to *Concrete Deck – Fiberglass Insulation U-0.18* for all walls of the model, and Wood –Fiberglass *insulation 0.027*, and then simulation were don on the hottest day in the year 21 first of July .

A. Calculating Hourly temperatures:

Outside temperature range is 35- 41 c. Wind speed is represented by the green dotted line, and ranges between 0.2 k -0.5 k (w/m2).

zone temperatures which are shown in dark green line in the graph, ranges between *36-42 c*, this great decrease in temperature is due to using materials with very low U-value . (Figure 4.119 in appendix)

B. Calculating heat gains:

The heat gain amounts in the first base case scenario, the red line representing the heat gain via conduction ranges in this scenario between *180 and 330 W*. (figure 4.120 in appendix)

According to the simulation the amounts of heat gain decreased from the first scenario to the forth scenario where in each scenario the building material was changed to a higher insulated material.

When the building material has less thermal insulation the heat gain that took place through the building was higher, and when changing the building material to other material with higher thermal insulation the heat gain amount was reduced.

C .Calculating the cooling and heating loads

Figure 4.39 Shows the amount of cooling load for this configuration , notice the decrease in the cooling load of the building that become 16903W in this scenario, this decrease in cooling load of 37055W (base case) to 16903W means 54.38 % decrease in the cooling load which means more than half of the cooling load of the base case is removed .

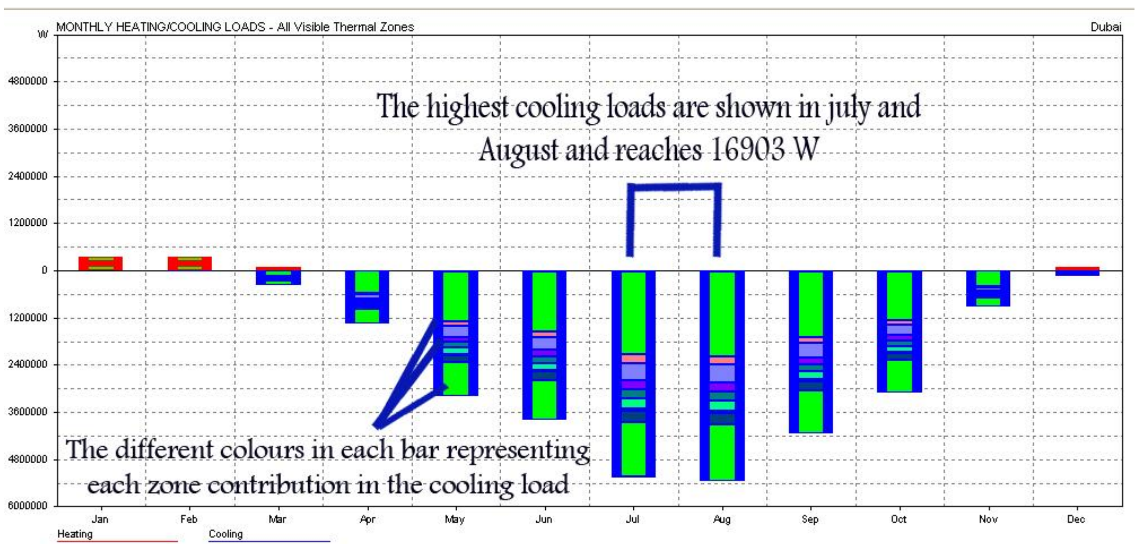


Figure 4.39 cooling load graph – higher insulation

<u>Four configurations results:</u>

Building's envelope constantly relates with the outside environment, and its performance has a great impact on the indoor environment and comfort conditions. The simulations results show a great reduction in room temperatures heat gain as well as cooling load. Table 4.6 shows the amounts of Heat gain, room temperatures and cooling load in the four tested configurations, notice the reduction that took place in every configuration.

Table 4.6 the four configurations amounts of room temperatures heat gain, and cooling load.

	1st Configuration Base case	2nd Configuration	3rd Configuration	4th Configuration
Walls	***Poured concrete U- 0.99***	***Wall masonry block U- 0.39***	***masonry brick U- 0.25***	***Concrete Deck – Fiberglass Insulation U- 0.18***
roof	***reverse brick veneer U- 0.68***	***Clay roof U- 0.36***	***Wood - Roof 0.21***	***Wood –Fiberglass insulation 0.027***
Room Temperatures Range	*46-47 c*	*40- 45 c*	*35-42 c*	*36-40 c*
Heat gain range -via conduction	*200-400 W*	*220-350 W*	*150-320 W*	*180-330 W*
Cooling load	*37055 W*	24186*W*	18397 *W*	*16903 W*

() Best () worst

-Zone temperatures conclusions:

four different thermal insulation building materials were tested , the worse scenario took place when materials that has high U-value was used in the first configuration ,where Poured concrete U- 0.99 was used for walls and reverse brick veneer U- 0.68 was used for roof , resulting in room temperatures that is ranging between 46-47 c means an average of 43.5 c and heat gain ranging 240-440 W means an average of 340 W. on the other the best scenario took place when building materials were changed to a low U-value materials in the fourth configuration where Concrete Deck –Fiberglass Insulation U-0.18 was used for walls and Wood –Fiberglass Insulation U -0.027 was used for the roof resulting in room temperatures that is ranging between 36-40 c means an average of 38 c and heat gain 180-330 W means an average of 220 W. figure 4.40 is a charts showing the reduction in zone temperatures that took place in the four insulation configurations.

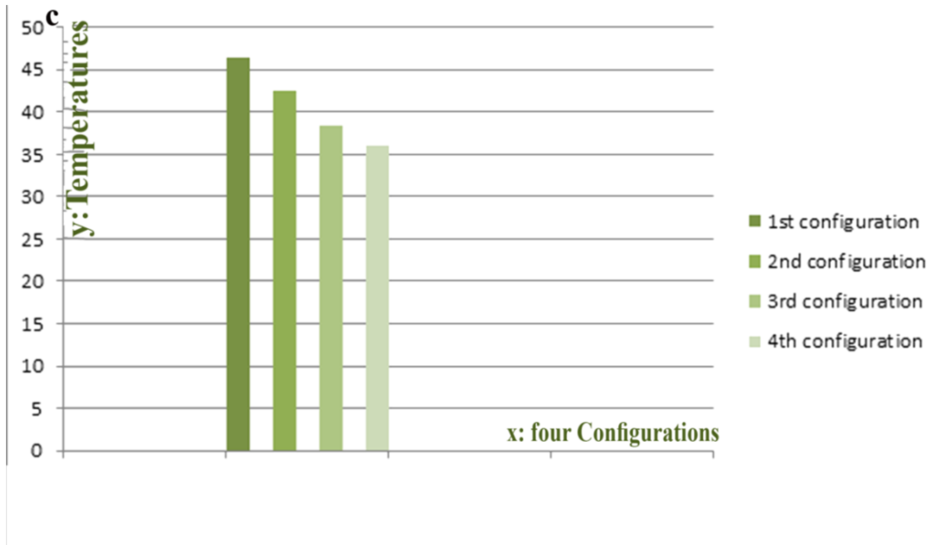


Figure 4.40 Chart showing the reduction in zone temperatures that took place in the four insulation configurations.

-Heat gain conclusions:

The heat gain amount was reduced every time when the insulation was greater, in the first scenario when a low insulated material was used , Poured concrete U- 0.99 for walls, and reverse brick veneer U- 0.68 for roof , heat gain ranged 200-400 W, afterword when the insulation for walls and roof was getting greater , the heat gain went down, until the last configuration when a high insulated material was used , Concrete Deck –Fiberglass Insulation U- 0.18 for walls, and reverse Wood –Fiberglass insulation 0.027 for roof , heat gain went down and ranged 180-330 W, this decrease proofs the strong relation between the building insulation and its heat gain.

Cooling loads conclusions:

the highest amount of cooling loads appeared when building material has very low insulation (bas case), cooling load reached 37055 W. Afterword when the building material was changed to a good insulated material for both walls and roofs, the cooling loads decreased by 34.72 % , then in the third scenario the materials of walls and roof were changed to a higher insulated materials and this change resulted in a reduction in the cooling load that reached 50.35% . At last, in the fourth scenario the materials of walls and roof were also changed to a very high insulated materials which reflected a great reduction in the cooling load by 54.38 %, this decrease proofs that using materials with high resistance such as glass fiber or any other high resistance material can reduce heat gains into the indoor environment and reduce daily climate fluctuations

As shown in the following figure 4.41 The reduction in cooling load that took place from the first to the last configurations was noticeable , cooling load went down sufficiently when higher insulated materials was used for walls and roof.

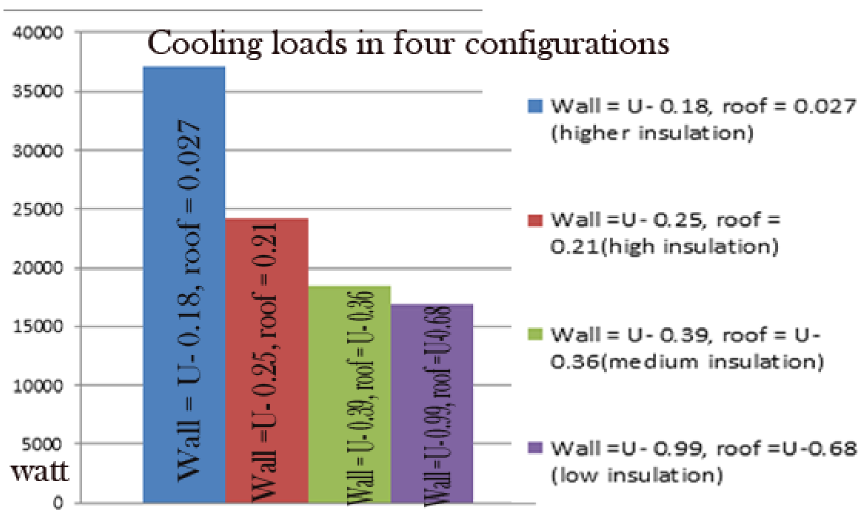


Figure 4.41 Chart showing the reduction in cooling load that took place in the four insulation configurations.

4.3 Thermal mass

In museum design, the most important fact that should be taken into consideration is to provide climatic stability, this climatic stability is important because museum collections acclimatize to their immediate surrounding environment as long as it’s stable.

Thermal mass and materials used to store heat, is considered integral part of passive solar design. Materials like concrete, masonry and wallboards, absorb heat during sunny days and gradually release it as temperatures drop. This can reduces the effects of outside air temperatures changes and controls indoor temperatures. Although even overcast skies provide solar heating, long periods of little sunshine often require a holdup heat source.

In this simulation, thickness of the base case model (2.5 inches) was changed to 4 different thicknesses 4 inches, 6 inches, 8 inches and 10 inches, then simulation was done for heat gains and cooling load, using materials with different thicknesses for wall in every configuration, this is to address the amount of impact that wall thickness can have on the thermal performance of the building.

Simulations were for four different scenarios, Heat Gain and cooling loads were calculated for every scenario in the hottest day of the year 21st of July. The simulations were done as follows:

- First configuration: material thickness = 4 inch (102 mm).
- Second configuration: material thickness = 6 inch.
- Third configuration: material thickness = 8 inch.
- Forth configuration: material thickness = 10 inch.
- Configurations results

First configuration :(4 inch thickness)

Reinforced Concrete 4 inch (102 mm) is used then heat gain graph as well as cooling load was calculated.

A. calculating heat gain :

In the heat gain graph, the colors legends represent the following:

- Red for conduction - gains/losses that occur through the fabric of the building itself.
- Dashed red for gains due to indirect solar exposure, also known as the Sol-Air temperature.
- Orange for direct solar heat gains. Those gains occur through transparent surfaces such as windows.
- Dark Green for gains and losses that occur due to ventilation and infiltration.
- Blue for internal gains due to artificial lighting, also occupancy by people and equipment.
- Cyan for gains and losses that occur between neighboring zones.

Conduction gain in this configuration ranging between 240-480 w, this gains indicates big amount of heat flow and its transmission into the building, this is caused by the low wall thinness used in this configuration.

As indicated with the orange line in the graph there is high solar gain, this direct solar gain is affected by the number and orientation of openings in the building, and because more openings are located on the south façade of the model caused rise in the direct solar gain into the building. (Figure 4.121 in appendix)

b. Calculating the cooling and heating loads

The monthly cooling loads graph in figure 4.42 is calculated, The blue bars which represent when cooling is required are plotted in the negative axis of the graph and states that the max amount of the cooling load appears July the hottest month in the year and reaches 31894 W.

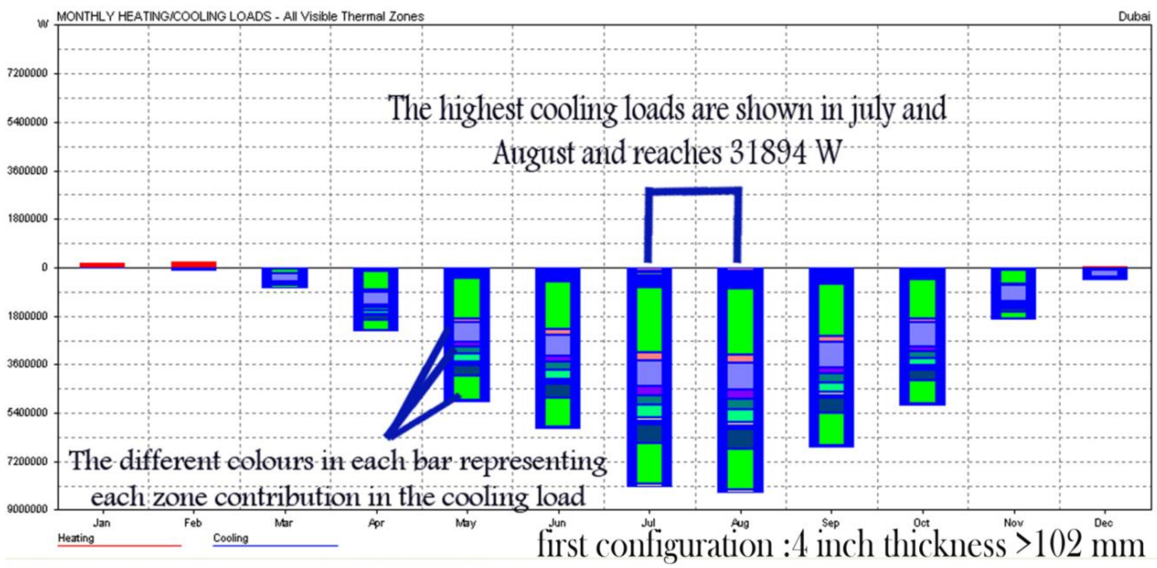


Figure 4.42 cooling and heating loads graph-4 inches wall thickness

<u>Second configuration (</u>6 inch thickness):

In this scenario the wall thickness was changed to a Reinforced Concrete 6 inch (150 mm) , means greater thermal mass, this is to explore the relationship between heavy weight constructions (more thickness) and light weight constructions (less thickness) in reducing energy consumption for mechanical cooling systems.

A. Calculating heat gain

The heat Gain Loss graph was recalculated. the Heat Gain Loss graph, Reduction in conduction gains took place, note how changing in material thickness gave a great effect in minimizing heat gains and minimizing energy consumption as a consequence.

Reduction in conduction gains happened because the material used has a higher thermal mass, conduction remained almost stable until 6 am in the amount of 100 W, then started to increase reaching to a peak of 200 W at 4pm, then decreased again reaching 100 W, as a minimum for the rest of the day. The increased thickness reduced the overall amount of heat flow and delay it transmission from inside to outside. (Figure 4.122 in appendix)

b. Calculating the cooling and heating loads

The cooling loads were again calculated for wall thickness of 6 inches .The monthly loads graph in figure 4.43 is a max amount of the cooling load appears in July, and reaches 29304 W. this is a 8.12% in the cooling load of the building from the previous scenario (4 inches thickness), this proofs the relationship between having a heavy weight construction, to the reduction in energy consumption for mechanical cooling systems.

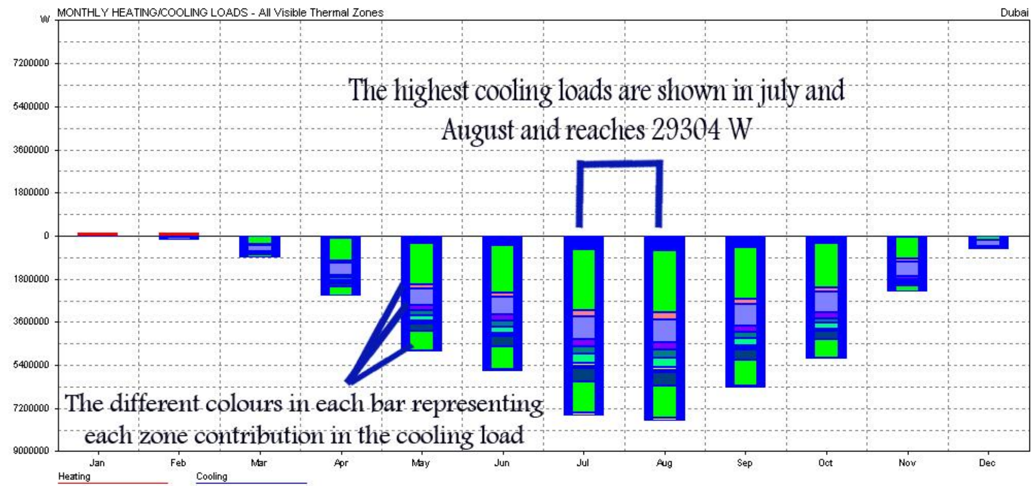


Figure 4.43 cooling and heating loads graph- 6 inches wall thickness

Third configuration (8 inch thickness):

In this scenario walls material was changed to a Reinforced Concrete 8 inch (200 mm mm) and then the heat Gain Loss graph was recalculated.

A. Calculating heat gain :

In the Heat Gain Loss graph, and its red line shows the heat gain that decreased in this case to range between 90 -160 W .(Figure 4.123 in appendix)

b. Calculating the cooling and heating loads

The cooling and heating loads were again calculated for wall thickness of 8 inches .The monthly loads graph in figure 4.44 shows a maximum amount of the cooling load of 27414 W. this is a 14.0% decrease in the cooling load of the building from the first scenario (4 inches thickness).

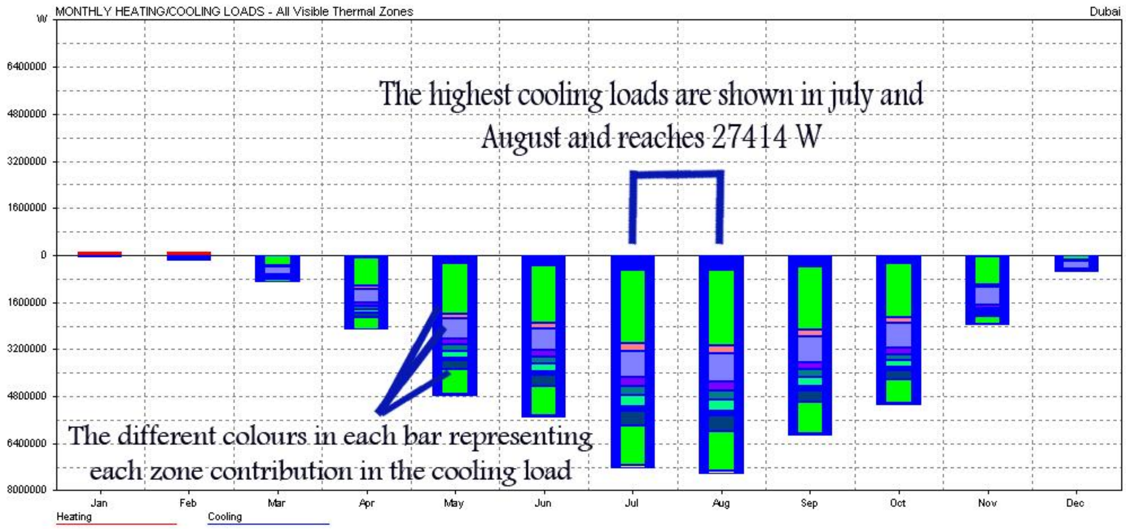


Figure 4.44 cooling and heating loads graph- 8 inches wall thickness

Fourth configuration (10 inch thickness):

In this last scenario for wall thickness, the wall was changed to a Reinforced Concrete 10 inches (254 mm) then the heat Gain graph was again recalculated.

A. Calculating heat gain:

in the Heat Gain graph, the red line which represents heat gain shows the decrease that happen to heat gain which in this case to range between 70-120 W . (Figure 4.124 in appendix)

b. Calculating the cooling and heating loads

Lastly, the cooling and heating loads were calculated for wall thickness of 10 inches, the monthly loads graph in figure 4.45 shows a maximum amount of cooling load of 26271 W, this is a 17.63 % decrease in the cooling load of the building from the first scenario

(4 inch thickness).

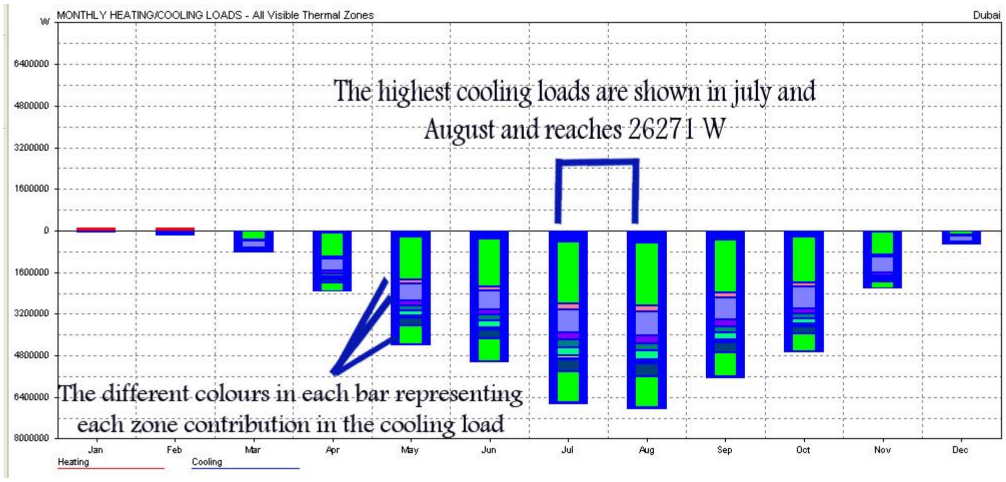


Figure 4.45 cooling loads graph- 10 inches wall thickness

<u>Configuration results:</u>

The simulation results proofed that materials used for the construction of the building envelope affects gain due to conduction that happen through the fabric of the building itself, it also effects the cooling load of the building. In the thermal mass simulations results as shown in Table 4.7 four different thermal mass building materials with different thickness were tested, the table shows the amounts of heat gain via conduction as well as the cooling loads amount in the four different configurations of wall thickness.

Table 4.7 Amounts of heat gain and cooling loads in the four different Configurations for wall thickness

Configurations				
	1st configuration	**2nd configuration**	**3rd configuration**	**4rth configuration**
	Reinforced Concrete 4 inch (102 mm)	Reinforced Concrete 6 inch (150 mm)	Reinforced Concrete 8 inch (200 mm)	Reinforced Concrete 100 inch (254 mm)

Heat Gain and -Conduction	240-480 W	110 -200 W	90 -160 W	70-120 w
Cooling load	31894 W	29304 W	27271 W	26414W

() Best scenario () worst scenario

Heat gain simulation conclusions:

the worse scenario took place when materials with less thickness was used, the worse scenario happen in the first configuration where Reinforced Concrete 4 inch (102 mm) was used for building walls resulting in heat gain ranging between 240 - 480 W, means an average of 360 W heat gain. And on the other the best scenario took place when building material was changed to another material with big thermal mass, this happen in the fourth configuration where Reinforced Concrete 10 inch (254 mm) was used for the building walls resulting in heat gain ranging between 70 - 120 W, means an average of 95 W absorbed heat gain, this means 73.61 % reduction in heat gain via conduction took place by changing the building material from a low weight to high weight material. Figure 4.46 is chart representing the amounts of heat gain in each of the previous wall thickness configurations, decrease in heat gain happened by only changing the thickness of the material used for the building.

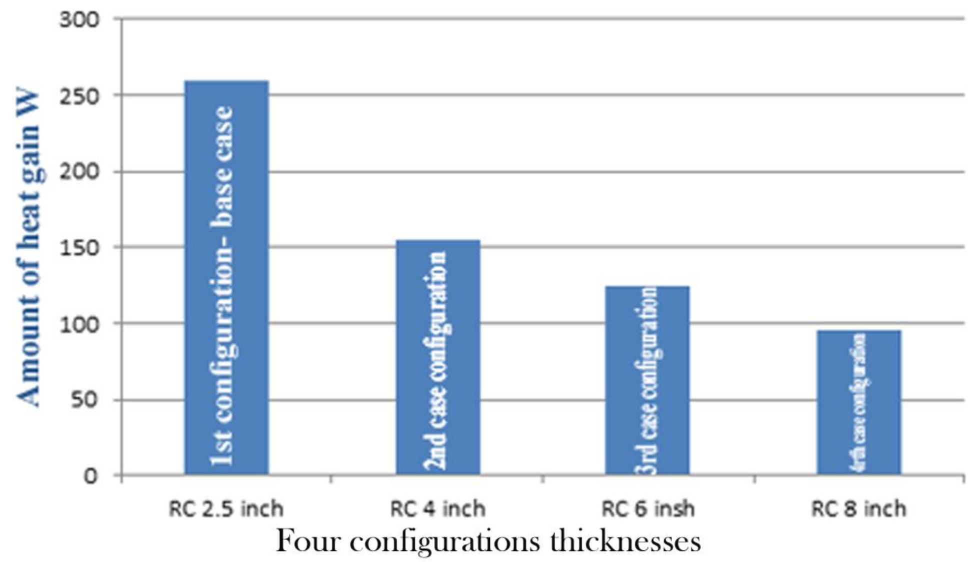


Figure 4.46 Chart showing four different wall thicknesses and the heat gain in each configuration

<u>Cooling load conclusions:</u>

Again in the cooling load simulations the worse scenario took place when materials with less thickness was used, the worse scenario for cooling load happen in the first configuration where Reinforced Concrete 4 inch (102 mm) was used for building walls resulting in cooling load of 31894 Watt. on the other the best scenario took place when building material was changed to another material with big thermal mass, this happen in the fourth configuration where Reinforced Concrete 10 inch (254 mm) was used for the building walls resulting in cooling load of 27271 Watt, this means 14.5 % reduction in cooling loads of the building took place by changing the building material from a low weight to high weight material.

