

# Windows concept between yesterday and today and its impact on buildings design

**Dr. Nawal Al Sanafi**

College of Basic Education. Public Authority for Applied Education and Training. State of Kuwait

[nalsanafi@yahoo.co.uk](mailto:nalsanafi@yahoo.co.uk)

## Abstract

Since man has lived inside caves, he is looking for light to allow him to see full and clear, so it was found in some caves in China and Europe, especially Turkey, they dug windows in mountain caves that turned into homes for them. And with the growth of human awareness of the construction process, he was able to develop his design and engineering for windows by designing them and putting artistic and decorative touches on them to increase the beauty and makes the building more valuable, whether a house or a place of worship, a mosque or a temple, or even public buildings. With various types and effects as well as implications of the windows, some most economical and energy-efficient windows are one of the top-rated and important considerations for both new and existing homes. These energy-efficient windows are responsible for the heat gain and heat loss through windows and account for 25%–30% of residential heating and cooling. The selection of new window designs and implications for newly constructed house or office space or to replace existing windows, it's important to know different between choices and what houses really needs to keep it necessary hot or cold for specific weather requirements that work best in your climate. Also in this research, it discusses the lack of privacy in some window designs is addressed and the opinions of some homeowners were surveyed on this issue.

## Keywords:

Windows designs, Modern windows designs, Latest window designs, outdated windows, Types of windows, Impact of windows on interiors.

### ○ Aim of the research:

Discussing the effect of window design on the building and people related in this place.

### ○ Research importance:

The importance of this research lies in the lack of privacy in houses because of using unsuitable size /place of windows which leads to discomfort in most houses, Loss of energy due to the need for cooling or heating, in addition to the lack of studies in this field.

## Research field:

Interior design; architecture.

### ○ Research Methodology:

The research methodology is the method that is followed to achieve the objectives of the research, and the research seeks to get to know a historical overview of the windows and their impact on the comfort of the users of the place in terms of providing adequate lighting while

enjoying the necessary privacy for individuals. The research also aims to reach the impact of window design on buildings, and to achieve this, the descriptive analytical approach was used to overview opinions of a random sample of homeowners were also discussed, and facts were presented about the research problem to explain it and determine its significance. By providing all these facts, the aim to reach a suitable design for the user, by presenting some models of buildings from different countries, including Kuwait, were presented in a different way from the usual to provide natural lighting and privacy for their users.

## 1. Introduction

As populations develop, there may be a growing need in distinctive international locations and cities to adopt a vertical fashion in urbanization considering confined land, which necessarily approach more hobby inside the observe of multi-storey buildings and their very own necessities, that have become a vital a part of the housing gadget inside the modern urban environment. visible privateness is one of the simple needs of the occupant of his residence, whether the living is independent or a unit in a multi-storey residential constructing, that specialize in requirements associated with visual privateness, which includes preceding mechanisms in the field of visible detection dimension and space notion to become aware of the great design alternatives to home windows in terms of visible privacy of the indoors space. The importance of studies is pondered in supplying a socially sound housing environment and improving its visible picture via presenting layout options through which citizens can avoid distorting the general layout of the building and its facades by means of including treatments that don't fit the overall layout or through closing the citizens' home windows most of the time to decorate visible privateness. The most probable and obvious factor that should be considered at first, is Natural light. (Zomorodian Z S, 2016).

## 2. Previous Research

A research study conducted by Lies Vanhoutteghem (149-156) and his research fellows about Impact of window design on energy, highlighting the needs of window designs with different implications, daylighting, and thermal comfort for the houses in residential areas. Their research study has discussed suitable window designs and solutions as being the decisive manner for the design of zero-energy solutions for the buildings and providing a healthy and comfortable environment within the houses. Their focus was to discuss a relationship between size of the windows, orientation of the windows, and glazing aspects of windows for different rooms within a house in Danish societies.

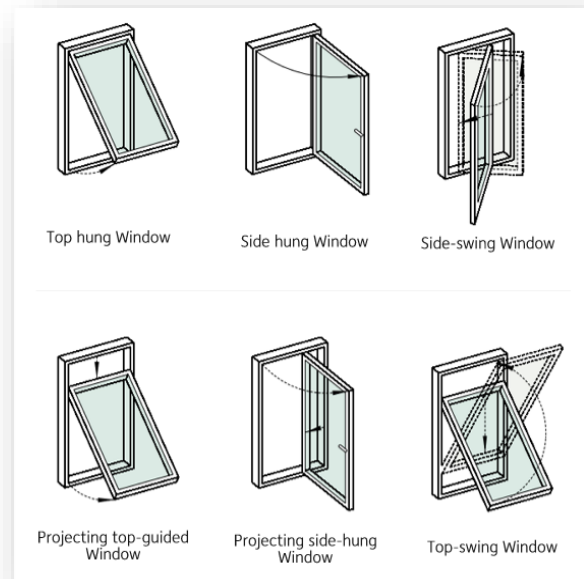
They discussed how different window designs can affect interior space heating demand, how it can affect in daylight and how it can contribute to thermal environment of the houses. The Danish society believes at building and constructing houses with open and spacious rooms illustrating the light effects and consuming the daylight more often to save energy and build better health of occupants. So, with this research study, they combined the effects of design parameters as according to the interior design's aesthetics and together with the management of minimum space demanding enough heating to provide better solution for space coziness utilizing the daylighting providing comfort to occupants.

(Figure 1) They discussed another aspect of managing windows in south-oriented rooms as to be designed in a way that it prevents overheating, providing optimum solution. However, they suggested better management of space as well. Furthermore, they suggested glazing with solar coating could be the alternatives to dynamic solar shadings. They discussed the room geometry being the basic for placing windows at certain space and positioning at certain space to give aesthetic look. Their research was mainly aimed at placing windows at right positions to utilize sunlight with its full potential (Lies Vanhoutteghem, 2015) (149-156).

