Sustainability in Building design

Term & Dimensions

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Sustainability is one of the most currently highlighted issues locally and internationally. Usually synonymous with the term "Green Building", the main difference between the two is that sustainability refers to the multi dimensional practices that allows for the development of "Green Buildings", defining the objectives that will help characterize the building process.

The main purpose of sustainability is reducing the impact of the "constructed environment" on the "natural environment" thus enhancing the efficiency of the building to ensure a good quality of life for future generations.

Organizations and Objectives of Sustainable Building

A "Green Building" can be define as a "building that considers and respects the natural order of the environment, designed to reduce the negative impact of humans, resources and material as well as the surrounding natural system". From this definition you can notice that the term "Green Building" is a general target that has been transferred to certain objectives and particular categories by different organizations, ultimately evolving its usage to the term "Sustainability". Some of the most recognizable organizations involved 'sustainable development' includes:

U.S. Green Building Council (USGBC) which established the Leadership in Energy and Environmental Design (LEED) rating system.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHARE).

Emirates Green Building Council (EGBC) that currently modifies the LEED system to make it more suitable for the UAE environment.

Although having several rating systems with many differences to evaluate sustainable building, all of these systems concentrate on the same main objectives:

1. The effective use of resources (energy, water and material) and the 3R concept of 'reduce, reuse and recycle.'
2. To protect nature; the source of all resources.
3. The design of high quality construction via the balancing of building performance, environment and resources. Moreover to concentrate on lifecycle cost (construction, operation and maintenance) rather than then the initial cost of construction.

Sustainable Building principals

Under the above objectives, six main principles can be identified to help in monitoring and evaluating the specifications of design, construction and operation. These six principals are:

1. Site & Land.
2. Innovation & Design.
3. Energy Management.
4. Water &Waste Water Management.
5. Material & Waste Management.
6. Indoor Environment Quality.

Principal 1: Site & Land

This principal is focused on encouraging:

- The reuse of buildings and constructed locations, which will help in protecting the land and reducing the effect of

continuous construction on the environment, especially on previously damaged lands from industrial use known as 'brown fields'.

- Controlling the pollution product by storm-water and lighting. In addition to decreasing the "Heat Island" which causes an increase in high temperatures in urban areas due to the replacement of the natural land cover with concrete and roads.
- Maximizing the use of the surrounding area by using the location of the building to most benefit the environment via desired targets for levels of conservation, through the direct or indirect use of daylight, shadow and topography.
- Promote recycling through having dedicated areas in the building that facilitates this with ease.
- Increasing the intensity of the green cover around the building, enhancing indoor air quality, increasing shadow, reducing heat through shadow and evaporation of water during summer and decreasing heat loss in the winter.
- Encouraging the use of public transport and single-occupancy vehicles in addition to strategically locating buildings within easy access to existing or proposed public transportation systems.

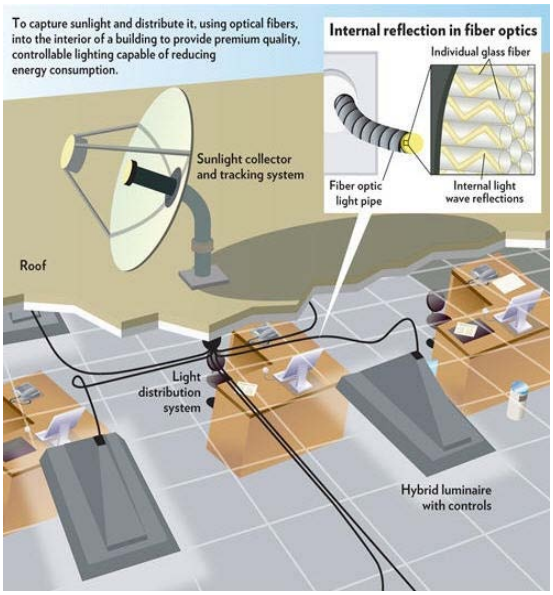
Principal 2: Innovation & Design.

