Green Design Initiatives in the UAE Construction Sector

By

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Green Design Initiatives in the UAE Construction Sector

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Abstract

The UAE has been progressing steadily on the path of growth and development over the last three decades, propelled by an oil-rich economy. In an economy largely based on hydrocarbon production, managing carbon emissions is a major challenge. Carbon footprint statistics suggest that UAE is an environmental disaster. But in the past 2 years eco-friendly initiatives have gained momentum in various sectors.

With the recent Dubai government's directive proposing a regulation that requires all buildings in Dubai to adhere to strict green standards, efforts in the construction industry towards green initiatives, in both public and private sector have gained pace. Though along with it are a series of speculation regarding its desired impact, and its immediate effect on the already volatile construction industry. Construction professionals need to educate themselves of green design, be informed of the whole lifecycle process and environmental impact of buildings so that they can encourage key stakeholders to make more sustainable choices. The thesis tries to better understand this process of sustainability in design, and its implications in Dubai. A compilation of the international green design practices along with its supporting regulations in Dubai are summarized to form a handy tool to future designers. The study methodology forms LEED rating system as its basis and verifies design aspects suitable for UAE through interactive discussions with designers, government officials, LEED facilitators along with active involvement in the design process. Parallel case studies of green buildings operational in the region are examined to verify the applicability of the data learnt. The study summarizes on the need for an Integrated Design Process as a key factor for successful green buildings as a primary conclusion from the research. A list of key sustainability elements to be implemented in green design and regulatory application guidelines for Dubai are compiled. By doing so, the writer hopes to contribute towards sustainable UAE and address the worldwide environmental challenge.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1: INTRODUCTION

This chapter is to provide a background on the research topic. It familiarizes the reader with the aims, objectives and relevance of the study. It illustrates the scope and structure of the research.

1.1 Background

The nature of the environment has been changing greatly. Rising temperatures, holes in the ozone, extinction of species, desertification are amongst some of the indicators of humans exploiting the earth in an attempt to seek a better lifestyle. As per the World Wildlife Fund(2006) UAE has extravagant fossil fuel consumption which propels its exceptional growth making it five times more unsustainable than any other country in the world. This is a time when complacency and consumption have overshadowed human connections to natural systems. Yet basic human needs are not being met.

These global conditions can be largely alleviated by responsible design, may it be automotive, product, machinery or building design. As Wann (1990) explains in his book *Biologic*, "Environmental deterioration is a lack of relevant information [and that] poor design is responsible for many, if not most, of our environmental problems."

Signifying the need for responsible design in an environment where need and urgency is amplified by phenomenal economic growth is a complicated process. This chapter provides a preface to the problem of unsustainability in the construction industry, with a focus on UAE and the need for reform. This is followed by the intent of this thesis, aims and objectives and research contents of the study.

1.2 Intent of Thesis

The last ten years have seen a great deal of debate and significant changes in the construction industry. The ever expanding construction industry faces many a challenges from time to time. The industry has changed and adapted in order to accommodate solutions to obstacles. The inculcation of green design strategy made mandatory by governmental regulations in Dubai and the appropriate way of introducing and infusing them, into the system shall be such a challenge.

Construction methods will need to adapt, as will the mindsets of all those involved in a project. Project timeframes and costs will also need to be reviewed, as will ensuring a skilled workforce is in place. Green building practices can substantially reduce or eliminate negative environmental impacts and improve existing unsustainable design, construction and operational practices. Green design measures reduce operational costs, enhance building marketability, increase worker productivity and reduce potential liability resulting from indoor air quality problems. Green design has environmental, economic and social elements that benefit all building stakeholders. This thesis aims to study such green design techniques.

Being of architectural background and as a contribution to this ongoing research towards a green future, it seems interesting to take up a study in understanding essential principles in the green building design processes.

The intention is to research and seek answers to sustainable design solutions for building in the desert region of Dubai. The thesis shall examine the design submittals of LEED which form the basis of the forthcoming green regulations in Dubai (Rogers, 2008), research its applicability in the local context and define a methodology by which these regulations can be incorporated into the design process of buildings.

1.3 Scope of the research

As the topic of sustainable construction, can be extensive to cover in the scope of this thesis, the researcher shall narrow the focus down to the fundamental *Design principles of Green buildings* and the review of best design practices that has evolved in sustainable building technology world over.

One can argue that these principles have already been complied by developed countries and can be implemented with much ease in the UAE. However, the impact on building design and its principles are heavily influenced depending on the geographical location. Also, as architecture varies vastly from place to place in response to its regional context, the focus is on designing sustainably and responsibly for the arid regions of Dubai. The design guidelines must be UAE-specific, closely related to its climate and conditions. The effort is to extrude applicable techniques from already developed practices elsewhere and to adopt it with refinement to suit the local, cultural and ecological conditions relevant to this region's context. The idea is to move forward from UAE's current status quo of design practices of glazed building blocks, with its strategic development plans of 2015 in mind rather than to ape the techniques that might not be applicable to the heritage as well as the vision for this place.

1.4 Aims and Objectives

Hence the **Aim** of the thesis is

To identify elements of sustainable building design based on internationally recognized rating systems and analyze the applicability of those elements against Dubai's urban context.

The **Objectives** sought in this study are**:**

- To review the worldwide issue of sustainability and the need for green initiatives, with a focus on the UAE.
- Evaluating design principles advocated by LEED green rating system, in order to identify design needs to be implemented in Dubai as an addition or with adaptation, thereby short listing green design elements relevant to the region .
- To investigate the design conditions, existing regulations, infrastructure and initiatives set up by the municipal authorities to support the green principles.
- To analyze case studies in an attempt to cross verify the design and implementation of shortlisted principles; learn different green strategies undertaken in live projects, understand its impact on the design along with the method of incorporating these green elements.
- To review essential changes required to the design process, for building green.

Hence, the thesis would be a compilation of regionally apt green design practices forming a handy tool to design professionals. The study shall conclude on an appropriate methodology to incorporate these sustainable principles in a green building design process.

1.5 Structure of the Research

Chapter 1 provides the reader with the intent of the thesis, the aims of the research and the objectives sought as the result of the study. It familiarizes the reader with the content that he should expect in the following chapters and provides a discussion explaining the flow of thought formulating the pattern of this research.

Chapter 2 discusses the worldwide issue of sustainability and emphasizes on the need for concern and immediate action. The history of sustainability, sustainable design and green buildings are explained along with the influence of UAE on this worldwide phenomena. The researcher's concern of the building industry's impact on the environment is explained. The need and relevance of the study is reasoned.

Chapter 3 evaluates data collected from the design submittals of the LEED system, which form the basis of the forthcoming green regulations in Dubai. A critical analysis as to whether these prescribed design requirements suit the local context of Dubai, its impact and effectiveness assessed and its applicability and need, advocated. These principles are reviewed in conjunction with current regulations and local requirements in Dubai, their alignment with the local culture and traditional architecture is discussed.

Chapter 4 describes the approach and methodology adopted to achieve the objectives. The main research method is data collection and case study which were built on interactive discussions, interviews and green rating system documents. Explanation of the techniques used, their relevance to the study and their appropriateness to the research is justified in the chapter.

On the basis of the gathered information, **Chapter 5** examines case studies of green buildings to evaluate the applicability of these proposed principles and the process methodology of incorporating them. Discussions and interviews with the design consultants of these buildings give further insight into the unique issues associated, specifically with this region. A detailed explanation of the sustainability factors incorporated is sought.

Taking lessons from the case studies **Chapter 6** reviews a suitable methodology for green buildings. The need for a renewed design process is realized and an apt design process to facilitate eco-friendly building, as learnt from literature reviews and consultant interviews is advocated. Focusing on the Integrated whole lifecycle design processes of buildings the change in design flow methodology is reviewed forming the conclusion of the study.

Literature is reviewed throughout the course of the contents to support ideas providing direct data for application. There is an extensive amount of literature available on the overall topic of green design forming a rich database, also making it difficult for the researcher to restrict the information gathered without straying away from the objectives. However, the lack of region specific data regarding design aspects and extensive design data is tackled through the support of a series of one to one discussions with green professionals and knowledge sharing with designers, active involvement in the design process and parallel case studies of efficient buildings operational in the region.

Sustainability Worldwide

"Society is living beyond its means. We are about to dispossess the earth of capital assets in the space of a few lifetimes through patterns of exploitation. These patterns are devastating the natural environment upon which we depend for our long-term survival."

Architects for Social Responsibility (cited by Hart, et al. 1994)

This chapter discusses the worldwide issue of sustainability and emphasizes on the need for concern and immediate action. It shows the influence of UAE, particularly the construction sector, on this worldwide phenomenon.

Chapter 2: SUSTAINABILITY WORLDWIDE

2.1 The concept of Sustainability

Sustainability has lately become a buzz word world over. It is an idea that recognizes that human civilization is an integral part of the natural world and that nature must be preserved and perpetuated if the human community itself is to survive. (Hart, et al. 1994)

Sustainability, in a general sense, is the capacity to maintain a certain process or state indefinitely. As applied to the human community, sustainability has been defined by the U.S. Environmental Protection Agency, (Bruntland Commission, 1987) as "Meeting the needs of the present without compromising the ability of future generations to meet their own needs." In meeting the needs of the human community, development must be designed and built with an awareness of the interrelationships between natural, cultural, social, and economic resources both locally and globally. As Hart (1994) mentions, "It is the capability of natural and cultural systems being continued over time." It is about creating healthy, economically viable communities that satisfy basic human needs.

Beginning with the environmental movement of the 1960s, there has been an increasing awareness that human use of the earth is approaching a range of environmental resource limits and that this trend, rather than diminishing, is escalating at an alarming rate (Meadows et al. 1972, WWF 2006). The 20th century has been marked by the re-emergence of environmental values within Western societies

2.2 History

Thompson (2000) explains that concern for the environment is not new and can be found to a varying degree throughout history. The debate on energy economic systems can also be traced into the 1800s, in the literatures of Nobel prize-winning chemist, Frederick Soddy (Cutler,2006). During the 1970s, while the developed world was considering the effects of the global population explosion, pollution and consumerism, the developing countries, faced with continued poverty and deprivation, regarded development as essential - to meet their need for the necessities of food, clean water and shelter. The 1972 United Nations Conference on the Human Environment, held in Stockholm was the UN's first major conference on international environmental issues and marked the beginning of global cooperation in developing environmental policies and strategies. In 1980 the International Union for Conservation of Nature published its influential *World Conservation Strategy*, followed in 1982 by its *World Charter for Nature,* which drew attention to the decline of the world's ecosystems. Confronted with the differing priorities of the developed and developing worlds, the United Nation's World Commission on Environment and Development (the Brundtland Commission) worked for two years to try and resolve the apparent conflict between the environment and development. The Commission concluded that the approach to development must change: it must become sustainable development (Bruntland Commission, 1987)

Proponents of sustainable development have been trying to reconcile the urgent needs of effective environmental protection and conservation of resources with economic development. While the concept has been politically successful at bringing sustainability into the mainstream, both in developed and developing countries, it remains controversial (O'Neill, 1999).

It is seen that development shifts land usage from natural, biologically diverse habitats to hardscape that is impervious and devoid of biodiversity. The far reaching influence of the built environment necessitates action to reduce its impacts. The environmental impact of the building design, construction and operation industry is significant. Buildings annually consume more than 30% of the total energy and more than 60% of the electricity used.(USGBC,2007) Construction contributes to about 60% of global material consumption (Voorspools, 2004). As Kris Voorspools(2004) argues, 'the demand for energy services (which must not be mistaken for the demand for energy itself) is proportional to the world's wealth, which, as monitored for the past 1000 years, still increases exponentially.' About 50% of all energy consumption in Europe and 60% in the US is building-related (Cuff, 2000, cited by Holm). With an expanding construction industry this utilization has been accelerated in the recent years. This heavy consumption in construction and lifestyle design has to be altered through responsible design, as Design covers an array of subjects under it. This led to the emergence of Sustainable design

2.3 Sustainable design

The concept of sustainable design has been popularized in the last two decades, though has existed for over a century (Cutler,2006). Sustainable design has been defined as the pursuit of any design activity that encompasses concern for energy efficiency, environment, water, conservation and the use of recycled products & renewable energy(GGBC, 2008). It is an approach that demands an understanding of the consequences of our actions. It integrates principles that enable humans to live in harmony with the rest of the natural world. Sustainable design articulates this idea through developments that exemplify the principles of conservation and encourage the application of those principles in our daily lives.

This is further applied to **Sustainable architecture**, which is a general term that describes environmentally-conscious design techniques in the field of architecture. In the broad context, sustainable architecture seeks to minimize the negative environmental impact of buildings by enhancing efficiency in the use of materials, energy, and development space. Better known as **Green building;** it is the practice of increasing the efficiency with which buildings use resources — energy, water, and materials — while reducing building impacts on human health and the environment during the building's lifecycle, through better orientation, design, construction, operation, maintenance, and removal.(Frej, 2005)

Efforts have been raised in various countries through governmental regulation or involuntary bodies to bring down this number through responsible design, by propagating and enforcing green building technology as is seen from the evolving number of green mandates necessitated by countries worldwide. Many cities have started to formulate and introduce "eco-regulations concerning renewable resources, energy consumption, sick buildings, smart buildings, recycled materials, and sustainability" (Holm, 2006). This is further reflected in the focus found among architects and industrial designers. Environmental design has also been marked with the rediscovery and further development of many “ancient” skills and techniques. In addition, technology is being developed to approach environmental concerns through the development of environmental high tech architecture and the more “traditional” environmental movement of ‘vernacular architecture.’

To reinforce the commitment to green buildings and built its global awareness, the AIA (American Institute of Architects) and UIA (Union of Architects) signed a *“Declaration of Interdependence for a Sustainable Future.”* In summary, the declaration states that today’s society is degrading its environment and that the AIA, UIA, and their members are committed to placing environmental and social sustainability at the core of practices and professional responsibilities The Inter professional Council on Environmental Design (ICED), a coalition of architectural, landscape architectural, and engineering organizations, have also joined in as a multidisciplinary partnership to shape a sustainable future (Hart . 1994).

Development must be limited to improving human life within the carrying capacity of resources and ecosystems. Development must not be an economic activity fuelling the belief in endless growth. Thus the goal of sustainable development and sustainable building design is to create optimum relationships between people and their environments. More specifically, sustainable development should have the absolute minimal impact on the local, regional, and global environments. Planners, designers, developers, and operators have an opportunity and a responsibility to protect the sanctity of a place, its people and its spirit.

2.4 Focus on UAE

2.4.1 Sustainability decision drivers in the UAE

The unprecedented growth in the UAE construction industry in the late years coupled with its massive fossil fuel energy consumption, with little concern for its environmental impact has not escaped media attention. Parallel issues like greening of the desert and its adverse climatic impact, luxurious lifestyles, excessive packaging, the use of non biodegradable wastes, non renewable energy sources have all been under scrutiny. This is indicated by repetitive articles pushing the green agenda in sections of the press, in 2008 (Royale, 2008; Oehme, 2008). The UAE has been extravagant in its energy consumption until lately.

The trouble with regulating the consumption of energy in the UAE is that energy has always been a cheap commodity. As per a report in the Gulf news, “UAE has the highest per capita gas consumption in the world. The growth in demand would be met by creating additional generation capacities fed by limitless gas resources” says Royale(2008). In lieu of that, the government has been seeking to locate energy intensive industries such as aluminum smelting and sponsoring the building boom . Similarly the general population has indulged in the over ventilating of living spaces with no reusable energy recovery which leads to the high per capita consumption of energy in the region.

Almost all developed nations have an Ecological Footprint which is the area of land needed to support a community and its waste. This should ideally be significantly larger than their geographic area indicating that they are consuming more than they are producing. However, the LIVE PLANET report in 2006 revealed that UAE has the world's largest ecological footprint. World Wildlife Fund revealed that UAE was five times more unsustainable than any other country in the world.(Anon 2007, WSP 2009) It was observed that UAE had an Ecological Footprint of 11.9 hectares/person, while the global average is at 2.2 hectares/person and the sustainable average should be at 1.9 global hectares/person.(Oehme, 2008)

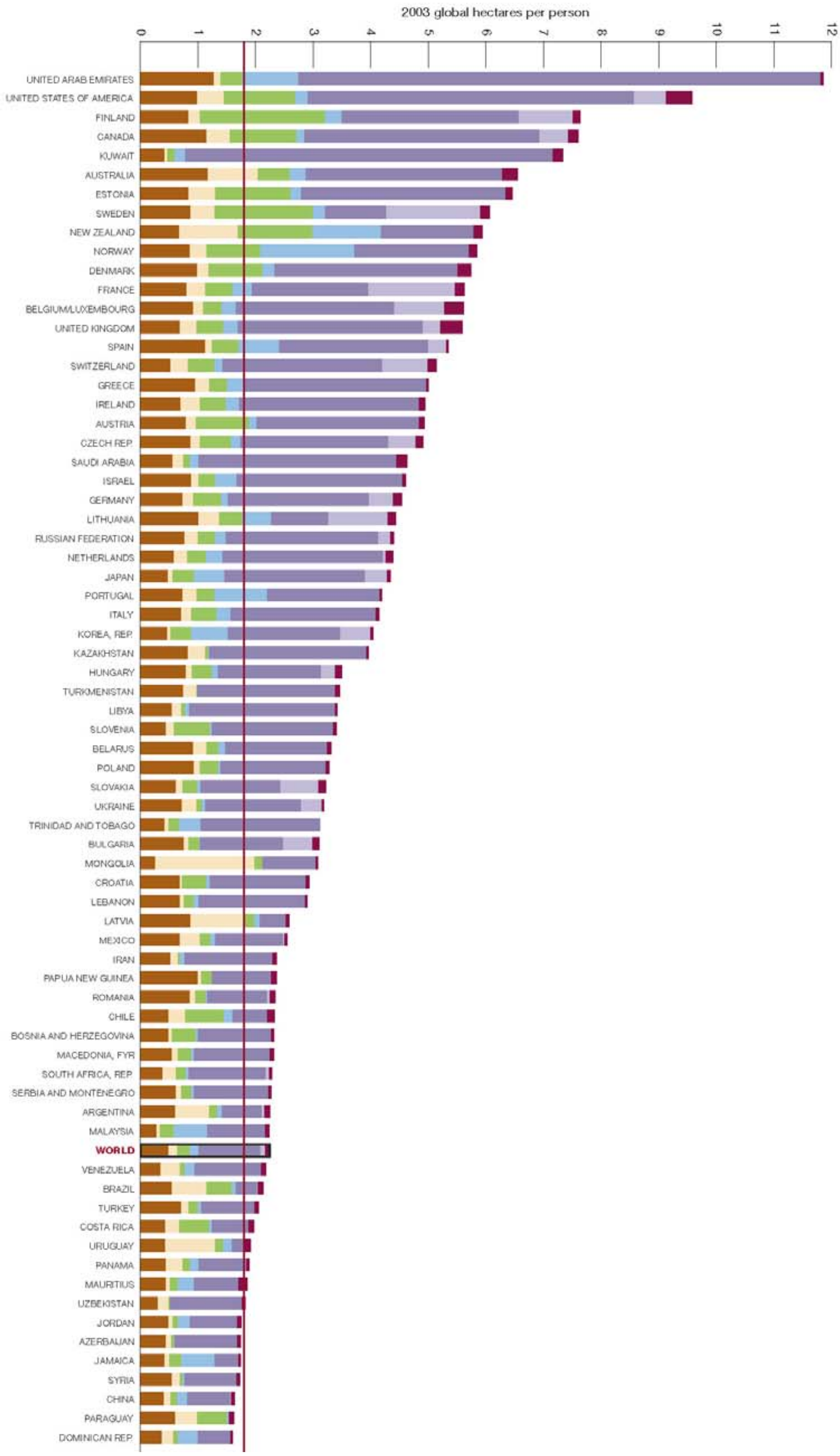


Figure 1. Ecological footprint per person by country (WWF, 2006)

2.4.2 Government initiatives and green regulations

Rasied eyes of the green advocates are now on United Arab Emirates with concerns on how it would foster sustainability without hampering the glitz and pace of its economy and booming construction activity. The increasing concerns with health and safety, the environment and the need for sustainable development have resulted in higher benchmarks being expected by clients and required by worldwide standards.

It is at this juncture that Dubai government announced a directive proposing a regulation that requires all buildings in Dubai to adhere to strict green standards prescribed worldwide.(Sell 2007)

2.4.3 Advent of the Green concept in UAE

The advent of the green concept began with UAE being a signatory of the Montreal Protocol which initiated the sustainability movement in 1987 (Bruntland, 1987). The Montreal Protocol on Substances that deplete the Ozone Layer is an international treaty designed to protect the ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion, though it is evident that not much was being done to bring about environmental awareness in the UAE.

Initiatives marking the realisation of the green concept were recognised in the recent years. In the early 2005, JAFZA started implementing environmental policies for the development of the buildings within the JAFZA region, the free economic zone located in the Jebel Ali ports area of Dubai; (http://www.jafza.ae/en/) suggesting that all Green Certified Buildings must provide annually evidence of operational compliance from their certifying bodies (EHS, 2007).

A new wing called the EHS (Environmental health and safety; http://www.ehss.ae/) within JAFZA was formed to formulate rules and regulations enforcing the green principles and monitoring the construction quality of buildings within the CED (Civil Engineering Department, http://ced.dubaitrade.ae) (EHS, 2007). This department overlooks the regulations within the newly proposed developments of JAFZA region.With time this department adopted 32 green credits which can be traced back to the LEED (Leadership in Energy and Environmental Design) system of sustainable buildings, a popular green building rating system widely used in the United States.

In a response to the heavy global criticism faced and to set standards as a pioneer in the region for green buildings, the CED implemented regulations enforcing LEED in its new developments of Dubai World, comprising of DP World, one of the largest marine terminal operators in the world; Drydocks World & Dubai Maritime City designed to turn Dubai into a major ship-building and maritime hub; Economic Zones World (http://www.ezw.ae/) which operates several free zones around the world including JAFZA and TechnoPark in Dubai (Dubai world, 2009). LEED certification of at least Gold rating was necessitated on all upcoming developments within the regions of Waterfront and parts of New Dubai. Along with this push, stakeholders were compelled to participate in the green building process. Initiatives towards building with efficiency in mind gradually became visible in the UAE. Developers adopted green policies and some ventures have been set up with sustainability advisory group for community town planning projects like Nakheel, Aldar, EHS etc.

In due time, initiatives for policy reforms were noticed from the Dubai Government encompassing control over all developments in Dubai. Greening the future was the message delivered by H.H. Sheikh Mohammed Bin Rashed, the ruler of Dubai and Prime Minister of UAE, in his order issued as DM Circular 161; 2003 which underlines the fact that all buildings constructed in Dubai from the beginning of year 2009 shall conform to green standards.

Thus a new resolution on the implementation of sustainable building specifications in Dubai was finally announced. As reported by the Arabian Business.com, "Under the new resolution, all owners of residential and commercial buildings and properties in Dubai must comply with internationally recognised environmentally-friendly specifications. The resolution was said to be effective from January 2008. The aim of this resolution is to turn Dubai into a healthy city that meets the demands of best practices and benchmarks of pollution-free sustainable development (Arabian business, 2007).

As quoted by H.H., Sheikh Mohammed Bin RashidAl Maktoum, Ruler of Dubai and Prime Minister of UAE, in his speech at the Sheikh Zayed International Environmental Prize; he said,

"Dubai and the U.A.E. are aware of the magnitude of the environmental threat faced by our planet. We are aware, too, of the fact that the efforts currently being exerted by the international community are insufficient to combat this threat. Our concern for the environment goes hand in hand with our development plans for the country.

The single environmental destiny shared by mankind, requires the possibility of cooperation between all nations on the chance to provide future generations with a safer and more dignified life."

Contractors, consultants and property developers are obliged to abide with this regulation in order to sustain UAE's development and promote its green future. This new course highlights the fundamental steps for acting green and lays the ground for the construction industry and other industries to ride on the 'Green Future in the UAE.'(Oehme, 2008).

Thus it was visible that, the UAE had gradually begun to take positive steps towards promoting sustainable development. This is further confirmed by press articles (Al Bawaba, 2007) which say that the UAE is making a proactive impact on global climate change. Abudhabi, in 2007 hosted the UAE's first Global Climate Change conference, under the patronage of H.E. ENG. Hussain Nasser Lootah, Director General of the Dubai Municipality. But the most impactful thrust towards this effort has been Dubai government's recent announcement to pass a regulation that requires all buildings in Dubai to adhere to strict green standards prescribed worldwide. (Sell,2007)

"Through implementing this resolution, Dubai becomes the first city in the Middle East to adopt green building specifications," stated Al Gergawi, who is also the UAE Federal Minister of State for Cabinet Affairs. "The resolution falls in line with Sheikh Mohammed's keen interest in dealing with the current environmental challenges...The move is also part of The Dubai Strategic Plan 2015 announced earlier by Sheikh Mohammed bin Rashid," added Al Gergawi.'(Arabian Business, 2007). Good intentions can only go so far; only when policies are put into action will Dubai and the wider region contribute to the international drive for sustainability. Accordingly these effort towards being green was further reinforced by legislations passed by the government.

A regulatory framework prescribing mandatory regulations was aimed at being put in place governing the construction of all upcoming buildings. In a DM seminar on green buildings, it was explained that as against a voluntary rating system practiced in most countries where participation is only by those who choose to implement it, a mandatory system of regulations shall be implemented. Such a system has the ability to engage everybody in the building industry to drive this goal. A regulatory policy shall be focused, strategic and predictable and ensure that all upcoming buildings and the market has a measure of understanding of green principles.

These moves lead to a general awareness of green buildings within the UAE construction industry. With the construction boom in the region more and more stakeholders worked with the regulations set by the EHS and an appreciation for the advantages of green principles was noticed within the sector. The industry was made to understand the benefits of an environmental regulation by aggressive media campaigns, government seminars showing the cost comparison post construction and with the support and help of large powerful firms working in the green sector. The industry has begun to appreciate the need for green through the general awareness being brought about. The desire to pursue sustainability by the industry was already here (Oehme, 2008) as there seems to be a welcome attitude amongst industry professionals towards the new regulation. Others were made to abide by the system by the enforced regulation and rigorous planning approval processes. Examples of these are seen in the form of a few green buildings scattered across the city. The Dubai Chamber of Commerce has lately been redesigned and implemented as a sustainable, low energy, green building and forms a perfect example of how an existing facility can be altered to be efficient. Ventures like the Bab Al Shams, a self sustainable resort hotel, Pacific controls; a LEED platinum certified commercial building, to name a few have all been making news with its newly adopted approach of being eco sensitive.

2.5 Factors inhibiting Sustainability

Sustainability metrics have the potential to turn the generic concept of green development into action. Beginning with the developed countries during the 1990s, many countries have developed their own standards of energy efficiency for buildings. There are more than 200 international rating methodologies that can be used to demonstrate the environmental performance of various building aspects, with 140 topics that describe green buildings(Rogers 2008). The difficulty then arises that these solutions were never designed to be used across multiple countries and often have features with a significant 'local' flavour. "We cannot just take the technology from western countries and dump it here because the market is totally different; research needs to be done first," says Dulsco general manager Prakash Purab (Blackman, 2009). This explains why a successful system may not be applied similarly elsewhere and the comparisons between the systems at an international level are not straightforward.(BREAM 2008) There is currently no standardized set of indicators, and several international institutions are still trying to develop a generic indicator for measuring and monitoring sustainable development. The many existing measures vary enormously both in their complexity and in their application.

There has been similar speculation over the green regulations set forth to come to the UAE. A survey by Construction weekly indicate that the regulation has been well received by many industry professionals though there has been ambiguity about a clear understanding of the specific details of the regulation as they are yet to be officially published.(Sell 2007). Its desired impact is yet unknown. Though it is inevitable that this will cause considerable alteration in construction methodologies, along with a need for renewed attitudes and mindsets of all those involved within the industry. Events in the timeline are required to be re-assessed, revisited and re-engineered. The measures of success also require revisiting (Oehme, 2008).Municipal authorities, consultants, & contractors are all, already equipping themselves to understand & adopt green processes, re-review design principles and align themselves with sustainable practices set to become an integral part of Middle East building construction.

While many questions remain unanswered on exactly how designers, developers and contractors will need to adapt, yet there seems to be a unanimous desire to change for the sake of preserving the global environment. Though the enthusiasm is high, one must keep in mind that the fabric of the construction industry in Dubai is made up of a well-proportioned mix of small, medium and large sized local and foreign contractors, consultants and investors. The industry functioning under time and cost constraints largely depends on the cohesive symbiotic functioning of all of these diverse segments complementing each other to get the job done within desired project frameworks. Getting the message of the need for green development through, to these varied types of people involved, tagged with its high financial perception would be a matter of concern during actual implementation. Despite the welcome attitude, it cannot be ignored that there has been speculation about the economic impact of these green techniques over current building methods and hence the reluctance to adopt it immediately. As Renn et al(1998) suggests, even if there were agreement on a general concept there would be further disagreement about how to apply the concept at a regional level, and any selected approach will raise analytic uncertainties: how are a large number of activities by disparate communities to be amalgamated while simultaneously addressing interactions with entities and systems outside the region. Along with this, is the problem of tight deadlines and poorly co-ordinated designs which have become a feature of a typical Dubai project.

2.6 Need for further Study

In light of the discussion above, it is realised there is a need to study an appropriate methodology to incorporate the forthcoming changes. This can be done only once the nature of the change in the form of design variables and its impact on the design process is realised. Examining of design requirements is the first step to understanding a design brief. This is essential as the concept of green is relatively new to Dubai. Designers need to equip themselves through extensive reading, green building certification systems or through company initiatives taken to educate the employees regarding these green requirements. It shall be a gradual process, as explained by Dubai Municipality (Rogers, 2008) who aims to introduce green mandates for buildings in four tiers beginning 2009 to 2012. Successful implementation requires that the changes to the current building permitting and approvals system be kept at a minimum and that new processes are phased and streamlined to complement that which is already in place. The intention would then be to build additional capacity over time to develop the support services and the research base from which to expand and improve the regulations at future dates (DM ,2009).

An open ended listing of design elements for a green building will familiarize designers with practiced techniques and stimulate them to think about innovative green ideas and new techniques of promoting sustainability which they will come across in the process of their work. In an attempt to trigger this possibility, the researcher shall list out best practices from the LEED guide- Version2.2, knowledge gained from practical work and as an observer of the system and information collected through one to one interaction with design professionals.

Accordingly, the next chapter lists the data collected as design requirements from various sustainable Green Building rating systems popular worldwide.

Chapter 3: STUDY OF PLANNING METHODS

This chapter evaluates data collected from the design submittals of the LEED system, which form the basis of the forthcoming green regulations in Dubai (Rogers,2008). A critical analysis as to whether these prescribed design requirements suit the local context of Dubai, its impact and effectiveness assessed. These design elements are reviewed in conjunction with current regulations and requirement in Dubai, their alignment with the local culture and traditional architecture.

3.1 Preface

The design phase of a building process is the most critical stage for the inculcation of sustainability principles. A majority of green elements should be primarily applied to the Design phase. This is important as the capacity to regulate the building's performance is greatest early in any project's lifecycle.

Furthermore, the greater insights on methods to achieve the effects desired and produce maximum outcome comes from the Design Phase. This is demonstrated in the "MacLeamy Curve" created by Patrick MacLeamy (Construction Users Roundtable, 2004). The MacLeamy Curve demonstrates that the "effort and effect" through either the Traditional or Preferred method comes in the design phase, well before the bid and construction phase. Additionally, as the phases and time move forward, the ability to impact cost and functional capabilities decreases while the cost of design change increases. A majority of the green design principles will be primarily applied to the Design phase. This is especially important as the ability to alter the building's performance is greatest early in any project's lifecycle. Hence changes after the design stage are not recommended. This also makes it crucial to implement sustainability in the design phase where ideas are achieved at the best cost and functional capacities.

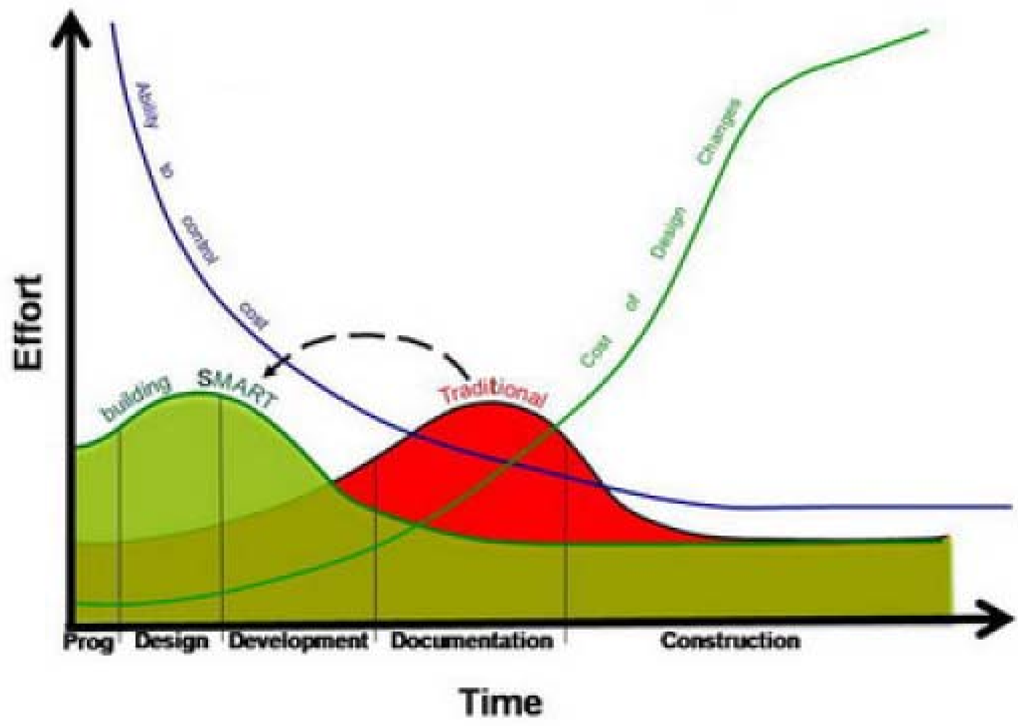


Figure 2. **MacLeamy Curve (Patrick MacLeamy, 2008)**

It is noticed that the LEED green building rating system has been popularly used as the basis of formation of Green Building regulations. Dubai Municipality(DM) is in the process of formulating their green building regulations based on LEED as mentioned in a seminar by Susan Rogers at DM(2008). EHS and CED as well as Abu Dhabi have implemented LEED as the basis of the rating system that is adopted in buildings within their jurisdiction. As defined as United States Green Building Council (USGBC, 2007); '*LEED is a voluntary, consensus based, market- driven building rating system based on existing proven technology. It evaluates environmental performance from a whole building perspective over building lifecycle, providing a definitive standard of what constitutes a green building.*' USGBC says that the intent of LEED is to assist in the creation of high performance, healthful, durable, affordable and environmentally sound buildings.

For the purpose of our study we shall research on the applicability of LEED guidelines in Dubai and assess its implementation in Dubai's environment.

This requires an understanding of the current systems already in place in the city, to support sustainable design. More appropriate design principles suited to the UAE may not be defined by LEED, but is learnt through the action research, one to one interaction with experienced design professionals working in the region, engineers at DM and DEWA (Dubai Electricity and Water Authority) are also listed. Local regulatory systems set up to support green initiatives are thus learnt about.

As stated by USGBC (1996), ' Local governments own and maintain a wide range of buildings and facilities, including administrative and office buildings, park facilities, health clinics and hospitals, fire and police stations, convention centers, wastewater treatment plants, and airports. At their disposal are a variety of administrative, regulatory, and financing tools that can help local governments develop and operate these building resources in a sustainable manner.

Local governments can create policies for municipal procurement, contract specifications, building performance, and building codes regulating community standards; enact resolutions, training and education programs, and ordinances that focus attention on sustainable development; create community boards and commissions to study local sustainable issues; and provide economic incentives for sustainable development.

Finally, many local governments have the experience and capability to create model programs and buildings, which set examples for resource-efficient guidelines and support green building programs elsewhere in their communities. Green building programs can be a first step to helping local stakeholders—policymakers, businesses, citizens, financiers, homeowners, and building owners—understand the economic and environmental wisdom of adopting sustainable principles for their communities.' This shows that the government has an important role to play in the propagation of sustainable building design and hence the study of provisions set in place by the government forms an important part of this research. DEWA and DM authorities have been approached in an attempt to gather information and insight into government rulings regarding resource conservation and sustainable practices.

Thus suggested actions for design professionals to establish and achieve sustainability goals is reviewed. Along with it is information relating to the infrastructure set up by the government and the regulations mandating their use to support these initiatives. Thus a summary of apt green design elements for UAE help to encourage best practices for green design as part of the overall design process.

Overview of the LEED process:

LEED is split into 5 primary categories as represented below with their percentage impact on the process.

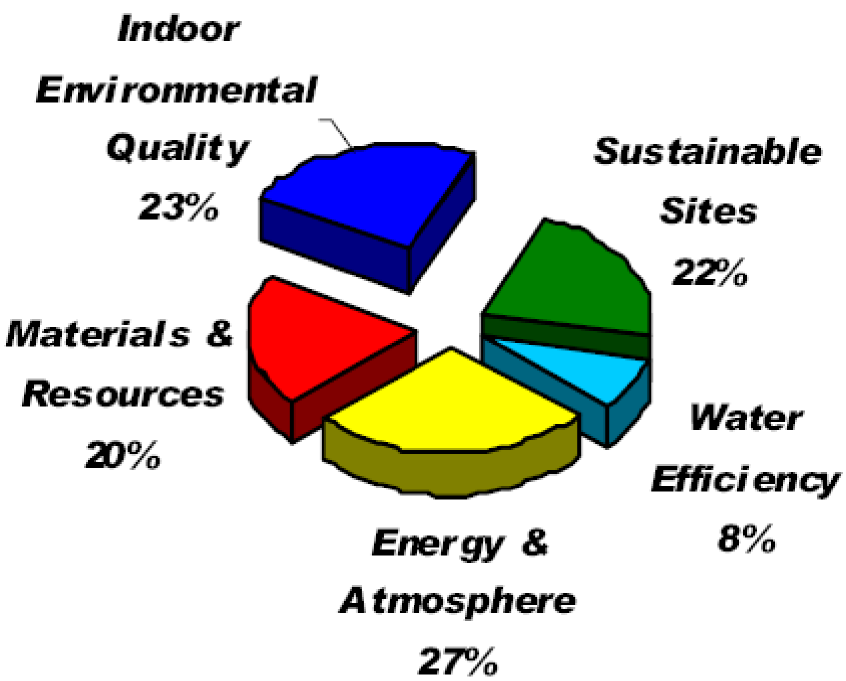


Figure 3. Overview of the LEED process

A study of the LEED text Version 2.2 has been carried out in order to identify sustainability elements relevant to the region. Factors that need to be kept in mind at the onset of a green building design exercise, additional to the design requirements of a conventional building are listed in this chapter. On the basis of the study conducted, which is explained in the paragraphs to come, the researcher has identified six sustainability elements of importance to the context of Dubai. They are:

1) ENVIRONMENT AND PLANNING
2) WATER EFFICIENCY
3) ENERGY EFFICIENCY
4) MATERIALS AND RESOURCES
5) ENVIRONMENTAL AIR QUALITY MANAGEMENT
6) VERNACULAR DESIGN FEATURES

These are further subdivided into building elements that need to be considered in the design phase. They are classified and explained further in the chapter. The LEED credits used as guidelines have been included as a code wherever applicable, inorder to reference it as an aspect of LEED that the item is referring to.

Before we get into the details of sustainable design elements, the impact of climate on sustainable design needs to be stressed upon and the climate of Dubai explained. Understanding the climatic conditions of a place, forms the foundation for understanding and interpreting the building typology apt for the region. Climate is one of the largest environmental considerations in building design and construction. By understanding climatic conditions that are specific to a project's location, design teams are able to develop climate responsive building designs. The result is a building that utilizes less energy and provides a high quality and comfortable environment for the occupants.