Here is another research study conducted by Soojung Kim (1424-1431) and his research fellows on the topic of assessment of the Impact of Window Size, Position and Orientation on Building Energy requirements. They discussed improvement of energy efficiency of buildings; mostly houses with residential purposes, where windows can play a significant role because they can divide or manage the energy load well. Though various research has already discussed energy efficient window design, yet there is a need to analyze the impact of windows' size, their position to righteously inlet sunlight, and orientation of the energy efficiency (Niewitecki, 2017).

So, for this purpose, they took an example of family house, discussed it with different house design scenarios and varied it with different window sizes, position of the windows, and orientation of the windows. They instill the calculation of the total energy load and automated it with different Green Building aesthetics. So, as to maximize the effects of windows, they emphasized on placing them at right spot and save energy solutions, utilizing the natural energy sources.

They used their results and discussed how windows can be positioned with different orientations and how it can work out the energy load just by changing the position of windows in each orientation. Their results have proved them right that if windows are placed at right position in buildings it would lower down the load requirements whenever the windows are placed in the middle height in all orientations (Soojung Kim, 2016).



**Figure (1). Different shapes of windows to solve each room needs( homevary.2020)**

### 3. Beginning of windows

The window is a hole in the wall, used to introduce natural lighting into the interior of the building, as well as is largely used (especially in our Arab countries) to ensure natural ventilation. According to many international architects, the window is the most important architectural element of the building, as it is the main element of the facades and will be the first architectural element to make an impression on the same visitors to the building.

They began in the form of open vents to secure lighting and ventilation, or arrows out (Figure 2) and sometimes some animal leather pieces were inferred to achieve proper heat insulation at night. In the Middle Ages, wooden glazes were added to the windows from the inside, making lighting and ventilation easier to control. This continued until the glass was invented and used in the windows for the first time in the form of small glass plaques connected to each other in Roman architecture, and these plaques, interspersed with bronze strips, formed the beginning of the windows we know of our time. Many international glass manufacturers still offer this form to their customers.



Figure (2). Castle Arrow Slit or Arrow Loop from inside castle (castlewales.2009)

#### 3.1 Types of windows in the past

Windows can generally and initially be divided into two main sections, the first section is the regular windows that are on the wall on the side of the building, and the second section is very similar to the first section but is at the top on the ceiling and is called Roof light or Sky light.

The main difference between these two types lies in the amount of lighting that is allowed in each. The first type depends on the amount of lighting entering the height of the ceiling, where it increases and decreases by decreasing. Since high ceilings could not be built in ancient civilizations, this type offered very limited lighting compared to the lighting provided by the ceiling openings, which do not depend on the height of the ceiling in their spread, and the ceiling openings were used to illuminate places where the lighting of regular windows is not long.

The most common windows in the houses, known as horizontal windows, are at the top of the wall to give better lighting to spacious, high-ceilinged spaces, but the natural development of this type of window is to make them connect to each other, the problem of a whole bar that sometimes wraps the building as the famous architect Le Corbusier was one of the most famous advocates of this form of windows. These windows appeared in the 19<sup>th</sup> century because of the need for better lighting for workers in English factories, and with the emergence of this type, a new construction system was needed to provide hard support for these windows. Once again, the natural development here was the extension of the window along the façade from top to bottom, and it was modern construction techniques that helped to create this type of window, and some windows were wrapped around the corners of the buildings when construction techniques allowed it. This system of windows became global after being used as a standard system for office buildings. Finally, not in historical order, the hard windows come. They are

very similar to horizontal windows but differ from length to width. These windows appeared in the 14<sup>th</sup> century but were not popular until the 18<sup>th</sup> century when they became the main window in Georgian Caucasian architecture.

Entering the natural light, windows have a basic purpose behind their orientation that these are the only thing that matters when it comes to the amount of natural light entering or leaving the room. There might not be a consideration of the size of windows, but rather the important thing is the direction of the windows. Either these are directed towards sunlight or directed away from the sunlight. For example, rooms facing north will receive less natural light throughout the day and requires to be designed in such a way that they capture and retain brightness.

Larger-sized windows are one of the effective ways of capturing natural light, but another option is there that you can install a new set of windows that are less affected and irrespective of the orientation of the frames. A more panoramic set of windows, for example, a wider window can open even the darkest room (Enedir Ghisi, 2005). If your existing windows are in good condition, you can also opt for ways to reduce the energy loss through windows and can make your home more comfortable and cozier as well as topped up with your requirements. On the other hand, big windows mean also less privacy.

Privacy as part of the security needs comes within Maslow's hierarchy (Figure 3) in the second order of human needs after physiological needs directly, which confirms the sense of security and privacy is an innate requirement that a person seeks regardless of his culture and religion, and although the degree of seeking privacy varies from place to place, it remains a basic requirement.



Figure (3). Maslow's hierarchy of needs explains human needs (insights.2022)

## 4.2 Types of privacy

Privacy is classified into three types:

**4.2.1 Visual specificity** which is human being has the possibility to carry out his various life activities in a timely manner without anyone seeing him like taking a bath and wearing clothes.

**4.2.2 Audio privacy** is person can carry out his/her various life activities without passing on his voice to others.

**4.2.3 Intellectual specificity** is engaging in intellectual activities without bothering others.

### 4.3 Privacy levels

The first level is at the level of only one individual so that he engages in an activity that cannot be seen from others. The second level so that a person engages in an activity that can involve a person close to him, whether family members or friends. The third level to be at the level of a group of close individuals such as family members or co-workers. The fourth level general at the level of strangers and dealing between members of the community. Therefore, the internal spaces of the dwellings can be classified from the point of view of privacy based on the following (Figure 4):

A general space that allows all people to be present or use it as an elevator, stairs, and entrance in the buildings. Half- general space - half-private and allows certain people to be present and use it as sports clubs where only members are allowed to use it. Private space allows only specific individuals to use it as bedrooms, and a very special space that allows only one person to be in it like a bathroom during use.