The main objective of this principle is to understand the local environment in order to help in the design of the building. Moreover, to focus on the integration of different disciplines in building design so they can support each other in providing the highest performance and multiple benefits at a lower cost. This principle includes - but not limited to the following objectives:

- ***Integrated Building Design:*** Through integrating different disciplines of building (lights, HVAC, internal design, landscape and general architecture) and identify highly attractive solutions of design solutions that would otherwise not be found. To enable this, a cross-functional team must be established in the design phase to identify the different characteristic that can be integrated with the key issues addressed early in the facility planning and design process. The most recognizable opportunities for this principal are:

a) <u>Usage of Daylight:</u> Daylight can be a key aspect in the design strategy. This aspect takes into account the reduced need for artificial lighting as well as the thermal affect that is associated with it. This method does not merely take into account the number of windows and artificial lighting, but it also focuses on the effective use of sun light through the location, shape and orientation of the building in addition to establishing an effective strategy of using glazing emphasizing aesthetics more than the technical aspect of a design.

b) <u>Capturing and transporting daylight through pipes:</u> This technique relies on transferring the daylight to internal locations not exposed to direct sunlight through twisting and/or straightening pipes. This is achieved through the reflection of fiber optics. Ultimately the most important benefit of using daylight is to enhance internal design and increasing the productivity of the building's occupants.



c) Natural Ventilation: An old concept than has been adopted and modernized - this utilizes variances in temperature and pressure to create airflow throughout the building creating an indirect cooling method. This technique is dependant on two natural effects: 1) Buoyancy for temperature. 2) Wind for pressure.

The buoyancy method is particularly apparent in classical UAE architecture known as the "Barajel". In summer and winter, the buoyancy effect is very beneficial due to the difference in thermal temperatures both inside and outside of the building.

Understanding that indoor pressure is more than outdoor pressure, photovoltaic cells are used to open and close window shutters and louvers, to maximize wind-induced airflow throughout the building. However this technique is not entirely suitable for use in the UAE where temperature and humidity often reaches high levels rendering the photovoltaic cells less effective.

One of the drawbacks of natural ventilation is the pollution, noise, heat and humidity that come with it and the need for an air cleaning device to overcome it.

d) Passive solar design: This is the use of sunlight as a source of thermal energy which can provide space heating, cooling load avoidance, natural ventilation, water heating, and natural daylight.

Passive solar design can be enabled through integrating different aspects of construction from the walls, windows, and materials used; using daylight has a chain reaction of benefits that will result from it. Daylight reduces the need for artificial lighting, which in turns reduces the heat produced by it thus reducing the need of cooling and the size of any air conditioning. This reduces initial cost, ultimately reducing consumption while enhancing overall performance.

- ***Building Envelop:*** We can define the building envelope as the structure that separates the indoor environment from the outdoor environment, consisting of the roof, walls, windows and doors. This envelop protects the building, its occupants and regulate the indoor environment. Any successful building design will enable the use of the building envelop to work with the climate; reducing cooling and heating loads as well as the size of the equipment needed for such activities and the level of consumption occurring. Aspects of this includes:

a) Thermal Insulation: Thermal Insulation' is considered as the most effective long term technique for reducing energy, and service costs and enhancing indoor air quality.

Typically heat flow through windows, walls, roofs and louvers, are about 70% of the cooling load used to offset the thermal leakage from the building envelope.

Thermal insulation material comes in many forms such as organic (wool, animal hear, fiber, cellulose as in cotton, bamboo and sugarcane), non-organic (fiber glass) manufactured material (rubber, foam plastic and Polyurethane) and reflective material (aluminum, steel sheet and reflective

paint) which help in the long term support of building sustainability and performance.

'Wall and Roof' can be used to reduce the cooling load through the use of reflecting surface and wall shades.

'Green Roof:' This incorporates growing foliage on the roof to dramatically reduce the heat inside the building.

Unfortunately growing plants on the roof comes with it some disadvantages this includes the additional weight it adds to the building, the initial costs, the irrigation costs and the general cost of maintenance. However in return it helps reduce "Heat Islanding". Therefore any developer wishing to engage in this type of design will need to weigh up the costs, advantages and disadvantages of such an approach.

b) Glazing and windows: This has a significant impact on the amount of consumed energy and the indoor temperature. Considering the need of daylight through the windows, the solar heat gain must be reduced through the use of shading and thermal insulation. Moreover, double glazing or multi-glazing, where the space between the glazes may be filled with air or a high-conductivity gas such as argon or krypton can substantially reduce the thermal flow through it. Another aspect that must be considered is the use of insulated frames for the windows, such as wood. Thermal insulation or glazing is unpractical in case or moderate climate locations.

Principal 3: Energy Management.

The integrated building design mentioned earlier is a good aid to energy management via its various methods for managing the cooling load, the utilization of natural daylight and ventilation, as well as direct and passive solar energy.

