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The use of intelligent buildings to achieve sustainability through an architectural proposal for public buildings in Cairo

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Abstract:

Through the study of the current situation in the city of Cairo, noted the existence of shortcomings in the design of public buildings to achieve the principles of sustainability.

By studying the reasons for this deficiency it founded that was because of the lack of a clear methodology for the sustainable building design in that city.

The research determined the most important elements must be achieved in public buildings in Cairo city to achieve the sustainability.

The research identified the most important elements of intelligent architecture that can be applied for public buildings in Cairo city to achieve the principles of sustainability in that city.

The research concluded an architectural proposal for public buildings in order to achieve sustainability elements using the recent techniques of intelligent buildings that are compatible with users in Cairo city in Egypt.

Aim of the research:

The research aims to provide a proposal for achieving sustainability by using the capabilities of intelligent buildings for the public buildings in Cairo city.

Research problem:

By studying the current situation of public buildings in Cairo, it appears clearly the lack of awareness of energy consumption of buildings and lack of achieving sustainability in most public buildings, because of the absence of an architectural proposal to achieve sustainability for public buildings in Cairo.

The scope and limits of the research:

The research determines a proposal to achieve sustainability for public buildings in Cairo city by using intelligent buildings capabilities.

1- Sustainability and public buildings in Cairo:

The need to apply sustainability and energy efficiency of public buildings in Egypt, especially in Cairo, has become urgent, due to the large of energy consumption of buildings in Cairo, Kurt Wiesegart [(1)] said that "Egypt can provide about a third of its electricity through improved energy efficiency in the buildings sector". [(i)]

2- Intelligent Buildings:

Intelligent buildings have the advantage of automated systems that control the environment and communicate with users. With the increasing levels of sophistication in technology, intelligent systems can be used to achieve the requirements of sustainability.[(ii)]

[(1)] Dr. Kurt Wiesegart is the team leader of (MED - ENEC) project, which means raising the energy efficiency in the Mediterranean region .

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2-1 Sensors in intelligent buildings:

Sensors can monitor everything motion, temperature, humidity, precipitation, occupancy and light [iii].The buildings coexist with nature. Intelligent buildings can also reduce energy consumption and CO2 emissions.

2-2 Energy efficiency strategies in intelligent buildings:

Building automation systems (BAS) in intelligent buildings do wide facilities, they combine with building energy management systems (BEMS) and many systems and technologies to achieve the energy efficiency of buildings as the followings: ([iv])

2-2-1 Using energy only when really required.

2-2-2 Use only the amount of energy that is actually required.[v]

2-2-3 Intelligent systems control heat loss in winter and heat gain in summer.

2-2-4 Intelligent systems shut down sources of energy consumption in spaces, such as lighting systems, air conditioning and other systems, in case of empty spaces, except emergency corridors and exits escape.

2-2-5 Intelligent systems can response to the environmental changes outdoor and indoor in order to decreasing the energy consumption.[vi]

2-2-6 Intelligent Systems can use natural light and outdoor air movement and changes of external temperatures to reduce the use of electrical and mechanical systems to reduce energy consumption.

2-2-7 Intelligent systems can save a part of the energy needed for the building through generating energy from renewable energy systems and integrating it into the total energy required for the building.[vii]

2-2-8 Efficient daylight penetration using suitable shading devices.

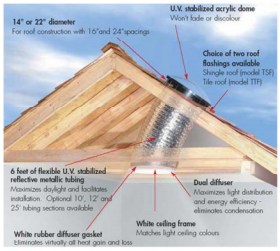
2-2-9 Efficient appliances that reduce the electricity consumption and cost.

2-2-10 Passive heating and cooling through the building envelope.[viii]

2-2-11 Building Energy Management and Control. [ix]

3-Advanced natural lightings techniques:

There're some methods used to transfer natural lightings to inner spaces like sun tunnel , smart light which is a technology that uses sunlight, electrofluidic cells, and a series of open-air ducts to use sunlight to naturally illuminate spaces deep inside [x], and blind system with shutter control unit [xi] which is an optimum incidence of external light with minimum glare results from the sun position.