As noticed , the amount of heat gain via conduction in walls have decreased by 73.6% , while the cooling load decreased by 14.5% only , the reason of this is the southern exposure of a large glazing area that equals to 32.10 m2 as well as the large total glazing area that equals to 43.479 m2 (base case) .

Figure 4.47 is chart representing the amounts of cooling load in each of the previous wall thickness configurations. Note the decrease in the cooling loads of the building, this again proofs that thermal mass is effective in improving building comfort and minimize cooling loads.

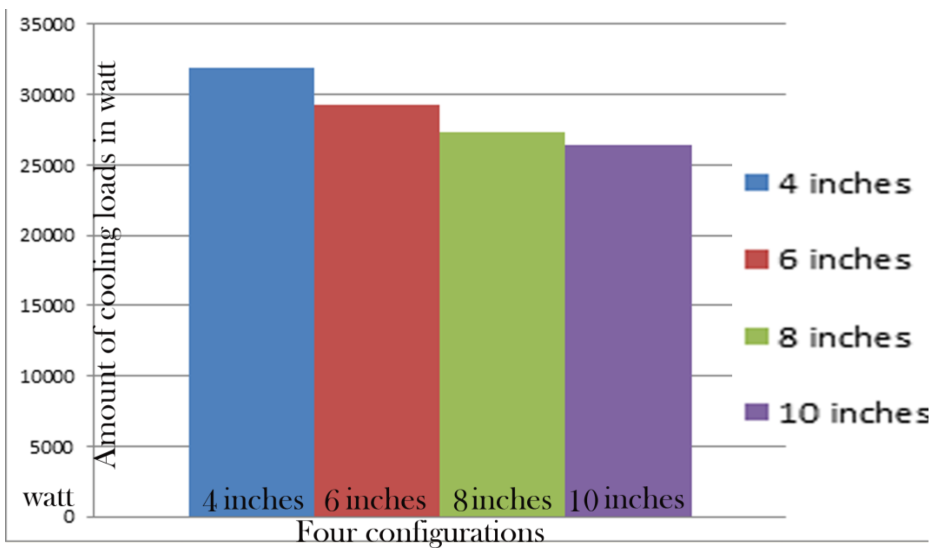


Figure 4.47 Chart showing four different wall thicknesses and the cooling load amount in each configuration

4.4 Glazing Analysis

Windows and glazing affects energy use in many major ways. Heat losses and heat gains through windows impact cooling demands. Windows also offers daylight penetration into the inner spaces of the building and this can reduce the need for electrical lighting.

Windows and Glazing affects the summer performance, meaning solar heat gain which is on east and west facing windows is most difficult to control. It needs to be sized to let access of day lighting and views while avoiding excessive glare. The desirable size of windows depends on their placement and orientation. South facing glazing should be at least 5 % and generally no greater than 12 % of the conditioned square footage of the building area. In our base case building the total glazing area equals to 42.501 m2 (7.9% flr area), and the south facing glazing equals to 32.10 m2 (6.1 flr area), that means the south glass exceeds 7 percent of the floor area, this big amount of glazed southern exposure wall definitely have an impact on day lighting, heat gain and cooling loads in the building .

In this glazing analysis, changes were done to size of openings, then overall lighting, heat gain , absorbed solar radiation and cooling loads will be studied for the base case building configuration then for other configurations where size and properties of the glass will be altered and improved, this is to explore the relation between glazing size and properties with the amount of lighting penetration and cooling load of the building, and to estimate both visual and thermal effect of glazing.

The following are the glazing configurations properties for the different building scenarios:

- <u>First configuration</u>: glazing area = 42.501 m2 (7.9% flr area), with single glazing.
- <u>Second configuration</u>: glazing area = 28.687 m2 (5.3% flr area), with double glazing.
- <u>Third configuration</u>: glazing area = 18.452 m2 (3.4% flr area), with triple glazing.
- <u>Configurations results.</u>

The simulations will study four outputs as follows:

A. The absorbed solar radiation (W/m2).

B. The amount of heat gain (W).

C. The overall lighting simulation (Lux).

D. The amount of cooling and heating loads (W)

The results to be described for absorbed solar radiation and cooling loads were for all months in one full year. And results to be described for heat gain and overall lighting were for one day in summer (21 July).

First configuration:

- Glazing total area: 42.501 m2 (7.9% flr area).
- South facing glazing area: 32.100 m2 (6 .0 % flr area).
- Type of glazing: Single glazed

The sun path diagram in the weather file shows that direct sunlight comes from the south direction, the building advantage from indirect daylight not to have the influence of overheating.

Software lighting and heat simulations were carried out to show the effect of glazing size and properties on the overall heat gain as well as on the day light penetration. Figure 4.48 is showing the building oriented toward south (base case orientation).

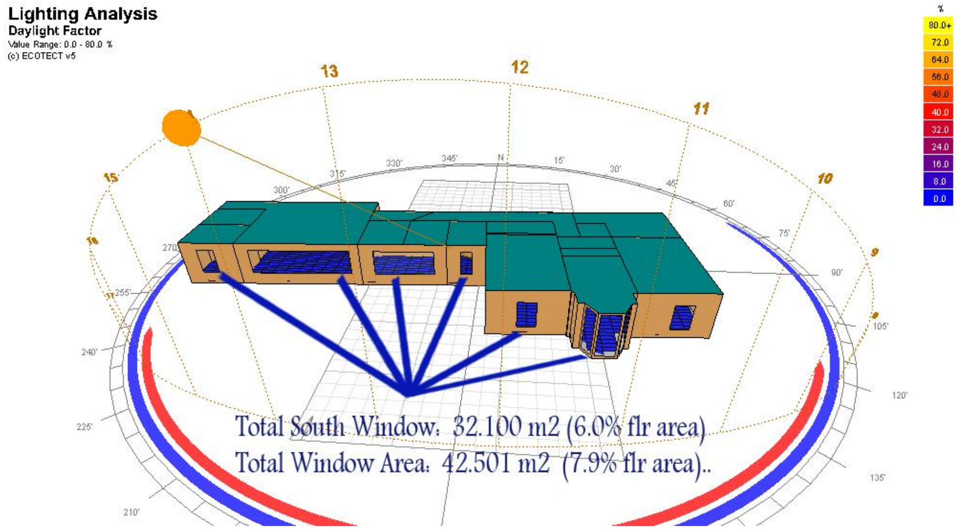


Figure 4.48 shows 3D model oriented toward south

A. Calculating the absorbed solar radiation:

As shown in figure 4.49, the absorbed solar radiation ranged from 20 to 70 Wh/m2 as a maximum, this is a common effect of having big windows and single glazing.

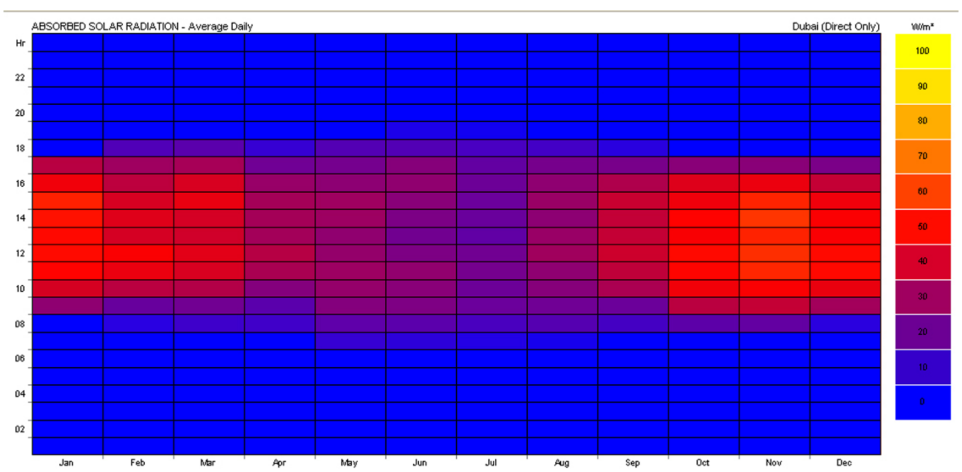


Figure 4.49 Absorbed solar radiation graph – big glazing

B. Calculating the amount of heat gain:

As shown in Figure 4.50 below, the amount of heat gain which is represented by the red line is ranging in this scenario between 240 and 450 W this is due to the large glazing , and south glazing exposure which permitted large amounts of direct solar gain into the building.

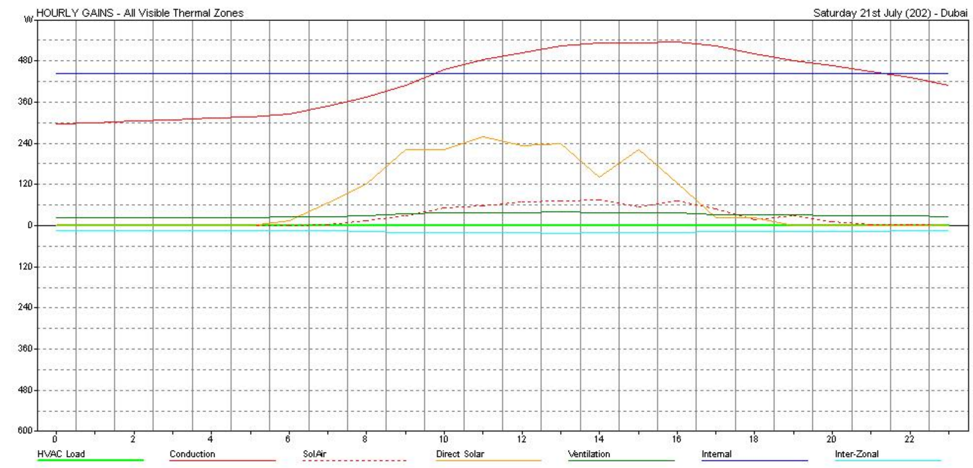


Figure 4.50 Heat gain graph – big glazing

C. lighting simulation

Both day light and electrical light simulations are done for the model in order to explore the relationship between glazing size and properties and the amount of overall light.

-Daylight simulation

In this glazing configuration the total south facing glazing is 32.10 m2 (6.1 flr area), this is a big area of un shaded glazing facing south that permitted high amount of unwanted direct rays .

As shown in the analysis grid the daylight is penetrating the museum through side windows. The daylight simulation in figure 4.51 shows an amount of 100-200 lux light penetration into the exhibition areas, through windows as well as an amount of 150-240 lux light penetration into the lobby area, through the main entrance glazing and side windows. It is considered a big amount of direct light penetration that should be moderated by shading devices to block the unwanted direct light. Taking into consideration that the exhibitions are deep rooms having glazing on one wall only, and so, it received very high daylight levels near the windows and very low daylight levels at the rear, this is considered un uniform type of lighting, that can be moderated by using shading devices, because the big south-facing windows allows for unwanted direct rays and its recommended to block these direct rays with a roof overhang or any type of shading device, to minimize the southern exposure on glazing.

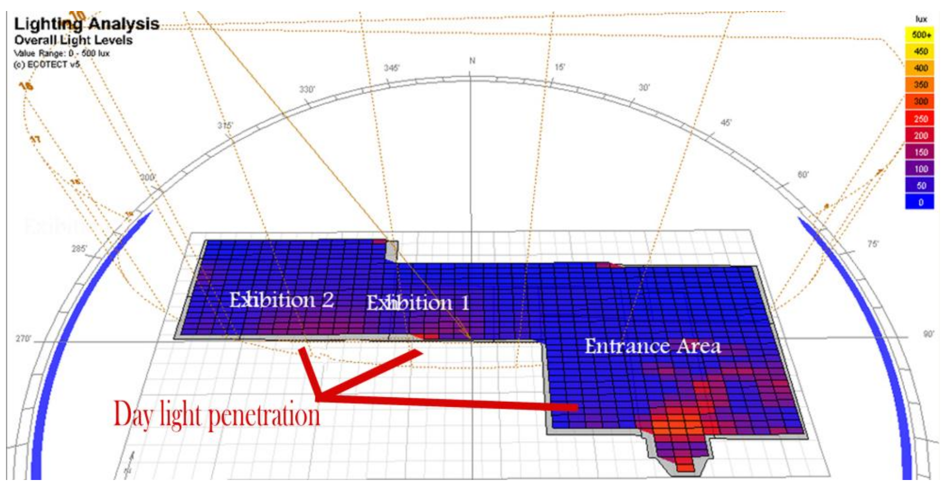


Figure 4.51 shows daylight penetration through glazing

-Electrical light simulation

Although the amount of sunlight around the glazed areas of the model were naturally lit with an enough amount of light (200-300) lux, but this natural light through the side windows haven't lit all the inner spaces, only areas around the windows received the light and other inner spaces still needs to be lit.

As there is a need of more lighting to improve the lighting inside the model, there was an addition of electrical lights of normal incandescent globes, this light was chosen because its suitable for the museum functions, for the preservation of the museum objects it is recommended that UV levels are kept below 75 μw/lumen, Halogen and fluorescent lights have an extensive UV module however incandescent lights have virtually no UV (M&G NSW 2011). Therefore normal incandescent globes were fixed all over the model ceiling.

The distribution of the electrical lights was changed several times because positioning lights effects the distributed light within the inner spaces and, so lights were fixed in a certain alignment to provide an equal amount of lighting throughout model. The amount of light required for the museum ranges between 200 and 300 lux. Figure 4.52 shows the distribution of electrical light excluding the sun light which is not displayed on the analysis grid. Note that there are some dark areas on the analysis grid; this is due to interior walls.

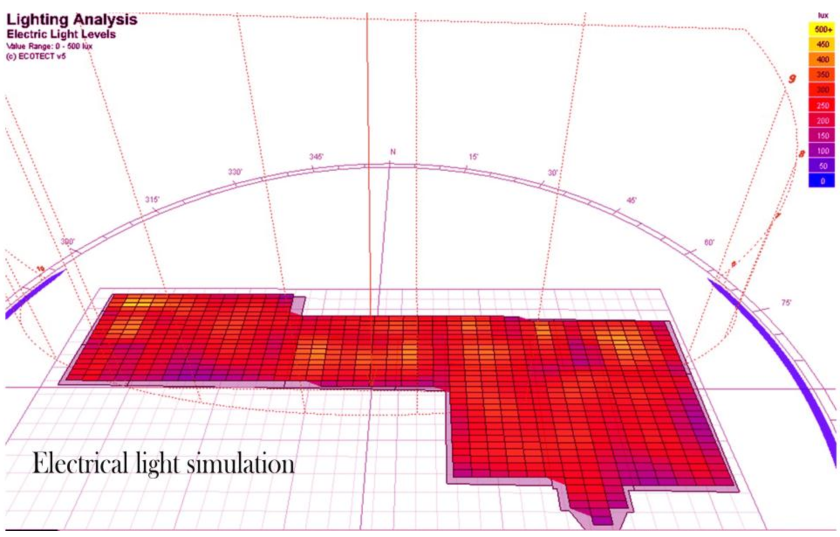


Figure 4.52 the distribution of electrical light exclude sun light

-Overall light simulation (Daylight +Electrical):

This simulation was carried out to calculate the total amount light for both daylight and electrical light and whether the required amounts of light have been achieved or not. Figure 4.53 shows the amount of lux falling on the floor of the model, as shown it considered satisfactory for the museum need. Overall lighting on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

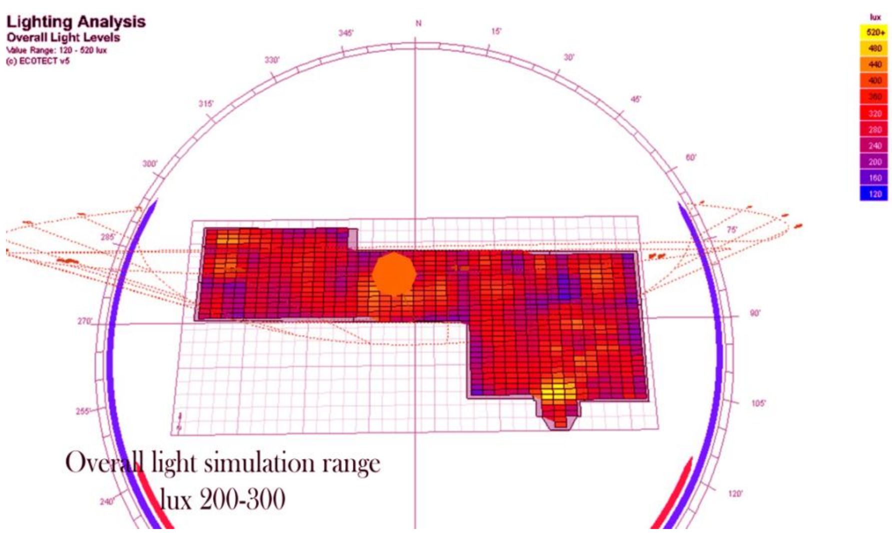


Figure 4.53 the distribution of overall light (electrical + natural)

D. The cooling and heating loads simulation:

The monthly loads graph in figure 4.54 displays the measured cooling load which has reached 37055 Watts in this base case configuration.

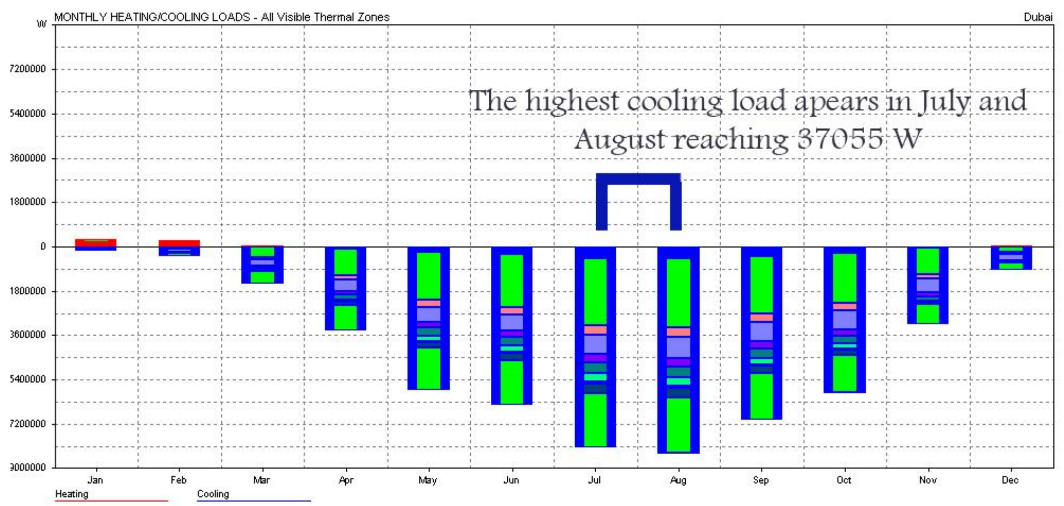


Figure 4.54 the cooling and heating loads measured in Watts

<u>Second configuration</u>:

In this scenario windows were redesigned to smaller sized windows with double glazing and then amount of daylight penetration, cooling load, heat gain and solar absorption were calculated, the glass properties in this scenario are as follows:

- Glazing total area: 28.600 m2 (5.3 % flr area).
- South facing glazing area: 21.687 m2 (4.0% flr area).
- Type of glazing: Double glazed

A. Calculating the absorbed solar radiation:

As shown in the Figure 4.55 There is reduction in the solar absorption that ranged in this scenario between 20 Wh/m2 to 60 Wh/m2.

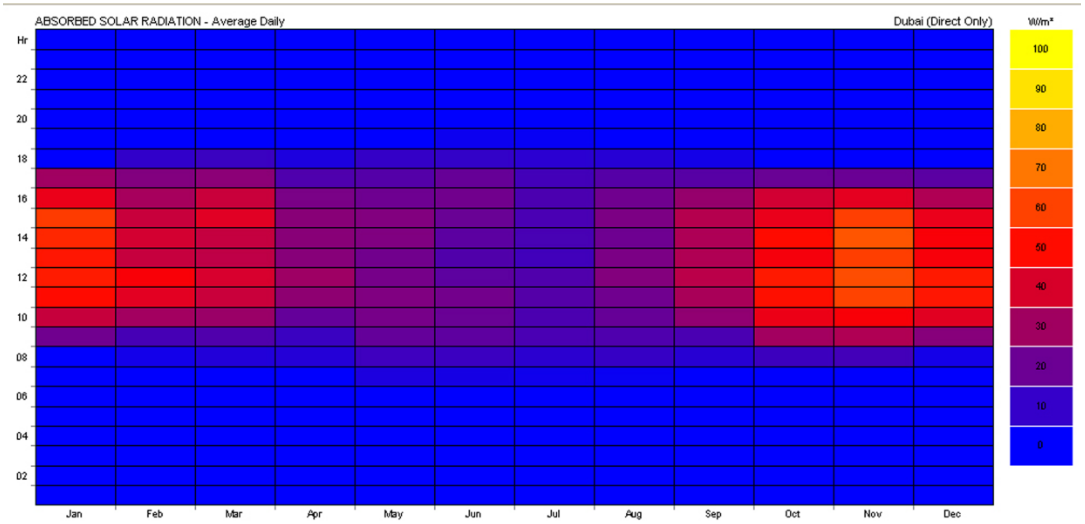


Figure 4.55 Absorbed solar radiation- smaller glazing

B: Calculating the heat gain:

As shown in Figure 4.56 below, the amount of heat gain which is represented by the red line is ranging in this case between 110 and 190 W, this decrease in the amount of heat gain is due to smaller glazing area which allowed for less heat gain.

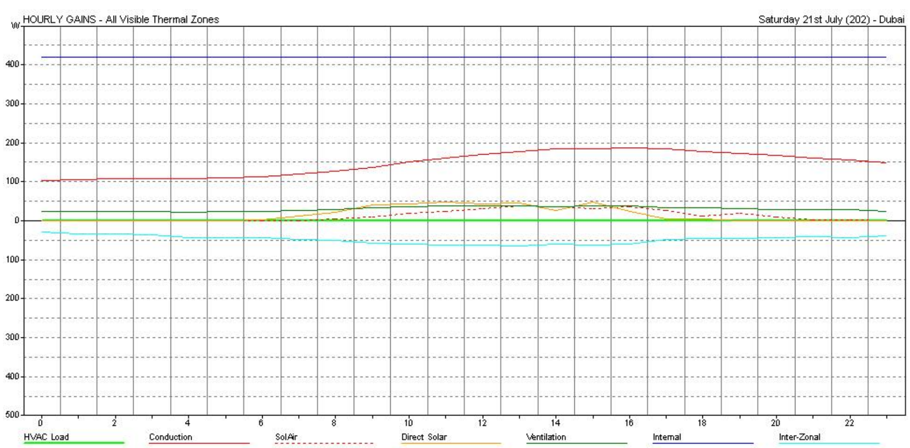


Figure 4.56 Heat gain amounts- smaller glazing

C .lighting simulation

Figure 4.57 the 3D model was redesigned with smaller windows, then the lighting simulation was carried out to explore the relation between less glazing area and the overall light, both natural and electrical light have been carried out.

Figure 4.57 the 3D model is redesigned with smaller windows

-Daylight simulation

The daylight simulation, figure 4.58 shows an amount of 100-150 lux light penetration into the exhibition areas through windows, as well as an amount of 100-200 lux light penetration into the lobby area though main entrance glazing and side windows, obviously the amount of sun light that is received in this scenario has been decreased a little and became less than the previous scenario where sunlight ranged from 150 - 240 lux, this is a good consequence of having smaller glazing that permitted less direct unwanted light that has a negative impact on the preservation of the museums artifacts.

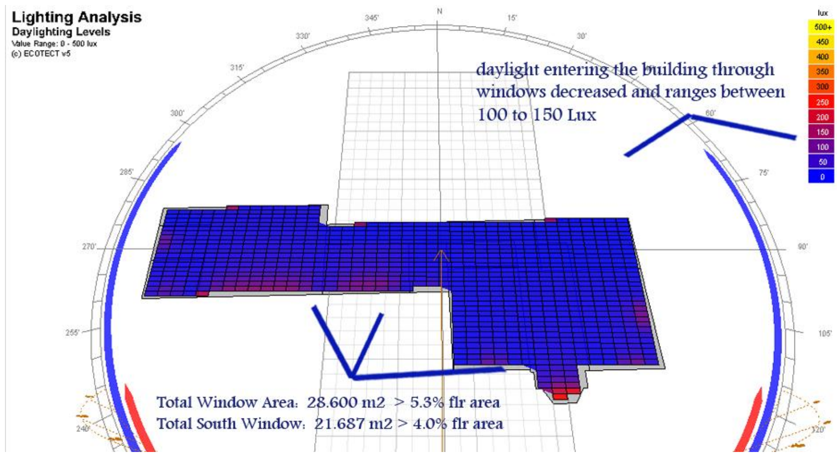


Figure 4.58 daylight penetrations through glazing –smaller glazing

-Electrical light simulation

Before carrying out the simulation more incandescent globes were added and fixed on the roof of the model , this is because the smaller glazing of this scenario minimized the sunlight received , so in order to reach the required amount of light (200-300) lux , more electrical light were needed. The following figure 4.59 shows the distribution of electrical light excluding the natural sun light. The lighting grid shows that the provided electrical lights did provide a uniform pattern of light all over the inner space in the museum.