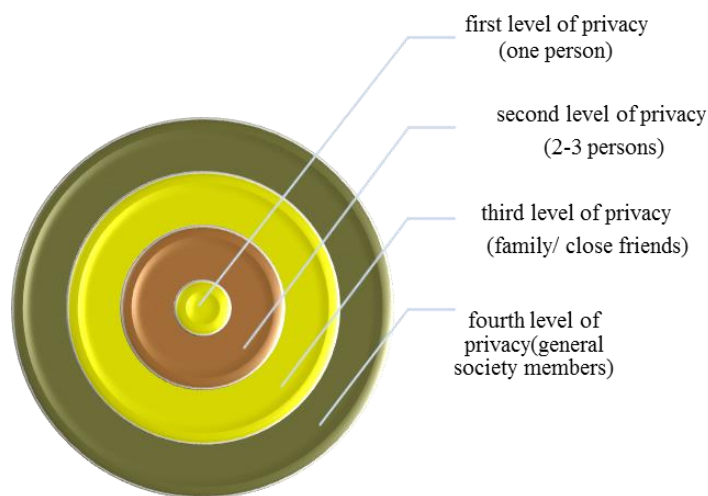


Figure 4. Human privacy levels chart (made by the researcher)

### 4.4 Privacy in Islamic cities

The concept of privacy differs in Islamic societies from European societies, as privacy in Islamic society means a balance between the privacy of the individual and the group, and this does not mean isolation or separation, but rather that this balance achieves social communication.

Rather, this balance achieves the necessary social communication so that privacy is a tool for regulating this communication (Figure 5). The traditional built environment was not governed by building laws and engineering arithmetic relations as in the current era but was based on respect for the traditions of life and the basic needs and functions associated with the surrounding

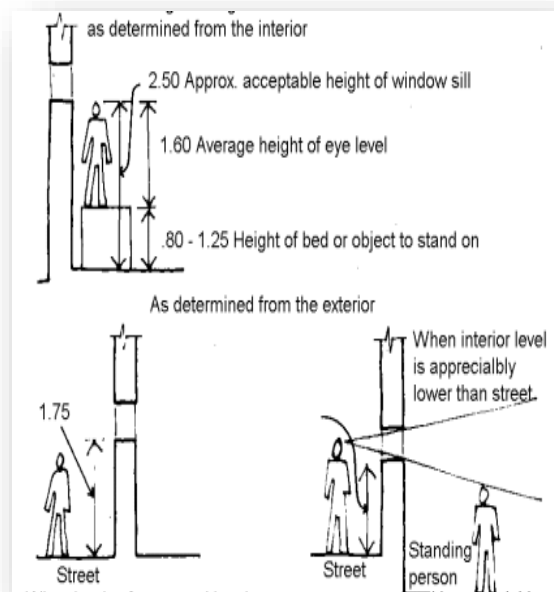


Figure (5). Traditional Islamic window height guidelines in Arabic cities as perspective of privacy (encrypted.2014)

environment of the inhabitants. The construction process was organized according to three factors: the social structure, defense requirements and economic needs. Despite this the orientation, but privacy is one of the most important principles that formed the architectural thought in Islamic architecture, and this principle was achieved internally, externally, audio and visually.

In present time, in case with larger groups of windows or floor-to-ceiling models, the right window design and aesthetically bound options of windows can help emphasize a natural daylight, and rather opting for the bad window option can have the opposite effect (Yanyi Sun, 2020).

#### 4.5 Classification of classical windows and their exposure

There are different types of windows (Figure 6) are available based on framing material, location, design, operational movement of shutter, position, casement size and shape, casement material, manner of fixing, aesthetic purpose, etc. The window is primarily split into two parts, Window Shutters, Window Frame. There are 23 types of windows used for houses around the world, we will discuss some of them next:

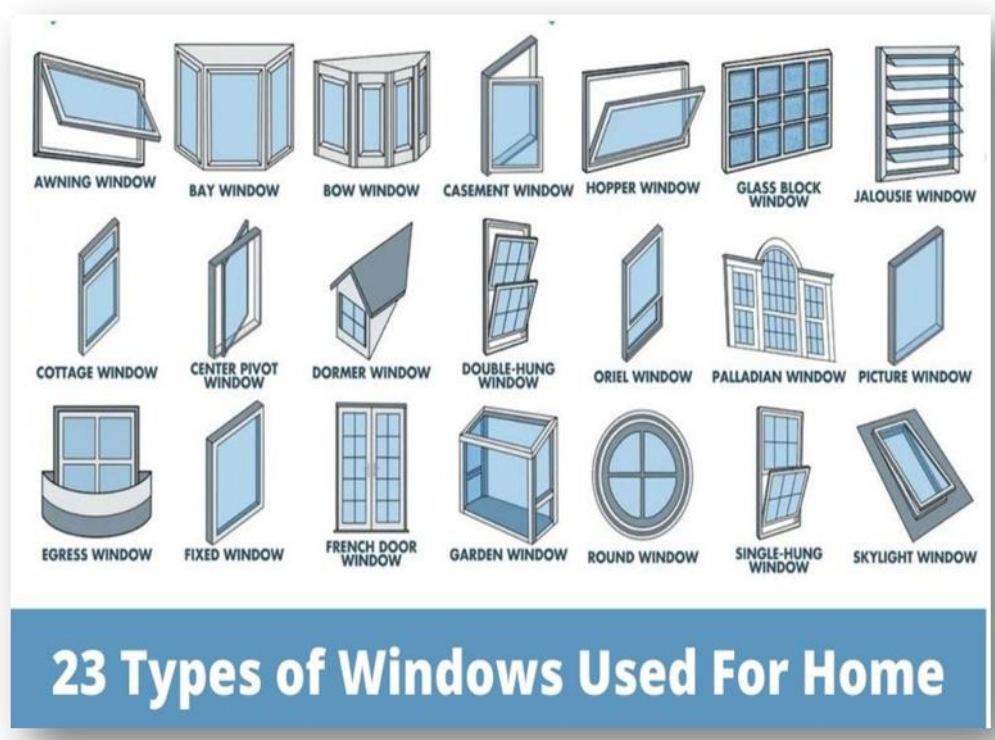


Figure (6). Different solutions of windows to solve the need of each room (civiconcepts.2022)

**4.5.1 Single Hung and Double Hung windows:** These are two basic and simple types of windows. The only difference between the two is that in Single Hung windows, the upper window panel is fixed and the lower is movable. Whereas, in Double Hung windows, both upper and lower panels can be lowered, raised, and tilted. Single-hung windows can cost 20% less than double-hung windows.

