5. PASSIVE AND ACTIVE SYSTEMS USING RENEWABLE ENERGY SOURCES

Today, population growth and consequent need for industrialization has increased the energy requirement, bringing environmental pollution to dangerous levels. Excessive use of resources and increasing high demand have led to efficient use of energy and accelerated renewable energy-based efforts (Sanchez and Izard, 2015). As it is the case in all sectors, it has become necessary to design buildings that use renewable energy sources which are easy to maintain, economical and environmentally friendly; and applications that use solar energy, wind energy and geothermal energy have gained importance in the construction sector.

It can be said that solar, wind and geothermal energy are the most widely used renewable energy sources for heating, cooling, ventilation, lighting, and electricity production in buildings. Concerning the use of these energy resources in buildings, there are two types of systems as passive and active systems. The use of solar and wind energy for heating, cooling, ventilation, and lighting during the design phase of the buildings is considered as "passive systems". Every technological product added to the building design can be defined as "active systems". Although there are many definitions of passive and active systems in the literature, it is difficult to differentiate these systems in some cases. In this study, passive and active systems are examined in the scope of heating, cooling, lighting, and electricity generation in buildings.

5.1. Passive Systems

Passive systems are the oldest systems used to benefit from solar and wind energy in buildings. In these systems, it is important to optimize the effects of solar radiation (Özdemir, 2005). Heating, cooling, ventilation and lighting are provided through passive solar systems; cooling and ventilation through passive wind systems. Passive solar system applications can be utilized as heat gain in winter, natural ventilation and cooling in summer. Passive systems are realized through planning decisions and materials used during the design phase. In these systems, the sun rays reaching to the wall, window and roof components of the building are collected, stored and distributed to the interior spaces by using one or more of the transmission, transport and radiation paths (Gültekin and Demircan, 2017).

Considering the passive systems in terms of solar energy, there are three elements in the applications. These elements can be classified as "collectors, storers and distributers". Solar walls (trombe walls), water walls, metal walls, roof ponds, solar rooms, thermosiphon systems, solar chimneys and double-layer façades act as collectors to collect and convert solar energy into heat. The collected heat enables the use of heat through the "storers" in the absence of sunlight. After the energy is stored, some of the heat is used immediately and the rest is spread to the thermal mass (floor and walls) for later use. Thermal masses can be made of stone, brick or water. The task of "distributors" is to transfer the energy collected by the collectors to the storage elements and the required places by radiation and transport (Gültekin and Demircan, 2015).

In addition, in the use of solar energy through passive systems light shelves, light pipes, heliostats, and anidolic ceiling applications are used for illumination and the labyrinth system is used for heating and cooling. When passive systems are considered within the scope of wind energy, cooling and ventilation is provided by shading elements, wind towers, chimney ventilation and atria, venturi chimneys and wind cowls.

Passive systems are classified as "direct and indirect passive systems in the literature. These systems utilize openings that provide heating and cooling. These openings are southern openings, roof openings and discrete (distant) openings (Özdoğan, 2005). Heating and cooling methods in passive systems are given in Table 5.1 and Table 5.2 within the scope of direct and indirect systems (Bekar, 2007).

Table 5.1. Heating methods in direct and indirect passive systems (Bekar, 2007)

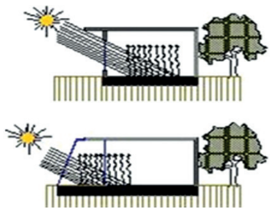
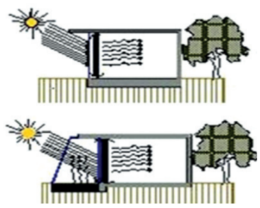
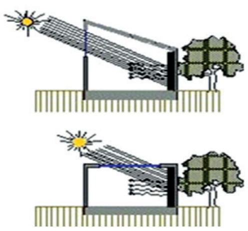
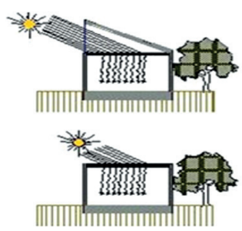
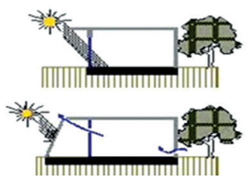
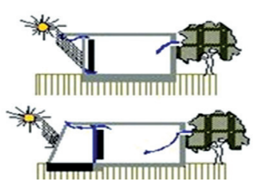
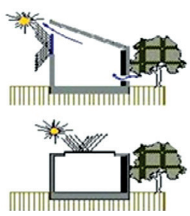
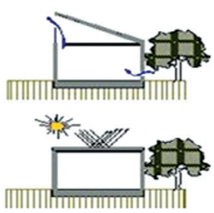
DIRECT PASSIVE SYSTEMS		INDIRECT PASSIVE SYSTEMS
Southern Openings		
Roof Openings		

Table 5.2. Cooling methods in direct and indirect passive systems (Bekar, 2007)

DIRECT PASSIVE SYSTEMS		INDIRECT PASSIVE SYSTEMS
Southern Openings		
Roof Openings		

In direct passive systems, the façade space consists of south facing façades and greenhouses. In order to gain heat during the winter months, the ratio of the glass surface on the southern façade should be increased and the glass surfaces on the other façades should be kept at the minimum level. In the façade openings, sunlight is taken from the south façade into the space and is stored by massive walls and converted into heat energy (Figure 5.1). In cases where the temperature of the environment is high heat is absorbed by the massive elements, and when the temperature decreases heat energy is returned to the environment by convection and radiation. Apart from the dimensions of the windows, their shape and position also affect the transmission of radiation to the space. In winter, almost horizontal rays can reach the deepest parts of the internal space through vertical windows. In summer, the sun does not affect the internal space much due to the steep angle of incidence of the sun rays. Therefore, the arrangement of the windows in the vertical position can be considered as the most appropriate choice. Roof openings used in direct passive systems are not as effective as façade openings. However, it is recommended when there is insufficient sunlight from the southern front. With the principle of rising up of the warming air, it is seen as a suitable method for cooling the space in summer although it is not very efficient in heating the space in winter (Sayın, 2007).