As described by Architectural Energy Corporation (2008), Climate-responsive design is a strategy that seeks to take advantage of the positive climate attributes of a particular location, while minimizing the effects of attributes that may impair comfort or increase energy requirements. Designers who strive to develop comfortable, low-energy buildings can enjoy the benefits of climate-responsive design by considering five basic points in the course of designing new buildings.

1. Understand climate zones and microclimates.
2. Understand the basic physiology of human thermal comfort.
3. Control the sun to reduce loads and enhance visual comfort.
4. Use thermal mass to improve comfort and efficiency.
5. Select space-conditioning strategies that are climate responsive (AEC, 2008).

All of these factors are considered and split into building elements in the classification described throughout the chapter.

The UAE is defined as having a tropical desert climate, and experiences two distinct seasons: a hot, dry summer (approximately May to October), and a milder winter (approximately November to April). Away from the more humid coastal zone, summer temperatures may reach in excess of 50ºC (120 ºF). Temperatures in the winter months typically range from 10ºC (68 ºF) to 25ºC (77 ºF). The Figure shows the long-term daily mean and average minimum and maximum temperature trends from 1986-2004 for Dubai. (WSP, 2009)

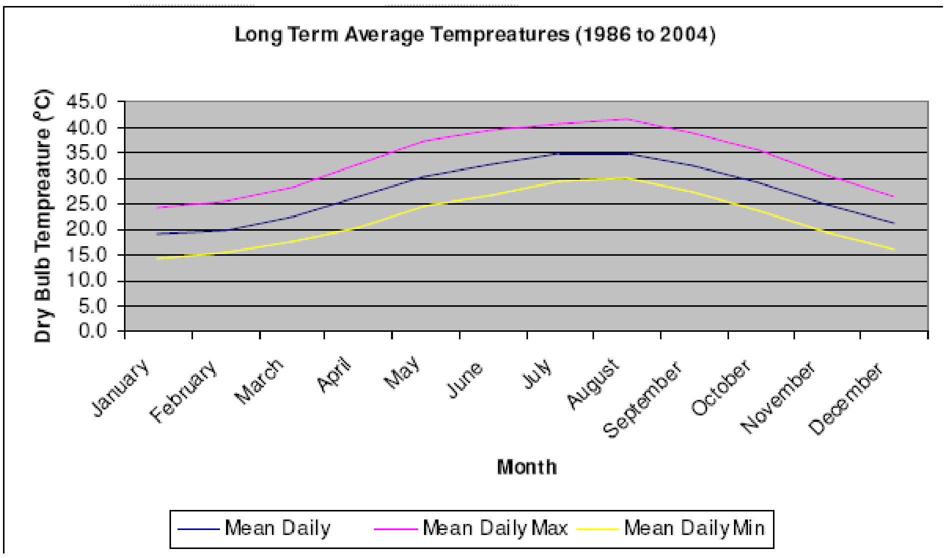


Figure 4. Daily mean and average minimum and maximum temperature for Dubai (WSP, 2008)

The weather in the UAE is hot for most of the year round, occasional rainfall (typically in short, heavy bursts) and on average, medium to high humidity. Temperatures remain high all year round, with maximum temperatures between April to November. Humidity can also be high especially at night time to early morning with typical a mid afternoon drop. Afternoon sea breezes are pleasant, especially either side of the hot summer months (i.e. March, April- May and November-December-January)

Temperature is usually the most important parameter to consider in determining comfort. The factors of air temperature, radiant temperature, wind speed and humidity all contribute towards a level of comfort. It is possible to achieve the same comfort level by various combinations of factors, for example, air movement can reduce the heat sensation and compensate for higher air temperatures. A key contributor to comfort conditions is air movement, which can be enhanced by exploiting wind pressure and direction where desirable. Wind speed in Dubai are generally quite high, and its direction variable (Arup, 2004).

Climate responsive design has been the underlying principle while identifying green building design elements. Positive climatic attributes are enhanced and unwanted impacts are eliminated through careful design consideration.

3.2 ENVIRONMENT AND PLANNING CRITERIA

This sustainability criteria deals with basic design factors involving the site, its ecology, the impact of the building on the site and its orientation.

3.2.1 Site Selection

The selection of an appropriate site has the biggest impact on a sustainable design. The process of site selection for sustainable developments is one of identifying, weighing, and balancing the attractiveness (environmental, cultural, access) of a site against the costs inherent in its development (environmental, cultural, access, hazards, energetics, operational). Spatial zones meeting programmatic objectives, within acceptable environmental parameters, are likely development sites (Hart , 1994).

i. Scenario in Dubai:

Most of Dubai's land is underdeveloped and only 20% of the emirate has been occupied so far (WSP, 2008).

In Dubai, site selection is often based on the commercial viability of the location. Though connectivity is an important aspect it is not always a driving factor for site selection as most of the city commutes through privately owned vehicles and so far the impact of public transport has been minimal and rarely contributes to the success of a building location, though it is important to note that the scenario is gradually changing with the advent of rail transport. So buildings closer to mass transit will have an advantage over others.

Another preferred option is to develop pre-developed land. However in Dubai, it is not appropriate to restrict development to previously developed sites as against virgin land, considering that most of the city is underdeveloped. However, preference should be given to developed sites as their infrastructural requirements will be limited leading to minimal environmental disruption. Besides care should be taken not to exploit the natural ecology by restricting developments along Creek areas including Ras-Al Khor, land connecting to the mangroves which from habitat for migratory birds; along the Beach side which are already over developed desert zones with wildlife and such sensitive zones. The Dubai Desert Conservation Authority has demarcated sensitive land and the planning and development of such areas is under their control.

ii. Design guidelines for site selection :

Design guidelines inferred from the study of LEED at parallel with the Dubai scenario leads to the listing of the following elements:

- During site selection process, give preference to sites that do not include sensitive site elements and restrictive land types. Avoid land identified as habitat for desert wildlife, endangered species, near wetlands or public parkland (LEED Sustainable Sites Credit 1).
- Wherever possible, the best strategy for selecting a building site is to choose a previously developed site. Since these sites have already been disturbed damage to the environment is limited and virgin land areas can be preserved (LEED S.S.C 2).
- During the site selection process give preference to urban sites with pedestrian access to a variety of services. Provide shaded pedestrian pathways connecting ancillary amenities like car park, bus station etc (LEED S.S.C 2 &4.1).

- Encourage development in an existing neighbourhood with atleast 10 units/acre and within half mile of at least 10 basic services connected by pedestrian access from the development (S.S.C 2).
- During the selection process give preference to Brownfield sites (S.S.C 3).
- Select a site that has convenient access to existing transportation networks to minimize the need for new transportation lines. Site the building near a mass transit. Locate a proposed development within half a mile of a railway station or within quarter mile of bus lines usable by building occupants (S.S.C 4.1).
- Select a site that provides convenient access to safe bicycle pathways and secure bicycle storage areas for cyclists (S.S.C 4.2).

The availability of land in Dubai may make Brownfield sites unattractive for development. Brownfield sites are property, which may be complicated by the potential presence of hazardous substance, pollutant or contaminant. Brownfields can offer attractive locations and are rather inexpensive properties. They often have existing infrastructure in place including utilities and roads reducing the need for further environmental impacts due to construction of new infrastructure (USGBC, 2007). Consider rehabilitating damaged sites by developing sites documented as contaminated. It is an alternative to developing on a green field site.

Site selection process can benefit from the expertise of landscape architects, ecologists, environmental engineers as well as local professionals who can provide site specific expertise (USGBC, 2007).

3.2.2 Building Footprint

i. Scenario in Dubai:

In Dubai, a building footprint is always in response to the site access roads and neighboring building. Elevational criteria for road frontage govern the orientation and commercial maximization decides the extent of the vertical and horizontal spread for the building. Climate responsive design is rarely observed as playing a role in the building form and placement. Landscaping mainly consists of turf grass lawns and high maintenance plants in discontinuous patches providing little relief from the building mass. Hence the concept of a thoroughly thought building footprint and its relevance needs to be stressed. Much help can be sought by following the LEED principles mentioned below

ii. Design Guidelines:

- Evaluate potential environmental disturbance that will occur as a result of the proposed development. Choose a development footprint and location that minimizes disturbance to the existing ecosystem. Try and reduce the environmental impact from the location of a building on a site (S.S.C 5.1).

- Channel development into previously developed areas to prevent sprawl and habitat loss. Channel development to urban areas with existing infrastructure (S.S.C 2).

- When designing the building, consider a smaller footprint and set aside large contiguous areas for natural space on the project site to minimize disruption of the environment (S.S.C 5.2).

- Build in dense blocks to limit the development footprint and site disturbance to the smallest area possible. Consider issues such as building orientation, day lighting, heat island effects, storm water generation, significant vegetation, existing green corridors and other such sustainable issues.

- Integrate neighboring activities to create a development with shared amenities and spaces (S.S.C 5.2).
- Identify site elements and adopt a master plan for development of the project site. Incorporate natural features that already exist on the site, into the design, natural shelter from trees or terrains, natural areas for outdoor activities. Enhance water feature for thermal, acoustic and aesthetic benefit. Creative and careful site design can integrate the natural surrounding with the building, providing a strong connection between the built and the natural environments, minimizing adverse impacts on the non built portions of the site.
- Provide a high ratio of open space to development footprint to promote biodiversity. Reduce the building footprint, hardscape, access roads and parking (i.e. development footprint). Strategies include stacking the building program, tuck-under parking and sharing facilities with neighbors to maximize open space on the site. Design and construct a compact parking, road and building footprint layout by tightening program needs and stacking floor plans.
- Provide vegetated open space within the project boundary to exceed the local zoning's open space requirement for the site or equal to the building footprint.
- Open spaces should provide for passive and active recreational opportunities. E.g. pocket parks accessible green roof decks, plazas, courtyards etc. provides occupants with a connection to the

outdoors. Well designed open spaces significantly increases property values (USGBC, 2007).

Along with every land plot affection plan, issued by the DM, a set of development parameters are prescribed which needs to be adhered to while designing. The Floor Area Ratio (FAR) of the land is such a parameter on the affection plan, which decides the extent of the building footprint on the plot. However, presently these numbers are rather generous. Hence it is the responsibility of the design architect to restrict the sprawl of building mass and take preventive actions with the help of the above mentioned guidelines.

3.2.3 Parking and Transportation

Parking facilities and roadways have negative impacts on the environment because impervious surfaces increase storm water run-off while contributing to urban heat island effects. Encouraging the use of mass transit reduces the demand for transportation thereby reducing the space needed for parking lots, which encroach on green space on the building site (USGBC, 2007). The increase in public transport development in the UAE in the form of public buses, inter-emirate buses, the proposed light rail transport and tramps which shall all be operational from the end of 2009 onwards shall help boost the use of mass transit and the UAE hopes to see a reduction in number of private vehicles as anticipated by the government. In accordance, parking lots can be minimized to reduce the building footprint and sets aside more space for natural areas or greater development densities.

i. Design Guidelines

- Perform a transportation study of future occupants to identify transportation needs (S.S.C 4.1).

- Reduce the size of parking areas based on anticipated use of public transit. This may also alter operating costs associated with parking lot maintenance.
- Design the building with underground parking to reduce the building footprint. This strategy also helps in reducing heat island effects. Place parking under cover like multistory, subterranean or shade structure or utilize a parking deck (covered parking) (S.S.C 7.1).

Another alternative to reduce the impact of vehicles is to look at the other modes of transport or ride sharing. These are currently being reviewed and promoted by the government.

ii. Bicycle Usage

There is encouragement for the use of bicycles in Dubai, as most new communities are being designed as being bicycle friendly. The Road Transport Authority (RTA) has carried out a study on the use of the bicycle as a means of transport and a fun sport in the Emirate. In corporation with consultants, the RTA has been instrumental in setting up Bicycle Network Master Plan that will be implemented in stages from 2008 (Noort, 2008). It shall provide 1300 kms of cycling paths, as part of the 2015 strategic vision. To ensure the success of this strategy, it is important to provide amenities like bicycle storage and showering areas as support facilities.

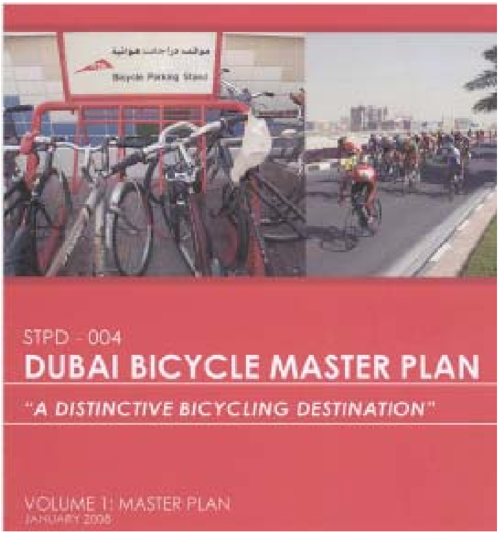


Figure 5. Dubai Bicycle Master Plan , (Dubai RTA, 2008)

- Building should be equipped with transportation amenities such as bicycle racks and showering facilities (S.S.C 4.2). In Dubai, storage should protect bicycles from theft.
- LEED requires showering and changing areas that are easily accessible from the bicycle storage areas which include bicycle racks, lockers and storage rooms (S.S.C 4.2). These spaces would be highly appreciated in colleges and universities.
- To protect bicycles from the harsh desert sun and dust, their storage should be under cover or shaded or indoors

The use of bicycles as an alternative mode of transportation is an important part of long-term sustainable transportation and energy strategies. Cycling produces no emissions and does not require the use of fossil fuels. Bicycle commuting contributes to relieving traffic congestion and reducing noise pollution. Bicycle and walking expose people to community, encouraging interaction among neighbours and allowing for enjoyment of the area in ways unavailable for automobile passengers. Designing spaces for this interaction should be considered.

DM authorities in an interaction suggested that wherever feasible the building design should link up with the proposed Bicycle paths in consultation with RTA to provide safe access routes during the design stage, though it shall not be made mandatory. Larger numbers of cycle rack provision are recommended for institutional buildings like Academic city and Knowledge village and other areas where teenage hangout is common. The use of bicycles amongst the younger generation should be encouraged, as against the use of cars as a means of transport, which is currently rampant.

iii. Vehicular Traffic:

Current projections of population growth indicate that the expected number of private cars in Dubai may increase to 1,500,000 cars by 2020 (RTA, 2008) The large numbers and the types of vehicles used in Dubai are major contributors to the levels of air pollution in the city. Encouraging the use of fuel-efficient, low-emission and carpool vehicles will assist in reducing both air pollution levels and traffic volumes. Whilst these types of vehicles are not presently common in Dubai, providing designated parking for these vehicles will help to encourage their use. Initiatives to promote them have begun by the government, as many low- emission taxis are now visible on Dubai roads.

Design considerations from LEED that can be applied successfully are listed below:

- Provide preferred parking for low-emitting and fuel-efficient vehicles. Preferred parking spaces, i.e. parking spots closest to the main entrance of the project shall be designated to accommodate fuel efficient vehicles (S.S.C 4.3).
- Minimize parking lot/ garage size by providing parking to not exceed the minimum local zoning requirements. Dubai Municipality

requires a standard size of 5.5m x 2.5m for an individual parking, with 1 carpark provided for every 500sqft of leasable area(DM, 2009).

- Consider sharing parking facilities with adjacent buildings. Limit availability of parking as a means of encouraging the use of alternative forms of transportation to and from the site.
- Integrate the design of carpool drop-off areas, designated parking for vanpools and shuttle service spots. Consider alternatives that will limit the use of single occupancy vehicles. Provide infrastructure and support programs to facilitate shared vehicle usage or car-share services, ride boards, and shuttle services to mass transit (S.S.C 4.4).
- Carpooling reduces the size of parking areas needed, thereby reducing the cost of land for parking and infrastructure needed to support vehicles (S.S.C 4.4).

The design should oversee development of a transportation demand management strategy in order to reduce the number of parking spaces required to meet the needs of occupants. For e.g. Strategies like the bus shuttle service from the open parking lot to the Atlantis hotel has eased the parking scenario without creating a chaos or burdening the parking within the hotel complex, while making it convenient for guests and tourists to park their cars, at the same time provides comfortable access to the hotel amenities.

Dubai has the highest rate of car ownership of any city in the world, and the RTA sees carpooling as part of the overall long-term solution to the emirate's traffic woes (Sambidge, 2008). "Traffic congestion is caused by several factors including high car ownership rate which is 451 vehicles per 1,000 people in Dubai, " which is too high compared with 57 in Hong Kong and 103 in Singapore, Mattar Al Tayer, Chairman of Dubai's Roads and Transport Authority, was quoted as saying (Xinhua, 2007). In an effort to ease the emirate's traffic congestion and help cut emissions the RTA has launched their carpooling scheme called *Sharekni* (http://www.sharekni.ae/dcp/Home.do) initiative in July 2008 (Sambidge, 2008). The scheme promotes ride sharing to reduce the number of cars on the road at a given time, aiming to decrease traffic congestion.

3.2.4 Cool Roofs

i. Scenario in Dubai:

The idea of cool roofs and green roofs is a fairly new concept to the UAE. It is recommended to design buildings that use materials with higher Solar Reflective Index values, i.e. the capacity of a material to reflect solar radiation; to help reduce the day time temperature range. This will improve pedestrian and building occupant comfort and is likely to reduce cooling demand within some building typologies.

Heat islands are created due to the temperature difference between urban and natural areas. The heat content in built materials like concrete and tarmac absorb solar radiation during the day and re-radiate it off, leading to a substantial temperature difference between built areas and green areas. In addition, in the UAE, hot air released from air conditioning units contributes to warming up of built spaces, leading to Heat islands (WSP,2008).

Green roofs reduce heat island effect by replacing heat absorbing surfaces with plants, shrubs etc. They provide insulating benefits, aesthetic appeal and lower maintenance than standard roofs. They provide acoustic insulation through deflection of sound, as plants block noise. However, Green roofs require an additional upfront investment , but tangible economic benefits are realized through increasing the operational lifetimes of protective roof elements and by lowering costs associated with the provision of roof-top thermal insulation. A number of companies in Dubai advertise their experience with green roofs and it is noticed that their use is becoming more and more common. DM has, in July 2009, enforced a regulation(Circular 171) that mandates all new buildings to be provided with at least 30% green roofs. Façade green cladding is also highly encouraged in the circular with commercial incentives in return for the usage.

ii. Design Guidelines

1. Choose roofing material with higher Solar Reflective Index. E.g. Light-coloured polymeric roof membranes and coatings, white ceramic tiles, clay tiles, gravel etc. are good emitters of heat. Such roofs known as Cool roofs help to reduce indoor heat gain. More information on SRI of various materials and cool roofs can be obtained in the Appendix (S.S.C 7.2).

- Consider covering roofs with photovoltaic panels or solar hot water collectors.

- Install high-albedo and vegetated roofs to reduce heat absorption (S.S.C 7.2).

- Avoid the use of dark natural stone finish, concrete pavers and fair finish exposed concrete around walkways and at ground level as these lead to heat islands (S.S.C 7.1).

- While designing green roofs, attention must be given to support, waterproofing and drainage of the planting bed. Green roofs typically include a waterproof and root repellant membrane, a drainage system, filtercloth, a lightweight growing medium and plants. Modular systems are available nowadays.

- Select plants that are likely to support the species which are most likely to utilize this space (S.S.C 7.2).

3.2.5 Light Pollution

i. Scenario in Dubai:

The glitz and glamour of the UAE night life, especially Dubai is well know and sought after by tourists. Many iconic buildings are strategically lit, illuminating the skyline with an interesting display of articulated shapes. According to environmentalists in the UAE, residents have a difficult time seeing the stars at night, partly due to installed flood lights - which waste 40% into the night sky. 'The root behind the floodlight idea lies in exhibiting the 'character' or rather making it noticeable from the rest of the adjacent buildings. However this has also led to a phenomena called photo pollution, arising from the reflection of excessive light' (Moody, 2009). Hence there is a need to make sure that excessive night lighting is avoided also preventing the waste of energy. LEED prescribes design alterations that can help reduce the impact of photo pollution which can be applied effectively in Dubai.

Figure 6. Blinded by Lights: A typical Dubai night sky.

View of Sh. Zayed road . Source: http://starrynightlights.com/; 2009

ii. Design guidelines for better lighting from LEED S.S.C 8

- Classify project as per lighting zones and design accordingly. Determine the type of environment the project falls under to design efficiently.

- Adopt site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution. Technologies to reduce light pollution include full cutoff luminaries, low-reflectance surfaces and low-angle spotlights. Design thoughtfully to address night sky visibility issues and site illumination requirements.

- Minimize site lighting where possible and model the site lighting using a computer model. Utilize lighting design software to develop a site illumination model.

- Design exterior lighting to achieve lighting power densities that are less than the requirements set forth in ASHRAE. Use the least amount of lighting equipment possible to achieve the goals of the project. Select efficient fixtures using efficacious sources to reduce lighting power and illumination intensity. Balance quantity of equipment with glare control and uniform lighting.

- Consider the use of low intensity shielded fixtures. Minimize the lighting of architectural and landscape features. Utilize down lighting techniques rather than up lighting.

- Design interior lighting to maintain the majority of direct beam illumination within the building. Locate interior lighting fixtures in such a way that the direct beam illumination produced by the interior luminaries intersect solid or opaque surfaces, preventing light spill through transparent/translucent surfaces to exterior areas. Study manufacturer's photometric data to assist the design process.

- All non- emergency interior lighting fixtures should be designed to be automatically controlled and programmed to turn off following regular business hours. Controls like automatic sweep timers, occupancy sensors programmed lighting control panels, curfew timers can be effective components of the overall lighting strategy. Manual override capabilities that enable lights to be turned on for after hours use must be included in the design. Turn off non essential site lighting after closing hours.
- Employ a lighting professional to design the projects lighting needs.
- Commission lighting system to ensure it is operating properly. Carry out regular maintenance to ensure that it continues to operate correctly and that light pollution is minimized' (USGBC, 2007).

Carefully designed exterior lighting solutions can reduce infrastructure costs and energy use.

3.2.6 Building orientation and Landscaping

As discussed before, building orientation in Dubai is in response to the adjacent development like roads or natural/manmade beaches to maximize commercial viability. The lack of natural landforms and expansive desert land has restricted the articulation of the buildings architectural form. This is where the need for climate responsive design becomes critical. Accordingly landscaping should be planned to enhance the design and utilize natural resources to create comfort zones in design. Various strategies are described and its study extensive. On discussing with a senior landscape engineer, various strategies evolved. Listed below are LEED pointers which he suggested could be most popularly used and apt to be applied in Dubai.

- Develop a site map showing existing or planned structures, topography, orientation, sun and wind exposure, use of space and existing vegetation.
- Cost can be reduced or eliminated through thoughtful planning and careful plant selection and layout.
- Perform shadow profiles of landscaped areas for each season. Illustrate the plant selection within the profiles.
- Plant hardwood trees to increase shade canopy. Shade from trees helps to lower air and soil temperatures, which in turn reduces the moisture loss of nearby plants and soil (S.S.C 6.1).
- Shade south facing windows. Vegetation can aid passive solar design, serve as a windbreak, provide pleasant views for building occupants and muffle offsite noise.
- Provide shade using native trees. Trellis and other exterior structures can support vegetation to shade parking lots, walkways and plazas. Deciduous trees allow buildings to benefit from solar heat gain during winter months (S.S.C 4.1).
- Orient windows and skylights to the North to utilize the benefits of North sunlight.

3.3 WATER EFFICIENCY

UAE has one of the highest water consumption levels in the world due to climatic conditions and high per capita income (Chaudhury, 2005). Per capita demand in the UAE has been estimated at 378 litres/day compared with the international benchmarks of 189 – 265 litres per day. Abudhabi has a total per capita daily domestic water consumption rate of 993 liters per person per day, currently the highest in the world (Abu Dhabi Water Resources Statistics, 2002) while in 2008, Dubai consumed 402 billion litres of desalinated water (Brooks, 2009). Dubai's water consumption has been the subject of increasing attention because the city has virtually no natural supply of fresh water. Total water consumption within the UAE has been calculated by the Federal Environment Agency to be 2.3 billion litres for 2005 and is projected to rise to approximately 4.7 billion litres by 2010. The rapid development in Dubai suggests that a lot of this growth will be driven by the booming Emirate. The annual recharge rate of groundwater in the UAE is estimated at 20 million m^3 per annum whilst the rate of abstraction is estimated at 880 million m^3 per annum. Clearly this deficit is likely to generate severe water resource depletion and saline intrusion issues in the coming years if no mitigation measures are identified and implemented (WSP,2009).

The main environmental impacts of water consumption in this region are considered to be associated with resource depletion and pollution generated through water abstraction, treatment and pumping. 97% of the fresh water Dubai uses has to be desalinated – an expensive and energy intensive process. Groundwater levels are also low, and over-abstraction has caused them to drop further causing them to become increasingly saline and preventing potable use without desalination treatment (Abu Dhabi WRS, 2002).

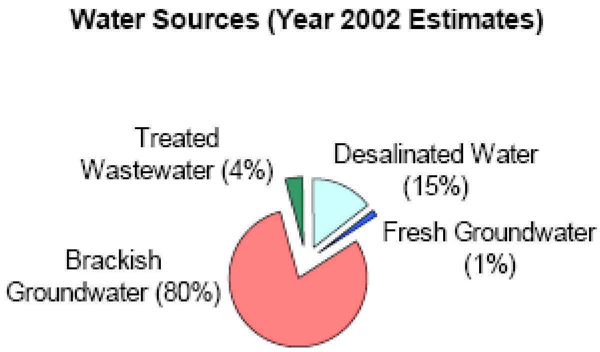


Figure 7. Abu Dhabi Water Resources Consumption Statistics (ADWRS, 2002)

The study of the LEED credits show that the intent of the LEED water efficiency credit can be applied to this region. Efforts should be made through regulation and design to achieve the following:

- Reduction in potable water consumption.
- Reduction in wastewater volumes generated.
- Promoting the use of captured recycled gray water, rainwater or treated water for non-potable applications like sewage conveyance, irrigation, toilet and urinal flushing, and other custodial usage.

3.3.1 Potable water consumption

In Dubai, potable water supply volumes are currently 210,000 m^3 per day and are projected to rise to 660,000 m^3 per day by 2020. 85% of this total is however consumed as a result of extensive irrigation practices. Desalination provides much of the potable water for the Emirate and the option chosen for discharge of this water will play a key role on the status of the natural groundwater resource.

Municipal water supplies are likely to consist mostly of desalinated water blended with groundwater to improve mineral content and flavour. The process of desalination and to a lesser extent abstraction is particularly energy intensive especially in circumstances where the energy is derived from burning fossil fuels and heavy oil in particular.

Dubai Electricity and Water Authority (DEWA) is the sole provider of potable water in Dubai and has an extensive network of potable water transmission pipes around and within. Potable water is made available by DEWA via the main water supply networks. The average per capita demand is adopted from the "Guidelines for New Development Projects" given by DEWA. Figure below gives the potable demand rates for the different land uses which indicates the average water demand values for these functions. The estimates of the water consumption given are based on standard unit consumption rates specified by DEWA(DM, 2009).

Land Use	Daily Demand Per Capita (l/c/d)
Hotels (per room, including workers/visitors etc.)	400
Swimming pool/clubhouse	100
Residential Villas	300
Mosque	40
Restaurants/Café	15 l/day per meal
Schools	60
Health Clubs	100

Table 1. Dubai Municipality Potable Water Demand Rates (WSP, 2009)

DEWA provides potable water for domestic and potable consumption only. It neither provides nor allows the use of potable water for irrigation or for district cooling plants.

Considering the extensive amount of energy and infrastructure invested in providing potable water to Dubai, the careful use of water should be enforced through policies and awareness should be brought about amongst the public about water conservation.

i. General Measures for Water Conservation:

- Specify high-efficiency fixtures. Use automatic fixture sensors, and metering controls, occupant sensors, installation of flow restrictors, reduced flow aerators on lavatory, low consumption fixtures for sink and shower, dual-flush water closet and ultra low flush urinals, dry fixtures such as composting toilet systems and non water using urinals, to reduce the potable water demand and subsequent wastewater volumes(LEED Water Efficiency Credit 3).

- Use water-conserving fixtures to reduce potable water use for building sewage conveyance. While selecting fixtures consider flush fixture type, fixture manufacturer and flush rate in gallons per flush or flow rate in gallons per minute (W.E.C 3).

- Inorder to account for user responsibility of water waste, metering should be necessitated by DEWA and water wastage heavily charged. A regulation for Metering of water consumption and electricity has been passed by the government with various slabs for consumption. Tariff meters must be incorporated at the design stage.

3.3.2 Wastewater Reuse

Wastewater presents itself as both an environmental threat and a potential opportunity. Whilst the characteristics of wastewater may be inherently damaging to the environment, treating wastewater to tertiary level offers the prospect of reuse for irrigation and the recharge of depleted groundwater resources.

i. Dubai Scenario:

In the arid region of UAE where fresh water is scarcely available the need for reusing waste water for non potable activities should be heavily stressed upon by the government. The growth of Dubai's population and infrastructure will lead to rapid growth in the volumes of wastewater generated broadly in line with 95% of the water consumed. The majority of future increases will be derived from desalinated water and the treatment and reuse of this water therefore increases the level of available wastewater for irrigation.

Wastewater can be treated on-site to tertiary standards required by Dubai Municipality Technical Guideline 62 before it is used for irrigation or toilet flushing. Options for on-site wastewater treatment include packaged biological nutrient removal systems, constructed wetlands, and high-efficiency filtration systems. Use technologies like constructed wetlands, a mechanical re-circulating sand filter, anaerobic biological treatment reactor.

However, the necessity and availability of wastewater reuse and treatment strategies is heavily influenced by the project size and location. Irrigation water in Dubai is Treated Sewage Effluent (TSE). DM manages and operates all the public sewage treatment plants in Dubai. The distribution of TSE to the various areas in Dubai is allocated by the DM Irrigation Department. DM has an existing network of irrigation water distribution lines around the emirate. It has an established network to distribute TSE and has undertaken, in conjunction with DEWA, to provide TSE to any new district cooling plants and community landscaping if required(DM, 2009). Dubai already has an established circulation infrastructure for TSE, which can be utilized by building owners and developers. In city centers where land is scarce and onsite wastewater treatment is not economically feasible, municipally treated wastewater can be used, instead of setting up wastewater treatment infrastructure. TSE from sources approved by the Municipality must be contracted and implemented. Treated Sewage Effulent (TSE) used for landscaping purposes must fulfill DM water quality standards and necessary permits obtained. When using water for irrigation and ornamental water features, human health implications must also be considered. For instance water for irrigation may require salinity to be below a certain limit in order to promote plant growth. The proposed end use of TSE from the existing DM supply defines the required quality of the final effluent. For certain uses, such as for human consumption and human contact, water quality will be clearly defined by what will be safe for those purposes and parameters are often set by national and/or international legislation. DM Technical Guideline No. 62: *The Re-use and Irrigation of Wastewater and Sludge (1998)* provides standards for the unrestricted irrigation of Class A Waters and the restricted irrigation of Class B Waters as follows:

- Class A waters – sewage effluents shall be treated to secondary standard, sand filtered and chlorinated. The maximum E. coli level in the final effluent shall be less than 10 per 100ml; and
- Class B waters – the effluent shall be secondary treated and E. coli level must be reduced to 1000 per 100ml.

Irrigation method	Permissible water class
Drip irrigation on to trees and bushes.	A or B
Low mist hand spray class	A or B
Spray irrigation in parks and green spaces that are closed to the public or after the hours of use, subject to a 2 hour break before public use begins	A or B
Unlimited spray irrigation of public areas with precautions to reduce mist formation.	A only

Table 2. Acceptable Uses of Treated Sewage Effluent

ii. Design Guidelines for wastewater reuse:

- Gray water and storm water should be used for non-potable applications such as toilet and urinal flushing and custodial uses, and for sewage conveyance (W.E.C 1.2).

- If a gray water system will be used, install dual plumbing lines during the initial construction to avoid the substantial costs and difficulties in adding them later (W.E.C 1.2).

- The high humidity in Dubai results in significant amounts of condensate being produced by air conditioning equipment. A significant quantity of condensate water can be collected from Main Air handling units, if tapped appropriately. This condensate needs to be collected and disposed of correctly. Rather than draining this water into the sewer system, condensate can be captured and used for irrigation and other various non-potable water applications on site.

- The condensate water from all air conditioning equipment units handling outside air, or a mixture of return air and outside air where the outside air is not preconditioned, must be recovered and used for irrigation, toilet flushing, or other onsite purpose. One of the largest condensate recovery systems in the world has been incorporated into the design of the Burj Dubai (WSP,2008).

- All car washing facilities can recover and reuse their wastewater.

3.3.3 Water Efficiency in Landscaping

The greening of the desert is a commonly noticed phenomena in the UAE. Landscape irrigation in the UAE consumes the maximum amount of total water used. Water use strategy depends on site location and site design. Plants which are better adapted to hot arid climate consume less water, should be inculcated in the landscape design. Well known as Xeroscapes i.e. landscape which minimizes water usage, should be incorporated in the design with the help of experts in the field. Hence the amount of water required for irrigation will be considerably reduced. The planting of low water demand plants could lead to large potential savings in water consumption.

i. Design Guidelines for Landscaping:

- Design the landscape with indigenous plants to reduce or eliminate irrigation requirements. Install landscaping that does not require permanent irrigation systems. Determine appropriate plant material with a soil/climate analysis (W.E.C 1.2).

- Contour the land to direct rainwater runoff through the site. This gives vegetation an additional water supply. Plants should be located and grouped according to their water requirements. This allows for an irrigation schedule to apply the appropriate amount of water to each landscaped area. Plan water use zones segregated as High- regular watering, Moderate- Occasional watering and Low- Natural Rainfall (W.E.C 1.1).

- Use only captured rainwater, recycled graywater, or treated water for non-potable uses such as irrigation (W.E.C 1.2).

- Night time irrigation is more efficient since evaporation is much lower and wind usually decreases at night (W.E.C 1.1).

- Where irrigation is required, use high-efficiency equipment and/or climate-based controllers. Check irrigation systems for efficient and effective operation. Use drip, micro misters, sub surface irrigation systems and smart irrigation controllers throughout. Provide computer interface for monitoring and schedule modifications from a central location (W.E.C 1.1).
- Minimize the amount of land covered with turf due to its high water requirement. A large number of golf courses proposed in the UAE, are with expanses of green water-consuming turf. In addition, it is observed that turf grass forms a large part of the planted areas around buildings in Dubai. Plant turf grass only for functional benefits such as recreational areas, pedestrian use or for soil conservation.
- Use appropriate plant material considering mature size, location, growth rate, texture and colour. Use mulching alternative mowing and composting to maintain plant health. Use mulch on trees, shrubs and flowerbeds. By mulching around trees and planting beds, moisture is retained in the soil and weeds are discouraged.

Plant species indigenous to the region should be encouraged in the landscape scheme. Native planting shall be reminiscent of the culture and true landscape of the UAE. Restrictions should be imposed by the Municipality assigning the volume of water available for landscaping, thus restricting water waste.

Examples of plants suitable to the UAE are listed in '*The Comprehensive Guide to the Wild Flowers of the United Arab Emirates*.' Marijcke Jonbloed, Environmental Research and Wildlife Development Agency, 2003.

3.3.4 Storm water design and Rain water harvesting

Dubai Municipality (DM) is the governing authority for the stormwater networks in Dubai.

Storm water volumes generated can be reused for non-potable uses such as landscape irrigation, toilet and urinal flushing and custodial uses by implementing a storm water management plan. Storm water is popularly used in many countries worldwide and strategies vary depending on different regions and climate zones. Similarly rainwater harvesting volume depends on the amount of precipitation that the project site experiences, the rainwater collection surface's area and efficiency, and storage tank capacity Located within a region influenced by the sub-tropical anticyclone, rain is a rare occurrence. As the desert region of UAE experiences very little rainfall, it is not always feasible to invest in stormwater infrastructure.

In general, storms in the Arabian Gulf region are intense, short in duration, and infrequent. Dubai Municipality figures for the years 2000-2004 recorded a range of average annual rainfall between 24mm and 74mm. Nevertheless, the goal can be to prevent storm water run-off by reducing impervious cover and to limit disruption of the natural water hydrology.

In areas like Ras Al Khaima and Al Ain, where rainfall is substantial to be tapped, the inculcation of a storm water system can be considered. If natural drainage systems are designed and implemented at the beginning of site planning, they can be integrated economically into the overall development. Stormwater naturally filters into the soil and pollutants are broken down by microorganisms in the soil and plants. Non structural measures help recharge ground water, are less costly to construct and maintain.

There are various design requirements for capturing and reuse of storm water run off. It ranges from where stormwater could be captured and used, to length of time stormwater can be held in a cistern, to the type of water treatment required before reuse. If stormwater volumes are treated on site then additional site area may need to be allocated to construct treatment ponds or underground facilities (USGBC, 2007).

i. **Design Guidelines:**

- Design the pipe networks such that the reused stormwater and graywater system are not connected to other domestic or commercial water systems (W.E.C 1.2).
- Use alternative surfaces (e.g., vegetated roofs, pervious pavement or grid pavers) and nonstructural techniques (e.g., rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling) to reduce imperviousness and promote infiltration thereby reducing pollutant loadings (W.E.C 1.2).
- Use sustainable design strategies (e.g., Low Impact Development, Environmentally Sensitive Design) to design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters, and open channels to treat stormwater runoff.
- Cost of construction, operation and maintenance should be considered when making a decision to collect stormwater/ rainwater.

- Where wastewater and stormwater is conveyed to a public drainage system, collection point, gutter or similar disposal method, water discharge limits, retention design and water quality must comply with DS 96 – DM Sewerage and Drainage Design Criteria and Local Order No. 61/1991 – Article 19.

All these need to be taken into consideration while designing the storm water system. Water detention and retention features require cost for design, installation and maintenance. However, with an annual rainfall less than 100mm in the UAE, it is not always feasible to harvest in storm water in underground cisterns. The cost implications for designing and constructing a storm water harvesting tank and the area that would be needed to be tapped inorder to collect a substantial amount of water is too extensive for the scheme to be economically feasible. Hence prior thought needs to be given and its feasibility worked out before including it as part of the sustainable design strategy.

3.4 ENERGY EFFICIENCY

The energy use of buildings is closely related to their size, use, the way they are operated, their construction characteristics, shape and of course the climate.

3.4.1 Dubai Scenario

The city's per capita energy consumption is growing at the rate of 15 per cent a year. Al Tayer, who is also the chairman of Dubai Infrastructure, recognized the city's status as having the world's highest per capita consumption at 20,000kWh per year (Sinclair, 2008). The International Energy Agency in its report in 2008, said governments needed to do more to encourage the development of renewable energy, citing solar power as one of the most under-developed. Al Tayer said the department was raising awareness among the public about renewable energy as the consumer can maximise its use.

On the onset of a design programme it is essential to set minimum energy efficiency requirements for the project, for all the proposed building and systems. A good practice is to design the building project to comply with the mandatory provisions of American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE)/IESNA Standard 90.1-2004 for the climate zone of **1A** in which UAE is located. (Rogers, 2008). This establishes minimum requirements for energy efficient design of buildings. In addition, design the building envelope, HVAC, lighting, and other systems to maximize energy performance(USGBC, 2007).

3.4.2 Minimize Energy Losses

The hot temperatures and humidity in UAE, necessitates that all buildings require air conditioning and mechanical ventilation to be installed. Mixed mode systems combining natural and mechanical ventilation should be encouraged as for five winter months of the year the weather is pleasant and air conditioning can be optional.

i. **Design Guidelines:**

- For mechanical ventilation, design as per mandatory provisions for HVAC performance in ASHRAE 90.1-2004. Design should include minimum system efficiency requirements, load calculation requirements, controls, HVAC system construction details, insulation requirements and completion requirements. Design to accomplish energy demand reduction by optimizing building form and orientation (LEED Energy and Atmosphere Prerequisite 2)

- Reduce internal loads through shell and lighting improvements.

