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Investigating the Use of Chemicals in Sustainable Architecture to Save Energy

Golnaz Farjadian[1], Atieh Mollaahmadi[2,*]

Department of Architecture, Najafabad Branch, Islamic Azad University, Najafabad, Iran

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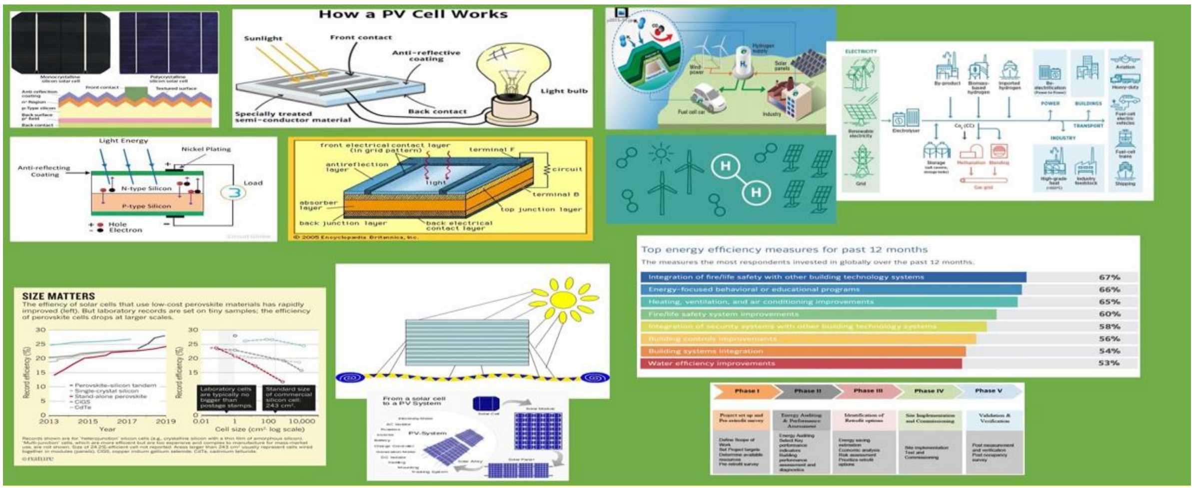
A B S T R A C T

The purpose of using chemical additives is to improve one or more properties in fresh or hardened concrete. Some chemical admixtures are used to improve one property; meanwhile others affect several properties of concrete. On the other hand, some chemical additives affect the properties of fresh concrete, while others are used to improve the properties of hardened concrete. The goal of this article is energy savings in sustainable architecture. According to the forecast of scientists and the IAEA, the demand for energy consumption and production in the future will also increase rapid and worrying. So, from year 1 to 2, the global demand for electricity increased by 2 % to 2 tra-wat and by 2 % to 2 tra-wat. According to the scientists' studies, by year 3, wind power supplies the world's electricity. The principle of resource saving, on the one hand, deals with the proper use of non-renewable resources and energies, such as fossil fuels to reduce consumption, and on the other hand, the control and use of natural resources as renewable and durable reserves is paying serious attention. You can save energy by using new solutions and intelligent building. One of the most commonly used ways of a high-powered energy is the utilization of photovoltaic systems in architecture, including the combination of this system with a building as a photovoltaic building.

G R A P H I C A L   A B S T R A C T



* Corresponding author: Atieh Mollaahmadi
✉ E-mail: Forat. atiehmollaahmadi@yahoo.com

Introduction

The history of using chemical additives in construction is very long. It is known that the Romans used animal fats, milk, and blood to improve the characteristics of their building materials. The use of these chemical materials mainly leads to the improvement of efficiency; in addition, due to the presence of hemoglobin, the blood could produce air bubbles in a way, which improves the durability of construction materials. The Chinese used rice paste, tang oil, and molasses to improve the properties of materials. In Iran, they used eggs, ash from the hammam oven, animal wool, and similar materials to make saroj and improve the materials properties used in construction [1].

The old architects have built masterpieces by using these materials in different historical periods, which might not have been possible without the use of these materials. Examples of these structures are the dome of the Pantheon of Rome during the Roman Empire, which had the maximum height of the dome in its time, and the Abbasid Tabas Arch of the Safavid period, which was the tallest double dam in the world. It has been in its time, and the Zanjan Soltaniye Dome, which was the largest brick dome in the world in its time and is now the third largest dome in the world after Santamar del Fiore and Hagia Sophia [2]. The use of these materials is still continued in some traditional constructions. After the industrial revolution and the evolution of construction methods, on the one hand, and the need for special structures with new features, on the other hand, a new chapter was created in the application of the use of additives. The idea of research and study about additives after the industrial production of cement in the second half of the 19th century and the knowledge of the compounds and the hydration process was initially investigated in scientific and academic centers and gradually their use in the industry became popular [3]. Lubricants, accelerators, retarders, and foaming agents were invented as common chemical additives in the first years of the third decade in the 20th century. The oldest reliable scientific and technical document tells that the lubricant based on naphthalene formaldehyde sulfonate is the primary organic compound that was invented and registered by an American company in 1932, and then during the 1930s and 1940s, the use of other lubricants that they were based on lignosulfonates and became popular [4]. After that, around the 1950s, other organic derivatives such as hydroxycarboxylic, polymer compounds, and fatty acids became popular. Some other additives such as bubblers were accidentally discovered by observing and checking the durability of some concrete surfaces in North America. The story of the discovery of these materials was such that studies revealed that some of these procedures are more reliable against cold and frosty environmental conditions. Referring to the technical documents of the project and carrying out tests indicated that in the preparation of the cement of this section, cow fat was used as a grinding aid in the grinding of clinker. More recent investigations demonstrated that these cements have increased the concrete durability against the melting and freezing cycle due to the production of air bubbles [5]. The publication of scientific reports and research articles on chemical additives began in the 40s, among which the first special report of Technical Committee No. 212 of the ACI Institute in 1944 and the first ASTM symposium entitled the effect of water-reducing additives and control Girish Beton noted in 1959. Iran has always special national programs in terms of geographical scope and environmental diversity in the energy sector. One of the shortcomings in our architecture today (Figure 1) is the lack of a specialized center for architecture [6].

Such a center can be suitable for the arrival of architects, enthusiasts, and students of architecture. The center can be a place for architectural conferences, specialized meetings, review of world architectural works, designing, holding architectural competitions, familiarizing with modern design technologies, planning, and organizing the architectural film festival. It can also work to preserve the valuable architectural works and the works of great architects. The purpose of the present study is to use the modern energy -saving technologies in design and manufacturing. In our country due to the huge source of solar energy, it is necessary to maximize this energy (Figure 2). The use of this renewable energy is very reasonable and can be exploited in most parts of Iran. Sustainable architecture is one of the most important developments in the field of architecture whose purpose is to design based on the principles of sustainability and energy saving. Sustainable sustainability and development is of high significance for designers and architects to reduce environmental pollution and optimize energy consumption. This architecture is in fact a reaction to the crises in today's industrial and modern world. In the present era, the creation of sustainability and development due to the industry problems is very essential in architecture and special attention should be paid [2].