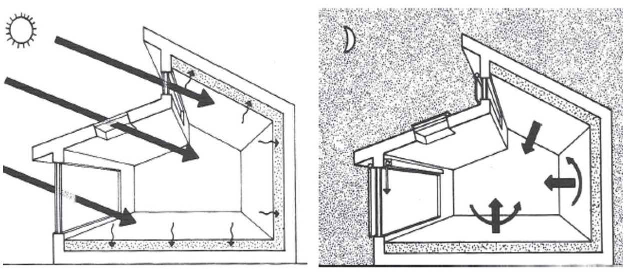


Figure 5.1. Direct passive systems (Yüre, 2007)

The operation principle of direct passive systems is given in Figure 5.2. Solar energy passing through the transparent surface during the day (see Figure 5.2.a) is stored by building elements such as concrete slabs and solid walls (see Figure 5.2.b, c). At night, the solar energy stored during the day is used indoors (see Figure 5.2.d) (Özdemir, 2005).

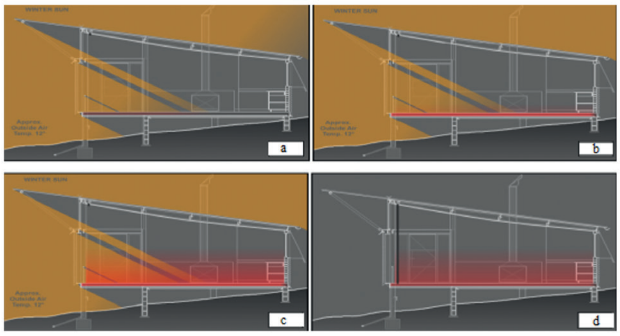


Figure 5.2. Working principle of direct passive systems (Özdemir, 2005)

In indirect passive systems, solar radiation is converted into heat outside the space and then transmitted to the space by conduction, convection and/or radiation. In this system, the energy gain is provided with the help of an outside collector, whereby it is possible to give it to the building at night hours. However, one of the disadvantages is the heat loss that occurs in this system which has a worse insulation level than a well-insulated roof or façade (Sayın, 2007).

Solar walls (trombe walls), water walls, metal walls, roof ponds, solar rooms, thermosiphon systems, solar chimneys, wind towers, atria, double-layer façades, venturi chimneys, wind cowls and labyrinth systems can be examined within the scope of indirect passive systems. In addition, advanced natural lighting systems that use new technologies today, also known as advanced daylight systems, aim to reduce electricity consumption in buildings as much as possible, as well as providing natural lighting by significantly improving the light quality of the interior. In this context, light shelves, light pipes, heliostats and anidolic ceilings can be considered in the context of passive systems.

5.1.1. Solar Walls (Trombe Walls)

The solar walls consist of a glass surface and a thermal mass that stores the energy placed behind it. This mass can be usually black colored concrete, adobe, solid brick or stone. In this system, which is expressed in

Figure 5.3, transferring the stored heat to the interior in winter, and in summer, transferring heat from the gaps such as chimneys or windows without transferring the heat to the interior are the main principles. According to Figure 5.3, firstly the sun rays pass through the glass surface and come to the solar wall (see Figure 5.3-1). Solar heat is transmitted to the surface through conduction by the solar wall, and then to the interior by radiation and convection (see Figure 5.3-2). During the day, the indoor cold air heats through the openings on the solar wall and a circulation takes place (see Figure 5.3-3). At night, the openings on the solar wall are closed so that the stored heat remains indoors (see Figure 5.3-4).

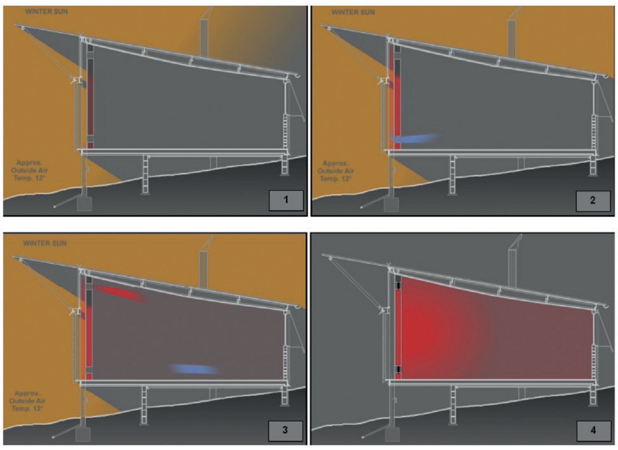


Figure 5.3. Working principle of solar walls (Özdemir, 2005)

In summer, natural ventilation is achieved by opening the wings on the glass surfaces and the interior windows. In addition to the summer shade and winter night insulation measures, another measure to be taken for winter evenings is to close the ventilation openings on the wall in order to prevent the cooling of the interior by withdrawing the cold air from the holes in the bottom so that the air movement reverses and the heated air goes between the glass surface and the wall. Figure 5.4 describes the working principle of the system.

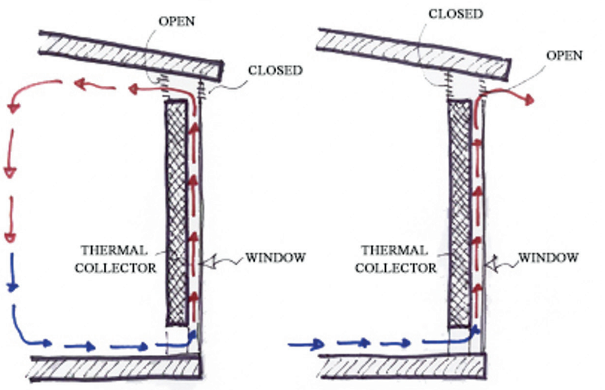


Figure 5.4. Heating-cooling principle in trombe walls (Gültekin and Demircan, 2015)

5.1.2. Water Walls

Water walls were first developed by Steve Baer in 1971. In the houses designed by Steve Baer, 55 water filled cans were used behind the glass units and large aluminum shutters were used to cover these cans (Figure 5.5). These shutters also serve as reflectors.