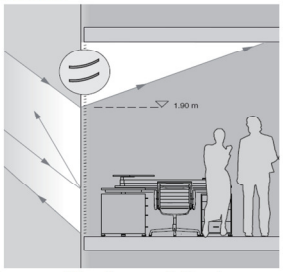
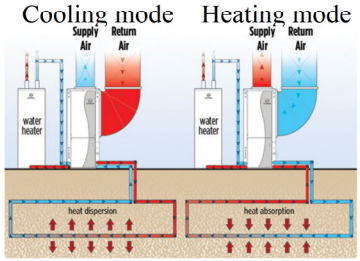


Figure (1) shows sun tunnel [xii] *Figure (2) shows blind systems* *Figure (3)shows smart light*

4-Geothermal heating and cooling systems:

Using of geothermal heating and cooling systems to reduce the energy consumption. [xiii]



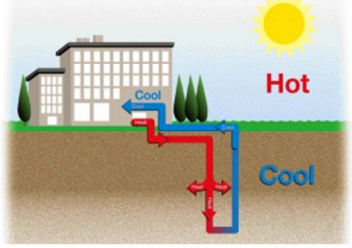


Figure (4) shows geothermal systems

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5- The current situation of public buildings in Cairo and its relation with sustainability:

By studying the current situation of public buildings in Cairo there's an indication of the absence of some of sustainability aspects, as follows:

	sustainable elements	The headquarters of the Bank for Development and Agricultural Credit [xiv] 	Children's Cancer Hospital 57357 [xv] 
Systems	Presence of Intelligent systems	Doesn't exist	exist
Water	Water management reduction & recycling	Doesn't exist	Using waste and water management systems
Outer environment	Minimizing negative impact on the surrounding environment	Don't do that	exist
Energy	Integration of intelligent systems to reduce energy consumption	Doesn't exist	exist
	Building Energy Management System (BEMS)	Doesn't exist	exist
	Efficient use of energy	Doesn't exist	exist
	Installing geothermal heating & cooling systems	Doesn't exist	Doesn't exist
	Double skin facades	double glazing	Doesn't exist
	Automated louvers	Doesn't exist	Doesn't exist
	Facades sensors to response to outer environment	Doesn't exist	Doesn't exist
	Controlling natural & artificial lighting	Doesn't exist	natural day lighting by using glazing facades
	Automatic daylight control	Doesn't exist	Doesn't exist
	Integration of lighting control systems through (BMS)	Doesn't exist	Doesn't exist
	Energy-saving lamps and Led lighting	Using compact fluorescent lamps	Using compact fluorescent lamps
	Installing energy-efficient ventilation systems	Doesn't exist	Doesn't exist
	Innovated design to reduce energy	Doesn't exist	Doesn't exist
	Encouragement natural ventilation systems	Doesn't exist	Doesn't exist
	Responsiveness to the environmental changes	Doesn't exist	Doesn't exist
Renewable energy	Installing renewable energy tools like photovoltaic panels (BIPV), wind turbines, and solar heaters.	Doesn't exist	Doesn't exist
Materials	smart materials	Doesn't exist	Doesn't exist
	The use of environment -friendly material	Doesn't exist	Few exist in facades and flooring
Recycling	Recycling materials	Doesn't exist	Sandstone
Indoor quality	Indoor air quality systems	HVAC systems	HVAC systems & Air purification system
	Indoor thermal quality systems	exist	exist
	Indoor acoustic quality systems	Doesn't exist	Few exist
pollution	Reduction pollution&Co2 emission	Doesn't exist	Few exist
Architectural treatments	Compatibility with climate &usage of treatments to deal with climate	Few exist	Medium exist

Table (1) shows the current situation of public buildings in Cairo and its relation with sustainability.

