The Importance of Intelligent Architecture Techniques in Saving the Electrical energy

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Abstract
Design practices in architecture need to judge the feasibility of applying the intelligent systems as a possible alternative to conventional systems from the point of electrical energy consumption and the convenience of occupants. The integration of these systems may also address the problems that are caused by the orientation towards the large glass surfaces and the open spaces.
Brief description of Intelligent Architecture was presented, It was found that the most important characteristic is its responding to the internal and external changes of the building, and that the most important functions that take an important role in energy saving that Can be performed by the application of intelligent architecture, is to take advantage of natural ventilation , daylight control function and cooperation with industrial lighting with a certain dim system to maintain the required level of lighting, which is called the Responsive lighting system, Solar radiation control function using an intelligent shading technique, which has a response function that automatically adjusted throughout the day while distinguishing among the different shading modes (internal - external - compact).
In the analytical study, global examples were analyzed using the previous functions of ventilation, shading and lighting with an explanation of the used techniques to achieve these functions and compared them with traditional systems in terms of energy saving and ensuring comfort for the occupants.

Keywords: intelligent architecture - intelligent systems – electricity consumption.

1- Introduction: The using of technology in simple details covered all aspects of life. So It was essential that architecture must conform to this technological context and provide unconventional solutions based on the designer's creative abilities and his ability to adapt the uses of technology, from design to final production. This is only a result of a different way of architectural thinking due to the maturity and development of the user himself, and change in the nature of life that emerged Intelligent architecture.

2-The importance of research and its objectives: Design practices in architecture need to judge the feasibility of implementing the intelligent systems as a possible alternative to conventional systems in terms of energy consumption and occupant comfort requirements. The integration of these smart systems into the design process may address the problems that are caused by the orientation towards large glass surfaces and open spaces due to waste of energy.

3-Research Methods: The concept of Intelligent architecture and its advantages will be explained in addition to a detailed study of intelligent energy saving systems with an analysis of some global examples.

3-1- Intelligent Architecture Definition: intelligence of Building can be defined as a building response in a way that is described as intelligent. generally, intelligence in architecture is associated with three main subjects: Intelligent materials, Intelligent facade and Intelligent buildings:

a- Intelligent Materials: Materials that are capable of responding to external stimulants in a predictable way

b - Intelligent Facade: The ability to conform to a particular situation in response to a change already expected, so it should be able to adapt itself, to provide the ideal thermal response to any set of external climatic conditions, requirements of occupants, guidance and type of building.

c- Intelligent Buildings: The ability of buildings to recognize changes in external and internal conditions, and to respond appropriately to those changes, with the aim of achieving the best use of resources and improving the internal environment and comfort of occupants. On the other hand, traditional buildings are characterized by silence and inability to respond.

3-2- Intelligent Architecture Features: The development of smart buildings was in response to the needs of the work environment through the three main elements: occupants of the building and its employees (the worker - the stuff), and work (product - production process) as well as the building (workplace - services and building systems).

The efficiency of any intelligent building requires the balance of the three factors (environment, comfort and economic viability). In light of the three points, The advantages of smart architecture are:

1-Ability to achieve environmental comfort: Intelligence achieves appropriate response to environmental changes in and outside the building as well as enables the building to achieve compatibility and adaptation to the needs of the internal environment.

2- Comfort for occupants: Intelligence can improve in the internal comfort levels environments by adding an automatic response to the requirements and needs of occupants of the building towards changes in the interior and exterior environment in order to improve thermal, audio and visual comfort.

3- Economic Efficiency: Intelligence helps building users to achieve better performance with minimizing operational cost despite of the high cost of foundation.

The importance of intelligent building in the context of energy conservation: One of the reasons for the emergence of intelligent buildings is to respond to the environmental needs, and the most important concerns are the use of energy, and many buildings went to improve the comfort levels in their internal environments and save energy by replacing the facades of buildings with intelligent ones. Energy is provided by relying on natural sources of lighting, ventilation and activating cooling and heating strategies, all that within the intelligent outer envelope system.