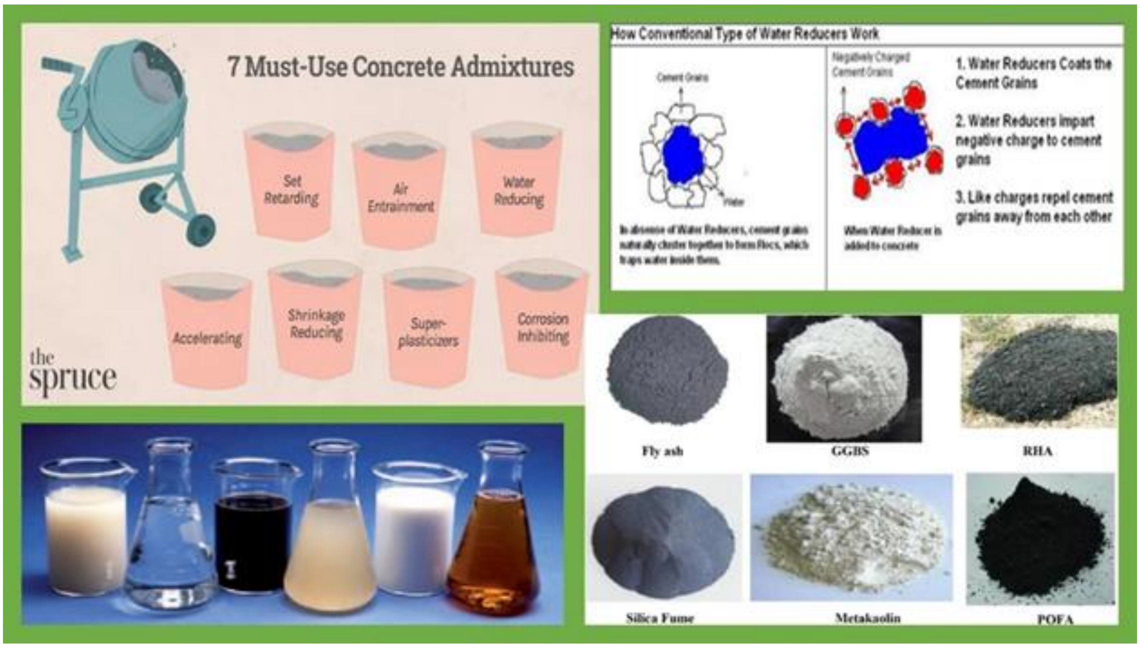


Figure 1: Schematic of the function of chemical additives concrete

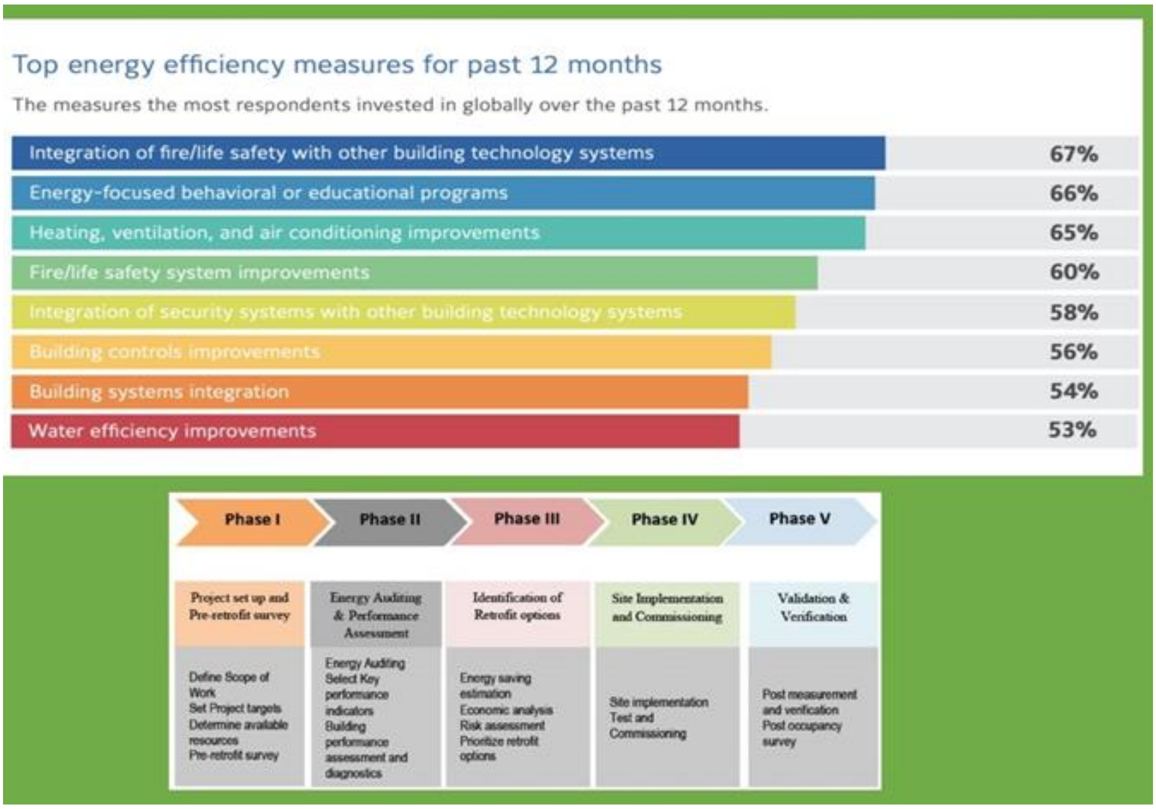


Figure 2: An energy efficiency indicator survey expect to increase investments in energy efficiency, renewable energy, or smart building technology in 2022

This type of architecture reduces the damage caused by building design by energy and environment. Therefore, a sustainable building has the least incompatibility with the environment. Sustainable architecture, also called green design, is unlike the common construction patterns of action and is based on ecological design and nature. Green design is actually a triangle in which energy, ecology, and climate form three.

Materials and Methods

The searching process was done in Scopus, Google scholar, PubMed databases, and by searching with keywords such as "Chemicals in Sustainable Architecture", "Energy", and "Chemical Material" to obtain articles related to the selected keywords [3]. Case report articles, editorials, and articles that were not published, or only an introduction of them were available, as well as summaries of congresses and meetings that were in languages other than English, were ignored. Only the original research articles that evaluated the effectiveness of different drugs in the treatment of COVID-19 by using standard methods were studied (Figure 3).

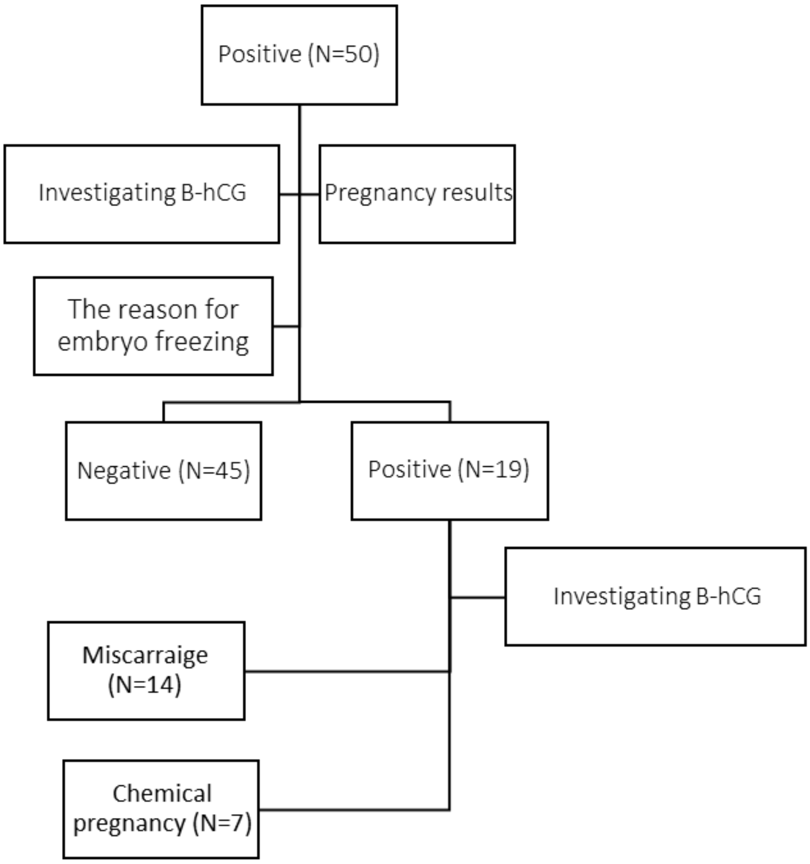


Figure 3: Flowchart of included subjects

Overall goals of sustainable architecture

Observe human life and improve its physical and mental state.
Use materials that are compatible with the environment.
Match and coordinate the environment.
Limited consumption of fossil fuels.
Use natural energies such as sunlight.
The minimum damage to the surroundings.
Reduce carbon dioxide gas production.
Respect the nature and apply the potential in it.
Reuse building materials and recycled materials.
Reduce construction waste production.
Increase the shelf life of the building.

Preventing the use of building materials incompatible with nature [3].

Sustainable architecture is an important evolution in the field of architecture

Sustainable architecture is one of the most important developments in architecture that aims to design the building based on energy consumption optimization and sustainability principles. Sustainable architecture is also called green architecture based on ecology design and nature. Construction that is implemented based on this type of architecture cause less damage to the environment and energy resources and is less incompatible with the environment.

Types of renewable energy

Solar energy

On sunny days, the space inside the building is heated. The heat inside the buildings due to the penetration of the solar radiation energy through the windows acts as a greenhouse, preventing it from getting out, and warming the room.

Plant fuel energy

Green plants convert light energy into chemical energy during the photosynthetic process. Herbal burns can be liquid, alcohol, and gases such as methane. These fuels are efficiently wood balance because the energy source is much less and less space. The animals obtain their demanding food through plants.

Wind energy

Electricity can be made from wind energy. When the air cools, the air shrinks and rushes down, but when the air is warm, the air expands and goes up. Therefore, hot air goes up and the cold air replaces it, which is the cause of the sun called the wind.

Water energy

Water is used to launch machinery. The water mills are made by the river. Part of the blue river flow is directed through the pipe to the water turbines, which moves them, and by the rotation of the connected water turbines, electricity generation is generated. It is appropriate to build a dam in places with steep slopes or high valleys.

Water energy benefits

Water turbines do not use any fuel and do not produce any contamination.

Nuclear energy

In year 2, nuclear energy was discovered by a scientist named Henry Becker. There are currently about 5 nuclear power plants, a quarter of which is located in the US. The plant generates electricity from the heat of the nuclear fuel. The only difference between the nuclear power plants is the type of fuel and its heat. Fuels such as fossil fuels should be burned to freeze their energy, but produce energy in nuclear power plants without burning.

Earth's thermal energy

Earth's heat energy is called heat that is naturally present underground and can be converted into electrical energy. The electricity force obtained in this way is called the earth's heat energy.

Fossil energy

Less than 5 years ago, the first attempts to extract oil were started. The invention of the car and its prevalence expanded in the early twentieth century. The outbreak of World War II to 5 has clarified the importance of dominating oil resources. Oil products such as gasoline are used to operate in-house engines.

Coal and gas coal

Coal is used in factories and locomotives. The Chinese consumed coal about 5 years ago to make copper. Three centuries later the Greeks and the Romans began using coal. Research shows that early British inhabitants used coal for a long time before and before the Roman invasion of the land in 5 BC.

Hydrogen energy

75 % of the mass of materials and more than 90% of the atoms making up the hydrogen nature.

Hydrogen is shown as a chemical element with the letter H and atomic numbers. Hydrogen is a colorless, unpublished element, a two -atomic capacity with high flame properties. Hydrogen is the lightest and the most abundant element in the world and is found in water and in organic compounds of living things. It is capable of chemical reaction to most of the elements (Figure 4).

