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ARCHITECTURE

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## GREEN ARCHITECTURE EVOLUTION AND CONTEMPORARY TECHNOLOGIES AT UAE

*The United Arab Emirates (UAE) is facing a significant increase in the number of high rise buildings that are associated with the industrial revolution in the region. These buildings mostly consist of facades made of glass, leaving the thermal comfort function to the artificial technologies which require massive power and energy to operate due to the hot and humid characteristics of the area.*

*To accommodate the diversity of the environmental conditions in the different climate zones, architects need to consider a number of factors other than the creativity of their design to include the comfort of individuals, the power and energy consumption, in addition to the environmental impacts associated with the design. Furthermore, Thermal Comfort is considered one of the challenging aspects that require a special attention during the design phase of any project.*

**Keywords:** *Mashrabiya, solar glare, solar gain, cooling system, dynamic shading system*

### **Energy-Saving Technological Standards in principles of Green Architecture Design:**

The energy consumption in buildings are affected by a variety of factors which need to be studied carefully when choosing the right technology to implement for sustainability saving energy and to apply the principles of green architecture. These factors include:

*The Design Process:* Represented by the overall Architecture Principles & elements design, such as: the orientation of the building, the design of external building envelope & openings, the finishing materials, in addition to the operational hours and the purpose and activities of the building.

*Prevailing Climate:* The climate factors of the area (Temperature, Wind, Humidity, Solar Radiations ...) and its effects on the required of air conditioning energy.

*Topographic Situation:* The location of the facility with respect to height from sea level and nature topographic of the land which can be associated with certain environmental conditions.

*Surrounding Environmental Conditions:* Include the surrounding buildings, neighborhood, streets, occupancies and exposure to sun radiation.

The evolution and the contemporary technology systems in the field of Green Architecture have provided architects around the world with a variety of options that can impact and affect the sustainability of the design. In UAE the Hot & Hot Humidity zones is facing a significant increase in building activities, which require a lot of energy & power, in Emirate Of Dubai the power consumption has been increased more than three times last 12 years between 2000 to 2012 (fig.1). Many researches find that energy conversation in principles of Green Architecture Design can be achieved by the following main Strategies and Technological Systems:

### **A- Cooling Energy-Saving Technologies:**

Several studies point out that cooling system is the largest sector consuming energy in buildings. In General the cooling system consumes (65...68%) of total consumption of electrical power in the building (fig. 2). Therefore, monitoring and controlling the cooling system and reducing the needs of the buildings for cooling operations is the most important and essential element in reducing energy consumption.

Energy saving technologies are trending for their undeniable benefits for both the environment and for cost saving. The implementation of these technologies is most efficient if taken into account during the design phase of the project, design-adjustments to accommodate for the utilization of these technologies to ideally achieve a cost-efficient and environmentally friendly design. The diversity of the available cooling and ventilation systems has provided architects with options that suit the purpose and the requirements of their design. The term Air Conditioning system is used to describe the science of applying engineering aspects and technologies to control the internal environment by providing cool, dry and clean air despite the external environmental conditions, thus HVAC systems are used for controlling temperature, humidity, airflow and quality of air in buildings.

The practical applications strategies in energy-saving technologies can achieve with the association of the following considerations:

- *insulating thermal materials for external envelope (outer walls and roofs).*
- *using double skin façade systems in high rise building to reduce the solar gain and solar glair.*
- *the Natural Ventilation and protecting the openings from the direct sun radiation.*
- *thermal controlling system to provide the sufficient cooling*

**B- Illumination and Lighting Energy-Saving Technologies:**

Artificial lighting is the second largest sector consuming energy in buildings. Artificial lighting consumes 15...20% of electrical power consumption (fig.2).

Providing the required quantity of illumination in the different areas of a building is quite challenging, especially if associated with cost considerations.

Designing the artificial lighting control system requires the study of:

- The availability of natural lighting and its utilization.
- The use of photochromic panels as renewable energy.
- The control options sensors including the use of computers and smart phones for adjusting the lighting as needed.