Using the smart interface in energy conservation: Many smart systems try to increase energy conservation rates by providing the facade with many attributes:
•Increasing the reliance on natural daylight lighting, overcoming sometimes intense and sometimes weak lighting through intelligent control systems, with using the most efficient lighting sources.
•Increasing the reliance on natural ventilation to reduce industrial ventilation loads.
•Use a façade with a good insulation system, making air-conditioning systems ideal for energy consumption, even if this is followed by an increase in the initial costs of the project or in the required spaces.
•Increasing the reliance on night cooling to reduce daytime cooling loads.
•Improve facade performance by expanding the use of external shading and selecting appropriate materials.
•Utilization of renewable energy to provide the building's needs of heating, cooling and lighting.
•Reduce device loads with better power management and low-power flat-panel monitors.

Intelligent Architecture is a Responsive one: The most important advantage of intelligent systems is that they are efficient systems which mean the ability to monitor variables, and then respond to a pre-expected automatic reaction and then to adapt to new conditions. This must be done in a manner that is appropriate to the needs of the occupants of comfort and energy saving , Whereas traditional systems in response to variables rely on human ability to observe. When intelligent building systems are said to be responsive, they response:

a- Response to external variables: the response to climate changes such as changes in temperature, natural light intensity, wind movement or noise levels.
b- Response to the internal variables: ie, the response to changes in occupancy in the place and temperature as needed.
c- Response to the requirements of the occupants: the response to changes in the needs of privacy or the desire to change activity or control levels of lighting and heat as desired by the occupants.

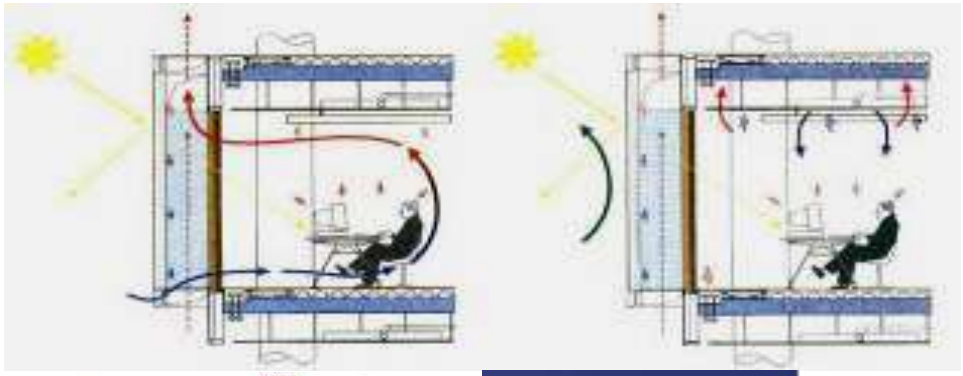
3-3- Intelligent Architecture Techniques that save energy: The most important intelligent energy saving systems will be discussed. The goal of the intelligent envelope is to control automatically the facade functions for energy saving purposes and improve internal comfort levels. One of the most important functions is control of natural ventilation and natural lighting as well as thermal control.

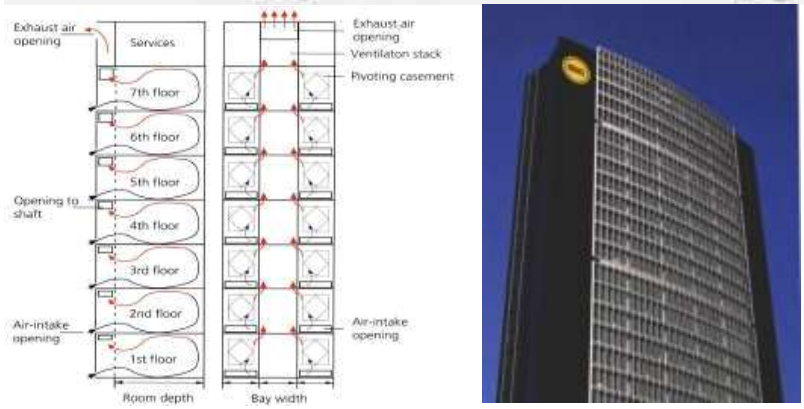
3-3-1- Natural Ventilation Function: Natural ventilation is intended to maintain a minimum air quality and to achieve internal comfort, especially in hot climate when the outside air temperature is lower than the internal air temperature. It also aims to cool the building. It is useful for removing the stored heat in the building and removing the heat acquired during the day from solar radiation And the exploitation of the building block itself in the storage of cold resulting from natural ventilation at night to be used during the day and in the sunny hours when re-emitted from the building block to reduce the heat of internal spaces, they are useful especially for administrative buildings that are not used at night and It is also useful for energy saving considerations in cooling in buildings.