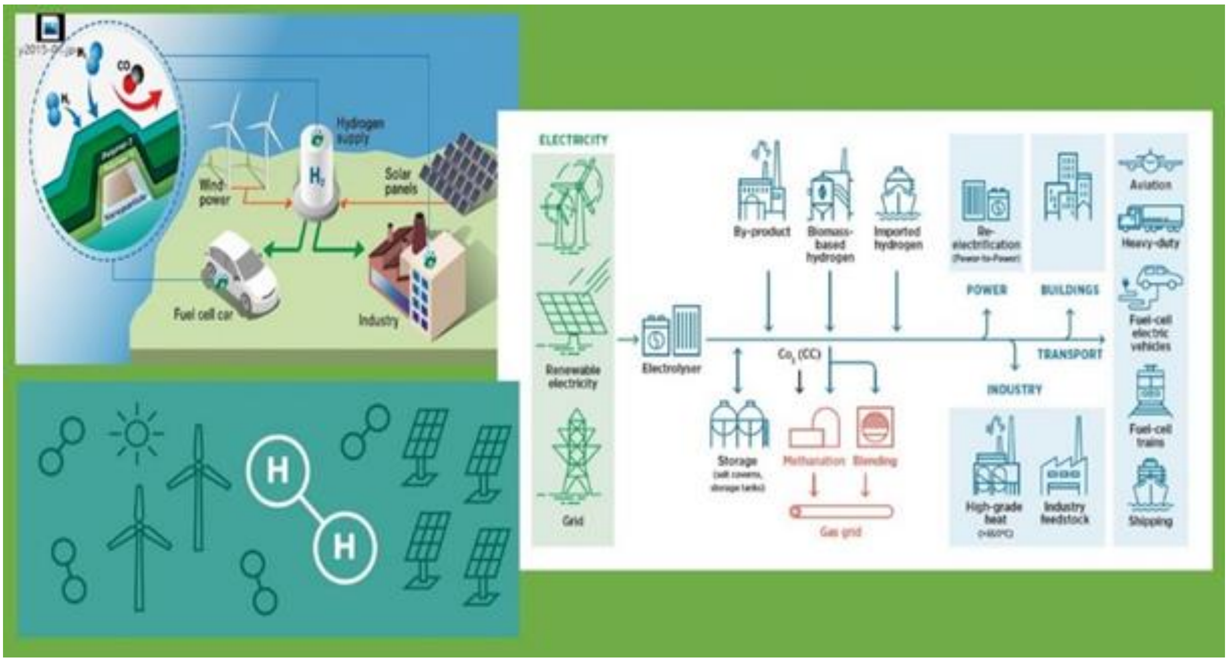


Figure 4: The use of hydrogen as energy storage system

Solar cells (photovoltaic)

The main element of photovoltaic technology is the solar cell. Photovoltaic cells, generally known as solar cells, consist of semi-conductive substances of solid state. Silicon is the most common semiconductor material used in PV cells because of its abundance. Although silicon is a large element and forms a large percentage of the Earth's crust, silicone cells are highly priced due to the construction process and the silicone purification. Photovoltaic cells are produced by the use of sunlight and solar cells and by causing electrical pressure differences in the appropriate semiconductor of electricity. Today, the most effective and cheapest solar cells are a substance called silicism. Sand is one of the most important sources of silicism obtained after refining the crystals of silicism and preparing the plate after being cut. In other words, photovoltaic cells, sometimes referred to as solar cells, are made of sequins that convert light directly into electricity [4].

Orientation of photovoltaic panels

The maximum collection of sunlight occurs when it is collected on direct radiation beams. The best angle for a PV array is essentially a time function of the year with the highest amount of electricity. Hot climates require the most electricity during the summer and for air conditioning, while cold climates require the maximum electricity in the winter and for pumps and fans of heating and lighting systems. Usually, the optimal orientation is facing the south. However, up to 20 degrees to the east or west from the south, there is a slight drop in the system. However, the number of daily loads can affect the orientation [5].

The integrated photovoltaic of the building

Photovoltaic can be used today in existing and new buildings. Its usage in the coverage is very diverse and opens new ways to creative designers. Since the supply of photovoltaic cells is sunlight. Therefore, the cells' location is the walls of the building that have a good ground for direct sunlight and the use of photovoltaic tiles is often the exterior and outer surfaces of the building roof. Photovoltaic cells are made in glass in different colors so that architectural engineers can use them in addition to the main function to beautify buildings. These cells have the ability to pass between 80 and 90% of sunlight. This quality allows windows equipped with solar cells to help keep indoor air cool in the summer, and besides making the facade of the building, they provide the necessary electricity energy [6].

Building facade plates

The views occupy the majority of the shell surface of a building. In fact, a view transmits the first visual sense of the building to its viewers, and the architects of the building also express the ideas and translate the employer's desires in a special language of shape and color. The standard photovoltaic modules can be attached to the existing wall of the building to provide a successful view. These units are connected to the structure without the need for insulation, which is done by a network infrastructure in the photovoltaic modulations. Therefore, photovoltaic systems can be considered as an important part of the building's facade elements. The main face of a photovoltaic layer as a coating material resembles a colored glass. Photovoltaic layers provide the long-term protection against atmospheric conditions and can be cut and prepared in size, shape, design, and color, and even part of the day's light. These building elements can, as the simple facades, multi-functional elements for cold and hot views as shadow or open systems.

Semi-transparent views

Photovoltaic sheets, like windows, can perform their transparency and back-up in two ways. The photovoltaic cell alone can be very delicate or laser, making it possible to filter 20 to 50 percent. Semi-transparent, non -crystalline silicone modules are made for this function. On the other hand, crystalline cells can illuminate the interior in a similar way to create a filter. Even by adding layers of glass to the main unit of semi-transparent photovoltaic, thermal, and audio insulation provides for the special needs of the building.

Canopy systems

In today's architecture, there is a strong need for shadow systems in the building market, which leads to the widespread use of large openings and curtains or other canopies. In the meantime, photovoltaics can be used as canopies on the top of the windows or part of the roof structure, provided that the use of these canopies does not impose additional load on the structure. Photovoltaic shade systems can be used in a way that can be used both to produce the highest energy and provide variable degrees of shade.

Roofing

Roofs are very ideal for photovoltaics. Because the shade factors on the roof are usually less than the ground surface, and the roof gives the surface unused. An ideal sloping roof for photovoltaic is a south side with an angle equivalent to latitude 15 for the best energy production. In this regard, the roofs of the southeast and southwest are also acceptable. Photovoltaic plates can also be easily installed on the roof of existing buildings. A beautiful way to use photovoltaic on the roof of the building is to use pv tiles or todels allowing them to be easily installed by a roof contractor such as tiles or other roofs. Flat roofs have also benefits such as convenient access and easy installation. The classic method is to lay the arrangement and arrangement of photovoltaic units on its network infrastructure, and then install them on the roof. In this method, in addition to paying special attention to the modulus configuration and installing them on the sloping roof, the wind force should also be concerned. The recent experiences and progress in this area have made these systems light, ease, and speed of use. Ideally, sloping ceilings are the best option for installing panels. Dental ceilings are better than flat ceilings because parts of the ceiling facing the north can be used to enter the space. Whereas, the southern level of the teeth can be a place for photovoltaic installation. The southern-photo show coating can also be done by using semi-transparent panels, which can both enter the space and produce electric current. If the females are designed with the ceiling body, bent, or tile pieces can be used [7].

Benefits of using photovoltaic systems

Mature photovoltaic technology is strong and reliable and has no moving components, and also it requires little maintenance.
It does not require fuel or fuel supply network.
Installation of the photovoltaic system is relatively easy and fast, especially network connected systems.
The components used in photovoltaic systems have proven their reliability over long-term use.
They are resistant to ultraviolet and climate and tolerate the high temperatures.
They are modules and systems can exist in any size.
The independent photovoltaic system can provide power almost anywhere on the planet.
The photovoltaic system reduces greenhouse gas and carbon dioxide radiation.
The photovoltaic system generally reduces pollution.
The photovoltaic system helps protect scarce resources (Figure 5).

The main components of the photovoltaic systems

Solar Cells
Modules
Regulator and controller
Arrays
Storage battery
Converter

Solar Cells

The first device and the smallest independent unit of photovoltaic systems is the solar cell. The size of solar cells is several millimeters. For example, calculators, wristwatches up to 10 x 10 cm. Today, the most effective solar cells are made of a material called silicon. Sand is one of the important sources of silicon, although silicon is an abundant element and constitutes a large percentage of the earth's crust (Figure 6).

Modules

The primary structure of solar collectors in photovoltaic systems is modules. Each photovoltaic module consists of a number of solar cells that are electrically connected to each other, embedded, and protected in a supporting frame. Currently, silicon-type modules are made in different voltages and currents from 200-800 cm^2.