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5-1 The best practice examples in Egypt :

HSBC Bank Egypt Global Service Centre **,** is one of the best practice examples in Egypt, it has the first golden LEED certificate project in Egypt. [xvi]

HSBC Bank Egypt Global Service Centre:	 *Figure (5) shows HSBC Bank Egypt Global Service Centre.*
Location	Giza, Egypt's Smart Village.
Gross square feet	210,000 sq ft.
Space Type Use	Offices (17% of activities) .
Description of the building	- A four storey building Ground floor and three typical floors (3000 sq ms each) and two underground parking floors (4500 sq ms each). - The 3000 sq.m semicircular plan responds to an important corner plot in Smart Village with a sweeping fully glazed north facade and a mostly solid south service and gateway facade. An offset Atrium brings daylight from clerestory windows to the deep zones and break out areas.
Gold rating is the result of a range of green features including	-Energy consumption cost saving by 9%. -Chilled water consumption cost saving by 39%. -Domestic water consumption cost saving by 47%. -84% of construction waste diverted from landfill. [xvii]
Water efficiency	- 50% reduction in potable landscape water use**.** - 20% reduction in baseline indoor water use.
Energy and Atmosphere	- 28% improvement on baseline building performance rating**.** - The building uses smart technologies to help monitor and control energy use throughout the building. Meters will record electrical use and a centralized control system will determine usage trends and help building managers increase the efficiency of the building systems.
Indoor environmental quality	90% of occupied space has quality views.
Dust control	The building used an erosion and sedimentation control plan to improve dust control. Airborne dust was kept to a minimum by keeping sand piles covered and moistened with non-potable water.

Table (2) shows the best practice example in Egypt for sustainability.

6-Proposal to achieve sustainability in Cairo through using intelligent buildings:

6-1 Building management systems (BMS):

Presence of intelligent systems which integrate together to achieve sustainability (integrated management systems) like:

Building Energy Management System (BEMS), intelligent (HVAC) systems, fire alarm & fire fighting smart systems and electrical network management systems which include electrical power management system (EPMS) and intelligent lighting systems.[xviii]

6-2 Act on users:

Educating users on intelligent buildings, efficient use of energy, buildings sustainability, methods of energy conservation and conservation of natural resources.

6-3 Legislation and laws:

-Enactment the appropriate legislations to increase reliance on intelligent buildings for achieving sustainability, and implementing energy efficiency of buildings.

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-Not to allow to construct of any building doesn't achieve the sustainability requirements .

6-4 Water management:

The Intelligent systems reduce water consumption as the following:

- Adopting the process of recycling the collecting rainwater and wastewater after specific treatment and reuse in WC's and urinal flushing.
- The use of smart water sensors to minimize the loss in water when not needed.
- The use of smart sensors to lock water valves when any leakage happened this leads to minimize the waste of water.[xix]

6-5 Energy & atmosphere:

Installing Building Energy Management Systems (BEMS) that integrate with the building through the following:

6-5-1 Efficient use of energy in intelligent buildings:

Building Energy management systems (BEMS) operate on the efficient use of energy consumption by adapting elements of intelligent building through :

- Increasing reliance on natural light and reduce the reliance on artificial lighting.
- Increasing reliance on natural ventilation and architectural treatments to reduce reliance on mechanical systems in air conditioning systems and ventilation.
- Providing an appropriate thermal, lighting and acoustic environment depend on maximum utilization of natural resources and reduce energy consumption.
- Take advantage of renewable energy to provide a part of the energy required.
- Protection from solar radiation when it is not needed and encourages the entry of solar radiation if necessary.

6-5-2 Outer envelope:

-Installing intelligent Systems in facades to deal with ventilation, shading and brightness of the sun controlling natural light, temperature and humidity to achieve the best possible climate control, which reduces reliance on mechanical systems (HVAC) to reduce energy consumption.

-The use of moving louvers which are controlled automatically by automated system depending on the movement of the sun to protect against solar radiation in summer and encourage of solar radiation in winter, these louvers are covered by photovoltaic cells to generate electrical energy.

-The presence of the required sensors for facades like rain ,temperature ,relative humidity, wind direction, air quality, angles of the sun radiations and wind speed.

- Ensuring that the intelligent systems that deal with facades to increase reliance on natural lighting and natural ventilation to reduce energy consumption.