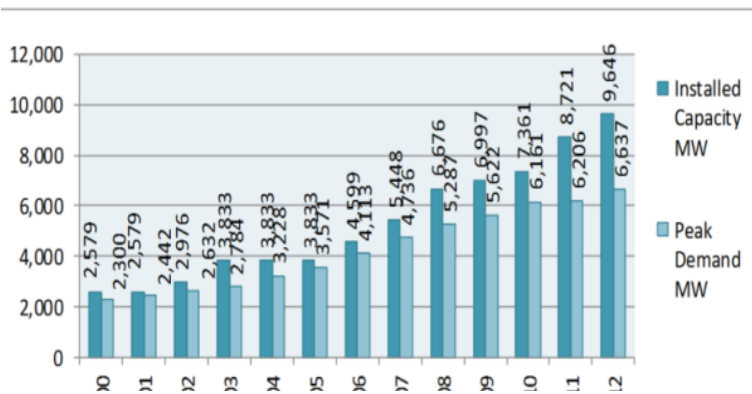


Fig. 1. Electrical Consumption in Dubai – UAE [1]

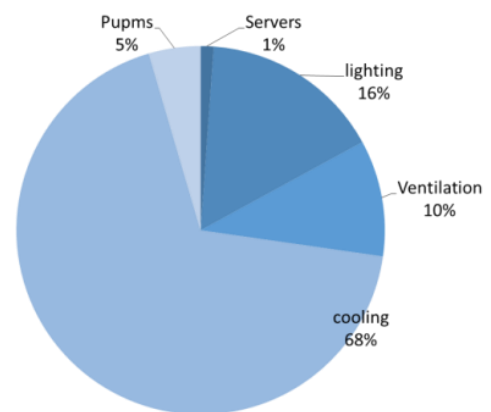


Fig. 2. Electrical Load Distribution for High Raised Offices Building - UAE

**C- Smart Building Systems**

There is no doubt that with the current revolution in technologies, being able to live in an intelligent smart building is considered a luxury. Nowadays, these intelligent buildings are receiving a significant attention from individuals due to the privileges they provide for their residents. These buildings are

environmentally friendly, cost efficient, maintainable, and accommodate with the individuals' needs and requirements to achieve the highest possible levels of comfort. Moreover, the equipment and devices implemented in these buildings are adjustable and automatable, providing the residents with a full control of the environment they're living in. Smart systems can be classified into the following categories with respect to their purpose and functions:

1) Energy consumption and natural resources rationalization systems, 2) Security, protection and safety systems, 3) Household appliances control systems, 4) Maintenance and development automated systems, and 5) Convenience and entertainment systems.

The benefits of Smart Technological System in buildings is contributing to reduce of the power cost and energy consumption, increasing productivity, enhancing communication, providing safe, secure and healthy place for individuals, in addition to providing areas for improvements and future enhancements and increasing the demand from individuals to switch to smart-buildings.

#### **D- Climate Integration Systems**

Climate integration systems enable the reduction of energy consumption and provides comfortable internal environment while maintaining an economical and an efficient performance. Climate integration systems are classified into:

Envelope Systems: the basic function of the building envelope is to protect and to cover the interior spaces from influence of the external environmental conditions by responding to sunny conditions, windy and humidity to create a balance that maintains the internal environment to meet the requirements, to providing a safe and a secure place for residents.

Mechanical Systems: used in association with the envelope systems to provide solutions for cooling, lighting, acoustic and safety requirements in buildings.

Interior Space Systems: aims to provide comfort for individuals while supporting their activities by the application of spatial, thermal, acoustic and visual performance standards that meet their needs.

#### **E- Double-Skin Façades System**

In hot and hot humid climate, the envelope (Shelter) of the building plays a main role in saving of consuming the energy and improving the thermal comfort and internal environmental performance of the building, considering the type of the envelope design, aesthetic factors, multifunctional and integration approach of the building. Michael Fox said "The primary goal of intelligent kinetic system should be to act as moderator responding to changes between human needs and environmental conditions" [2].

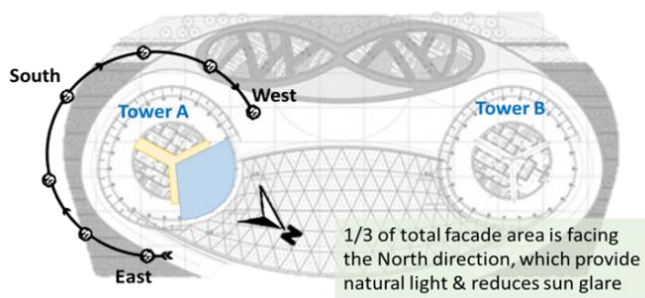
Usually, this Double – Skin Façades system consists of two separated layers of materials allowing air to flow in the cavity in between naturally (External Glazing Skin of the building +Cavity Air Space +Outer Layer Skin). The advantages of this system are covering protection from the sun glare and direct heat gain, where solar shading devices can be placed on the outer skin [3].