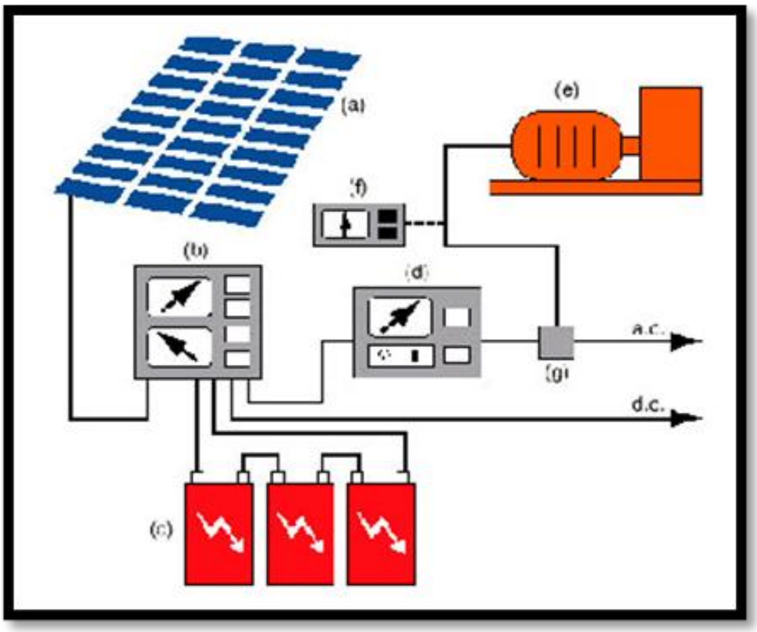


Figure 5: The main components of the photovoltaic system

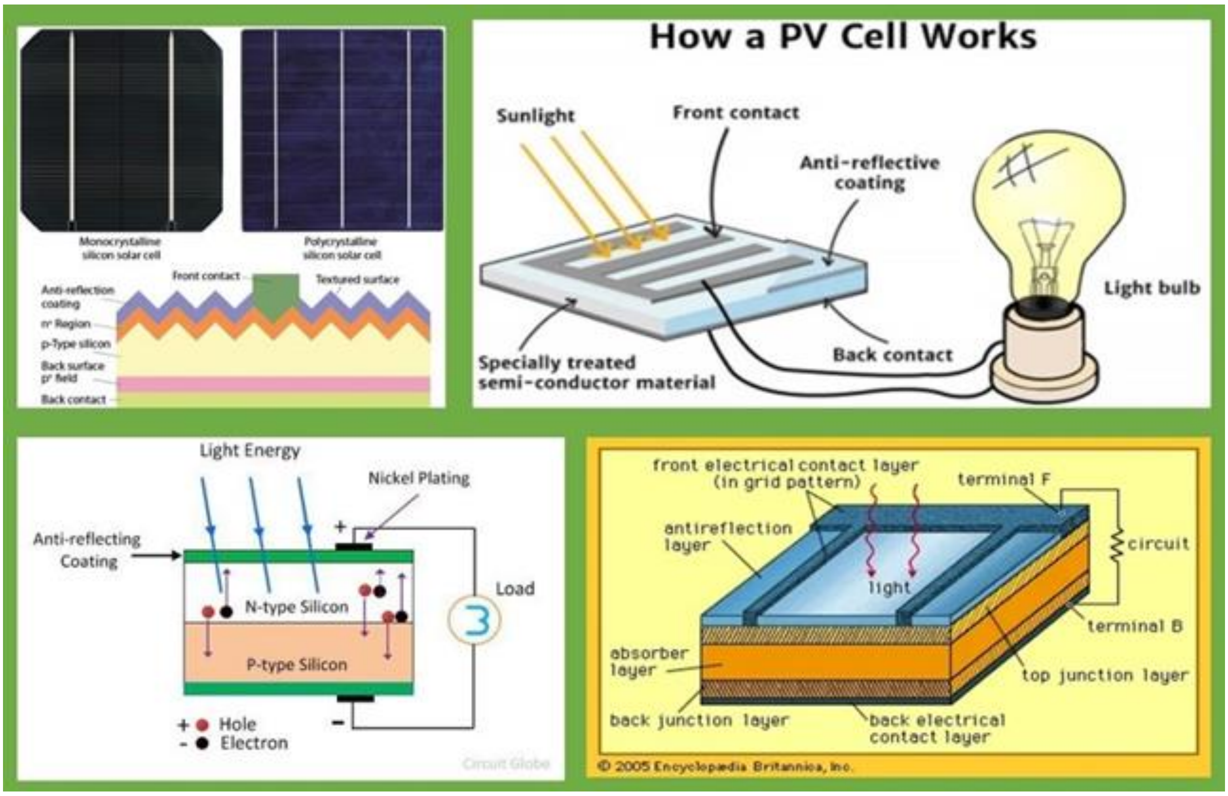


Figure 6: Photovoltaic cell module

Arrays

Photovoltaic arrays are photovoltaic modules and their support frame on which the modules are electrically and mechanically mounted. Designing arrays is done in two ways:

Flat arrays: Where solar cells are connected to each other by using the appropriate and usually non-fragile materials.

Focusing presentations: Where the rays are focused on the cells by using appropriate methods such as lenses, mirrors, etc.

Regulators and controllers

They are equipment that adjust the battery voltage and control the electric current entering the battery and also prevent the possible damage to the battery. The purpose of their installation is to prevent overcharging of batteries and disconnection to drain the battery at night [8].

Converter

Concerning the electricity produced by the photovoltaic arrays is DC direct current. Therefore, it is necessary to convert the demanding output into alternating current and the standard AC with voltage, phase, and frequency suitable for connecting to the power grid. The preparation and conversion of electricity is done by a device called a converter (Figure 7).

Photovoltaic systems integrated in architecture are available in the following forms:

Classic framed modules

Flexible crystal transparent modules

Thin film modules with solar cells

Roof tiles with solar cells

Modules with colored solar cells

Translucent modules with tiny holes

Solar systems based on facade:

Curtain wall system

Rain cover system

Fixed shades

Movable shades

Retaining wall with sloping panels

Steep wall

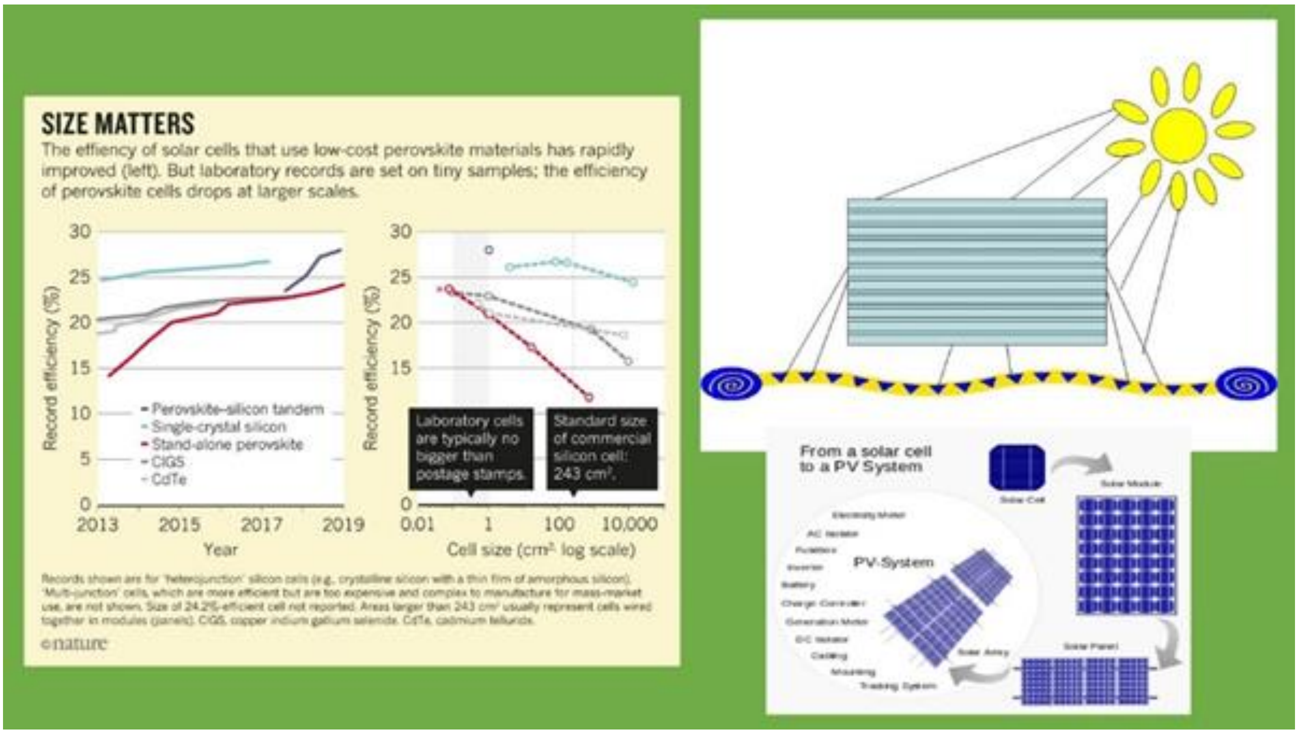


Figure 7: Photovoltaic cell

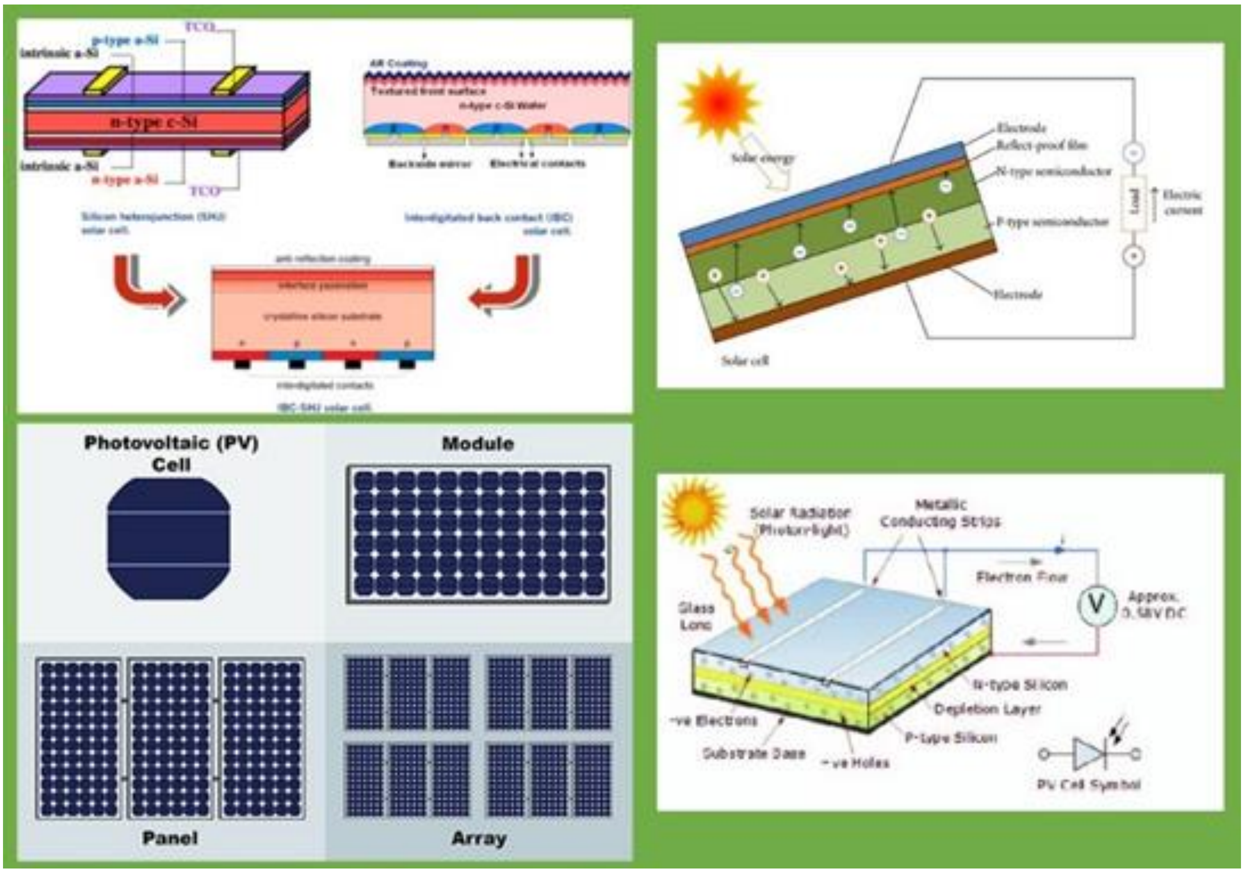
Photovoltaic systems integrated with the building

First, photovoltaic systems were used separately in the building, the most common of which was placing solar panels on the roof, until in 1994; solar architecture was formed for the first time in Japan. In the beginning, it was tried to use solar panels according to the local aesthetics and architecture, until today they reached a place where solar cells are referred to as a material. Nowadays, the use of photovoltaic systems has become very important and attractive among designers and architects. Therefore, these buildings should be built in a correct way and with a suitable design that does not cause problems for the photovoltaic system itself or for the building after installation. Based on this, to avoid architectural contamination, it is necessary to consider photovoltaic systems as a self-defined design or an architectural element, so that photovoltaics become a known part of the building and completely integrated with it during the design process. Just as in the design of building elements such as walls, windows, and awnings, attention is paid to the geographical latitude of the place and climate, neighborhoods, coordination with passive solar systems, sizes, directions, angles, and other things, photovoltaics are also in the status of building elements is related to these issues. Therefore, in the design and combination of photovoltaics with the building, the attention should be paid to all the things that an architect goes through during the design process of various factors. The purpose of this treatise is to describe the methods of using photovoltaics in buildings [9].