-The use of intelligent skins, double skin façades and intelligent facades systems to reduce energy consumption.[xx]

6-5-3 Lighting:

6-5-3-1 Integration of Lighting control systems:

-Lighting control systems integrate natural lighting with artificial lighting to maximize the use of natural lighting in order to minimize the use of artificial lighting, artificial lighting used only when the inability of natural lighting to provide illumination required rate, that controlled by building management systems (BMS) in intelligent buildings.[xxi]

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-Building Automation System (BAS) and intelligent integrated lighting systems can minimize the energy by using occupancy sensors for lighting that by:

-Controlling lighting where people work a predictable schedule.

- Automatically turn on and off lights by photocell or computer schedule.

- Modifying lighting levels through the use of photo chromatic windows.

- Managing energy consumption by monitoring room occupancy and adjusting lighting to suit.

6-5-3-2 Maximum natural lighting:

-Maximum use of natural lighting.

-The use of glass overlying of materials to allow light to pass preventing solar heat or glare, such as Laser cut panels, Prismatic panels and light diffusing systems.

- Delivering natural light to deep areas, such as basements by Light pipe systems and mirror ducts.

-Installing sun tunnel techniques to provide natural lighting.

- Installing smart light systems to lighten the deep spaces.[xxii]

-Installing roof skylights and roof windows over atriums, inner spaces and corridors to provide natural lighting to save energy, these skylights can be supported by intelligent mechanical system that can prevent solar radiation in summer periods.[xxiii]

6-5-3-3 Artificial lighting:

-Installing energy-efficient lightings like energy saving lamps and Led lighting.

6-5-4 HVAC systems in Intelligent Buildings:

6-5-4-1 Intelligent HVAC systems:

- Installing energy-efficient air-conditioning.

-Using intelligent Systems that integrate with (HVAC) Systems that lead to energy control.

- The system consists of : sensors to measure temperature, flow rate of air inside the rooms and electronic control devices to adjust the air flow rate as needed automatically. Climate sensors can measure humidity, switch off air conditioning machines when room is empty to save energy.

-HVAC intelligent systems are integrated to provide natural ventilation.

-Installing Geothermal Heating and Cooling systems.

6-5-4-2 Natural Ventilation:

- Installing energy-efficient ventilation systems in building they use less energy.

-Encourage natural ventilation, which include ventilation holes in the walls and wind towers thus to minimize air conditioning use.

6-5-4-3 Responsiveness to the environmental changes:

-Sensors can monitor everything in building like motion, temperature, humidity, precipitation, occupancy and lights. Intelligent Systems can respond to the environmental changes indoor and outdoor.

-System used to control (HVAC) and lighting systems makes building responsive for thermal and climatic changes.

6-5-5-Heating systems:

-Installing energy-efficient boilers.

-Installing systems generate biomass fuel for boilers and heating.

- Use of solar energy to heat water controlled by smart systems.[xxiv]

6-5-6 Renewable energy:

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5-5-6-1 Take advantage of renewable energy as following:

-The integration of photovoltaic cells with the building, building integrated photovoltaic cells (BIPV) to provide some of electricity needed to building.

-Generating Electricity by wind turbines on roofs or external facades that can provide part of the electrical energy required.

- Installing techniques for electric power generation, such as Parabolic dish collectors.

5-5-6-2 Installing solar water heating systems use heat from the sun to work alongside the conventional water heater.

5 -5-6-3 Installing of the geothermal heating and cooling systems that integrate with the building through intelligent systems.

6-6 Integrated systems:

The systems integrate together in intelligent buildings to achieve the best benefits and less consumption of energy. (xxv)

6-7 Smart materials:

- The use of smart materials on facades, in order to reduce energy consumption.

-The use of color-changing smart materials in windows to prevent glare and undesirable reflection, these materials change its colors when exposed to electrical current.

-The use of (HOE) material which allows natural light to pass and prevents solar radiation.(xxvi)

-The use of smart self cleaning glass on exterior facades where there are a large percentage of air dust in Cairo.

-Installing of electro-changing smart materials which can convert energy from a case to another, like thermo-electrical materials that can convert thermal energy to electrical energy, and Piezoelectrical materials which can generate electrical energy by pressing that can be used in corridors and outdoor roads.(xxvii)

6-8 Materials & Resources:

- The use of environment-friendly material non-polluting and biodegradable.

-The use of recyclable materials .