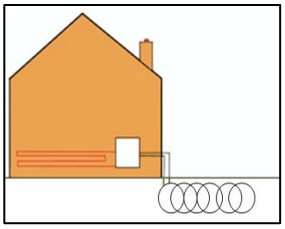
To enable this principal, several techniques have to be applied for the use of renewable energy. One method is the way wind energy is utilized to move turbines and generate electricity in the Bahrain International Trade Center; another way is using solar energy and bio-diesel and biomass to generate electricity.

(a). Heating, ventilating, and air-conditioning systems (HVAC): It is preferable to replace existing inefficient equipment with more efficient with ones to reduce consumption and make savings. For industrial purposes single or multiple boilers, furnaces or chillers to meet varying demands must be used. Moreover, using solar energy to energize the equipment, or heat air and water can help in reducing energy consumption.

Automation or control system should be used as an alternative to fixed equipments for ventilation and air distribution; this will enable an ease in the controlling and adjustment of airflow, which eventually reduces energy consumption.

Furthermore, using cool water for chiller and dry air for air conditioning has its benefits.

(b). Passive Solar water heating: Water is heated or cooled through passing it via underground pipes. This technique depends on heat displacement between ground and pipes, which will reduce the need of a heater and the requirement of having pumps to transfer water, in addition to the use of direct sunlight for heating. Moreover, cooling towers are used for cooling



purposes. A cost-benefit analysis has to be considered when applying any of previously mentioned techniques to enable developers to come to a decision.

(c). Energy Management and Control Systems(EMCS): This is used to eliminate energy dissipation and enhance the monitoring of consumption through local or centralized control systems for energy management which will simplify its management by an operator in the control room.

(d). Light & Installation: Using an advanced system of controls and sensors in addition to natural day lighting is the best opportunity to trim down lighting consumption. Routine maintenance for these types of installations enhances the effectiveness of its operation and reduces consumption.

(e). Office Equipment: it is preferable to use more effective equipment with standby or an auto switch-off feature.

Principal 4: Water &Waste Water Management.

This principal is focused on encouraging:

- **Effective water management:** The reducing of water loss through leakages can be achieved through regular pipe maintenance, using low flow models for toilets, showers, faucet and drinking fountains with a narrower spray jet to provide same felling as full-volume models.

  The replacing of regular faucet tips with automated controlled or metered-valve faucets has the advantage of delivering a preset amount of water before shutting off.

  Thermostats can be used to auto-regulate the temperature using preset temperatures which assist energy and water conservation.

  It is preferable to use batteries instead of an electrical installation for a power apparatus as it is both safer and cheaper. Such a method will require regular replacement of the battery and the development of a replacement plan to avoid any disturbance.

  Moreover, a control system is preferable for large premises to monitor and control consumption and leakage.

- **Collection and use of Graywater:** This is water produced by shower, bath, dish washer, water fountains and the water produce by air conditioner units and refrigerators. This water can be used for general irrigation, cooling, toilets, fire protection and in industrial process. However, it should not be used in fruit and vegetable irrigation. The main drawback of using graywater is the need for a water stream separated from the sewage system, and the need to have some filtering system before using at an above ground level for health reasons.

  Affective use of reclaimed water: Wastewater (gray-water or black-water-which is produced by toilet or industrial purposes) are treated and reuse for above ground irrigation and in addition in to the purposes mentioned earlier in the gray-water application such as toilet flushing.

  On-site wastewater treatment should be considered for buildings that consume high volumes of water for industrial use to support conversation and recycling efforts.

- **Rainwater harvesting**: This refers to the collection, storage, and use of rainwater. In this technique a roof could be used for such collection via galvanized steel, fiberglass and polyethylene tanks (as the storage). However, rainwater must not be stored for long periods of time and it must be purified before it is used for drinking purposes.

Principal 5: Material & Waste Management.

Materials: The types of materials used are a key aspect of sustainability in building. When selecting the material, it is preferable to use recycled or renewable material in building construction to lessen the negative impact on the environment.

Also sustainability practices encourage the reuse of an old building envelop in a new building's structure, such as windows and doors.

Issue related to material selection can be address as:

(a). Roofs: The main purpose of the roof is for the protection and reducing weather impact. For this a reflected material that can be recycled is preferable for use. Furthermore the roof area can be used to place solar cells if needed.

(b). Floors: It is preferable to use materials that are easy to clean, maintain and recycle. Moreover, the materials that have low VOC (volatile organic compounds) emission must be used, as well as using a minimum amount of glue for carpets. Another useful tip is to use a doormat in front of doors to reduce the amount of dirt entering the building. Also prevent carpets from remaining wet/damp as this will allow fungous to grow.