- Increase efficiency with a more efficient envelope, and appropriately size HVAC systems (EA.C 1).

- Recover waste energy through exhaust air energy recovery systems, gray water heat recovery systems and cogeneration.

- Heat rejection from water cooled air conditioning systems, particularly cooling towers use large amounts of water due to the losses from evaporation. Treated Sewage Effluent (TSE), can be used instead of potable water at a cost benefit for the system operator.

- The use of vestibules at building entrances is an important feature in minimizing energy loss to the outside environment. The loss of cooled air to the outside environment is a common feature seen in the buildings in the UAE. The main external entrances, must include a door design which acts as a barrier, in the form of a double door, or an air-curtain, to minimize the loss of conditioned air. The door design must consider the location and traffic of the space.

- Design also should prescribe for piping insulation, pool heaters and pool covers.

- All pipes carrying refrigerant, hot water or chilled water and ducts, including prefabricated ducts, supplying conditioned air must be insulated to minimize heat loss and prevent condensation. Ducts passing through outside or unconditioned spaces must be insulated.
- Air conditioning ductworks should be tested to reduce possible air leakage. Similarly the building components and the building envelope should also be inspected for air leaks to the outside environment (EA.P 1).
- Provide for the design of thermal bridges at wall, floor, roof junctions, at connection points between concrete or steel beams, external walls and columns, and around doors and windows.
- Metering strategies should be considered at the design stage. In the rental apartment buildings in Dubai, the cost of air conditioning is included in the rental cost and calculated on the basis of floor area. If the supply of chilled water is metered and billed to the user based on actual consumption there would be a financial incentive for the user to manage the use of air conditioning. DEWA recently introduced a slab tariff system, whereby the higher the consumption, the higher the rates(Sinclair, 2008). This will require the metering infrastructure being put in place to allow a charging method based on actual consumption.

In mechanically ventilated systems use heat recovery, where appropriate, to minimize the additional energy consumption associated with higher ventilation rates. By using a Heat Recovery System, it is possible to use the cooled air being exhausted from the building to pre-cool incoming air and reduce the energy expended in cooling the new air. Energy recovery is most economical when there is a large temperature differential between the incoming and outgoing airstreams, such as exists in Dubai.

3.4.3 Building envelope requirements

Ventilation and air conditioning equipment in Dubai's buildings has been shown to account for up to 60% of the total energy consumed in buildings(DM, 2009). The majority of this energy is used to provide cooling to achieve comfortable conditions for building users. The thermal performance of the building envelope is one of the main drivers in determining what the cooling load and resultant energy use will be and minimize its wastage. Hence it is important to consider the design of building envelope with primary significance. DM prescribes strict U values to adhere to, for Building thermal insulation as per DM Administrative Resolution 66 of 2003.

When warm humid air in Dubai, comes in contact with a colder objects like pipes and air handling ducts, it may cool to form condensation. This condensation causes damage to building components. This condensation can be prevented by providing insulation around ducts and pipes which prevents the air from coming into contact with cold surfaces. In buildings with central chiller and ventilation systems, there may be considerable lengths of pipework carrying water from the chiller to devices such as fan coil units or ducts carrying air which has been cooled at a main air handling unit. If pipes and ducts are not suitably insulated, energy loss is experienced before its destination. Such losses require additional energy use to provide extra cooling. Hence proper insulation helps to prevent moisture and thus prevent mould. It is noticed that the insulation of pipes and ductworks is already a common practice in the UAE.

Computer simulation energy models of buildings are very beneficial at the design stages. The main purpose for undertaking a dedicated energy modeling study is to ensure that the Green Building Regulations have specific benefits quantifiable in the context of Dubai. The dynamic thermal modeling approach used allows the detailed consideration of all these factors to understand their sensitivity to the energy use of buildings.

It has been understood that the complexity of interaction among the various participants of the construction industry is one of the greatest barriers to energy efficient building(WSD report, 2007).Careful designing with this aspect in mind helps to eliminate the shortcomings which arise due to lack of co-ordinated design work.

i. Design Guidelines:

- Design the building envelope requirements and systems to maximize energy performance. Use a computer simulation model to assess the energy performance and identify the most cost-effective energy efficiency measures (EA.C 1).
- In Dubai's humid climate insulation plays an important part in reducing the heat exchange between the inside and the outside environment as well as the formation of condensation. Installation of insulation material must be addressed at both the design and construction stages.
- Design for insulation, installation of fenestration and opaque assemblies. Building envelope requirements should be based on UAE's climate zone 1A classification. All building envelope components must meet the minimum insulation and maximum U value and Solar Heat Gain Coefficient (SHGC) requirements listed by the DM. Better thermal performance by the building envelope will reduce the energy demand for cooling and so these properties must be incorporated into new buildings.
- In order to reduce heat built up window area must be less than 50% of the gross wall area. The skylight area must be less than 5% of the gross floor area. Limit fenestration to 50% of gross wall area and uniformly distribute it to all 4 orientations (EA.C 1).
- Strategic planting can shade the building which can decrease cooling loads during warm months.

Thermal specifications for materials should be used during design to enable building designers to allow calculation of the performance criteria for composite building elements. Designers should seek this technical data before deciding on external materials and finishes. The best means of controlling energy use in Dubai is by ensuring that buildings are designed and constructed to provide the most efficient thermal performance for local climatic conditions.

3.4.4 District Cooling

There is a growing demand for economical cooling alternatives in the UAE, such as District Cooling towers.

District Cooling can be defined as the distribution of cooling from one or more sources to multiple buildings. District cooling systems produce chilled water at a central plant, which is used to cool air and then that energy is piped out to buildings in the district for air conditioning use. Hence individual buildings do not require their own chillers or air conditioners anymore This benefits the local power grid by reducing peak power demand and alleviating power congestion due to power transmission limitations in cities. It helps alleviate the challenges posed by high electric consumption as it helps reduce the annual energy consumption by 55%.(Anon, 2009) In addition, a central plant room should use ozone friendly refrigerant such as HFC-134a. Leakage from one central plant is much lower than from many scattered plants or units.

District cooling plants are major providers for Air conditioning systems for Dubai buildings. A significant number of prestigious mega developments in the UAE, including the Gardens Residential Complex (25,000 Tones of refrigeration (TR), Jumeirah Islands (15,000 TR), Discovery Gardens (126,000 TR),Palm Jumeirah Trunk (126,000 TR), The Jumeirah Lake Towers (167,000 TR), Palm Jumeirah Crescent (124,000 TR), Jumeirah

Village South (255,000 TR), International City (125,000 TR) and Dubai Maritime City (100,000 TR) are utilizing the energy benefits of District cooling system (Dubai News Online, 2008).

Active measures have been taken up by the government to promote district cooling. District cooling utility service provider established by government-owned investment firm *Istithmar*, a major investment holding and part of the Dubai World group of companies, has recently announced that it has been actively promoting the strategic benefits delivered by Palm District Cooling's (PDC) world-class cooling solution. With recent studies by Middle East Economic Digest (MEED) predicting the regional market to grow up to 8.3 million (TR) by 2015 from just 1.8 million TR in 2007, district cooling is an economical solution for the region's increasing air conditioning requirements.(Dubai News Online, 2008)

The incorporation of district cooling should be an integral part of the building design. In addition to reducing energy demands it also helps to displace bulky equipment from the building facade and roofs as is often seen on Dubai. Consider including thermal storage systems inorder to offset energy demands from peak to off-peak periods and reduce electrical costs.

3.4.5 On-site renewable energy

Encourage and recognize increasing levels of on-site renewable energy self-supply in order to reduce environmental and economic impacts associated with fossil fuel energy use.

Green power is derived from solar, wind, geothermal, biomass or low-impact hydro sources. Harvesting site energy includes using free resources such as daylight, ventilation cooling, solar heating and power, and wind energy to satisfy needs for space-conditioning, service water heating and power generation. Onsite renewable energy is superior to conventional energy sources such as coal, oil, nuclear etc because of its negligible transportation costs and impacts. It can improve power reliability and reduce reliance on the local power distribution grid.

There are difficulties associated with implementing it here in Dubai, as the technology is not developed sufficiently for it to be more cost effective than conventional energy sources, making it difficult to convince the market to invest in it. It is hoped that with time the region shall understand the pressing need to invest in renewable sources and be able to perceive it cost benefits despite the investment. Initiatives are already visible in the form of MASDAR which is aiming at using an array of renewable sources, mainly PVCs for electricity generation. Dubai is now the headquarters of IRENA(International Renewable Energy Agency) is a major impetus for research and investment in renewable sources. Accordingly, encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

i. **Design Guidelines:**

- Assess the project for non-polluting and renewable energy potential including solar, wind, geothermal, biomass and bio-gas strategies all of which can be implemented in Dubai. When applying these strategies, take advantage of net metering with the local utility (EA.C 6).

- Design and specify the use of on-site, non polluting renewable technologies to contribute to the total energy requirements. Use on-site renewable energy systems to offset building energy cost (EA.C 6). With IRENA forming headquarters in UAE it would soon be possible to engage in green power contracts. Determine the energy needs of the building and investigate opportunities to engage in a green power contract. Provide the building's electricity from renewable sources by engaging in at least a two-year renewable energy contract.

- The maintenance of Photovoltaic cells should be considered at the design stage and provisions made for the same. In the desert conditions of UAE, with high dust content and high humidity in the air there is a build up of dust on the solar collector panels. This requires regular cleaning as the dust reduces the efficiency of the system.

- Exterior lighting can be powered entirely through renewable electricity sources such as photovoltaic systems. This is noticed as being used in various parts of Dubai for operating signals and bill board lighting. E.g.at Knowledge village.

- Similarly, solar water heaters can be widely used to utilize the potential of the hot summer sun. UAE has very high solar resources and Solar Hot Water systems are the most cost effective means of using the power of the sun. Residential buildings, hotels, villas and labour accommodation with consistent need for hot water, and their large roof expanses can make the most of this technology. Design should consider incorporation of solar hot water systems as this will have a significant reduction on electricity usage.

3.4.6 Refrigerant Management

The most efficient way of handling refrigerants is to design and operate the facility without mechanical cooling and refrigeration equipment. But in the hot and humid climate of UAE it becomes essential to cool and condition air for healthy habitable human conditions in the summer months. Refrigerant management can minimize negative impacts of refrigerant use on ozone depletion and global warming. For new buildings, specify new

HVAC equipment in the base building that avoids the use of CFC-based refrigerants as CFC causes depletion of the Ozone layer.

UAE is a signatory of Montreal Protocol of 1987 which has resolved to phase out substances that deplete the Ozone Layer in an international treaty designed to protect the ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion. The thinning of the ozone layer increases the amount of UV rays reaching the earth, which can cause numerous health problems.

i. Design Guidelines:

(Taking guidiance from LEED EA credit 4)

- Design buildings that do not rely on chemical refrigerants.
- Where mechanical cooling is used, utilize base building HVAC and refrigeration systems for the refrigeration cycle that minimizes direct impact on ozone depletion and global warming. Select refrigerants with zero or low Ozone Depletion Potential and minimal direct Global Warming Potential
- Design HVAC&R equipment that uses energy efficiently. Maintain HVAC&R equipment to reduce leakage of refrigerant to the atmosphere.
- Avoid CFC based Refrigerants for equipment.
- Employ natural refrigerants. Follow best practices for refrigerant management and equipment maintenance. This can minimize the loss of refrigerant to the atmosphere
- When reusing existing HVAC systems, conduct an inventory to identify equipment that uses CFC refrigerants and provides a replacement schedule for these refrigerants. Complete a

comprehensive CFC phase-out conversion prior to project completion.

- A Phase out plan for CFC based refrigerants with a timeline of 5 yrs from completion of the project must be in place. Chilled water systems must be CFC free.
- Select equipment with efficient refrigerant charge and an increased equipment life.
- Utilize fire suppression systems that do not contain HCFCs or Halons.

3.5 MATERIALS & RESOURCES

Human use of materials is increasing exponentially in volume, number, diversity and toxicity. Escalating industrial production and improved logistics has accelerated distribution across continents. Much of the sustainability effort is directed at converting the linear path of materials from one of extraction to production and disposal as waste, to a cyclical one that reuses materials indefinitely, much like the waste cycle in nature.

3.5.1 Dubai Scenario

It is recognized that Dubai is facing significant challenges associated with waste generation and disposal. Construction and demolition waste generated in Dubai registered a record 163% growth last year compared to the previous year, according to the annual report of DM's Waste Management Department, Dubai's vast number of building sites means that industrial and construction waste has gone from three million tonnes in 2000 to 10.5 million tonnes in 2006. In 2007, a total of 27.7 million tonnes of construction waste were removed from the various construction sites within the city(DM,2009). According to figures from DM, construction and demolition waste accounts for 75% of all waste produced in the city, 50% of which could be recycled. Concrete accounts for 70% of all construction waste and can be re-ground and used as road and construction base aggregate. The amount of waste generated on a daily basis greatly surpasses the average waste generation of other countries.

Dubai generates 10,000 tonnes of general waste per day. The volume of domestic solid waste generated in Dubai rose by 13.7% in 2007 as compared to 2006 with a total of 3.34 million tonnes. The total volume of liquid waste (mainly consisting of drainage water carried from areas that are connected to the sewage network) was 76,456 tonnes. If these generation rates persist and a different waste management strategy is not adopted, new landfill sites will be required.

According to the DM Waste Management Department, present figures state that only 1.4% of the solid waste stream in Dubai is recycled, with the remainder being land filled (WSP,2009). The DM waste characterisation is shown below.

Type of Waste	%
Organic	34
Paper and cardboard	14
Plastic	17
Rubber	0.54
Glass	4.6
Metals	3.05
Hazard	0.3
Fabric	2.61
Green waste	9.05
Other	14.85

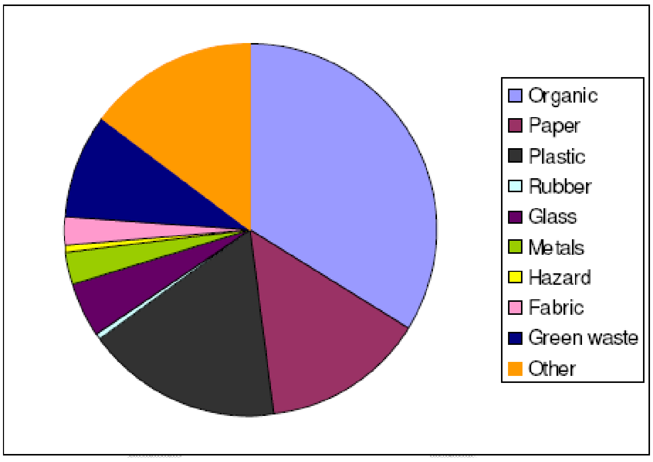


Figure 8. Dubai Waste Characterization (WSP,2009)

The market believes that the government needs to take action by putting funds into recycling. “It is not profitable to recycle unless you get subsidies from the government to do so.” says a contractor in an weekly article (Blackman, 2009). Accordingly, a new AED 66 million recycling plant is to be set up in conjunction with DM. When operational, it will be able to recycle 8.5 million tonnes of waste a year. DM recycles, by means of a public-private joint venture initiated last year with Al Rostamani Group, eight million tonnes of construction waste at the Emirates Recycling Plant located in the Al Lusaily area on the Al Ain-Jebel Ali Road. The remaining waste goes to landfill (WSP,2009).

DM's endeavours to recycle various types of waste are yielding positive results. Each year the gap between treated and non-treated waste is being reduced despite the fact that the total volume of waste generated in the city is increasing drastically. Last year, DM treated over 31 million tonnes of general solid waste, 83 million gallons of liquid waste, and 347 tonnes of hazardous waste (DM, 2009).

In addition to the recycling plant for construction and demolition waste, DM has entered into several other joint ventures with groups like Tadweer, Zenath Group and Al Serkal Group to recycle domestic waste, medical waste and waste edible oil. These joint ventures are currently run on a BOOT (build, own, operate and transfer) basis. Tadweer, one of the biggest investment projects in the region, treats a total of 4000 tonnes of solid waste daily. Al Serkal Group's AED10m waste treatment facility in Al Awir recycles waste edible oil from hotels, restaurants and food processing factories. A hazardous waste landfill run by DM exists in the Jebel Ali Free Zone to accept any hazardous wastes produced.

The following are the landfill facilities in Dubai:

1. Al Qusais Landfill
2. Al Warsan Landfill
3. Al Bayada Landfill
4. Al Lusailly Recycling Centre
5. Jebel Ali Hazardous Waste Landfill

3.5.2 Legislation and Guidance

The laws, regulations and specifications with regards to solid waste which apply in the Emirate of Dubai are as follows:

- Chapter Ten of Local Order No. 11 of 2003 titled *"Public Health and Community Safety in the Emirate of Dubai"* refers to the Public Health and Community Safety issues and requirements within the Emirate of Dubai. The Waste Service Section of Dubai Municipality is responsible for enforcing the aforementioned chapter.

- Article 51 and 52 of the Administrative Decision No. 125 of 2001 Approving Regulation of Building Conditions and Specifications issued by Dubai Municipality. These articles refer to Garbage Rooms and Specifications for Garbage Rooms respectively.

- Technical Guidelines regarding solid waste, such as: ETG2, ETG23, ETG24, ETG26, ETG27, ETG28, ETG36, ETG47, ETG49, ETG50, ETG59; and

- Information Bulletin on Waste Oil Collection and Re-use.

Along with the regulatory guidelines from DM, LEED construction credits for diverting waste from landfills, recycled content and the reuse of materials in design should be applied.

3.5.3 Design Guidelines for waste disposal

(From LEED Material and Resources Prerequisite 1)

- Create dedicated recycling collection area that meets the project occupant's needs and the needs of the collection infrastructure. Coordinate the size and functionality of the recycling areas with the anticipated collection services for glass, plastic, office paper, newspaper, cardboard and organic wastes to maximize the effectiveness of the dedicated areas.
- Design team should size the facilities appropriate to the specific building operations.
- Consider employing cardboard balers, aluminum can crushers, recycling chutes and collection bins at individual workstations to further enhance the recycling program.
- Designate well-marked storage areas for recyclables. Locate central collection and storage area in common areas that provides easy access to the maintenance staff as well as collection vehicles. For projects with large sites, consider creating central collection area

that is not located within the building footprint. Design enough space for front loader bin and a ramp up to the recycling area.

- Research local recycling programs for a particular building location. Involve the local hauler who will provide waste management services to the site while allocating space for centralized collection point of recyclables. Decide whether it is comingled or a source separation strategy. Accordingly allocate space.
- Activities that create odours, noise and air contaminants should be isolated or performed during non-occupant hours to maintain optimal indoor environmental quality.
- A sorting and storage facility for recyclable materials must be made mandatory by regulation. Occupants of the building must have easy access to an area where recyclable waste can be deposited for sorting, storage, transport and processing. Establish a project goal for recycled content materials and identify material suppliers that can achieve this goal.

i. Use of Recycled materials in design

- Consider reuse of existing, previously occupied buildings, including structure, envelope, and interior non-structural elements.
- Recycled content goals should be established during the design phase. Project teams should run a preliminary calculation during the design phase as soon as project budget is available inorder to set appropriate recycled content target (MR.C.1.2 & 1.3).
- Identify opportunities to incorporate salvaged materials into building design. Consider salvaged materials such as beams and posts, flooring, paneling, doors and frames, cabinetry and furniture, brick and decorative items.
- Ensure that the specified recycled content materials are incorporated in design concept and specifications. Consider a range

of environmental, economic and performance attributes when selecting products and materials. Sources of nontoxic, renewable or recyclable, and environmentally responsive building products are available to use when specifying materials.

- Project team should work with sub-contractors and suppliers to verify availability of materials that contain recycled content. Project team must identify products which contain recycled content.
- Adopt a construction waste management plan to achieve these goals.

Recognizing that the disposal of waste is such a major issue in Dubai, design of individual buildings should facilitate the appropriate collection and disposal of waste by sorting and reusing at preliminary levels. All efforts should concentrate on minimizing waste. Recognize that there is no such thing as waste, only resources out of place.

3.5.4 Strategies for procuring materials

Encouraging the use of locally sourced materials promotes local economy and provides impetus for growth. By requiring a percentage of regionally produced materials to be used, transportation costs and energy use will drop while local industry will be encouraged to develop more materials to supply the construction industry. This may not seem very relevant now, but with the proposed development envisaged for the manufacturing units in Dubai it may be a potential design consideration in time to come.

- Establish a project goal for locally sourced materials, and identify materials and material suppliers that can achieve this goal. Some of the regional materials available here in the UAE are glass, cement, concrete, ceramics. Evaluate this aspect early in the design process. Project teams should run a preliminary calculation during the design phase as soon as project budget is available inorder to set appropriate regional material targets (MR.C.5).

- Identify rapidly renewable materials and suppliers. Consider materials such as bamboo, wool, cotton insulation, agrifiber, linoleum, wheatboard, strawboard and cork, composite panels that are made from agricultural fibre such as wheat, substituting for composite wood panels. Incorporate products into project specifications and plans (MR.C.5).

UAE has always sourced wood and timber from all over the world, including Africa, Asia and America. With the boom in the construction industry over the late years, large quantities of timber have been imported into the country.

- Encourage environmentally responsible forest management. LEED recommends the use of structural framing and general dimensional framing, flooring, sub-flooring, wood doors and finishes, wood-based materials and products, certified in accordance with the Forest Stewardship Council's (FSC) principles and criteria, for wood building components. Establish a project goal for FSC-certified wood products and identify suppliers that can achieve this goal (MR.C.7).
- Specify in contract documents that wood products shall come from forests that are certified as well-managed according to the rules of FSC and require Chain of custody documentation (MR.C.7).
- Wherever possible employ a line item strategy based on current availability of specific products rather than a blanket approach.
- Try using lower grades of wood to reduce pressure on forests, grade 2 or 3 for lumber or veneer rather than grade 1 (MR.C.7).

3.6 AIR QUALITY MANAGEMENT

3.6.1 Common pollutants

Management of outdoor air quality is of primary importance due to the potential health impacts and wide scale impacts, such as climate change. Poor air quality is known to cause respiratory diseases. Air pollutants are released to the air from a number of natural and anthropogenic sources. Key examples of pollutants in Dubai are emissions from man-made sources which include motor vehicles and fossil fuel burning power stations, emissions of dust from construction and other such activities. A range of common pollutants found in the UAE are Particulate Matter, suspended in air found in desert regions which are typically higher during the summer months due to more unsettled weather conditions and higher air temperatures. Other common pollutants are Nitrous Oxides (NO and NO_2) a clear indicator for road traffic emissions and Sulphur Dioxide (SO_2) derived from the combustion of fossil fuels. A brief description of a range of common pollutants found in the UAE is provided in the Appendix.

From the study gathered the following measures have been recommended in Dubai to improve Air Quality.

3.6.2 Environmental Tobacco Smoke (ETS) Control Required

A legislation was passed by the Dubai Municipality to restrict smoking in public places in an effort to discourage smoking and protect public health. Several campaigns are being run in this effort and demonstrations on the ill- effects of smoking are put up for public display. This regulation applies to buildings and must be considered in the design of new buildings.

This DM legislation also applies to existing buildings. Smoking is totally prohibited in the public transportation vehicles, clinics, medical centres, hospitals, entertainment centres, restaurants, cafeterias, shopping centres, hotels, official buildings, commercial buildings, companies, housing compounds, public institutions, with the exception of places for which a permit allowing smoking has been obtained from the Public Health and Safety Department of Dubai Municipality (DM, 2009).

Dubai Municipality (DM) Administrative Resolution No 92 – 2009 *"Regulating Smoking in Public Places"* has as an annex the '*Manual of Regulating Smoking in Public Places'* which details the restrictions and requirements for smoking in public places. The manual specifies areas in buildings where smoking is prohibited, and the conditions and regulations for smoking designated areas. The requirements for ventilation and air conditioning are also detailed.

i. Design Guidelines:

(From LEED Environmental Quality Prerequisite 2)

- Prohibit smoking in the building or except in designated smoking areas. Locate any exterior designated smoking areas at least 25 feet away from entries, outdoor air intakes and operable windows inorder to prevent ETS intake during outside air intake.
- Prohibit smoking in commercial buildings or effectively control the ventilation air in smoking rooms.
- For residential buildings, prohibit smoking in common areas, design building envelope and systems to minimize ETS transfer among dwelling units.
- Locate designated smoking rooms to effectively contain, capture and remove ETS from the building. At a minimum, the smoking room must be directly exhausted to the outdoors with no re-circulation of ETS-containing air to the non-smoking area of the building, and enclosed with impermeable deck-to-deck partitions.

- With the doors to the smoking room with door closers, operate exhaust sufficient to create a negative pressure with respect to the adjacent spaces of at least an average of 5 Pa and with a minimum of 1 Pa (USGBC, 2007).

3.6.3 Improved Air quality

With enclosed buildings and recirculating air in Dubai, it is necessary to monitor and improve indoor air quality with adequate ventilation requirements. Guidelines for efficient ventilation are suggested below.

i. Ventilation design guidelines:

- Project has to be designed to meet or exceed the minimum requirements of ASHRAE Standard 62.1-2004, *'Ventilation for acceptable indoor air quality,'* using ventilation rate procedure.
- Design should provide adequate ventilation with focus on cross ventilation. All naturally ventilated spaces shall be manually operable openings. This shall constitute at least 4% of the net occupiable floor area. Location and size of window openings shall be as per ASHRAE 62.1-2004 (EQ.P.1).
- Install permanent monitoring systems that provide feedback on ventilation system performance ensuring that ventilation systems maintain minimum design ventilation requirements.
- Provide additional outdoor air ventilation to improve indoor air quality for improved occupant comfort (EQ.C1).
- A supply of outdoor air must be provided to each parking level. It is essential to ventilate parking to ensure health and safety of parking facility users (EQ.C 2).
- CO and CO_2 should be constantly monitored in car parks. CO_2 being heavy, monitoring locations shall be between 3 feet and 6 feet above the floor (EQ.C1).

For Naturally ventilated Spaces, the Carbon Trust Good Practice Guide 237 recommends the following –

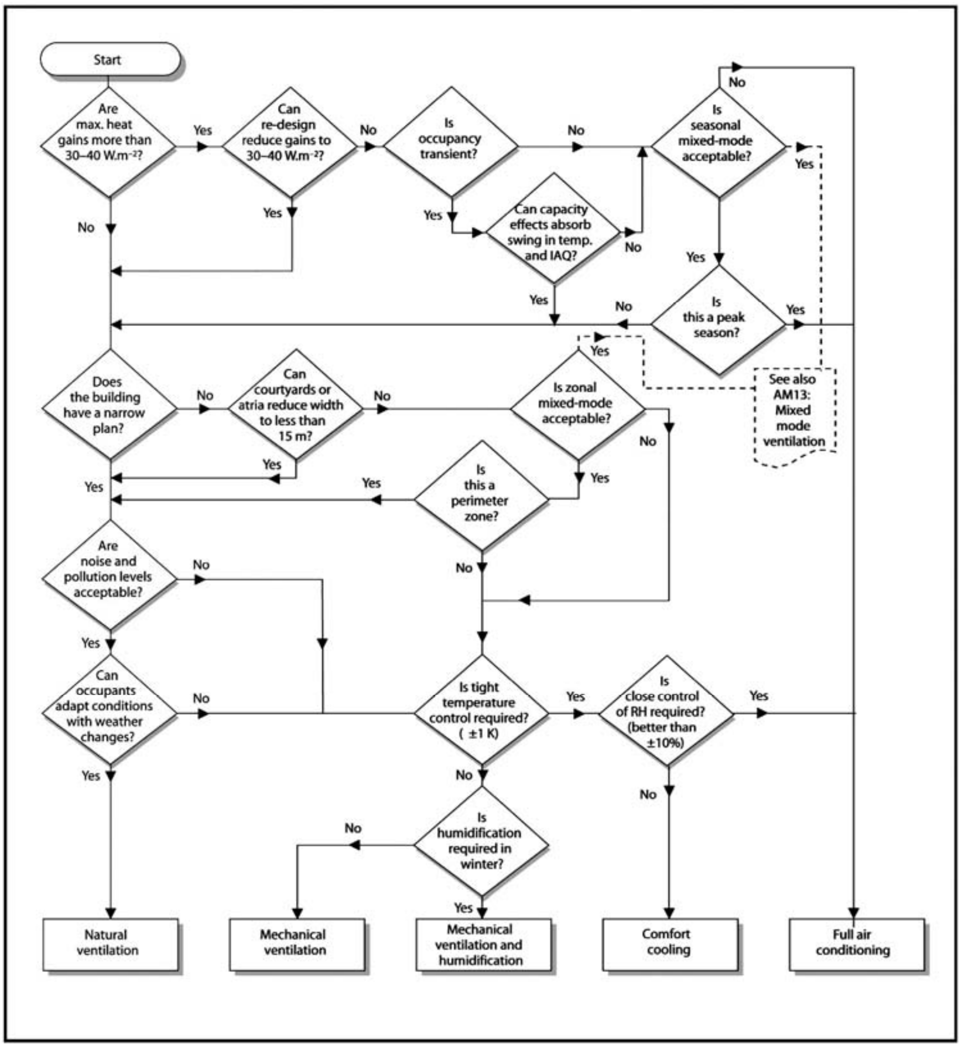
1. Develop design requirements,
2. Plan airflow paths,
3. Identify building uses and features that might require special attention,
4. Determine ventilation requirements,
5. Estimate external driving pressures,
6. Select types of ventilation devices,
7. Size ventilation devices,
8. Analyze the design.

For Mechanically ventilated Spaces: The HVAC design and sizing should account for increased ventilation rates. Ventilation strategy should include

1. Air flow paths,
2. Airflow rates planned for different operational periods during the day and night,
3. Peak internal temperature,
4. Means of shading for summer solar gains,
5. Opening size for operable windows, trickle vents and louvers,
6. Driving pressure showing the effects of both wind and stack induced pressure differentials.

The Diagram below is recommended by Charted Institute of Building Service Engineers as well as LEED to decide on an appropriate strategy for ventilation.

Selecting a Strategy, from CIBSE Applications Manual 10:2005, Natural ventilation in non-domestic buildings



Reproduced with permission from The Chartered Institute of Building Services Engineers, London

Figure 9. HVAC strategy selection (USGBC, 2007)

- HVAC systems should accommodate filtration systems. Install high level filtration systems in air handling units processing both return air and outside supply air. Ensure that air handling units can accommodate required filter sizes and pressure drops (EQ.C 2).

- Install permanent architectural entryway systems at all high traffic exterior access points such as grills or grates to prevent occupant-borne contaminants from entering the building (EQ.C5).
- To remove airborne contaminants and prevent cross contamination into occupied spaces copy, print and fax rooms must be equipped with a dedicated exhaust system with no return air that creates a negative pressure within the room (EQ.C5).
- Chemical storage and mixing area should also be located away from occupant work areas. Maintain physical isolation from the rest of the regularly occupied areas of the building (EQ.C5).
- Design facility cleaning and maintenance areas with isolated exhaust systems for contaminants.

3.6.4 Low-Emitting Materials

In the Indoor Air Quality management plan, low emitting materials should be specified. Groundwork for baseline testing of materials and HVAC system should occur during the design process, making sure that testing requirements are included in the project specification. The availability of low emitting products in Dubai is growing rapidly and local manufacturers and suppliers are now producing and stocking such products.

- Specify low-VOC (Volatile Organic Component) materials in construction documents. Ensure that VOC limits are clearly stated in each section of the specifications where adhesives,paints and coatings and sealants are addressed. Common products to evaluate include: general construction adhesives, flooring adhesives, fire-stopping sealants, caulking, duct sealants, plumbing adhesives, and cove base adhesives (EQ.C 4.1).
- For carpet systems select products that are certified under the Green Label Plus program (EQ.C 4.3).

- Specify wood and agrifiber products that contain no added urea-formaldehyde resins. Specify laminating adhesives for field and shop applied assemblies that contain no added urea-formaldehyde resins.
- Request for material samples in the form of cut-sheets, material safety data sheets certificates and test reports to verify and approve materials.

3.6.5 Occupant Controls

i. Design for Thermal Comfort:

Design the building with occupant controls for ventilation. All buildings in the UAE have mechanical ventilation and air conditioning. The opportunity to combine both mechanical and natural ventilation for many months of the year must however not be ignored. The natural ventilation will be sufficient in some buildings, like villas and apartments during the months of October to March. This can help in energy savings and could result to better indoor air quality. With a mixed ventilation system, natural and mechanical ventilation can be utilized at different times of the day, or seasons of the year, to provide a comfortable living and working environment and suitable indoor air quality.

By providing openable windows and doors in buildings, the occupants are able to exercise control over the indoors environment. There are psychological and health benefits associated with naturally ventilating spaces and people having more choice as to how they control their environment.

- Design building envelope and systems with the capability to deliver performance in the extreme temperature and humidity of Dubai.

- Evaluate air temperature, radiant temperature, air speed, and relative humidity in an integrated fashion.

- Design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy (EQ.C 7.2).
- Allow comfort control adjustments to suit individual needs or those of groups in shared space. Integrate individual controls with occupancy sensors. Design team should determine the level of individual control desired (EQ.C 6.2).
- Design for individual adjustment controls like individual thermostat controls, local diffusers at floor, desk or overhead levels, or control of individual radiant panels (EQ.C 7.1).
- Systems design should incorporate operable windows, or hybrid systems integrating operable windows and mechanical systems, or mechanical systems alone (EQ.C 7.1).
- The portion of the window that can be opened should be 4% of the net occupiable area as prescribed by LEED. Windows must be readily accessible to occupants (EQ.C 2).

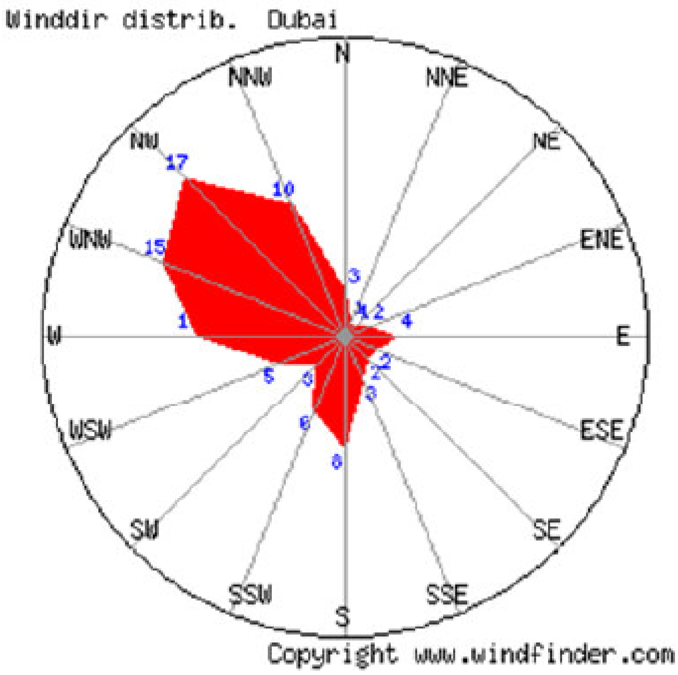


Figure 10. Annual Wind Rose for Dubai (Arup, 2004)

- A wind rose diagram for Dubai illustrates that the prevailing wind conditions arise from the north-west and west-north-west. These winds which blow in from the Arabian Gulf and are likely to bring a cooler breeze onto the land. Design to position windows and wind catchers along these directions. Consider the possibility of cross ventilation between spaces.

- Facility operators should develop procedures to survey building occupants about thermal comfort conditions. Agree to implement a thermal comfort survey of building occupants within a period of 6to 18 months after occupancy. This survey should collect anonymous responses about thermal comfort in the building including an assessment of overall satisfaction with thermal performance and identification of thermal comfort-related problems.

3.6.6 Daylight & Views

While designing for maximum views and day lighting, designers must evaluate and balance a number of environmental factors such as heat gain and loss, glare control, visual quality and variations in daylighting availability.

i. Dubai Scenario:

The UAE lies at near equatorial latitude. Here the North sun is preferred than the solar radiation on the south, west and the east as the sun appears along them at higher polar angles (Arup, 2004). Direct solar radiation through glazing substantially increases the cooling load of buildings. Restrict the amount of glazing which faces the sun. This direction of sunlight can be calculated with the help of a Sun Path Diagram and sciographies can be charted out to help orient building design. In Dubai the maximum impact of the sun is on those portions of a building which face south, southwest and southeast.

It requires designers to take early consideration of building form, orientation and rationalization of the use of glass in buildings which ultimately will help reduce the demand for cooling in buildings. A number of soft wares also aid this process. In order to reduce the solar impact on heat gain within a building, the orientation of a building and the façade design should take the sun's impact into consideration. By aligning the shorter sides of a building to face north/south, the solar heat gain can be reduced. In Dubai it is often difficult to change the building orientation due to site restrictions, but there is often some flexibility when tower blocks sit on top of podiums.

A typical Dubai building has glazed facades with no shading structure. This results in higher cooling loads and increased energy consumption. In addition, excessive brightness contrast between externally lit surfaces and building interiors causes visual discomfort. This is altered by switching on internal lights permanently, leading to unnecessary energy consumption.

A well considered daylighting approach in buildings will not only reduce the incidence of glare and discomfort but also reduce the need for electrical lighting if part of an integrated daylight strategy with lighting controls. The use of external shading devices should be incorporated in building design. This helps in reducing solar gains in the buildings and is an old popular and efficient technique used in building design of all temperate regions. Techniques such as blinds and shading fins are also highly useful in cutting out the lower sun angles during late noon and reducing internal temperature.

All the design factors for daylighting should be brought together and be considered early during the conceptual design stages. Architectural elements can also be used to divert daylight into the building if desired.

ii. Design Guidelines:

(From LEED EQ.C 8.1 and 8.2)

- Provide the building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building. The use of natural light and the access to outdoor views creates a stimulating environment for building occupants.

- Strive to incorporate courtyards, atriums, clerestory windows and skylights into the project to increase daylighting potential. Evaluate the building's orientation on possible daylighting options.

- Window area above 7'6" is considered to be daylight glazing. Achieve a minimum glazing factor of 2% in 75% of all regularly occupied areas. LEED recommends direct line of sight to the outdoor environment via vision glazing between 2'6" and 7'6" above finish floor for building occupants in 90% of all regularly occupied areas. This needs to be carefully incorporated along the north facade in Dubai considering the heat gains from exposed glazing and high occupant loads.

- Add interior light shelves, exterior fins, louvers and adjustable blinds, appropriate glazing selection.
- Suggested strategies to maximize view opportunities include building orientation, shallow floor plates, increased building perimeter, exterior and interior permanent shading devices, high performance glazing and automatic photocell-based controls.
- Predict daylight factors via manual calculations or model daylighting strategies with a physical or computer model to assess footcandle levels and daylight factors achieved.

- Daylight strategies should address light levels, interior colour schemes and integration with the electrical lighting system. Photo responsive controls for electric lighting can be incorporated into day light strategies to maintain consistent light levels.
- Integrate lighting systems controllability into the overall lighting design. Provide ambient and task lighting while managing the overall energy use of the building. Ensure uniform ambient illumination.

- All exposed glazing surfaces should be backing insulated panels.

- The direct solar heat gain for windows on the north shall be significantly lower and hence glazing should be predominantly North- oriented. The North light is also popularly used in architectural design for its pleasant quality, glare free, reading light.
- The best strategy to reduce heat load is to provide external shading elements which restrict the amount of sunlight passing through the windows. The shading can be integrated parts of the building structure or be elements which are fitted to the main structure. If shading is used, it is most effective on the west- and south-facing walls (EQ.C 7.1).

- Horizontal shading reduces the impact of near vertical sun in the middle of the day, while vertical shading reduces the impact mostly on the morning and afternoon sun (EQ.C 7.1).