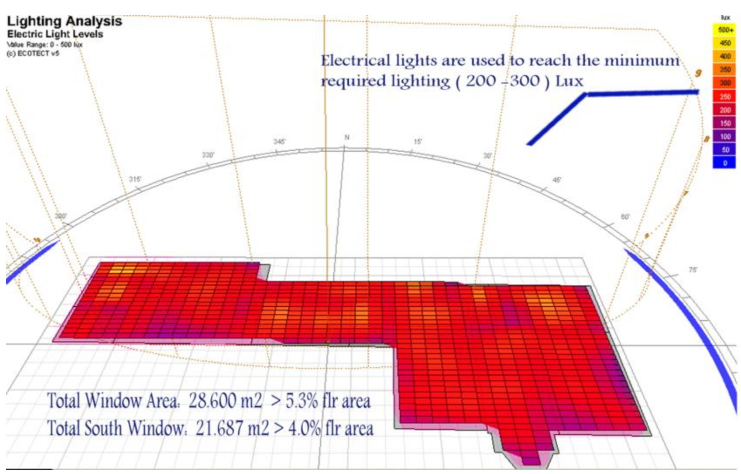


Figure 4.59 shows the distribution of electrical light

-Overall light simulation (Daylight +Electrical):

The following figure 4.60 shows the total amount light for both daylight and electrical light, as seen combining electrical light with available sun light made the required amount of light all over the analysis lighting grid. Overall lighting on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

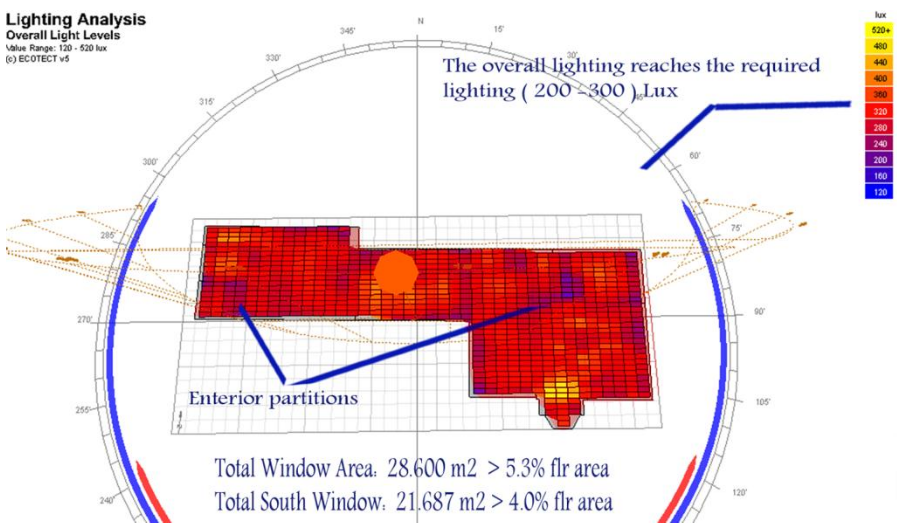


Figure 4.60 the distribution of overall light (electrical + daylight)

D . The cooling and heating loads simulation:

Cooling load simulation shows the impact of the smaller glazing areas of this scenario, on the overall cooling load of the building. The monthly loads graph in figure 4.61 shows cooling loads for all zones of the model, measured in Watts (W). The blue bars represent when cooling is required, and are plotted in the negative axis of the graph.

The simulation shows that cooling load reached 35385 W, while in the previous scenario 37055 of watts were calculated; this means a 4.5% reduction in the cooling load of the building.

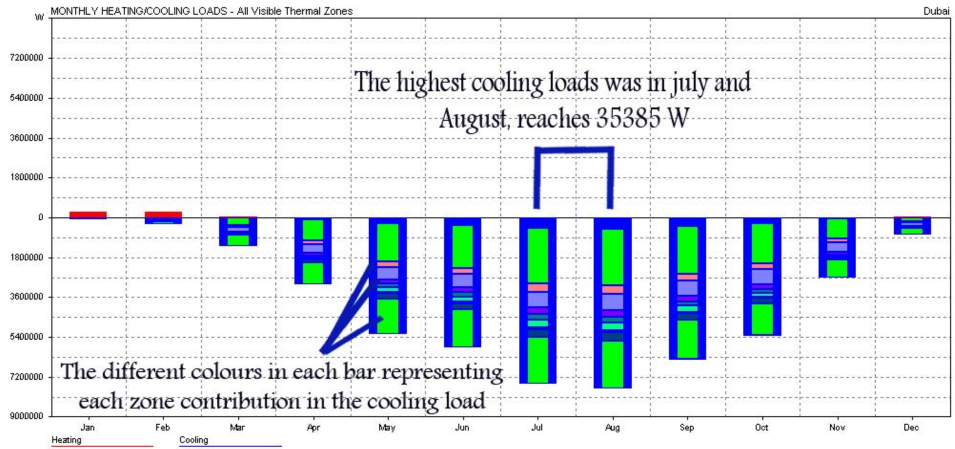


Figure 4.61 the cooling and heating loads measured in Watts- smaller glazing

<u>Third configuration</u>:

In this scenario windows were again redesigned to a more smaller sized, using triple glazing for them, then amount of daylight penetration , cooling load , heat gain and solar absorption were calculated, the glass properties in this scenario are as follows :

- Glazing total area: 18.452 m2 (3.4% flr area).
- South facing glazing area14.807 m2 (2.8% flr area).
- Type of glazing: Triple glazed

A. Calculating the absorbed solar radiation:

Reduction happened in the solar absorption as shown in Figure 4.62 it the solar absorption ranged in this case between 20 Wh/m2 to 50 Wh/m2, which is less than the previous scenario where windows were bigger and solar absorption reached 60 Wh/m2 .

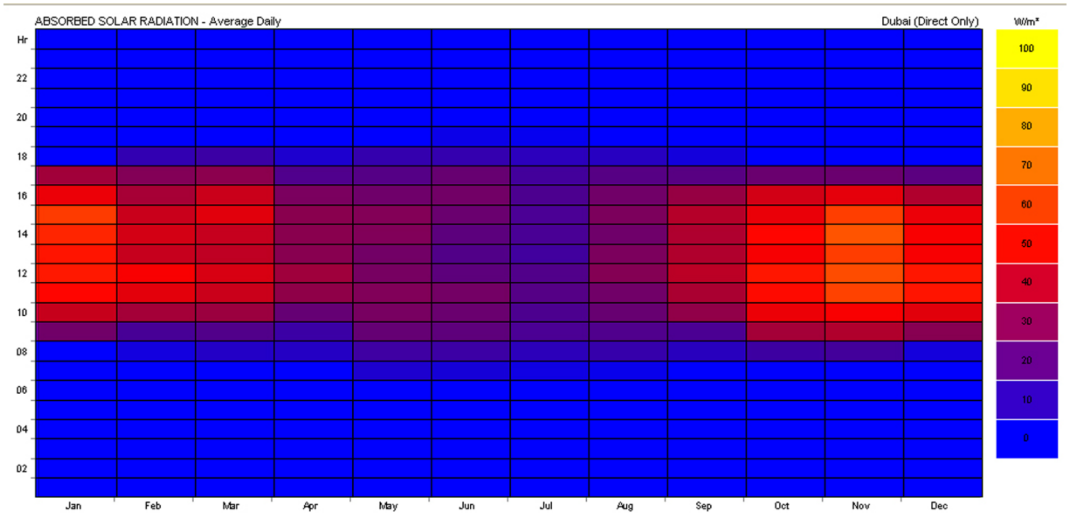


Figure 4.62 Absorbed solar radiation-smallest glazing

A. Calculating the amount of heat gain:

As shown in Figure 4.63 below, the amount of heat gain which is represented by the red line is has decreased more and ranges in this case between 100 and 115 W ,this more decrease in the amount of heat gain took place due to the smaller glazing which n this scenario has an area of 18.45 m2 . This proofs that changing the glazing parameters like changing the size of windows and type of glazing used in those windows will have impact on the amount of absorbed solar radiation and heat gain in the building.

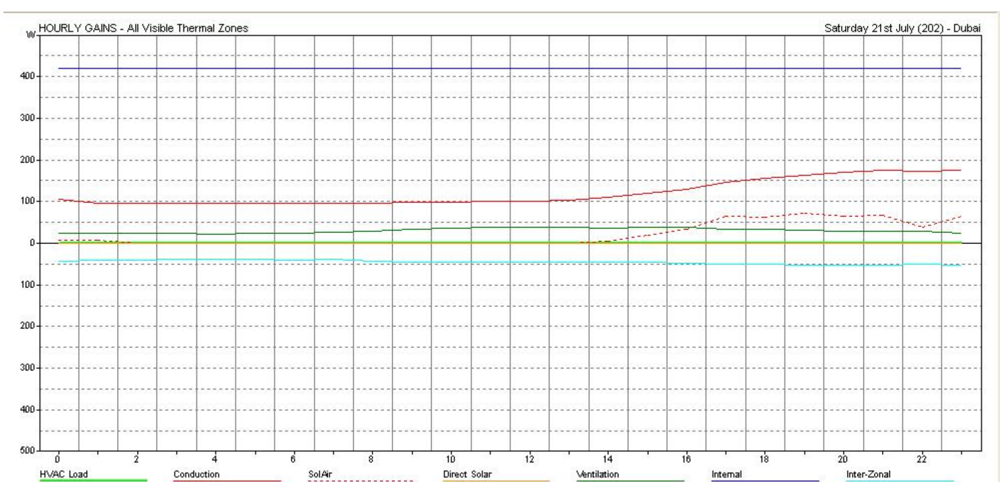


Figure 4.63 Heat gain amounts -smallest glazing

B. lighting simulation

Overall Lighting simulation were carried out again (Both daylight and electrical light), for this last glazing scenario, this is to address the amount impact that smaller glazing with better glazing properties can give. Figure 4.64 shows the 3D model that is redesigned with smaller windows.

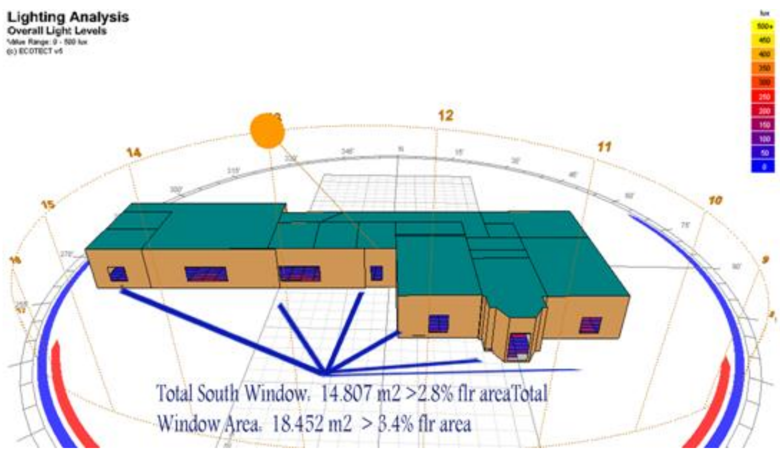


Figure 4.64 the 3D model is redesigned with smaller windows

-Daylight simulation

The daylight simulation, figure 4.65 shows an amount of 50-100 lux light penetration into the exhibition areas through windows, as well as an amount of 100-150 lux light penetration into the lobby area through main entrance glazing and side windows, clearly the amount of daylight that is penetrating the building has decreased by around 50 lux, this is a normal reduction happened due to the smaller glazing of this scenario.

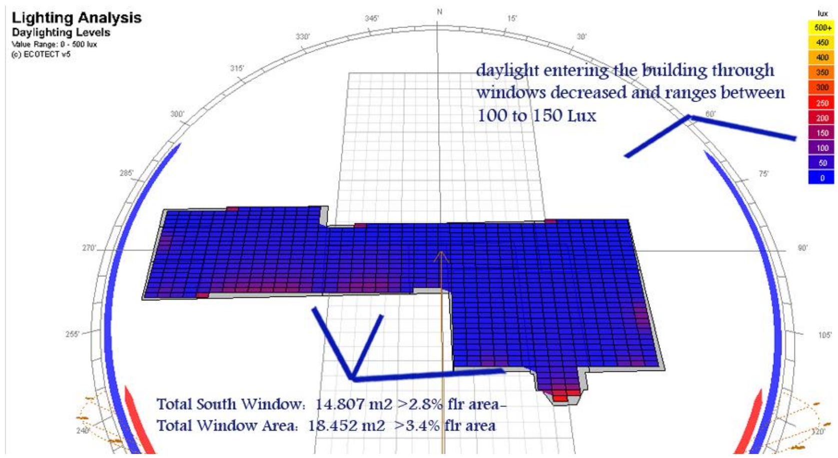


Figure 4.65 daylight penetration through glazing - smallest glazing

-Electrical light simulation

As a consequence of the smaller glazing of this scenario, more incandescent lights were fixed on the ceiling of the model in order to improve the lighting inside the model, and reach the required amount of light (200-300) lux shown on the analysis lighting grid in figure 4.66. The lighting analysis grid shows that the provided electrical lights did provide a uniform pattern of light all over the inner space in the museum.

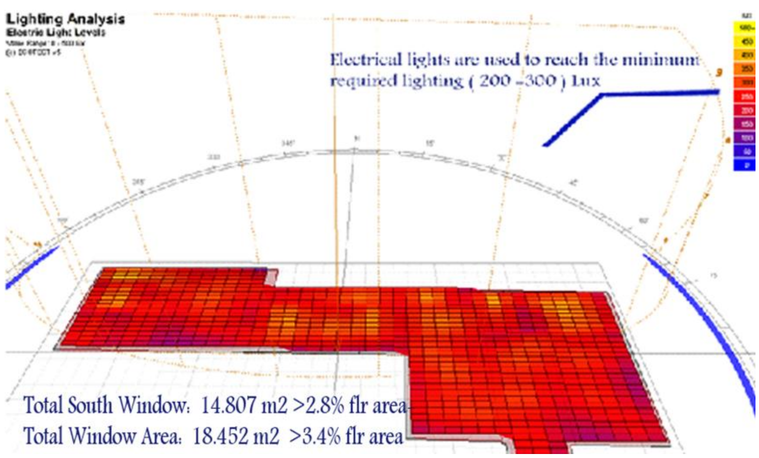


Figure 4.66 the distribution of electrical light exclude natural light

-Overall light simulation (Daylight +Electrical):

This simulation was carried out to show the total amount light for both daylight and electrical Figure 4.67 the shows the overall light. Overall lighting on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

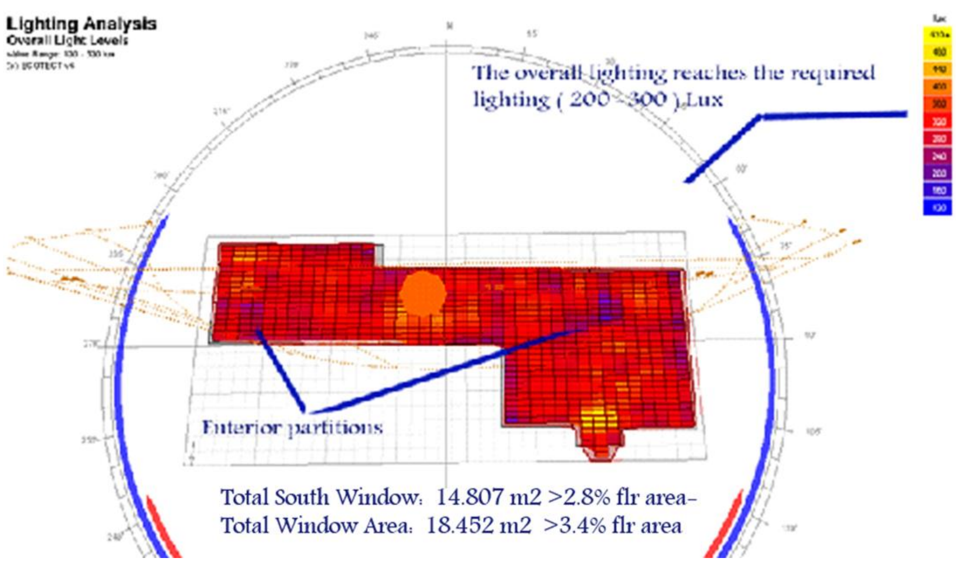


Figure 4.67 the distribution of overall light-smallest glazing

D. The cooling and heating loads simulation:

The monthly loads graph in figure 4.68 the heating and cooling loads measured in Watts (W) shows 34799 Watt of cooling loads, as realized there is a slight decrease in the cooling load from the previous scenario when glazing was bigger and cooling load reached 35385 W, this means there is a reduction of 1.65 % in the cooling load , and when comparing the amount of cooling load of this scenario with the first scenario the reduction is 6.0% ,happened because of the smaller glazing area that allowed less direct solar absorption into the building.

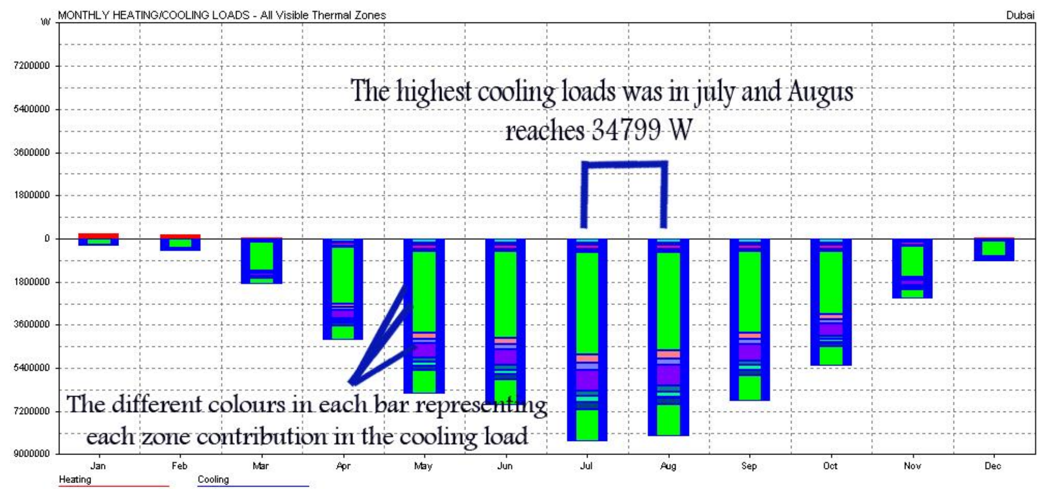


Figure 4.68 the cooling and heating loads -smallest glazing

<u>Configuration results:</u>

in the previous tested configurations , windows with three different sizes and three different glazing were tested ,big glazing with single glass, medium glazing with double glass and lastly small glazing with triple glass . Following table 4.8 Summarizes the absorbed solar radiation, heat gain and cooling loads results:

Table 4.8 amounts of absorbed solar radiation, heat gain and cooling loads in the three glazing configurations

Glazing parameters	1st configuration (Base case)	2nd configuration	3rd configuration
Glazing area	42.501 m2 (7.9% flr area).	28.687 m2 (5.3% flr area)	18.452 m2 (3.4% flr area)
Type of glazing	Single glazing	Double glazing	Triple glazing
Daylight penetration	150-240 lux	100-200 lux	100-150 lux
Absorbed solar radiation range	20-70 Wh/m2	20-60 Wh/m2	10-50 Wh/m2
Heat gain range	240-450 W	110-190 W	100-115 W
Cooling load	37055 W	35385	34799

Heat gain conclusions:

the worse scenario happened in the first configuration where glazing area was big (42.501 m2) and made of single glazing, that configuration resulted in heat gain range of 240-450 W means an average of 345 W, on the other hand the best scenario took place when the glazing area was minimized in the fourth configuration to 18.452 m2 resulting in less heat gain range that was 100-115 W means an average of 112.5W, this is a 44.04% reduction in heat gain.

Absorbed solar radiation conclusions:

high absorbed solar radiation was in the first configuration where glazing area was big (42.501 m2) and made of single glazing, that configuration resulted in absorbed solar radiation range of 20-70 W/m2, means an average of 45 W /m2, on the other hand less absorbed solar radiation happened when the glazing area was minimized in the fourth configuration to become 18.452 m2 resulting in less absorbed solar radiation range of 10-50 W/m2 means an average of 30 Wh/m2. This is a 47.05 %reduction in absorbed solar radiation.

-Lighting conclusions:

In lighting simulations, different amount of daylight was received in the building in every configuration. The highest amount of direct light was received when the building was having a big glazing, the amount of direct light in the big glazing scenario reached 240 lux on areas near the windows and the entrance glazing this is a big amount of sun rays have a negative impact on the museum displays, and has to be moderated through using a shading device to block the excess amount of sunrays that is received.

Later on, on other glazing scenarios, the lighting simulation showed that daylight received was less when using smaller windows, in the second configuration where windows were smaller the maximum amount of light was 200 lux on areas near the windows and the entrance glazing ,it is still considered a big amount of direct light penetrated into the exhibitions.

On the other hand, the amount of light in the last scenario where smallest windows were used reached 150 lux; it is considered the best scenario since it has less direct sun light penetration. So having smaller glazing is considered best for the museum building since the sun rays received are less .bellow in table 4.9 representing the amount of received daylight in each of the four glazing configurations.

Table 4.9 the amount of received daylight in each of the four glazing configurations.

Day light in each of the four orientations			
	1st configuration (Base case)	2nd Configuration	3rd configuration
Glazing area	42.501 m2 (7.9% flr area).	28.687 m2 (5.3% flr area)	18.452 m2 (3.4% flr area)
Day light	150-240 lux	150-200 lux	100-150 lux
Average daylight	195 lux	175 lux	125 lux

() Best orientation () worst orientation

Cooling load conclusions:

high amount of cooling load was in the first configuration where glazing area was big (42.501 m2) and made of single glazing, that configuration resulted in cooling load amount of 37055 Watt,on the other hand less cooling load happened when the glazing area was minimized in the fourth configuration to 18.452 m2 resulting in less a cooling load amount of 36000 watt . This is a 6.0 % reduction in cooling load.

Table 4.10 shows the reduction in absorbed solar radiation, heat gain and cooling load ,which took place from first to the last configuration, note that although the amount of heat that is getting into the building was sufficiently dropped due to the minimization of the glazing, but still the cooling loads was not reduced as much as heat gain reduction, this happened because in every scenario when the glazing was getting smaller the amount of natural light received by the building was decreased , so there was addition of electrical lights in order to provide the required light (200-300 lux), this addition of electrical lights led to more cooling load, as heat is associated with light and comes with it.

Table 4.10 the reduction in absorbed solar radiation, Heat gain and cooling load from 1st to 3rd configuration

Reduction from 1st -3rd configuration	**Absorbed solar radiation**	**Heat gain**	**Cooling load**
	47.05 %	44.04%	6.0%

4.5 Shading devices:

Effective exhibit lighting must balance exhibition and conservation needs and enrich the museum experience (IESNA, 1996).

In designing day shading system, followings should be considered to protect material deterioration.

▪ Direct beam radiation should be blocked.

▪ Total exposure limits should be considered.

Its known that when shading windows, external shading is more effective at reducing heat gain than internal shading, and when applying shading elements, great consideration has to be taken in to account is blocking the direct beam radiation. Shading devices were installed to block the UV radiation (IESNA).

In this shading study different scenarios were done to study the effect of applying shading devices on the glazed parts of the building envelope.

As shown in the base case , more windows are facing south, windows on the southern elevation is not considered a good idea especially if there were no shading devices added to them to eliminate direct solar gain.

Below are scenarios, when windows on the southern elevation, first were tested without any shading devices, and then tested again with two different sizes of shading devices added to them first a small shading overhang then big shading overhang, but keeping the glazing size and properties the same in all of the three scenarios.

Simulations are done for the three different scenarios as follows:

- First configuration: without a shading device.
- Second configuration: small shading device.
- Third configuration: big shading device.
- Configurations results.

As in all previous tested configurations the results to be described for absorbed solar radiation and cooling load were for all months in one full year. And results to be described for heat gain and lighting were for one day in summer (21 July). As follows:

A. The absorbed solar radiation (all months in one full year).
B. The heat gains amount (one full day in summer -21 July).
C. The overall lighting simulation (one full day in summer -21 July).
D. The amount of cooling and heating loads (all months in one full year).

First configuration: no shading (base case)

This configuration is same as the base case that was tested and discussed previously in the glazing part of the study, the glazing is a Single glazing with an area of 42.501 m2 (7.9% flr area).

The result of the base case will be used in this configuration, as follows:

- Daylight penetration: 150-240 lux (average= 195 lux)
- Absorbed solar radiation range: 20-70 Wh/m2
- Heat gain range: 240-400 W
- Cooling load: 37055 W

Figure 4.69 is showing the 3d model south glazing which has no shading devices; as was mentioned before, it allowed for more direct light received reaching 150-240 lux, on the spaces around windows and glazing of the entrance.