Examples of applying natural ventilation techniques:

A-The commercial exhibition tower building (ARAG), Hanover. Located in Dusseldorf, Germany designed by Architecture Foster, The height of the building is 125 m and the shape of the project is arc .it has two service levels divided into four sections and each section consists of 6 floors (offices ,a service floor and a garden) the facade became divided and each section works as an air column extended to eight floors and connected with openings of the top and bottom with the other sections of the facade Its dual façade works as a sound insulation in addition to ventilation function.

Ventilation Technology: prepared Ventilation vents for each floor of a low level allow fresh air flowing from outside to a 55 cm cavity between the two front panels and then it is pulled in by opening ventilation windows on the inner layer of the façade. The heating depends on the coming air from the vents above the windows, which rises within the cavity of the two layers of the facade and leaks on the service floor of each section through a valve. And the process depends on the idea of buoyancy in the vacuum of the double facade because of the hot air at the bottom which flows to the top, the height of the facade acts as an air column, which ensures the movement of the air under the influence of the pressure difference Even when the wind movement is nil in outside. the facade includes sliding vertical aluminum panels can be opened individually to ensure ventilation.

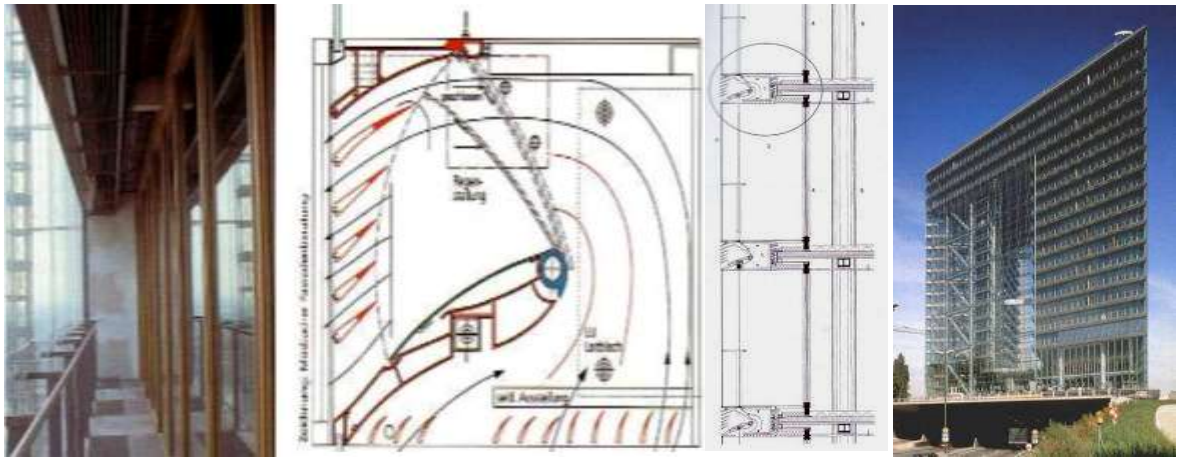




Photos showing the idea of natural ventilation

b- City Gate is an administrative building located in Dusseldorf, Germany, designed by Reem Kulhas: the height of the building is 70m, it has semi-lozenge shape. The facade of the building combines the double facades and the use of automatic valves, which are ventilation holes at the top and the bottom of each floor. The building consists of two parallel towers with a height of 16 floors, a lobby is located between the two towers in the middle of the building, this lobby rises until the last three floors, the interior façade, which overlooks the lobby, is a glass facade in order to reducing both of the air pressure on the building and the noise inside the offices, The most exposed external facade for noise is designed in a double way.

