## Environmental factors affecting building design. Analysis of thermal and visual environment.

*Usage renewable energy resources*

Renewable energy sources (sun, wind, biomass, biogas, geothermal energy, hydro, wood, ocean thermal, ebb and flow, wave, sea flows) are the energy resources that can be used by all living creatures on the earth and accepted as inexhaustible thanks to their continuous renewal. It is possible to benefit from renewable energy resources with passive and active methods.

*Usage renewable energy resources with passive techniques:*

***Passive heating***: Passive solar heating systems are categorized by the relationship between the solar system and the building. There are three categories of passive solar heating systems: direct gain systems, indirect gain systems, and isolated gain systems. In the passive solar heating system, building elements (windows, walls, floors etc.) collect and store heat and then distributes indoor space.

***Direct gain systems****:* The direct gain passive solar building has windows that admit the winter sun directly into the occupied space. These solar gains serve to either meet part of the current heating needs of building or are stored in the thermal mass to meet heating needs that arise later. Most direct gain buildings include:

(1) large, south-facing windows (for north hemisphere) to admit winter;

(2) thermal mass inside the insulation envelope to reduce temperature swings;

(3) calculated overhang above the south glass (or other strategy) to shade the glass in the summer while admitting lower angle winter insolation;

(4) a means of reducing heat loss at night. In a direct gain building, sunlight is admitted directly to interior through glazing. It strikes massive interior surfaces (typically concrete floor and masonry wall surfaces), is absorbed, and is converted into the heat. Some of the heat from the surfaces is immediately released back into the room interior. The remainder of heat absorbed is conducted into the thermal mass which slowly warms up; later at night, the stored heat is released back to interior.

***Indirect gain systems***: An indirect gain passive solar system has its thermal storage between facade and the indoor spaces. Heat is collected and stored in an exterior wall or on the roof (with water or brick/concrete) of a building, and distributed to the indoor.

***Isolated gain systems***: Isolated gain passive solar concept contains solar collection and storage that are thermally isolated from the indoor space of the building. The most common use in isolated gain systems is a sunspace. Collection and storage are separate from the occupied spaces but directly linked thermally. A sunspace is a room attached to or integrated with the exterior of a building in which the room temperature is allowed to rise and fall outside the thermal comfort zone.

***Passive cooling and ventilation***: Passive solar heating is divided into categories according to application configuration. On the other hand, passive cooling is better understood as a series of research fields that focus on the basic heat sinks. While this organization is helpful to scientists and inventors, it is a source of frustration for designers and policy makers because so many workable systems involve multiple heat sinks.

Nonetheless, this characterization of ***passive cooling*** will be described below.

<u>Ventilative cooling</u>: Warm building air and replacing it with cooler outside air. Directing moving air across occupants' skin to cool by combination of convection and evaporation. In passive applications, the required air movement is provided either by wind or by stack effect. In hybrid applications, movement may be assisted by fans.

<u>Radiant cooling</u>: All building objects radiate and absorb radiant energy. Building objects will cool by radiation if the net flow the outward. At the night, long wave infrared radiation from a clear sky is much less than the long wave infrared radiation radiated from a building. Thus, there is a net flow to the sky.

<u>Evaporative cooling</u>: Water has been used to improve the thermal comfort of buildings with or cascades. Because when water is evaporates, energy is lost from the air and reducing the temperature. When water evaporates, it draws a large amount of sensible heat from its surroundings and converts this type of heat in the form of water vapor. As sensible heat is converted to latent heat, the temperature decreases. This phenomenon is used to cool buildings in two different ways. If the water evaporates in the building or in the fresh air

intake, the air will be not cooled, but also humidified. This method is called direct evaporative cooling. If, however, the building or indoor air is cooled by evaporation without humidifying the indoor air, the method is called indirect evaporative cooling.

<u>Dehumidification</u>: The removal of water vapor from room air by dilution with drier air, condensation, or desiccation. In the case of condensation and desiccation, dehumidification is the exchange of latent heat in air for the sensible heat of water droplets on surfaces: both are the reverse of evaporative cooling and as such are adiabatic heating processes.