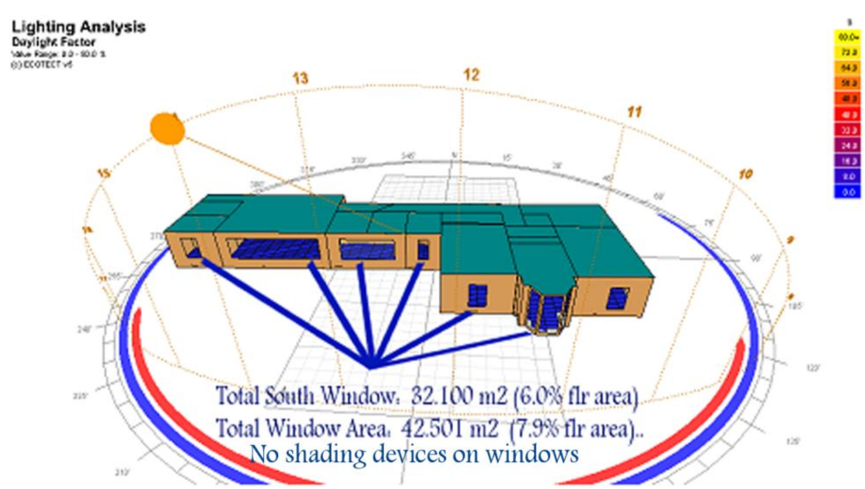


Figure 4.69 3D model of the first configuration - no shading devices

Second configuration

The aim is to control intense direct sun light to provide a space that is comfortable .This is considered important aspect for the occupant visual and thermal comfort and loads.

In this scenario outside small shading devices were fixed along the windows on southern elevation then simulations were done to calculate day lighting, absorbed solar radiation, heat gain amounts as well as cooling loads.

The shading device is a small size overhang, designed in a horizontal position relative to the window opening and the angle between the hypotenuse and the horizontal is 90º, the triangle legs are oriented to the outside.

A. Calculating the absorbed solar radiation:

Direct solar radiation shown in figure 4.70 has decreased and ranged between 20-70 W/m2, this is due to the shading devices that were added on windows specially the windows facing south. Highest amount of solar gain was shown on October, November and December ranging between 20-60 W/m2. Lowest mount of solar gain is presented on July ranging 20-30W/m2.

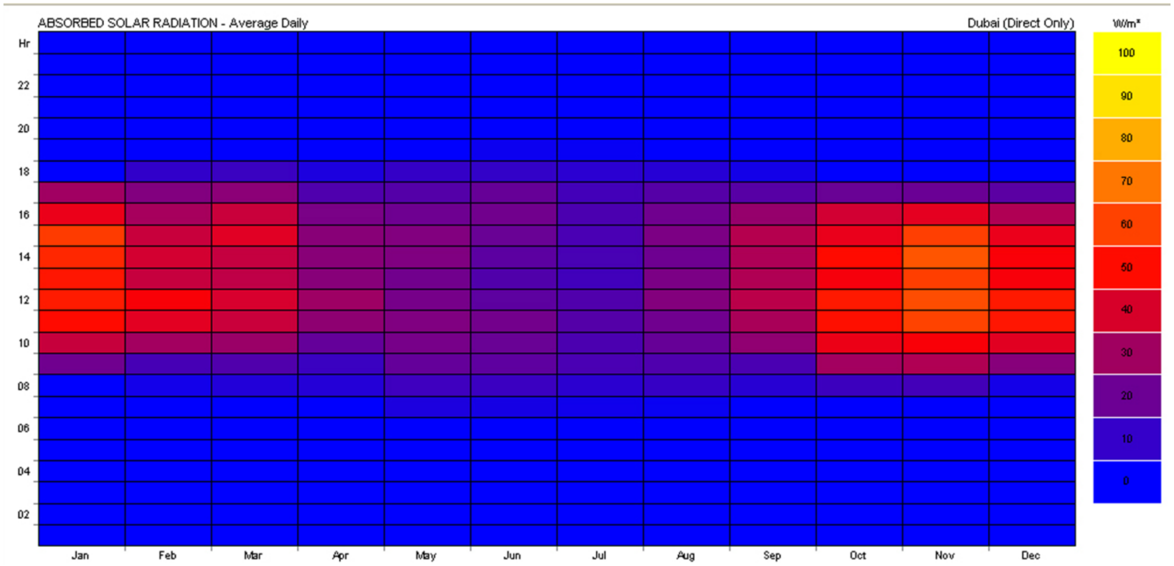


Figure 4.70 Total monthly absorbed solar radiations- small shading device

B. Calculating the amount of heat gain:

As shown in Figure 4.71 below, the amount of heat gain which is represented by the red line is slightly decreased and ranges in this case between 200 and 360 W, this decrease in the amount of heat gain took place due to the shading devices which minimized the glazing southern exposure.

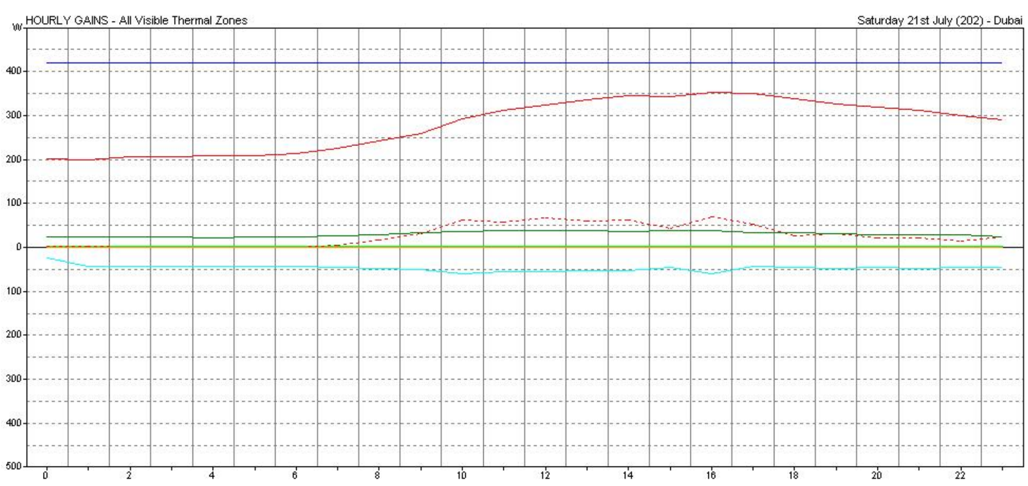


Figure 4.71 heat gain amounts - small shading device

C. Lighting simulation:

Having a shading device on the glazing will shade the unwanted direct solar gain but on the other hand will impact and decrease the daylight received into the building. In the following daylight simulations we will be able to compare the amount of light (lux) that is received when using shading devices with the case of not having a shading device. Figure 4.72 shows the 3D model with small overhang fixed on the glazing

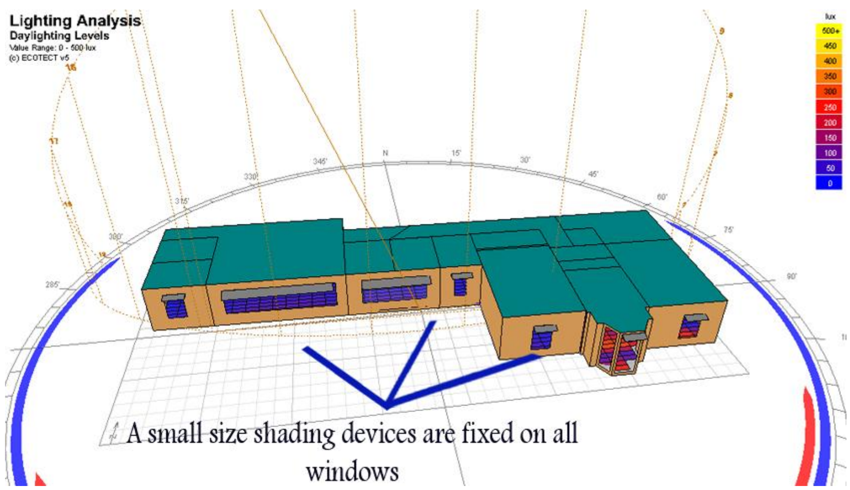


Figure 4.72 3D model with small overhang fixed on the glazing

-Daylight simulation

South facing windows were shaded with small overhangs that will block the high summer sun, but allow the low sun to shine in and provide daylight.

The daylight simulation in figure 4.73 Shows an amount of 100 lux of light near windows and 200 lux of light near the entrance glazing, this is less light penetration than it is in the previous non shaded scenario simulation that had an amount of light range equals to 200-240 lux, this reduction in received daylight is a cause of having a shading overhang on the glazing, this small overhang partially blocked some of the daylight as well as it allowed for more uniformity in the received sun light than it in the previous un shaded scenario. The overhang blocked the excess sun rays that was entering the building and creating un uniform strong light.

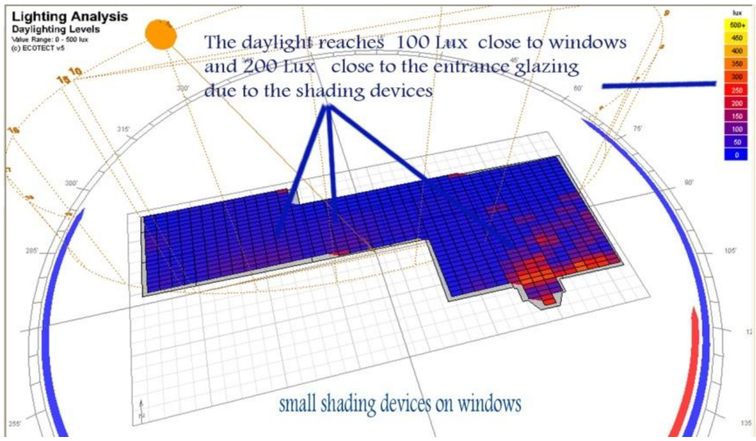


Figure 4.73 daylight penetrations through glazing –small shading

-Electrical light simulation

An addition of electrical lights was done to improve the lighting inside the model and reach the required light (200-300) lux, obviously because of the shaded windows there was a need for more electrical light than was used in the previous scenario (un shaded windows), figure 4.74 shows the distribution of electrical light on the analysis grid, the lighting analysis grid shows that the provided electrical lights did provide a uniform pattern of light all over the inner space in the museum.

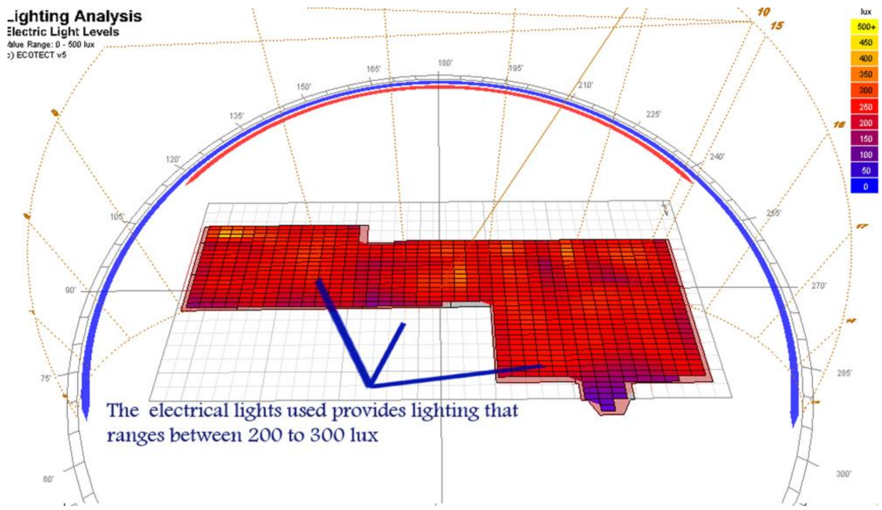


Figure 4.74 the distribution of electrical light exclude natural light– small shading

-Overall light simulation (Daylight +Electrical):

This simulation was carried out to calculate the total amount light for both daylight and electrical light for this scenario , As shown in the overall light figure 4.75 the required lighting is provided. Overall lighting on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

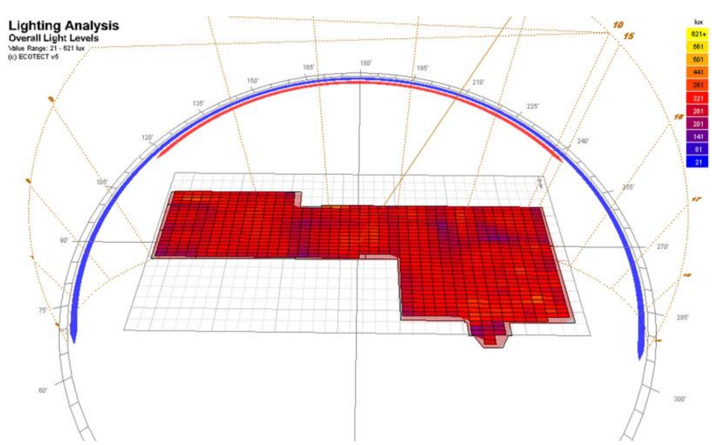


Figure 4.75 the distribution of overall light– small shading

D . The cooling and heating loads simulation:

The simulation figure 4.76 shows that cooling load reached 36156 W, while in the previous scenario (un shaded) cooling load was 37055 of watts; this means a 2.4 % decrease, its considered a small decrease in the cooling load of the building, and is mainly because of the shading device which blocked some of the direct solar gain reaching the building.

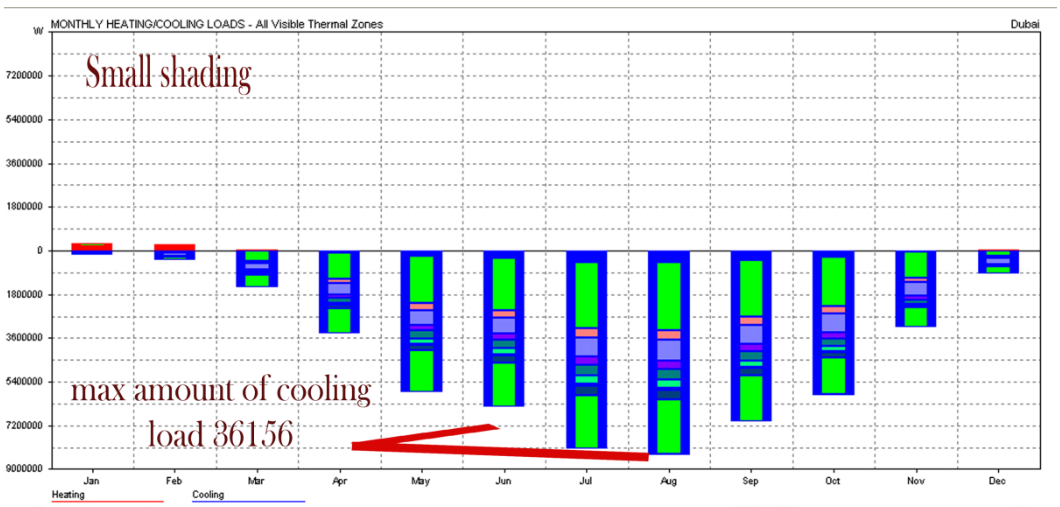


Figure 4.76 the cooling and heating loads measured in Watts- small shading

<u>Third configuration</u>

In this configuration, bigger shading devices were on the windows and then the model was again tested for heat and lighting.

A. Calculating the absorbed solar radiation:

Figure 4.77 shows the direct solar radiation which was decreased and ranged between 20-50 W/m2, this is due to the bigger shading device that was added on windows. The Highest amount of solar gain was presented on October, November and December ranging between 10-50 W/m2. Lowest mount of solar gain is presented on July ranging 20-30 W/m2.

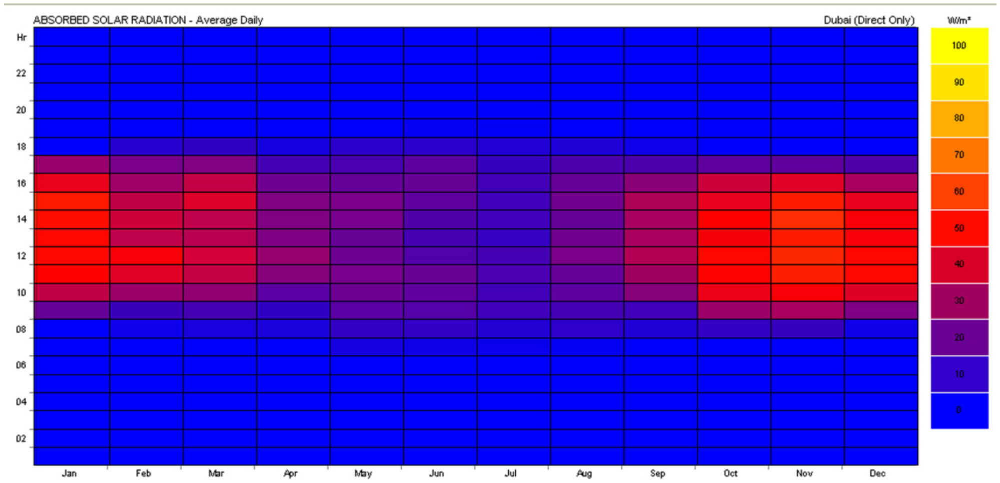


Figure 4.77 Total monthly absorbed solar radiations- big shading

B. Calculating the amount of heat gain:

As shown in Figure 4.78 below, the amount of heat gain which is represented by the red line is has decreased more and ranged in this case between 190 and 320 W ,this little more decrease in the amount of heat gain took place because of the bigger shading device in this scenario. This proofs that using shading devices on windows can have a sufficient impact on the absorbed solar radiations inside the building as well as the amount of heat gain that is happening through the building fabric.

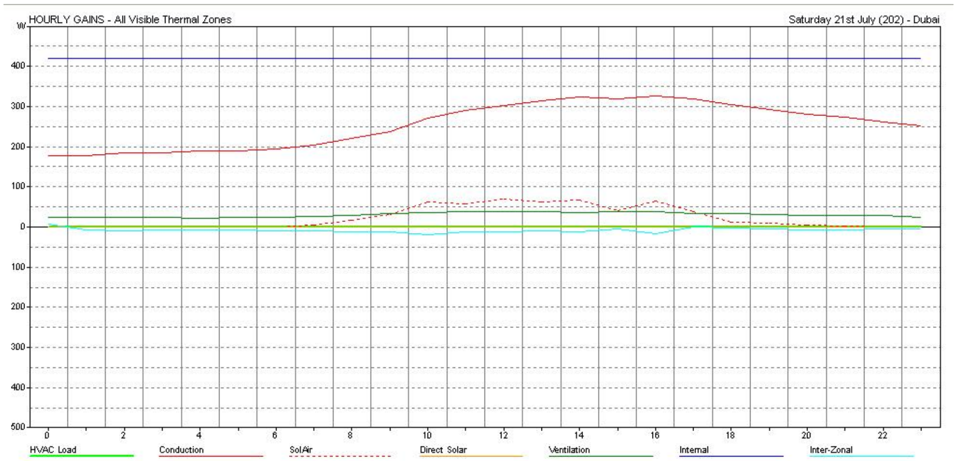


Figure 4.78 heat gain amount - big shading

C. lighting simulation

Figure 4.89 shows the 3d model of the building with the big shading devices used in this scenario.

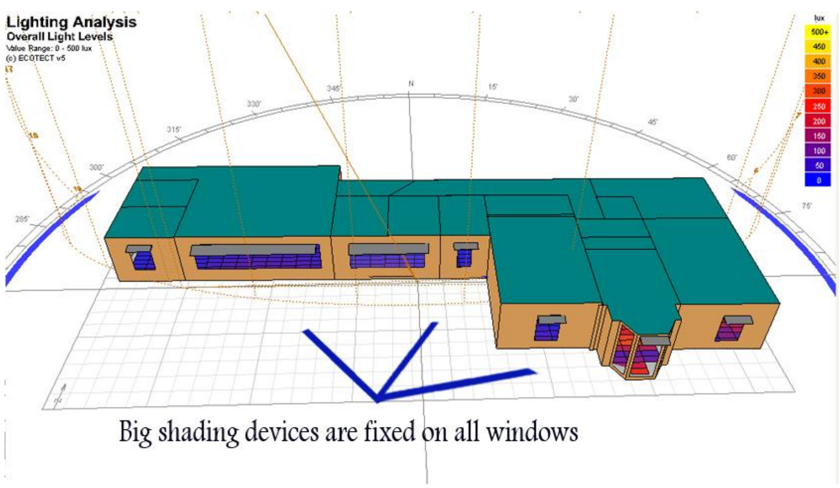


Figure 4.89 shows 3D model with big shading devices

-Daylight simulation

The day light simulation shows more decrease in the amount of daylight, this is due to the bigger shading device, daylight reduced to reach 100 lux all around the glazed area, and a small area around the entrance received 200 lux of light as shown on the analysis grid, figure 4.90. This big overhang blocked the excess direct sun rays from entering the exhibitions, which is more convenient for the museum. It also allowed for better uniformity in the received sun light than it in the previous small shading scenario. The overhang blocked the excess sun rays that was entering the building and creating un uniform strong light.

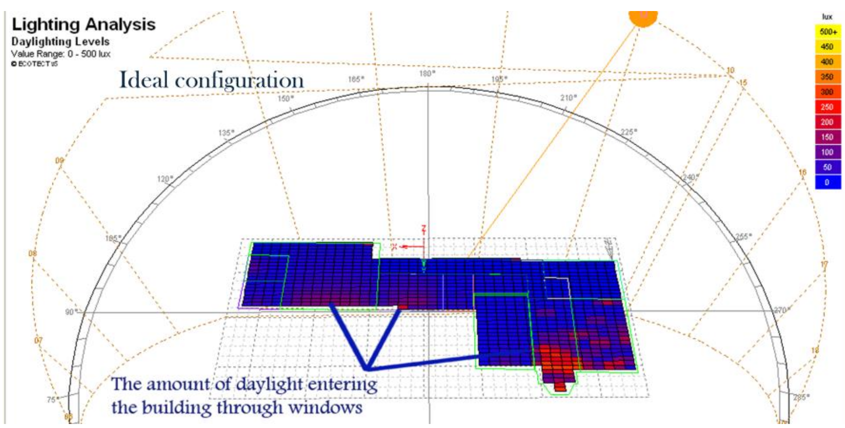


Figure 4.90 shows daylight penetration

-Electrical light simulation

Because of the decrease in day lighting in that took place there was a need to add more electrical light in order to provide the required light, this addition of electrical light usually will have an impact on the cooling load of in the building. , as shown in figure

4.91 the required amount of light (200-300) lux was provided. The lighting analysis grid shows that the provided electrical lights did provide a uniform pattern of light all over the inner space in the museum.

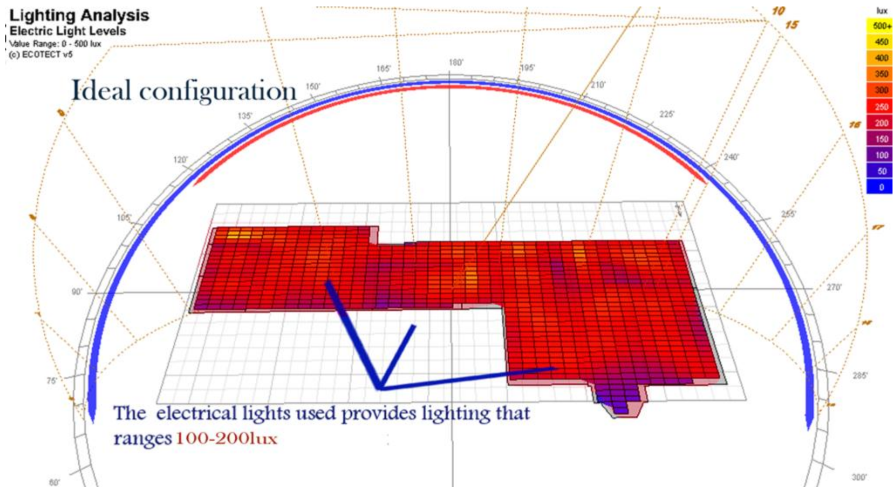


Figure 4.91 the distribution of electrical light- big shading

-Overall light simulation (Daylight +Electrical):

Shown in figure 4.92 the overall light simulation, This simulation was done to calculate the total amount light for both daylight and electrical light and show that is has reached the required amount of light. Overall lighting on the analysis grid is uniform and provided through both electrical and natural lighting. The overall light has reached the required amount of light 200 to 300 lux, needed for good vision in the museum.

Note that there are some dark areas on the analysis grid, this is because of some interior walls in the model as mentioned and shown before.

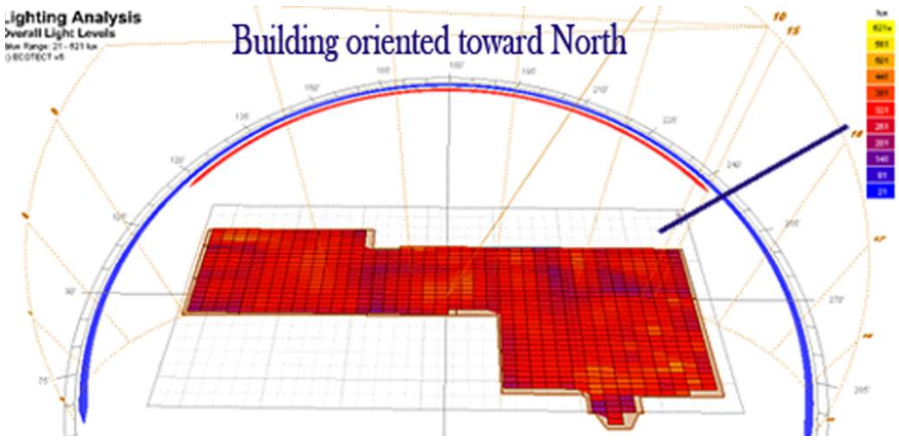


Figure 4.93 the distribution of overall light- big shading

D. The cooling and heating loads simulation:

The simulation shows in figure 4.94 that cooling load reached 36000 W, while in the first scenario (no shading) 37055 of watts were calculated; this means a 2.84 % decrease, again this decrease in the cooling loads is a consequence of having big shading device that blocked the unwanted direct solar rays.