**4.5.2 Skylight Windows:** These are meant to provide more daylight. These are installed in the rooms that are built across the middle of the house and have no side windows, so the skylight

windows allow natural light in from above. Some of these skylight windows can be opened and closed to allow ventilation.

**4.5.3 Bay Window Style:** This is a classical type of window design that dates back to medieval times. These are projected out of the house. Bay windows are installed with angled or straight frames that are built out of the exterior wall. These types of windows are accompanied by the perfect spot for seating known as a window seat for gazing at the view.

**4.5.4 Boxed Garden Window:** These are typically kitchen windows and are meant to provide you a little Greenhouse Corner. These windows are accompanied by shelves accommodating as many plants as possible. The garden windows are a healthy option to come across the taste and blend of fresh herbs and plants into your home, improving the air quality as well.

**4.5.5 Port Hole Window:** These are the perfect solution to let light in while maintaining your privacy. So, these are mostly installed in washrooms or dressing rooms. Mostly the tub room or woman cave has a porthole window located high up on the wall, letting enough light in, and giving the confidence of privacy as well.

**4.5.6 Egress Window:** Not everyone has a concern about beauty while replacing or installing a new window into their house. So, this window design serves the security purpose. These windows are installed in the upper part of your wall, through which you can climb out in the case of an emergency. If you have a basement in your house, then an Egress Window is a must.

**4.5.7 Custom Window:** If you have a replenishing outer view then opening your home with custom windows is a must. Hiring an interior designer will do this job for you. So, that there is a mesh of the outside view with the inside decor. Custom Windows might be a way to increase your expenses but will give you options, so you won't blow out your budget.

**4.5.8 Storm Window:** These are exterior windows that add a protective layer to your current ones. You need to install these windows or shutters if you live in an area where a storm hit badly. The people living in Florida know the importance of having good storm shutters and storm windows. This might be more exciting to design other parts of the home and selecting the right windows might be a boring task. But remember, cozy and replenishing windows can change the whole look of your home design and can add marvelous beauty to your home.

#### **4.6 Windows in the State of Kuwait**

Windows in the dwelling are an important architectural element, however this element did not receive sufficient attention from designers as well as engineers, that the function of the windows has changed significantly in models or old traditional dwellings (Figure 7) and modern dwellings that use air conditioning, so, the windows were an important element for the ventilation of the dwelling where these openings are placed in a practical way to be a stream of air inside the dwelling.





**Figure (7) Traditional Kuwaiti House Model shows the old windows of Kuwait-Kuwait Museum (kuwaitlisting,2014).**

The openings were placed over the windows openings to exit the hot air and the lower openings were intended to enter the cold air and are usually opposite because of the ease of movement of the air current (Figure 8). In the past, windows and windows had an important goal: natural ventilation as well as lighting, and the openings were often not large because of the heat they could enter, and they did not have another goal, such as enjoying the exterior views due to the nature of the customs and traditions of the conservative people of G.C.C countries, but the entry of air conditioners as well as the change of construction methods radically changed the function of windows and openings and housing became totally dependent on Ventilation and industrial cooling make housing very expensive. Unfortunately, architects and designers have not been able to find solutions that benefit from the ideas of the old buildings that prevailed. The total reliance on mechanical and industrial solutions does not serve sustainable architecture, the buildings have become concrete blocks fully dependent on electric power that drains the resources of the citizen, and therefore it is necessary to return to architectural solutions that benefit from the climate and the surrounding environment, that changes in the design of housing went through changing stages, the construction was initially primitive either mud or stone and then began to shift the transformation It comes to the reinforced concrete and then entered various means and alternatives in building materials until the Kuwaiti dwelling became materials that have nothing to do with the surrounding environment and during this change windows or windows were items that were modified and changed and the use of very modern materials such as glass, aluminum, iron and stainless steel but materials that emerged over the past few years such as plastic or fiberglass and improved the quality of glass and the use of glass and structured



**Figure (8) Traditional window of house in Muharraq, Kingdom of Bahrain - photographed by the researcher**

Double or Triple-insulated glass (Figure 9) as well as other more isolated types such as glass containing reflective materials, in any case the continuous development and change due to the openness of the construction market to construction markets around the world. Every day there is a diversity and change in the materials used in the windows where the technology entered the closure or opening of windows remotely as well as colors, shapes, and types of glass, yet the architects were unable to benefit from modern materials and their applications in forms that serve the dwelling and provide solutions to reduce energy or provide comfort to the population better.

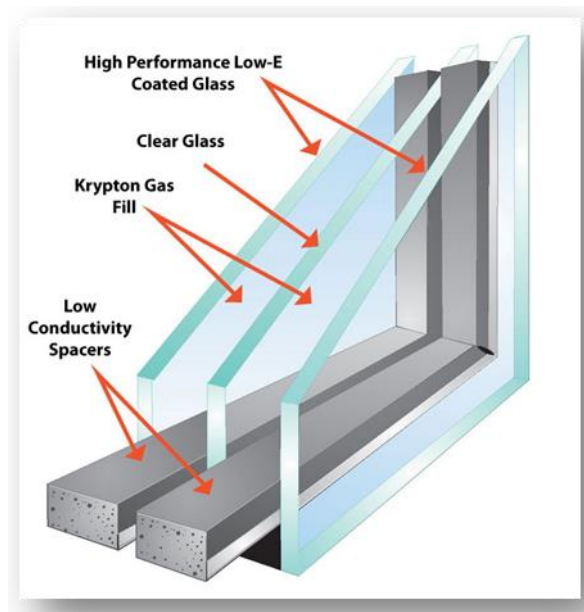


Figure (9). Triple-insulated glass to isolate indoor temperature (royalty windows.2022)

#### ▪ 4.7 Opting for windows that complement the room

Architectural knowledge and experience can plan out the design of buildings considering the space where windows will be placed. He/she can decide whether you need to top up your voluminous rooms with benefits from clearstory windows high above the ground or multistory windows. Smaller rooms can take advantage of plentiful sunlight through these single-story or multistory windows and can have better views with windows. It's better to choose a style that consider room's best features (Figure 10) (Al-Tamimi Nedhal, 2016)

#### 4.8 Modern Windows

Trendy modern windows: Plastic windows quickly became an integral part of modern architecture. Plastic windows are ideal for residential premises, private homes, as well as for many different offices and institutions. So why are old wooden windows usually replaced with plastic ones?