Figure 5.5. Water wall application in Steve Baer house (Corrales, New Mexico) (Baer, 2009)

Benedictine Monastery, designed by Steve Baer in 1978, also shows that passive systems are used. At the same time, water walls are included in the scope of passive systems (Figure 5.6).

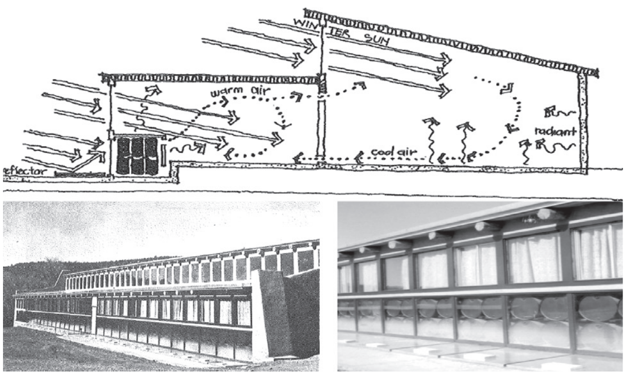


Figure 5.6. Water wall application in Benedictine Monastery (Baer, 2009)

In the water walls, the heat storage mass (cans) is filled with water or a similar fluid (see Figure 5.7). The cans are painted black to form a beam collecting surface, so that the cans perform the collector and thermal storage tasks together. The sun's rays passing through the glass are absorbed by the black surface of the can and the thermal energy heats the water in the can. The heated cans transfer their energy into the building by radiation and convection. During the night, in order not to lose the heat gained during the day, insulated covers in the shape of walls are closed in the evening and thermal losses are prevented (Özdemir, 2005). The most important problems encountered in water walls are evaporation, corrosion and leakage (Gültekin and Demircan, 2015).

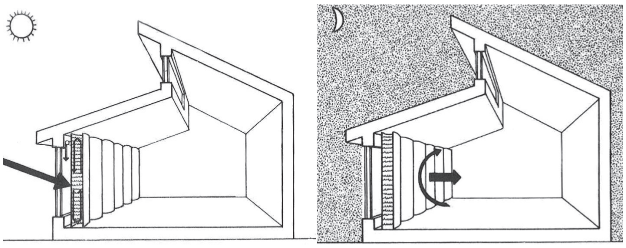


Figure 5.7. Working principle of water walls (Alparslan, 2010)

When the behavior of the water wall is examined in summer, seasonal and intraday periods, similar problems are encountered with the solar wall. Overheating of the system during summer days is a possible problem. Similarly, another possible problem is the loss of heat at night collected during winter days. For this reason, shading elements such as panels and shutters that provide solar control and insulation on the outer surface of the water wall should be used in order to ensure a continuous and efficient performance of the water wall within 12 months (Yasan, 2011).

5.1.3. Metal Walls

Metal walls were first produced in 1981 by a company called Wieneke in Germany to pre-heat the air supplied to buildings for ventilation. In the following years, some of these systems were used for heating buildings and others for drying food. Metal wall applications have started to gain new prevalence today (Ay and Khanları 2015).

Metal walls are placed on the southern façade of the buildings, approximately 10-30 cm from the building (see Figure 5.8). The south-facing exterior wall of the building is covered with metal sheets such as perforated, dark aluminum or steel instead of a transparent layer. The difference from other passive systems is that the air is taken in through the holes in the sheets. The air entering to the gap between the wall and the metal sheet heats up and rises inside the façade by the chimney effect and is transferred to different parts of the building through fans (Erengezgin, 2001). The absorber plate on the metal wall is generally corrugated since it is thin. In this way, it is ensured that the air is brought into contact with a larger surfaceas well as increasing the resistance of the absorber surface against wind and other factors. In addition, the thin production of the absorber plate ensures that all parts of the plate can be heated homogeneously and quickly (Ay and Khanları 2015).

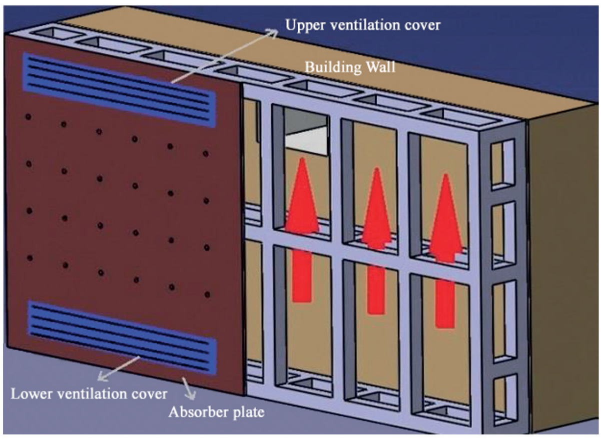


Figure 5.8. Placing the metal wall on the building façade (Ay and Khanları, 2015)

The work of metal walls is examined in four zones. The first zone is the surface in front of the absorber plate. The second zone includes the inside of the holes on the absorber plate and the ventilation covers. The third zone is the intermediate zone between the absorber plate and the wall. The fourth zone consists of the distribution channel cover, fan and distribution channel.

In the winter application of the metal walls, the upper ventilation cover in the second zone is closed, the lower ventilation cover and the distribution channel cover in the fourth zone are open. When the lower ventilation cover is partially open, a portion of the air leaving the building is discharged therefrom, and the remainder enters the gap for reheating. This air entering the gap combines with the heated air in the first and the second zones, entering into the space through the opening of the distribution channel cover in the fourth zone (Figure 5.9).