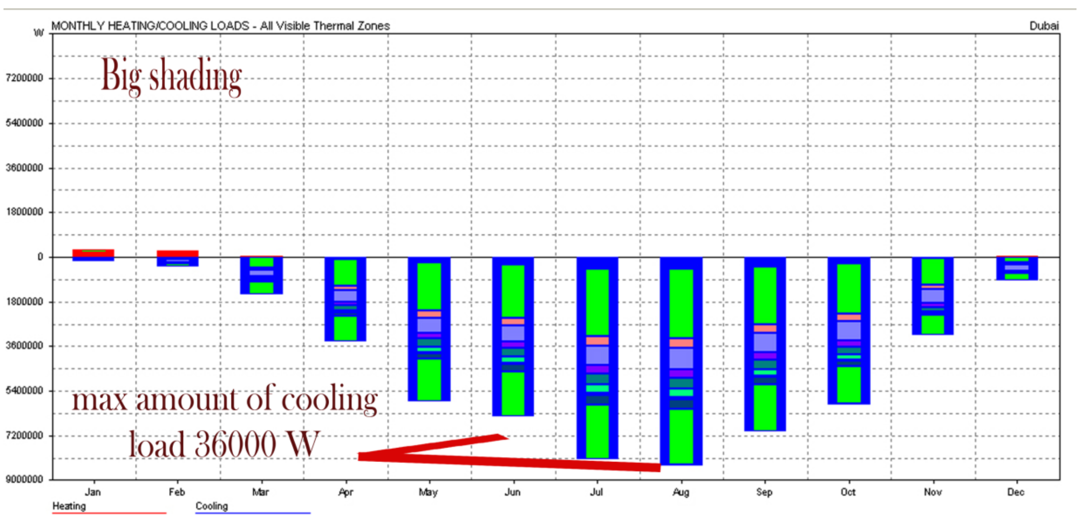


Figure 4. 94, the cooling and heating loads- big shading

Configuration results:

Table 4.11 represents the results of each of the shading configurations , the first configuration where windows were left without shading devices, second was windows were having small shading devices and third when windows had big shading device .

Table 4.11 Absorbed solar radiation, Heat gain and cooling loads amounts in each of the three shading configurations

Configurations			
	1st configuration (Base case)	**2nd configuration**	**3rd configuration**
External Shading device	No shading	Medium shading device	big shading device
Daylight penetration percentage	150-300 lux	100-240 lux	100-200 lux
Absorbed solar radiation range	20-70 W/m2	20-60 W/m2	10-50 W/m2
Heat gain range	240-400 W	200-360 W	190-320 W
Cooling loads	37055 W	36150 W	36000 W

1. () Best scenario () worst scenario

Heat gain conclusions:

The worse scenario happen in the first configuration where windows had no shading resulting in heat gain ranging between 250-400 W means an average of heat gain equals to 325 W. on the other hand the best scenario took place in the third scenario where glazing were having big shading device, resulting in less heat gain ranging between 190-320 W, means an average of heat gain equals to 255 W. this is a 21.5 % reduction in heat gain. Figure 4.95 a chart showing heat gain amounts in each of the shading configurations.

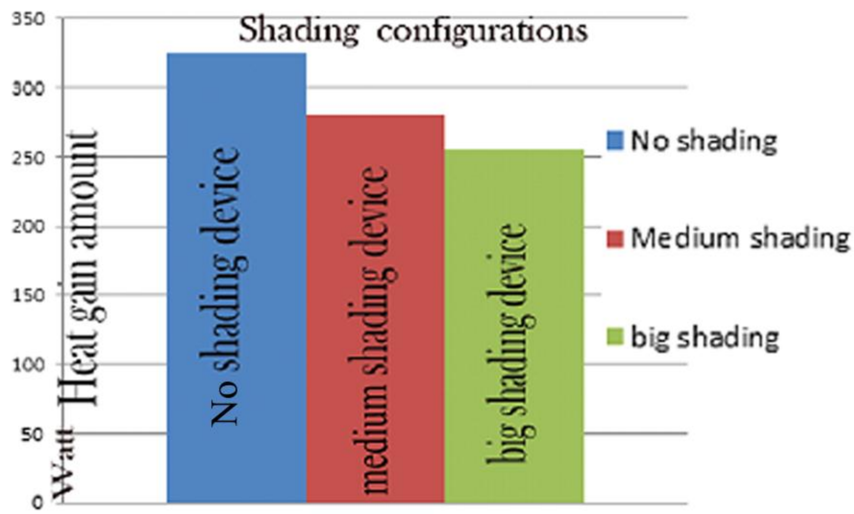


Figure 4.94 chart showing amounts of heat gain in each of the shading configurations

Absorbed solar radiation conclusions:

High amounts of Absorbed solar radiation happened in the first configuration where windows has no shading resulting in absorbed solar radiation ranging between 20- 70 W/m2 means an average of 45 W/m2 monthly solar radiation. on the other hand less amounts of Absorbed solar radiation happened in the last scenario where glazing were having big shading device, resulting in less absorbed solar radiation ranging between 20-60 W/m2, means an average of monthly solar radiation equals to 40 W/m2 this is a 34.0% reduction in Absorbed solar radiation .figure 4.95 a chart showing Absorbed solar radiation amounts in each of the shading configurations.

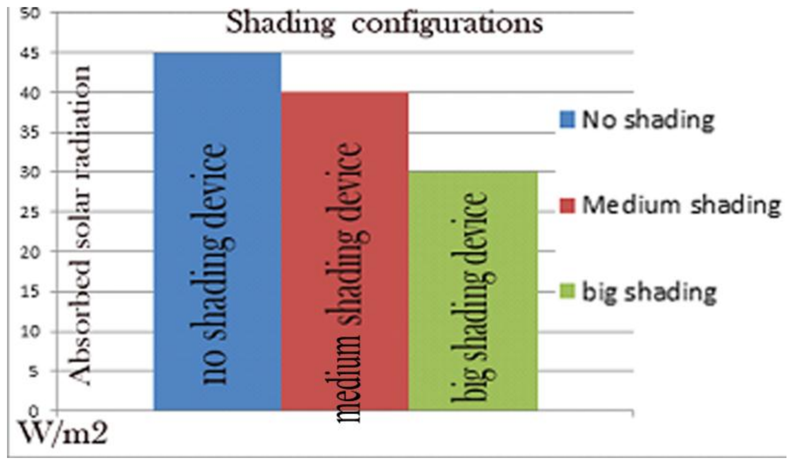


Figure 4.95 chart showing amounts of absorbed solar radiation in each of the shading configurations.

-Lighting conclusions:

In lighting simulations, different amount of daylight was received in the building in every shading scenario. The highest amount of direct light was received when the building was having no shading devices on its glazing, the amount of direct light on the un shaded scenario reached 240 lux on areas near the windows and the entrance glazing this is a big amount of sun rays have a negative impact on the museum displays, and has to be moderated through using a shading device to block the excess amount of sunrays that is received.

Later on, on small shading scenario, the lighting simulation showed that daylight received on the was less, the maximum amount of received light was 150 lux on areas near the windows and the entrance glazing, this is still a big amount of direct light penetrated into the exhibitions that has to be moderated in order to be suitable for the museum.

Later on, the amount of light in the big shading scenario reached 100 lux which is, which is considered the best scenario as it has less direct sun light penetration, so using bigger shading devices on southern windows is considered the best scenario since the sun rays received was less on this orientation, bellow in table 4.12 representing the amount of received daylight in each of the three shading configurations.

Table 4.12 amount of daylight penetration in each of the three shading configurations

Day light in each of the three shading configurations			
	1st configuration (Base case)	**2nd configuration**	**3rd configuration**
	No shading device	Small shading device	Big shading device
Day light	150-240 lux	100-150 lux	50-100 lux
Average daylight	195 lux	175 lux	75 lux

() Best scenario () worst scenario

Cooling load conclusions:

Cooling load as well was reduced when shading devices were used, in the first scenario (no shading) cooling load was 37055 W, then went down to become 36156 W in the second scenario (small shading), and then again in the final scenario (big shading) the cooling load went down again to become 36000W , this is a 2.4 % decrease in the cooling loads. On the other hand when lighting was tested , it was found out that when applying bigger shading devices there was a need for addition of electrical lights, this is a common effect of shading device which blocked some of the light penetrating into the building. Figure 4.95 a chart showing cooling load amounts in each of the shading configurations.

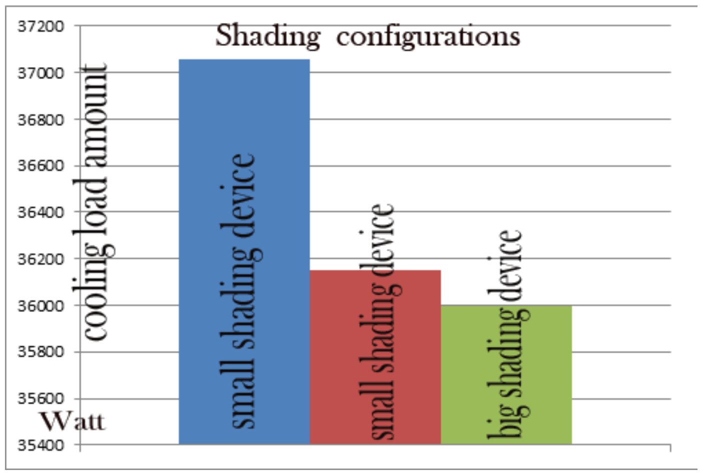


Figure 4.95 chart showing amounts of cooling load in each of the shading configurations

The following table 4.13 shows the reduction in absorbed solar radiation, Heat gain and cooling load this took place when in the shading configurations

Table 4.13 the reduction in absorbed solar radiation, heat gain and cooling load from 1st to 3rd configuration

Reduction from 1st -3rd configuration	**Absorbed solar radiation**	**Heat gain**	**Cooling load**
	34.0%	21.5 %	2.4 %

Overall results

The case study examined several passive design technologies, Building orientation, Thermal Insulation, Thermal mass, Glazing and shading. In each of these parameters several configurations were tested, cooling loads simulation results in each parameter were as follows:

-Building orientation:

The simulation results showed a relation between the building orientation and the cooling loads of the building. In the simulations, the highest amount of cooling loads was when the building was oriented toward south, cooling load reached 37055 W, and this is because of the solar gain received into the building through the southern windows. Later on when the building was reoriented to north the cooling loads decreased by 5.3%, this decrease happened because of the minimization of the southern glazing exposure. On the other hand the other two orientations east and west, the cooling loads were almost the same. Figure 4.96 shows the reduction in cooling loads that took place in every configuration and the total reduction from the first configuration to the last configuration.

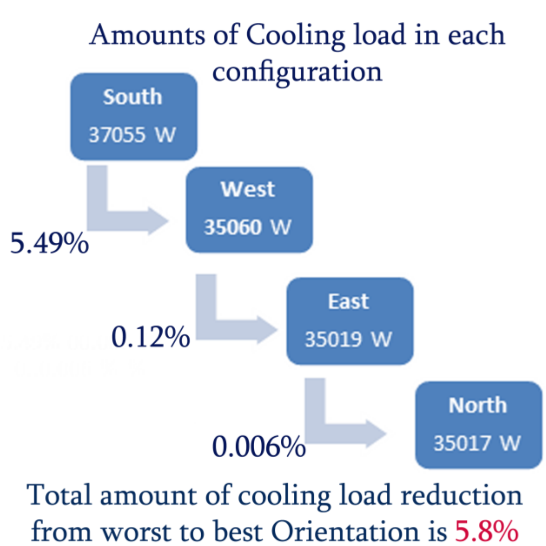


Figure 4.96 the amount of reduction in cooling load in each of the four orientations.

-Insulation:

Building's envelope constantly relates with the outside environment, and its performance has a great impact on the indoor environment and comfort conditions. The simulations results show a great reduction in room temperatures heat gain as well as cooling load when the insulation of walls and roof was better.

In the simulation, the highest amount of cooling loads appeared when building material has very low insulation (bas case), cooling load reached 37055 W. Afterword when the building material was changed to a good insulated material for both walls and roofs, the cooling loads decreased by 34.72 % , then in the third scenario the materials of walls and roof were changed to a higher insulated materials and this change resulted in a reduction in the cooling load that reached 50.35% . At last, in the fourth scenario the materials of walls and roof were also changed to high insulated materials which reflected a great reduction in the cooling load by 54.38 %, Figure 4.97 Shows the reduction in cooling loads that took place in every configuration and the total reduction from the first configuration to the last configuration.

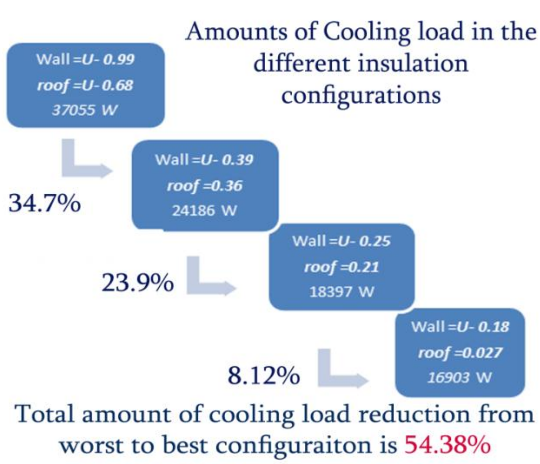


Figure 4.97 the amount of reduction in cooling load in each of the four insulation configurations.

Thermal mass:

Materials used for the building envelope affects the heat gain due to conduction happening through the fabric of the building itself, it impacts the cooling load of the building. In the thermal mass simulations results four different thermal mass building materials with different thickness were tested, in the cooling load simulations the worse scenario took place when materials with less thickness was used, the worse scenario for cooling load happen in the first configuration where Reinforced Concrete 4 inch (102 mm) was used for building walls resulting in cooling load of 31894 Watt. on the other the best scenario took place when building material was changed to another material with big thermal mass, this happen in the fourth configuration where Reinforced Concrete 10 inch (254 mm) was used for the building walls resulting in cooling load of 27271 Watt, this means 14.5 % reduction in cooling loads of the building took place by changing the building material from a low weight to high weight material. Figure 4.98 shows the reduction in cooling loads that took place in every configuration and the total reduction from the first configuration to the last configuration.

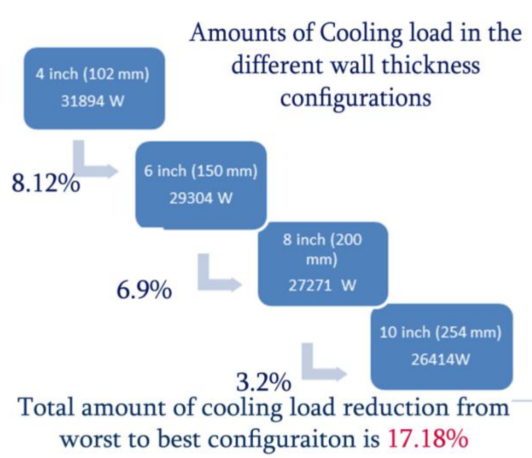


Figure 4.98 Amount of reduction in cooling load in each of the four insulation configurations.

Glazing:

high amount of cooling load was found in the first configuration where glazing area was big (42.501 m2) and made of single glazing, it resulted in cooling load amount of 37055 Watt, on the other hand less cooling load happened when the glazing area was minimized in the fourth configuration to 18.452 m2 resulting in less a cooling load amount of 34799 watt. This is a 6.0 % reduction in cooling load. Figure 4.99 shows the reduction in cooling loads that took place in every configuration and the total reduction from the first configuration to the last configuration.

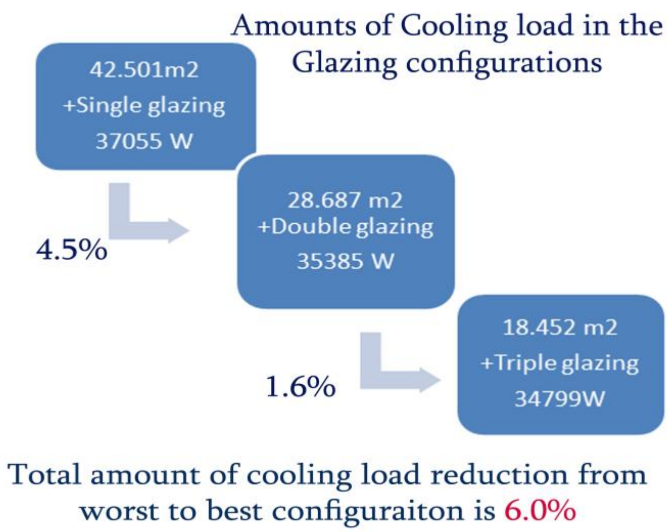


Figure 4.99 the amount of reduction in cooling load in each of the four insulation configurations.

Shading:

Shading are efficient for reducing heat gains in buildings, in in the first simulation scenario (no shading) cooling load was 37055 W, then went down to become 36156 W in the second scenario (small shading), and then again in the final scenario (big shading) the cooling load went down again to become 36000 W, this is a 2.8 % decrease in the cooling loads. Figure 4.100 shows the reduction in cooling loads that took place in every configuration and the total reduction from the first configuration to the last configuration.

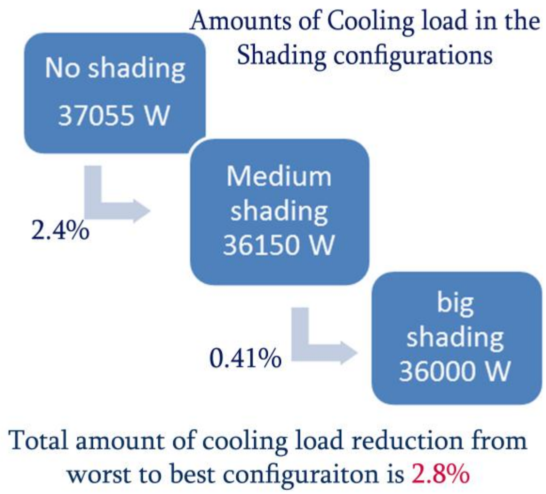


Figure 4.100 Amount of reduction in cooling load in each of the shading configurations

As noticed, results of the simulations showed different levels of impact on the overall cooling load in each passive technology; the following Table 4.14 represents the reduction amount of cooling load that took place in each parameter .it showing the most and the least influential parameter according the reduction in cooling load that took place each of the previous configurations.

Table 4.14 the cooling load reduction percentage in each of the five studied parameter (orientation-thermal insulation- thermal mass - glazing and shading)

Design parameter	Cooling load reduction
Orientation	5.38 %
Thermal Insulation	54.4 %
Thermal mass	17.18%

Glazing	6.0 %
Shading	2.8 %

4.6 Optimal case:

Based on all the previous simulations and analysis of all previous scenarios, an optimal configuration was made for the building made of the best scenario in each configuration, orientation, insulation, wall thickness, glazing and shading. The best scenario in each parameter is the scenario that has the least amount of cooling load. And then a model was composed and tested for absorbed solar radiation, heat gain and cooling load. To end with a comparison between the base case and the optimal case.

Base case and the optimal case layout:

The following table 4.15 represents the features of both, base case and the optimal case.

Table 4.15 Base case and optimal case configurations

	Base case configuration	**Ideal configuration**
Orientation	South	North
Insulation	*(Wall=U- 0.99, roof =U- 0.68)*	*(Wall = U- 0.18, roof = 0.027)*
Wall thickness	4 inch (102mm)	10 inch (254 mm)
Glazing area	42.501 m2 (7.9% flr area)	18.452 m2 (3.4% flr area)
Glazing type	single Glazing	triple Glazing
External Shading	no shading	big shading

Note: the same occupancy and building operation data of previous configurations are used as the following:

-Date of simulation: full day in summer (21 July)

-Museum hours of operation: 8 am – 6 pm

-Occupancy (m2/person) : 4 m2

-Persons type of activity: walking slow (115W)

-Sky IL luminance: 89146 lux (overcast sky conditions)

-Glass cleanliness: x0.90 (clean)

To explore the effectiveness of these passive technologies on the overall cooling load of the building. The optimal case also was simulated for lighting, absorbed solar radiation, heat gain and cooling loads, to be studied and compared with the base case.

1- Base case:

Since the base case was tested previously, its results will be used in this comparison with the ideal configuration; the following are the results of previously tested Base case configuration:

- Received daylight: 150-240 lux
- Absorbed solar radiation range: 20-70 Wh/m2
- Heat gain range: 220-400 W
- Cooling load: 37055 W

2- Optimal case:

<u>Calculating absorbed solar radiation:</u>

The absorbed solar radiation simulation was done as shown in the Figure 4.101, the figure shows a great reduction in the solar absorption which ranged from 10 Wh/m2 to 50 Wh/m2, that means an average of 30 Wh/m2 absorbed solar radiation.

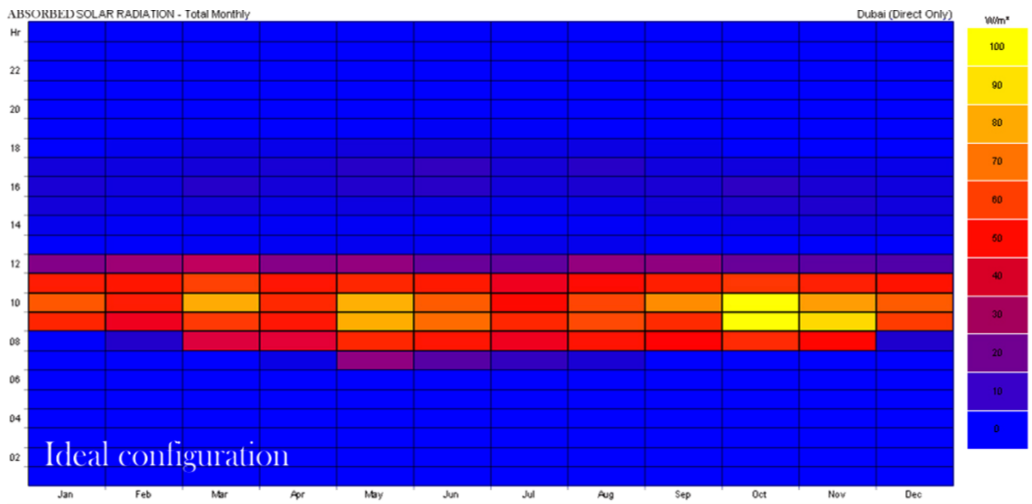


Figure 4.101 Total monthly absorbed solar radiations- Optimal case

A. Calculating heat gains:

Figure 4.102 below shows the great heat gain reduction, the red line that is representing the heat gain via conduction ranges between 100 and 150 W, clearly heat gain has sufficiently decreased.

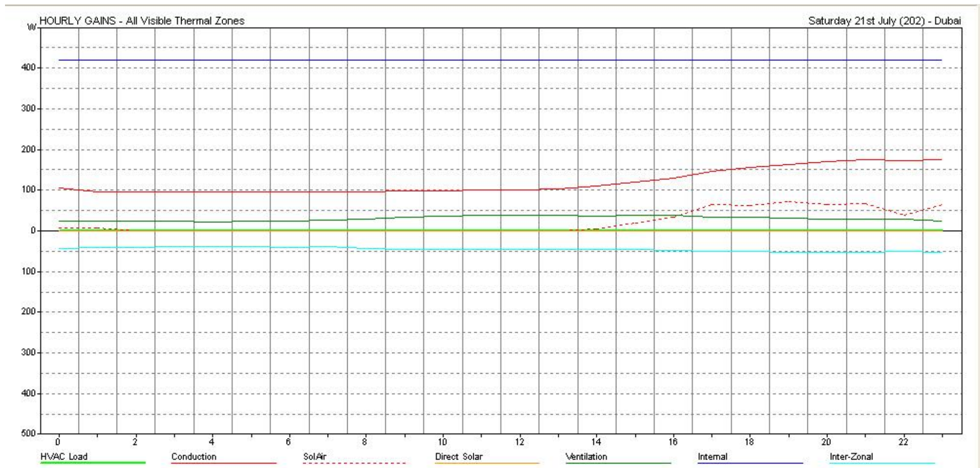


Figure 4.102 Heat gain amounts – Optimal case

B. Calculation cooling loads:

Figure 4.103 shows the heating and cooling loads for all zones of the model measured in Watts (W). , the cooling loads have sufficiently decreased to reach 14265 W.