<u>Mass-effect cooling</u>: The use of thermal storage to absorb heat during the warmest part of a periodic temperature cycle and release it later during a cooler part. Night flushing (where cool night air is drawn through a building to exhaust heat stored during the day in massive floors and walls) is an example of daily-cycle mass-effect cooling.

*Usage renewable energy resources with active techniques*:

**The active use of solar energy systems in buildings**: It is possible to produce heat and electricity with solar energy in buildings using such equipment solar collectors, photovoltaic (PV) panels, and building integrated PV (BIPV). The potential application of PV panels in high-rise buildings is more than the low-rise buildings because of higher neighbouring buildings; it gives more possibility for direct solar radiation. Requirements for regulation of large amounts of PV panels are the most important problem. Because it is necessary to maintain aesthetics and PV panel's productivity in buildings. The active systems where solar energy is used are the systems composed of the aggregation of mechanic and/or electronic components that convert solar radiation absorbed via collectors produced for this end into energy in a desired form and permit this to be used in building. Through these systems, solar radiation can turn into heat and electric energy.

These systems that transform solar radiations into energy are divided into two according to the energy they produce:

- solar thermal systems producing thermal energy and
- thermal electric (photovoltaic) systems (PV systems) producing electric energy.

These systems are briefly described below.

**Solar energy thermal systems**: Solar energy thermal systems (effective solar thermal systems) are the aggregation of mechanic and/or electronic components that convert solar radiation into thermal energy via collectors, make it possible to directly use this energy with water, air, and a similar fluid, or make it usable by evaluating it in a storage unit. Solar energy-efficient thermal systems are used for heating pool water, preheating of climatization air and heating environment. The general operation principle of thermal systems is based on collecting heat via collectors, storing thermal energy to be able to use later if needed and distributing it to relevant fields.

**Solar water heating systems**: These systems are composed of the elements that transform solar radiation into thermal energy, keep and distribute this heat in an aquatic environment. In contrary to the fact that systems show differences depending on the complexity and magnitude of necessity, all of the solar water heating systems are based on heating water, storing, and distributing it. As the hot water produced with the transformation of solar energy can be directly used for having a bath, laundry, and washing dishes depending on the characteristics of the system, it can also be used for supporting the conventional heating system.

**Photovoltaic systems**: The aggregations of the components that produce electric energy via collectors from solar radiation and make this energy usable are called photovoltaic (PV) systems. With simple or complex structuring, PV systems are used to produce electricity in a large number of different fields such as road lighting, lighthouses, vehicles, constructions, and electric power-plants. A photovoltaic system generates electric energy, stores the produced energy for necessary conditions and safely transfers this energy to the areas of usage. By being placed on fronts and roofs of buildings, photovoltaic batteries convert the solar energy coming to these surfaces into electric energy. The active use of wind energy systems in buildings: Wind energy is the fastest-growing renewable energy source in the world. Wind energy is a clean fuel source and does not produce atmospheric emissions that cause acid rain or greenhouse gasses. Wind energy is an inexhaustible energy source. More recent developments in this technology have allowed wind turbines to be utilized in building design. Consistent with the high performance approach to building design, the use of wind turbines on high buildings is significantly enhanced by their integration with building architecture.

When the height of the structure increases the wind without interruption in direct contact with structure, wind speed increases linearly with height and utilizing the turbine at high buildings with this feature it is possible to produce significant amounts of electricity. Implementation of wind turbines in high buildings in the design stage consideration of this parameter is required: site plan layout, wind aerodynamics in building form, local wind pattern, wind speed density, frequencies of the wind speed distribution, and prevailing wind direction. Must be designed taking into account the prevailing wind direction which mass form of the building and placement in the wind turbine. Previous studies show that optimal angle between the prevailing wind direction and wind turbines for maximum efficiency is determined as 45°

**Use of geothermal energy in buildings**: Geothermal energy is used in heating and cooling in houses, greenhouse cultivation, and agriculture. Geothermal energy systems are applied in three different ways according to application methods such as heat pumps, downhole heat exchangers, and heat pipes. Their common usage in buildings is in the form of heat pipes.