Ventilation technology: The façade is characterized by the automatic valves that represent the ventilation holes at the top and bottom of each floor, which control through entry and exit of air the space between the two front panels, and they adjust the flow of air in summer and winter.
The ventilation box, which is located at the level of each floor, works as a corridor along the facade, it has an automatic valve that is controlled automatically, to make the ventilation boxes which are located on each floor work as an input or outlet to the air to the vacuum between the façades, or they are closed completely in unsuitable climatic conditions for Mechanical ventilation.
The Building Automatic System (BAS) controls both the ventilation vents in the lobby, and the valves of ventilation boxes , It is fed instantaneously by sensors for information about internal and external temperature, wind speed and its direction outside, pressure in rooms, outside. and in the space of the double façade controlling the opening and closing of windows that overlook the corridor is done manually, the thing Which is considered flaw to the system. This is done in the case of mechanical ventilation. Then, a red light is displayed on the keyboard to alert the occupants of the building to close the windows. The work of the ventilation boxes depends on the pressure differentials on each floor and for each facade.
In winter, when the temperature is below 5 degrees, the valves are automatically closed. In summer, ventilation valves are opened to provide natural ventilation as long as the temperature is more than 22 degrees and the wind speed is appropriate.



Photos showing City Gate building in Germany and ventilation technology

3-3-2- Lighting control function:

Provide non-glare natural sunlight to light the interior spaces, which are mainly used in administrative buildings where times of sunlight coincide with the operation of the building. The benefits of natural

lighting design go beyond the visual comfort of the occupants to reducing energy for lighting, heating and cooling.

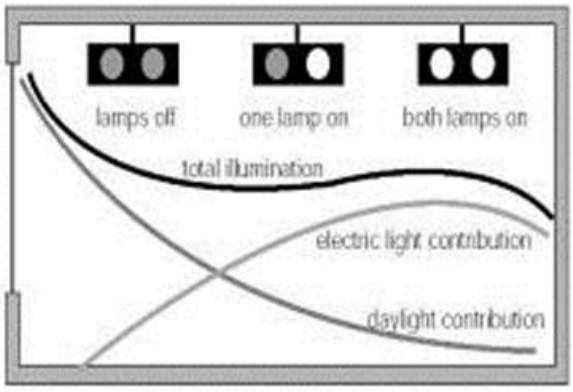
Strategy of the natural light system of the smart envelope: The goal is to interact and integrate with the artificial lighting system to achieve two main objectives:

•Reduce the consumption of the electricity which is consumed in artificial lighting.

•Improved lighting levels for visual comfort.

The achievement of these objectives should not be inconsistent with both ensuring the visual continuity inside and outside, and reducing the heating loads as a result of the increase of solar radiation in the internal spaces (in winter). Therefore short-term strategies that deal with changing the sun's position in the sky during daylight hours are stored within the memory of the intelligent envelope system In order to increase natural lighting and reduce the acquisition of excessive solar radiation to maximize the benefits of energy saving and provide natural comfort requirements.

Daytime lighting control: The daytime lighting system is a secondary system of the intelligent envelope, and there is a great cooperation between natural lighting and artificial lighting. The real benefit of day lighting techniques will only be achieved by controlling the artificial light by dimming it responding to the natural levels of available natural light. Therefore, the most important feature of this system is the response so it is called responsive artificial light.



(Right) lighting system dimmed where the lighting row away from natural light is more light

(Left) The system of opening and locking of the lights - the intensity of the lighting required The sum of natural lighting and the closest possible industrial lighting.

Electrical lighting represents 15% of the energy consumed in offices and administrative spaces and can exceed 50% of the total energy consumption in the building. Electric lighting can generate an additional heat load, which increases energy consumption,

The traditional lighting systems in administrative offices operate at their total capacity for most days regardless of external conditions. Daytime lighting can provide most office activities with sufficient lighting levels, resulting in negative consequences for non-dimming of electrical lighting, causing tension to the occupant eye (because of Excessive light)

Dimming lighting system also offers additional benefits for traditional lighting systems:

a- responsive lighting systems provide 30% more lighting to avoid a decrease in lighting output over time. This system compensates this reduced output automatically to give a constant light level over time.

b- The day lighting control system adjusts and gives the required light level for any space. When the shape of the plan is variable it is easy to adjust lighting levels to meet the lighting needs of each area.