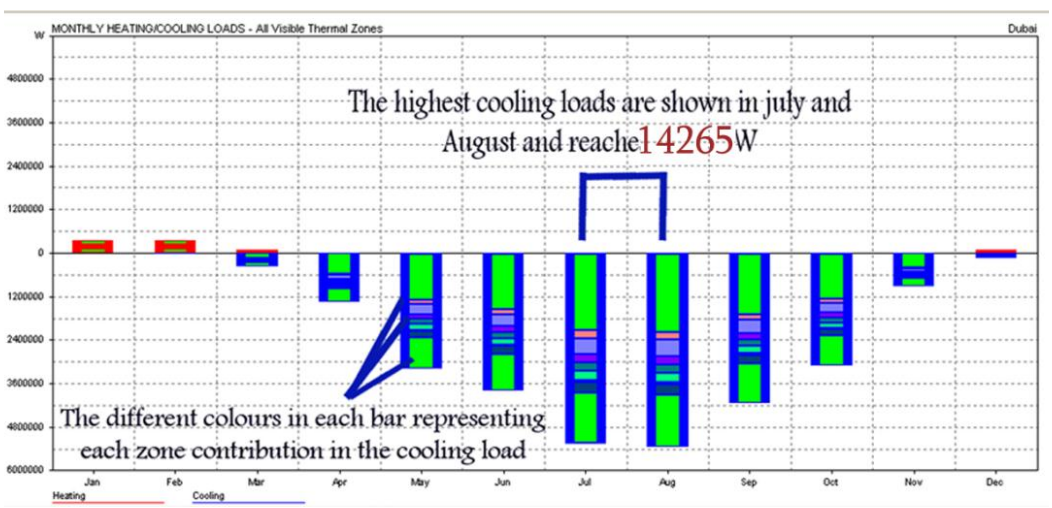


Figure 4.103 cooling loads amounts – Optimal case

C. Lighting analysis:

Figure 4.104 shows the 3d model of the building showing the big shading devices and smaller windows.

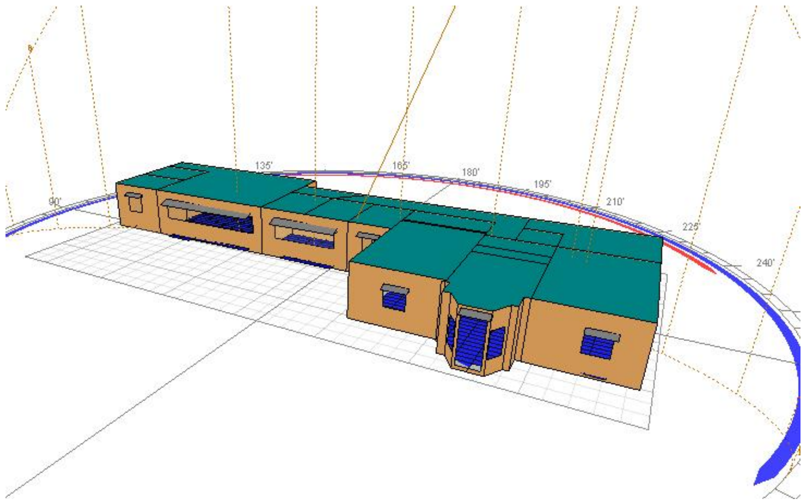


Figure 4.105 shows 3D model showing the smaller glazing and big shading devices

-Daylight simulation

The day light simulation analysis in figure 4.106 shows a decrease in the amount of direct light ,this is due to the less glazing and bigger shading that blocked the unwanted direct rays , light simulation shows 100-150 lux all around the windows, and 200 lux of light received entrance around. This is considered an appropriate amount of light penetration as it is within the required range (200-300) lux.

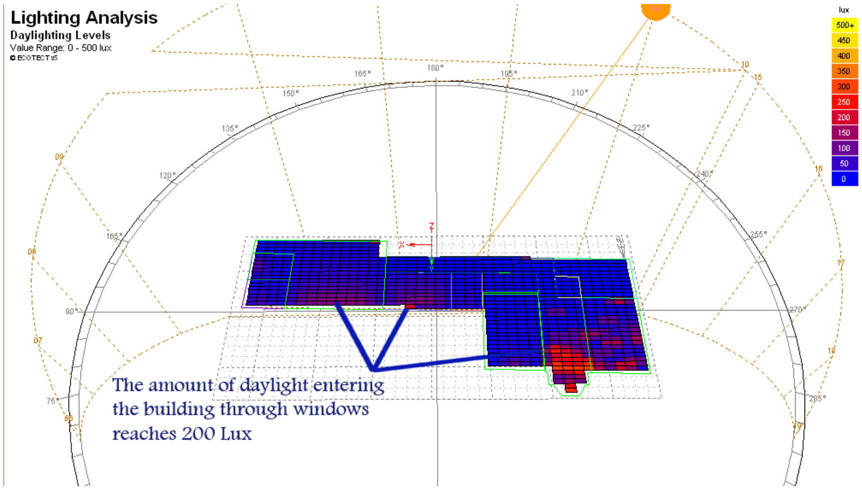


Figure 4.106 shows daylight penetration through glazing – Optimal case

-Electrical light simulation

Because of the decrease in day lighting that took place there was a need to add more electrical light in order to provide the required light, so the electrical lights where fixed on the ceiling of the model, then the electrical lighting simulation was done to display the amount of electrical lighting we have on the lighting analysis grid as shown in figure 4.107.

Note: the dark areas in the middle of the analysis grid are due to some interior walls as presented previously.

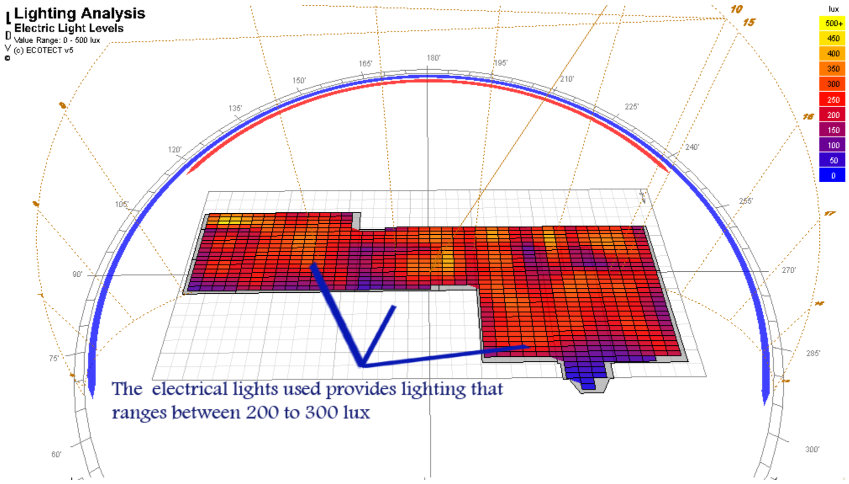


Figure 4.107 the distribution of electrical light excluding natural light – Optimal case

<u>-Overall light simulation (Daylight +Electrical):</u>

This simulation was carried out to calculate the total amount of light for both daylight and electrical light, figure 4.108 shows that lighting was reached the required amount of light (200-300) lux.

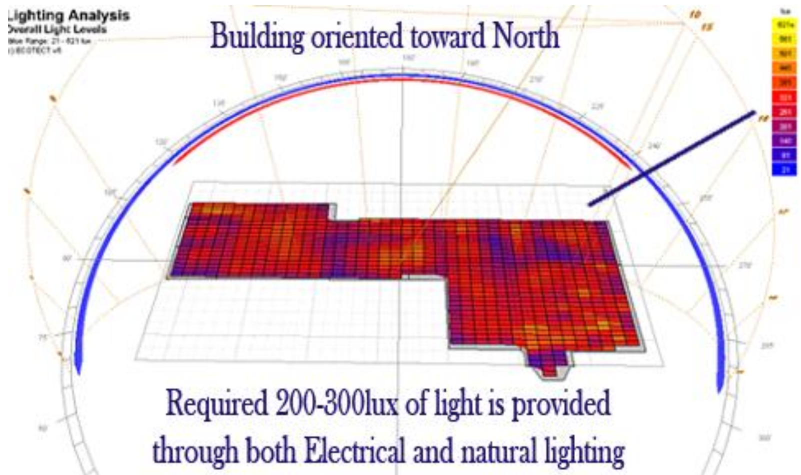


Figure 4.108 the distribution of overall light– Optimal case

“Base case” and “Optimal case” data comparison:

Both the base case and optimal case results were compared bellow table 4.16 represents the amount of absorbed solar radiation, heat gain, daylight and cooling loads of both the “Base case” and “optimal” configurations. There is a great reduction in all the tested simulations.

In the base case the building was oriented toward south which allowed for more absorbed solar radiation and heat gain through the building envelope.

Glazing in the base case was huge, this caused a big amount of heat gain due to the southern solar exposure, mentioning that windows in the base case were not shaded with any kind of shading device; this permitted the unwanted sunrays causing a high amount of absorbed solar radiation and heat gain.

Also the building in the base case was made with a very low insulated material that caused a higher heat gain via conduction, meaning that the building will be heated up quickly by the outside temperature fluctuation and as a consequence the building will need more air-conditioning in order to cool the indoor environment and reach the human comfort zone. And this means higher energy use.

Another factor is that building in the base case was designed with less thermal mass, wall thickness of the base case model was light , having a light weight construction made the heat flow via conduction higher. All these building design parameter of the base case caused more heat gain and as a consequence high cooling demand and electricity usage.

On the contrary, the optimal case building was designed with building technologies that made the building more energy efficient.

First the building in the base case was oriented toward the best orientation on the proposed site, this allowed for better lighting and less absorbed solar radiation and heat gain through the building envelope.

Glazing in the optimal case was in an appropriate size, this caused less amount direct solar gain, taking into consideration that windows were shaded with a big shading device; this shading device blocked the unwanted sunrays causing less amount of absorbed solar radiation and heat gain.

Also the building in the optimal case was made with a very high insulated material that reduced the heat gain via conduction; this means less need for air-conditioning for cooling the indoor environment and reaches the human comfort zone. Wall and roof insulation is recommended in hot humid climates like the climate if the UAE, this is because the sun is high so a thermal insulated material with a low U-value can effectively minimize heat gain in building. Using materials with high resistance such as glass fiber, or any high insulated material can reduce heat gains and losses indoor and minimize daily climate fluctuations

Another factor is that building in the optimal case was designed with a high thermal mass, the wall thickness of the base case model was big , and having such a heavy weight construction made the heat flow via conduction smaller, meaning that the building will have more time until its heated up by the outside temperature fluctuation and as a consequence the building will need less air-conditioning . All these building design parameter of the optimal case caused less heat gain and as a consequence less cooling demand and electricity usage.

Table 4.16 absorbed solar radiation, heat gain and cooling loads in the base case and the optimal case

	Base case configuration	**Optimal case configuration**
Absorbed solar radiation range	20-70 Wh/m2	10-50 Wh/m2
Heat gain range	220-400 W	100-150 W
Cooling loads	37055 W	14265 W

According to the simulation results in both configurations, presented in the previous table 4.16. The following reduction in cooling load took place:

- Absorbed solar radiation reduction: 64.7%
- Heat gain range reduction: 39.28%
- **Cooling loads reduction: 56.82 %**

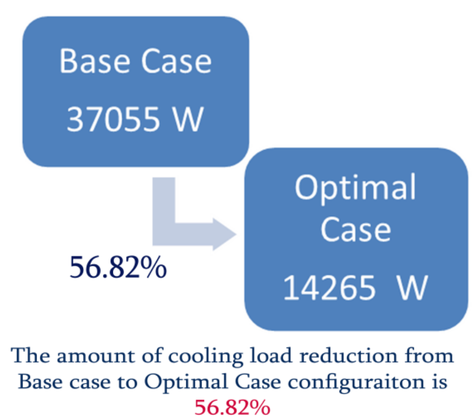


Figure 4.109 the amount of reduction in cooling load in "base case" and "optimal case" configurations

This reduction in cooling load in the optimal case proofed that applying design strategies such as building orientation, insulation, thermal mass, glazing and shading can sufficiently decrease the cooling load and as a consequence minimize the energy use.

From this case study we learn that environmental strategies and passive design elements like Site and Orientation, insulation , Thermal Mass ,glazing size and properties as well as external Shading, proven that they have a great effect on the thermal efficiency of the building. They demonstrated that building design can develop occupant comfort by offering protection from undesirable forms of heat and energy. And throughout properly applied passive design ideology, can significantly reduce building energy requirements. And implementing passive design approaches to the fullest level possible we can minor building energy use.

CHAPTER FIVE Conclusion and Recommendations

5.1 Conclusion

Green building and energy conservation strategies provide valuable insight into how the world can sustain itself for the future. Sustainable development strategies using solar energy, passive cooling techniques like orientation, insulation, thermal mass, glazing and shading are the key to energy consumption reduction in construction.

This study analyzed the impact of applying these design strategies on the absorbed solar radiation, heat gain, cooling loads as well as the amount of light penetration in museum buildings. The study showed how applying these passive design strategies can enhance the indoor environment inside the museum.

Building orientation has an impact on absorbed solar radiation, heat gain, cooling loads as well as the amount of light penetration. In the case study when building was oriented toward the south which is considered the worst orientation on the studied location, the simulation results showed a relation between the building orientation and the cooling loads of the building. In the simulations, the highest amount of cooling loads was when the building was oriented toward south, cooling load reached 37055 W, and this is because of the solar gain received into the building through the southern windows. Later on when the building was reoriented to north the cooling loads decreased by 5.3%.

Building orientation also had an impact the amount of light penetration in to the building, The highest amount of direct light was received when the building was oriented toward south, the amount of direct light on south reached 240 lux on areas near the windows and the entrance glazing, this is a big amount of sun rays have a negative impact on the museum displays, but was moderated by changing the orientation of the building toward the best orientation “north”, the lighting simulation showed that daylight received on the north orientation is less, it reached 200 lux on areas near the windows and the entrance glazing which is more convenient amount of light.

Wall and roof insulation of the building has no effect on received lighting amount but it proofed that is has a very big impact on the amount of absorbed solar radiation, heat gain and cooling load . Because building’s envelope constantly relates with the outside environment and its performance has a great impact on the indoor environment and comfort conditions.

In the insulations simulations, results showed a great reduction in room temperatures heat gain as well as cooling load. In the first scenario where the insulation of walls and roof was low, a high amount of cooling load was there, while in the fourth scenario where a high insulated material was used ,the materials insulation had a great impact on the cooling load of the building , a reduction in the cooling load by 54.38 % took place.

Thermal mass of the building has no impact on the amount of light penetration but has a great impact on its cooling loads, Materials used for the building envelope affects the heat gain due to conduction happening through the fabric of the building itself, it impacts the cooling load of the building. In the thermal mass simulations results four different thermal mass building materials with different thickness were tested, in the cooling load simulations the worse scenario took place when materials with less thickness was used, the worse scenario for cooling load happen in the first configuration where a 4 inch (102 mm) wall thickness was used for building walls resulting in cooling load of 31894 Watt. on the other the best scenario took place when building material was changed to another material with big thermal mass, this happened in the fourth configuration where a 10 inch (254 mm) wall thickness was used for the building walls resulting in cooling load of 27271 Watt, this means 14.5 % reduction in cooling loads of the building took place by changing the building material from a low weight to high weight material.

Glazing size and properties has an impact on both, daylight penetration as well as cooling loads of the building, high amount of cooling load was found in the first configuration where glazing area was big (42.501 m2) and made of single glazing, it resulted in cooling load amount of 37055 Watt, later on less cooling load happened when the glazing area was minimized in the fourth configuration to 18.452 m2 resulting in less a cooling load amount of 34799 watt. This is a 6.0 % reduction in cooling load.

Glazing size and properties also impacts the amount of penetrated sun light inside the museum, in lighting simulations, different amount of daylight was received in the building in every configuration. The highest amount of direct light was received when the building was having a big glazing, the amount of direct light in the big glazing scenario reached 240 lux, while the amount of light in the last scenario where smallest windows were used reached 150 lux, this proofs that remodeling glazing size and properties can have a good impacts the amount of penetrated sun light inside the museum.

Shading devices proof they are efficient for reducing heat gains in buildings, in the first simulation scenario (no shading) cooling load was 37055 W, in the final scenario (big shading) the cooling load went down to become 36000 W, this is a 2.8 % decrease in the cooling loads.

Shading devices also blocked the unwanted sun rays penetration into the museum exhibitions, the amount of direct light penetration was reduced from 240 lux to 150 lux by adding a big size shading device that blocked the excessive sunrays penetration and helped in having a more uniform distribution of daylight inside the museum.

5.2 Recommendations

All countries must implement green building strategies using solar energy and other alternative power sources to produce passive cooling and thermal mass to reduce energy consumption. Partnerships with international energy providers for green building energy conservation to develop the worldwide built environment will create a continuous global network of strategic alliances, knowledge, information and communications throughout the different divisions and related organizations that will increase environmental sustainability, productivity and efficiency. International governments should implement more green building strategies integrating passive cooling and thermal mass to reduce energy, water and electricity consumption to increase long-term environmental sustainable development.

Some of the green building energy conservation recommendations that nations can implement for their future sustainable environmental development include:

- Integrate passive cooling into green building strategies to provide better indoor environment that will reduce air conditioning and electricity charges
- Incorporate thermal mass into green building strategies to reduce energy and heating costs by using solar energy panels to capture and store natural heat and natural light to use later.

- Use passive cooling techniques like shading devices, window design and building orientation to decrease internal heat from direct sunlight to reduce energy consumption and increase thermal comfort for all buildings
- Use passive building strategies that incorporate shading devices into the building to reduce the need for air conditioning.
- Use passive building strategies that incorporate building insulation into the building to reduce the electricity use.

5.3 Future work:

The field of solar energy passive cooling techniques is enormous and not studied enough especially in our region and more work is needed in this field, future works might include the followings:

- Natural day lighting for museum galleries in hot climates including the use of natural day lighting in corridors and galleries, studying the fact that direct daylight can be harmful to works of art.

- Studying the practicality of building passive solar design, the cost benefits and sustainability issue.

- Thermal mass in passive solar and energy conserving museums study, outlining the museums thermal performance and activities at each level of investigation for the thermal mass.

- The high potential of minimizing energy consumption in passive designs necessitate a research on the cost of construction of such buildings to estimate the cost benefit when compared to energy saving.

REFERENCES

Aaron, P. (2012). Federal High Performance and Sustainable Buildings. National Institute of Building Sciences.

Al-Marashi, H, Salama H. (2008). Encouraging sustainable urban development in the UAE. UAE Government Urban Planning.

Andamons,Myle, M. (2010). Thermal Comfort and Building Energy Consumption in the Philippine Context. RMIT.

Anderson, Parry & James T, Parry & James T. (2011). ANSI-ASHRAE Standard 55. Thermal environmental conditions for human occupancy.

Arnold, T, Brandlhofer S, Vrtikapa K. (2010). Sustainability the new buzzword in UAE growth. The National.

Badih, S. Haynes B, Matzdorf F .(2011). Arabian Construction Company wins 750 million Masdar contract. Gulf News.

Bradfield, V. (2009). UAE financial crisis unique opportunity for green growth shift. UN Economic and Social Commission for Asia and the Pacific (UNESCAP). Available from: http://www.greengrowth.org/ [Accessed 22. Jan 2012]

Bradford, T. Leaman A, Bordass B. (2008). Sustainable. Whole Building Design Guide. Available from: http://www.wbdg.org/design/sustainable.php [Accessed 15. Jan 2012]

Collett, P. Graham P (2009). All along the water table. Construction Week.

Allen T, Bell A. Davidson, C. (2005). The UAE: A Study in Survival. Boulder: Lynne Riencer Publishers.

Davidson, Onifade, E. Davidson, W. Campbell, C (2009). International: Oil and beyond. NY: Hurst.

Davidson, C. (2009). International's New Economy. NY: Hurst.

Davidson, C. (2011). International's new economy: Oil, investment and domestic development. Middle East Policy, Vol. 16, No. 2.

Dominic, J. Haynes B, Matzdorf F. (2011). Low-carbon future will require strong partnerships. The National.

Everett, J. Zweibel, E (2011). UAE. EIA. Available from: http://www.eia.gov/cabs/UAE/Full.html [Accessed 2nd. March 2012]

Fromonot, F. (2009). Glenn Murcutt's ecological architecture. *Progressive Architecture*, Vol. 75, No. 4.

Gore, A ,Marion W, Urban K.. (2007). The Inconvenient Truth Documentary.

Gould, C. (2010). Writing, Reading and research. NJ: Blackwell Publishing.

Granger, T, Marsh A .(2009). Energy consumption. USGBC. Available from : http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220 [Accessed 20. March 2012]

Greer, L, Nabil A , Perez R. (2011). International's Nuclear Plan. Middle East Economic Digest (MEED).

Guy, S , Michalsky J, Stewart R.. (2010). Reinterpreting Sustainable Architecture: The Place of Technology. BBC.

Hamad, A. (2010). International's Economic Policy Priorities. Masdar City. Available from: http://www.masdarcity.ae/userfiles/files/economic-vision-2030-section-1.pdf [Accessed 22. April 2012]

Hamner, S, Perez H. (2007). World's first carbon-free city. Business.

Hancock, P. (2010). A meta-analysis of performance response under thermal stressors. Human Factors, Vol. 49, Issue 5.

Harrison, W, Reinhart CF, Herkel S. (2011). UAE. Economy Watch.

Hartsig, W. (2007). Emirates Investments. Business Week. Available from: http://investing.businessweek.com/research/stocks/snapshot/snapshot.asp?capId=20358598 [Accessed 20. April 2012]

Hartsig, W, Nelson, R. (2007). UAE Investments. Business Week. Available from: http://investing.businessweek.com/research/stocks/snapshot/snapshot.asp?capId=20358598 [Accessed 18. March 2011]

Hauck, T, Rogers Z . (2009). Electro-Thermal Simulation of Multi-channel Power Devices: From Workbench to Simplorer by means of Model Reduction. NAFEMS.

Hope, B, Tregenza PR, Waters IM. (2009). Al Jaber secures Masdar deal. The National.

Hraiz, A, Shakespeare R, Ward G. (2011). Rooted in sustainability. AD Council For Economic Development.

Hui, S. (2002). Sustainable Environment. Environmental Architecture. Available from: http://www.arch.hku.hk/research/BEER/sustain.htm [Accessed 13. Nov 2011]

Inskeep, S, Won, U. (2008). Oil-rich AD builds renewable-energy city. NPR.

Jabareen, Y. (2009). Sustainable Urban Forms Their Typologies, Models, and Concepts. Green Building Designs.

Jaber, A. (2007). Gulf States. AXT. Available from: http://www.axt.org.uk/antisem/archive/archive1/gulfstates/ [Accessed 18. Feb 2012]

Jassim, A. (2009). Masdar HQ to be located in world's first positive energy mixed-used building. Masdar.

Jassim, A, Ian M Grey ,Whitford, ,. (2010). The International Economic Vision 2030. Executive Council. Available from: http://www.tdic.ae/en/media/get/20110814_economic-vision-2030-executive-summary-mandate2propertypdf.pdf [Accessed 16. Jan 2012]

Karim, L. (2000). Growing Nations. Gulf States. Available from www.gulfstates.org/

Karim, L. (2009). Growing Nations. Gulf States. Available from: www.gulfstates.org/ [Accessed 22. April 2012]

Karim, M. (2011). UAE, South Korea promoting political and economic partnership. UAE Arab Network.

Klein, G. (2012). ADIB's International headquarters bags LEED Gold Pre-Certification. World Interior Design Network.

Klosterman, R. (1985). Arguments For And Against Planning. Town Planning Review, Vol. 56, Issue 1.

Knight, A. (2008). Advanced Research methods in the built environment. NY: Wiley-Blackwell.

Krause, B, Sergey ,P. (2011). Impact of indoor air temperature and humidity in an office on perceived air quality, SBS symptoms and performance. International Center for Indoor Environment and Energy.

Kulatilaka, N, Klosowski, J.. (2011). Green revolution: A sustainable energy path. Boston University.

Landais, E. (2011). UAE's energy use. Gulf News.

Lewis, B, Raton, C. (2010). UAE sustainable growth. Reuters.

Lewis, J . (2007). Fundamentals of Project Management. American Management Association.

Marashi, H. (2006). Encouraging sustainable urban development in the UAE. UAE Urban Development Magazine.

Martin, B. (2006). Investing in Emirates. Emirates Investment Promotion Department. Available from: http://www.investinuae.com [Accessed 27. March 2012]

Martin, B. (2006). Investing in the UAE. The UAE Investment Promotion Department. Available from: http://www.investinuae.ae/ [Accessed 18. March 2012]

Martin, D, Wolf, A. (2011). Human Development Report 2011. United Nations. Available from: http://www.beta.undp.org/undp/en/home/librarypage/hdr/human_developmentreport2011.html [Accessed 18. Dec 2011]

Mays, V, Roodman, D, wolf, D (2008). Positive energy. Architect, Vol. 97, No. 8.

Mesbah, R, Enkvist, P. (2011). Plan International 2030. AD Urban Planning Council.

Moody, D, Rodolf, A. (2009). Empirical research methods. IDI.

Myhren, J. (2008). Flow patterns and thermal comfort. Energy and Buildings, Vol. 30, No. 4.

Nambiar, S. (2011). Masdar Institute. Architectural Record.

Omer, W ,Qenssen, N.. (2008). Renewable building energy systems and passive human comfort solutions. Renewable Sustainable Energy Reviews, Vol. 12, No. 6.

Ottoman, W. (2011). UAE. World Development Indicators Database.

Perrault, N, Rambiar, M . (2011). Masdar City, International, implements renewable energy and raises the standard for others to follow in its carbon-free footsteps. Drake Journal.

Peterson, E. (2010). UAE Services Location Index. AT Kearney.

Peterson, E. (2011). Offshoring opportunities amid economic turbulence. AT Kearney.

Peterson, M. (2008). Sustainable building materials. Informed Building. Available from: http://www.informedbuilding.com/Informed-Materials/Main7/Characteristics-of Sustainable-Building-Materials/ [Accessed 20. Feb 2012]

Peterson, T. (2010). Report on the World Commission on Environment and Development. United Nations.

Philips, W. (2006). New Urbanism. TOD. Available from: http://www.transitorienteddevelopment.org/ [Accessed 18. Jan 2012]

Salama, M. (2010). Green buildings and sustainable construction in the UAE. Heriot Watt University.