Figure (10). windows from roof to floor could provide more light especially if the room located in the south side (denfair.2017)

First, plastic windows are highly airtight structures, capable of excellent sound and thermal insulation. Therefore, in the house with new plastic windows it will be much warmer in winter, and with closed windows you will almost not hear any sound from the street.

#### 4.8.1 Modern designs provide sun light, view, and privacy

There are some success examples of buildings provides sunlight beside privacy around the world such as:

##### Project 1:

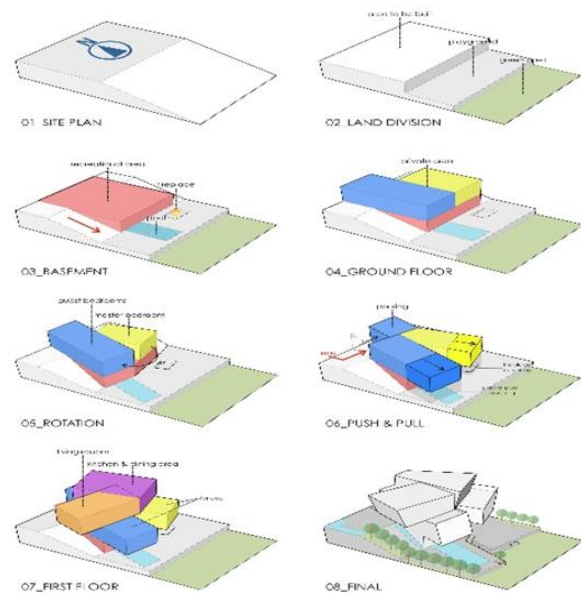
A Project is in Mosha (Figures 11.a.b&c), Damavand, 60 Km from Tehran at 2400 meters The land area is about 600 m<sup>2</sup> with dimensions of 30 x 20 meters. The houseowner ask for a design with lot of privacy especially in windows whether from neighbor's houses or from each room. As it shows each window had its own privacy which any person who stand in any window won't expose the privacy of the person who is standing next window.



Figure (11.a) Private villa, Mosham Iran (cantilever house.2022)



Figure 11.b & c different elevations of Private villa, Mosham Iran(cantilever house.2022)



##### Project 2:

Another Project is an Elderly care center in Portugal (Figure 12a &b). Its main ensuring the well-being of the patients as a priority. utilizes the minimum space for the required functions to fit within the area of land available and maintain a connection to the existing building. the concept is based on this principal and aims to provide a very user-focused experience. the volume dematerializes itself through the projection of rooms outward, making a remarkable

façade and forming a special sculptural help users to have their own privacy especially windows.



Figure (12 a & b). Elderly care center in Portugal(arqa.2019)

### Project 3:

This project is CORE Modern Homes (Figure 13). It's about a 7-unit townhouse, which explores the potential of “spatially oriented apertures” that maximize light while creating a new element of visual interest. The street facing windows reference an inverted model of traditional bay windows, which are found in much of An example of a Toronto's Victorian house that shifted their positioning, creating a unique façade.

In Kuwait, with lack of lands, houses built next to each other makes neighbors exposed their privacy so lately many homeowners design their houses trying to have more privacy especially when using windows.



Figure (13). CORE Modern Homes - Toronto, Canada(architizer.2019)

### Analytical study in Kuwait:

People have become aware and daring to abandon prevalent designs, which force their residents to close windows throughout the evening so that they are not exposed to view from the outside. Therefore, a group of houses appeared in Kuwait that deviated from the norm with different designs that consider their residents' need for privacy, including the following:

#### Case 1:

This Villa was built in Al Salam area in Kuwait on area with 500-625 sqm. This L shaped plan of the villa encloses within it a spacious garden, which is directly accessible from the main

reception space. The first floor contains four large bedroom suites surrounding a sky light daily living space and open kitchenette to provide the house with day light and to make up deficiency of windows (Figure 14). The window designed to be narrow to provide more privacy but only in the front façade, but as its shown on the side of the house there are windows can be exposed by neighbors.



Figure (14). Plan & pictures of Al Salam area Villa, Kuwait(archdaily.2016)

### Case 2:

This project is in Al-Adilyah, Kuwait with a plot area of 1000 m<sup>2</sup>. The rectangular plot has neighbors to the east and south in addition to a pedestrian alley way along its longer northern edge (Figure 15). A community garden is located across the street from the western side's shorter street front. The massing is designed to seem like a slice of cake, with a triangular wedge put into the plot and tilted to enhance privacy from neighbors to the east and across the street. The home's views and main frontage are also subtly oriented towards the garden across the street thanks to the slanted border. The design of this house is similar to the design of case 1 villa, except in this villa the occupants add a lattice shape sunscreen on windows whether to illuminate sun glare and to provide privacy to occupants.



Figure (15). Plan & picture of Al-Adilyah, area Villa, Kuwait (archdaily.2016)

#### 4.9 Smart Glass Windows

Given the important and key role of windows in any building, it has been prolonged by the wave of global intelligence and has gone from being just a hole in the wall with a glass panel, to a highly advanced technological tool for controlling light and heat, rationalizing energy consumption, and making the most of the renewable and clean energy surrounding us. Known as Smart Glass Windows, this type of window has great control over window transparency (Figure 16), where it changes color automatically) based on the temperature of the surrounding environment and lighting conditions, which improves energy efficiency. The dark color in the summer months reduces the sun's heat from moving into the building, reducing the need for air conditioning. This is done by controlling the electrical field to which these windows



Figure (16). Smart glass windows can Tints through a full spectrum of neutral gray options to block solar heat and glare (viracon.2021)

is done by controlling the electrical field to which these windows

are exposed, resulting in the degree of blackout being controlled depending on the intensity of the power supply.