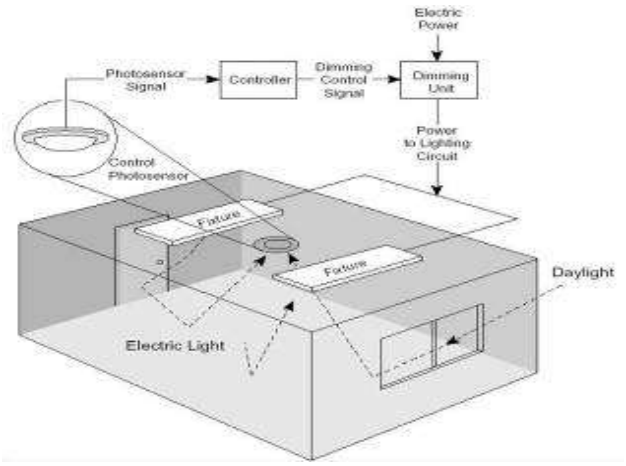


Figure showing work of respondent industrial lighting

Basic Functional Requirements of the Daylight System: The natural lighting system redirects sunlight by the systems that incorporate reflective and adjustable surfaces. Thus it redirects the light and distributes light diffused into the room's space and prevents the incandescent areas. The basic functions of the natural lighting system are:

1- The entry of natural lighting to the interior spaces to get the maximum benefit in case of the intensity of the natural light is equal to the required light intensity within the blanks by adjusting the equipped devices of the facade in a position to allow transmission of the required amount of lighting by the solar tracking function.

2- Increase the natural lighting that can enter the internal spaces in a case that the intensity of natural light is less than the intensity of the required lighting within the interior spaces through the reflective lighting tools which called reflective polished mirror.

3- Reduce the natural lighting that can enter to the internal spaces in a case of the intensity of natural light is higher than the intensity of the required lighting within the internal spaces through the tools of reversing lighting such as: shading devices that enter into the protection function of glare.

All of the previous functions are done with devices that control the deviation of the solar radiation, including techniques that guide daylight into the interior, or are reversed back to the sky. These techniques and devices, that control the deviation of solar radiation to achieve the former functions, are divided into two parts:

•Devices and tools that achieve the function of lighting supply and improve the internal lighting.

•Devices and tools that achieve glare protection function.

The techniques used in the space are usually static, while integrated techniques between glass panels can be venetian blinds with polished surfaces equipped to direct the natural light to the ceiling and can be static or moving, the exterior technique is easy to operate automatically and can have an additional function of protection Of excessive sun radiation or protection of glare.

It should be clarified that natural light does not guarantee visual comfort. Sunlight can cause visual discomfort when unevenly distributed in a room, resulting in high contrasting patterns of illumination, causing the annoying glare that pushes the occupants to close the curtains and turn on the industrial

lighting, Resulting in unnecessary use of electrical lighting. Therefore, the study of the intelligent envelopes went to propose intelligent techniques to control the natural lighting.

- Global examples of intelligent lighting technology (responsive industrial lighting)

a**. The Brund Land Center in Tofland, Denmark**: is a part of a project for United Nations to be implemented for low energy consumption purposes. Before the operation of the building, the amount of potential energy consumption in the lighting was calculated through the simulation programs in the application of lighting technology and control of daytime lighting, where the annual saving of buildings similar to traditional systems are estimated at about 60% for lighting and about 85% for heating.

An integrated system of curtains with double glass has been adopted. The function of these systems is to redirect the sun's oblique light to a reflective roof, and the sunlight is reflected back into the room.

The windows are divided into three sections

1-The upper part of the windows has thin rotary panels that can be rotated so as to allow for continuous damping of the sunlight going inward

2- The middle part corresponds to the level a standing person is vision. and has a curtain with very thin reflectors, to allow visual communication outside and redirect sunlight also to the ceiling and it is controlled by the central control system in the building. During the period of direct sunlight, the curtains are automatically closed to avoid glare inside the room.

3- The lower window is normal with curtains that open manually.