-Selecting materials in building that can be reused later in new construction.

6-9 Indoor Environment Quality:

-The usage of intelligent systems to achieve the optimization for comfort and health for indoor environment.

-Achieving indoor visual quality.

-Using intelligent systems that integrate with artificial and natural lighting systems to achieve the required lighting for indoor spaces.

-Using intelligent systems that integrate with (HVAC) systems to achieve indoor air quality and thermal quality.

-The use of smart materials and insulating materials for facades with integration by intelligent systems to achieve indoor acoustic quality.

6-10 Innovation designs:

- Innovative architectural designs for designing forms, areas of openings, building orientation, windows orientation, protection from solar radiation in summer, increasing heat gain in winter, reducing water consumption and utilization of renewable energy, for compatibility with the environment, and reducing the energy consumption.

-Providing innovative solutions to control the permeability of natural lighting to the areas that are away from windows.(xxviii)

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-Providing innovative solutions to control the movement of air in inner spaces.

6-11 Pollution reduction:

-Control the gases, pollutants and carbon dioxide by (HVAC) systems, which work to prevent the entry of these gases to the building and reduce the production of polluting gases.

-Installing stoves that use the power generated from renewable energy sources.

-Increasing landscape areas indoor and on roofs to increase the amount of oxygen and reduce carbon dioxide.

- Integration of Biomass which is a low carbon renewable fuel.

6-12 Avoiding negative impact on the environment and site:

Buildings must avoid any negative impact on the sites and the surrounding environment.

6-13 Compatibility with climate :

-Protecting the facades and windows from solar radiation in summer.

-The use of large thermal resistance materials on external facades and increasing shaded areas on facades as much as possible.

-Reducing the areas of windows on the exterior facades which exposed to large amount of solar radiation.

-The use of sun-breakers on the exterior windows to protect from solar radiation.

-The use of vacuum double glazing that provided with film to protect from heat transfer.

-Adding thermal insulation for walls and roofs.[xxix]

-North direction is the preferred orientation.

-Adjust long side of the building to north direction.

-Increasing natural ventilation, adding internal courtyards to the building.

-Adding sky lights areas to increase the amount of natural light which must be designed to prevent the entry of solar radiation in summer.

-Increasing the underground spaces in designs to protect from solar radiation and high air temperature. [xxx]

7- Threats and obstacles to apply the proposal:

- Lack of awareness for decision-makers of the importance of sustainability for public buildings in Cairo.
- The lack of specialists who are familiar with the advantages of intelligent buildings and sustainability of buildings.
- The lack of availability of intelligent buildings technologies locally.
- The absence of legislation needed to implement the sustainability of public buildings in Cairo.
- Lack of funding required to modify existing public buildings so as to comply with the requirements of sustainability by using the intelligent buildings technologies.
- Most of Egyptian codes & standards do not take into consideration the sustainability factors.
- The initial cost of using renewable energy , implementing of sustainability and installing of intelligent buildings systems is considered fairly high.

Conclusion:

1 - Most of existing public buildings in Cairo don’t take into account the aspects of sustainability and the fundamentals of energy conservation.

2- There's no use of the capabilities of intelligent buildings in the field of sustainability of public buildings in Cairo.

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3- Intelligent building systems can be employed to achieve sustainability.
4- The increasing of global trends in the fields of energy conservation and renewable energy that can be used to reduce energy consumption for public buildings.
5- The absence of a comprehensive proposal for achieving sustainability and energy efficiency of public buildings in Cairo.
6-The research submit a proposal for achieving sustainability for public buildings in Cairo through the capabilities of intelligent buildings.

Recommendations:

1-Applying the proposal to all new buildings that will be built in Cairo.
2-Making the obligation for the owners to provide a confirmation prove that the building achieve the terms of sustainability and to be a condition for the approval of the permits.
3- Activating the role of research centers and universities in the field of intelligent buildings to achieve sustainability in Cairo.
4- Assessing existing projects in Cairo and making the required modifications to achieve the aspects of sustainability for these buildings.
5- Increasing the users' awareness of intelligent buildings and sustainability.
6- Increasing the educational interest in the fields of sustainability and intelligent buildings.

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