3.7 VERNACULAR DESIGN FEATURES

Architecture in any society constitutes one of the most important and often one of the most enduring cultural artifacts (Velinga, 2005). Local archeology, history, and people are the existing matrix forming the foundation of new age architecture. In addition to illustrating the cultural embodiment of architecture, vernacular architecture also focuses on contemporary issues such as urbanization, emergency housing, technology transfer and resource management. *Vernacular Architecture* (1999) shows that vernacular traditions are not anachronistic survivals of a vanishing world, but are infact important to the future provisions of culturally appropriate and sustainable architecture. Every culture, every civilization has a fingerprint of those things that are unique to it and if one can take things on, reinterpret them with contemporary building systems and materials, we can refresh the genius of that place in the world (Anon, 2008).

There is a growing recognition that cultural issues need to be acknowledged for a project to be successful. There is an increasing need for anthropological involvement in the design of sustainable architecture. Effectively what Oliver calls for is an approach that regards the vernacular as a locus of indigenous knowledge – one that critically examines the possibilities of implementing local vernacular know-how in both a development and modern context.

Sustainable principles seek balance between existing cultural patterns with new development. Sustainability has often been an integral part of the composition of both tangible and intangible cultural resources. Developing an understanding of local culture and seeking their input in the development processes can make the difference between acceptance and failure. The book Homework(Khan,L. 2004) demonstrate the strength of the need, desire and capacity of human beings all around the world to be in control of their own built environment , to create buildings that are intimately related to their sense of identity.

The vernacular buildings are portrayed as sophisticated works of art that are fully in touch with their environment while the architecture of modern societies is described as unimaginative, made of inflexible and toxic materials and leading to social isolation. The vernacular conveys '*a personal and human beauty*' while the modern often dose not (Velinga, 2005). This gap between the modern and vernacular has to be bridged for a truly sustainable design. Oliver's action oriented objective calls for 'a modern vernacular that is inspired by a responsive and sensitive balance between the knowhow and wisdom of the past and that which is sustainable and modern.'

In response, contemporary Gulf architecture should be about applying tradition, culture and modernity in equal parts, to create something that is undeniably 'Gulf' yet clearly modern.

3.7.1 SUSTAINABILITY AND CULTURAL RESOURCES

It is not just nostalgia that draws people to historic developments. Much of what is valued in these developments is their response to the climate, natural setting, and locally available building materials. Their usefulness as model for new buildings only adds to their value. Many preserved buildings, districts, and landscapes consist of vernacular design architecture without architects, built with onsite or locally available materials. (Hart .1994)

A symbiotic relationship of human activities within their host environment is evident in the Bastakiyas of Dubai now preserved as the cultural heritage zone of the city. Natural sandstone, date palm leaves and local mud were used to build and shelter communities from the harsh desert. Permanent houses were made of stones or *Guss* (mud mixture made as blocks) and covered with palm trees leaves (Mahgoub, 2009). Small courtyards enhancing the stack effects, common mud walls to reduce exposed surface area of dwellings to the sun, wind catchers known as *Al-Barjeel,* in the form of ornate towers with small openings in all four directions acting as arab air conditioners, were all features of UAE architecture The occupants' structures were their direct response to the environment. They built them with what they had, and built them in such a way as to be cool in the summer, easily warmed in the winter, and with small openings that could be blocked over quickly in the event of a sandstorm.

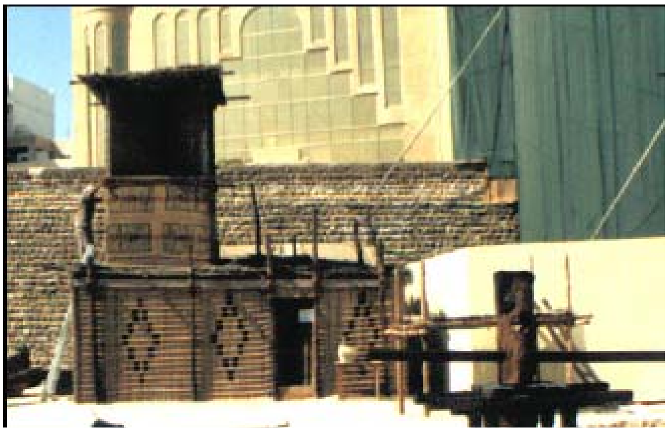


Figure 11. Al Arish (Palm tree leaves shelter) at Dubai Museum (Mahgoub, 2009).

The vernacular response to climate, setting, and materials provides opportunities for presenting positive lessons in ecologically sound design. Often older buildings were designed to take advantage of natural light, non-mechanical ventilation, passive solar heating, and the ability of native materials to hold heat or cold when assembled in certain fashions. Conversely, more recent structures rely on energy-consumptive systems for their continued use.

Building construction prior to the 20th century, were built with locally available materials. Obtaining these materials and erecting the buildings were relatively low in energy consumption. In contrast, many modern buildings consist of materials from all over the globe, obtained at an enormous cost in energy and resulting in the rapid depletion of worldwide resources. Interpretation of architectural styles through features such as thick adobe walls, broad eaves, small windows, wind towers and high ceilings can provide valuable lessons in sustainability. How these low-tech features functioned during times when energy consumption was limited provides examples of principles applicable to today's efforts to conserve energy.

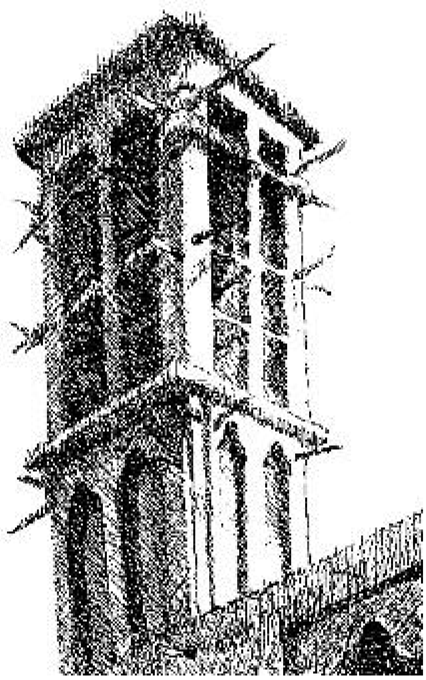


Figure 12. Al-Barjeel or Al-Kashteel traditional wind towers (Mahgoub, 2009).

i. Design Guidelines:

Sustainable building decisions usually fall into one of these three basic categories:

1. **Materials & Equipment** (specifications and application methods)

2. **Active/Systems Design** (mechanical, electrical, plumbing systems)

3. **Passive/General Design** (placement/orientation of building and rooms)

- Great thought and effort should be invested to spatially fits the building and its design “program” into the natural environment so as to take advantage of existing, free benefits—such as light and heat from the sun, shading from trees, wind etc.

- A large amount of heat can be reflected away from a building through the use of reflective exterior surfaces. Passive building design and material choices that avoid absorption of the sun's heat to promote thermal comfort and energy conservation, are traditional methods used by early inhabitants of UAE, who constructed their homes and buildings from light coloured and white materials. Dubai’s traditional buildings, like the ones at the Bastakiya have light coloured exterior finishes and they help in reducing energy use. Light exterior colours with high SRI are highly recommended.

- It is common to see water features in the UAE used for aesthetic enhancement. Water features can be incorporated to promote passive cooling during the hot summer months. However due to the high levels of humidity and the vulnerability of the Legionnaire’s disease, in the UAE, this technique should be implemented with regular easy maintenance as a part of the design. The temperatures in UAE encourage growth of Legionella bacteria and hence it becomes very essential to carry out regular checks and maintenance to ensure that any contamination does not become a general health hazard. Water bodies add to the humidity levels during the summer months, causing further discomfort, hence their usage thoughtfully designed.

- Cooling towers are commonly used for Air conditioning usages. Building water features connected to the cooling towers should be regularly inspected and maintained to reduce the risk of occurrence of Legionnaire’s disease.

- Wind catchers can be positioned to trap and filter breezes aiding natural ventilation during the cooler months of the year. Mechanical controls can be incorporated to shut off or promote air circulation.

The focus on environmental design has been marked with the rediscovery and further development of many “ancient” skills and techniques. Sustainable building can include a wide range of methods, materials, and systems. Sustainable building has active and passive components. Technology can lead us towards sustainability, but must be applied cautiously as in some instances it can end up doing more harm than good. A decision *not* to use certain high-tech gadgets can be as important as the decision to use others. Apply strategies or measures that demonstrate a comprehensive approach and quantifiable environment and health benefits. This could be the most essential requirement for the development of contemporary sustainable architecture.

3.8 Construction phase requirements

Though construction phase requirements could run into many details, those which need to take shape at the design stage are reviewed here. Preplanning the construction process will help identify alternative methods that minimize resource degradation. Throughout construction, resource indicators should be monitored to ensure that resources are not being adversely affected.

Monitoring of the proper implementation of the design requirements must be carried forth into the construction phase to realize the capacity of the green design. The following procedures are recommended by LEED.

i. Guidelines:

- Create an Erosion and Sedimentation control plan for all construction activities. This should be incorporated into the construction drawings and specifications with clear instructions regarding responsibilities scheduling and inspections. This planning shall be an integral part of the design phase (SS.P.1)

- Designate an independent commissioning authority to lead, review and oversee the completion of all commissioning process activities. Begin the commissioning process early during the design and execute additional activities after systems performance verification is completed. Have a contract in place to implement additional commissioning process activities. (EA.C 3).

- Develop an Measurement & Verification (M&V) Plan to evaluate energy system performance. Install the necessary metering equipment to measure energy use (EA.C 3).

Commissioning can minimize the negative environmental impacts buildings have on our environment by helping verify that buildings are designed, constructed and operated as intended and in accordance with the Owner's Project Requirements. The importance of commissioning and 3rd party verification is yet not completely realized in the UAE. This is also reflected in the lack of appropriate certified commissioning agents, making it difficult to apply this procedure to its effect. More awareness needs to be raised regarding the importance of commissioning in order to statistically monitor the benefits of green principles.

Many Air Quality management issues need to be addressed during construction. Though this is beyond the scope of this study, they have been briefly reviewed in order to analyze its impact on the design stage and the pre preparation required during design. Pointers for air quality need to be part of the specification documentation. Key elements are listed in the Appendix for further information.

3.9 List of Indicators

From the study gathered above, a summary list giving an overview of essential design guidelines along with the guiding DM regulations is prepared below as a handy tool for designers. The environmental concern of a building can be cross checked against these requirements to assess its sustainability index.

Requirement	**DM regulations**
Environment and planning	
Climatic response	
1. Develop climate responsive building designs	DM building regulations Administrative resolution No. 125-2001, Article 26.and The regulations, codes of conduct & practice for the Dubai desert conservation reserve.
2. Understand microclimates.	

3. Use thermal mass to improve comfort and efficiency.	Administrative Resolution N0 30 – 2007, Article 63, which in turn implements Local Order 11 – 2003, Chapter 9, Article 54.
4. Select space-conditioning strategies	
5. Shade south facing windows	
6. Orient building design with Sunpath Diagram	
7. Align shorter side of a building to face north/south	

Site Selection	
1. Develop previously developed land in an already developed area	Technical Guideline (TG)No. 53:Environmental Impact Assessment Report & TG No. 56: Environmental Development Plan.
2. Avoid sensitive land types.	DM Local Order No. 61 of 1991 on The Environment Protection Regulations in t Dubai
3. Provide shaded pedestrian & bicycle access to surrounding areas.	Federal Law No. 24/1999, PROTECTION AND DEVELOPMENT OF THE ENVIRONMENT
4. Develop Brown fields.	ENVIRONMENT PROTECTION & SAFETY SECTION,Number 54, Clean-up of Contaminated Land
5. Develop close to Mass transport.	

Building Footprint	
1. Design small footprints for buildings	
2. Minimize disruption of the eco-system	DM Technical Guideline No 4
3. Build in dense blocks	
4. Share amenities and spaces with neighbours.	
5. Incorporate natural features existing on the site	
6. Provide vegetated open for recreational opportunities.	
7. build minimal/no additional infrastructure to support the building	
8. Design accessible open spaces for recreational activities.	

Parking and transportation	
1. Perform a transportation study of future occupants	
2. Reduce size of parking lots	

3. Provide underground/ multistory/deck parking	
4. Provide secure bicycle storage + bicycle path + shower areas.	Dubai Bicycle Master Plan (January, 2008), Dubai Roads & Transport Authority (RTA)
5. Provide minimum required parking	DM building regulations Administrative resolution No. 125-2001, Article 24, 25 and 27.
6. Provide preferred parking for low-emission vehicles	UAE Federal Law No. 25, 1999. Article 22 for special needs.
7. Provide infrastructure to facilitate shared vehicle usage	
8. Build re-fuelling stations for hybrid cars	

Cool Roofs	
1. Provide green roofs where possible	DM circular 171 -2009; Landscaping of Rooftops and Building Facades, July 09
2. Provide roofs with high SRI/vegetation	
3. Cover roofs with PV panels or solar water collectors.	
4. Design as per DM Circular 191	

Light Pollution	
1. Avoid off-site lighting and night sky pollution	
2. Minimize site lighting	Lux levels should meet the Code of Construction Safety, Practice, Section 3.9.
3. Minimize architectural and feature lighting	
4. Select low intensity efficient fixtures	
5. Shield fixtures, use downlighting.	
6. Prevent interior light spill	
7. Install programmed lighting control panels	
8. Install occupancy sensors	

Building orientation and Landscaping	
1. Increase shade canopy	
2. Plant native or adapted plant material.	The Comprehensive Guide to the Wild Flowers of the United Arab Emirates. Marijcke Jonbloed, ERWDA, Abu Dhabi.2003.
3. Increase green area on building sites	

Water Efficiency	
Potable water	
1. Reduce potable water consumption for irrigation.	TG No. 57 – Bunding of Storage Tanks and Transfer Facilities
2. Specify high-efficiency fixtures	
3. Install occupancy sensors	
4. Install metering controls	DM building regulations Administrative resolution No. 125-2001, Article 28.
5. Capture/reuse treated water for non-potable uses.	Circular No. 93 – Ref:812/02/19931 – Rainwater Drainage Orifices and Number 62, The Reuse and Irrigation of Wastewater and Sludge
Wastewater reuse	
1. Reduce wastewater volumes generated.	Technical Guideline No. 12 – Requirements for Gravity Oil-water Separator
2. Treat wastewater to DM technical guideline 62	Standards for Disposal of Wastewater - Executive Regulations of DM Local Order No. 61/1991 (Article 19)
3. Install dual plumbing lines for wastewater	DS 96 – DM Sewerage and Drainage Design Criteria, DM building regulations Administrative resolution No. 125-2001, Article 43, 45, 46
4. Collect condensate water	Management of Legionella in Water Systems and Industrial Plants,1994
5. Use alternative permeable surfaces	Circular No. 93 – Ref:812/02/19931 – Rainwater Drainage Orifices

Water Efficient Landscaping	
1. Use captured water/TSE for irrigation	
2. Design landscape with indigenous plants	Circular No. 77, Concerning the Perennial Trees within the Existing Plots of Land and Farms
3. Plan water use zones & group plants accordingly	DM Circular No. 77, Concerning the Perennial Trees within the Existing Plots of Land and Farms
4. Use high-efficiency Irrigation equipment /climate-based controllers.	
5. Minimize the amount of land covered with turf	
6. Reduce impervious surfaces on the site	

Energy Efficiency
HVAC requirements:

1. Design as per ASHRAE 90.1	
2. Recover waste energy	
3. Use TSE for water cooled HVACs.	
4. Provide vestibules at building entrances	
5. Insulate pipes and ducts	DM building regulations Administrative resolution No. 125-2001, Article 50. National Fire Protection Association (NFPA) Standards as applicable for use in Dubai.
6. Incorporate thermal bridges	
7. Install metering controls	DM building regulations Administrative resolution No. 125-2001, Article 28.
8. Connect to a district cooling system	
9. Include thermal storage systems at District cooling plants	
Building envelope	
1. Use a computer simulation model.	
2. Design Building envelope with insulation	
3. Design U value requiremts according to DM decree 66	Administrative Resolution No 66 -2003 'Approving Regulations on the Technical Specifications for Thermal Insulation Systems and Control of Energy Consumption for Air-Conditioned Buildings in the Emirate of Dubai'
4. Window area > 50% of the gross wall area.	DM building regulations Administrative resolution No. 125-2001, Article 26.
5. Skylight area > 5% of the gross floor area.	
On-site renewable energy	
1. Design for use of 35% renewable energy	
2. Use on-site renewable energy	
3. Engage in a green power contract	
4. Exterior lighting powered through renewable electricity	
5. Install Solar Hot Water systems	
Refrigerant Management:	
1. Avoid/Phase out the use of CFC-based refrigerants	Technical Guideline No. 55, Replacement of CFCs in Degreasing and Cleaning

2. Select refrigerants with low ODP	DM Circular No. 108-2001, Concerning the Special Protocol Control Procedures of Ozone Depleting Substances; Dubai Municipality Technical Guideline Number 58—Policy for the Control of Ozone Depleting Substances
3. Use equipment with increased equipment life.	
4. Fire suppression systems should not contain Halons.	
MATERIALS & RESOURCES	
Material Procurement:	
1. Use locally sourced materials	
2. Use rapidly renewable materials	
3. Use FSC-certified wood products	
4. Specify the above in contract documents	
5. Usage of lower wood grades.	
Waste Disposal:	
1. Provide for segregated waste disposal	New rubbish collection system involving underground containers
2. Locate central collection and storage area	DM building regulations Administrative resolution No. 125-2001, Article 28.
3. Provide sorting and storage facility for recyclable materials	Dubai Municipality Building Regulations – Administrative Resolution 125-2001
4. Incorporate salvaged materials into building design	
5. Involve local hauler to provide waste management services	
6. Design for front loader bin and a ramp up to recycling area	ENVIRONMENT PROTECTION & SAFETY SECTION, Waste Minimization. Technical guideline No. 28/2000
7. Hazardous waste disposal permits as per DM	Dubai Municipality Technical Guideline Number 26 - Requirements and Procedures for the Disposal of Hazardous Wastes, January 2005 Revision.
AIR QUALITY MANAGEMENT	
Tobacco Smoke management	
1. Prohibit smoking in the building	DM Information Bulletin, Environmental Standards and Allowable Limits of Pollutants on Land, Water, and Air Environment. May 2003

2. For smoking rooms, obtain permit allowing smoking	Dubai Municipality Local Order No 11 – 2003 and Administrative Resolution No 92 – 2009 "Regulating Smoking in Public Places"
3. Design as per DM Resolution No 92 – 2009	
4. Exterior smoking areas at least 25 feet away from entries/ air intakes/ windows	
5. Smoking room must be directly exhausted to the outdoors	
6. Provide impermeable partitions to smoke rooms	
7. Design for a negative pressure with Door closers	
Improved Air quality	
1. Design systems to meet ASHRAE Standard 62.1-2004	TG No. 29 - Requirements for the Discharge of Waste Gases, Fumes, and Dusts to the Atmosphere
2. Provide naturally cross ventilating spaces	DM building regulations Administrative resolution No. 125-2001, Article 12, 13 and 14.
3. Install permanent air monitoring systems	DM Administrative Resolution 30 – 2007, relative to Implementation of Local Order 11 – 2003
4. Supply outdoor air to parking levels	DM building regulations Administrative resolution No. 125-2001, Article 63
5. Install CO_2 & CO monitoring at 3 - 6 feet AFFL in parking.	
6. Install high level filtration systems in AHUs	
7. Install permanent architectural entryway systems	
8. Dedicate exhaust systems for print & fax rooms	
9. Maintain negative pressure in rooms with chemicals.	
10. Dedicate exhaust systems for cleaning & maintenance areas	
11. Isolate chemical storage and mixing area	Technical Guideline No. 57 Bunding of Storage Tanks and Transfer Facilities
Low-Emitting Materials:	
1. Specify low-VOC materials in design	TG No. 48 - Safety in Handling Asbestos

2. Select certified Green Label Plus program carpet systems	DMS 20:2005—Specification for Paints and Varnishes
3. Specify assemblies with no added urea-formaldehyde resins	DM building regulations Administrative resolution No. 125-2001, Article 63.
4. Specify testing in the project specification.	
Occupant Controls:	
1. Provide for combination of mechanical and natural ventilation	DM building regulations Administrative resolution No. 125-2001, Article 12, 13 and 14.
2. Design HVAC systems according to ASHRAE 55-2004	DM building regulations Administrative resolution No. 125-2001, Article 15.
3. Integrate individual controls	
4. Provide for occupancy sensors	
5. Openable windows constitute 4% of occupiable area	
6. position windows/ wind catchers along NW & WNW directions	

Daylight & Views:	
1. Restrict glazing which faces the south	
2. Use external shading devices to reduce glare & heat	DM building regulations Administrative resolution No. 125-2001, Article 26.
3. Provide min 2% glazing in all regularly occupied areas	
4. Add interior blinds, louvers, light shelves etc	
5. Use high performance solar control glazing	
6. Provide Photo responsive controls for electric lighting	
VERNACULAR DESIGN FEATURES	
1. Design to take advantage of existing natural resources.	
2. Design exteriors with light colours with high SRI	
3. Promote use of courtyards	
4. Provide wind catchers with filters.	
5. Include maintained water features in design	

Construction requirements	
1. Create an Erosion and Sedimentation control plan	Dubai Municipality Technical Guidelines 29 and 48. Dubai Municipality Building Department's circular papers for construction and demolition activities C 77,C 89, C 108, C 117, C 139, C 154, C 158, C 161; and Dubai Municipality's Building Department's 2008 Code of Construction's Safety Practice.
2. Designate 3rd party commissioning for all systems	
3. Evaluate energy system performance through M & V Plan	
4. Protect the HVAC through IAQ management plan during construction	
5. Sequence the installation of materials to avoid contamination	
6. Depressurize construction work area	Dust Supression techniques as per UAE Federal Law 24 – 1999,Article 52 and DM Code of Construction Safety Practice Section 3.12.
7. Perform a building flush-out of HVAC pre-occupancy	Dubai Municipality Information Bulletin, Environmental Standards and Allowable Limits of Pollutants onLand, Water, and Air Environment. May 2003.

For all standards not mentioned by DM, British standards or ASHRAE standards are adhered to.

Refer to Circular No. 161—2008, Concerning the Implementation of Green Building Standards in Dubai for an insight on the overall green building guideline announced to come.

Further to the guidelines suggested above, the process of design is inherently creative. So is the process of sustainable buildings. Creativity and thoughtful green intent could lead to various expressions of sustainable architecture. Hence more than the need of applying any guideline to green design,a creative thought process could lead to various sustainable innovative solutions which would be apt to the conditions of the building setting. Thereby encourage creativity thinking in sustainability!

Chapter 4: RESEARCH METHODOLOGY

4.1 Introduction

The previous chapter gives an overview of the intent of this thesis along with its aims and objectives. This chapter details the appropriate techniques it can adopt to achieve these objectives.

4.2 Research Methodology, Approach and Strategy

i. Methodology

From the three different ways mentioned by Yin(2003) of the methodology for research, the approach adopted for this study is that as being descriptive as well as exploratory. Descriptive research explains empirical generalization (Yin, 2003) based on existing theories and hypothesis. Exploratory research is one in which a problem is difficult to limit coupled with little or restricted research available on the topic.(Chaudhry, 2007 cites Eriksson et al,1997)

In order to gain a deeper knowledge of green principles and its influence on the design process in the construction industry of Dubai various sustainable design measures are explored. Description of the Dubai climate and conditions along with the conventional construction habits are documented. The issue of sustainability and governmental commitment are reviewed. Regional influences and theories showing the effectiveness of vernacular architecture as sustainable design prototypes are examined. Hence the study is largely descriptive. However, as the study is being carried out in a region and industry, new to sustainability ideas it can be considered as exploratory as well. Thus the methodology utilized for this research is descriptive cum exploratory.

ii. Research Approach:

A qualitative research is ensued to gain a deeper understanding and description of the problem, as described by Holme and Solvang (1991). It is a through gathering and analysis of data of ideas, feelings and attitudes is conducted through meaningful interviews in companies (Tull and Hwakins,1990), along with tacit knowledge learning and direct observational study to obtain comprehensive information. This enables the researcher to have an overall view. (Saunders et al.2000). Hence in light of the above discussion, the qualitative approach to the defined objectives is found appropriate and pursued in this study.

Research strategy to perform this study can be termed as that of Survey, and Archival analysis as defined by Yin (2003). A casestudy approach is utilized as it helps to maximize and gain indepth knowledge (Stake,1995; Yin 2003). A case study tries to illuminate a decision or a set of decisions, explain why they were taken how they were implemented.(Yin 2003). This helps to acquire in depth information from the designers perspective and therefore a case study approach is found appropriate.

A questionnaire approach is not considered appropriate for this study. Conducting a large scale employee survey is not sought as it has limited value to the solutions of the desired objectives. This stance ensues from two reasons; firstly that information for green design available with professionals currently working in the construction industry in Dubai at this stage is very primitive and is limited to the few knowledge centric individuals who are considered as green building experts. Since surveys are used to generalize the results of the sample(Yin 2003) conducting a survey for the purpose of this research will be of little value. Furthermore, survey results are based on breadth (Stake, 1995) whereas this research pleads depth rather than breadth. In light of this stance, case studies along with the following data collection techniques were found apt.

4.3 Evaluation of literature for Green design

The first step involves collection of a knowledge bank for green rules. The most popular, amongst the various pre existing models of green design are evaluated and explained. Extensive data collection from green design guides used world over, primarily focusing on the study of the design submittals from the LEED system is carried out, as in Chapter 3; Study of planning methods; as this forms the basis of the forthcoming green regulations in Dubai. The purpose of this is to prepare a database of all the popular techniques used world over while acquainting the researcher with accepted practices.

At parallel, the study of the systems and procedures relating to the building industry in Dubai are gathared. Applicable regulations, government requirements and public and private social green initiatives are taken into account and archived. The existing infrastructure and regulations available to support its applicability are researched as they form an essential part in the success of the green principle. This is studied in conjunction with the prescribed green regulations to examine their influence over each other or the lack of it.

These existing systems are combined in a way that matches the research objectives and a new model is developed. This new set of parameters are used to evaluate the case studies, questioning the usability, influence on the design process and the difficulties associated with its implementation in Dubai. Case studies are analyzed in an attempt to cross verify the design and implementation of shortlisted principles; learn different green strategies undertaken in live projects, understand its impact on the design along with the method of incorporating these green elements. Discussions and interviews with the design consultants of these buildings give further insight into the unique issues associated, specifically with this region.

Design knowledge acquisition, retention and retrieval is an ongoing process, with several steps and levels to be considered. The researcher shall decide how to parse the process into ecologically meaningful stages that are subject to verification and measurements. (Walsh and Ungson, 1991). Hence design knowledge retention can be considered to be a continuous ongoing process.

This helps in bringing forth a clear picture of the additional requirements in a building proposed to be green, from the design perspective.

4.4 Tacit knowledge/ Individual to individual

Socialization and sharing knowledge at an individual level is an effective technique in learning tricks of the trade. By constant interaction with individuals in design consultancies, gathering of design knowledge pertinent to the objectives is achieved. An attempt is made to learn and expolate ancient and primary self sustaining design methodologies, now sparingly used from experienced professionals and find out how they can be adapted into today's environment with their advise.

Individuals are important not only because they themselves are a source of retained information, but also because they largely determine what information will be acquired and then retrieved from their memory banks.(Al-oum, 2008). In order to build and sustain their competitive advantages, the knowledge and expertise of staff members need to be seen as critical strategic resource (Bender and Fish, 2000). Several years of expertise lead to extensive untapped tacit knowledge of the regional context and other aspects of design such as difficulties in design articulation, this knowledge is gathered through the process of design workshops, frequent co-ordination as a team member and one to one interactive advice on design aspects. As Nonaka(1994) describes, individuals are knowledge creators and the key to acquiring tacit knowledge is experience. Individuals are an excellent starting point for examining information acquisition, its retention and retrieval process.(Walsh and Ungson, 1991). Sharing allows the distribution of captured knowledge of an individual to another individual that may require this relevant information(Mc Manus et al, 2003).

This knowledge is transposed and enriched with the help of literature which is then offered as information in the thesis.

4.5 Action oriented Research/ Direct observation

The best way to get a first hand impression of the incoming changes is to be an involved spectator of the industry employing direct observation technique. As Yin(2003) notes, direct observation technique provides evidence that is contemporary based on the observations of the researcher and hence is one of the strengths of the case study approach.

Being an architect and working in a world-class consultancy practicing responsible design the researcher is actually in the midst of the design change process performing action research; therefore direct observation forms an important part of the data gathering process. Action research studies the system in its environment and surrounding circumstances along with getting involved with the members of the system to change it towards a desirable direction through active collaboration of both the researcher and the client. Hence co-learning is a feature of the process (Al Hammadi cites Gilmore et al. 1986). . Having the opportunity of being involved in green design workshops, having undertaken a certification course in the LEED rating system, and being the regulatory authority liaising engineer for the consultancy employed with, the researcher has ample opportunities for interaction with the system and makes him a good direct source of information. A sudden increase in the number of green seminars, conferences and workshops was noticed with the announcement of the forthcoming green regulations. The information gathered from these interactions has further enriched the data collected by the researcher.

4.6 Interviews

Dialogues in the form of face to face communication between persons is a process in which one builds concepts in cooperation with others. (Nonaka 1994). Research advocates interviews where textual depth and insight is required (ONS, 2005; May 2001). Interviews yield rich insight into people's experiences, opinions….” (Lilleker, 2003).

Further, given the infantile nature of green technology in the Middle east and the indepth insight required for the analysis, it is essential that the interview be conducted with individuals possessing detailed knowledge of the project , with involvement throughout the design process of a green building in Dubai and encompassing proper authority to justify the application of a certain design decision and ensuing procedures.

Interviews should provide a holistic view of the entire process with proper insights, hence the researcher should deliberately seek out individuals who fit the bill (Jick, 1979). Lead project Architect, Consultant Project Manager, Cladding Engineer and engineers from regulatory authorities were chosen as a source information based on their involvement in decision making and years of experience in the region. Semi-structured informal interviews was adopted as a method of collecting data from these individuals. AlHammadi (2009) notes that the use of informal interview is preferred in the UAE culture where socialization is considered more appropriate than rigid formal interviews. Semi structured interviews are flexible allowing the interviewer to cover the predefined checklist of topics and interact with the interviewee by formulating ad hoc questions to obtain the desired information. (AlHammadi, 2009). Hence, the interview's questions are more likely to be conversational and fluid rather than rigid structured interviews (AlHammadi cites Yin, 2009). The fact that these interviewees are team members or are in a job profile where occasional interaction comes about, added to the informal nature of the interview sessions. The questions included in the interviews were related to the design elements in the case studies and applicable regulations for building design. Topics covered in the interview are listed in the Appendix. Open ended questions relating to the design process gathering opinions about green design practices in UAE was the intent of the interview.

4.7 Data collection/ Documents:

4.7.1 Information sourcing

Help is sought from the government officials in gathering Dubai relevant data through personal meetings and via web correspondences requesting assistance. The advise of green professionals in public and private sector is sought as valuable input in listing out green design requirements. Local articles and literature supporting green initiatives are reviewed.

4.7.2 Websites and Circulars

Data is collected from UAE specific online websites propogating green building design, like the Emirates Green Building council, Dubai Municiplaity , MASDAR to name a few (Complete list provided in the Appendix). The need for local information was found essential as the literature covers information used word over which may not be apt for application in Dubai. Contextual forces are critical to change (Abrahamson and Fairchild,1999). The collected data helps in pinpointing certain requirements whose adoption is not appropriate for Dubai. These are investigated to assess if any amendments can make its usage more favourable.

Dubai Municipality circulars releases forms an integral part of the research as these have direct impact on the sequence of activities carried out in a project. These study of these circulars has an impact on when and how these activities are to be undertaken, modifications to building specifications and hence goes forth to shape design decisions and procedures.

4.7.3 Local Media

Media accounts have been gathered for the purpose of this research from industry related publications. This provided the latest market information on the topic along with industry attitude, reaction and responses to the subject. An attempt has been made to restrict the information collected to two well known regional publications and two well respected English daily newspapers. Information has been gathered from the following:

- ITP's "Architect" magazine,

Can be accessed online at:

- ITP's Construction Week" bi-weekly.

Can be accessed online at:

- 'Gulf News' a daily newspaper

Can be accessed online at: www.gulfnews.com

- Khaleej Times:

Can be accessed online at: www.khaleejtimes.com

Hence, the rationale behind the requirement, impact of contextual factors, the implementation procedures followed, the new process followed are discovered through the above mentioned methods and a rich account of the entire design effort required will be synthesized.

Chapter 5: CASE STUDIES

Case studies are carried out in an attempt to understand the application of the reviewed sustainability elements in project design and execution. Vast amount of information and project management techniques can be learnt from the practical experience gathered in case studies. Similarly, the following case studies aims to understand green design principles better and showcases various ways to execute them. These case studies have been collected by the simple technique of site visits, data collection from design reports and one-one interviews with design consultants of the project. Anonymity has been maintained on the request of the consultants and client.

5.1 Case Study I: Beach Resort

5.1.1 Introduction

This case study has been prepared in relation to a proposed five star luxury beach resort in Dubai. The resort will be located in the district of Jumeirah and the site is surrounded predominantly by residential houses and small businesses. It is proposed to be a LEED accredited building and is still in the construction documentation stage. The Project will comprise both hospitality and commercial facilities including the following uses:

- Guest accommodation;
- Spa, fitness, and recreation facilities;
- Retail shops;
- Food and beverage facilities; and
- Administrative space.

The resort complex comprises of a main vitality building along with a fitness centre. A series of connected chalets provide accommodation to the guest and are supported by 2 restaurants and other wellness facilities.

This case study has been compared against the list of green elements compiled in the previous chapter. A check list with reasoning for each of the elements were prepared. This was done in co-ordination with the project team's lead architect, who explained the factors impacting the decisions during the design stage. Design Workshops consisting of the architectural, structural and MEP consultants were held every week to monitor the design progress. The researcher was invited to attend such a design workshop in order to understand the green building design process. The list and the information gathered by attending the design workshops are discussed and analyzed below.

5.1.2 Importance of Sustainability

i. Important Of Sustainable Design elements in this project:

The inclusion of sustainable design elements is considered to be one of the driving forces of the Project in a bid to minimize potential environmental impacts and in lieu of the energy conscious market. A balance between economic, human and environmental implications of the development are sought to ensure that the proposed development adheres to the principles of sustainable development. The sustainability component of the Project will have the greatest potential to positively impact on the baseline environmental conditions.

ii. Sustainability at design stage:

The sustainability goals for the project are being integrated into the design as opposed to being a separate sector of the development as it is essential that the design of green elements is an integrated process. An integrated design approach is utilised and the project is being guided by a LEED Accredited Professional (AP). Sustainable design options for the project are being considered and incorporated into all sectors of the project to minimise its environmental footprint.

iii. Additional activities undertaken to incorporate sustainability: Prior to the start of construction activities, the prevailing environmental conditions have been studied and utilized when designing energy-consuming installations such as power, ventilation, air conditioning, lighting and vertical transportation systems. An Environmental Impact Assessment (EIA) report and Construction Environmental Management plan (CEMP) have been prepared and is being practiced. As the building is designed to be LEED rated, various design credit elements are incorporated.

5.1.3 Verification of list of green elements

Requirement	Provided	Remarks
Environment and planning		
Climatic response		
1. Develop climate responsive building designs	✗	Not possible due to commercial restriants. Features included to utilise positive climatic impact
2. Creation of microclimates.	✓	Created with water bodies and vegetation
3. Use thermal mass to improve comfort and efficiency.	✗	
4. Select space-conditioning strategies	✗	Mechanically conditioned spaces
5. Shade south facing windows	✓	With trellises and planting
6. Orient building design with Sunpath Diagram	✗	Site restrictions due to privacy issues related to Adjoining Ladies Club plot
7. Align shorter side of a building to face north/south	✗	
Site Selection		
1. Develop previously developed land in an already developed area	✓	Hotel development previously
2. Avoid sensitive land types.	✗	Built on existing Marine flaura and fona

3. Provide shaded pedestrian & bicycle access to surroundings.	✓	Connection to RTA bicycle path provided
4. Development of a Brown field.	✗	NA
5. Develop close to Mass transport.	✓	Well connected to public transport.

Building Footprint		
1. Design small footprints for buildings	✗	Sprawl structure due to nature of commercial usage.
2. Minimize disruption of the eco-system	✗	Building of Breakwater restaurant affecting flaura and fona
3. Build in dense blocks	✗	Buildings scattered all over site.
4. Share amenities and spaces with neighbours.	✗	Nature of commercial usgae require all amenities within plot for security reasons.
5. Incorporate natural features existing on the site	✓	Beachfront,. Existing vegetation reutilised
6. Design accessible green spaces for recreational activities.	✓	frequent green relief provided between building masses as interactive spaces.
7. Build minimal/no additional infrastructure to support the building	✓	As it is a reused plot infrastructur already exists.

Parking and transportation		
1. Design to accomodate transportation requirements of future occupants	✓	Public bus, metro, tram route and vehicular traffic studied and designed accordingly.
2. Reduce size of parking lots	✓	As per DM standards.
3. Provide underground/ multistory/deck parking	✓	Lower ground and basement parking decks provided.
4. Provide secure bicycle storage + bicycle path + shower areas.	✓	Near Fitness centre and for public and staff usage.
5. Provide minimum required parking	✗	Provisions for additional Parking provided.
6. Provide preferred parking for low-emission vehicles	✓	Provided
7. Provide infrastructure to facilitate shared vehicle usage	✗	Due to 5 Star nature offacility sharing not encouraged.

Cool Roofs		
1. Provide green roofs where possible	✓	40% green roof provided.
2. Provide roofs with high SRI/vegetation	✓	Reflective ceramic tiling proposed

3. Cover roofs with PV panels or solar water collectors.	✓	Solar water collectors designed.

Light Pollution		
1. Avoid off-site lighting and night sky pollution	✓	Prevented
2. Minimize site lighting	✗	Lighting required as architectural connections and identify pathways.
3. Minimize architectural and feature lighting	✗	Architectural lighting along road elevation and for beach side recognition from the sea.
4. Select low intensity efficient fixtures	✓	Specified
5. Shield fixtures, use downlighting.	✓	Downlighting used.
6. Prevent interior light spill	✗	Open nature of restaurant, prevent this design aspect.
7. Install programmed lighting control panels	✓	
8. Install occupancy sensors	✓	

Building orientation and Landscaping		
1. Increase shade canopy	✓	Undulating roof across main building to promote shading. Overhangs and screens provided for villas and restaurants.
2. Plant native or adapted plant material.	✓	Xerophytic landscape design and relocation of existing vegetation.
3. Reduce use of Turf grass	✓	Resort ambience premeditates the use of vegetation.
4. Increase green area on building sites	✓	Changed to xeroscape and rockscape.

Water Efficiency		
Potable water		
1. Reduce potable water consumption for irrigation.	✓	Only TSE used
2. Specify high-efficiency fixtures	✓	
3. Install occupancy sensors	✓	
4. Install metering controls	✓	Individual buildings provided with meter. Villas have common meter.
5. Capture/reuse treated water for non-potable uses.	✓	Spa water reuse considered. Filtration plants designed accordingly.

Wastewater reuse		
1. Treat wastewater generated to DM technical guideline 62	✓	
2. Install dual plumbing lines for wastewater	✓	
3. Collect & condensate water for toilet usage	✓	

Water Efficient Landscaping		
1. Use captured water/TSE for irrigation	✓	
2. Design landscape with indigenous plants	✓	
3. Plan water use zones & group plants accordingly	✗	Vegetation is in discontinuous zones.
4. Use high-efficiency Irrigation equipment /climate-based controllers.	✓	
5. Minimize the amount of land covered with turf	✓	
6. Reduce impervious surfaces on the site	✓	
7. Use alternative permeable surfaces fdor groundwater	✓	Permeable pavers used.