These inorganic nanocrystals are blended with special organic compounds that help them disperse into solvents.

Many countries around the world are now encouraged to create designs for more environmentally friendly buildings, and here the importance of designing the windows of these buildings and the quality of the glass used in them is shown, as the use of smart glass saves energy, while not affecting the aesthetic appearance of the building's engineering design. Studies have shown that smart glass windows enhance energy efficiency in construction by up to 70 % in summer and 45 percent in winter, when compared to traditional double-panel windows. This reduces total energy consumption by 25 %, and smart window manufacturer Anderson Corporation says the shift toward smart glass windows, for example, saved \$2.4 million at the Empire State Building in New York after the first year of installation. At the environmental level, this has contributed to a 4,000-metric-ton reduction in carbon emissions, equivalent to the cultivation of 750 acres of pine forests. If we know that buildings in America consume about 40 quadrillion British energy units a year, and this huge amount of energy costs \$400 billion, if energy efficiency is improved by 20 % by 2020, this will save more than \$1 billion. Smart glass market projects are expected to be worth about \$700 million annually by 2020, and the cost of smart glass will drop by 50 % by the same year, with the current cost per square foot of \$100, and with increased global interest in the technology, these windows are expected to become an essential part of architecture and one of the energy saving strategies in the next decade.

#### **4.9.1 Design intelligence**

Sunlight contains visible light and other invisible radiation, such as infrared radiation that heats buildings and heats the dwellings directly exposed to them, requiring the use of air conditioning and cooling devices consumed by large amounts of electricity. Many researchers have therefore sought to develop special techniques to control the intensity of sunlight passing through the windows of buildings and dwellings, where several intelligent techniques have been developed to control light passing through windows that rely on some of the physical characteristics of the materials involved in their installation, the most important of which are:

#### **4.9.2 Suspended particle screen**

In smart future homes everything in the house will be remotely controlled.

Suspended particle displays are known as optical valves and are based on two panels of glass or plastic between which there is a transparent material with suspended particles connected to electricity. When the electrical current passes between the two panels, the suspended particles move and result in a way that allows sunlight to pass through, and when the electrical current is removed, the suspended particles are randomly dispersed, block the light and prevent it from entering, and the order of particles can be controlled or scattered by a remote-control unit.

#### **4.9.3 Crystals are liquid.**

Liquid crystals have been used in the production of some modern computer and television screens and have been used to manufacture smart windows capable of controlling the amount of light in force as an alternative to suspended particle technology. Smart window glass made

of liquid crystals controls the amount of light passing through it thanks to the ability of these liquid crystals to respond to electrical charges, which regularly rearrange crystals through which sunlight can pass through, and when the electrical effect is removed, the suspended particles are randomly scattered, block light and prevent it from entering. Liquid crystal technology relies on materials known as electrochromic, whose properties and capabilities change to block or allow light to pass through a chemical reaction of the oxidation reaction type, where some molecules lose electrons and turn into ions that affect the degree of light passing through the electro chrome layer.

#### **4.9.4 Electrolyte window technology**

Several research have contributed to the development of electrolyte windows (materials used in projectors and systems that control color change), but the most prominent of this research was the work of researcher Lourdes and her research team at the Lawrence Berkeley National Laboratory in America, where she used a type of nanoparticle compound that was included in special window glass (Delia:2013). The research team succeeded in conducting careful control of glass blindness on request, and the research team produced a nanoscale compound consisting of indium tin oxide crystals and used in glass containing niobium oxide. Nanocrystal dispersion is controlled by a weak electrical current, which causes the visible light to change as well as infrared radiation that causes temperature changes within buildings. The glass is an electric pole, and on the second glass panel the second electrode made of lithium is installed, and in the normal case the light and infrared are carried out through this glass like any normal glass, and when an electrical effort is placed on the poles of the glass tablet, lithium ions and electrons that act as charging carriers are transmitted towards the other panel and the nanoparticles are chemically reduced, creating a glass blackout that prevents the passage of infrared radiation. And by modifying the amount of voltage, it's increasing.

#### **4.9.5 Intelligent glass controlled by a remote control.**

Darkness and visible light are also prevented from passing through the glass. The main principle of smart electromagnetic windows depends on the dispersion of nanocrystals and their assembly according to the voltage to which they are exposed. These inorganic nanocrystals are blended with special organic compounds that help them disperse in solvents, without causing a cluster that affects their electrical and light properties. Nano-indium tin crystals have electromagnetic qualities due to exposure to different wavelengths, oxidized and reduced electrochemically, and these processes are returnable, reduced when absorbed into infrared and darkened, and when oxidized they become transparent, and to enhance these qualities, nano oxide crystals and niobium oxide are combined to form a material that can control how absorbable it is to visual light and radiation under visible light and radiation underneath the rays. For an electrochemical glue. The material, which is being produced, is currently being experimented with for use to produce smart windows that adjust the heat and light passing through it. Experiments conducted by Lourdes and her colleagues have shown how controllable this type of smart window is still in testing, but the lithium electrode needs to be disposed of for public safety reasons and another type of safe electrode is used. Researchers at University College London have been able to develop smart windows with a thin layer of vanadium dioxide that prevents heat from moving from inside and outside the building on cold days and prevents infrared sunlight from entering



the building. In addition, it also has the advantage of preventing water droplets from sticking to them, as well as preventing dust atoms from collecting on the outer glass, making these windows partially self-cleaning.