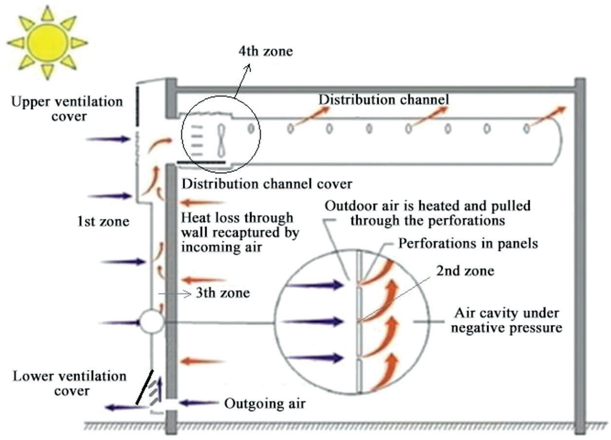


Figure 5.9. Working principle of metal walls in winter (Solar Wall, 2019)

In the summer application of the metal walls, the ventilation covers on the upper and lower sides of the system in the second zone are completely opened and the distribution channel cover in the fourth zone is closed. Thus, a ventilation channel is created in the gap(Figure 5.10). The absorber surface acts as a shield against the sun's rays, while the air flow in the gap makes the building wall cooler. At the same time, cooler air is circulated throughout the building through a window that opens from a north-facing façade inside the building (Ay and Khanları, 2015).

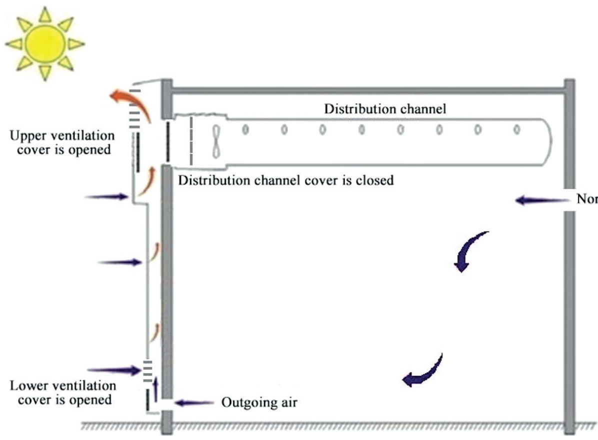


Figure 5.10. Working principle of metal walls in summer (Solar Wall, 2016)

5.1.4. Roof Ponds

Roof ponds were first developed by Harold Hay in 1973 under the name "Skytherm." The operating principle of Skytherm House is given in Figure 5.11. In this system, the roof is made of metal. There are plastic bags filled with water on top of the metal cover and movable insulation materials on top of them.

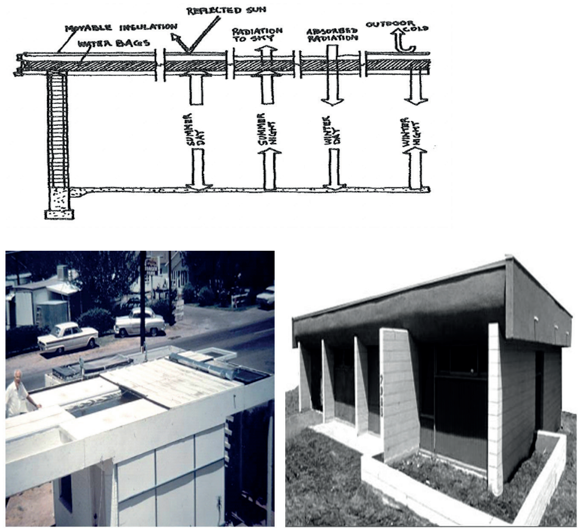


Figure 5.11. Skytherm House (Atascadero, California-USA) (Baer, 2009; Solar Wall, 2016)

Roof ponds differ from other passive systems in terms of the plane in which they are built. In other systems, the heat trapping mass is formed vertically, while in this system the heat trapping mass is formed horizontally. The heat trapping mass on the roof is carried by the metal construction below it. In this system, the mass of water in the roof fulfills the task of thermal mass (Yüre, 2007).

Roof ponds are based on the principle that the solar energy stored by the water-filled pool or plastic bags is transferred from the ceilings of the space to indoors as heat. With the help of insulating elements (such as rolling shutters), these thermal masses are opened during the daytime in winter and provided with solar energy, while at night they are closed to prevent heat losses. In summer, the opposite is applied during the day, it is covered for protection from excess heat, and at night, insulation elements are opened, allowing the space to be cooled by heat transfer to outside (Uslusoy, 2012). Figure 5.12 and Figure 5.13 give the working principle of roof ponds for the summer period. First of all, the roof pond should be covered with insulated panels for protection from the heat of summer. During the day, the indoor air can be cooled by the effect of the roof pond which is kept cool by means of insulation (see Figure 5.12.a, 5.12.b). During the daytime, the cooling air through the roof pond descends and is replaced by heated air. At night time, the panels are opened (see Figure 5.12.c), and the pool transfers the heat to the exteriors (see Figure 5.12.d). During the winter season, the water in the pond heats up during the day with the effect of solar radiation. Thus, the effect of the roof pond ensures that the air in the space is also heated (Özdemir, 2005).