#### **Case Study: Al Bahr Towers - Designed by AEDAS**

Al Bahr Twin Cylinder Towers are located in Abu Dhabi the Capital of UAE with a unique architectural design. Abu Dhabi climate is classified as hot and humid weather as the temperature is around 40...46°C and humidity of 85% in July/August.

##### **1. The Contemporary Architectural Design Concept & Main Features**

The Twin Office tower have a state-of-the-art advanced concept and sustainable design techniques, the tower rising up to 150 meters, built up area of 56500 sqm, and accommodated over than 2000 employees. The architecture design was aimed to create a landmark building to reflect the essential tradition Emirates



**Fig. 3. Sun Path/Site plan**

The cylinder curved type of the floor layout and tower profile gives a lot of adaptability, The main Core cylinder structure has utilized for service area facilities (corridors, elevators lobby, staircases & vertical transportation and the border for the offices open to the outer. The main Architecture Design Concept has some essential feature such as:

- 1) Inspiration from Nature& Organic Design Style considering Envelope Adaptation, Energy Efficiency.
- 2) Inspiration from the Traditional Islamic Architecture which involves Geometry Pattern Composition and Solar Treatment.
- 3) Sustainable Technology involving Air Circulation, Shading system and Renewable Energy.

## **2. Iconic Dynamic Mashrabiya System (Double Skin facade)**

The designer looks for solutions that will help reduce the energy use associated with providing internal comfort by using dynamic double skin system, and the innovative design was the “Mashrabiya”. Moreover “Mashrabiya” became the landmark theme design in these towers, and acting as a shading device.

The element Mashrabiya provides 80%...90% shading to the outer skin, accordingly fundamentally diminishing sun powered warmth pick up as a direct aftereffect of its capacity to open and close because of the fluctuating sun ways (Sun-path). Also, it will guarantee that insignificant direct sunlight enters the vision territory whenever, reducing sun powered glare and decreasing the requirement for interior blinds.

### **The Conclusion and benefits of Dynamic Mashrabiya System**

- Provide shading to the Glass façade thus, reducing solar heat gain.
- Minimizing the direct sunlight penetrates the offices area and reducing solar glare.
- Mashrabia has adjusted the amount of natural day light, thus, reducing the use of artificial lighting.
- Allow using clear Glass with higher transparency and providing the users a superior viewing outside the surrounding view.
- The Dynamic Mashrabiya System reductions the essential load for cooling from  $140 \text{ kW/m}^2$  to  $100 \text{ kW/m}^2$ , which is has 20% reducing in total Electricity Feeding (AC and lighting usage), 20% decrease in CO<sub>2</sub> Emissions ( 1750 Tons per Year) and 15% reduction in Cooling Plant Capital Cost [5-8].
- The dynamic envelope system improves the environmental performance of the building.
- Advanced Technologies and computer science the and smart building Technologies Dynamic envelope system strategies have effected of the Architectural World Styles and have improving more creativity by conveying the Architecture massing styles from a Static situation to a Dynamic situation.

architecture cultural and the modernist prestigious lifestyle in Emirate of Abu Dhabi considering the Green Architecture Principles [4].

The main design concept inspired from Geometry Traditional Islamic transparent patterns “Mashrabiya” which is protect the most exposed parts of the glazed building façades, contributing to a 20% reduction in the building cooling load. The “Mashrabiya” has been conceived as a dynamic façade which will open and close in response to the sun’s path.