(c). Walls & Paints: Walls must be painted with light colors to reflect the light, reducing the amount of light required needed to brighten a room. Another tip is to use paint that contains low VOC emission. In the use of wall paper, it is preferable to use the one made from naphthalene instead of traditional wall paper material as it more resistant to humidity.

- ***Reducing operational waste and recycling:*** By reducing the amounts of material used in the operation and the devising of ways to use it in a more efficient manner will reduce the overall amount of waste and therefore reduce the amount of money required to dispose of it.

  To accomplish this it is necessary to educate building occupants about the importance of recycling by providing areas all over the building facilitating the collection of material. Recyclable materials include metal (iron, aluminum, copper, mercury and zinc), paper, cartoon, plastic, glass, rubber, fluorescent lamps and air condition units.

- ***Reducing construction and demolition waste***: This refers to the majority of waste any given building would produce. A great idea to reduce the amount of this waste is to reuse parts of old buildings or store them for later use - creating a new term to describe this practice as 'deconstruction.'

  Deconstruction is the opposite of construction and it is mainly done before the demolition of a building. In this method, all parts that are in good condition and building materials that can be reused are removed before the demolition process and reused in new developments.

Principal 6: Indoor Environment Quality.

The primary cause of indoor environmental pollution stems from mistakes made in the construction and operational stages of the building, creating real health concerns. This can be avoided in any stage by:

- **Ventilation and smoke management:** Poor indoor quality affects the occupants of the building. To avoid this, a smoke management policy must be established through allocating smoke areas with air filters throughout the building and the restriction of smoking in other areas.

- **Indoor pollution causes :**
  a) Organic substances such as mildew, bacteria and dust are formed due to leakages and the humidity of a building. To avoid this, humidity absorbing material must be used to ensure that humidity does not exceed 50%.
  b) VOC emission in new buildings which occurs as a result of paint, carpeting, furnishing and cleaning material.
  c) Flammable material.

- **Enhancing indoor air quality:**
  a) Ensure that the building has been ventilated before use (flash over ventilation) and at periodic intervals.

Educate occupants about the importance of regular ventilation.

b) Enhance the indoor temperature and keep the building dry to avoid humidity preventing the growth of bacteria and mold, especially on outdoor walls, foundation and roofs.

c) Closing all gaps surrounding the electrical installation of water pipes.

d) Provide enough ventilation for appliances that generate a high level of exhaust, such as laser printers, cookers, bathrooms and smoke areas.

e) Keep the building clean by providing a doormat to prevent and reduce sand and dirt entering and polluting indoor air.

f) Avoid using material with VOC properties.

g) The building foundation must be tight which will not allow for any leakage that can cause humidity or for polluted air to enter the building.

h)Using daylight which offers visual relief and a healthy environment that supplies the body with vitamin (D), improves mood, enhances productivity and individual proficiency.

i) Using furniture that does not emit VOC.

j) Encouraging building occupants to get closer to the nature by providing natural views within the building and generating an interest in internal gardening.

- **Noise Control:** Noise control is more effective if it is addressed earlier on in the design stage. Noise can be avoided using voice barriers, double glazing and carpets, and having narrow passageways that connects the building with the outdoor environment to reduce the noise flow to the building.

Some good voice absorber materials include fiber glass, insulation material, blankets and carpets. Moreover, avoid using voice reflecting materials that allow for noise transfer over longer distances; this includes material such as metal, flat glass, wood that cover with solid layer and ceramic.

Sustainability abstract

Eventually, to accomplish sustainability we have to measure, manage and control the building performance to enhance it and evaluate it at the design stage. This is done through measuring consumption and the monitoring the indoor air quality, noise and pollution measurement.

A useful aspect of sustainability is that it encourages the construction and building industry to focus on balancing the performance of a building and energy efficiency, in addition to the economic and surrounding environmental aspects. To accomplish that, the integrated building design must enable us to employ different disciplines in the design process to support each other, such as using a building envelope and internal design to support lighting and reducing noise and pollution. Also we can use a cooling tower for the cooling of water, earth temperature to heat out the water, and other examples that benefit of surrounding area to serve the building and reduce the negative impact of it in the environment.

Reference:

- GREENING FEDERAL FACILITIES, Department of Energy, USA.
- LEED rating SystemWhole building design guide