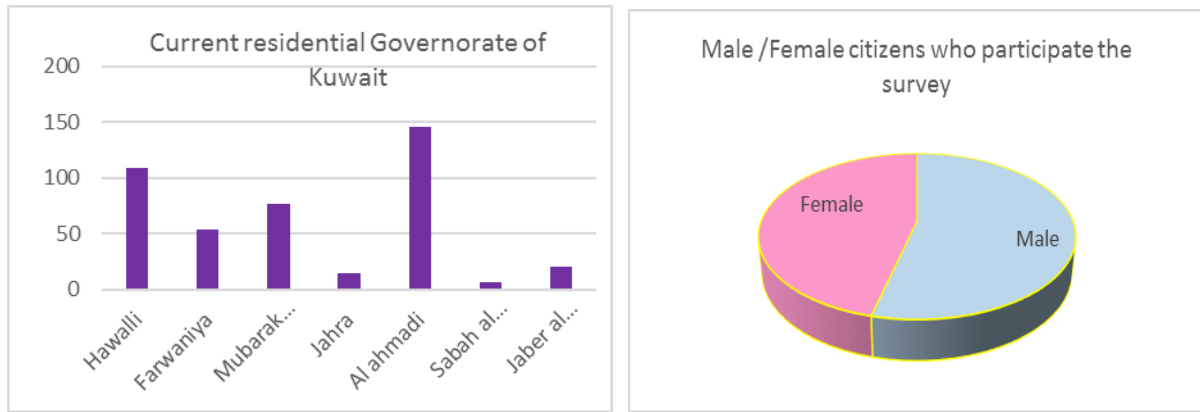
#### 4.9.6 Windows that produce energy

In a related context, smart windows have been unveiled that not only control the light and heat of the sun passing through them, but can also generate electricity from built-in solar cells, or store energy for use by electrical appliances in the building. This great scientific achievement was developed by a team of researchers from Shanghai University of China. Researcher (Yanfang Zhao: 2022) explains that vanadium oxide particles have been used between two polycarbonate panels, where the chemical qualities of this compound change when exposed to the sun and heat. When the temperature is less than 20°C, the material in the window passes light and heat, and when the temperature increases more than 20°C, the window works unlike infrared radiation. On the other hand, researchers used nanotechnology to make windows whose glass changes color as the brightness of sunlight changes while absorbing and storing energy to power electrical appliances at home, such as a TV screen and computer, or to charge mobile phones and turn on alarms. These smart energy stored windows are known as energy storage smart window. They are made from arrays of polyaniline nanowires deposited on a transparent layer that is wrapped in a layer of electrically conductive material. External reflected on the windshield and adjust visual transparency, as well as to reduce the amount of infrared that penetrates Windows that produce energy depending on the degree to which the lighting is manageable.

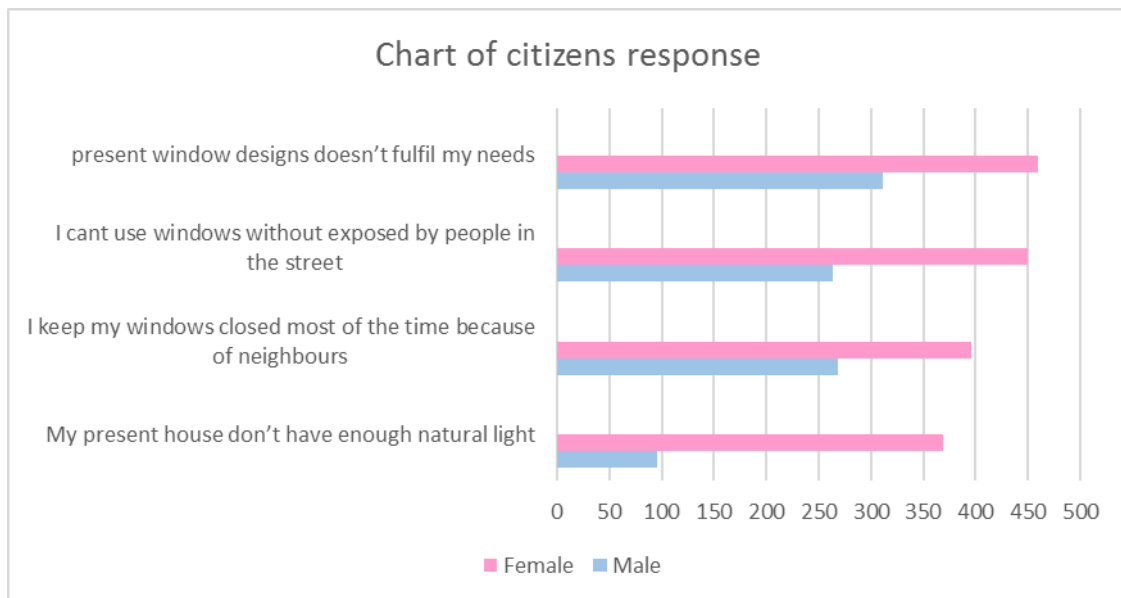
The vehicle's glass in the afternoon. A team of researchers from the University of California, USA, announced their success in developing a new type of ultra-flexible and low-cost plastic photovoltaics that can be integrated into the windows of homes and shops or installed on building facades to produce electricity that can be used to charge mobile phones, tablets and portable electronic devices. Materials scientist (Huynh:2003) explained that a type of plastic that can deliver the electric current known as P3HT was mixed with stylized rods made of semi-conductive materials, then sprayed on a thin film-like base, and placed between two conductive layers, one transparent to pass light, and these two layers act as electrodes, resulting in a hybrid light cell of stylized rods and a polymer less than a centimeter thick. Like the hair of the human body. The efficiency of these photovoltaic cells, Huynh said researchers are seeking to significantly improve their efficiency, as the traditional photovoltaic cells currently in use swallow up their transformative efficiency by about 20 %, meaning that out of every 100 watts of solar energy, the solar cell produces 20 watts of electricity. The new type of cell has an efficiency of only 8 to 9 %. This is a small proportion, but it can be seen as a good start for new technology.

## 5. Survey results

Several questionnaires were distributed been made by the researcher and sent by e-mail to a number of 1000 Kuwaiti citizens, only 479 homeowners had replied with number 258 male, and 221 females randomly selected from different governorates of Kuwait (Figure 17 a, b).



**Figure (17 a, b). Survey participates information**



**Figure (18). Chart of the Citizens response**

As it shown above in the chart (Figure 18), the Females were the highest response about present windows by not providing enough sunlight or privacy, comparing to the response of Males which been the lowest demand of that, being the nature of Males don't spend much time inside houses comparing to females, so they don't feel those differences as much as females.