Design methods of photovoltaic systems integrated with the building

Determining the optimal direction and slope of photovoltaic panels

The output of the photovoltaic system also increases with the increase in the intensity of the sun's rays. Therefore, the power efficiency of the photovoltaic system has a direct relationship with the amount of solar energy received. On the other hand, the change in the angle of the sun's radiation and the amount of radiation at different times during the day further affects the power production of photovoltaics. Therefore, the efficiency of the photovoltaic system depends on the direction and slope of the installed panels in relation to the sun's radiation, and as a result, the orientation and slope of the photovoltaic panels is affected by the amount of solar energy received. The amount of receiving solar energy in various places is diverse based on the difference in geographical latitude, height above sea level, and atmospheric phenomena. Thus, to obtain information about the radiation, the meteorological station, the geographic latitude and altitude of that place should be determined so that the average monthly and annual radiation received from the sun can be determined at the horizon level and all levels with different directions and slopes for the desired location. One of the methods used in the world to find the right direction and slope of photovoltaic panels is the use of actions. In this method, based on meteorological data of direct and scattered solar radiation and by using computer programs, the amount of solar radiation on all horizontal and vertical surfaces in different directions and slopes is drawn monthly or annually [10]. If the photovoltaic panels are placed according to the angle of each of these slopes, they will have different efficiencies based on the amount of energy they receive from the sun. Hence, it is possible to determine the optimal directions and tilt angles of photovoltaic panels. The maximum point in this action is the place receiving the most amount of energy from the sun throughout the year. Because the more vertical the sun shines on a surface, the more energy will reach that surface. As a result, if a photovoltaic panel is placed in this direction and inclination angle, it will produce maximum electricity energy. Therefore, finding the orientation of photovoltaic panels is an important issue, but determining its angle does not require much accuracy, because a little difference in deviation from the optimal direction will not cause problems. However, the angle of inclination of the panels to the horizon is a more important issue. By determining the optimal tilt angle, depending on the time of using the system, about 95% of the maximum output energy can be obtained (Figure 8).



Picture 8: Photovoltaic panels tilt angle shape

The effect of shadows on photovoltaic panels

Shadow is one of the factors that affects the amount of access to the sun. The reflection of the ground, the shadow of the surrounding buildings, the shadow of the building itself, and the shadow of the panels on each other may impact the photovoltaic system. The architect should design the position and location of the photovoltaic panels in such a way that there is no shadow effect on them. This is because the shadow on the photovoltaic cells will damage the cells in addition to the reduction or lack of efficiency. Therefore, in the design of such a building, it is necessary to pay attention to the issue of shading from the beginning and to carry out a detailed analysis of the shadow before the photovoltaic system is combined with the building to obtain the maximum electricity production. In terms of shading in building design, the following issues should be concerned [11].

Shading of the building itself, neighborhoods, and obstacles

Shading between buildings should be avoided. Building density is an interesting area. In dense spaces such as urban centers, the distance between buildings is limited. Therefore, facade systems are more sensitive to shading, and in comparison, with roof systems, more distances are needed between buildings.

Shading due to architectural forms should be avoided. The distance between photovoltaic roofs and other objects should be such that it does not create a continuous shadow.

Where shading is unavoidable, careful selection of components, the shape, and position of panels reduces power loss.

Shading trees

Vegetation shade may also have an inappropriate effect on photovoltaic systems. Therefore, as much as possible in the landscape design, plants, and trees should be planted in a direction that does not block the sunlight on the panels, or shorter shrubs with limited growth should be used. Planning in this field is important to prevent shading problems in the years after building construction and tree growth.

In the northern hemisphere, it is better to plant trees in the north and in the southern hemisphere in the south of the building.

According to the height of the building, trees with limited growth should be used. If there are trees on the east side of the site, but not on the west side, it may be better to place the photovoltaic panels slightly to the west.

Cloudy sky shading

Likewise, cloudy environments cast shadows on photovoltaic panels. Due to the reduction of the sun's rays and the brightness of the light from the cloudy sky, the output of photovoltaics is reduced.

Shading pollution

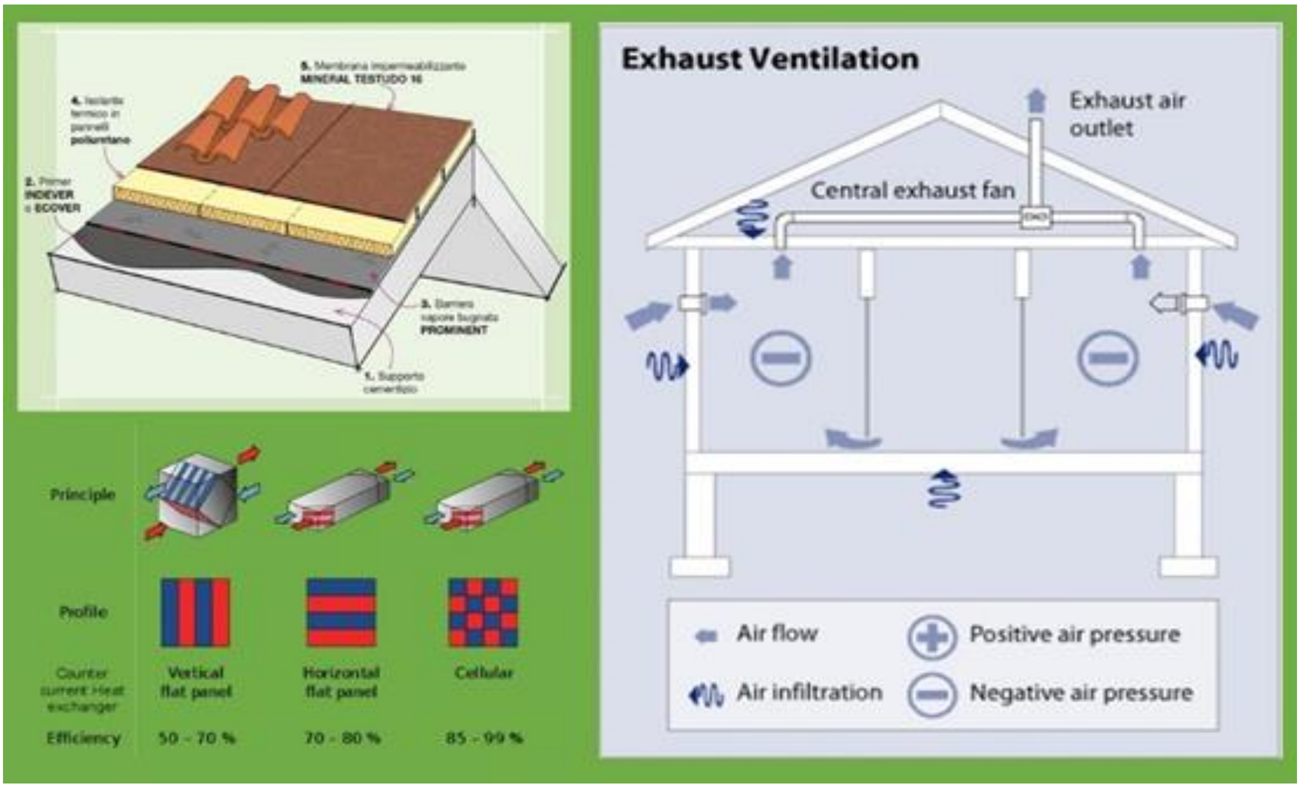
Pollution is also a form of shadowing. If pollution prevents light from reaching the solar cells, the environment should reduce the efficiency of the photovoltaic panel by about 4% or more. Although panels with an angle of more than 20 degrees will be washed and cleaned by themselves through rain, certain types of contamination should be cleaned by other methods.

Coordination between photovoltaic systems and passive solar systems in the building

Usually, designers consider solar design as a limitation rather than an opportunity. If the architect designs the building according to the climatic conditions of the place and in accordance with the passive solar systems, the conditions of that building will be close to the comfort limit of the residents, and if the photovoltaic system is combined, which is an active solar system, with the building in a suitable way, the result will be better work and the energy efficiency of the building will be much higher. In this way, the micro-climatic conditions of the building will be closer to the comfort limit and turn it into a self-sufficient building. In the design, it should be noted that the use of photovoltaic systems by the passive solar systems such as heating does not conflict with the solar project, and both systems are perfectly coordinated by the designers to reduce energy consumption. If the photovoltaic system is properly integrated in the building envelope, it is possible to prevent the sun penetration and produce the electricity needed for cooling. Designers can integrate photovoltaic systems with the building in such a way that ventilation, use of the sun's heat in winter and natural light (direct and indirect), view to the outside landscape, and other things are provided together. The result is that the best efficiency is achieved when the active and passive solar systems are coordinated and adapted to each other in a building. To achieve this goal, before starting the design process, the overall energy solution for the building should be predicted [12].

Ventilation of photovoltaic systems

As the temperature increases, the output power from the cells decreases and as a result, the efficiency of photovoltaic panels decreases (Figure 9). Therefore, in the photovoltaics combination with the building, attention should be paid to the issue of their natural or mechanical ventilation in the design process so that they reach a lower temperature and continue their optimal efficiency.