Green and sustainable advanced Technology

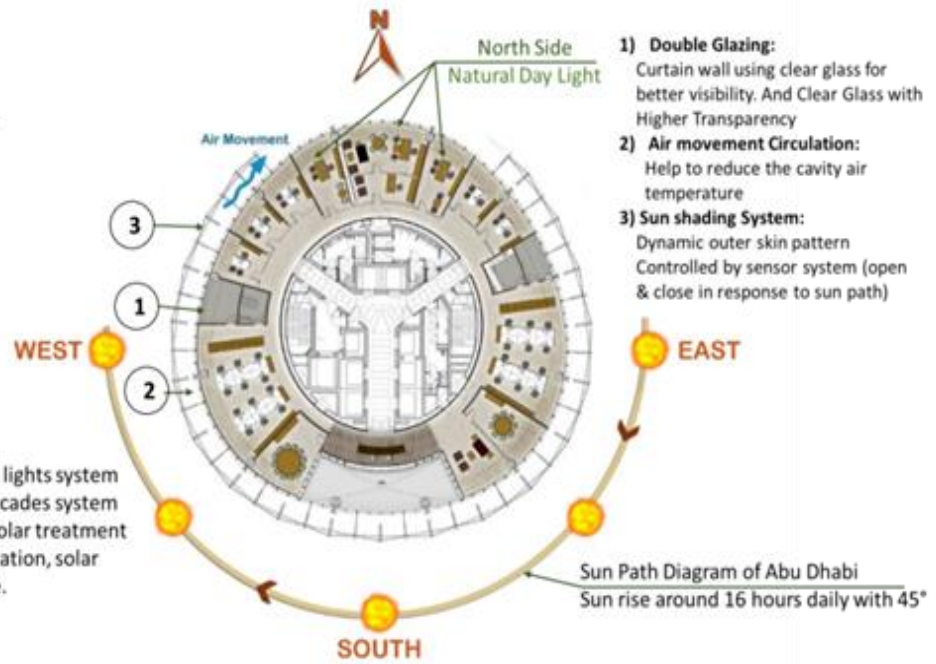


Fig 4. Typical layout showing the analysis of the dynamic doubled skin concept



**Mashrabiya:**

Is an element of Traditional Arabic architecture, it is Arabic term given to a type of projecting at the higher stories of the building enclosed with carved wooden element.

Fig. 5. Traditional Mashrabiya Elements Pattern

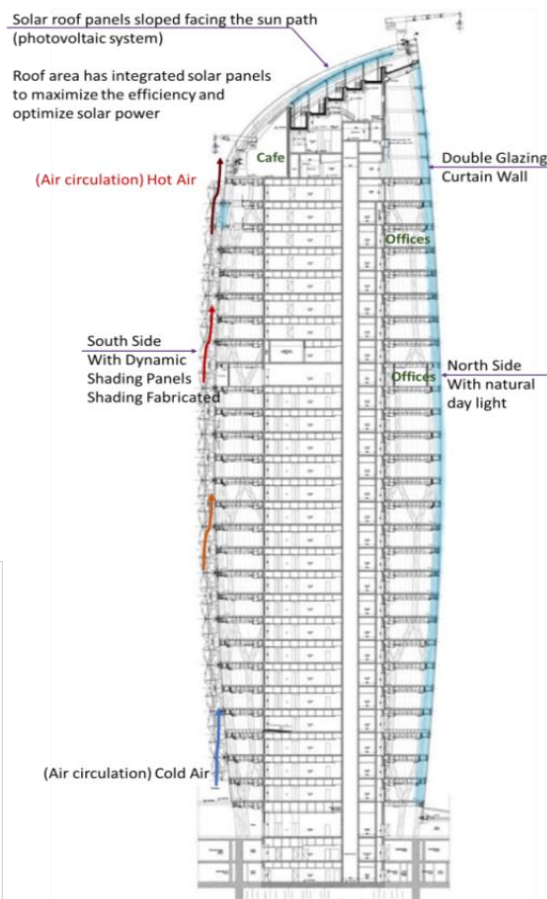


Fig. 6. Al Bahar section showing the technical elements of the dynamic facade system, [5]