Energy Efficiency		
HVAC requirements:		
1. Design as per ASHRAE 90.1	✓	
2. Recover waste energy	✓	
3. Use TSE for water cooled HVACs.	✓	
4. Provide vestibules at building entrances	✓	
5. Insulate pipes and ducts	✓	
6. Incorporate thermal bridges	✓	
7. Install metering controls	✓	
8. Connect to a district cooling system	✗	Plant room with AHU provided.
9. Include thermal storage systems at District cooling plants	✗	NA

Building envelope		
1. Use a computer simulation model.	✓	
2. Design Building envelope with insulation	✓	
3. Design U value requirements according to DM decree 66	✓	
4. Window area > 50% of the gross wall area.	✗	Certain buildings like restaurants exceed 50%, some don't due to privacy and security reasons.
5. Skylight area > 5% of the gross floor area.	✗	

On-site renewable energy		
1. Design for use of 35% renewable energy	✗	PV cells used for solar water heating
2. Use on-site renewable energy	✗	Not feasible as large investment against small output
3. Engage in a green power contract	✗	Not available currently in the region
4. Exterior lighting powered through renewable electricity	✓	
5. Install Solar Hot Water systems	✓	

Refrigerant Management:		
1. Avoid/Phase out the use of CFC-based refrigerants	✓	
2. Select refrigerants with low ODP	✓	
3. Use equipment with increased equipment life.	✓	
4. Fire suppression systems should not contain Halons.	✓	

MATERIALS & RESOURCES		
Material Procurement:		
1. Use locally sourced materials	✗	Prescribed where ever possible. Exclusive finishes are required by client due to luxury nature of the project. Hence not utilized everywhere.
2. Use rapidly renewable materials	✗	Not used

3. Use FSC-certified wood products	✓	For exterior finish woodworks, wine cellar wood etc. may not be available. Besides, longer lead time have prevented its use in some cases.
4. Specify the above in contract documents	✓	Specified
5. Usage of lower wood grades.	✓	Used for partitions, interior woodwork etc.

Waste Disposal:		
1. Provide for segregated waste disposal	✓	Segregation supported at primary level.
2. Locate central collection and storage area	✓	Central loading dock with waste collection facility.
3. Provide sorting and storage facility for recyclable materials	✓	Supported by TRASHCO
4. Incorporate salvaged materials into building design	✓	From previous hotel, good quality wood work like doors, frameworks, features and scrap metal are being reused
5. Design Garbage rooms as per DM Article 51 and 52/2001	✓	Incorporated
6. Involve local hauler to provide waste management services	✓	TRASHCO (Garbage collection company) to advise on design.
7. Design for front loader bin and a ramp up to recycling area	✓	Provided

AIR QUALITY MANAGEMENT		
Tobacco Smoke management		
1. Prohibit smoking in the building	✓	Designated spots assigned with smoke ventilation ducts. In all restaurants and bars and Villas.
2. For smoking rooms, obtain permit allowing smoking	✓	
3. Exterior smoking areas at least 25 feet away from entries/ air intakes/ windows	✗	Due to the sprawl of the building the 25ft restriction is difficult to attain in all spaces.
4. Smoking room must be directly exhausted to the outdoors	✓	Dedicated exhaust ducting provided.
5. Provide impermeable partitions to smoke rooms	✗	Public Space. Door closers and partitions cannot be incorporated.
6. Design for a negative pressure with Door closers	✓	

Improved Air quality		
1. Design systems to meet ASHRAE Standard 62.1-2004	✓	
2. Provide naturally cross ventilating spaces	✓	Provided in Villas, not in main building.
3. Install permanent air monitoring systems	✓	In car parks. Smoke detectors provided elsewhere.
4. Supply outdoor air to parking levels	✓	Fresh air vents provided to basement car parks.
5. Install CO_2 & CO monitoring at 3 - 6 feet AFFL in parking.	✓	Installed
6. Install high level filtration systems in AHUs	✓	Equipment with high levels of filtration installed. Regular maintenance specified.
7. Install permanent architectural entryway systems		Being considered
8. Dedicate exhaust systems for print & fax rooms	✗	NA
9. Maintain negative pressure in rooms with chemicals.	✓	Dedicated ducting provided with fresh air supply vents.
10. Dedicate exhaust systems for cleaning & maintenance areas	✓	
11. Isolate chemical storage and mixing area	✗	NA

Low-Emitting Materials:		
1. Specify low-VOC materials in design	✓	
2. Select certified Green Label Plus program carpet systems	✗	Unavailability of suppliers.
3. Specify assemblies with no added urea-formaldehyde resins	✓	Woodworks tested for volatile resins. Flush out of interiors after fitout work specified.
4. Specify testing in the project specification.	✓	Commissioning for 15 days prior to occupancy.

Occupant Controls:		
1. Provide for combination of mechanical and natural ventilation	✓	Villas with openable windows
2. Design HVAC systems according to ASHRAE 55-2004	✓	

3. Integrate individual controls	✓	Villas have integrated manual and automatic controls. Not recommended in public spaces. Manual overrides for HVAC provided, which can be controlled by authorized staff.
4. Provide for occupancy sensors	✓	Provided for Back of House lighting, public restrooms, escalators.
5. Openable windows constitute 4% of occupiable area	✓	
6. Position windows/ wind catchers along NW & WNW	✗	Dependent on building orientation.

Daylight & Views:		
1. Restrict glazing which faces the south	✓	Any glazing along South are shaded with Screens or planted trellises.
2. Use external shading devices to reduce glare & heat	✓	Wood finish photo sensitive louvers and roll up blinds provided.
3. Provide min 2% glazing in all regularly occupied areas	✓	More than 10% provided to enhance connection to the beachfront.
4. Add interior blinds, louvers, light shelves etc	✗	Curtains provided as an interior feature.
5. Use high performance solar control glazing	✓	
6. Provide Photo responsive controls for electric lighting	✗	

VERNACULAR DESIGN FEATURES		
1. Design to take advantage of existing natural resources.	✓	Beach front maximized.
2. Design exteriors with light colours with high SRI	✓	Beige and woodworks as exteriors with natural colours and finishes.
3. Promote use of courtyards	✓	Courtyards created between villas to promote air movement.
4. Provide wind catchers with filters.	✗	
5. Include maintained water features in design	✓	Intermittent water features and landscape as relief.

Construction requirements		
1. Create an Erosion and Sedimentation control plan	✓	Contractor shall prepare and submit to consultant for approval.
2. Designate 3rd party commissioning for all systems	✓	Done by consultant.
3. Evaluate energy system performance through M & V Plan	✓	Part of commissioning.

4. Protect the HVAC through IAQ management plan during construction	✓	Polythene covers used under strict supervision.
5. Sequence the installation of materials to avoid contamination	✓	Construction phase strategy documents lists and details specifications for procedures and requirements of installation.
6. Depressurize construction work area	✗	
7. Perform a building flush-out of HVAC pre-occupancy	✓	Essential to a luxury resort set up. Flush out and Commissioning beings much prior to handover.

5.1.4 Analysis of sustainable design elements incorporated

i. Water Usage :

During the operational phase of the project, the requirement for potable water will be high. According to the estimates of standard unit consumption rates within the DEWA 'Guidelines for New Development Programs', the average per capita potable water demand for hotel rooms is 400 litres per capita per day. This rate is significantly higher than for other land use types estimated. The standard potable water demand for the project, which includes the requirements for the water features proposed within the Project Site, is calculated to be approximately 220 m3/day.

The development will also have a relatively high water usage due to the requirements for irrigation of landscaped areas. Improved resource efficiency, wastewater reuse and resource replenishment will all be possible through the use of the treated sewage effluent from DM.

A mains water tank capable of storing a 24 hour supply of water will be required within the project site in order to store the water provided by DEWA. Suitable drainage networks and stormwater drains exist within the Project Site and an irrigation network will serve to distribute TSE to landscaped areas of the Project Site.

The following are predicted for the Project:

Potable water: 220 m3/day; and

Foul discharge: 19 l/sec peak flow.

- **Potable Water**

The potable water demands of the Project will be high given the luxury nature of the proposed facility, which have a higher water consumption compared to other facilities, and the proposed external water features and other features such as swimming pools. Mitigation measures such as the incorporation of water saving technologies within the building design has been considered.

Potable water supply for the project site will be provided by DEWA via the mains water supply, which connects into the site in the north eastern corner and comprises a mains water supply, sewerage and treated sewage effluent (TSE) supply.

- **Irrigation Water TSE**

The Project will have a relatively high water usage due to the requirements for irrigation of landscaped areas. Demand for landscape irrigation water will be determined by the various land uses and areas of landscaping, as well as the various types of planting to be used which comprise various ornamental plant species as well as grass, ground cover, shrubs, trees and palms

Nevertheless, the source of irrigation water will be TSE (Treated Sewerage Effluent) from the existing DM network. The benefit to the environment is that these effluents are directed away from the coastal environment. Such schemes therefore are able to make a significant contribution to the sustainable development of Dubai and the wider region.

The irrigation network will serve to distribute TSE to fulfill the irrigation demand requirements of the landscaped areas. The network shall have a designated storage tank and pump room. The system will comply with the guidelines of the Drainage and Irrigation Department of Dubai Municipality.

Water requirement for the plantation shall be according to Dubai Municipality specifications which are as follows: 13.2 l/m3/day for the assumed land area to be irrigated and 35 litres each for trees and shrubs during normal conditions. This is for application over a 12 hour period.

According to estimates made based on the current design specifications the total irrigation demand for TSE for the Project is calculated to be approximately 55m3/day.

The irrigation water application will be completely automatic in operation requiring no manual labour to run the system and will be based on the acceptable industry system. Following the configuration of the landscape design, solenoid valves with timers shall be appropriately located. The solenoid valve will control the application of irrigation water to the landscape.

According to estimates made based on the current design specifications and professional judgement, the total irrigation demand for TSE for the Project is calculated to be approximately 55m3/day.

TSE used for the irrigation of landscaped areas within the Project Site will meet DM safety standards as set out in Technical Guideline No. 62: *'The Re-use and Irrigation of Wastewater and Sludge (1998)'* as a minimum.

The use of native plants within the landscaped elements of the Project will serve to reduce the amounts of TSE required for irrigation. Additional measures should also be introduced to reduce the amount of irrigation water required, including the following:

- Irrigation systems should be operated at night or early morning when there is little sunlight, to minimize evaporation rates;

- Sub-surface drip feed piping should be used in preference to above ground spray systems;
- Landscape planting shall be dense to reduce evaporation losses from the soil surface or covered with loose bark or gravels; and
- Soils should include water retentive gels or water retentive mulch added to retain water and thus reduce the requirements for irrigation inputs.
- Native desert adapted xerophytic plants shall be incorporated within the landscaping plan, which will minimize water requirements for irrigation purposes.
- TSE and sludge used for the landscaping will meet safety standards given by the authorities as a minimum.

- **Waste Water**

The wastewater treatment capacity and sewerage network in Dubai have already exceeded their capacities due to the increasing demand for these services, so wastewater produced by the project will result in additional pressure upon these facilities. Despite this, the Project will result in the replacement of the former beach club facility within the site rather than the Project being a completely new source of waste water. However, the implementation of water saving measures would decrease the generation of waste water and thus the impact upon central treatment facilities. It is predicted that the overall sewage discharge by the Project will be a maximum of 19.8 l/sec at peak flow.

During construction, water will also be required for activities such as dust suppression and the washing down of plant and vehicles, which can result in high peak water demands. Water generated during dewatering operations is utilized for this purpose. This will serve to reduce the use of potable water and would also avoid the need to transport water to the Project Site, which would potentially result in greater impacts upon the local transport network and increase costs.

- **Stormwater Discharge**

It is proposed that stormwater will be dealt with in three ways. Firstly, the two main buildings are proposed to discharge the storm water drainage to the DM storm water network. The peak run off rate would be 90 l/s in accordance with the DM design criteria based on a 5 year return period.

Storm water drainage from the villa roofs would be collected by rain water pipes and connected to a private underground drainage system before discharging to a permeable block paving system aggregate sub base. The depth of the sub base would be designed to provide attenuation requirements for both the roofs and hard landscaped areas. It is also proposed to use a permeable block paving system approved for the external hard landscaped areas and for the vehicular access roads. The depth of the aggregate sub base would be subject to attenuation requirements based on the volume of rainfall and the rate of soakage of the underlying sand. It is advised that the permeable block paving system would provide screening of contaminates from vehicular overrun. Alternatively screening for the access roads could be provided by the use of interceptors.

The proposed storm water infrastructure would be a combination of pipe or box culverts for the roads and car parks.

For the built-up areas along the road and car parks, a soakaway drainage system will be used in line with the principles of Sustainable Drainage Systems (SUDS) design.

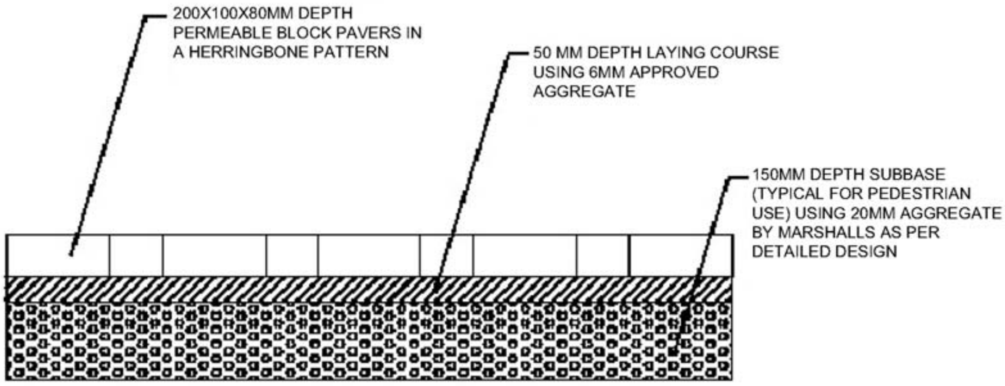


Figure 13. Permeable Block Paving System (WSP, 2009)

For the lower beach level villas it is proposed to discharge the storm water via a soakaway which drains directly to the beach. Stormwater runoff from villas situated near to the beach will be collected and discharged to a soakaway on the beach itself. This will have negligible significance as there will be few sources of potential contamination and such events would occur only rarely.

In this way, the Project incorporates the principles of Sustainable Urban Drainage Systems (SUDS) while taking measures not to significantly increase the load on the existing stormwater facilities within Dubai.

- **Design Measures implemented to reduce water usage:**

Potable Water Use and Waste Water Generation

Sustainability measures is implemented within the design of the Project, including sustainable practices and technologies aimed at water saving (such as water-saving devices in the toilets, showers and taps), and re-use (such as the utilisation of 'grey' water for irrigation or other non-potable processes) including the following:

- The installation of water conservation devices at the point of specification represents the greatest single opportunity for savings. Dubai now has water tariffs being applied for consumption. Where there are water tariffs in place, adaptation can realize economics benefits in addition to environmental benefits. In addition, there may be a reduced requirement for storage capacity by design or increased capacity without having to upgrade local supply networks.

- Percussion or infra-red operated taps are accepted as providing a 50% saving in comparison to twist or manually operated taps without aeration. Both operate for a preset period of time (usually 1-30 seconds) following initiation.

- In areas where water has a low carbonate content, spray taps and aeration increases efficiency to approximately 65%.

- In public areas such as restaurants, bars and cafés, sustainable toilets can achieve very significant reductions in water use. Essentially the cistern only flushes when it has recorded a specified number of urinal visits. If the system is not used for a number of hours then a hygiene flush will occur to pacify odour problems. Waterless urinals are developing in terms of their popularity although some designs suffer from design deficiencies resulting in increased maintenance and odour issues.

- Cistern volumes are not required to exceed 6 litres for mechanical or hygienic purposes. Modern sanitary ware may require retrofitting of cistern dams or volume reducing devices to achieve a similar result. Typical efficiencies can reach 16% when coupled with dual flush toilets which have an optional 4 and 6 litre flush volume. In addition, urinal cisterns should serve more than one urinal unit where applicable.

- Power showers are standard in new developments and use over 12 litres of water per minute. Water saving shower heads can be used without restricting flow substantially.

- The water distribution network are designed such that future water connectivity of grey water recycling systems could be adopted.
- Commercial kitchen areas are designed with efficient dishwashing equipment, macerators with manually controlled water supply and should be discouraged from running water over frozen goods. In public areas and kitchens, automated foam soap dispensers will reduce the amount of time required for hand washing and foot operated taps are both efficient and hygienic.
- Residents and staff should receive water awareness training to educate them about the importance of conserving water and practical ways in which to do this. In addition, Spa staff should be encouraged to take part in the maintenance activities.

If the mitigation measures set out above are implemented, it would reduce the residual impacts of the Project upon potable water supplies and central waste water treatment facilities to negligible.

ii. Landscaping:

The landscape design philosophy is to provide a densely vegetated landscape setting for the individual villas. A concept landscaping drawing which demonstrates the type of landscaping that is likely to be utilized incorporates palms, lawn areas and other ornamental tropical plants.

The project will comprise of several buildings and villas set amidst lush, island type vegetation, textured exterior building materials and external pool areas and waterways and will be visible from neighboring developments and surrounding pathway networks. Careful landscaping of the Project including low building heights and dense landscaping. The incorporation of vegetation is expected to greatly enhance the aesthetic value provided by the Project, resulting in a pleasant visual amenity for nearby communities.

A number of landscaping trees and shrubs were translocated to a temporary nursery, which will be reused within the landscaping scheme, thus allowing an immediate landscape of mature vegetation which will both improve the landscape value of the project site and also provide natural habitats and ecological value.

Terrestrial Ecology

Figure 14. Retained Landscaping Trees and Plants

Figure 15. Translocation of existing landscaping trees; B. Irrigated on-site Palm nursery; C. Shrubs and plants within the Palm nursery.

The Project will replicate the landscaping conditions previously present and it is therefore considered unlikely that the impacts of clearing previously landscaped areas would be significant in the long term. Prior to demolition, the removal and translocation of a significant amount of landscaping trees and plants present within the Site is considered to be the most influential and beneficial mitigation measure. The translocation of trees and shrubs to the temporary palm nursery ready for the future use has ensured the survival and continuation of mature vegetation which would have taken many years to achieve had the vegetation been lost and new planting dominated the project site.

The application of fertilisers to landscaped areas has the potential to enter the marine environment, particularly through leaching, which can result in water quality issues through localized eutrophication. In order to prevent contamination to the marine environment the application of fertilizers and pesticides shall be kept to a minimum to prevent the build up of excess chemicals in the soils and subsequent leaching to the marine environment. It has also been proven that the use of organic rather than chemical fertilisers significantly reduces the effects of nitrate leaching from soils.

The inclusion of native, desert adapted plants considered within the landscaped areas could include the following species:

- *Sesuvium sp*: the fast growing, low spreading characteristics of this variety means that vegetative cover can be achieved quickly and is easy to maintain;
- *Portaluuca* or *Crassula*: these plants are also very hardy and are both xerophytic succulents; and
- *Wedelia* which is easy to maintain and requires relatively little water.

iii. Solid Waste Management:

- **Waste Management Strategy**

A Waste Management Strategy (WMS) has been developed for the Project, which aims to facilitate the implementation of waste minimization, segregation and recycling methods. The WMS considers the key issues associated with the sustainable management of waste produced as part of the project, with particular reference to identifying:

- Reduction, re-use, recycling and recovery of operational wastes;
- Opportunities for the segregation of waste streams within the various Project uses;
- The requirement for a flexible waste mitigation strategy that meets DM requirements;
- A strategy that can adapt to future recycling markets and legislative changes.

Daily waste generation estimates are provided which reveal that the total waste generation per day, by all components of the development, is estimated to be 3,274kg.

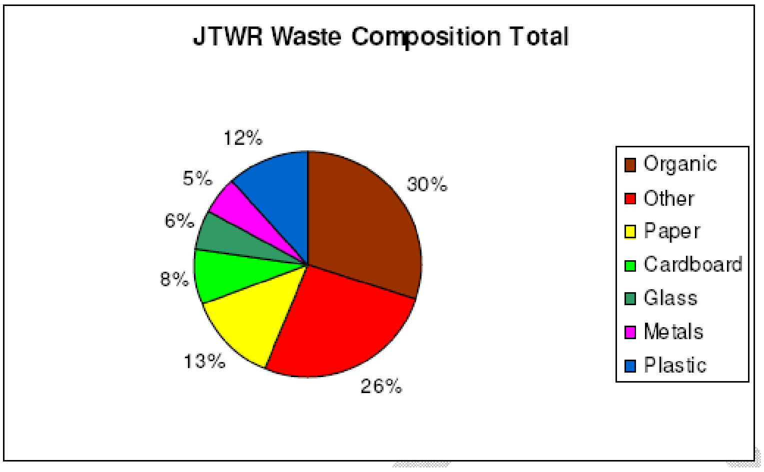


Figure 16. Estimated Project Waste Composition (WSP, 2009)

- **Mitigation Measures**

— Sufficient recycling bins shall be provided all around the site to encourage segregation at source of recyclable waste. The contents of these bins will be regularly removed to a centrally controlled waste facility on site.

— Recycling stations will be provided for paper, cardboard, metals, glass and plastic at a minimum. Reduction and recycling of waste will be encouraged.

— All waste materials will be safely stored in adequately bundled areas, managed and disposed off at the correct waste disposal points in the correct manner for these materials, as per DM requirements.

— According to the 'Duty of Care' best practice principles, all relevant consignments of waste for disposal would be recorded, specifying the type, destination and name of the carrier.

- **Disposal of hazardous and nonhazardous wastes**

If asbestos is found within the Project Site the correct handling and disposal of this material shall be put in place. Procedures are established for the storage, handling and transportation of hazardous waste found on the site. DM's approved list of contractors for the removal of hazardous waste shall be assigned to carry waste to the hazardous waste landfill run by DM in the Jebel Ali Free Zone. All waste from construction shall be segregated on site and recycled where possible. Land filling of waste shall be kept to an absolute minimum.

iv. Air Quality

In addition to air quality effects associated with traffic, impacts on ambient air quality may result from the use of site plant including stand by generators, cooling plant and HVAC, laundry equipment which would result in emissions of NO (Nitrous oxide), SO (Sulphorous Oxide) and particulates, causing respiratory problems for humans. Air shall be continuously monitored for air contamination levels.

Similarly, noise shall be monitored for ambient levels. Noise from mechanical services plant will be designed and installed such that is does not increase the existing background noise levels. This will be achieved by considerate selection, location and attenuation of all building services equipment.

- **Ozone Depleting Substances**

There is the potential of hazardous gases (e.g. ozone depleting substances such as man-made CFCs) being released into the atmosphere during maintenance of cooling plants and air conditioning units operating during this phase of the project

Cooling plants and air conditioning units operated without ozone depleted substances shall be specified in design and installed. Where it is not possible to use equipment that does not use ozone depleting substances, appropriate measures shall be undertaken during the maintenance of these equipment to ensure that these gases are not released to the atmosphere. Regular inspections and maintenance of all plant items shall be undertaken throughout the operational phase of the Project to ensure efficient operation, which will reduce the potential for significant emissions.

v. Energy Reduction

More efficient energy saving technologies tends to attract higher initial capital costs that are offset over the life-cycle of the facility by reduced energy consumption (translating directly to reduced operating costs). In many cases more efficient technology will also result indirectly in reduced infrastructural requirements, such as reduced cable sizes, reduced transformer sizes, reduced switchgear requirements, reduced heat load – resulting in reduced cooling requirements (e. g. in lighting installations).

System design and performance will be determined by:

- External environmental conditions – All components within the Project have lush landscaping punctuated with water bodies;

- Hours of operation – It is a mixed use development in which one component will balance the energy consumption of the other due to the nature, purpose, use and hours of operation;
- Building fabric –External design and materials to include materials suitable for recycling
- Building orientation –To maximise benefit of high quality views by introducing natural shading elements where possible; and
- Solar shading and external façade treatment to reduce solar gain.

Following the successful completion and commissioning of the various components of the Project, energy efficiency will be directly influenced by a number of on-going factors relating to building and facilities services maintenance. Factors which will have an impact are:

- On-going monitoring of guest occupancy, demands and requirements;
- Adjustment of building installations and controls to achieve maximum energy efficiency; and
- On-going education of facility users with regard to energy efficiency and conservation.

vi. Public Transport

There is a wide network of existing bus services serving the Jumeirah area. The Table below summarizes the bus service numbers, origins, destinations and frequencies operating along Jumeirah Road. In addition to the routes listed, bus services 90, 92 and 98 operate along Al Wasl Road a short distance from the proposed development site.

Route No.	Origin	Destination	Frequency
8	Gold Souq Bus Stn	Al Mina Al Siyahi	Every 20 Min
8A	Gold Souq Bus Stn	The Gardens	Every 20 Min
C10	Hamriya Port	Jumeira Beach Park	Every 10 Min
N1	Rashidiya Bus Stn	Jebel Ali Gardens	Every 30 Min
N2	Al Qusais Bus Stn	Mina Al Siyahi	Every 30 Min
N4	Satwa Bus Stn	Al Qusais Bus Stn	Every 30 Min

Table 3. Existing Bus Services

- **Pedestrian/cyclist Access:**

Figure 17. Dubai Strategic Bikeway Network (WSP, 2009)

Dubai is currently constructing a wide strategic network of cycle and walking tracks that will total 580km when complete. A full plan indicating the existing and proposed routes is provided.

The first walkway \ cycling track has been completed and runs on Jumeriah beach in the vicinity of the proposed development site and is highlighted by the Dark Green route on Figure above. Light green routes are proposed off-road facilities, while the red routes are on street.

Tracks to follow include Jumeriah Road from the proposed development site to Al Diyafah Street, on Al Mina Road, Al Mankhool Road and the Dubai Creekside. The Resort is therefore well placed to take advantage of the proposed improvements for sustainable travel.

vii. Additional Considerations:

In addition, the following design measures have been implemented to increase the sustainability credentials of the Project:

1. Translocating as many trees on site as possible for reuse within the landscaping rather than removal;
2. The use of native, desert adapted plants where possible in the landscaping to minimise irrigation water use;
3. Solar thermal water heating technology will be incorporated within the guest villas and potentially on the roof of the main building, in order to minimise energy use;
4. Greywater recycling shall be incorporated into the building design together with the use of other water saving technologies such as water saving shower heads, taps and low flush toilets, shading over water features etc;
5. Use of energy saving technologies are considered to reduce energy demand, such as insulation, building orientation, shading and energy saving bulbs;
6. Use of locally sourced materials where possible, that blend in with the natural landscape and benefit local goods and service providers;
7. Developing stringent sustainable waste management strategies during construction and operation;

8. Sourcing of local and sustainably grown goods and services to stimulate the local economy.

9. Equity and fair trade options for goods and services that the Project requires. This can affect people from wider foreign populations, making sure that these goods and services are gained at fair prices and are from sustainable sources;

10. Sustainable transport linking of public transport systems to the Project are being considered in order to minimize use of private vehicles and therefore, traffic emissions and associated noise impacts.

11. Use of modern methods and materials in construction which combine insulating properties with waste reduction, ease of construction and give high quality finishes using local labour; and

12. Using savings on road and service infrastructure to invest in more energy efficient buildings, renewable energy systems and sustainable water management.

viii. Sustainability during Construction

A Construction Environmental Management Plan (CEMP) is developed for the site works that will require all works to be undertaken in accordance with the relevant guidelines and best practice. Typically this will involve the use of measures such as pollution prevention techniques and equipment to reduce the risk of pollution to soil or groundwater. Specific procedures for the delivery, handling and storage of any oil, fuels and chemicals are put in place where necessary. All construction contractors will be required to implement this CEMP and adhere to its procedures as a minimum.

The CEMP would consider, the environmental actions required during the construction phase of the Project in order to comply with legal and other requirements, to prevent pollution and to continually improve the environmental performance of the Project.

This can be undertaken via implementing a controlled informal system or through a formal certified system such as ISO 14001. This has been referenced by Dubai Municipality Technical Guideline No 56 "Establishment of Environmental Management Systems – Implementation of ISO 14001 in Dubai ".

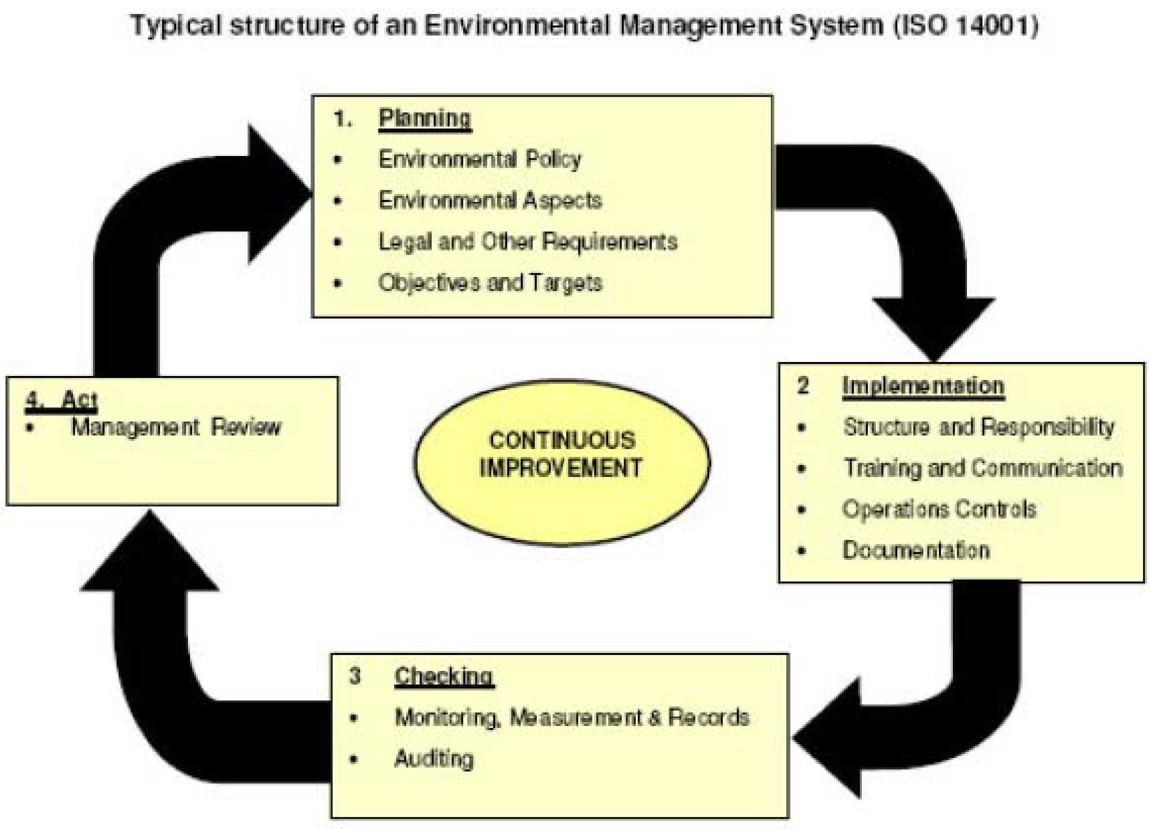


Figure 18. Environmental Management Plan Structure

- **Main Mitigation Measures during Construction**

The potential for **fine sediments** to enter the marine environment will be controlled by the implementation of the following measures:

- An Erosion, Sedimentation and Dust Control (ESC) Plan shall be produced which details comprehensive mitigation measures to be adhered to during the demolition phase of the Project.
- A 3 metre high masonry wall runs along the perimeter of the Project Site boundary on three sides. It is considered that this boundary wall will afford some protection to adjacent residential homes and businesses from the potential impacts caused dust generation and should be retained for as long as possible during the construction phase.

The following measures will be implemented as part of the final CEMP, which will be developed more completely, and additional measures included where required, once specific activities and methods are determined:

1. In order to minimise the direct disturbance to marine habitats associated with the existing breakwater structure at the Site, the working areas should be kept to the minimum required so as to minimise the direct loss of or damage to existing habitats.
2. Emergency spill response procedures should be adhered to in the event of any accidental releases to the marine environment, or on the shoreline in proximity to the tide line.
3. Alternatives to CCA (copper chrome arsenate) treated timbers and other harmful anti-fouling products should be used for marine construction purposes.
4. Post operation cleaning of construction machinery and heavy plant such as concrete mixers should be undertaken within a specified washing area that is bunded and sealed to prevent marine pollution through surface run off.

5. Temporary silt barriers could be installed in order to reduce the effect of sedimentation upon habitats within close proximity of the Project Site.

6. The generation of waste water at construction should be minimised and measures taken to ensure that runoff from the Project containing potential contaminants are controlled, channelled, contained and adequately treated before disposal.

7. Monitoring of runoff should take place with particular attention to sanitary wastewater from temporary ablutions, washing down of equipment, dewatering and concrete work.

8. The storage during construction of chemicals such as solvents, paints, cleaning fluids, fuel, heavy or other equipment, and oil must be in adequately bunded storage facilities, adequately labelled with the contents ad hazards associated. Care must be taken when using these substances not to spill and drip trays should be used.

9. If any significant spills occur accidentally, appropriate testing, remediation and verification work should be undertaken.

10. Water to be sprayed on dust prone areas such as site access routes, to minimise dust arising from vehicle movements and site activities. Water just enough to contain shall be used to control dust or reach the optimum moisture content for compaction.

11. Construction entrances and main routes through the site, should be stabilised to reduce dust generation and any sediment tracked onto Jumeirah Beach Road to be swept away.

12. Ground disturbing activities are to be kept to a minimum.

13. All stockpiles of materials or soil are to be stacked at least 100 metres away from the sea and to be located out of the wind in

sheltered areas where possible. They are to be keep to a minimum height with gentle slopes.

14. On site vehicle speeds to be controlled to reduce dust suspension and distribution by traffic within the Project Site.

15. Impacts identified relating to resource consumption during operation of construction machinery and vehicles can be mitigated by including minimising journeys by construction vehicles by optimising carrying capacity of vehicles and ensuring that idling equipment is not permitted on site when not in use.

16. Where possible vehicle movements be restricted to stabilised routes through the project site.

17. All dust generating materials transported to and from the Project Site to be sheeted to ensure no loss of materials.

18. Minimise the area of land to be disturbed at any one time by staging of construction activities and the progressive implementation of the works.

19. Minimise excavation and transfer operations of surface materials on windy days.

20. Drop height of excavated materials should be controlled to a minimum to limit fugitive dust generation from unloading as far as practicable.

21. Regular checks throughout the day by site supervisor's representative to visually inspect dust generation and to recommend mitigation measures;

22. Implementation of a construction phase dust-monitoring program on site (incorporating use of a dust monitor such as a dust

deposition gauge or volumetric air sampler) to monitor respirable dust and nuisance dust. This can provide trigger data to justify alteration of work practices during periods of high dust generation (such as strong winds).

23. Landscaping of bare areas should be prioritised where it is unlikely to be damaged by later development;

24. Minimise surface areas of stockpiles (subject to health and safety and visual constraints regarding slope gradients and visual intrusion) to reduce area of surfaces exposed to wind pick-up.

25. Use of dust-suppressed tools for all construction operations.

26. The use of potable water should be avoided wherever possible for dust suppression and washing down of plant and machinery during the construction phase.

27. Large amounts of wastewater can be generated from dewatering operations. Water derived from dewatering water should be used where possible for dust suppression and non-potable water used for washing down of plant and machinery and dust suppression, when water from dewatering is unavailable. It may be possible, subject to agreement by DM, to discharge water generated by dewatering operations, the generation of which will occur mainly during the construction of the foundations directly to the marine environment. This would require the creation of settlement lagoons and potentially water quality monitoring to ensure that the discharge water quality remains in accordance with DM standards.

5.1.5 Recommendations and Conclusion

i. Drawbacks of the scheme

From the check list responses it can be noticed that the five star nature of the project and the associated security and quality issue perceived has, in certain cases made it difficult to achieve some of the sustainability criteria.

The adjoining ladies club plot and the need to ensure that the design has no direct vision into that plot, has imposed restrictions on the site layout. Accordingly, orientation of individual buildings have not been designed to maximize climatic response. Rather they have been oriented to maximize views to the sea and provide visual connection to nature. The main commercial buildings has sprawled across the road frontage of the site to capatalise on prominence of the location and make the presence of the brand recognized.

It is felt that the consultants could have achieved a more efficient design layout, prioritizing both the commercial as well as the needs of a climate responsive design. Though a study of the sun paths and wind rose have been carried out during design initiation, an attempt to gain the best out of these studies are not reflected in the layouts, whereas commercial viability is seen as a key guiding factor. Pointers from the sun and wind directions study have been utilized to enhance interior occupant comfort levels, which is seen through the in-corporation of architectural elements like a cascading roof providing shelter from the south sun, permanent manually adjustable wooden louvers and blinds, intermitted waterbodies positioned in the flow of wind etc.

The large expanse of building footprint spread all across the site necessitated by the nature of resort buildings, has disturbed the natural state of the site. Though this sort of spilling of building masses is dictated by the typology of resort building, careful addition of native planting and the restoration of existing site plant material being wisely incorporated in the landscaping scheme has added value to the quality of natural eco system created within the resort premises. An attempt is made to minimize disturbance to the eco system and factors to sustain and promote the existing system are put in place.

The need for no new infrastructure to be placed, due to the existence of the prior resort facility, has been a bonus to the site as no major excavation and laying of infrastructure lines is now required.

One of the major environmental impacts of the proposed development is the effect of the breakwaters and the construction of a water restaurant at the tip of the breakwaters.

The required piling during the construction phase shall have adverse effect on juvenile coral growth and the burgeoning marine life noticed along the concrete rip rap and boulders. Measures should be planned to make good this loss of marine life post construction phase.

It is noticed that sustainable design elements form an overarching component of the Project, and is considered in all aspects of the project design and execution. Sustainable design in the building plays a vital role in minimizing or mitigating negative environmental impacts, particularly in terms of water and energy resource consumption. Water, energy and resource demands as well as waste and wastewater outputs are attempted in being reduced without affecting the overall experience of the building and surrounding landscaping. On the whole this project is a good example of sustainable building design in practice in Dubai.

ii. Typical issues associated with a green design and building

The project architect pointed out that efficient co-ordination between all team members is a difficult task. An integrated design approach was employed and design workshops were held frequently. A project co-ordinator was essential to the successful progress of the design.

Due to the lack of practice of sustainability elements within the region, there are no suppliers to provide specific green products. Regional materials are very few and those available are not cost-effective.

On the whole, the most difficult aspect was to reach at a environmentally friendly design while making sure that the commercial benefits were not impacted.

5.2 Case Study II: A Shopping mall

5.2.1 Introduction

Dubai has witnessed the burgeoning of various shopping malls in the past two years. Many touristic malls, where 5 star hotel developments are linked with shopping, popularly known as *Resort shopping destinations* have gained popularity in the city. Retail sales in Dubai are high and Dubai is currently one of the most popular shopping destinations worldwide with most of the popular brands setting up shop here. This case study is about such a resort shopping destination within the city; a site, currently adjacent to a hotel development at the north end, facing the creek to its west and a residential development at the south.

The mall consists of 3 main elements. The main mall building which forms the bulk of the building mass, a central water body forming the canal space, small broken up building masses called Pavilions connected to the main building through bridges, facing the creek which ultimately culminates as the quayside. It is ground and 2 storyed low rise building with 2 levels of underground car park.

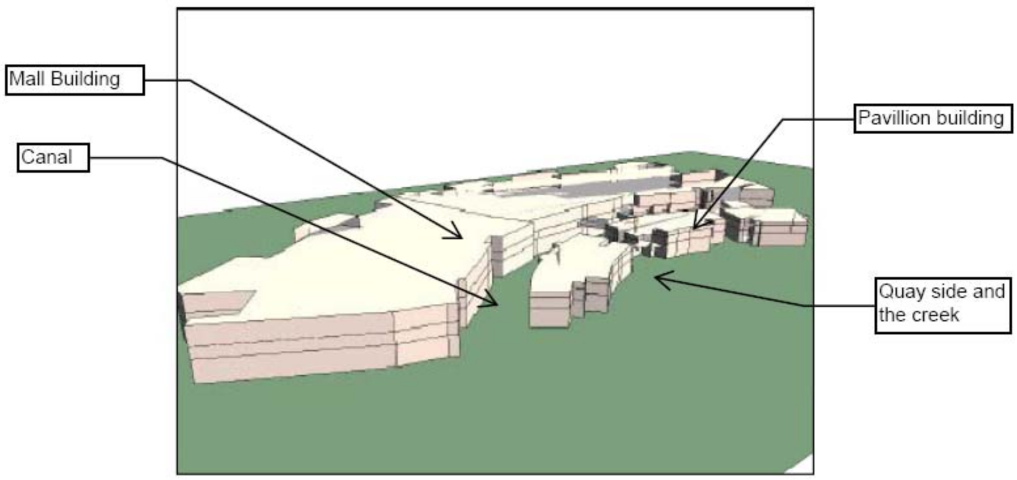


Figure 19. Mall Building Composition (Arup,2004)

This project was conceived in 2003; before the trend of green architecture and sustainability came about to Dubai. Nevertheless it was still considered as an excellent example of the use of passive elementary architectural features, which are easy to maintain and operate. Not all features suggested in the design have been implemented due to design modifications.