Salama, S. (2008). New Emiratization Drive. Gulf News.

Salama, S. (2010). New work permit rules in UAE from 2011 will ease job switch. Gulf News.

Saleem, N. (2010). Sustainability remains key to UAE's future. Gulf News.

Santamouris, M. (2005). Passive cooling of buildings. Advances in Solar Energy.

Schmitz, J, Jonson, K. (2011). UAE competitiveness report 2011-2012: UAE ranked in the highest stage of economic development as innovation-driven economy. UAE Chronicle. Available from: http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2010-11.pdf [Accessed 11. Feb 2012]

Schwab, K. (2011). The UAE competitiveness report 2010-2011. World Economic Forum.

Shaw, R. (2007). *Climate change adaptation by design: A guide for sustainable communities*. London: TCPA.

Tolat, D, Venkes, L . (2010). Using LEED on Building projects. National Institute on Building Sciences.

Yu, W. (2011). Analysis of a Residential Building Energy Consumption Demand Model. Energies 2011, Vol. 4(3).

Zikmund, W. (2003). Business Research Methods. Australia: Thomson.

Bibliography

Aalton, C ,Wolf, G. (2012). Thermal comfort. Canadian Center for Occupational Health and Safety.

Abbas, W. (2011). IMF doubles global growth to 1.3% in 2010. Emirates 24/7.

Abu Baker, M. (2008). UAE Service Sector. UAE Government Portal. Available from: http://www.dubai.ae/en.portal?topic,Article_000239,0,&_nfpb=true&_pageLabel=home [Accessed 23. Jan 2012]

Ahmad, M, Gelman ,K. (2010). UAE will continue to use oil wealth to fuel sustainable economic growth. Business Intelligence Middle East

Ahmed, M. (2007). New Initiative for the UAE. Emiratization. Available from: http://www.emiratization.com [Accessed 20. Feb 2012]

Ahmed, M. (2011). UAE. The World Factbook. Available from: https://www.cia.gov/library/publications/the-world-factbook/geos/ae.html [Accessed 13. Jan 2012]

Ahmed, R. (2008). UAE Governments. General Information Authority (GIA). Available from: http://www.gia.gov.ae/giawebsite/arabic/index.asp [Accessed 3. Feb 2012]

Al Lawati, A. (2009). Masdar Plan. The Economist.

Allen, P, Roodman, N, Zelson,W. (2002). Transportation, Infrastructure, Environment. Dreso. Available from: http://www.dreso.com/page/media/en/broschueren/standortbroschueren/pdf-broschueren/SB_DS_Infra.pdf. [Accessed 22. Jan 2012]

Allen, P, De Buyl, F. (2007). Transportation, Infrastructure, Environment. UAE: UAE Printing Press.

Al-Maktoum, M. (2006). Highlights Dubai Strategic Plan—2015. UAE: Dubai Printing Press.

Alnasrawi, A. (2001). Oil, Sanctions, Debt and the Future. Casi. Available from: www.casi.org.uk/info/alnasrawi.html [Accessed 3. March 2012]

Arens, E. (2006). Partial and Whole-body Thermal Sensation and Comfort: Uniform Environmental Conditions. Journal of Thermal Biology, Vol. 31.

Arora, A, Carbary, L ,Fiby, A. (2001). Markets for Technology. Cambridge: MIT Press.

Augustine, B. (2008). UAE's non-oil GDP to exceed 70%. Gulf News.

Bakr, A. (2009). UAE sees energy plant ready in 2015. IAEA.

Bakr, A. (2010). UAE eyes sustainable growth. Reuters.

Baltagi, B. (2006). Econometric Analysis of Panel Data. NY: Wiley & Sons.

Bardi, E. (2006). Management of Transportation. NJ: Thomson South-Western.

Barney, J. (2005). Looking Inside for Competitive Advantage. The Academy of Management Executive, Vol. 9, No. 4.

Barney, J Carbary, L, Hayez, V. (2007). Firm resources and sustainable competitive advantage. Journal of Management, Vol. 17, No. 1.

Barras, R, Wiseman, K. (2008). Towards a theory of innovation in services. Research Policy, Vol. 15.

Basit, A, Sartori, I, Hestnes,G. (2011). UAE's economic growth engines recovering well. Khaleej Times.

Bell, M. (2004). Environmental Sociology. London: Pine Forge Press.

Bennett, R. (2007). International Business. London: Prentice Hall.

Beynon, J. (2000). Globalization: The reader. NY: Routledge.

Bishop, L. (2006). UAE's Real Estate Expansion. UAE: The Emirates Center for Strategic Study and Research.

Bishop, M, Hestnes,O. (2010). Regulatory reform and productivity growth in the UK's public utilities. Applied Economics, Vol. 24.

Blaikie, N , Lenssen, N. (2007). Approaches to Social Enquiry. Cambridge: Polity.

Block, E. (1971). Accomplishment/Cost: Better Project Control. Harvard Business Review, Vol. 49, Issue 3.

Boddy, D , Roodman, W. (2002). Leadership in Management. London: Prentice Hall.

Brager, G. (2010). Thermal adaptation in the built environment. Energy and Buildings, Vol. 27, Issue 1.

Brooks, M, Wolf, K. (1988). Four Critical Junctures In The History Of The Urban Planning Profession. Journal Of The American Planning Association, Vol. 54, Issue, 24.

Brugmann, J. (2009). Welcome to the urban revolution: How cities are changing the world. London: Bloomsbury Press.

Byrne, D, Buyl, F. (2001). Understanding the Urban. UK: Palgrave.

Campbell, D, Elmond ,Z. (2010). The democracy ranking of the quality of democracy. Democracy Ranking. Available from: http://www.democracyranking.org/en/index.htm [Accessed 13. Jan 2012]

Carter, T. (2007). The UAE. UK: Longman.

Cavusgil, T, Lenssen, N. (2009). Conducting market research for international business: GMOA. NY: Business Expert Press.

Chaffee, E, Zseman, A. (2008). Three Models of Strategy. Academy of Management Review, Vol. 10, No. 1.

Chaffey, D, Rodolf, A. (2006). Business Management. NJ: Pearson Education Ltd.

Chakravorti, B. (2007). The slow pace of fast change. MA: Harvard Business School Press.

Challenger, J. (2009). There is No Future in the Workplace. Public Management, Vol. 81, Issue 2, 20-24.

Chamoun, Y. (2008). Professional Project Management. NJ: McGraw-Hill.

Chiras, D. (2011). The solar house: Passive heating and cooling. Chelsea Green.

Christensen, C, delmands F. (2007). The innovator's Dilemma. MA: Harvard Business School Press.

Chynoweth, P. (2010). The built environment interdiscipline: A theoretical model for decision makers in research and teaching. Hong Kong: CIB Working Commission Building Education and Research Conference.

Coulton, B, Relman,E. (2008). GCC faces inflation flare-up as money supply surges. Silo Breaker.

Crampton, P. (2005). UAE Tourism. UAE Pages. Available from: www.UAE-pages.org/tourism/shopping.html [Accessed 4. March 2012]

Crampton, P. (2005). UAE Tourism. UAE Pages. Available from: www.UAE-pages.org/tourism/shopping.html [Accessed 22. Jan 2012]

Crawford, K. (2011). UAE. World Economic Outlook Database.

Crawford, L, De Zeyl, F.(2009). Abu Dhabi Open For green building strategies. All Business.

Cromwell, R. (2007). Fighting Traffic with Technology. The Futurist, Vol. 34, Issue 5.

Darby, S, Lency,L. (2005). Thermal comfort. Environmental Change Institute, University of Oxford.

DeLaCruz, M. (2006). Economic Highlights of UAE. Credit Guarantee Report. Available from: http://www.creditguarantee.co.za/report.asp [Accessed 13. Jan 2012]

DeLaCruz, M, Larny,O. (2008). Economic Highlights of UAE. Credit Guarantee Report. Available from: http://www.creditguarantee.co.za/report.asp [Accessed 13. Jan 2012]

Delgadillo, R. (2009). Future historians: Their quest for information. College & Research Libraries.

Dellinger, A. (2005). Validity and the review of literature. Research in the Schools, Vol. 12, No. 2.

Duch, R, Renzan, C. (2004). It's not whether you win or lose. American Political Science Review.

Dulaimi, M. (2004). Managing Change. Boston: Pearson Education.

Dunston, L. (2006). UAE. UAE: Motivate Publishing.

Edge, A,kelman ,A. (2009). Copenhagen climate change conference 2009. The Guardian.

Elliott, C, Zecker, R. (2011). Country profiles: Human Development Indicators. Human Development Report. Available from: http://hdr.undp.org/en/data/profiles/ [Accessed 22. Jan 2012]

Fahey, L. (2006). Linking e-business and operating processes: The role of Knowledge Management. IBM Systems Journal.

Fisher, R. (2008). The UAE. The World Factbook. Available from: https://www.cia.gov/library/publications/the-world-factbook/print/ae.html [Accessed 12. Jan 2012]

Fleming, Q, Zelman,E. (2003). What's Your Project's Real Price Tag? Harvard Business Review, Vol. 81, Issue 9.

Foglesong, R. (1996). Readings In Planning Theory. MA: Blackwell Publishers.

Folke, G. (2001). Turning problems into advantages. Holon. Available from: http://www.holon.se/folke/written/stuff/ines/FEASTA2.pdf. [Accessed 16. March 2012]

Fox, J. (2006). Globalization and the Gulf. NY: Routledge.

Francis, J. (2011). Thermal Mass. Australian Government. Available from: http://www.sustainability.vic.gov.au/resources/documents/Thermal_mass.pdf [Accessed 22. Jan 2012]

Francis, K, Buyl, P. (2007). UAE Events of 2006. World Report 2007.

Freestone, R. (2000). Urban Planning. London: Taylor and Francis Group.

Friedmann, J. (1987). Planning In The Public Domain. Princeton: Princeton University Press.

Gaffikin, F. (2006). New Visions for Old Cities: The Role of Visioning in Planning. UK: School of Environmental Planning.

Galbreath, J. (2006). Corporate social responsibility strategy: strategic options, UAE considerations. Corporate Governance, Vol. 6, Issue 2.

Georgiades, N. (2008). Leadership for Competitive Advantage. NY: John Wiley & Sons.

Gibson, J, Zarny, G. (2003). Organizations. NY: McGraw-Hill/Irwin.

Gramlich, E. (2004). The distributional effects of higher employment. Brookings Papers on Economic Activity, (2).

Green, B. (2006). Writing narrative literature reviews for peer-reviewed journals. Journal of Education, Vol. 5, No. 3.

Hall, P. (1989). Classic Readings In Urban Planning. NY: Mcgraw Hill.

Hamed, A. (2007). Emiratization Policies. the UAE Foundation. Available from: http://www.qf.edu.qa/output/page523.asp [Accessed 12. April 2012]

Hana, A. (2009). The UAE Energy and Climate Change. Embassy of UAE in Wash DC.

Hannagan, T, Huan Y. (2005). Management, Concepts and Practices. NJ: Pearson.

Hanzl, M. (2007). IT As A Tool For Public Participation In Urban Planning. Design Studies, Vol. 28, Issue 3.

Hassan, A. (2007). UAE Tourism. Experience the UAE. Available from: www.experienceuae.com [Accessed 22. Dec 2011]

Havrylyshyn, O. and McGettigan, D. (2009). in Transition Countries: A sampling of the Literature. International Monetary Fund (IMF).

Heerkens, G, Welson, M. (2008). Project Management. NY: McGraw-Hill.

Heinberg, R. (2004). The party's over. NJ: Longman.

Henige, D. (2009). Primary, secondary and tertiary sources. Scholarly Definition.

Hill, R. (2004). Managing Change. NJ: Prentice Hall.

Himmelberg, C., Hubbard, G. and Love, I. (2007). Investor protection, ownership, and investment. NY: Columbia University.

Holmberg, S. (2008). Indoor air. Energy and Buildings, Vol. 42, No. 1.

Hostovsky, C. (2000). Integrating Planning Theory and Waste Management. Journal of Planning Literature, Vol. 15, Issue 2.

Hurriez, S. (2007). Folklore and Folklife in the United Arab Emirates. UAE: UAE Printing Press.

Hussein, A. (2010). Finding a balance: UAE seeks sustainable economic growth. The Peninsula Qatar.

Hussein, J. (2011). The UAE. UAE FAQs.

Hussein, M. (2011). Dubai: FDI destination of choice. DED. Available from: http://vae.ahk.de/fileadmin/ahk_vae/FAQ/Business_Support/Foreign_Direct_Investment_-_Dubai.pdf [Accessed 22. Jan 2012]

Ibramim, D. (2006). UAE E-Government Projects & E-Services Summit. EGov. Available from: www.datamatixgroup.com/conferences/..%5Cagenda%5CParticipation_3rduae.pdf [Accessed 14. Jan 2012]

Indraganti, M. (2010). Adaptive model of thermal comfort. SciTopics.

Jackson, L. (2005). GCC Economies: Time for Revival. The Middle East. Available from: http://dspace.dial.pipex.com/icpubs/me/may00/meca0501.htm [Accessed 22. Jan 2012]

Jackson, R. (2005). Competition in Today's Business World. 1000 Ventures. Available from: http://www.1000ventures.com/business_guide/crosscuttings/competing_main.html [Accessed 24. Jan 2012]

Jackson, T, Minson ,D. (2003). Implementing E-Government into all Nations. E-Government handbook.

Jacoby, H, Larny K. (2007). Infrastructure Investment. Economic Journal.

Jarvis, A. (2004). Report on Labor Practices. US Department of Labor. Available from: http://www.dol.gov/ILAB/media/reports.htm [Accessed 12. March 2012]

Jasper, H. (2007). Addressing sustainability issues a must. Gulf News.

Jasper, W. (2010). WTO lauds UAE issuance of trade policy review. Khaleej Times.

Jelic, R. (2003). The Choice of Method and the Financial Performance of Newly Privatized Firms in Transition Economies. Journal of Business Finance & Accounting, 30 (7), 905-940.

Johnson, G. (2009). Exploring Corporate Strategy. NJ: Prentice Hall.

Johnson, L. (2009). The Economic and Social Benefits of Stock Markets. FEE. Available from: http://www.fee.org/vnews.php?nid=3588 [Accessed 2nd. Jan 2012]

Johnson, R. (2005). UAE's Expansion Strategies. UAE Department of Tourism and Commerce Marketing. Available from: www.dctpb.gov.ae/ [Accessed 12. April 2012]

Johnson, R. (2008). UAE's Expansion Strategies. UAE Department of Tourism and Commerce Marketing. Available from: www.dctpb.gov.ae/ [Accessed 5. Feb 2012]

Johnson, T. (2011). Secondary Research. Webster's Dictionary. Available from: http://dictionary.reference.com/browse/secondary+research [Accessed 22. Jan 2012]

Johnson, W. (2005). MNC Case Studies. NY: Pendant Publishing.

Kawach, N. (2008). No magical cure for UAE inflation. Business 24/7.

Khodakarami, J. (2009). Achieving thermal comfort. VDM Verlag.

Khoury, M. (2007). Migrating from Emiratization to Skill-based Emiratization. Gulf News.

Kikeri, S, Zinson O. (2011). Sustainability: The Lesson of Experience. Wash DC: The World Bank.

Kobrin, S. (2007). Foreign Direct Investment, Industrialization and social change. MA: Jai Press.

Lanvin, B. (2008). The E-Government handbook for Developing countries. InfoDev.

Levine, R. (2010). Financial development and economic growth: Views and agenda, Journal of Economic Literature, 35.

Lewington, I. (2007). Utility Regulation. London: International and Center for the Study of Regulated Industries.

Maceda, C, Larny, G. (2008). UAE leads Gulf states in streamlining trade. Gulf News.

Mannan, M. (2008). Best practices in the hospitality sector. DTCM. Available from: http://www.dubaitourism.co.ae/News/default.asp?ID=1101&title=BEST%20PRACTICES%20IN%20THE%20HOSPITALITY%20SECTOR [Accessed 19. March 2012]

Mantysalo, R. (2005). Approaches to Participation in Urban Planning Theories. Finland: University of Oulu.

Marks, J. (2005). Gulf of Expectations. World link.

Marks, J. (2005). Gulf of Expectations. World link. Available from: http://backissues.worldlink.co.uk/articles/19021999195259/22.htm [Accessed 22. Jan 2012]

Masudi, F. (2008). Michael Douglas and Catherine Zeta-Jones receive US$ 1.9 million donation for water projects. Water, Sanitation and Hygience (WASH) in Developing Countries.

McAllister, S. (2010). Seba Properties to redevelop Mushrif Park into People's Park. Gulf News.

McCallaster, C. (2007). The 5 P's of Change. NY: Elsevier Inc.

McCarthy, C. (2003). Contesting culture. Harvard Educational Review, Vol. 73, Issue 3.

McDermott, P. (2000). What is E-Government—How will it affect us? National Institutes of Health Forum.

Meladi, I. (2011). UAE Municipality launches environmental sustainability initiative. UAE Municipality.

Michie, J. (2008). Globalization, growth and governance. Oxford: Oxford University Press.

Miller, W. (2011). United Nations. Millennium Goals. United Nations.

Mittleman, J. (2007). Globalization. Boulder: Lynne Rienner Publishers.

Mofid, K. (2008). Globalization for the Common Good. London: Shepheard-Walwyn.

Mohammed, A. (2007). UAE's Diversification Process. UAE Tourism. Available from: www.dubaitourism.co.ae/ [Accessed 22. Feb 2012]

Mohammed, A. (2008). UAE's Diversification Process. UAE Tourism. Available from: www.dubaitourism.co.ae/ [Accessed 22. Feb 2012]

Mohammed, A. (2011). Highlights of the UAE Government Strategy: 2011-2013. UAE Government Prime Minister's Office. . Available from: http://www.uaepm.ae/pdf/PMO%20StrategyDocEngFinV2.pdf [Accessed 12. March 2012]

Mohammed, H. (2010). International Economic Vision 2030. International Council for Economic Development (ADCED).

Moncrieff, J. (2008). Is strategy making a difference? Long Range Planning Review, Vol. 32, No.2.

Nasser, A. (2003). E-Government Strategies. E-Government Journal of Business, Vol. 3, No. 2.

Nasser, M. (2011). Health Services. International Government. . Available from: http://www.abudhabi.ae/egovPoolPortal_WAR/appmanager/ADeGP/Citizen?_nfpb=true&_pageLabel=p_citizen_homepage_hidenav&lang=e [Accessed 22. Feb 2012]

Newman, R. (2006). Sustainability and Cities. NY: Thomson.

Newman, T. (2011). Country Profiles. IMF. Available from: http://www.imf.org/external/country/uae/index.ht [Accessed 22. Jan 2012]

Newman, W. (2008). UAE Initiatives. Emiratization. Available from: http://www.emiratisation.org/ [Accessed 4. Feb 2012]

Njeri, J. (2012). How prepared is the UAE for solar energy roll-out? Power Engineering.

Noori, N. (2006). International Organizations. Department of International Studies.

Nowell, S. (2010). Now & Then UAE. UAE: UAE Printing Press.

Obstfeld, M. and Taylor, A. (2002). Globalization and Capital Markets. National Bureau of Economic Research.

Papacostas, CS. (2006). Transportation Engineering and Planning. NJ: Prentice Hall.

Pardo, T. (2000). Realizing the Promise. Center for Technology in Government.

Patel, R. (2011). Strategic planning for doing business in the UAE. Dubai Chamber of Commerce & Industry (DCCI).

Patel, R. (2011). Strategic planning for doing business in the UAE. Dubai Chamber of Commerce & Industry (DCCI).

Rajaee, F. (2000). Globalization on trial. Canada: IDRC.

Ranis, G. (2008). Economic Growth and Human Development. World Development, Vol. 28, Issue 2.

Rao, S. (2007). Urbanization: Preventing an Urban Explosion. Gulf News.

Reichheld, F. (2010). The loyalty effect: The hidden force behind growth, profits, and lasting value. Boston: Harvard Business School Press.

Robert, P. (2005). The end of oil. NY: Blackwell Publishing.

Robinson, J. (2001). The Discipline of Architecture. Minnesota: University of Minnesota Press.

Roland, G. (2009). On the Speed and Sequencing of Urban Planning and Restructuring. The Journal of Financial Economics, Vol. 53.

Rutlidge, S. (2007). UAE Infrastructure Improvements. UAE Government. Available from: http://www.dubaigov.ae [Accessed 9. Feb 2012]

Rutlidge, S. (2007). UAE Infrastructure Improvements. UAE Government. Available from: http://www.dubaigov.ae [Accessed 9. Feb 2012]

Salem, O. (2010). New law will make it easier for expatriates to change jobs. The National.

Sampler, J. (2011). Sand to Silicon. Great Britain: Profile Books.

Santillan, P. (2010). UAE. Country Studies.

Sarkar, S. (2007). Innovation, market archetypes and outcome: An integrated framework. NY: Springer Verlag.

Saunders, M. (2006). Research methods for business students. NJ: Pearson.

Savage, M. (2003). Urban Sociology, Capitalism and Modernity. UK: Palgrave.

Schirato, T. (2003). Understanding globalization. London: Sage Publications.

Schmukler, S. (2008). Emerging Market Instability. Oxford Journal. Available from: www.wber.oxfordjournals.org/cgi/reprint/16/2/171.pdf [Accessed 20. Feb 2012]

Selznick, P. (1957). Leadership in Administration. NY: Pearson.

Shaheen, K. (2011). UAE to draft population strategy to address imbalance. The National.

Shahid, W. (2011). Applying the research and lessons from reviews. London: Oxford University.

Shediac, R. (2010). Economic Diversification: The road to sustainable development. Department of Planning & Economy.

Shihab, M. (2010). Economic Development in the UAE. Petroleum Review.

Shtub, R. (2008). Project Management: Processes, Methodologies And Economics. NJ: Prentice Hall.

Shuttleworth, M. (2008). Definition of research. Experiment Resources.

Sies, M. (1996). Planning The 20^{th} Century City. Baltimore: Johns Hopkins University Press.

Simpson, W. (2005). UAE Information Infrastructure. OECD. Available from: http://www.oecd.org/dataoecd/3/58/1896739.pdf [Accessed 23. Feb 2012]

Skyrme, D. (2007). Capitalizing on Knowledge. Oxford: Butterworth Heinemann.

Stevens, M. (2001). Extreme Management. NJ: Pearson.

Stewart, D. (2006). Secondary research: Information sources and methods. London: Sage Publications.

Stolz, B. (2010). Official Millennium Ecosystem Assessment. United Nations.

Suresh, M. (2007). Nakheel leads sustainability drive. Gulf News.

Szokolay, S. (2010). The basis of sustainable design. Introduction to Architectural Science, Vol. 6, No. 1.

Thomas, J. (2009). Planning History And The Urban Experience. Journal Of Planning Education And Research, Vol. 14, No. 1.

Ventura, E. (2011). UAE Economy. Legatum Prosperity Index.

Vickers, J. (2010). UAE: An Environmental Analysis. United Nations.

Waterson, D. (2007). Pollution Program. NonPoint. Available from: http://nonpoint.deq.state.la.us/sepproj.html [Accessed 21. Feb 2012]

Waterson, E. (2011). AD Department of Economic Development issues Sustainability Report 2010. UAE Interact.

Westley, D. (2011). New labor laws a powerful boost for the UAE economy. MidEast Posts.

Willis, F. (2002). Western Civilization, An Urban Perspective. NY: Longman.

Wilson, R. (2006). Economic Development in the Middle East. NJ: Prentice Hall.

Wurst, J. (2009). Middle Powers Initiative Briefing Paper. World Bank. Available from: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/LACEXT/UAE/EXTN/0,,menuPK:316030~pagePK:141159~piPK:141110~theSitePK:316024,00.html [Accessed 24. March 2012]

Yukl, G. (2008). Leadership in Organizations. NJ: Prentice Hall.

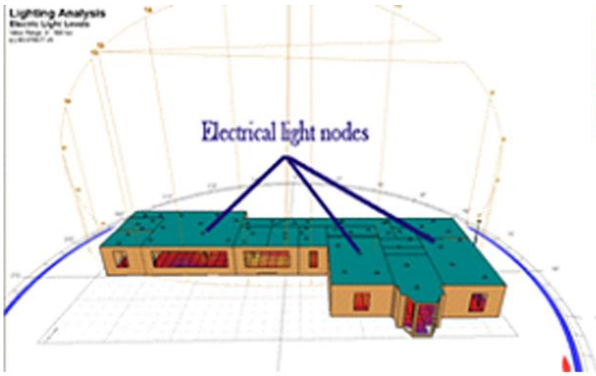
Zahra, S. (2008). Transforming Technological Pioneering Into Competitive Advantage. Academy of Management Executive, Volume 9, No. 1.

Zhang, H. (2005). Modeling Thermal Comfort in Stratified Environments. Indoor Air International Conference on Indoor Air Quality and Climate, Beijing.