Another form of geothermal energy usage is the methods where earth temperature is used. A little under earth, temperature is always in between 45 and 75 F (7.22 and 23.88°C) depending on latitude. This temperature of the earth can be benefitted via air or water. The air taken through the funnels dug in various depths of earth is transferred into building and indoor is enabled to reach the same level with earth temperature. This application is ensured in the direction of heating in winter and cooling in summer. A similar application is performed to utilize the temperature of underground waters, the water circulated within the building via pipes expands the heat it has into internal volumes.

**Use of hydrogen energy in buildings**: Hydrogen energy can be used for heating houses, providing hot water, cooking and meeting electricity need. In order to use hydrogen here, we first need to produce it, then store and transfer it. Hydrogen can be produced from such renewable energy sources such as sun, hydroelectric, wind, and geothermal. Nowadays, among the renewable energy sources, solar-hydrogen hybrid system strikes us as the most productive system. In such a system, there is a need for such constituents as photovoltaic panels, electrolyser, fuel cell, hydrogen (H2) storing tank, battery pack, and inverter.

In solar-hydrogen house energy mechanism, system works as follows:

1. with PV panels, electricity is produced from solar energy,

2. with electrolyser, $H_2$ and $O_2$ are produced,
3. gases are taken into storage tank for heating place and water,
4. in winter, by burning hydrogen “flamelessly” with catalytic hydrogen lighter (1.5 kW), the air in the ventilation system is heated,
5. if additional electricity is needed, fuel cell runs,
6. a part of the heat emerging in fuel cell is used to heat water.

**Use of biomass energy in buildings**: Biomass is a strategical energy resource, which is renewable and environment friendly, can be grown everywhere, enables socioeconomic improvement, and can be used for power generation and for obtaining fuel for vehicles. Biomass is utilized in the energy sector by being directly burned or its fuel quality is increased with various processes and thus gained alternative biofuels (easily movable, storable, and usable fuels), which are equal to existing fuels. From biomass is produced fuel with physical processes (size reducing-breaking and grinding, drying, filtration, extraction and briquetting) and transformation processes (bio massive and thermochemical processes). In the houses, biomass is used for biogas power generation adopted with airless increpation, ethanol heating adopted with the pyrolysis method, and hydrogen water heating adopted with the directly burning method.

**Natural lighting**: Natural lighting in buildings is carried out through a most basic windows and skylights. Choice of direction in the windows and roof lighting is important. The most suitable directions for natural lighting are south and north. The north direction is not exposed to radiation, but can always get daylight in the same quality. In the west and east directions, the sun radiates in horizontally and makes it difficult to control. In the south direction, the effect of the sun is permanent and sun rises at a right angle compared to the west and east directions. Therefore, it is easy to control.

In order to increase daylight’s entrance into the building, light colours should be used on windows’ wings that direct the light and light shelves. Moreover, the elements used to reflect light must be made in a position to reflect the light to the ceiling. Wall and ceiling surfaces must be light coloured so that the light can be spread. Desirable reflectance according to Illuminating Engineering Society’s recommendations: ceilings >80%; walls 50–70% (higher if wall contains window); floors 20–40%; and furniture 25–45%.

The proper design and selection of the daylighting systems can help in improving energy efficiency and reducing environmental pollution. Windows, clerestories, and roof monitors when properly designed can provide of the lighting needs without undesirable heat gain and glare. And therefore, electric lights can be turned off or dimmed in day-lit spaces when the target illuminance is achieved by daylighting. Energy savings can only be achieved by implementing light controls, sensors, and light dimmers for the lighting system of those day-lit spaces. The usage of daylight in buildings decreases the electric energy consumption. For instance, it has been shown that artificial lighting of nondomestic buildings represents 50% of the energy consumption in Europe. It also has been shown that it is possible to reduce this consumption by between 30 and 70% by combining the use of artificial and natural lighting. Potential savings depend on orientation, the size and shape of the window, and the shape and surface reflectance of the room.