The researcher has been a part of the team involved in construction and supervision of this mall. Many systems and architectural elements were specifically designed to accommodate local conditions and create comfort zones. In an attempt to find more about the building the researcher approached the project manager who has worked with an international team of architects, right from the concept stage to the handover of the building. In a conversation with Mr. Adams, the Project Manager, he quoted , ‘A building built within the norms of worldwide best practices can easily achieve a LEED Silver rating, without following the credits by the book. This building is designed responsibly, by a reputed consultancy, and hence responds to its duty of environment wellness.’

5.2.2 Importance of Sustainability

It was learnt that sustainability was not a guiding factor during the planning stages of the building. It was not considered as one of the primary aims of the project, yet best practices were employed in all sectors of design which in itself incorporated sustainability elements. No benchmarks for green building design were set at the conceptual design stage, however a design in response to climatic conditions was a part of the design brief. Enhancing the comfort level of occupants and providing a comfortable pleasant outdoor and indoor ambience to make the shopping experience enjoyable was a design need. This necessitated the need to consider the environmental impact while designing unlike typical Dubai buildings. A detailed climatic study with the movement of sun, temperatures, wind, the impact of the large creek water body and associated humidity factors were considered. As the project manager mentioned, the design inculcates basic design criteria for good responsible design with internationally recommended design standards being adhered to. Along with it are age old proved and recommended techniques of wind catching, courtyard effect, water body enhancement and passive shading elements infused into the design to suit the contemporary context of a modern shopping mall. The resultant is a user friendly, eco-friendly sustainable development.

This case study was then compared against the green elements shortlisted through the study of sustainable techniques. A check list with reasoning for each of the elements were prepared. This was done with the help of the project manager, who threw further light on the reasons impacting the decisions taken. As the researcher was part of the execution team, it helped in understanding the need and difficulties associated with the design and implementation of the prescribed principles. Further insight was also gained about the market attitude regarding the issue of sustainability, cost implications, contractual issues related to availability and maintenance etc. However it is beyond the scope of this dissertation to cover these issues and calls for areas of new research. The list and the information gathered through this form of interactive action research along with added insight from the Project manager are discussed and analyzed below.

5.2.3 Verification of list of green elements

Requirement	Provided	Remarks
Environment and planning		
Climatic response		
1. Develop climate responsive building designs	✓	Climate impact studied. Effect of sun and wind considered in design. Building materials are climate friendly, recyclable.
2. Creation of microclimates.	✓	Microclimates created with architectural elements.
3. Use thermal mass to improve comfort and efficiency.	✓	Building mass articulated to promote comfort

4. Select space-conditioning strategies	✓	Used with cooling elements.
5. Shade south facing windows	✗	Windows in south rather than north. No shading feature provided. Skylights shaded using sunpath analysis.
6. Orient building design with Sunpath Diagram	✗	Orientation may not respond to sunpath analysis due to creek frontage and adjoining masterplan. Therefore microclimates promoted.
7. Align shorter side of a building to face north/south	✗	

Site Selection		
1. Develop previously developed land in an already developed area	✗	Virgin land used to promote development of a new community.
2. Avoid sensitive land types.	✗	Creek flaura and fauna disturbed due to marine dredging.
3. Provide shaded pedestrian & bicycle access to surroundings.	✓	Jogging Track and bicycle path are provided. Tree canopy cover forms part of larger masterplan.
4. Development of a Brown field.	✗	NA
5. Develop close to Mass transport.	✓	Mass transit designed around building.

Building Footprint		
1. Design small footprints for buildings	✗	Sprawl structure due to need of the commercial usage it incorporates.
2. Minimize disruption of the eco-system	✗	Creek is cut to achieve desired landform.
3. Build in dense blocks	✗	
4. Share amenities and spaces with neighbours.	✓	Community spaces built for a large development.
5. Incorporate natural features existing on the site	✓	Landfills converted into a hillside community.
6. Design accessible green spaces for recreational activities.	✓	Green relief areas provided.
7. Build minimal/no additional infrastructure to support the building	✗	New undeveloped plot with a large masterplan. Hence supporting infrastructure needed to be built.

Parking and transportation		
1. Design to accommodate transportation requirements of future occupants	✓	Public bus, metro, tram route and vehicular traffic studied and designed accordingly.
2. Reduce size of parking lots	✓	DM prescribed size maintained.

3. Provide underground/ multistory/deck parking	✓	Basement level parking designed
4. Provide secure bicycle storage + bicycle path + shower areas.	✗	
5. Provide minimum required parking	✗	3 times more subterranean parking provided.
6. Provide preferred parking for low-emission vehicles	✓	Low emission vehicle, not available in UAE during design and construction phase.
7. Provide infrastructure to facilitate shared vehicle usage	✗	For staff vehicles, car pool areas provided.

Cool Roofs		
1. Provide green roofs where possible	✓	Used in small microclimate spaces
2. Provide roofs with high SRI/vegetation	✗	
3. Cover roofs with PV panels or solar water collectors.	✗	Roof used for MEP equipment. No additional space.

Light Pollution		
1. Avoid off-site lighting and night sky pollution	✗	Lighting used to create a landmark identity. Hence excessive lighting is employed. Building external facades are brightly lit polluting the night sky.
2. Minimize site lighting	✗	
3. Minimize architectural and feature lighting	✗	
4. Select low intensity efficient fixtures	✓	
5. Shield fixtures, use downlighting.	✓	
6. Prevent interior light spill	✗	Focus is on retail shopfronts exposed to the outside. Hence interior light spill is unavoidable.
7. Install programmed lighting control panels	✓	
8. Install occupancy sensors	✓	Installed in all Staff areas.

Building orientation and Landscaping		
1. Increase shade canopy	✓	Planting installed. Growth phase. Site is covered with expansive foliage trees which in due time will cover roads and pathways.
2. Plant native or adapted plant material.	✓	Palms used.

3. Reduce use of Turf grass	✓	
4. Increase green area on building sites	✗	Building site extensively paved.

Water Efficiency		
Potable water		
1. Reduce potable water consumption for irrigation.	✓	Only TSE used
2. Specify high-efficiency fixtures	✓	
3. Install occupancy sensors	✓	
4. Install metering controls	✗	Not required as it is a public mall operation.
5. Capture/reuse treated water for non-potable uses.	✗	Not feasible, besides condensate water available for custodial activities.

Wastewater reuse		
1. Treat wastewater generated to DM technical guideline 62	✓	
2. Install dual plumbing lines for wastewater	✓	Separately identified and labeled.
3. Collect & condensate water for toilet usage	✓	

Water Efficient Landscaping		
1. Use captured water/TSE for irrigation	✓	Connected to DM TSE line.
2. Design landscape with indigenous plants	✗	Wherever possible, palms used.
3. Plan water use zones & group plants accordingly	✗	Landscape is discontinuous and patchy
4. Use high-efficiency Irrigation equipment /climate-based controllers.	✓	
5. Minimize the amount of land covered with turf	✓	
6. Reduce impervious surfaces on the site	✗	Site covered with interlocking pavers due to infrastructural lines beneath, which require frequent maintenance during the completion of masterplan. Wide road infrastructure expanses at road junctions.
7. Use alternative permeable surfaces fdor groundwater	✓	Permeable pavers used.

Energy Efficiency		
HVAC requirements:		
1. Design as per ASHRAE 90.1	✓	
2. Recover waste energy	✓	Used in external cooling walls
3. Use TSE for water cooled HVACs.	✓	
4. Provide vestibules at building entrances	✓	Essential due to high public footfall in retail spaces.
5. Insulate pipes and ducts	✓	Insulated and labeled.
6. Incorporate thermal bridges	✓	
7. Install metering controls	✓	For individual tenant readings.
8. Connect to a district cooling system	✓	The entire development has its own district cooling system.
9. Include thermal storage systems at District cooling plants	✗	Thermal storage being a relatively new idea was not incorporated in 2003.

Building envelope		
1. Use a computer simulation model.	✓	Yet designed badly, many leaks are visible due to poor construction supervision and tight deadline schedules.
2. Design Building envelope with insulation	✓	
3. Design U value requiremts according to DM decree 66	✓	Higher standards specified by consultant to enhance energy savings.
4. Window area > 50% of the gross wall area.	✓	Large window expanses due to Show window as retail shop frontage provided.
5. Skylight area > 5% of the gross floor area.	✓	

On-site renewable energy		
1. Design for use of 35% renewable energy	✗	
2. Use on-site renewable energy	✓	PV cells for cool walls.
3. Engage in a green power contract	✗	Not available in the region.
4. Exterior lighting powered through renewable electricity	✗	
5. Install Solar Hot Water systems	✗	

Refrigerant Management:		
1. Avoid/Phase out the use of CFC-based refrigerants	✓	CFC free systems used.
2. Select refrigerants with low ODP	✓	Low ODP equipments specified.
3. Use equipment with increased equipment life.	✓	
4. Fire suppression systems should not contain Halons.	✓	

MATERIALS & RESOURCES		
Material Procurement:		
1. Use locally sourced materials	✓	Building cladding stone and glass locally procured.
2. Use rapidly renewable materials	✓	Partitions and ceilings in Gypsum boards.
3.Use FSC-certified wood products	✗	Not available in the UAE market
4. Specify the above in contract documents	✓	Specified wherever applicable.
5. Usage of lower wood grades.	✗	

Waste Disposal:		
1. Provide for segregated waste disposal	✓	Waste disposal area very well planned and located from all Back of house areas to the lower basement loading dock and garbage collection space which is connected by a dedicated service tunnel for loading vehicles and garbage trucks to the main road external to the development.
2. Locate central collection and storage area	✓	
3. Provide sorting and storage facility for recyclable materials	✓	
4. Incorporate salvaged materials into building design	✗	
5. Design Garbage rooms as per DM Article 51 and 52/2001	✓	
6. Involve local hauler to provide waste management services	✗	
7. Design for front loader bin and a ramp up to recycling area	✓	Designed as per DM requirements.

AIR QUALITY MANAGEMENT		
Tobacco Smoke management		
1. Prohibit smoking in the building	✓	Allowed only in open terraces of restaurants or external spaces.

2. For smoking rooms, obtain permit allowing smoking	✗	No smoking rooms provided
3. Exterior smoking areas at least 25 feet away from entries/ air intakes/ windows	✗	Could not be provided due to the sprawl of the structure and intermittent open spaces.
4. Smoking room must be directly exhausted to the outdoors	✗	NA
5. Provide impermeable partitions to smoke rooms	✗	NA
6. Design chemical rooms for a negative pressure with Door closers	✓	Interiors maintained at positive pressure to reduce outside hot air exchange.

Improved Air quality		
1. Design systems to meet ASHRAE Standard 62.1-2004	✓	
2. Provide naturally cross ventilating spaces	✗	Building mass too large to provide cross ventilation.
3. Install permanent air monitoring systems	✓	Smoke detectors installed.
4.Supply outdoor air to parking levels	✓	External air ducts provided to the basements.
5. Install CO_2 & CO monitoring at 3 - 6 feet AFFL in parking.	✓	CO monitoring systems installed in basements.
6. Install high level filtration systems in AHUs	✓	AHUs maintained regularly.
7. Install permanent architectural entryway systems	✗	Not provided.
8. Dedicate exhaust systems for print & fax rooms	✗	NA
9. Maintain negative pressure in rooms with chemicals.	✓	Janitor rooms, filtration rooms and stores have negative pressure built up.
10. Dedicate exhaust systems for cleaning & maintenance areas	✓	
11. Isolate chemical storage and mixing area	✗	NA

Low-Emitting Materials:		
1. Specify low-VOC materials in design	✗	Concepts were not very well known in the UAE in 2003 and hence difficult to market.
2. Select certified Green Label Plus program carpet systems	✗	
3. Specify assemblies with no added urea-formaldehyde resins	✗	
4. Specify testing in the project specification.	✓	Air quality testing specifications before occupancy.

Occupant Controls:		
1. Provide for combination of mechanical and natural ventilation	✗	Both are provided but segregated in their usages.
2. Design HVAC systems according to ASHRAE 55-2004	✓	
3. Integrate individual controls	✗	Not advisable for a mall space. Though can be altered by mall staff for the occupant comfort.
4. Provide for occupancy sensors	✓	
5. Openable windows constitute 4% of occupiable area	✗	No operable windows except smoke exhausts. Many terrace spaces are however included leading to the same effect.
6. Position windows/ wind catchers along NW & WNW	✗	Used sparingly in microclimate spaces as wind directions are affected by the north end hotel building.

Daylight & Views:		
1. Restrict glazing which faces the south	✗	Extensive glazing along south side.
2. Use external shading devices to reduce glare & heat	✓	A variety of shading devices used.
3. Provide min 2% glazing in all regularly occupied areas	✓	Good outdoor connection provided.
4. Add interior blinds, louvers, light shelves etc	✓	Provided wherever necessary
5. Use high performance solar control glazing	✓	
6. Provide Photo responsive controls for electric lighting	✗	

VERNACULAR DESIGN FEATURES		
1. Design to take advantage of existing natural resources.	✓	Creek design maximized. Canal added.
2. Design exteriors with light colours with high SRI	✓	Light coloured stone cladding used.
3. Promote use of courtyards	✓	Microclimate created.
4. Provide wind catchers with filters.	✗	
5. Include maintained water features in design	✓	Many water features included as design highlights and asinteractive spaces.

Construction requirements		
1. Create an Erosion and Sedimentation control plan	✗	
2. Designate 3rd party commissioning for all systems	✗	Not implemented
3. Evaluate energy system performance through M & V Plan	✓	Being monitored currently to evaluate system performances.
4. Protect the HVAC through IAQ management plan during construction	✓	HVAC covered with polythene during construction phase.
5. Sequence the installation of materials to avoid contamination	✗	
6. Depressurize construction work area	✗	
7. Perform a building flush-out of HVAC pre-occupancy	✓	Provided as per consultant specifications.

5.2.4 Analysis of sustainable design elements incorporated

i. Creation of Microclimate:

The design of a development is largely dictated by the climate as is learnt in our planning techniques. In this mall, Microclimates have been created to enhance the shopping experience. The Microclimate study and its proposed scheme confirms the strategic design advice provided for the architectural and landscape detailed design, and provides further detail and comfort predictions to the microclimate zones. The design of Microclimate has added value to external spaces leased to restaurant/café operators.

During the design phase, a climatic analysis for the month of July, the hottest month is carried out. In this an external environment, the floor (which is hot) and the sun are the only sources of radiation. In the design, the microclimate is modified to create more comfortable outdoor conditions by incorporating various features that augment the outdoor environment. Typically used features are intelligent planting, water features like cool walls, topiary misting, waterfalls, shading devices like Teflon coated canopy shading, large umbrella structures, building mass shading, drop down shades and temporary screens, green roofs and wind shield structures. Microclimates were created along the Quayside and the canal side.

- **Area Assessments**

Quayside:

The quayside areas are intended for use around the evening time. There is less flexibility in design here as the spaces tend to be public plazas or promenades, which do not lend themselves to high levels of environmental control. Control over the microclimate is confined to well-defined areas. If spaces are not at least partly enclosed, it is difficult to moderate the air temperature.

Canal side:

The Canal spaces are intended for use all day, as extensions to the air-conditioned interiors of the main mall. Many areas are cafés, dining areas etc and it was found necessary to significantly improve the comfort conditions in these spaces in order to encourage their use. Long-term sitting has associated comfort requirements which had to be addressed by microclimate design.

It was realized that it is only possible to control air temperature if the spaces were effectively protected from the wind, such that the external air replacement rate is not too high. The areas under terraces were well protected by cooling walls or shades in windy conditions.

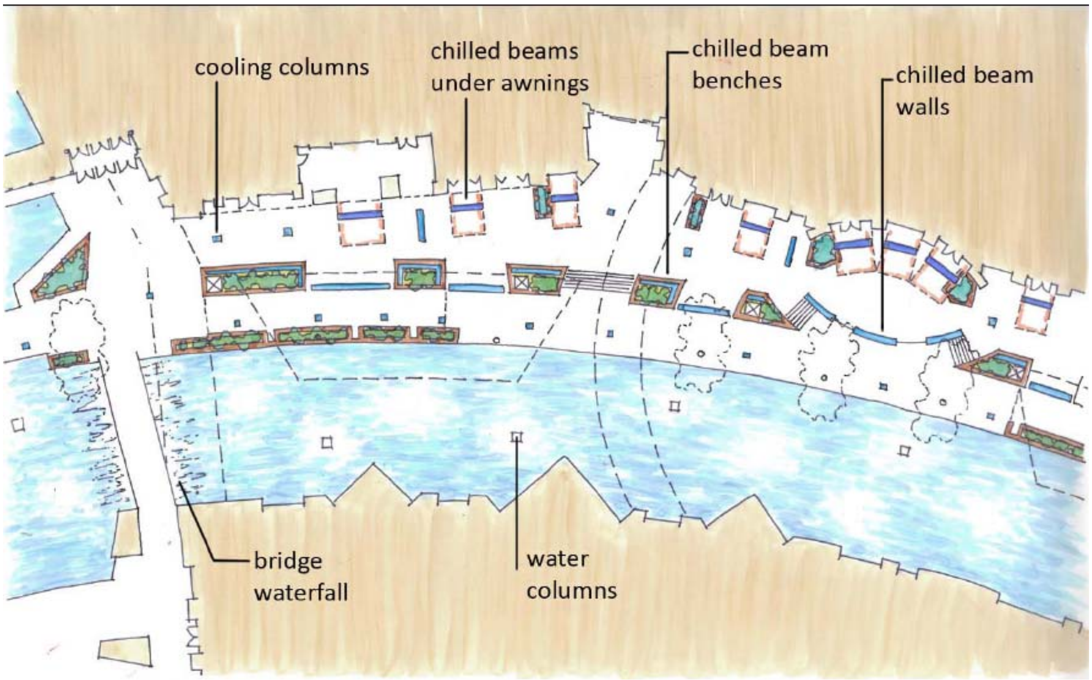


Figure 20. Plan showing Cooling strategies used (Arup, 2004)

- **Radiant Cooling:**

The microclimate zones are designed to provide fully shaded walkways. The canopies have reflective (but not metallic) properties. These canopies also provide shelter from heavy rainfall from November through until April when storms occasionally occur and can be violent with heavy rain or squalls.

By providing additional surfaces such as cooling walls, as well as planting and grass cover, the resultant temperature has greatly improved. In addition, high thermal mass of surrounding walls aid the pre-cooling process.

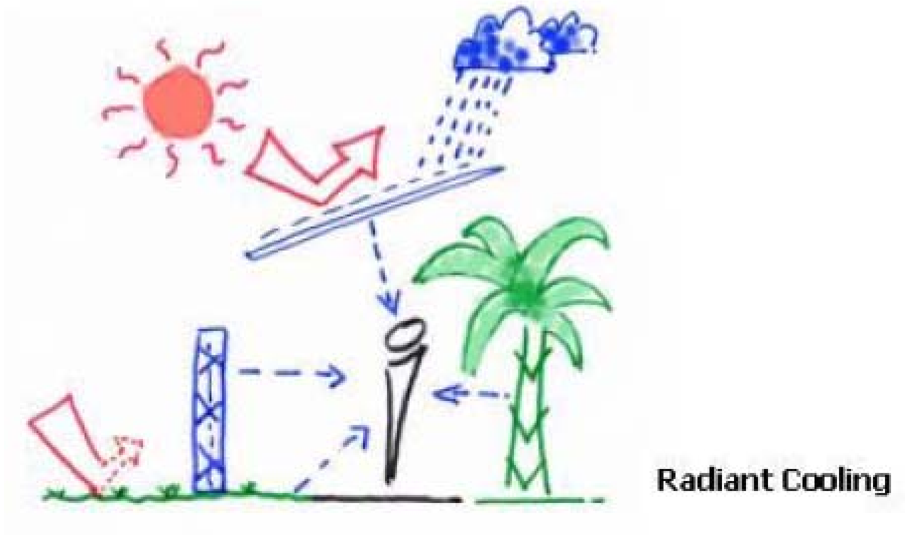


Figure 21. Radiant cooling

- **Conduction**

By suspending a lightweight walkway over the canal, and by ensuring contact with the water, heat is conducted away from the surface thus contributing to a lower resultant temperature. To apply this effectively, the canal water is both protected from direct sunlight, and is also cooled at certain periods (e.g. indirectly using deep water from the creek)

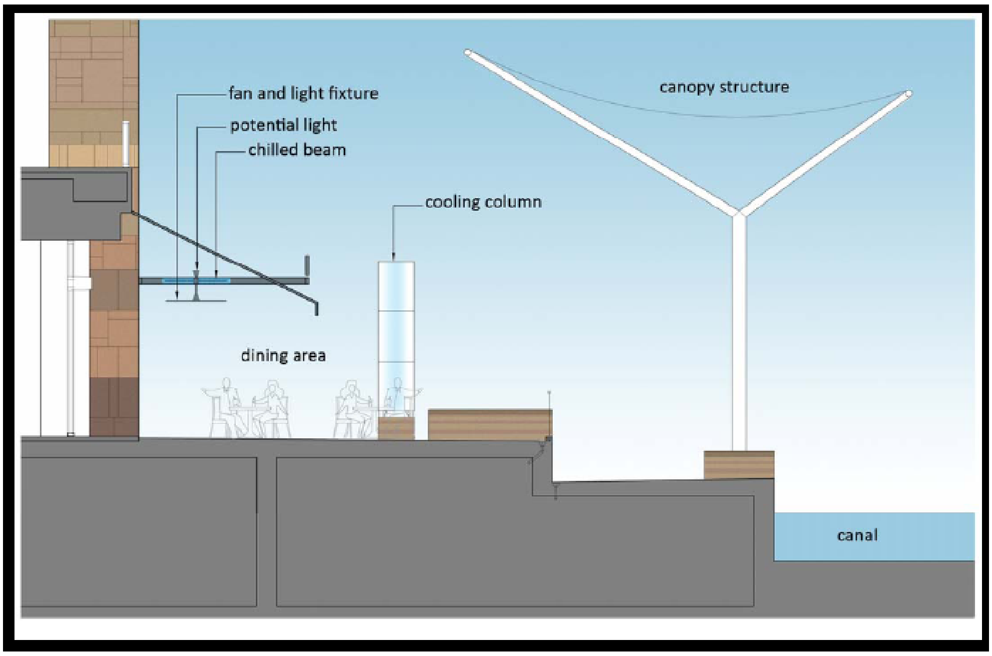


Figure 22. Cooling of the canal side (Arup, 2004)

Mentioned below are the important design parameters taken into consideration for the creation of a microclimate in the design of the mall.

ii. External Comfort:

The duration and type of use of outdoor spaces is linked to how comfortable they are, along with the achievable microclimate in the space. The microclimate is defined by the air and radiant temperatures, wind conditions and humidity. Modifying these factors according to the intended use of the space allows improvements in external comfort to be made by 'microclimate design'. Various outdoor spaces are created in this project through microclimate design. Examples of these spaces are added in the Appendix. These examples lead to an interesting understanding of the design of microclimates.

iii. Air Movement

The major advantage of wind in recreational development is its cooling aspect. The shape of the canopies, and positioning of walls are instrumental in providing air movement. Further study of wind direction and speed is taken up, to ascertain which winds are desirable or non-desirable. Clues to the way in which ventilation has been enhanced locally for a number of centuries is provided by the traditional middle-eastern wind towers. Design elements have been picked up from it.

The play with air movement is utilized in all the microclimates created for the outdoor recreational areas. Lightweight fans are suspended from the canopy frame. To encourage air exchange, the fans are situated below holes in the canopy. Increasing air movement by the fans improves comfort by reducing the effective temperature. The ceiling fans produce air speeds of 2m/s. This air speed significantly reduces the heat sensation. Microclimates are described further in the Appendix.

iv. The use of Courtyards

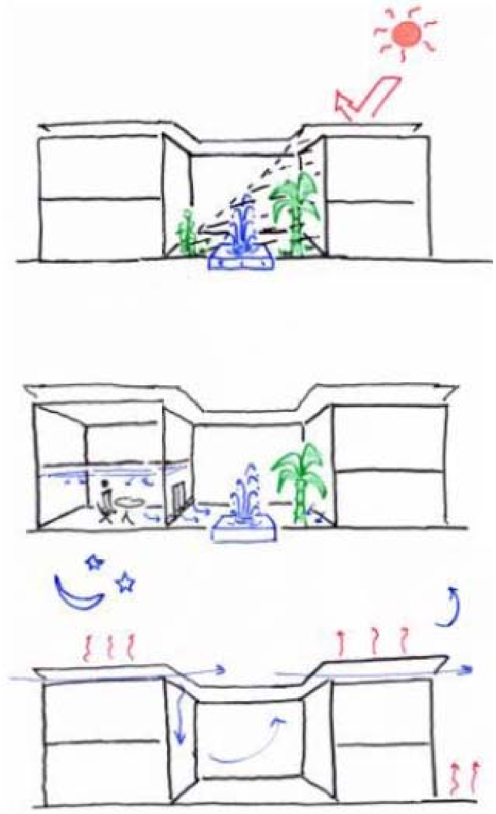


Figure 23. Courtyard actions

The traditional internal courtyard provides good shading by virtue of the enclosing buildings, and is aided by relatively small overhangs. Water features and planting provide local evaporative cooling, and are most effective when the relative humidity drops, typically mid-afternoon. The courtyard effect is achieved in between the building masses, at the canal walk and between pavilion building blocks, where shading is provided by the buildings and air movement is triggered by the stack effect.

Night time winds and re-radiation of the surfaces pre-cool the spaces ready for the next day. In addition, high thermal mass of surrounding walls aid the pre-cooling process.

v. Wind

There is a strong southerly influence from the desert all year round on the site. In the hot summer months, the winds tend to swing round to the North and North West in provenance from the sea.

The wind patterns in this area are largely dependent on the hotel development to the north. There is an increased volume of warm southerly winds during the worst microclimate conditions. In order to protect the space from uncomfortable wind conditions, planted trellises are used as wind breaks.

Daily patterns suggest that the afternoon sea breezes tend to drop off in the evening, when humidity is high again. Design accommodates these wind direction patterns to benefit from them.

vi. Water Features

Water can absorb a significant amount of heat, while maintaining a low level of heat transfer to the surroundings. Evaporation at the water surface further removes heat from a body of water. Misting is used frequently in created microclimates. Misting in the trellises humidifies and cool the dry, hot winds. Misting is only used in the daytime when humidity is low. Topiary misting devices (movable) are used as mini-cool towers to provide local evaporative cooling. Similarly water falls are used, wherein they provide 3 degree Celsius cooling in some areas.

Water features are used intermittently and abundantly throughout the project to provide relief from hardscape. The most effective water features are those with the lowest water temperatures and the highest rate of evaporation. The lowest water temperatures will be maintained by shading the surface from direct sunlight. When the water feature is exposed to the sun, the solar heating effect is minimized by constructing the feature out of light coloured, reflective material. Water is kept cool by shading and having light coloured materials behind them to reflect incident solar radiation rather than absorbing it.

The larger the mass of water, the more energy will be required to raise its temperature, so deeper pools are preferable. The effect of water features is most pronounced in enclosed areas such as courtyards and sunken terraces. The central canal water body is designed with the above principles in mind. It is large deep pond shaded efficiently by the surrounding building masses.

vii. Materials and Finishes

The urban microclimate is affected by a number of factors including the materials and colours of its fabric. In order to make external spaces as comfortable as possible, canopies and shading structures have light and reflective colours on their upper surfaces. This limits the heat absorbed by the canopy that would then be reflected down onto the occupants. Care is taken in the design to avoid glare-causing reflections to higher surrounding buildings.

Teflon coated glass fibre is a tensile material which is used for these applications as it directly reflects most of the incident solar radiation, and absorbs very little (which would then be reradiated below the structure) mainly because it is so thin. Canvas, which is a rapidly renewable material performs well again if it is white in colour, but would have surface temperatures a nominal 10°C higher than Teflon coated glass fibre. So Teflon was preferred and used in most applications.

In order to avoid uncomfortable glare, but ensure low surface temperatures, light but not too reflective finishes have been chosen for floor surfaces surrounding occupied spaces, especially where these are sheltered by buildings above. The best materials used are soil or grass (wet performs better), followed by light-coloured sand and stone or timber. Light paving materials used in unshaded regions helps lower the heat content of the region, preventing localized heat islands. Light colours used are white (best), followed by light beige followed by very light grey. Dark and metallic materials are not used. Aluminium foil performs well as a coating, but is likely to cause uncomfortable glare and therefore is avoided.

viii. Planting

Trees and planting in the design, significantly cool the local environment. Their impact is dependent on their size and location. Large and medium scale planted areas have a cooling effect due to evapo-transpiration which regulates foliage temperature. The temperature reduction is caused by evaporative cooling and shading of the ground. Smaller green areas are spaced at intervals for effective cooling of surrounding areas.

For small scale planted areas, apart from the evapo-transpiration, other major qualitative effects are:

- Shading effects due to trees: mitigation of the solar heat gain.
- Reduction of surface temperatures: decreasing convective and conductive heat loads.
- Reduction of radiation transmission from ground to occupied spaces by ground cover plants.
- Windbreak effect: wind speed mitigation.

High levels of planting used reduces surface temperatures and offer shading. Non-reflective and planted surfaces prevent heat reflecting into shaded areas. An irrigated green roof is incorporated which has resulted in a floor surface temperature being close to wet bulb temperature, reducing the resultant temperature. Planting is used throughout the project and incorporated in design thoughtfully to achieve the above effects.

ix. Occupant controls

The design consultants believed that if occupants know that at any time they can modify their conditions, for example by changing a thermostat or by moving, people tend to be more comfortable. If occupants choose to be in an external environment they are more likely to be satisfied than if they do not choose to be there – the results of research into this effect are shown below.

x. Shading

Where sun is abundant, it is imperative to provide shade for human comfort and safety in activity areas (e.g., pathways patios). The most economical and practical way was to use natural vegetation, slope aspects, or to introduce shade structures. Sun protection is provided, in the form of drop down shades or temporary screens which are used only when required. Alternatively, provisions are made for an awning at high level, combined with portable cooling walls to provide adequate shading. The need for natural light in indoor spaces and solar energy are important considerations to save energy and showcase environmental responsive solutions.

In order to assess the effectiveness of shading by building massing, a model of the building was produced and used in solar analysis. The geometry of the main mall buildings has been simplified to understand the external elements directly affecting the Canal and Quayside areas.

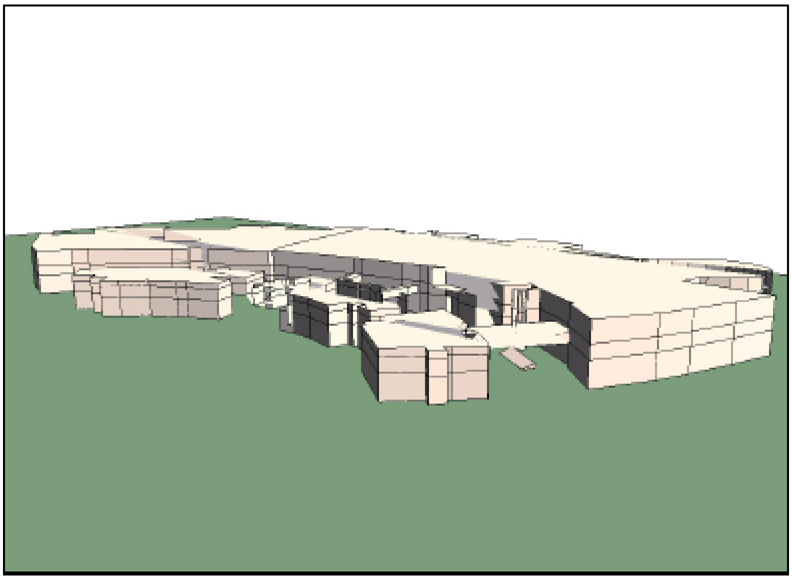


Figure 24. Shading Analysis I

Many areas are protected from above by building overhangs. However, with skylights and this building configuration lead to some other exposed faces through which direct sunlight can penetrate at certain times of day. Penetration of direct sunlight to seated areas will create uncomfortable conditions, so additional shading has been designed in the form of screens and overhangs.

Some areas are shaded from above by building overhangs. The north side of the quayside overhead shading is effective in the mornings, and reduces throughout the afternoon. The south side overhead building shading is fully effective from midday onwards. This is realized from the shading analysis, illustrated below. The seating areas are provided with some additional local shading, e.g. umbrellas, to be comfortable throughout the day. Ceiling fans improve air movement on still or humid evenings.

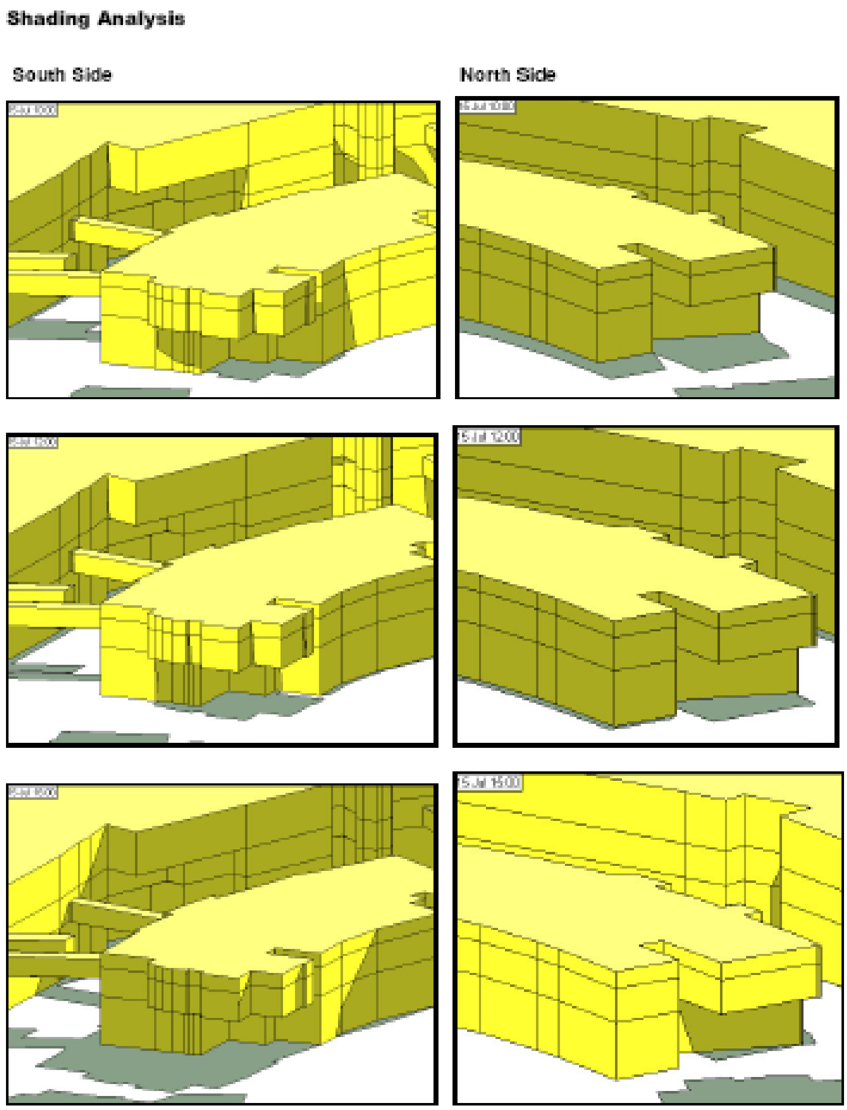


Figure 25. Shading Analysis II

Shading Analysis :

- Overhangs with south openings will be very exposed to midday winter sun. There will also be some penetration by midday mid-season sun. In the south façade, extending the overhang past the occupied space is found effective.
- East facing openings are exposed to morning sun and west facing openings to afternoon sun. Removable and mechanically operated adaptable shades and awnings are provided on these faces.

- North facades will be subject to low angle sun in the summer mornings and evenings. Treatment similar to the East and West openings is used. Drop down shades are found to be the most effective form of shading and offer versatility. They have been constructed from mesh screens and metal grids with louvered designs in order to block unwanted sun but still allow openings.

Figure 26. Daylighting through transparent roof with shading element with metal grids and glazing.

Computer generated shading mode have been used to study the impact of sunlight travelling throughout the day. The following pictures have been generated using lighting simulation software that models light interaction in a physically accurate way. They are modeled for midday in June. The pictures are included as a physical representation of the amount of light entering the space. The shading is designed to protect from the lowest angle unwanted sun with the help of this computer generated shading study.

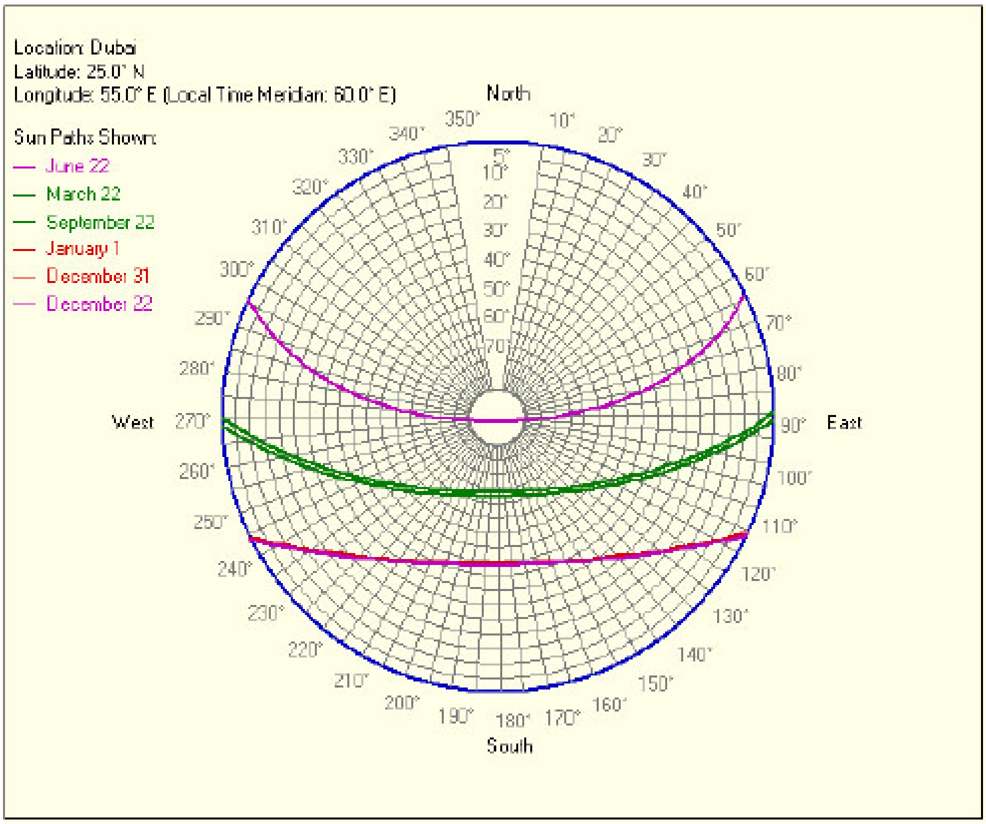


Figure 27. Sun Path Diagram for Dubai Generated Case study II. (WSP, 2009)

It is seen that facing north, the roof appears light and presents a good view of the sky, even with the extensive shading. Facing south the shade blocks the sky. This is because it is fulfilling the function of blocking out most of the sun.