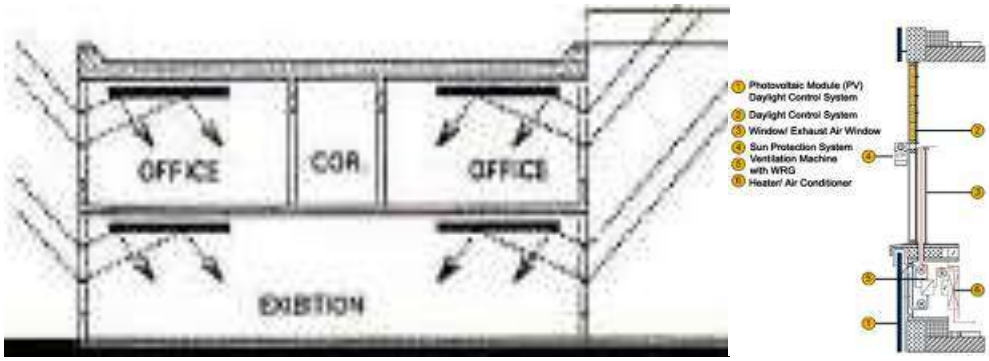
The daytime lighting system allows for transmission about 75% of daytime lighting which prevents the transmission about 20% of sunlight by shading.

The used technique in the example: The intelligent lighting system which is adopted in the building, is designed to integrate with the natural lighting system and to complete the deficit in the required lighting intensity, which is not provided by natural lighting, and all the above is done automatically through the central control system in the building and is equipped with manual control by users, For example, when the user presses (+), the automatic control system takes two steps:

A - Try to achieve the highest level of lighting by natural lighting through entering more amount of natural light without conflict with the visibility through the window, and that is done by adjusting the window curtains that control the deviation of light.

B- In the event that this is not possible, the industrial lighting shall be opened in the amount that achieves the required intensity.

If the intensity of the daytime light is increased in the space, the user may be pressed (-). In this case, the curtains are closed to the extent that the required light intensity is achieved.



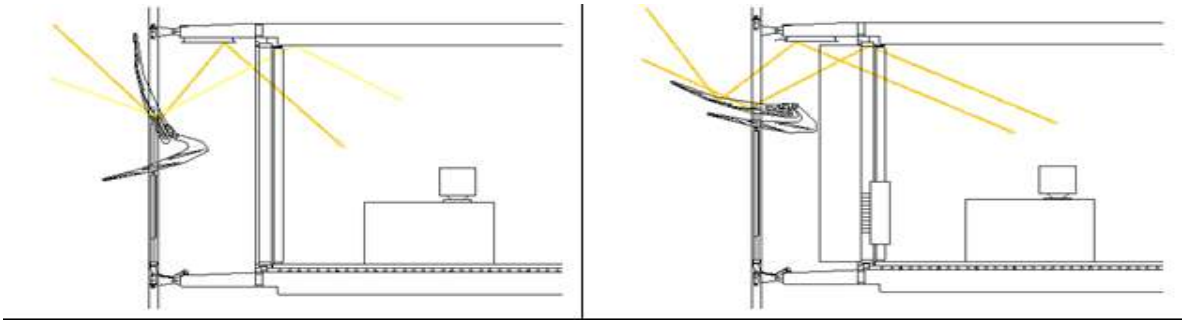
A form showing explanatory sections in the window and the placement of solar reflectors

b- **Wiesbaden Insurance Company Building in Germany**: is four buildings ,that allows for the flow of important East-West wind and thus the main facades of the building are oriented north to the south.

The design of the building is based on the idea of the intelligent facade that provides many options for lighting. The southern facade of the design is characterized by curved aluminum sunshades that act as means of shading and deviation devices of light. These elements on the sun-exposed façade are adjusted automatically to maintain adequate interior lighting in the spaces of the offices. These elements give vitality to the building from outside, they change to match the weather and the state of the sky. While the northern facade was equipped with fixed elements to improve and increase lighting.

The process of automatic control in the position of the moving aluminum sunshades is done in two main forms:

In the case of a non-pure sky, the position of the moving solar sunshades is adjusted in a position to allow the largest amount of light enter the space indirectly, as well as the position of the sunshades is adjusted if the sky is clear in a position to return the excess sunlight and allow the appropriate amount of light to cross Into the space indirectly.