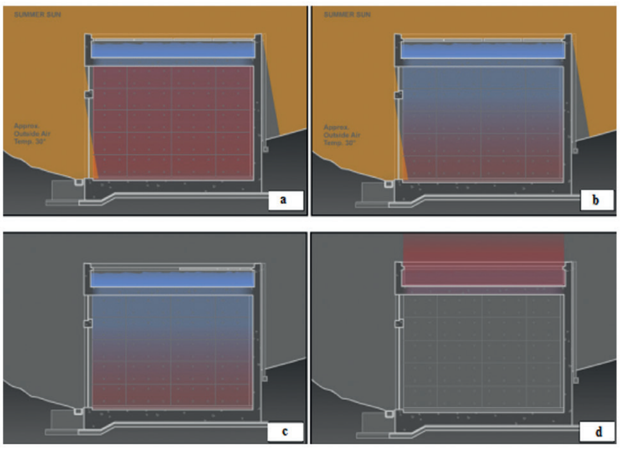


Figure 5.12. Working principle of roof ponds (Özdemir, 2005)

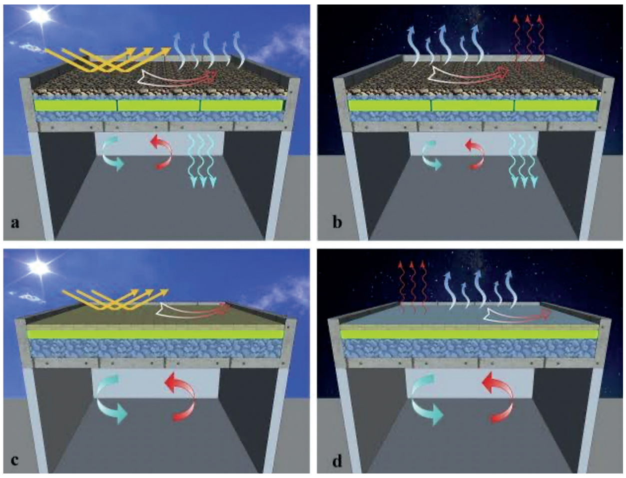


Figure 5.13. Working principle of roof ponds (Sharifi and Yamagata, 2015)

5.1.5. Solar Rooms

Solar rooms can be defined as collectors that are formed between indoor and outdoor spaces, providing heat, fresh air and humidity to the building and can be lived in. Increasing the glass surfaces facing the sun in the solar rooms during winter increases the heat gain and creates heat losses in the absence of sun. These surfaces cause negative effects such as increases in undesired heat gain in summer. For this reason, night insulation for winter evenings and sun protection for summer days are more important than the southern windows (Alparslan, 2010). Figure 5.14 shows the working principle of solar rooms for day and night, and Figure 5.15 shows the heating-cooling principle of solar rooms.

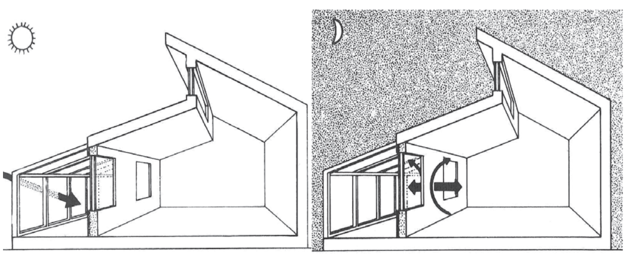


Figure 5.14. Working principle of solar rooms (Alparslan, 2010)

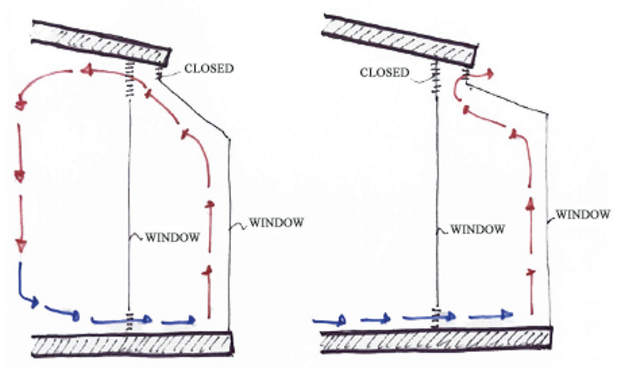


Figure 5.15. Heating-cooling principle of solar rooms (Gültekin and Demircan, 2015)

Besides providing an additional living space in winter and transition seasons to the building, the solar rooms function as livable places with high comfort value throughout the year with moving and controlled shading elements and ventilation units (Özdemir, 2005). The obtained solar energy is converted into heat energy and stored by the flooring and walls that work as a collector element. The stored heat is transferred to the interior that will be heated by convection. In order to transfer heat to the interior more quickly, the depth of the solar room should be less, the heat-trapping wall area should be larger, and small vents should be opened above and below the wall separating the solar room and the interior (Yüre, 2007).

5.1.6. Thermosyphon Systems

Thermosyphon is the name given to the natural movement of air or water due to temperature differences (Yedievli, 2009). Thermosyphon systems, which are continuous circulation systems, are generally used for heating purposes. The main element in the system is the solar collector called the thermosyphon current panel. The system consists of a heat-absorbing metal sheet painted in black and a glass or plastic surface covered on the sheet (Ovalı, 2009). This collector is similar to active solar panel collectors (Oral, 2005).

In the water heater systems, there is a collecting area which provides the direct connection between the solar radiation and living space separately from the building façade. In this area, thermosyphon current panels are embedded in the wall or placed on a plot with elevation lower than the building. When the cold air or fluid is at the lowest level of the collector area, it is heated by solar radiation. Heated air or fluid moves by rising up to storage mass to replace cold air or fluid to provide the circulation (Figure 5.16) (Özdemir, 2005). In the thermosyphon system given in Figure 5.16, the solar radiation is collected by a solar collector. In other words, the passive system is supported by an active system element.

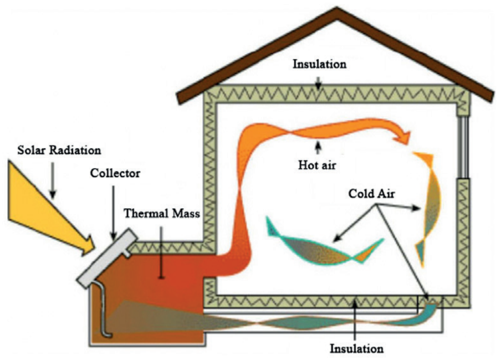


Figure 5.16. Working principle of thermosyphon systems (Özdemir, 2005)

5.1.7. Solar Chimneys

Solar chimneys and solar energy can be used for ventilation and cooling purposes. These chimneys are designed not to exceed the roof height on the south side of the building. The outer surface of the chimney is covered with transparent glass and the inner surface is covered with dark metal material for absorbing sunlight. The air inside the chimney rises with the effect of the sun and rises out of the chimney. When the wind speed is low, the expulsion of air is accelerated by the rotating wind cowl placed on the top of the chimney. Cool air entering the lower point of the chimney creates air circulation and natural ventilation is provided (Alparslan, 2010). Figure 5.17 describes the heating and cooling principle of solar chimneys.