Picture 9: Details of ventilation panels

Methods of combining photovoltaic systems with buildings

Photovoltaic systems can be integrated into the building with roofs, skylights, atriums, facades, canopies, etc. [13].

Photovoltaic systems integrated with the roof

Photovoltaic panels on flat roofs can be combined in the form of flexible thin film cells and on sloping roofs in the form of photovoltaic tiles. Besides, they can be used as a building shell with a sloping roof system or connected to the roof structure. The composition level of photovoltaic elements should be compatible with any other non-photovoltaic elements to combine structural and aesthetic issues in architecture and obtain a conscious and architectural product. In designing roof systems, the issue of snow accumulation and moisture removal is important. In this regard, you should choose appropriate solutions in accordance with the climatic conditions of the place to remove rainwater and snow accumulation on the photovoltaic panels.

Photovoltaic systems integrated with skylights and atriums

In this type of building, to combine photovoltaics with the roof, the architect can design the roof as integrated skylights with photovoltaics. Also, semi-transparent photovoltaic panels can replace the glass of ceiling windows and atriums, which the creative and experienced designer uses the light quality in the spots form. The building designer can integrate photovoltaics with atriums so that opaque or semi-transparent photovoltaics are placed on the side facing the sun and transparent glass on the back side. In this way, photovoltaics prevent direct sunlight from entering the interior space and, at the same time, generate electricity from the sun's rays [14].

Photovoltaic systems integrated with the facade

There are different ways to combine photovoltaic systems with the facade, each of which can be proposed in the design process depending on the type of design, the choice of designers, and the best option can be used according to the building’s conditions. In facade systems, it is possible to combine opaque, semi-transparent and glass panels side by side in a vertical or staggered manner so that each natural light enters the interior as much as necessary and photovoltaic panels produce electricity. Likewise, they prevent the unwanted sunlight from entering the space during hot weather.

Photovoltaic systems integrated with canopies

The opaque photovoltaic panels in combination with the building or light shelf on the facade as a window canopy, louvre, install, and protect the interior space from the direct rays of the sun and, at the same time, the condition of scattered light entering and they supply indirectly into the space. Photovoltaic canopies can be placed horizontally, inclined, or bridges on the vertical wall. The advantage of photovoltaic canopies compared with the other canopies or curtains is that, in addition to prevent heat from entering the building and reducing the load on cooling devices, it further produces the electricity required by cooling systems [15].

The effect of building plan form on photovoltaic system power

To test the effect of the building plan form on the amount of annual electricity production, we consider a four-story office building in Los Angeles at the geographic latitude of 33.9 degrees north with an area of 3716 m^2 and a substructure of 2929 m^2 and the height of each floor is 3.65 m. It is assumed that the entire four floors of the building are covered with vertical photovoltaic panels. The climate of this place is hot and dry and requires a lot of cooling. Two states can be considered for this building: In the first case, it is fixed, and with the change of the plan form, the area of the walls and the surrounding floor area change. In the second case, the area of the surrounding walls is assumed to be variable. In this change, the fixed form and floor area of five types of plans are examined in a diagram form. In general, in these cases, the influence of the building plan form on the efficiency and production rate of the photovoltaic system is determined. Another issue is that there is a significant difference in the amount of electricity production in the east-west and north-south layout of the plan. According to the diagrams, if we make the plan of this Los Angeles building in an elongated form in the north-south direction, it will reach the maximum electricity production in the whole year. Of course, it should be noted that the walls of this building are covered with photovoltaics in four directions, north, east, south, and west. In other words, it is clear that the eastern and western walls receive a lot of light from the sun throughout the year and, as a result, produce more power, but this analysis is only limited to the photovoltaic efficiency and the negative effects of this orientation are not taken into account [16].

The effect of the slope of the facade of the building on the power of the photovoltaic system

To examine the effect of different slopes of a south-facing curtain wall on the production of photovoltaic power, a four-story building with a south wall 5.30 m long and 6.14 m high and with a total photovoltaic area of 7.278 m^2 in the vertical direction is assumed. The effect of different slopes of this wall, from 90 to 40 degrees, on the amount of electricity generation is investigated in two cases. In the first case, the area of the photovoltaic panels is fixed, and the area of the floors and the area of the south wall changes with the change of slope. In the second case, by changing the slope of the wall, the photovoltaic area also changes so that as the slope of the wall gets closer to the horizon, the area of the photovoltaic panels further increases [17]. Of course, the height of the floors is fixed. According to the diagrams and calculations of the power produced by the photovoltaic panels, it is clear that the closer the slope of the wall is to the horizon, the more the photovoltaic surface receives the sun's energy. Therefore, the production of electricity and its efficiency will be higher. Besides, if we want to cover the entire surface of the wall with photovoltaic panels, as the slope of the wall gets closer to the horizon, the area of the wall will further increase, and as a result, the production of electricity will increase. In these diagrams, the surface area of the photovoltaic wall increases from 7.278 m^2 with a 90 degree slope to 5.433 m^2 with a 40 degree slope, but this increase in force resulting from the wall surface slope should be considered with other costs. Among them, the costs of building a sloping wall, which is more, or reducing the floor area in the higher floors inside the floors also receive more direct light in the ambient part, which requires more care during the half-day hours. The sloping wall improves the power efficiency of the south, east, and west walls throughout the year, while the efficiency of the north sloping wall increases only during the summer. As can be seen from these actions, sloping facades integrated with photovoltaics affect their optimal efficiency, but in the facade design, attention should also be paid to its effects on other aspects of the building plan. Issues such as the compression of the floor space around the wall, facade curtains on the floors that lead to a reduction in the amount of building space, as well as more costs for the construction of inclined walls, etc. [18].

Determining the type and power of the photovoltaic system

The type of a photovoltaic system depends on conditions such as the type of loads connected to the AC or DC system or both, the presence or absence of an auxiliary power generator, connection or non-connection to the local or national grid, and how the connection to that network is one-way or two-way. Before designing, one should first decide whether the independent photovoltaic system is self-supporting or connected to the city power grid. Independent systems need special batteries to store electricity, and their electricity production is lower than systems connected to the grid, and often in remote locations from the grid. Electricity is used. If the photovoltaic system is connected to the city grid, there will be a guarantee of electricity supply. Because electricity is exchanged between the system and the network, and the network acts as unlimited storage. Battery-powered systems also require battery maintenance, but unlike grid-connected systems, they do not require special maintenance. Of course, in deciding on the type of system, the battery, and maintenance costs should be considered and based on the needs and type of life, determine what type of system will be more suitable. The power of a photovoltaic system is defined as the maximum direct current efficiency of the solar system in kilowatts. Therefore, a 2kW system, when fully exposed to the sun's rays, produces 2000W of DC electricity, and then this direct current is converted into the usable AC alternating current through a converter, and its output is 1.7 kW decreases [19].

The power of photovoltaic systems depends on the following

The amount of electricity consumption and personal needs.
Time of use all year round.
System location and solar radiation climate.
The area of the space on the roof or facade.

However, the most important limitation for the power of the photovoltaic system is the available budget. In addition to affect the architecture and its design, this system also challenges those involved in the planning and design process, i.e. architects and other engineers, to develop their innovative solutions for the integration of the building support system with the provided photovoltaic power. A building maintenance engineer sees it as an electrical system that requires special design, communication, and monitoring. Architects and engineers who work with each other are asked to integrate photovoltaics during building planning and understanding at least at four levels of integration:

Designing a building (shape, size, orientation, and color).

Mechanical integrity (multi-functionality of a photovoltaic element).

Electrical integration (connected to the network or direct use of electricity).

The system should be integrated with the normal building care and maintenance [20].

Concerning the electricity consumption in Iran is increasing every year and a large amount of the country's energy is used in the building sector in the form of electricity (lighting, cooling, and heating) and also due to the increasing need for renewable energy sources. Fossil energy and water dams, electricity supply limitations, and fuel supply for remote points and attention to reduce air pollution. Therefore, it is necessary to use solar energy to generate electricity in Iran, where the sun's rays are available in many regions, and it is desirable to use solar energy [21]. With the technology advancement and the need to save energy in today's world, more and more photovoltaics are being integrated with architecture for electricity generation, and many examples of this development have been developed in different countries. For example, photovoltaics is combined with the building as a construction element or material, and in addition to the advantages that they have on their own, when combined with architecture, their benefits are multiplied many times and they will no longer be just energy producers (Figure 10).

Building design requirements with photovoltaic cells

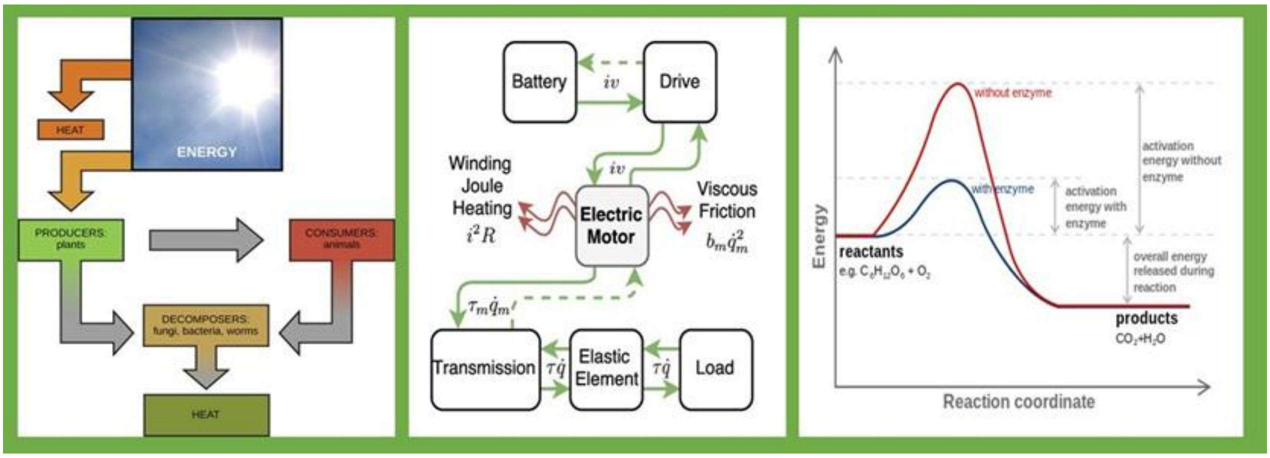


Figure 10: Energy path diagram

Today, architects are rapidly moving towards combining photovoltaics with buildings and replacing them with building materials, which is one of the fastest growing sectors of the construction industry, and this technique is well-known and used in Europe and America. Life is supported. Regarding the economic issues of this system, it should be mentioned that most of the expenses are related to the initial costs of its production. Considering the application of photovoltaics in architecture as the main component of the building and its replacement with building materials and its multi-functionality, the use of these systems has slowly become more economical and with the current trend, the price will increase in the near future. Photovoltaics will cost less than the price of electricity from the city grid, and when our oil and electricity find their true value and using photovoltaic electricity will cost the same as electricity from the grid in one-month, self-generated energy will rise. One of the most important factors for using photovoltaics is the condition of sunlight. In this sense, Tehran city has been compared with some European cities in terms of sunlight [22].