Williams, D. (2010). Secondary Research Methods. Academic Grammar Report. Available from: Available from: http://www4.caes.hku.hk/acadgrammar/report/resproc/research.htm#Secondaryresearchoptions [Accessed 21. Jan 2012]

Alnasrawi, A. (2001). Oil, Sanctions, Debt and the Future. Casi. Available from: www.casi.org.uk/info/alnasrawi.html [Accessed 24. Jan 2012]

Appendix



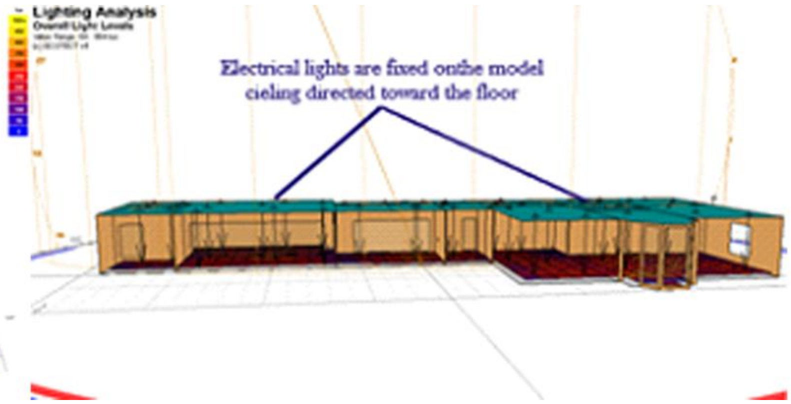


Figure 4.110 shows the location of the electrical lights that is fixed on the ceiling

Of entrance and exhibitions-south

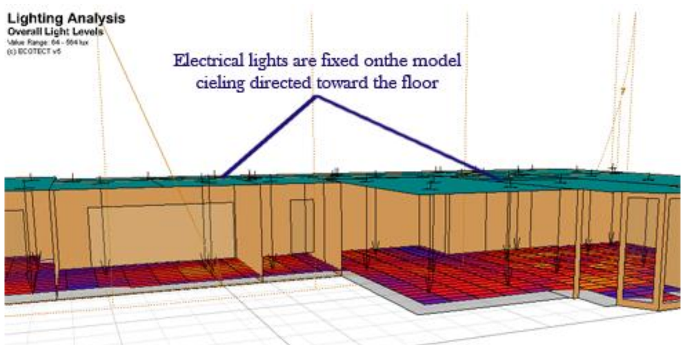


Figure 4.111 the location and direction of electrical lights –south

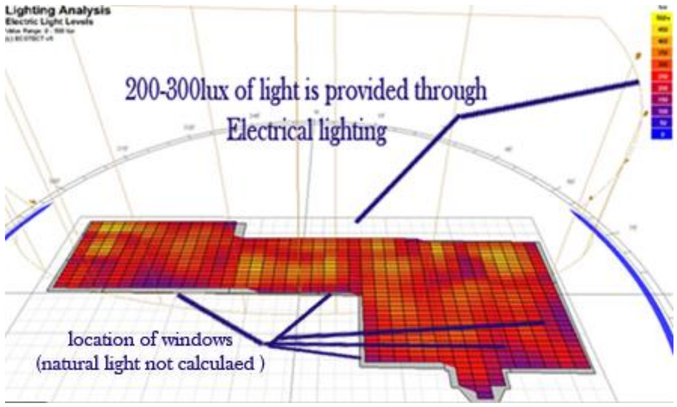


Figure 4.112 the distribution of electrical light excluding natural light –south

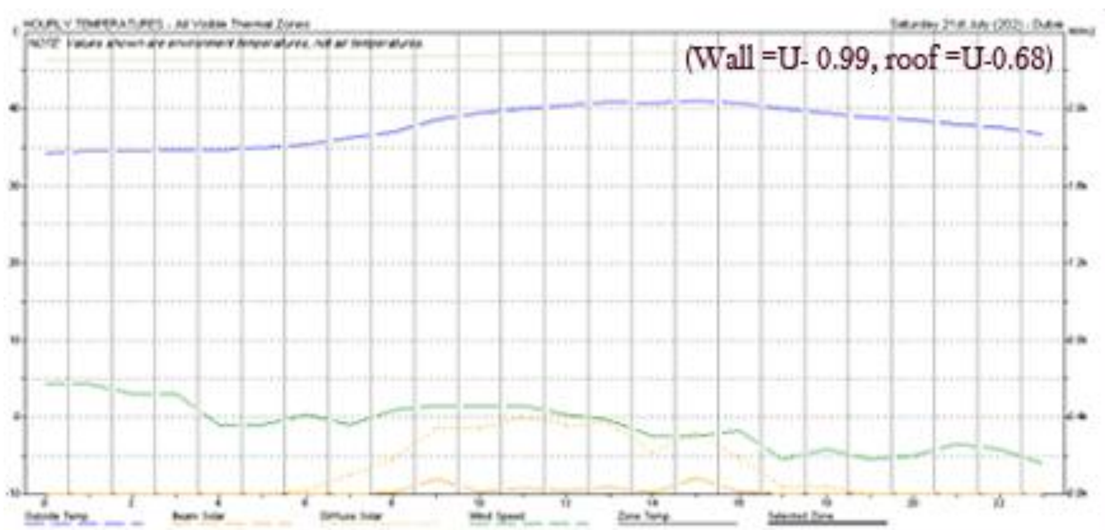


Figure 4.113 Hourly temperatures amounts- low insulating (base case)

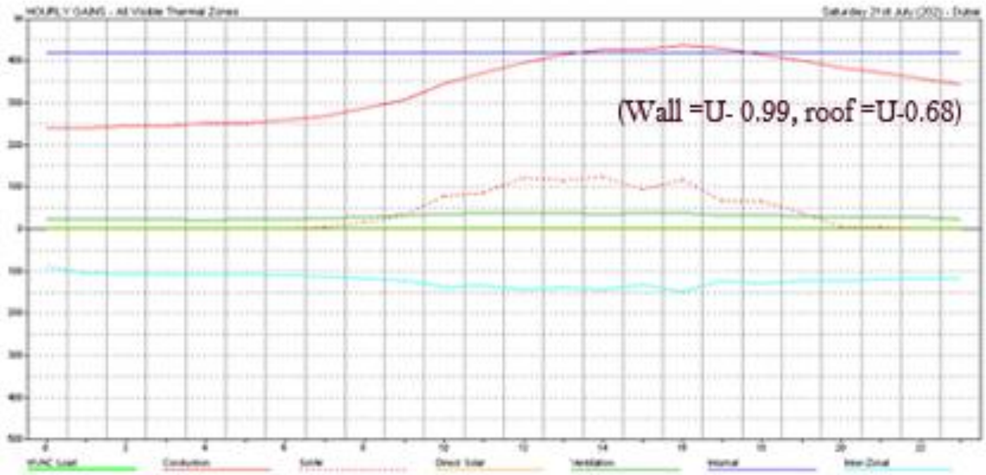


Figure 4.114 Heat gain amounts - low insulating (base case)

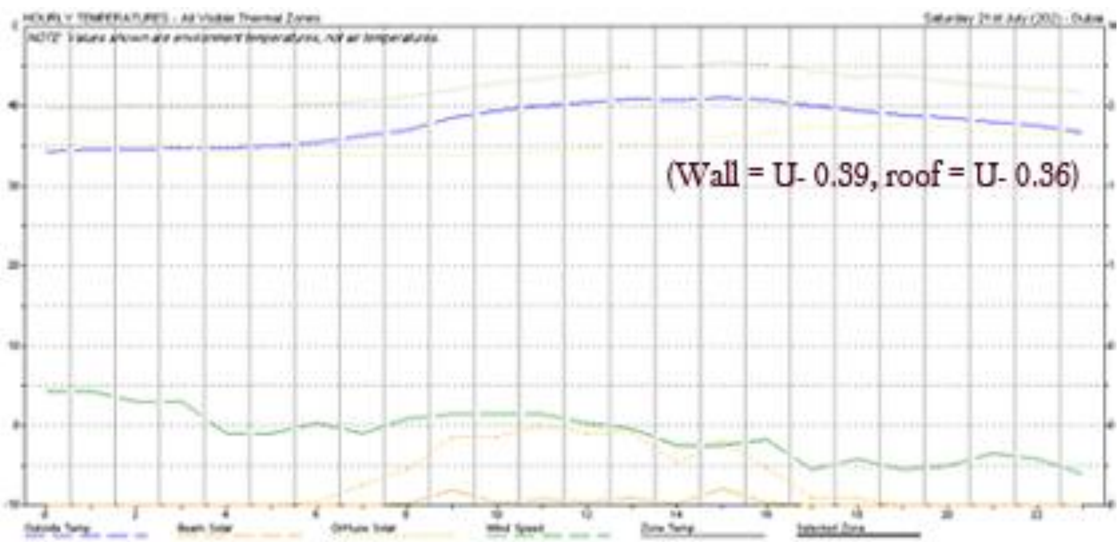


Figure 4.115 Hourly temperatures amounts – medium insulation

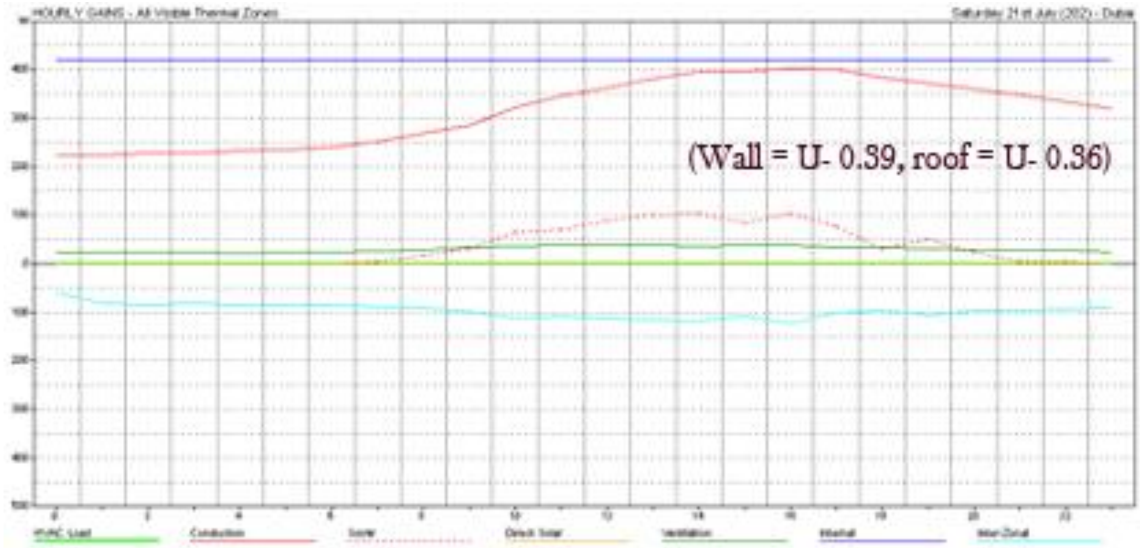


Figure 4.116 Heat gain amounts – medium insulation

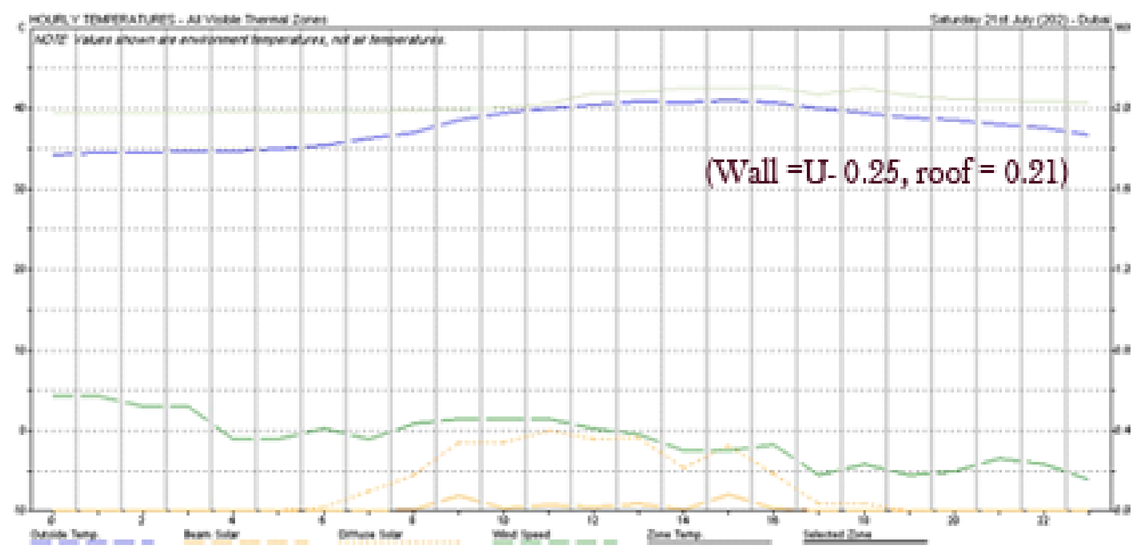


Figure 4.117 Hourly temperatures amounts –high insulation

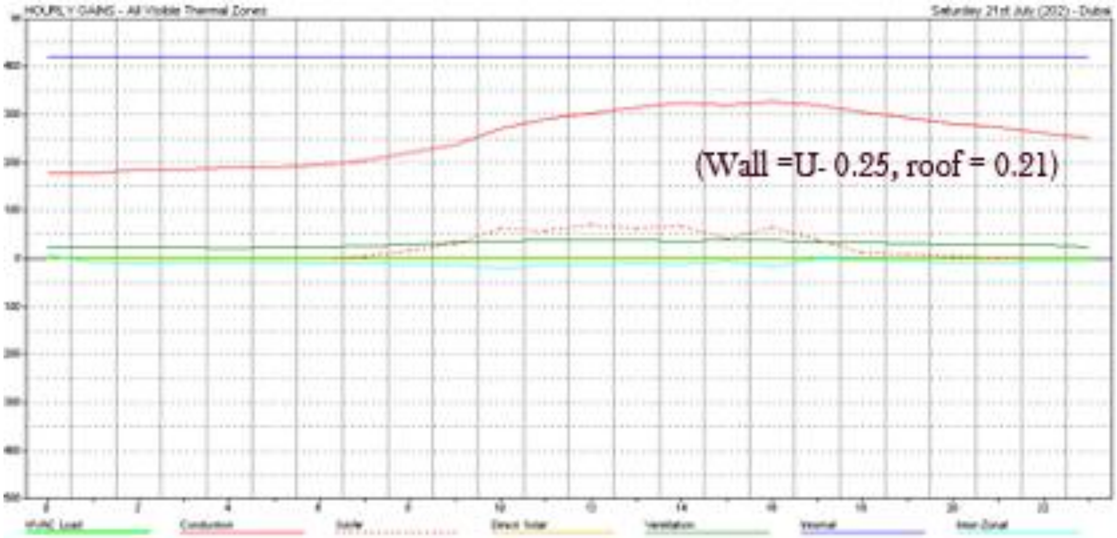


Figure 4.118 Heat gain amounts – high insulation

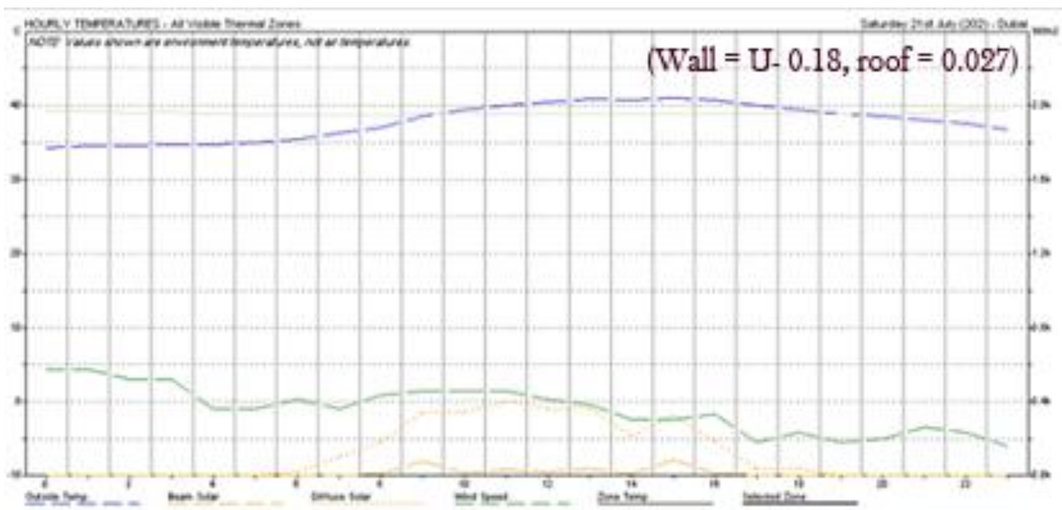


Figure 4.119 Hourly temperatures amounts – higher insulation

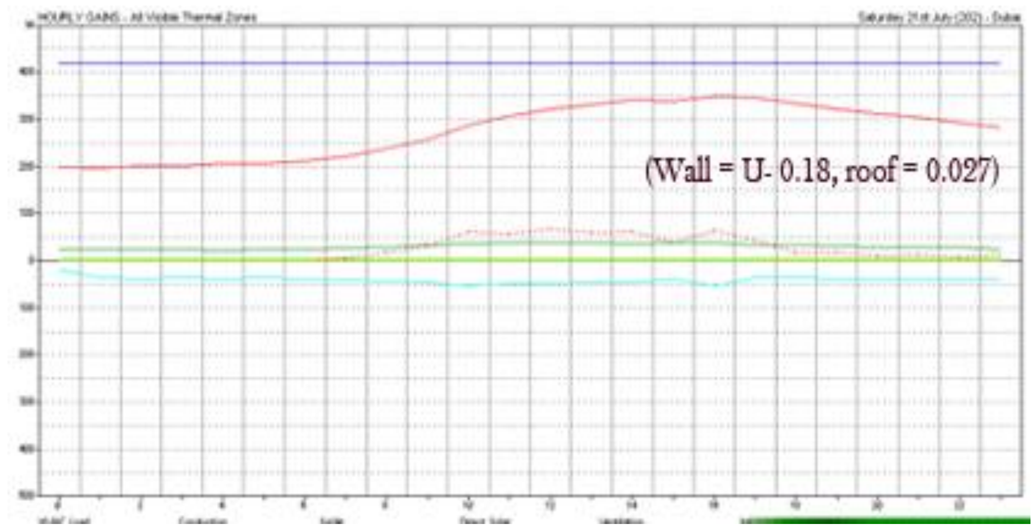


Figure 4.120 Heat gain amounts – higher insulation

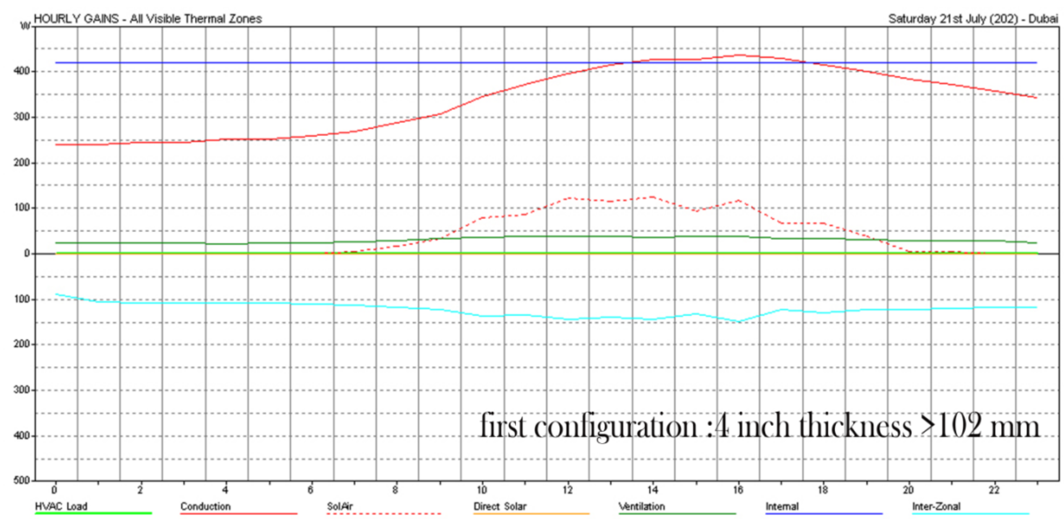


Figure 4.121 Heat Gain Loss graphs- 4 inches wall thickness

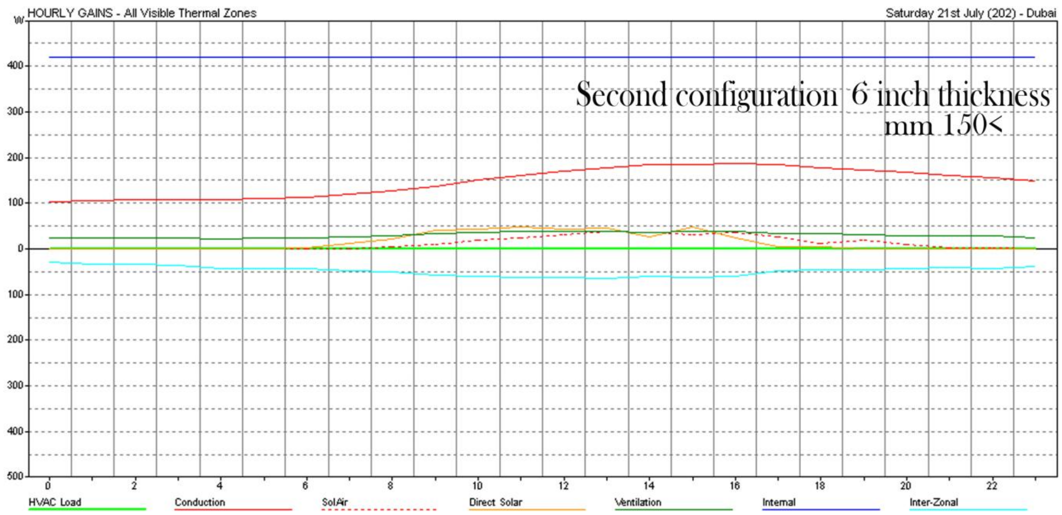


Figure 4.122 Heat Gain Loss graph- 6 inches wall thickness

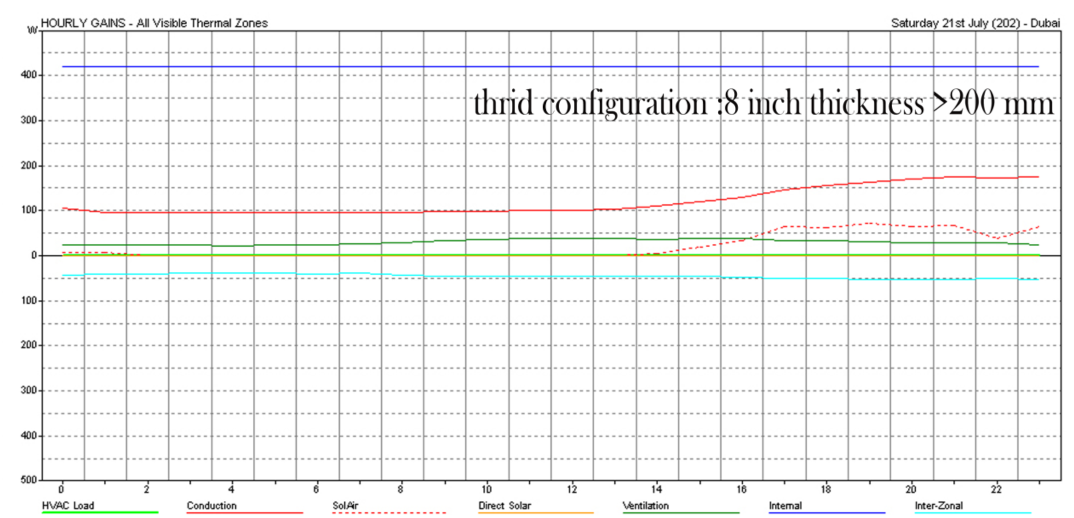


Figure 4.123 Heat Gain Loss graph-8 inches wall thickness

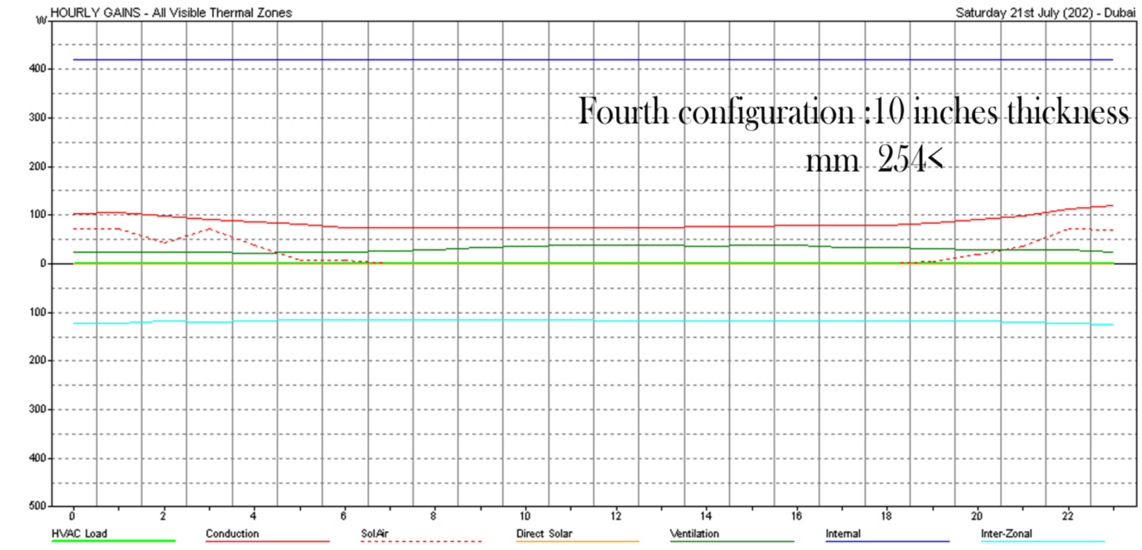


Figure 4.124 Heat Gain graph- 10 inches wall thickness