On the right is the position of the sunshades to improve the intensity of daylight, and from the left appears the position of the sunshades to reduce the radiation

3-3-3- Thermal control function: it is the most important functions of the intelligent envelope, and includes functions of protection from excessive solar radiation and insulation to accept or reject heat from outside. This function is associated with ventilation function to change the temperature associated with the transfer of air from outside to inside. The shading function adjusts the sun's rays which execute to inside with maintaining visual contact between inside and outside. As well as protection from glare to improve lighting standards within spaces. The insulation function controls the heat permeability in a way that differs in the smart envelope from the traditional buildings. It is related to the quality, thickness of the materials and the layers of the façade, the thickness and the conduction of heat of each layer, In the smart envelope, the characteristics of the response and dynamic that characterize the smart envelops are added to the previous properties. They can be transformed from insulation to conductivity according to the interface strategies and according to changing internal and external environment conditions.

Shading systems directly affect the building's energy consumption. Studies have shown that the facades of administrative buildings exposed to solar radiation can reduce the building's energy consumption to half if external shading is used compared to those that do not contain shading devices. While the internal shading means save only 20%, which explains the need to study the mode of shading compared to the facade. Thus, shading is important for all types of buildings to protect against

excessive heat of the sun, especially buildings with high cooling loads and buildings with large glass surfaces such as most administrative buildings.

Traditional fixed systems can not adjust shading in the situation directly facing the sun. While moving intelligent systems can be modified to respond to changes in altitude and changing sun conditions throughout the day and in different seasons, allowing for optimal shading. The double-glazed facades are characterized by the possibility of working in many options, where you can choose between external and internal shading and glass layers.

Shading control: Based on the principle of checking the following functions: Measuring the state of the sky - Determining the mode and condition of shading devices - Protection of direct sunlight - Raising the bottom of the curtains in case of direct sunlight does not cause a problem - Allow users to control the system - Ensure that the shading devices respond to the specific position in a suitable time (periodic measurements) - Re- previous program..

Possible options for shading mode: There are Three positions compared to the facade:

a. integrated Shading means between the layers of the facade
b. Internal shading means.
c. External shading means.

The preferred choice among the three positions is the middle of the glass panels, especially which non shut closely, which can be opened for easy cleaning and maintenance. So The outer curtain defect is avoided by the maintenance and cleaning difficulties. And the defects of the internal curtain are avoided, whether the possibility of impedance or lack of efficiency in the solar thermal control of their presence in the space.

Different modes of shading compared to the facade (external - compact - in).

-External shading controls: Horizontal sunshades for the highest windows on the sun-facing walls are the most common in external shading. Vertical sunshades are also effective when windows are directly facing the sun. The advantages of external shading are the reduction in cooling loads, The thermal comfort of building occupants, reduce glare and increase the richness of exterior architectural design. While the disadvantages are to increase total cost and increase maintenance and must be coordinated during design to fit the windows that are running.

Example: BMW building is located in Bavaria. The building is mainly used to train BMW staff. The main design idea is to ensure that the occupants of the building enjoy natural light and ventilation so that they do not experience of excessive heat or solar glare during summer months.

The design solution is based on the integration of a range of overhead lighting systems, natural ventilation and constant solar shading sunshades to control thermal acquisition and sun glare. As well as the use of moving external sunshades to shade the southern facade to be able to track the movement of the sun through an automatic control system ensures maximum illumination throughout the day. These moving sunshades cover about 1000m^2 of the southern façade of the building.

Images illustrate the shape of the sunshades

4- Conclusions and Recommendations: It was found that:

- Due to the multiple problems in dealing with the concept of intelligence in architecture and the diversity of its interpretations, it is decided in the research the closest concept of the intelligence, which gives the intelligent systems a set of characteristics that distinguish them from other traditional patterns namely the ability to adapt to the environment and response based on cognition, logical and appropriate action and control automatically, Integrated with other service building systems, contribute to energy conservation strategies and finally contribute to improving the quality of the internal environment (ensuring thermal and optical comfort) and thus improving the efficiency of occupants of the place.
- The systems of lighting and air conditioning are the two systems that have a direct impact on the standards of internal comfort and consumption of energy, as when HVAC systems and electrical lighting achieve the requirements of environmental and visual comfort, if the design of the outer envelope is good to limit and saving in consumed energy. They have both traditional and efficient (intelligent) patterns, and the traditional style of lighting and air conditioning systems is often intensive consumptive of energy in administrative buildings throughout the occupancy period, unlike the smart mode. This has been demonstrated through analysis and simulation.

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