The state of sunshine in Iran and the sky of Tehran

Iran is located between the latitude of 25 degrees and 10 minutes to 39 degrees and 25 minutes north, while the European countries are located between the latitudes of 40 degrees to 70 degrees, the United States of America between the latitude of 30 degrees to 50 degrees, and Canada between 50 degrees and 50 degrees latitude degrees up to 70 degrees have occurred.

Iran is located in the middle of this latitude and is close to the equator, and as we know, in the areas close to the equator, the sun's rays are perpendicular to the earth's surface, and in the areas close to the two poles, the sun's rays are inclined. Therefore, in terms of receiving solar energy, Iran has more power and possibilities than European and American countries, but these are the European and American countries where there are many examples of the integration of photovoltaics with these buildings. It is an increase. According to the diagram, the number of sunny hours in most European cities is around 1000 to 1500 hours per year. In the case that the total number of sunny hours in Tehran is 3031 hours in the year, and in comparison, it is found that the sunny hours of Tehran are twice to 3 times the sunny hours of European cities, which shows a great difference in visibility. However, in these European cities with few solar hours, there are a large number of integrated buildings with photovoltaics, which are very good examples of how this system works in the world. Iran is full of solar energy to have cities with more than 3000 hours of sunshine per year and it only needs a national planning program to use this energy. Due to the fact that the approach to photovoltaics is growing and successful in the world and it is justified from the science and economy viewpoints, it is widely used in different countries. To properly integrate photovoltaics with the building, they should be considered from the beginning of the design process as a part of the basic design of the building and in accordance with the architect's plan. To achieve this goal, it is necessary to pay attention to various issues related to photovoltaics and building, as well as the effect they have on each other, during the design. Since photovoltaics are integrated with the building, in addition to generate electricity, they are also related to the facade, the roof, the space behind them, other elements and systems, and even the environment around the building [23]. Therefore, it is necessary to examine this issue in the design process from different aspects and to find an appropriate and coordinated solution with other factors. Some of the design needs are general, that is, they can be the same everywhere, and the designers and building engineers, knowing their principles, rules, and methods, can solve the design in any place according to the type of design and related issues, but some other design needs of these buildings should be considered for the city and specially coordinated with the information and conditions of that place. In this part, the design requirements will be briefly introduced:

The effect of climatic factors on photovoltaic panels.

Determining the optimal direction and slope of photovoltaic panels.

The effect of shadows on the arrangement and composition and distance of photovoltaic panels, including the shadow of the building itself, the neighborhoods and obstacles, the shadow of trees, the shadow of the cloudy sky, and the pollution shadow.

Coordination between photovoltaic systems and passive solar systems in the building.

Ventilation of photovoltaic systems integrated with the building.

The methods of combining photovoltaic systems with the building, in this combination, photovoltaics can be integrated with the roof, roof windows and atriums, its elements, and canopies.

Replacing photovoltaics with regular building materials [24].

The effect of the building plan on the power of the photovoltaic system.

The effect of the facade slope of the building on the power of the photovoltaic system.

Determining the type and power of the photovoltaic system integrated with the building.

The effect of the need for cooling or heating on the tilt angle of photovoltaic panels.

The effect of building performance on the location and angle of the photovoltaic panels.

Coordination between the architect and other engineers in the building design.

Indigenous ways of designing integrated buildings with photovoltaics in Tehran

As mentioned, one of the goals of this thesis is to provide a strategy for the factors that influence the design process of such buildings. Thus, in the continuation of the design methods of integrated buildings with photovoltaics in Tehran city according to its local needs, the necessary suggestions and solutions have been examined [25].

The effect of climatic factors

Climatic and geographical factors can reduce the amount of photovoltaic energy production. Therefore, when photovoltaics are combined with buildings, the effect of climatic issues related to architecture in these systems should also be predicted to reach the desired result. The ambient temperature has a great effect on the efficiency of photovoltaic systems, so that with the increase in temperature, the production power of the cell decreases, and with the decrease in temperature, the voltage increases. In Tehran city, during the hot months, especially in the afternoon hours, the air temperature reaches above 25 degrees, and this temperature reduces the efficiency of photovoltaics, which is necessary to design with appropriate measures to reduce the heat of the panels and maintain the efficiency of the fan. Increase the natural or mechanical efficiency of the system. In double-layer facade systems, by creating an opening, you can use the wind and natural ventilation in the building to ventilate the back of the photovoltaic panels, and thus increase their efficiency.

In sloped roof systems, it is possible to create a vent under the edge of the roof and on the roof to allow air to flow behind the photovoltaics. Of course, an experienced and skilled designer can provide other solutions that are in harmony with other factors during the design process. It is necessary that the photovoltaics are washed at regular intervals. Therefore, in the building, the essential measures for washing the system, such as a crane or a ladder should be foreseen. It is also possible to use rainfall in these days, of course, rainfall without pollution, concerning that most of the rainfall in Tehran was in the cold days of the year and there is a possibility of freezing in these months, it should be included in the design of the slope of the photovoltaic panels. Do not collect on the water system because it lowers its efficiency and, in the case of ice, it disrupts the operation of the system. In the buildings' design, it is necessary to observe the building condition during these months and take appropriate measures to prevent the water and snow accumulation on the system and, as a result, to avoid freezing [26].

Determining the optimal direction and slope of photovoltaic panels in Tehran

The energy efficiency of the photovoltaic system has a direct relationship with the amount of solar energy received. From this side, the efficiency further depends on the direction and slope of the detached panels, and as a result, the orientation and slope of the photovoltaic panels is affected by the amount of solar energy received. Before determining the optimal direction and slope of the photovoltaic panels from the radiation patterns in Tehran, initially by using information and statistics related to monthly and annual radiation and based on the average annual pattern of radiation received from the sun and the surface. The building with different slopes identified which sides of the building would be more suitable for using photovoltaics. Regarding the path of the sun's movement in the sky and the angle it makes with the horizon, in Tehran city, the facades facing the north receive a small amount of radiation, which is not direct, and in the case that the slope is positive towards the sky, there is a shower. If this slope increases, the energy amount they will receive will be higher until the north side with a 60degree slope to the sky receives the same amount of energy as the east or west side with a 30 degree slope angle to the sky, and the south side receives the same amount of energy. In general, based on the diagram, it can be mentioned that the radiation received on the horizontal surface is more than all the fronts with different slopes, except for the fronts facing south, southeast, and southwest in the form of 45-60 degrees to the horizontal.

The effect of building performance on location and angle

The slope of the photovoltaic panels is another factor that can affect the design of the photovoltaic system integrated with the building in terms of the panel location and its direction, the angle of the panel's slope, and the type of building function. Therefore, it is necessary to see what capabilities each operator has for this system and how to achieve a conscious and better combination and integration for the purpose of using photovoltaics. Government offices usually start working at sunrise and their activity usually continues until evening and maybe a little longer. It is from there that the operation period of these types of buildings are during the day and it is almost equal to the same path that the sun takes in the sky. Therefore, if photovoltaic systems are used in these buildings, it will have a positive result. Administrative functions are the proper examples for using this system. Because the most amount of electricity is needed in office buildings during the hours when the sun's rays continue to shine on the surface of the photovoltaic panels. Likewise, their demand for electric energy is considerable and these buildings are further active in summer. Therefore, it can be concluded that the balance between demand and supply in the photovoltaic system is an important issue.

Evaluating the effect of building performance in combination with photovoltaics

Due to the fact that in the side streets and alleys of the city of Tehran, high-rise buildings have been built and the distances and attention to the sun and wind have not been considered and the texture is generally compressed, the problem is the shade size and lack of ventilation. How to solve photovoltaics integrated with housing? Based on the current costs of photovoltaics in the country, the issues, and problems mentioned about housing, perhaps it can be mentioned that it is better to use this system in the initial phase of BIPV residential operations in residential cities, so that issues such as the direction and slope of the panels and shade pay attention to the sun and the wind, all of them should be observed together. Another advantage of using this system in cities is that due to the large area of BIPVs and the amount of electricity production, capital can be made faster than the system. The surplus was sold to the city electricity network and in this way; it was recycled in government office buildings and businesses due to the existence of a lot of capital, especially government budgets and subsidies for offices and the size of usable space for combining with solar and electric utilities. They are usually located in the main streets and places where the sun and shade problem can be solved more easily than the residences, or they don't have any problems at all. The use of photovoltaic systems integrated with the building will be given more attention and the capital return from the system will be possible. Also, in the design of such buildings, the architect's hand is more open and he can combine photovoltaics in different ways with the building. In the commercial buildings, due to the use of modern materials and high costs for a beautiful appearance, it is reasonable to use photovoltaics in the building facade. It brings the beauty and modernity that these buildings demand. Residential, office, and commercial buildings need electricity all year round. Therefore, it is better to combine photovoltaics in accordance with the direction and slope of the panels annually, that is, in the southern view and with canopies with a slope of about 30 degrees to the horizon or with a sloping roof and roof lights and atriums. Since schools are closed in the hot months and they need more electricity for lighting, hot water, and heating facilities. Therefore, it is better to combine the photovoltaics in accordance with the direction and slope of the panels in the cold months, that is, on the south side of the building with a relatively high slope, and if possible, on the roof in a sloped form so that the output of power can be maximized in the cold season. Concerning the fact that in schools to prevent the sun's rays on the classroom board and the entry of heat during the hot season, awnings should be installed on the south side, these awnings can be combined with photovoltaics to have the awnings function [27].