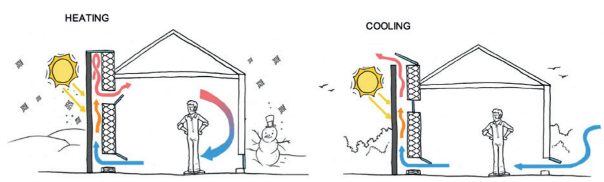


Figure 5.17. Heating-cooling principle of solar chimneys (Autodesk, 2017)

5.1.8. Shading Elements

Design of outdoor shading elements in an objective approach began in the 1940s with the research of the Olgyay brothers in climate-balanced architecture and urbanism (Ok et. Al., 2009). Shading elements are used to provide protection against unwanted thermal effects of the sun and to contribute to cooling. The shade elements can be used indoors, outdoors or between two windows according to different conditions, horizontally and vertically. Outdoor shading elements are components designed as supplements to the building. These components are produced from various materials such as glass, metal, concrete, wood, plastic, fixed or moving.

Fixed shading elements used outdoors are one of the most effective elements in reducing heat gain, since they prevent solar heat from reaching the façade (Figure 5.18) (Şahinoğlu, 2012). The cassette-type shading elements, which are formed by combining the vertical and horizontal shading elements, can cause negative consequences in terms of illumination as they provide protection against high and low sun angle of incidence.

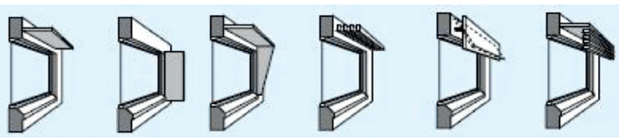


Figure 5.18. Fixed shading elements used outdoors (Stack et. al., 2002)

The movable shading elements used outdoors can be more easily adapted to the movement of the sun thanks to their flexibility and are more efficient than fixed shading elements. Movable shading elements can be listed as roller shutters, awnings, blinds and roller blinds. These elements can be collected according to climate conditions, can be completely disabled or associated with automation (Figure 5.19).

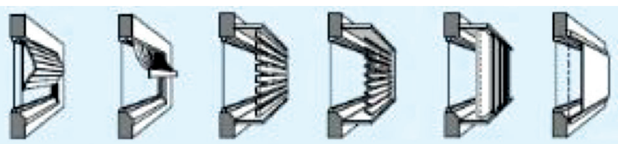


Figure 5.19. Moving shading elements used outdoors (Stack et. al., 2002)

Outdoor plants such as trees, shrubs, ivy can also be used as shading elements (Figure 5.20). At the same time, planting façades reduces the cooling loads of the building and provides thermal insulation.

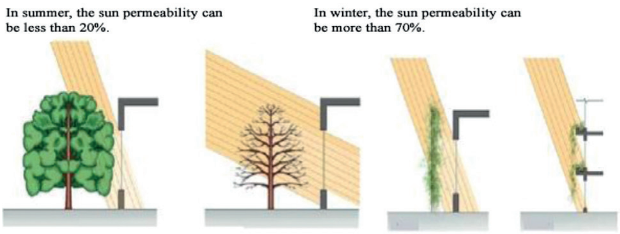


Figure 5.20. The effect of non-evergreen trees, ivy and potted plants on solar control (Stack et. al., 2002)

Shading elements used indoors can be listed as curtains, shutters and blinds (Figure 5.21). Internal shading elements are easier to control and maintain than external shading elements. In addition, it can be said that glare control is very effective with its ability to diffuse and reflect light (Şahinoğlu, 2012).

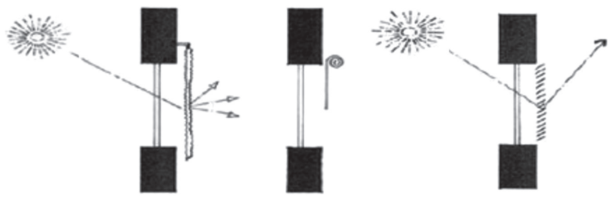


Figure 5.21. Shading elements used indoors (Şahinoğlu, 2012)

5.1.9. Wind Towers

In wind towers, solar and wind energy are used together. Wind towers provide natural ventilation for the interior and provide thermal comfort with necessary humidity regulations. It has been widely used in the Middle East in countries such as Egypt, , Iraq, and Iran as well as Afghanistan and Pakistan. Furthermore, in buildings in the old settlements of hot-humid cities such as Bandar Abbas, Abu Dhabi, Bahrain and Cairo located around the Persian Gulf and hot-dry climates such as Kerman, Yazd, Kashan, Bam, Meshed and Herat (Ali and Özer, 2011).

The wind towers take the cool air indoors and discharge the rising indoor air that has been warmed up. The cool air entering from the northern opening of the wind tower during the day provides the ventilation of the interior and the heated air on the south side is thrown out. At night, air circulation is provided in the indoor space through the wind tower (Figure 5.22).