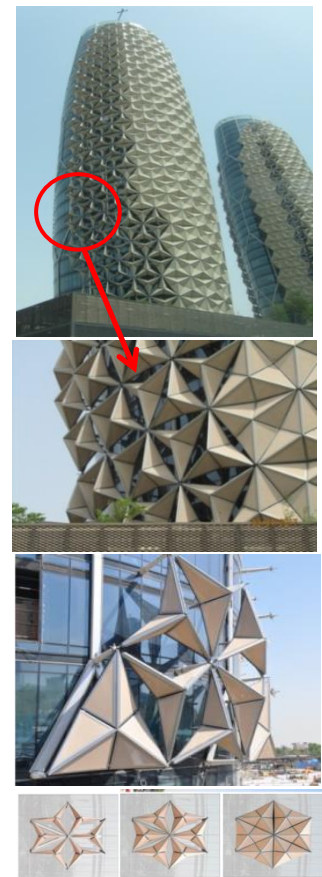


Fig. 7. Dynamic Mashrabiya and structural elements, [5]

## Conclusion

- The integration of modern and advanced technologies( IT, Hi-Tech, Telecommunications) into the Green Architecture Design of buildings is becoming a necessity to provide the required of thermal comfort, security and safety for individuals while maintaining cost effective, environmentally friendly and green architecture sustainable design at the same time.
- Technologies and Green Architecture principles are being developed to meet the human needs to ensure the provision of comfort and the feeling of a luxurious life. Further to the implementation of smart technologies in the design improves for significantly enhance the efficiency of the building facilities, in addition to reducing the total cost, the energy consumption and the environmental impact.
- The UAE has provided outstanding examples for the use of these technologies in high-rise buildings that take into account the difficult environmental conditions in the area, which integrated sustainable technologies, Islamic architecture and bio-mimetic extrapolation into its unique design.

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## ЭВОЛЮЦИЯ ЗЕЛЕННОЙ АРХИТЕКТУРЫ И СОВРЕМЕННЫЕ ТЕХНОЛОГИИ В ОАЭ

*В связи с промышленной революцией в Объединенных Арабских Эмиратах (ОАЭ) наблюдается значительный рост числа высотных зданий. В фасадах этих зданий в основном используется стекло, при этом решение проблемы теплового комфорта делается за счет искусственных технологий, требующих огромных затрат энергии в условиях жаркого и влажного климата в рассматриваемом регионе. Показано, что для организации архитектурно-пространственной среды, при разнообразии природных условий в различных климатических зонах архитектору необходимо учитывать ряд дополнительных факторов, как то: индивидуальный комфорт и потребление энергии вместе с учетом экологических последствий, связанных с реализацией проекта. Вместе с тем тепловой комфорт следует рассматривать как один из сложных аспектов, требующий особого внимания на всех стадиях проектирования любого объекта.*

**Ключевые слова:** *Машрабия, солнечное сияние, проникновение солнечного тепла, система охлаждения, динамическая система в тени, двойной внешний фасад*

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## ԿԱՆԱԶ ՃԱՐՏԱՐԱՊԵՏՈՒԹՅԱՆ ԷՎՈԼՅՈՒՑԻԱՆ ԵՎ ԺԱՄԱՆԱԿԱԿԻՑ ՏԵԽՆՈԼՈԳԻԱՆԵՐԸ ԱՄԷ-ՈՒՄ

*Արդյունաբերական հեղափոխության հետ կապված՝ Արաբական Միացյալ Էմիրություններում (ԱՄԷ) նկատվում է բարձրահարկ շենքերի թվի զգալի աճ: Այդ շենքերի ճակատների համար հիմնականում օգտագործվում է ապակի, ընդ որում ջերմային հարմարավետության խնդրի լուծումն արվում է ի հաշիվ արհեստական տեխնոլոգիաների, որոնք դիտարկվող տարածաշրջանում՝ շոգ և խոնավ կլիմայի պայմաններում էներգիայի հսկայական ծախսեր են պահանջում: Ցույց է տրված, որ բնական պայմանների բազմազանությամբ տարբեր կլիմայական գոտիներում ճարտարապետական-տարածական*



միջավայրի կազմակերպման համար ճարտարապետին անհրաժեշտ է հաշվի առնել մի շարք լրացուցիչ գործոններ, ինչպիսիք են՝ անհատական հարմարավետությունը և էներգիայի ծախսերը՝ հաշվի առնելով նախագծի իրականացման հետ կապված էկոլոգիական հետևանքները: Միաժամանակ ջերմային հարմարավետությունը պետք է դիտարկել որպես բարդ տեսակներից մեկը, որը հատուկ ուշադրություն է պահանջում ցանկացած օբյեկտի նախագծման բոլոր փուլերում:

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