A connection to the outdoor is maintained through out the mall with large expanses of daylighting and transparent roof features. About 50% of the external envelope consist of glazing with shading features.

Sun angles recommend for this design was taking 50° for southwest facing spaces, 30° for due west facing spaces

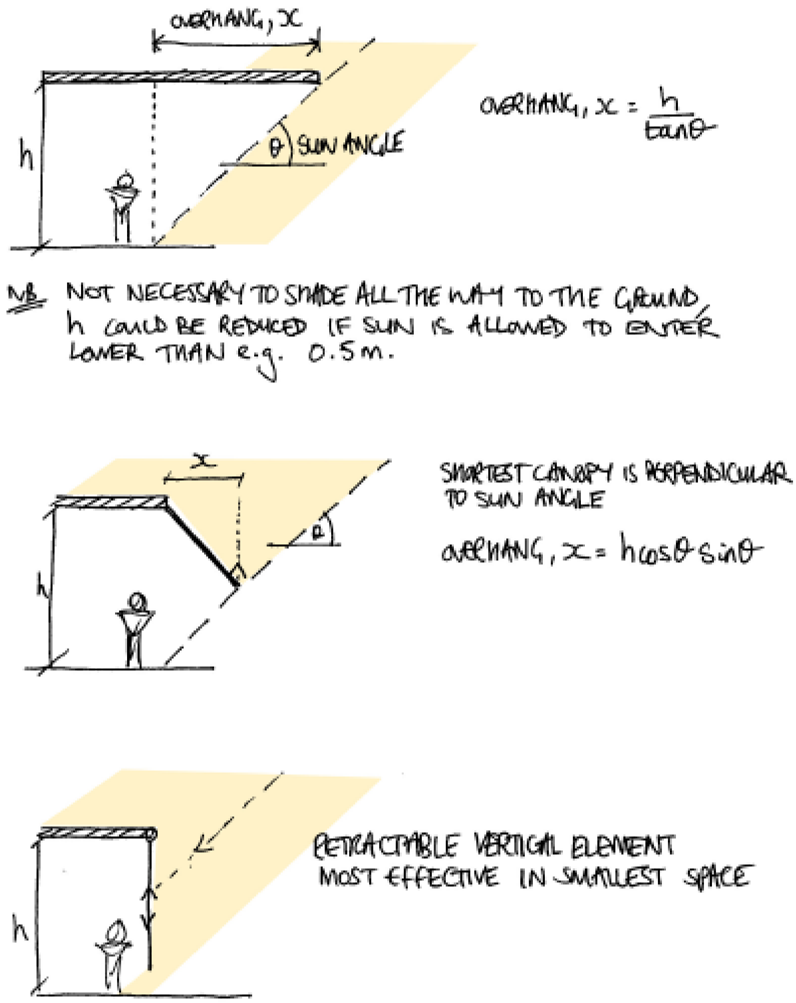


Figure 28. Various shading strategies considered and utilized for the shading design. (Arup, 2004)

The majority of first floor terraces spaces are shaded overhead by the second floor of the buildings. They are all facing between southwest and northwest so will require extra shading to protect from the afternoon sun. Angled awnings and movable screens are installed. Trellises with bougainvilleas and fabric awnings were recommended in design but not installed, due to additional maintenance requirements.

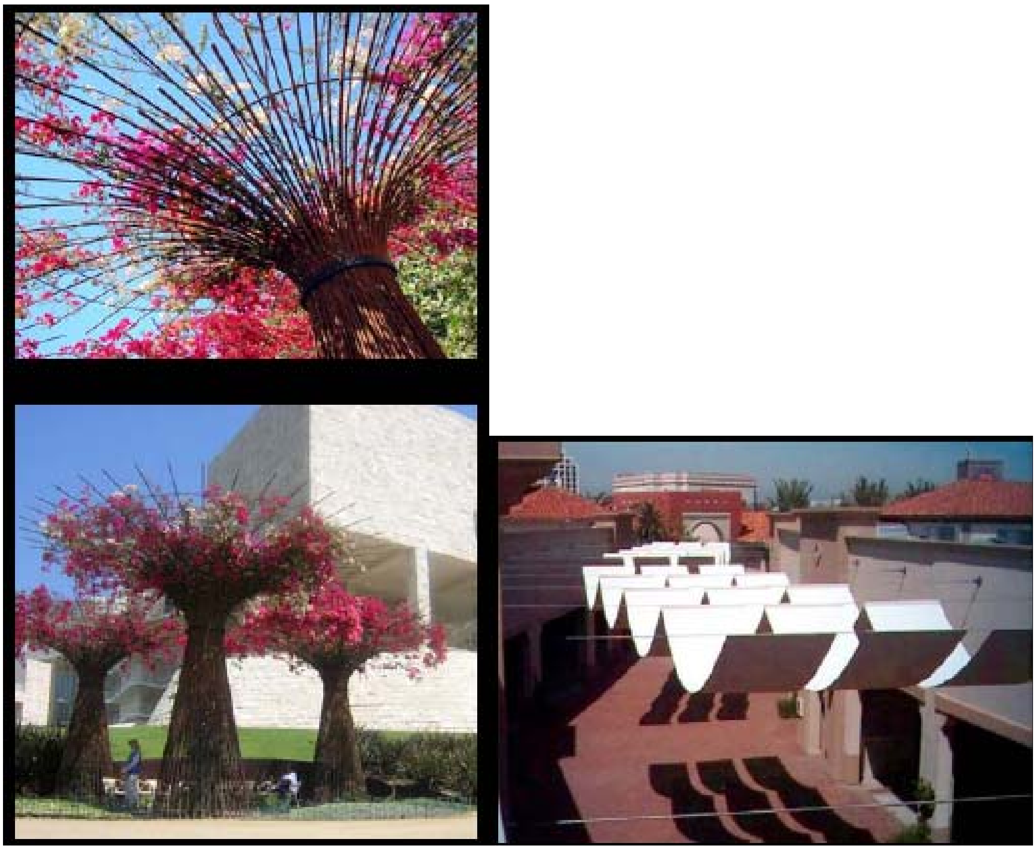


Figure 29.	Bougainvillea canopies and awnings.

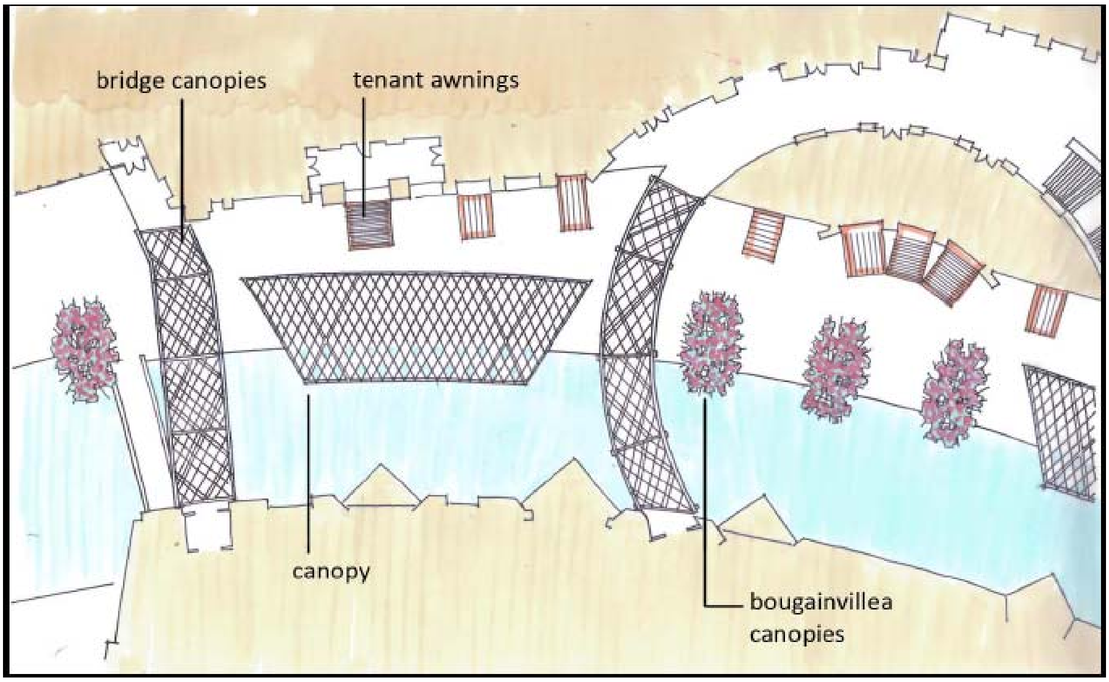


Figure 30.	Various strategies utilized for shading of the Canal Walk

xi. Cool Walls and Ceiling fans

Cool walls are utilized in appropriate areas to create a microclimate in exterior spaces cooling the immediate adjacent space. As a design element, it is important that cool walls are shaded at all times. The cool walls on the exposed perimeter of a space, are shaded by awnings. The effects of cool walls depend on their configuration.

There are essentially 3 types of radiant cooling walls:

- Permanent installation, using condensate from main building air conditioning system. (open system with discharge to canal)
- Permanent installation, closed loop using DX refrigeration and embedded plastic pipes.
- Portable installation, standalone "radiators", with associated DX refrigeration or condensate connection.

The large volume of waste condensate available made this the preferred "coolth" source, with concerns only of providing the condensate to the required location. Power (from the main building supply) is utilized to pump the condensate around the cool wall circuit. Permanent installations have thermal capacitors in order to store "coolth" and minimise peak hour energy consumption. The portable type are more lightweight, and is either powered by a PV cell installation locally, or by plugging into the main electricity supply.

Drainage channels and gullies are provided to collect condensation droplets from the wall surfaces. Control of the cooling walls are manual on/off, as determined by the tenant operators.

Materials suitable for external applications are used, i.e. stainless steel mesh treated (and maintained) with antibacterial finishes. An impermeable finish was required to prevent penetration of moist air into the unit.

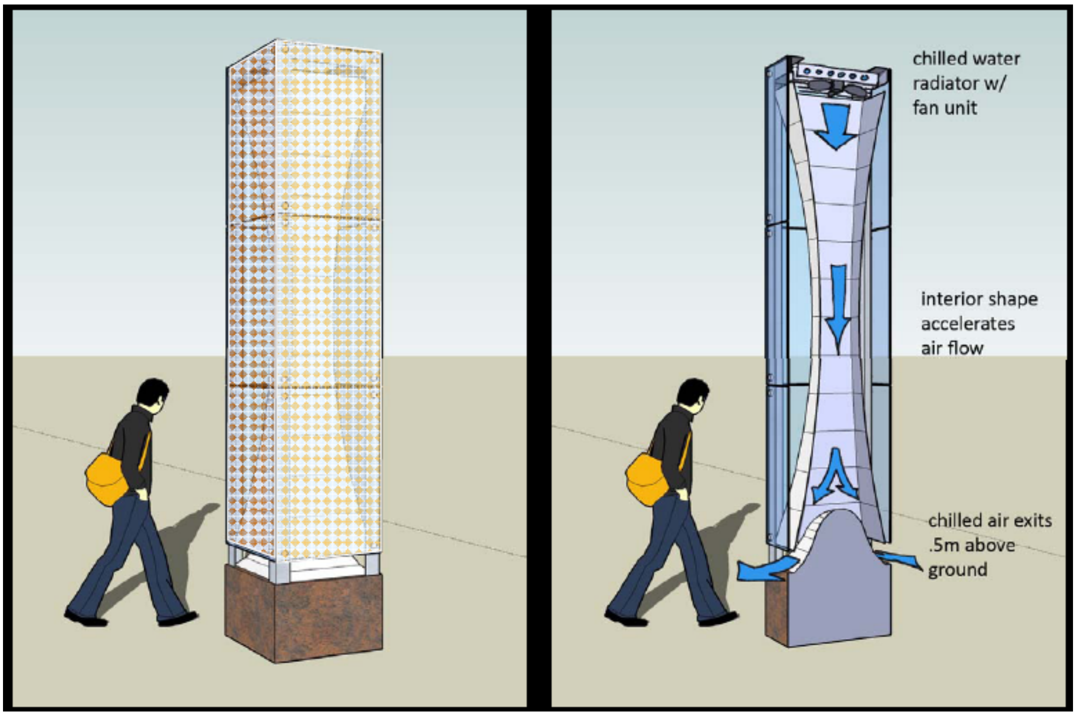


Figure 31. Cooling Columns (Arup, 2004)

Overhead ceiling fans are used to improve air movement in the evenings. Misters are used in areas which are sufficiently enclosed, when the humidity is not high. The volume of condensate required is approximately 0.6 l/h per m^2 of enclosed area. Ceiling fans have large diameter rotating blades. Where buildings overhang external spaces, ceiling fans are provided at a density of 1 per 5 x 5 grid. Control of the ceiling fans are manually operated by the terrace/restaurant staff.

Similarly Air handling units are installed at the amphitheatre spaces designed for children interaction and activities. This uses collected condensate water from the mall for operations. Their design is further described in the Appendix.

xii. Design Strategy for External Envelope

- **Types of External Envelope**

The external cladding engineer explained the designed cladding system to be an efficient thermal envelope. Where possible, the external glazed wall comprise of factory assembled, pre-glazed units based on a system of common extrusions with thermal breaks for economy. Glass except structural bonded glass is site-installed.

Lightweight vertical and horizontal sunscreen devices provide shade to the glazed walls, thus allowing the use of clear glass to achieve maximum 'transparency' in the shop-front facades and to limit the need for solar control glass. Where shading is impractical the glazing units comprise of solar control glass.

Glass types, glass unit configuration and thickness vary, depending on the performance required in different locations and with the differing acoustic requirements of the particular uses. In glazed walls, other than shop-fronts, manually operated internal blinds are used to assist in comfort control to suit the particular occupancy.

Glass in roofs are high performance insulating glass units with solar control tempered glass and ceramic fritting to reduce glare.

Solid roofs are constructed from cast-in-place concrete, thermal insulation and a waterproof membrane. In some areas roof members comprise of metal decking with insulation and waterproofing and metal covering. All of these are reusable building components.

Insulated solid walls with a 'rain screen' of natural stone, ceramic tiles, terracotta tiles are used to reduce energy losses. Insulated blockwork along with insulated metal panels are used. Natural stone is layered underneath with a blanket of rockwool insulation. Temperature and relative humidity values specified by the consultant are used by the specialist contractor to determine the thermal and hygrometric response of the cladding systems.

The design has endeavoured to consider the use of materials and finishes which are produced locally or are readily available from local suppliers/installers, though it has not been possible to implement all of the proposed design schemes. Due to the luxury nature of the project, downsizing on the finishes to match finishes to match locally available material was not a considered option.

A Design and Service Life of 25 years is assumed, within which period the overall assemblies will perform their principal functions. Warranty periods for certain components (eg. sealed insulating glass units, sealants) are usually less than 25 years and some elements may need to be replaced during the 25-year period. It is essential that components are to be designed to be capable of replacement with minimum disruption. The concept is that, the longer the design life, the more eco friendly the building and its materials are.

External envelope elements and their fixings are designed to accommodate structural movements and any differential movements due to thermal fluctations this region experiences and as well as any seismic influences.

- **Weather Resistance**

The design of the external envelope are built to the standards published by the UK Centre for Windows and Cladding Technology (CWCT). Laboratory testing of each different type or configuration of external envelope to the CWCT standards are specified and recommended to the contractors.

- **Thermal and Solar Control Performance**

Materials for the external envelope are selected to limit the heat transmitted from outside to the inside of the building. The following performance criteria, which are better than the minimum values required by Dubai Municipality are assumed.

'U' value for glazed areas:	2.0w/m^2K for glass units - with low-E coating and air space in Double Glazed Units. (DGU) 5.5w/m^2K for framing.

‘U’ value for solid wall elements:	0.50w/m²K.
‘U’ value for solid roofs:	0.40w/m²K.
‘U’ value for glazed roofs:	2.0w/m²K for glass units - with low-e coating and air-filled space in DGU. 5.5w/m²K for framing.

Thermally-broken glazing frames are used to reduce heat transmission and to reduce the risk of condensation.

Where glazed areas are not shaded from direct sunlight by other means, the insulating units incorporate a solar control glass to achieve a shading coefficient of 0.43 or better.

- **Materials and Finishes**

Curtain wall framing is used for 50% of the building envelope. Steel members and glass can easily be recycled at the end of their design life for reutilized.

In order to maintain maximum transparency in shop-front areas, neutral colour coated glass with low reflectance was selected.

Solid wall elements are constructed of blockwork with natural stone facing, timber, terracotta tiles, ceramic tiles or metal panels. Precast concrete sandwich-panel construction incorporating closed-cell insulation are used in various parts. The external face finish feature various treatments like smooth, pigmented colour and relief patterns.

Sun-screening materials (brise soleil), on lightweight metal framing/tension cables are used in most areas for shading. These include PTFE or PVC fabrics, woven stainless steel fabric supported on hardwood (meranti or similar).

xiii. Waste Management

General Provisions for waste:

1. A segregated waste strategy, which allows the recycling of a proportion of the waste generated by the site is adopted by the mall. Waste are split between dry (paper, plastics, packaging, aluminium, and glass) and wet waste.

2. All wastes are taken to a Central Waste Area (CWA) located adjacent to the service area (i.e. loading bays, etc) using services corridors in the basement. This provides goods vehicle access to the bulk waste storage and remove waste collection vehicles from pedestrian areas.

3. The use of a CWA allows the consolidation of waste, the coordination of collection vehicles, compaction and on-site segregation.

4. Chilled storage areas are provided for non-recoverable (wet) waste. These rooms reduce the infestation of bacteria, insects and rodents due to the hot conditions in Dubai. The chilled rooms are located within the CWA and interim waste areas.

5.2.5 Recommendations and Conclusions

i. Design aspects where the green design intent is not reflected

1. Excessive lighting has been used throughout the mall to highlight architectural features, to draw attention to certain areas as well as project it along the creek elevation as an exquisite outdoor recreational location. Little thought and care has been taken with regards to the excessive lighting energy consumption.

Identifying the mall from long distances, from air, road as well as water and creating it as a landmark feature was the aim of the lighting design. It was envisaged that the Mall lighting experience should start long before visitors arrive. The lighting design should be layered and should begin for visitors, depending on the viewpoint, at long distance travelling in by land, sea or air. As the visitor draws closer he is introduced to the development via a series of lit elements. Lighting to the boulevard roadway were proposed with lighting columns that are curved reflecting the shape of the site, sculptural. At this point other layers of light from the surrounding landscape treatment are revealed, such as light features, store entrances, trees, canopies etc.

The retail building, key mass areas of the façade are identified for architectural lighting treatment with the potential use of colour projection to create strong and vibrant images. Main entrances are lit to generate a sense of arrival before discovering the interior mall spaces. On the canal side with the consideration of the canal walk , lighting is used to reflect into the water areas while delineating the architecture.

2. Buildings are not oriented to maximize the natural conditions. Excessive exposure on to the southwest and northwest has necessitated additional shading elements.

3. Large amount of external paving and roadways is noticed throughout the site. Though the area is well-landscaped, the trees cover is as yet growing and currently the walkways are all exposed to direct sun and heat. Excessive paving is used. However it is noted that the paving blocks are of permeable type, allowing water seepage and of light colour with high Solar Reflective Index.

4. The water used in the canal is filtered and monitored continuously due to health hazard precaution necessitated by the Municipality. As the canal contains large volumes of water continuously recirculated , along with the other water bodies within the project, a large amount of energy is utilized. It must also be noted that evaporative losses of such a large

exposed volume of continuously circulating water is huge. In a city like Dubai, where water is a valuable resource, this wastage should be contained.

5. For the created marina and quayside, large amounts of dredging was carried out to shape the landform as desired by the design. It is now converted into a luxury yatch dock with ancillary amenities, where regular boat shows are held. It is imperative that ship corridors or channels do not traverse or that boat docks are not constructed over fragile marine environments such as coral reefs. Marine facilities should be developed to allow natural beach sand movement to continue unimpeded. Permanent anchor buoys should be installed in harbor areas to mitigate anchor damage to bottom environments. No marine ecological concern is reflected in the design and execution of the existing marina.

Chapter 6: CONCLUSION

6.1 Conclusion

6.1.1 Case Study I

It can thus be noted that a large number of design and execution points learnt in the planning techniques have been implemented to the design process of this resort building. A number of procedures have been put in place to ensure the successful implementation right from the design stage. Careful execution now forms a vey important part for the success of the green initiatives endeavored in this project.

Lessons learnt include that additional time and procedures need to be implemented to formulate procedures and systems customized to individual site conditions. Thoughtful specification forms an important part of design development. An Integrated design process is essential as all consultants need to contribute to optimize energy savings and resource consumption. It was also learnt that the Municipality procedures and infrastructure in place, like hazardous waste treatment facilities, an extensive TSE network to name a few, are very beneficial and aid the Green building design intent. The propagation and popularity of such projects will gradually tune the supply market too, for obtaining local and fair trade materials and stimulate the usage and market for green products and eventually successful green buildings.

6.1.2 Case study II:

Creation of a controllable Microclimate is an effective strategy that can be implemented in Dubai. Passive techniques, inspired from vernacular local architecture should be implemented as being a low-tech, low maintenance sustainable design feature. Though not all aspects of green design are considered in this project a variety of design recommendations found in LEED design submittals are covered.

Inspiration must be taken from the design techniques and lesson are learnt from aspects they have overlooked. The mall, currently operational since 2 years is very popular with heavy footfall and high retail sales. The popularity of this recreational destination speaks in itself about the success of comfortable sustainable design conditions that the consultants have attempted to create and succeeded.

This case study is interesting as it proves to the researcher that a rating system is not essential to ensure that sustainability factors are achieved. Responsible design along with an awareness of the deteriorating environmental situation and concern for minimizing water and energy resource consumption is the need of the hour.

These case studies showcase that green building practices can substantially reduce or eliminate negative environmental impacts and improve existing unsustainable design, construction and operational practices. Green design measures reduce operational costs, enhance building marketability, increase worker productivity and reduce potential liability resulting from indoor air quality problems. Green design has environmental, economic and social elements that benefit all building stakeholders (USGBC, 2007).

The case studies above, illustrate that in order to develop an energy and water-efficient building, which is both sustainable and practical, input from all members of the design and construction team is necessary.

Building design requires the integration of many kinds of information. When we talk about green buildings, we are really talking about redesigning the design process – rethinking everything from the place to the schedule and pace of design.

Common constraints learnt from the case studies identified are those of

- Lack of skill base
- Lack of Enforcement and inspection capacities
- Speedy pace of development
- Lack of public awareness
- Lack of Modeling and technical capacities

All of these constraints have been discussed and measured advocated in the case studies. Along with it, as is learnt from the above two case studies, our approach to Green should be primarily through Benchmarking and Building a system as is seen in the case of the Beach Resort where the green intent is specified clearly and systems are being set to achieve the same, by adhering to LEED ratings. These are also recommended by the "Hannover Principles" or "Bill of Rights for the Planet," developed by William McDonough Architects model of the new design principles necessary for sustainability.

6.2 Integrated Design Management

6.2.1 The need for Integrated Design Management

With the increasing boom within the construction sector it was noticed that the developers expected their buildings to be constructed within the shortest possible timeframe in an attempt to speed-up their revenue generation process. Tight deadlines and poorly co-ordinated designs had become a feature of a typical Dubai project. It is learnt that the trouble with most LEED projects which had begun in the UAE is that LEED would be often introduced after the design stage just before mobilization. This made it difficult to integrate the LEED principles into the project at this stage as a large amount of design work needed to be reworked to fit into the LEED requirements. Case studies suggest that an *Integrated Design Process* be part of the planning phase of a building proposed to be energy efficient or LEED certified. The challenge is to develop solutions that continue to allow the innovation in building design characteristic of Dubai, while acknowledging the need to reduce the amount of the buildings' energy use. This challenge can be overcome by the participation of all members of the design team to achieve integrated solutions.

A green building requires the co-ordinated planning of all the various consultants and the input and guidance of a green expert. By focusing on information exchange and the transfer of knowledge, this new approach may improve the efficiency and effectiveness of the building process. Since a project's success relies upon the right people having the right information at the right time; proactive resourcing of stakeholder views should ensure that appropriate participants are consulted early in the process. This approach serves the purposes of identification, definition and evaluation of client requirements in order to identify suitable solutions, as mentioned by Kaatz et al. (2005) who cites the work of Cooper et al, (1998). He says that the process view of building production popularizes a more integrated mode of construction, which requires effective communication between building participants and their early involvement in the building process to help mitigate the effects of fragmentation.

This effect of fragmentation is minimized by a green expert which could be a Project coordinator or a LEED AP, as he is able to highlight the requirements of the credits and point out a way in which all the consultants can utilize their resource potentials and its by-products, so as to minimize waste, hence working in cohesion to meet the requirements without the need for any additional human or material resource input. For example a LEED AP would advise the MEP engineer to keep an account of the condensed water generated and generally disposed into the sewers as waste. For, this water can be utilized by the Landscape Architect in the irrigation of the landscape, thus reducing external water input required.

Similarly, it must not be the responsibility of the mechanical engineer alone, to overcome large cooling loads created by the architectural and façade components. The mechanical engineer should be part of the team staring at the concept design phase, to ensure that the architects and façade designers are fully aware of how their design affects energy use.

The full team must be aware of the impact that each component may have on water and energy use and conservation, and they must understand the unique aspects of buildings in Dubai which drive the cooling loads, water constraints and similar attributes. The team must also remember that they are tasked with creating a building which will become a dominant factor in the lives of those people who will be working or living in the building. This is achievable only if the consultants work in close co-ordination and hence an integrated design process is highly advised.

The construction industry is commonly characterized as technically and organizationally fragmented (Kaatz et al.2005 cites Egan,1998). This fragmentation is a key factor preventing a tangible transition to sustainable construction (Kaatz et al.2005 cites Sheath et al., 1996; Lee et al., 2000). The allocation of responsibilities between the different building professions and their sequential intervention in the building process have led to a further specialization and inefficiency in the coordination and communication between the project roles (Kaatz et al.2005 cites Lee et al., 2000; Turin,2003). Moreover, the prevailing informal and unstructured nature of the learning process, resulting from the constant reforming and dissolution of project teams, acts as a barrier for improving performance within the sector. This is especially true for the Dubai construction sector. Under existing industry structures, participants have different perceptions of the building process objectives and purpose (Kaatz et al.2005 cites Turin, 2003), which leads to conflicting conceptual frameworks within the building process (Kaatz et al.2005 cites Groaˆk, 1992; Gann et al., 2003).

As highlighted by Kaatz et al, this school of thought is evident in the practice of 're-integrating the design process' (Kaatz et al, 2005. cites Lotspeich et al.,2003). In integrated design, process stakeholders are brought together at the earliest practical point in the project in order to develop and execute a common project vision. These meetings create a communication space, where stakeholders develop not only mutual understanding, but also mutual trust. Integrated design clarifies client goals, design options and solutions, which allows for achieving the intended building performance. More importantly, the design team can function in real-time rather than follow the usual linear design process with sequential interventions from an architect and an engineer (Kaatz et al, 2005. cites Lotspeich et al.,2003).

6.2.2 The Process of Integrated Design

In an attempt to understand the various interactive levels required in a green design, I met with a LEED facilitator **Nicole Hillis of Energy Management Systems,** Dubai. She highly subscribed the use of an Integrated Design Process as an efficient methodology for a LEED project. As described by her, a typical LEED project has the following features:

For every LEED project the client approaches a LEED facilitator with a clear vision of the design brief of the proposed buildings, with the architectural conceptual sketches of the same, perhaps representing a 3D image of the proposed development. The client's Project Manager identifies the need for building on the basis of quantifiable requirements for space and budgetary capacity to undertake the activity.

The initial product of integrated design is a design brief with plans, principles and objectives that should guide the design and construction processes (Kaatz et al, 2005. cites Lotspeich et al.,2003). Hence, in order to deliver a successful project, the project and stakeholders objectives should be integrated. As the project evolves its objectives should continue to fit stakeholders' interests (Morris, 1994). Performance criteria expected of the building are listed and the planning of the building is carried out under the guidance of a LEED AP.

Once the Pre-design activities are complete, the architect or other prime consultant, in consultation with his or her team of sub-consultants, may produce initial graphic suggestions for the project or portions of it. Such suggestions are meant to stimulate thought and discussion, not necessarily to describe the final outcome.

A preliminary meeting is held with the project team, which comprises of the clients representatives, the core consultants and the LEED facilitating team. A preliminary energy modeling of the building is prepared. The window to wall ratio is decided upon and LEED requirements are highlighted and explained to all the team members by the facilitator.

An attempt is made to integrate the construction credits during the initiation stages, itself, so as to ease the process and get a feedback from LEED. Most LEED construction credits need to be considered early to make sure they are planned for and included in specification documents. In addition, it is good to know how many credits are being targeted overall to reach the level thresholds (silver, gold, etc.).

The second workshop focuses on further details of the project. MEP, landscape engineers and the contractors form vital part of future meetings.. Simultaneously feedback is received from the Master Developer for the proposed development with their comments. Work is carried forth with coordinated responses and guidance of all these key players. Periodic meetings are held often to ensure that the project objectives are as yet aligned with the client's green interests. With time all the other sub-consultants are now incorporated for the meetings making all the parties aware of the progress achieved or obstacles faced. Code officials, building technologists, cost consultants, civil engineers, mechanical and electrical engineers, structural engineers, specifications specialists, lighting, BMS and consultants from many specialised fields are included. This must be considered as part of the whole building process (WBDG, 2009). The Client's Project Manager acts as a driving force to stimulate the process ensuring to get the desired work from the individual consultants and feedback from LEED and the Master-planner with the planned timeframe developing integrated solutions that have multiple benefits.

Figure 32. An Integrated Project Management Session

Involvement of sub-consultants is a critical part of the process at this stage - their individual insights made at this point can prevent costly changes further along in the process. Gradually a design emerges which embodies the interests and requirements of all participants while also meeting the overall area requirements which the project budget will have established during Pre-Design activities. The resulting Schematic Designs produced at this stage show site location and organization, general building shape, space allocation, and an outline specification which makes an initial list of components and systems to be designed and/or specified for the final result. It is often useful to have a cost estimate performed by a professional cost estimator at this point. This aids in the selection process for a contractor, assuming other prerequisites like bonding capacity, experience with the type etc.

After the general contractor is selected and during the Construction Phase, the designers and other members of the team must remain fully involved. Decisions previously made may require clarification; suppliers' information must be reviewed for compliance with the Contract Documents; and substitutions must be evaluated.

Specialized Consultants should be involved as needed by the special requirements of the project. These may include specifications writers, materials and component specialists, sustainability consultants, and technical specialists in lighting and parking etc. Like all contributors to the integrated design process, they should be involved early enough to include their suggestions and requirements in the design, not so late that their contributions must be remedial (WBDG, 2009).

The process of Integrated building design can now be further aided by specialized softwares. Building Design Advisor softwares (BDA) act as a data manager and process controller. It allows building designers to benefit from the capabilities of multiple analysis and simulation of **Daylighting Computation Module** (DCM), a simplified **Electric lighting Computation Module** (ECM) etc. through visualization tools throughout the building design process. Municipalities, NGOs and MNCs should take up active interest by assisting in training them to inculcate these principles in their work culture. "Effectively, a new trade has been created in the construction industry," said Keehn, MD, EMS (2007). "Projects will now need green building consultants, at least until the practices become more integrated into the design and build techniques of the more traditional consultants. And even then, third party certification will be necessary, which requires knowledge, time and coordination", he mentions. As Horsley, Andrew et al (2003) demonstrates, 'The Energy Toolkit process (i.e. using green principles in the form of a computer oriented building information systems) uses current proven industry techniques in a unique new framework, delivering decision support data to those key influential stages of the design process where there is currently a shortage of project-specific guidance. The ultimate goal that the Energy Toolkit and other approaches must contribute to, is the evolution of a new principal design driver, focusing on long-term value rather than short-term capital-dominated costs – a potential win–win–win scenario for building owners, users and the environment.' This suggests that, environmental consultancy shall soon be a booming profession.

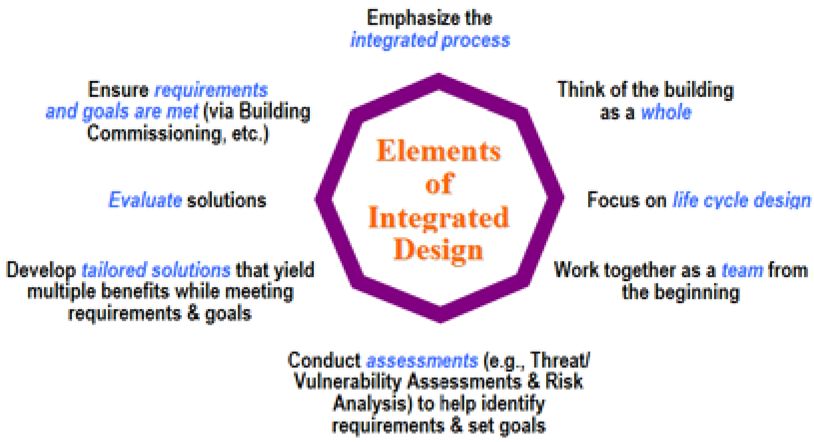


Figure 33. Elements of Integrated Design

The above figure and the summary below describes the standard operation of the integrated project team. An IDP depends on:

1. Clear and continuous communication
2. Rigorous attention to detail
3. Active collaboration among all team members

Adherence to these principles will assure the best result. An integrated process, or "whole building" design process, includes the active and continued participation of all stakeholders in the building. The best buildings in history are the result of high degrees of consistency at all levels of their realization. They result from active, consistent, and organised collaboration among all players. Good buildings result from an appreciation by all involved of the importance of formal consistency throughout the design. Every successful mission, in any field of work, relates to the consistent sincere commitment of all members of a team towards an integrated goal. The same holds true for our buildings.

6.2.3 Recommendations for further research

This study covers a very small segment of the green building industry setting up base in the UAE. A quantitative analysis with statistics of the amount of resource sustained for prolonged usage, energy savings in carbon emissions and cost benefits realized in comparison to a conventional project must be taken up. Various contractual and execution issues came about at various junctures of the research. Accordingly other topics which are an extension of this study and of interest are listed below.

- Critical success and failure factors in green design.
- Execution and supervision of green building
- Specification writing for green building components
- Integrated Design Process in practice in the UAE.
- Green design knowledge retention for a project
- Cost implications or benefits of green design through quantitative research.
- Green design in the UAE from contractor's point of view
- Supply chain management for sustainable building components
- Setting up of a green component supply chain in UAE
- Renewable energy in UAE

6.3 Limitations of the research

Due to the vast extent of the topic of green buildings, there are many more subjects that need to be researched to understand the impact of sustainability in the UAE. Only the design aspects have been looked at in this research, which is a very crucial but a small aspect of the overall construction process. Construction execution perspectives, end user responses and contractor views are not considered in this study. The paper is also limited to a qualitative research due to the absence of the lack of statistics, facts and figures as this area of work is relatively new to the region. Also the study covers the region of Dubai alone, due to the regulatory impact that may be too many for the whole of UAE and too extensive to cover in the time and content constraints that the dissertation stipulates; though design guidelines should suit the entire region.

The case studies do not cover all areas that have been looked at in the research document review. This in some cases is due to the confidentiality expected and in some cases due to the lack of information. The recent downfall of the market has further complicated the information gathering process as consultants; clients as well as regulatory authorities are now tight lipped about forthcoming schemes. Due to the complex nature of the current market in recession, information about forthcoming projects is highly confidential and there is lack of communication and reliable market information due to the calling off of the undecided fate of various envisaged green projects in the UAE. Hence the case studies have been restricted to two carried out in relevant detail. As the market for sustainability evolves, further areas of green building investigations shall open up and a more far reaching research needs to be conducted.

6.4 Conclusion

Energy conservation in the UAE can no longer be seen as a luxury or a choice. The adoption of sustainable development is a national duty, which should be adhered to by institutions and individuals alike.

Sustainability does not require a loss in the quality of life, but does require a change in mind-set, a change in values toward less consumptive lifestyles. Sustainable design must use an alternative approach to traditional design that incorporates these changes in mind-set. The new design approach must recognize the impacts of every design choice on the natural and cultural resources of the local, regional, and global environments. Like nature, design should not be static but always evolving and adapting to interact more intimately with its surroundings. These design principles should be considered more than just a random collection of environmentally friendly technologies. They require careful, systemic attention to the full life cycle impacts of the resources embodied in the building and to the resource consumption and pollution emissions over the building's complete life cycle. Sustainable site design reinforces the holistic character of a landscape. It conveys appreciation of and respect for the interrelationships of a site, illuminating the interconnection of all parts through responsive design integrated with interpretive and cultural objects. International rating systems like LEED are based on accepted energy and environmental principles and strike a balance between known established practices and emerging concepts. Hence using them to initiate the green journey, is a primary step. The technologies available today are not being used anywhere near their potential. Sustainable outcomes are readily available. The value proposition of using the available technologies will no longer meet the resistance that has previously occurred (Oehme, 2008), as the market now understands the pressing need for sustainable solutions. Increasing concerns with health and safety, the environment and the need for sustainable development have resulted in higher standards being expected by clients and required by law.

As advocated by the principles adopted by the World Congress of the International Union of Architects (UIA) in June 1993 at the American Institute of Architect's (AIA) Expo 93 in Chicago; the elements of human design should interact with and depend on the natural world. Design considerations should recognize even distant effects by understanding the limitations of design. No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not an inconvenience to be evaded or controlled.(UIA, 1993)

Projects need to be regarded under increasing scrutiny and market awareness. Studies advocate systematic planning and frequent evaluations of sustainability of the schemes to ensure control. Seek constant improvements by sharing knowledge. Encourage direct and open communication between colleagues, patrons, manufacturers, and users to link long-term sustainable considerations with ethical responsibility, and reestablish the integral relationship between natural processes and human activity. Emphasize the importance of biodiversity, and encourage responsible decisions. Assist planning with computer aided technology. Lastly always align project plans with the overall environmental goals and sustainability objectives in view.

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APPENDIX

A. List of websites in UAE for green design.

- http://www.environment.dm.ae
- http://www.thermal.dm.ae/ - Building Services and Energy Saving
- http://www.dm.gov.ae/DMEGOV/pcrecycle/pr-home.html - PC recycle
- www.emiratesgbc.org - Emirates Green building council
- http://www.moew.gov.ae/En/pages/default.aspx - Ministry of Environment and Water (UAE)
- http://www.ead.ae/en/ - Environment Agency - Abu Dhabi
- http://www.irenauae.com/en/home/index.aspx - IRENA
- http://www.panda.org/who_we_are/wwf_offices/united_arab_emirates/ - Emirates Wildlife Society
- http://www.un.org/esa/dsd/csd/csd_csd15_ipm.shtml- U.N. Commission on Sustainable Development
- https://portal.dm.gov.ae/AirQuality/AirQualityControllerPublic.action?COMMAND=Main&Language=Arabic - Air Quality Monitoring
- Further information on the Sharekni Scheme may be found at http://www.sharekni.ae/.

B. Common pollutants found in the UAE

- Particulate Matter (PM_{10}): PM_{10}, also referred to as particulates or fine matter, are small particles of solid or liquid suspended in a gas (air). Sources of particulates can be natural or man made. In arid desert regions, such as the UAE, the PM_{10} concentrations are typically higher due to inputs from natural sources. Ambient levels of PM_{10} are also typically higher during the summer months due to more unsettled weather conditions and higher air temperatures. There are also a number of anthropogenic sources of PM_{10} including vehicle traffic and construction and demolition.

- Nitrous Oxide (NO): This term is used to describe a binary compound of nitrogen and oxygen (see also NOX below) which oxidises to form NO_2. The most important sources of NO (and as such NO_2) are internal combustion engines (mainly from vehicles), thermal power stations, pulp mills etc. NO_2 is therefore a clear indicator for road traffic emissions. Health risks from nitrogen oxides (mainly respiratory) are well documented.