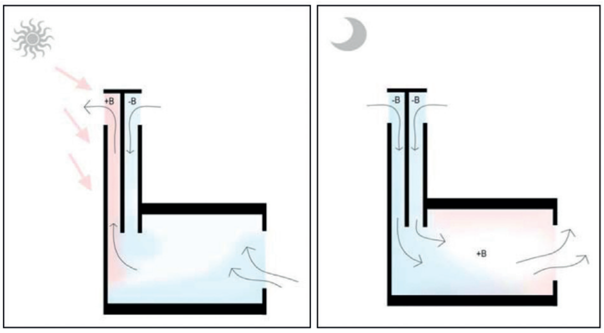


Figure 5.22. Day and night working principle of wind towers (Erkinay, 2012)

An example of the wind tower is the Ecology Research Center in Figure 6.23. In the method used in the Ecology Research Center, outside air is brought into contact with a body of water in the wind tower before entering the building, and the space is cooled by evaporation of water (Engin, 2012). Thus, the temperature of the air decreases from 85˚F to 59˚F and there is an increase in the humidity of the air (Figure 5.24).

Figure 5.23. Ecology Research Center (Stanford) (Dangermond Keane Architecture, 2016)

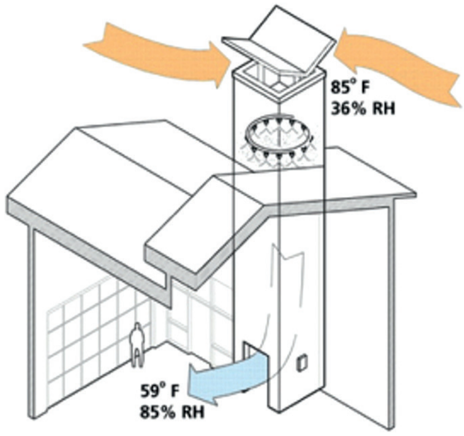


Figure 5.24. Working principle of evaporation ventilation (Center for the Built Environment, 2016)

A wind tower was also designed at the Masdar Institute in Abu Dhabi (Figure 5.25). This wind tower is 45 m high and designed to cool the courtyard of 6 buildings. By means of the tower, which became operational in 2010, the cooling requirement of the institute was reduced by 50% compared to a building in the United Arab Emirates (Middle East Sustainable Cities, 2016).

Figure 5.25. Masdar Institute Wind Tower (Middle East Sustainable Cities, 2016)

On the upper part of the Masdar Institute Wind Tower, sensor shutters have been designed to open in the direction of wind at a height of 6 m. In the same part, there is a thermal mass to store the air rising with temperature (Figure 5.26).

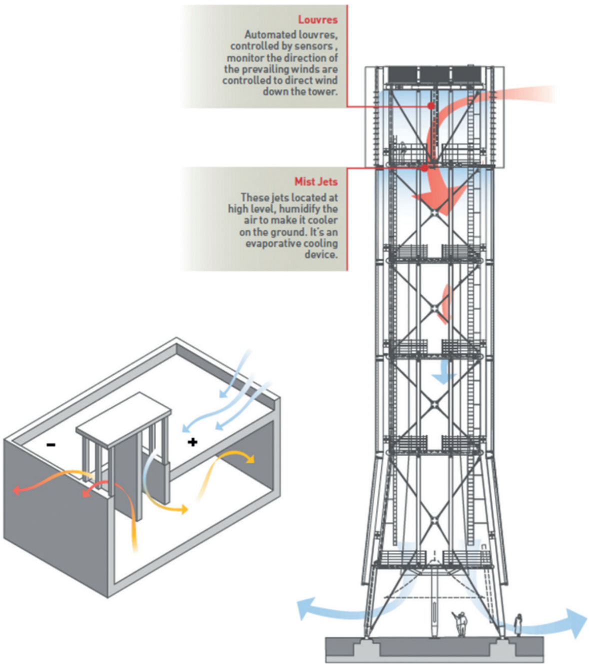


Figure 5.26. Working principle of Masdar Institute Wind Tower (Middle East Sustainable Cities, 2016)

5.1.10. Atria

The atrium is a large section in the middle of the buildings, optionally open or closed. Today, it is defined as an interior element that is protected from external environmental conditions, receiving natural light and constituting the social center of the building. By creating a chimney effect, the atria contribute to the comfort requirements of the buildings such as heating, cooling and ventilation. At the same time, it allows energy consumption to be reduced by enabling the surrounding areas to benefit from daylight (Göçer, 2006). Dirty air that expands and rises due to the chimney effect in the atria is thrown out of the building from the roof of the atrium and fresh air is provided into the building through the wall openings (Figure 5.27).

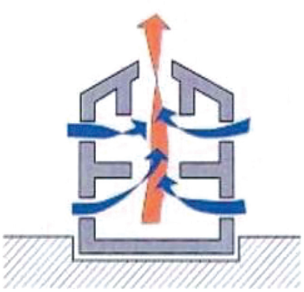


Figure 5.27. Working principle of atria (Uslusoy, 2012)

5.1.11.Double-Layer Façades

Double-layer façade applications have been widely used in recent years especially in developed countries in office buildings for ventilation, heating and cooling purposes. Double-layer façades are formed by placing two layers (outer shell and the inner shell) on the façade with air gap between them. The outer shell provides protection against the weather, while at the same time preventing outside sound from entering the building. The air gap between the outer shell and the inner shell creates a buffer zone, reducing energy consumption and allowing natural ventilation of the building. In double-layer façade applications, the outer shell can be designed to be continuous along with the height of the building or discontinuous with intervals at the floor levels (Ovalı, 2009; Alakavuk, 2010). Figure 5.28 shows a double-layer façade application. In these applications, the air taken from the lower part of the façade by inlet vents warms up after a while. During the cold season, the air that heats up in the air gap works as a thermal buffer zone to prevent heat losses. It can be supplied indoors with heated air automation systems. In warmer seasons, the air that is heated in the air gap is thrown out through outlet vents and cooling is provided (Erkinay, 2012).