### Conclusion

- House builders through history had chosen kind and shape of windows according to house orientation, surrounding atmosphere, and according to occupants needs.
- In some cases, modern designs put aesthetic of window design and façade shape before privacy which makes it uncomfortable for occupants.
- Some countries realized the importance of using window shades such as State of Kuwait. Its Research Institute announced the results of the project using window shades for buildings, which proved to reduce energy consumption by 6.7 %. This leads to the saving of about 9,763 kilowatts annually, which enhances the efforts of the Ministry of Electricity and Water to save energy. The results of the institute's studies were concerned with improving thermal performance in buildings, as some of them focused on the materials used in construction by determining the thermal performance of surfaces , walls , studying the types of window glass

and sunscreens. The studies aimed to reach an integrated analysis of the thermal performance of windows and how to reduce the gain. Several variable factors have been identified on the amount of heat gain through windows, such as: the effect of their orientation, the effect of blocking sunlight, the effect of the abundance of natural lighting, the effect of thermal bridges, air leakage, and the amount of the angle of elevation of buildings, indicating to reach typical proportions of glass spaces according to the directions of the facades, and according to the type of glass used, which are the percentages included by the institute in the energy conservation code that is currently applied by the Ministry of Electricity and Water (Al-Anba: 2010).

- Windows must be designed to ensure energy efficiency and provide comfort. Privacy is an innate requirement, although the degree of its pursuit varies from specific society to another according to customs, culture, and religious.
- Using Smart windows are more important in some regions of the world than others, especially in hot countries, as well as in large buildings and high towers in desert areas. The use of ordinary glass will increase the construction temperature indoors to a degree that may become uninhabitable, requiring the operation of air conditioning systems that consume large amounts of energy. Here, smart windows that control heat and infrared as well as human-harmful UV radiation are important, reducing the energy bill, as well as carbon dioxide emissions and other greenhouse gases. The high cost of these windows currently limits their use. But like any modern technological achievement, increased global interest in it will significantly reduce the cost of its production and ensure its widespread popularity.

## Recommendations

The researcher recommends conducting an awareness campaign for those who want to obtain a home building permit by engineers and designers from Ministry of Municipality to explain to future homeowners the need to choose the sizes and directions of windows based on the prevailing weather in the country, the activity in each room, the extent of its need for privacy, and rationalization of consumed energy. An awareness campaign should be conducted also for building designers and engineers to make designs that fit the actual needs of the owners and consider their need for privacy as a priority. The use of technology that helps conserve energy and thus contribute to the sustainability process should also be encouraged.

## References

- Al-Tamimi Nedhal, F. S. F. S. A. A., 2016. Relationship between Window-to-Floor Area Ratio and Single-Point Daylight Factor in Varied Residential Rooms in Malaysia. *Indian Journal of Science and Technology*, 9(33).
- Delia Milliron, 2013. Windows Upgrade. *Nature-International Weekly Journal of Science*, p.p282
- Enedir Ghisi, J. A. T., 2005. An Ideal Window Area concept for energy efficient integration of daylight and artificial light in buildings. *Building and Environment*, 40(1), pp. 51-61.
- Huynh, W.U., 2003. Controlling the Morphology of Nanocrystal-Polymer Composites for Solar Cells. *Advanced Functional Materials*.

Lies Vanhoutteghem, G. C. J. S. C. A. H. S. S., 2015. Impact of façade window design on energy, daylighting and thermal comfort in nearly zero-energy houses. *Energy and Buildings*, Volume 102, pp. 149-156.

Lies Vanhoutteghem, G. C. J. S. C. A. H. S. S., 2015. Impact of façade window design on energy, daylighting and thermal comfort in nearly zero-energy houses. *Energy and Buildings*, Volume 102, pp. 149-156.

Niewitecki, S., 2017. False Windows - Yesterday and Today. *IOP Conference Series: Materials Science and Engineering*, 245(5).

Soojung Kim, P. A. Z. S. S.-F. T. F. B. T. C., 2016. Assessment of the Impact of Window Size, Position and Orientation on Building Energy Load Using BIM. *Procedia Engineering*, Volume 145, pp. 1424-1431.

Yanyi Sun, D. L. J.-F. F. K. S. H. B. R. W. H. L. S. S. T. K. M. Y. W., 2020. Analysis of the daylight performance of window integrated photovoltaics systems. *Renewable Energy*, Volume 145, pp. 153-163.

Zhao Yanfeng, 2022. Fabrication of Al<sub>2</sub>O<sub>3</sub>/CaO with anti-sintering for efficient removal of As<sub>2</sub>O<sub>3</sub> in simulated flue gas: Experiment and DFT study. *ResearchGate*. 307(20):121812.

Zomorodian Z S, K. S. T. M., 2016. The Effect of Window Configuration on Daylight Performance in Classrooms: A Field and Simulation Study. *IJAUP*, 26(1), pp. 15-24.

### Electronic References

www. Al-Anba.com.kw retrieved on 5/5/2022

<https://homevary.com/pivot-window-dimensions-and-standard/> retrieved on 5/5/2022

<https://www.caslewales.com/arrow.html> retrieved on 5/5/2022

<https://www.bcarm.co.uk/insights-and-safety/what-are-your-employees-most-concerned-by/> retrieved on 6/7/2022

www.european-science.com retrieved on 6/5/2022

<https://civiconcepts.com/blog/types-of-windows> retrieved on 5/5/2022

<https://www.royaltywindows.com/window-blog/cost-triple-pane-windows/> retrieved on 5/7/2022

<https://www.estliving.com/defair-discovery-interview-vuue/amp/> retrieved on 5/4/2022

<https://www.archdaily.com/981773/cantilever-house-uc21-architects> retrieved on 2/5/2022

<https://arqa.com/en/architecture/santa-casa-da-misericordias-elderly-care-centre.html> retrieved on 5/5/2022

<https://architizer.com/blog/inspiration/collections/offset-window/> retrieved on 1/5/2022

<https://www.archdaily.com/893358/slice-house-alhumaidhi-architects> retrieved on 7/3/2022

<https://www.viracon.com> retrieved on 3/3