- Sulphur Dioxide (SO_2): Historically, sulphur dioxide (SO_2) and particulate matter derived from the combustion of fossil fuels have been the main components of air pollution in many parts of the world. Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources. SO_2 can also affect the respiratory system and the functions of the lungs, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract.

C. Construction air quality management study and key elements

- Develop and implement an Indoor Air Quality (IAQ) Management Plan for the construction and pre-occupancy phases of the building.
- Adopt an IAQ management plan to protect the HVAC system during construction, control pollutant sources and interrupt contamination pathways. Avoid using permanently installed air handlers for temporary heating/cooling during construction.
- Sequence the installation of materials to avoid contamination of absorptive materials such as insulation, carpeting, ceiling tile and gypsum wallboard. As these materials, especially insulation are used in large quantities in the UAE construction industry. It is therefore important to minimise their environmental impact throughout their life cycle.
- Depressurize construction work area allowing the air pressure differential between construction and clean areas to contain dust and odour.
- Prior to occupancy, perform a building flush-out or test the air contaminant levels in the building. The flush-out is often used where occupancy is not required immediately upon substantial completion of construction.
- Develop and implement an Indoor Air Quality (IAQ) Management Plan for the pre-occupancy phase. Before switching the HVAC system to the normal operational mode flush out a total of 14000cuft of outside air.
- Track the VOC content of all interior paints and coatings, adhesives and sealants during construction.

D. Interview Questions:

1. An explanation of the general scheme designed.
2. The importance of sustainability to this project
3. Was sustainability considered at the design stage? If yes how?
4. A discussion to collect Answers to the check list prepared
5. Explanation a few design elements incorporated
6. The use of regulations and Difficulties with authorities.
7. Drawbacks of the scheme with relevance to environmental concern.
8. Issues associated with designing green
9. The primary barriers to the increased use of sustainable building practices in their professions

E. List of interviewees:

- WSP engineer working in DM regulations.
- Senior landscape Architect at HOK
- DM architectural engineer: Mr. Ammar Mahmood Al Fakhry; Senior Architect, Building department, Major Projects.
- Project Architect for Beach Resort
- Project Manager for Shopping Mall, Mr Martin Adams.
- LEED Facilitator, EM Systems, Nicole Hillis.
- Cladding Engineer for Shopping Mall.

F. LEED data

1.1.1 Brownfield Sites

Brownfield sites means property, which may be complicated by the potential presence of hazardous substance, pollutant or contaminant.

Remediation efforts remove hazardous material from Brownfield site's soil and groundwater. Brownfields can offer attractive locations and are rather inexpensive properties. They often have existing infrastructure improvements in place including utilities and roads reducing the need for further environmental impacts due to construction of new infrastructure.

i. Design Guidelines:

- Co-ordinate site development plans with remediation activities. Utilize remediation experts to develop a master plan for site remediation. Remediation efforts on Brownfield sites are sometimes costly and time intensive. Several remediation strategies should be considered in order to identify the strategy with the greatest benefit and the lowest cost to property owner.

- Accordingly time and cost should be allocated for the appropriate technology, e.g. Traditional remediation, in-situ or Ex- Situ remediation.

G. Material information :

Cool Roofs:

SRI of a product can be determined at *The Lawrence Berkeley National Laboratory* and can be accessed online at: http://coolcolors.lbl.gov/assets/docs/SRI%20Calculator/SRI-calc10.xls

Roofing product information can also be found in the Cool Roof Rating Council website, at www.coolroofs.org

H. Microclimate creation of shopping mall:

Below are spaces identified along with the modifications incorporated for enhancing the microclimate.

Sabkha terrace:

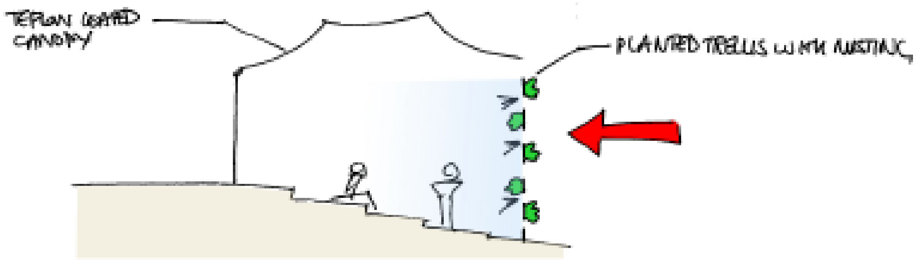
Plan of Sabkha Terrace

Features used:

1. Shaded with Teflon coated canopy
2. Misting
3. Wind shield
4. Planting

This area is shaded by a Teflon coated canopy, which prevents high surface temperatures developing. The structure protects occupants from direct sun. In order to prevent reflected radiation entering the space, surrounding surfaces are highly planted and non reflective.

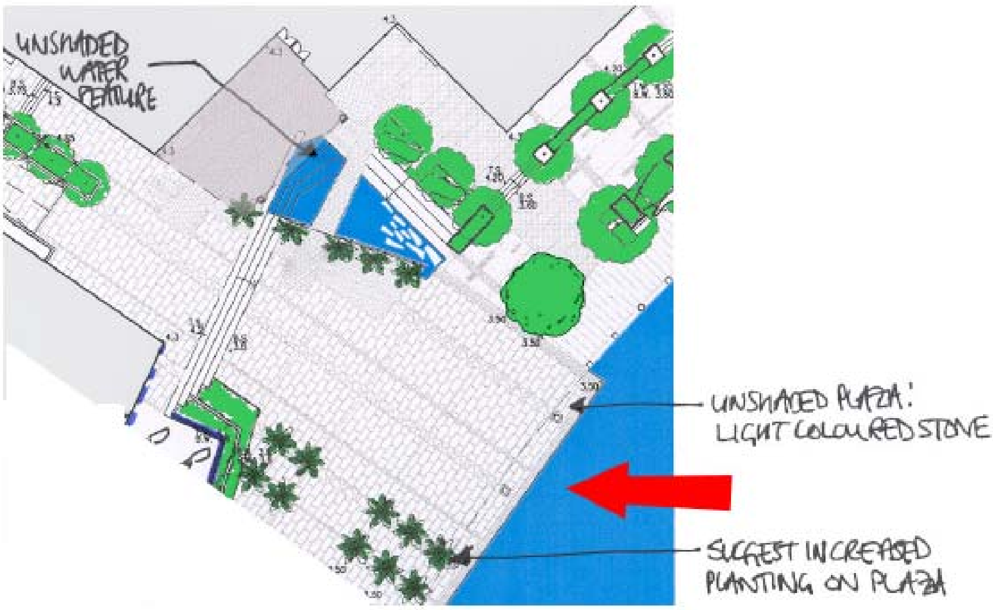
The wind patterns in this area are largely dependent on the hotel development to the north. There is an increased volume of warm southerly winds during the worst microclimate conditions. In order to protect the space from uncomfortable wind conditions, planted trellises are used as wind breaks.



Sabkha Terrace Section

Misting in the trellises humidifies and cool the dry, hot winds. Misting is only used in the daytime when humidity is low. The trellis dimensions are taken to be 20 x 2m, which represents a requirement of 0.16 l/s of water. This equates to 7 nozzles per metre of trellis that is misted. Misting the whole trellis requires 140 nozzles, which on continuous usage is high water expenditure.

North Quayside Plaza:



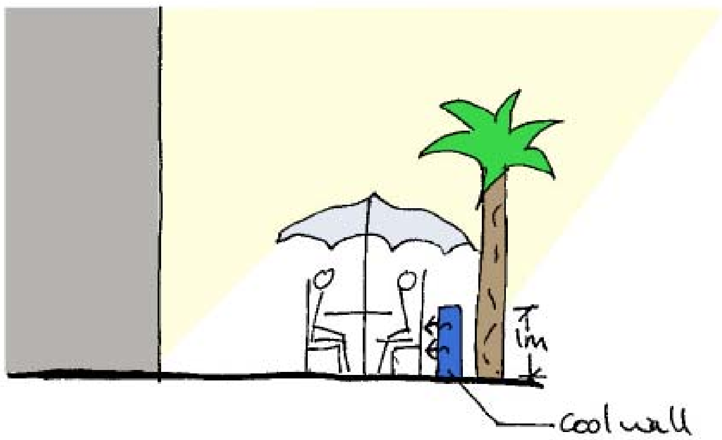
North Quayside Plaza Plan

This area is an open external space, so the air temperature cannot be significantly modified. Some areas are shaded from direct sunlight by buildings above or trees, which will reduce the resultant temperature. This helps to diffuse radiation in shaded areas. Light paving materials used in unshaded regions helps lower the heat content of the region, preventing localized heat islands.

Water Front promenade:

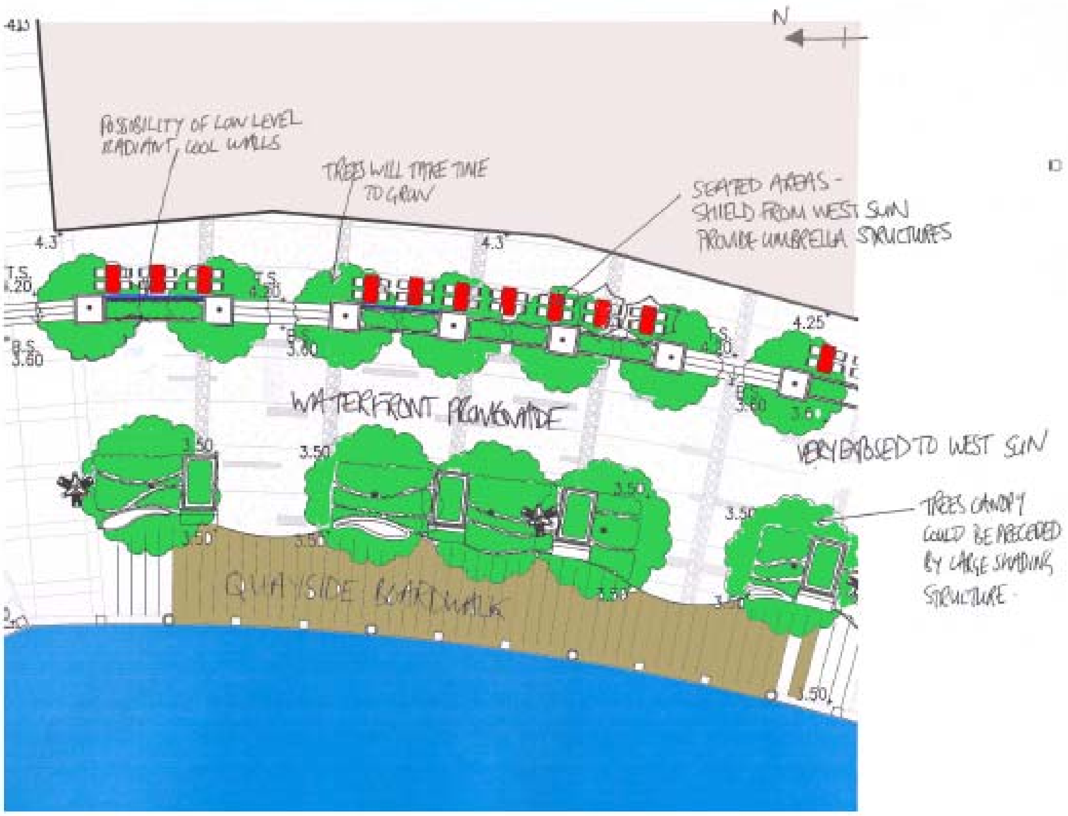
This area is very exposed to the afternoon sun. This area is well planted, however temporary shading has been provided in the while that the trees grow. Canopies cannot be used along the promenade, as it is an emergency vehicle route, so large umbrella structures are placed for seated areas in this location. If the seated areas are to be comfortable in the afternoon, it will be necessary to shield them from the west sun.

Cool walls are used adjacent to the seating areas. The open nature of the space reduces the effectiveness at a distance, but they improve local conditions.



Promenade Section

High levels of planting used reduces surface temperatures and offer shading. Non-reflective and planted surfaces prevent heat reflecting into shaded areas.



Typical Promenade/ Boardwalk Plan

Central Quayside:

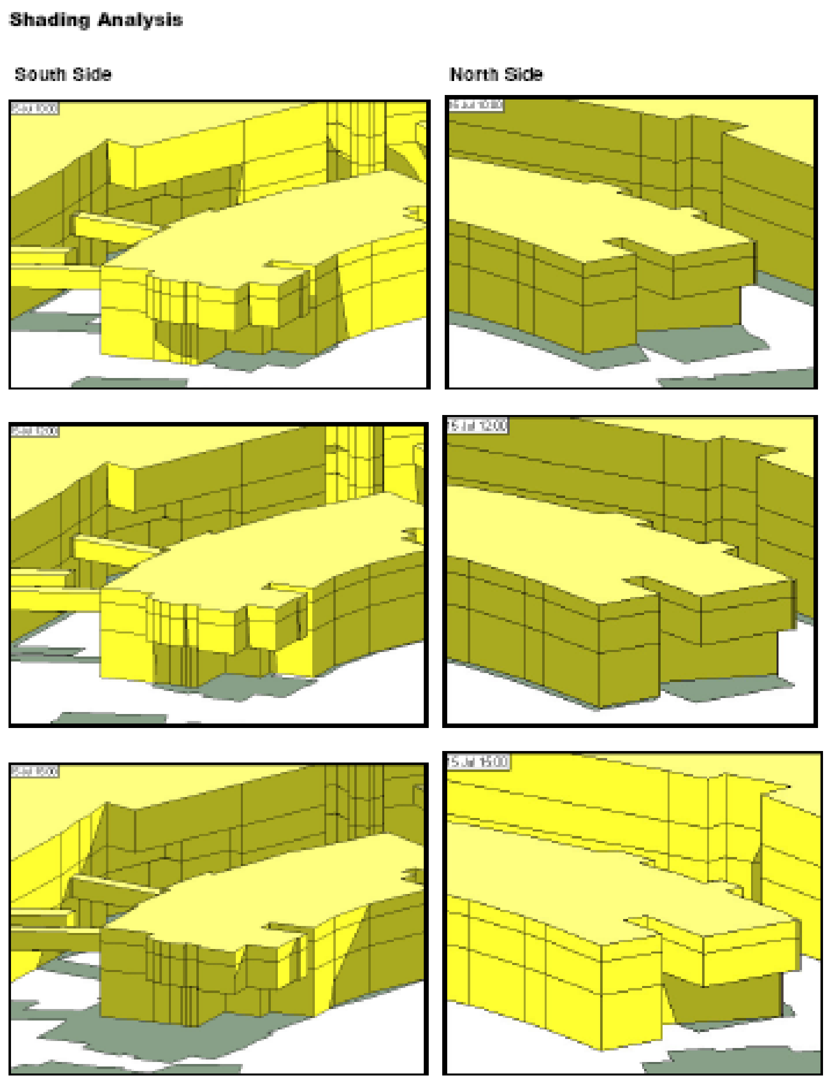
Features used:

- Shaded in some areas
- Sprays
- Planting
- Topiary misters/cool towers

Central Quayside Plan

These open areas are not intended for seating as they are exposed to the sun and wind. This is a busy junction as it opens up views into the creek and experiences heavy foot fall and transient traffic. The sprays used offer cooling. Topiary misting devices (movable) are used as mini-cool towers to provide local evaporative cooling in seating areas. Each topiary mister will require a maximum of 0.007 l/s of condensate, and 10-15 devices are assumed.

Some areas are shaded from above by building overhangs. The north side of the quayside overhead shading is effective in the mornings, and reduces throughout the afternoon. The south side overhead building shading is fully effective from midday onwards. This is realized from the shading analysis, illustrated below. The seating areas are provided with some additional local shading, e.g. umbrellas, to be comfortable throughout the day. Ceiling fans improve air movement on still or humid evenings.

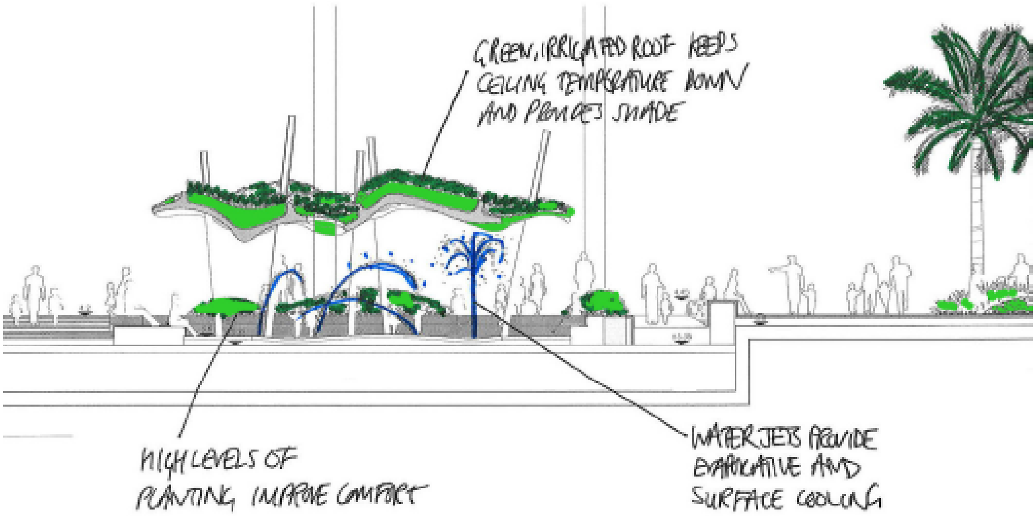


Children’s Water Play Area:

- Shading (green roof)
- Water sprays
- Planting

Water provides an additional comfort cooling effect to the air in the form of water sprays. An irrigated green roof is incorporated which has resulted in a floor surface temperature being close to wet bulb temperature, reducing the resultant temperature.

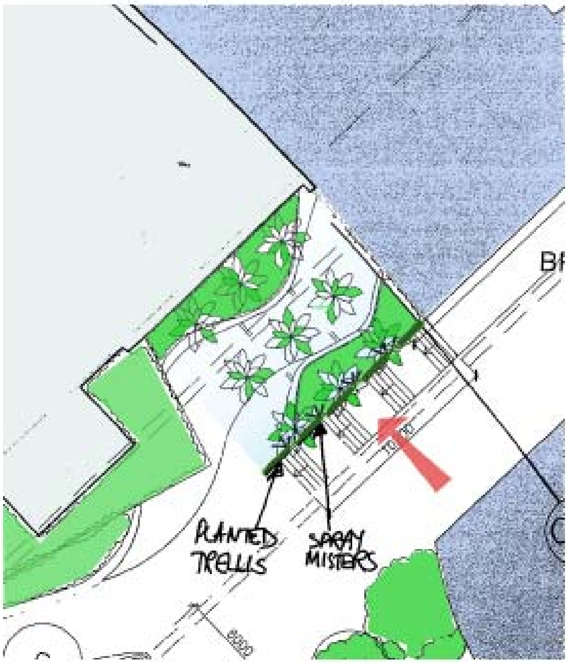
Children's Water Play Area Plan



Children's Water Play Area Section

The utilistaion of green canopy cover along with water bodies calls for regular careful maintenance of the space.

Extreme south Canal side area:



Extreme South Canalside Plan

- Shading (Teflon coated canopy/trees)
- Wind shields
- Misting
- Planting

To encourage use of this area, a temporary shade structure, which will later be covered by tree canopy is used to protect the space from direct sunlight. The area is exposed to warm southerly winds. A planted trellis with spray misters has been incorporated to cool and humidify this air while providing a degree of wind protection. A trellis area of 15 x 2m, requiring 0.13 l/s of condensate, 7 No. nozzles per metre of trellis, equating to 105 No. nozzles for the whole trellis to be misted is utilised. In order to prevent heat being reflected into the space, surrounding exposed surfaces are planted. Along with humidifying the place, solar radiation is effectively diffused.

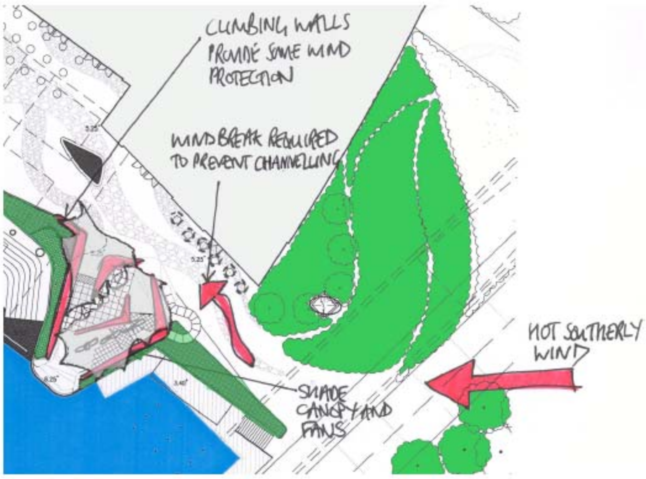
Climbing Wall area:

Features used:

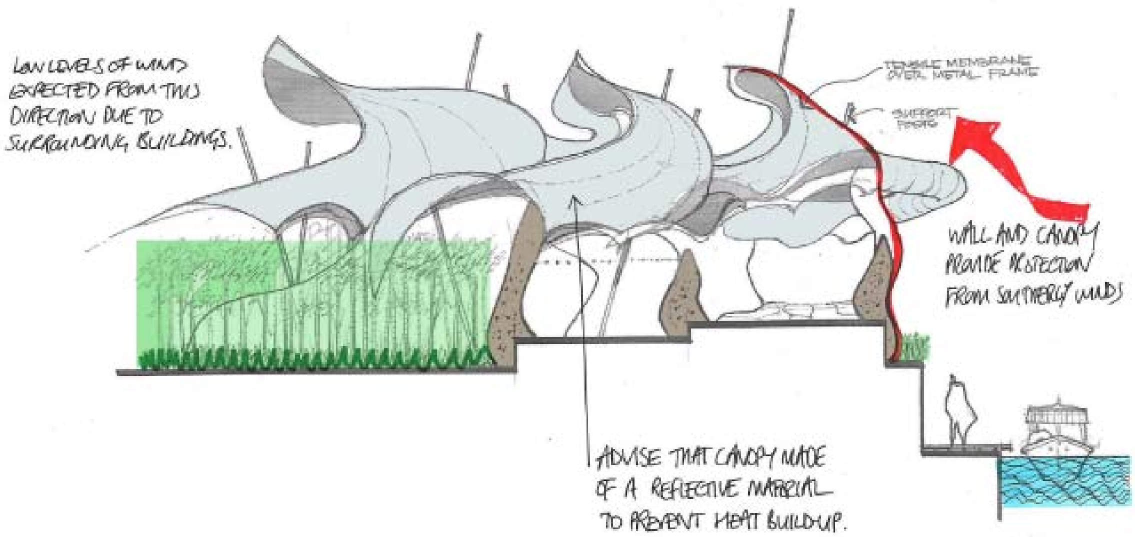
- Shading (Teflon coated canopy)

- Air movement encouraged by ceiling fans
- Wind protection

The climbing wall area promotes fun activities including rock climbing sessions promoting physical activity. No water is used in the microclimate strategy for safety reasons. The climbing walls itself and additional planting are used for wind protection. To prevent heat build up, Teflon coated glass reinforced plastic is used for the shade structure as this keeps the surface temperatures significantly lower than other materials.



Climbing Wall Area Large Area Plan



Climbing wall section

Comfort in this area is improved by increasing air movement. Lightweight fans are suspended from the canopy frame. To encourage air exchange, the fans are situated below holes in the canopy. Increasing air movement by the fans improves comfort by reducing the effective temperature. The ceiling fans produce air speeds of 2m/s. This air speed significantly reduces the heat sensation.

A windbreak is designed to prevent channeling in the area shown in the plan below. This is achieved by dense planting to a sufficient height to deflect the wind from this location.

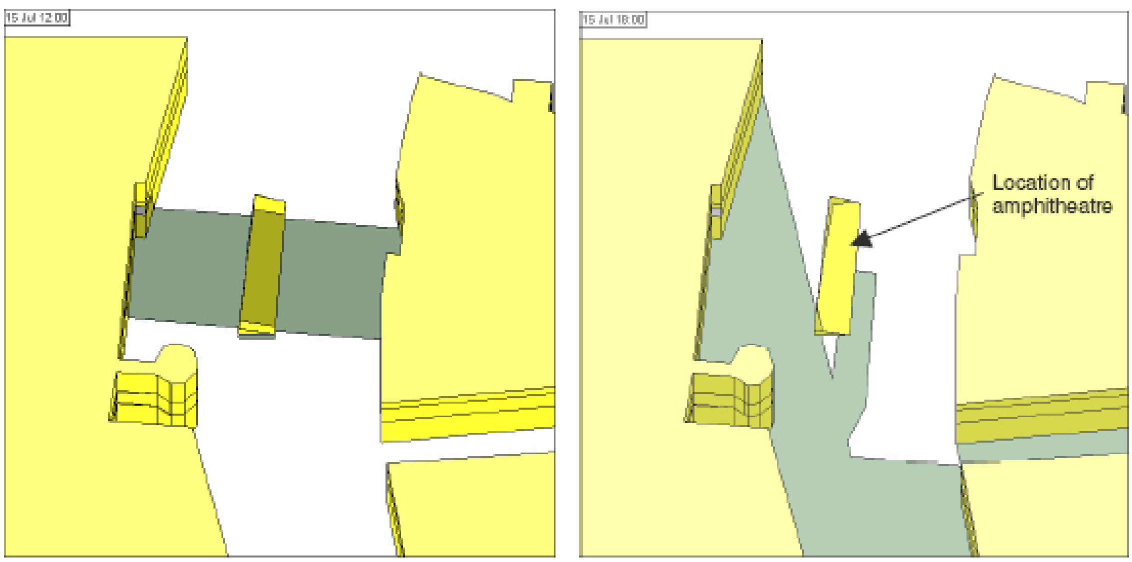
Children's amphitheatre:

Features used:

- Shaded by structures above
- Cool air supply
- Planting

Shading is provided overhead by a high level bridge. The shading analysis shows that, this is effective when the sun is overhead, but does not protect from lower angle sun. Additional shading was required, which has been suspended from the underside of the bridge.

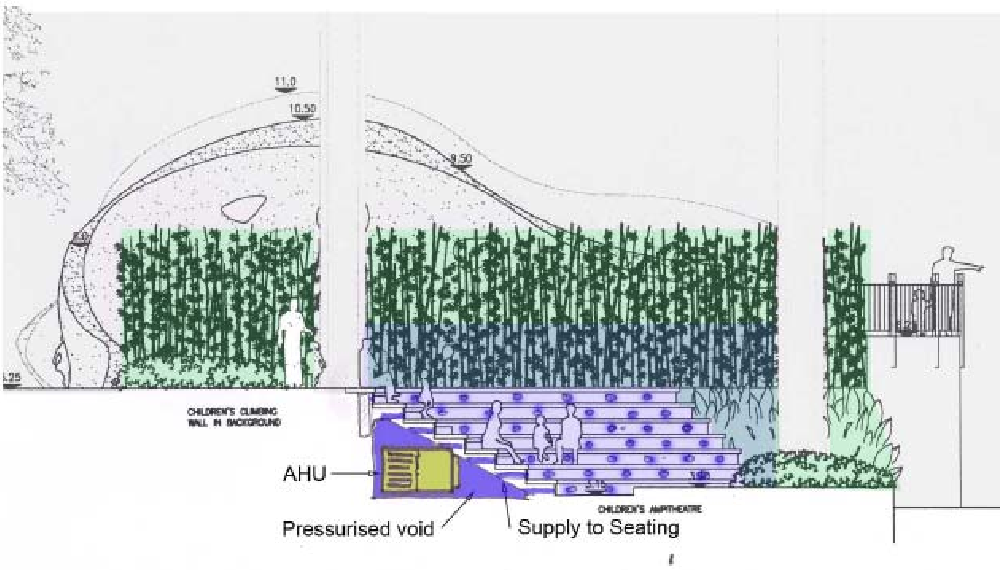
Shading Study



The bridge has been removed from the illustration to show the shading on the amphitheatre more clearly.

High levels of planting prevent solar radiation reflecting into space and improve comfort conditions. The void beneath the seating was used to duct air under the seats with a dedicated Air handling unit to provide cool air to this region. The air will be discharged at 0.6 – 1m intervals along the length of the seat to provide local cooling. 6 m^3/s of air required.

Amphitheatre Plan



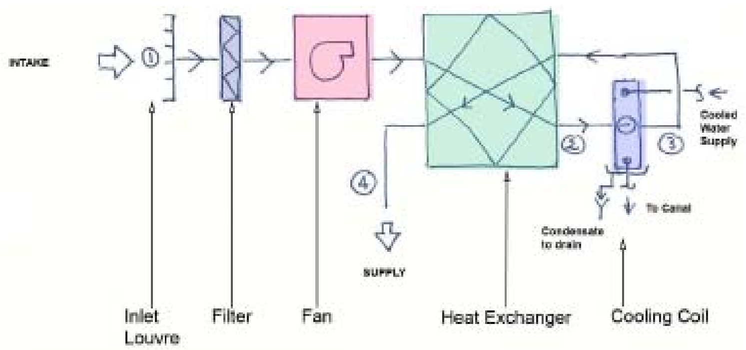
Amphitheatre section

Air Handling Units at Amphitheatres: Air handling units are installed at the amphitheatre spaces designed for children interaction and activities. This uses collected condensate water from the mall for operations.

Each AHU will have the following characteristics:

- 3 m^3/s supply flowrate, approx. 50 Pa External Pressure
- Filter
- Supply Fan
- Plate to plate heat exchanger, 60% efficiency
- Cooling coil, 165 kW, 7.8 l/s cool water (12°C / 17°C on/off, open system with discharge to canal)

See the diagram for system operation.

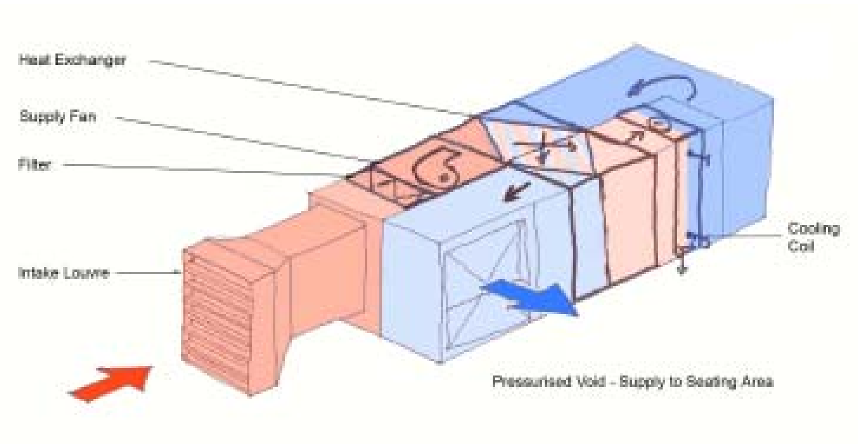


Amphitheatre Air Handling Units

2 "all air" air handling units are proposed, each at 3 m^3/s, to supply the amphitheatre with cooled air. External air will be drawn into the air handling units located in the void beneath the seating area. 2 intake louvres are provided at 1.2 m^2 free area each.

As the spaces are external, fine filtration is not required. A coarse filter (mainly dust and sand) for protection of the fans are provided.

The following schematic shows the main components, which are essentially a filter, a centrifugal fan, a plate-to-plate heat exchanger, and a cooling coil (supplied with condensate water from main building air conditioning plant)



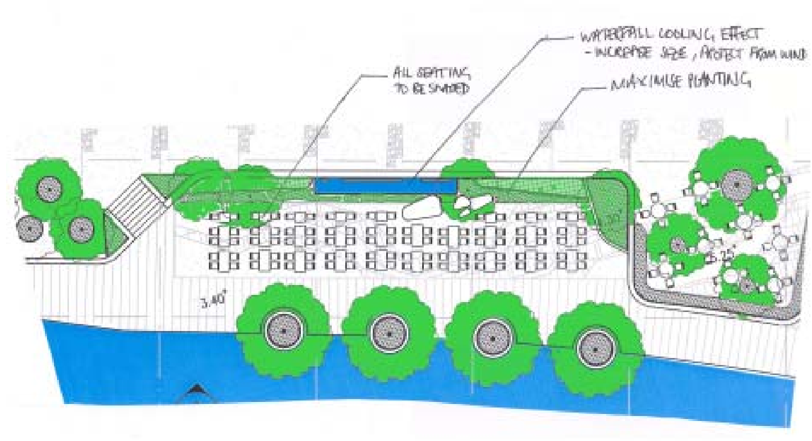
The heat exchanger has been included to ensure the air is re-heated on its way out by the incoming external air: as the air is cooled by the coil (mean temperature assumed to be 14°C), it's relative humidity will be close to saturation, and will therefore require an amount of re-heat to ensure a more comfortable supply condition.

Each cooling coil requires a maximum of 7.8 l/s of chilled water, assuming a 5° temperature drop. Drainage is provided for condensate off the coil.

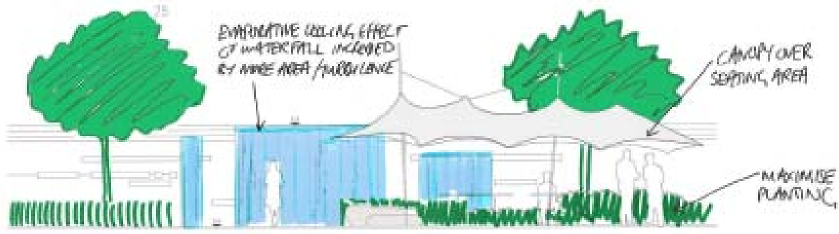
South Canal Leasable Dining Area:

- Waterfall
- Some shading
- Planting

The area is enclosed by walls and trees. The waterfall offers a cooling effect as it is effectively protected from the wind. Waterfall provides 3°C of cooling. Planting in this area also contributes to a cooler environment. The shading in this area is provided by tent-like structures which covers all seated areas. In some parts it is supplemented by large umbrellas.



South Canal Leasable Dining Area Plan

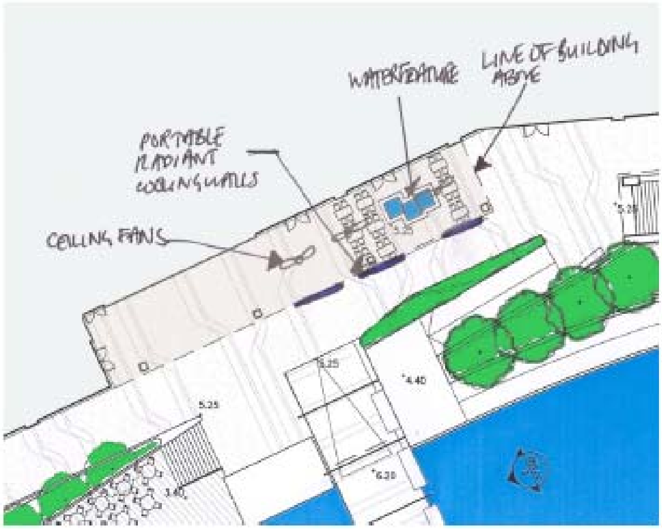


South Canal Leasable Dining Area Section

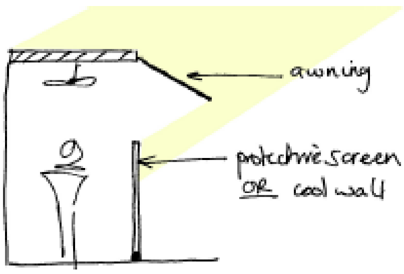
Central Dining Area:

- Shaded by building above
- Additional awning
- Portable cooling walls
- Ceiling fans

This area is exposed to the southwest afternoon sun. Sun protection is provided, in the form of drop down shades or temporary screens which are used only when required. Alternatively, provisions are made for an awning at high level, combined with portable cooling walls to provide adequate shading. Planting on adjacent external surfaces prevent heat from being reflected into the space and improves comfort.



Central Dining Area Plan



North Canal terrace:

- Shading from structures above and trees
- Additional shading – drop down screening and planting
- Portable cooling walls
    - A) Discharge air or misting
    - B) Ceiling fans
- Planting

Plan of North Canal Terrace

Area A has high levels of planting and is well shaded when the sun is overhead. Additional shading will be required to protect from low west sun. This is in the form of large tiltable umbrellas. The air temperature cannot be changed significantly in such an exposed location. Portable cooling walls offer localized radiant cooling – dense planting and screens maximise the effect of cooling walls by offering wind protection.

Area B is shaded from above, but requires additional protection from the southwest sun. This is the form of dense planting and drop down screens which are only used in the late afternoons. Discharge air from the adjacent building and misters are used to reduce the air temperature. Misting this area would require 0.019 l/s of condensate, misted by 17 No. nozzles. The area is partly enclosed by planting. Ceiling fans improve comfort in the evenings

I. List of abbreviations used in the report.

ADWRS:	Abu Dhabi Water Resources Statistics
AEC:	Architectural Energy Corporation
AFFL:	After Floor Finish Level
AHU:	Air Handling Unit
AIA:	American Institute of Architects
AP :	Accredited Professional
ASHRAE:	American Society of Heating, Refrigeration and Air-conditioning Engineers
BREAM:	BRE Environmental Assessment Method
BMS:	Building Management Systems.
CCA :	Copper Chrome Arsenate
CED:	Civil Engineering Department
CEMP:	Construction Environmental Management plan
CFC:	Chloro-Flouro-Carbon
CIBSE:	Charted Institute of Building Service Engineers.
CWCT:	Centre for Windows and Cladding Technology
CWA:	Central Waste Area
DCM:	Daylighting Computation Module
DEWA:	Dubai Electricity and Water Authority
DP :	Dubai Ports Authority
DS:	Document Submittal
(DM)	Dubai Municipality
EA.C 1:	LEED Energy and Atmosphere Credit(Number)
ECM:	Electric lighting Computation Module

EHS:	Environmental health and safety
EIA:	Environmental Impact Assessment
ESC:	Erosion, Sedimentation and Dust Control
ETS :	Environmental Tobacco Smoke
ETG:	Environmental Technical Guideline
EPS:	Environment protection & safety
EQ.C 1:	LEED Environmental Quality Credit(Number)
FAR:	Floor Area Ratio
FSC :	Forest Stewardship Council's
GGBC:	Godrej Green Business Centre
HCFC:	Hydro Chloro-Fluoro-Carbons.
HVAC &R:	Heating Ventilation, Air-conditioning & refrigeration.
IAQ :	Indoor Air Quality
ICED:	Inter professional Council on Environmental Design
IDP :	Integrated Design process
IESNA:	Illuminating Engineering Society of North America
IRENA:	International Renewable Energy Agency
ISO:	International Organization for Standardization
ITP:	A Middle East Leading Magazine Publishing company
JAFZA :	Jebel Ali free zone
LEED	Leadership in energy and environmental design
MEED:	Middle East Economic Digest
MEP :	Mechanical, Electrical, Plumbing
MNC:	Multi National Companies

MR.C 1:	LEED Materials and Resources Credit(Number)
M&V :	Measurement & Verification
NGO:	Non- Governmental Organisations
NO :	Nitrous Oxides
NFPA:	National Fire Protection Association
ONS :	Office for National Statistics
PDC:	Palm District Cooling
PTFE:	Polytetrafluoroethylene
PVC Fabric:	Polyvinyl chloride
PVC:	Photo Voltaic Cells
RTA :	Road Transport Authority
SO:	Sulphur Oxides
SRI:	Solar Reflective Index
SHGC :	Solar Heat Gain Coefficient
SUDS:	Sustainable Drainage Systems
S.S. C 1 :	LEED Sustainable Sites Credit(Number)
TSE:	Treated Sewage Effluent
TR:	Tones of refrigeration
UAE:	United Arab Emirates
UIA:	Union of Architects
UN:	United Nations
USGBC:	United States Green Building Council
UV:	Ultra Violet sun rays
VOC:	Volatile Organic Component

WE.C 1: LEED Water Efficiency Credit(Number)

WMS: Waste Management Strategy

WWF: World Wildlife Fund

WSD: World business council for sustainable development

WSP: A design, engineering and management consultancy