Another usage of natural lighting in buildings is the use of the daylighting system. Daylighting is defined as “the combination of the diffused light from the sky and sunlight.” A daylighting system preferred function is to redirect a significant part of the incoming natural light flux to improve interior lighting conditions, therefore located near or in the openings of building envelope. Daylighting systems are divided into two categories: side-lighting and top-lighting. Light can come from many types of glazing configurations, which are either vertical or horizontal and from the side or from the top. Side-lighting, which is more commonly observed, is simply a window opening. Top-lighting is an opening in the ceiling or roof element of the building. Applications of the daylight system are discussed below

**Energy-efficient designing methods in building phase**

Building phase includes the construction and usage processes of building. Building phase is possible with preferring building techniques consuming less energy and using energy-efficient equipment. The energy used in construction changes according to building systems. For instance, frame construction consumes less energy than a reinforced concrete frame construction during its life cycle. As the energy consumption of the buildings constructed with different materials changes, energy consumption also changes in the buildings constructed with the same materials. The energy consumption of the commonly used reinforced concrete frame building system was analysed according to three different building methods as follows:

1. **Conventional frame building system**: The most prominent characteristic of the conventional building system is that the whole of production is implemented in building site thanks to intensive man power. When it is analysed with respect to energy consumption, the energy consumption of the conventional system is at a low level due to the characteristics of the equipment (concrete mixer, roof crane) used in the stages of concrete production and concrete casting.
2. **Tunnel form concrete masonry system**: Tunnel form masonry system requires a certain preliminary investment. The system is suitable for large scale and permanent productions. Because lifting cranes consuming a lot of energy are used to carry big and heavy forms, energy consumption is high. The task of curing with concrete plant and intra-tunnel heaters raises the energy consumption of the system.
3. **Precast construction systems**: Since the majority of the processes realized in the building area in other systems are made in the manufacturing plant, energy consumption is very high. In these systems, downloading components from transportation vehicles to worksite, their storage and mounting are performed by lifting cranes. For this reason, at these stages as well, the high amount of energy is consumed. While heavy duty vehicles transporting ready building elements from manufacturing plant to building site lead to problems in traffic, they also increase the consumption of energy.

As a result, it can be urged that in a tunnel form, precast framework and precast panel building systems, manufacturing processes create negativities to a large extent in terms of energy consumption and emissions, energy consumption in the conventional systems is quite less compared with these but more negative with respect to the formation of solid waste. As it is understood from the reinforced concrete building system, there are different methods for the same material in the construction of buildings. Such heavy-duty vehicles as lifting cranes, concrete pumps, and concrete transit mixers consume the high amount of energy. For this reason, the building methods consuming less energy should be preferred on the condition that no concession is made in the quality of building. Usage process is the process that consumes most energy in buildings. According to WBCSD (World Business Council for Sustainable Development) report, 88% of the energy consumed in buildings is spent during usage and maintenance. The applications mentioned in designing process gain buildings energy efficiency during usage period. Besides this, the applications below have also the potential of procuring considerable energy saving during usage period.

**Supporting multiuse improvement**: Sustainable development advocates the combination of house settlement, trading area, office, and retail areas. Thus, people get the opportunity of living next to the places they work and shop. This renders the formation of a community different from traditional suburbs. 24-hour activity potential also makes the land safer.

**Combining design with public transportation**: Sustainable architecture on urban scale should be designed in a way to support public transportation. Thousands of vehicles coming in and going out the land during daily work pressure cause air pollution and traffic jam and they need parking areas.

**Using energy-efficient bulbs and energy-efficient appliance**: For example, the light-emitting diode (LED) is one of today's most energy-efficient and rapidly developing lighting technologies.

**Lighting controls**: Lighting requirements reply to a building design. The need for lighting, when during daytime, will depend on the window size and placement, and the position of buildings. The need for lighting is decreased by the use of automatic controls, which depend on the orientation of building windows, the supply of daylight, and usage of the room.

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