The effect of shade measurements on the arrangement, composition, and distance of photovoltaic panels

Another factor in BIPV design methods is shade size. This is where the role of the architect becomes more colorful along with other engineers, and he is the one who can design the building with his architectural ideas to accommodate both photovoltaics and architecture, and combine and integrate architecture and photovoltaics. To get the maximum efficiency and production from BIPV systems, obstacles and shadow sizes should be reduced as much as possible, which depends on: the location of the site and building, the arrangement of photovoltaics, and how they are combined with the surrounding buildings, etc. In this part, one of the ideas causing the shadow on the photovoltaic panels has been examined and some solutions will be presented. By using the chart of the path of the sun's movement for Tehran city, it is possible to calculate the angles of the sun's rays in different months and the shadow of the volumes and obstacles on the photovoltaic panels. Besides, the hours of the day from sunrise to sunset are obtained, and in this order, the arrangement and the distance between the panels based on the shadow size, in the case that the photovoltaics are combined with the ceiling lights. The shade size of photovoltaics is an important issue that should be taken into consideration. It is necessary to coordinate the angle of the panels and the angle of the opposite wall or reflector with the angles of the sun to prevent unwanted shadows on the panel. The distance between the panels causes the panels to benefit from the sun's rays in summer and winter, and these angles do not create a shadow on each other. In summer, due to the greater angle of radiation, the shadow problem is less in this case, and most of the direct light reaches the interior space. However, in the case that there is a need to use the radiation at all hours, even the first hours of the morning and the most sunset, you should have a low shade. It should also be calculated so that the panels shadow does not fall on each other, and in this case, the distance between the panels should be much more. Therefore, the greater the slope of the panels, the more their shadow size. Therefore, it is necessary to increase the distance between the panels to prevent creating a shadow on each other. To solve this problem, the reflector angle should be changed in relation to the panel angle or a gap should be created between the teeth, which of course can be used together. Another strategy is that the teeth are placed on a slope and each one is installed higher than the previous tooth [2].

Replacing photovoltaics with renewable building materials

Today, stone, brick, cement, glass, aluminum panels, and rarely wood and Carbonate Bridge are commonly seen in the buildings of Tehran. As building materials, photovoltaics can be opaque and semi-transparent, and provide the possibility of blocking the sun's rays and absorbing it without seeing it outside. In addition to the fact that photovoltaics perform the function of this type of equipment, they also have the ability to produce electricity, which is a very valuable advantage. New photovoltaics can even work as window glass. These cells have the ability to transmit between 80% and 90% of the sunlight, and this quality makes the windows equipped with solar cells able to keep the air inside the house cool in the summer. They show more beautifully and at the same time provide the electricity needed by the building. The side of glass is weak in terms of acoustic properties. However, photovoltaics can be very good sound insulation. When there is a need for anti-radiation materials or semi-inhibitory materials in the building, you can use opaque or semi-transparent photovoltaics providing inhibition, filtered vision, controlled light and heat, sound insulation as well as heat and humidity. If photovoltaics are used instead of a glass facade, the building will have the same appearance and, of course, with the beauty of Dokhandan, besides, controlled light and heat will enter the space and there is also a proper view [12].

The discussion of energy saving in sustainable architecture in the design of new structures

In the modern era, providing the welfare of the society was the main topic of development, but with the discussion of the relationship between humans, the environment, and development in the 1970s, the concept of sustainable development received serious attention. With the scientific activities of universities and humanities experts, along with the United Nations World Commission on Environment and Development, principles for sustainable development were determined in 1987, but the official introduction of sustainable development concepts to the world's issues was in 1992 at the Rio de Janeiro Environment and Development Conference. Urbanization as one of the four main pillars of today's world has caused various interdisciplinary issues to be concerned in urban planning to achieve sustainable development, the most important of which are economy, environment, and society. Of course, architecture with a reliable approach is also one of the reliable components of the city following the common concepts in its text. Environment, biological climate and its changes, reduction of energy consumption, green building, and ecological issues are among the most important influencing factors in the formation of sustainable architectural approaches in various layers of the design process, the process of construction, and production of materials. The concept of sustainable architecture appears in the continuation of Groholm Brantland's report in 1987 and is mainly based on two principles. A group that pays attention to the design of the building based on its connection and impact on the environment and another group that refers to the reduction of energy consumption in the building. Examining various currents of sustainable architectural design and sustainable architecture to achieve sustainable economic, social, and environmental strategic guidelines requires understanding the concepts of reliability and studying the implementation experiences of the last four decades. What can be studied about the principles and methods of sustainable architecture can be studied mainly in scientific publications and construction laws of the leading countries in this field and their practical experiences. After agriculture, construction is the second largest industry in the world. The pollution caused by the cooling and heating of buildings and the production of building materials exceeds the pollution of cars and consumes the exhausting fountains quickly. Reliability in architecture can be interpreted as the idea of designing future constructions, not only on the physical reliability of the building, but also on the reliability and preservation of this planet and its resources. Accordingly, the reliability can be imagined based on a model in which available materials and resources are used more efficiently rather than being wasted or ignored, and in other words, on the building's ability to integrate environmental and atmospheric factors and transform. They focused on spatial qualities and comfort and form. Sustainable architecture and advanced technology expressing scientific and technical achievements has always been one of the tasks of modern architecture development, and the early modernists paid attention to technology as a force that causes change, which over time has a critical aspect and, in some cases, leads to create the neutral spaces as flexible and wasted [3].

Developments of reliability and its examples in Iranian architecture

The convergence and alignment of the principles of the past architecture of Iran with the principles of sustainable design is not accidental and accidental, but the reliability and continuity of the concepts and ideas of the past architecture is indicative of the existence of such thoughts in the past of Iranian architecture, of course, in the meantime, the spirit of the time and the requirements of time as the principle. It is undeniably acceptable and should be included in our considerations. Whenever a phenomenon undergoes a transformation due to its own historical development, the new form of the phenomenon will enjoy coherence, solidarity, regularity, credibility, and the new order will sprout from the heart of the old organization. Interrupting this transition at some point and intervening in internal actions to achieve a new form, although it may cause a new face and another meaning for the phenomenon, but this is undoubtedly what should have been obtained from the heart of the historical transformation. The confrontation and conflict between the common principles used in the field of contemporary Iranian architecture and stable principles is the definitive result of this historical development. During many centuries, houses were built by its inhabitants or local builders [27-29]. These people tried to meet their needs by using available resources, the ancient techniques and traditions, and simple tools. The noteworthy point here is that when environmental and energy crises were not at this current level, more or less reliability principles with titles and form and context consistent with their era were formed in the form of sustainable principles of architecture, and today, by examining the available evidence and examples, features became more familiar [30]. Unfortunately, in the contemporary era, due to the emergence of cultural and identity problems along with environmental and energy crises, the aforementioned principles are no longer responsive to the traditional approach, and there is a serious need to adapt and align those principles with today's examples and needs based on modern technology [31]. And it becomes more vital day by day, and the sustainable principles of the past should be transformed into the principles of sustainable design in accordance with the ecological issues by taking on the modern and technical flavor. At the beginning of the industrial revolution in the 18th century, the concentration of carbon dioxide in the earth's atmosphere was 270 parts per million, and now its concentration has reached 377 parts per million. This amount is unprecedented not only in the last 740 thousand years but also since 55 million years ago. 55 million years ago, the Earth was a tropical planet and there were no north and south poles, and the sea level was 80 meters higher than today [32]. These conditions were not suitable for human life, and by eliminating these conditions, humans were able to continue their work on this planet, but now humans are consciously reshaping these conditions with their own hands. If the current trend continues, there will be the side effects including on ecology and ecosystem management, impact on human health, changes in sub-structures through flooding, movement of earth layers, flooding of rivers and rising sea water, drying up of continents and moistening of coasts, and catching fire [33]. Cities and forests, the loss of the ozone layer, the reduction of the temperature difference between night and day, the acidification of the oceans, and the change in the water distribution on the planet. Conservation of energy and sustainable use of those huge advances in the technology of extracting oil and other underground reserves have provided more use of these non-renewable resources [9]. Therefore, the building's design should be such that it minimizes fossil fuel consumption. It is also very important to observe the issue of where exploited resources are used in development systems and how to keep them stable and use resources that can be replaced faster. For example, the wood from trees that grow faster and can be replaced should be used.

Conclusion

Sustainable architecture is one of the important topics in the field of construction, which has received the attention of architects and designers today. Creating sustainability in architecture is an essential thing that should be given special attention to the problems existing in today's industrial and modern era. Green architecture is one of the new methods in architecture that is of high significance for many people. Nature and environment are God's gift that all living beings depend on for survival. Environmental pollution is one of the problems of the present industrial age in which humans play a significant role. Pollution has a significant impact on the natural cycle and life quality of organisms and has irreparable consequences on their lives. Therefore, to continue the life of all creatures, we should take measures to preserve and maintain the environment and natural resources. One of these measures is the implementation of green architecture. To construct a building, the photovoltaic system should be included in the design work and in combination with the building's architecture. To properly integrate photovoltaics with the building, photovoltaics should be considered as an element of the building from design beginning. Based on this, it is required that there is harmony and integration between the components of photovoltaic systems and other components of the building. Hence, photovoltaics should be part of the plan of the first months of the building and according to the architect's plan, it is also necessary to consider them as a complete part of the building's energy strategy and a significant part of its environmental system. Another point is that the combination of photovoltaic systems with the building affecting its design process requires the interdisciplinary cooperation of different specialists. The presence of the design team consisting of architects and other building-related specialists is necessary from the beginning of the design process to combine and integrate photovoltaics with the building from different aspects. Therefore, building designers should coordinate different factors in the design process to choose the best and the most efficient option.

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