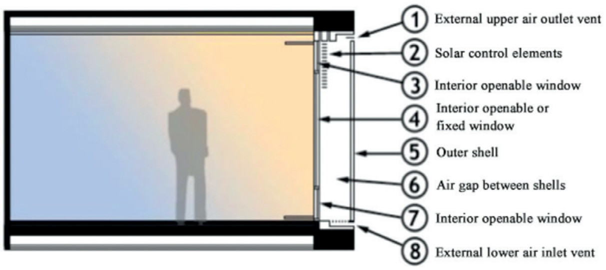


Figure 5.28. Double-layer façade application (Alakavuk, 2010)

The principles of ventilation in double-layer façades can be listed as follows (Alakavuk, 2010):

- In winter, the air taken from the interior, between the two shells in the lower levels of the inner wall layer, heats up as it rises between the front shells and is returned to the interior through the spaces in the upper points of the interior wall. Thus, the air with increased temperature is used for heating the interior (Figure 5.29.a).

- The air taken from the entrance opening at the bottom of the façade from the outdoor space to the gap between the two façade shells rises between the façade shells and is discharged from the external air vent at the top of the façade without being taken into the interior. During the rise of air between the façade shells, the amount of heat the inner shell has due to solar radiation reduces, as the air contacts the surface of the inner shell facing the air gap. Thus, the surface temperature of the inner shell is at lesser degrees than the absence of air flow and the amount of heat passing to the interior from exterior space decreases (Figure 5.29.b).
- In this ventilation method used to ventilate the interior space, the air taken between the two shells from the vents located at the lower levels on the inner shell is discharged from the air outlet vent located at the upper part of the outer shell to outdoors. (Figure 5.29.c).
- The air taken from the outer space into the space between the two shells from the outer air inlet vent located in the outer shell is heated and raised here and taken from the spaces located at the upper points on the inner shell into the interior. With this method, the temperature of the cold air in the outdoor environment is increased and taken into the interior. The amount of energy to be spent to bring the indoor air to the desired temperature values is reduced with this method (Figure 5.29.d).
- In this ventilation method, gaps and vents on the inner and outer façade layers are kept closed. No air inlet-outlet is made between the two frontal shells, thereby forming a buffer zone. The heat exchange between the indoor and outdoor space is prevented by the created buffer zone and the external heat is prevented from affecting the interior space (Figure 5.29.e).

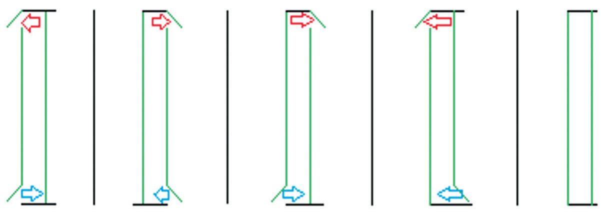


Figure 5.29. Ventilation types in double-layer façades (Alakavuk, 2010)

5.1.12. Venturi Chimneys and Wind Cowls

Venturi chimneys and wind cowls, which take fresh air in and exhaust used air, are simple devices that can be used in any building, from dwellings to industrial plants. As the blowing wind passes through a funnel-like device, whose mouth is narrowed, its speed increases just as the speed of the water that increases when the mouth of the hose is narrowed (Figure 5.30). This breeze is allowed to enter the interior with clean and cool air through the vertical channel. On the other hand, the dirty air that is heated and rising inside is ejected from the venturi chimney, which is a narrowed device, by the vacuum created by the wind during the horizontal transition. The method of venting a bottle is to blow strong air in a direction parallel to its mouth. The Venturi chimney draws the indoor air out on the same principle (Güneşevi, 2016). This system works with the principles of passive flue effect and performs its function even when the wind speed is low (Engin, 2012).

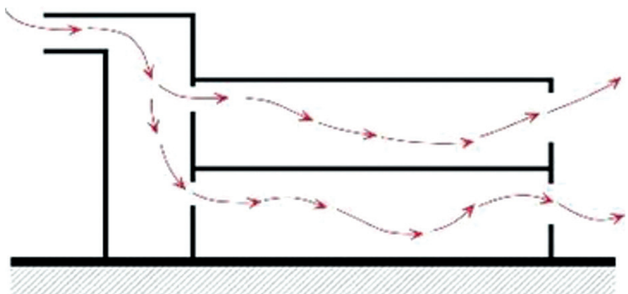


Figure 5.30. Working principle of venturi chimneys (Erkinay, 2012)

In the south of London, the architect Bill Dunster completed the first stage of a collective settlement, where wind cowls were used, in 2002 and opened the Wallington in Bedzed (Beddington Zero Energy Development) (Figure 5.31). These cowls provide ventilation by taking advantage of the positive and negative pressure of the wind. It provides air intake from kitchen, bathroom and toilet volumes, while transmitting heated or cooled air through heat recovery to living rooms and bedrooms.

Figure 5.31. Bedzed wind cowl application (Wallington, London, United Kingdom) (Alamy, 2017)

5.1.13. Light Shelves

Light shelves are horizontal elements designed to prevent excessive sunlight and direct the daylight to the ceiling. It can be an integrated element to the façade, or it can be mounted later. While it protects the area close to the window from intense sunlight in order to use daylight more efficiently in interior spaces, it provides general lighting in the depths of the space with the light reflected on the ceiling. It protects the indoor area close to the window from the intense sunlight and illuminates the depths of the place with the reflected sunlight. It provides more homogeneous light distribution by decreasing the daylight level at the window edges and increasing the daylight level in the depths of the interior space. Light shelves are the systems that reduce the cooling load by the function of shading element and reduce the light load by reflecting the daylight to the indoor ceiling thanks to the reflective surface of the shelf (Figure 5.32). With these features, light shelves are efficient systems in terms of reducing energy consumption (Şahinoğlu, 2012).

Figure 5.32. Working principle of light shelves (Günışığı, 2019)

Light shelves generally consist of a horizontal or almost-horizontal plate about 2 meters above ground level. The purpose of light shelves is to reflect sunlight into the space while preventing the sunlight coming at unwanted angles from entering. The position and dimensions of the light shelves at the front (inside, outside or on both sides) and dimensions are determined according to the shading and daylight and lighting requirements. In this context, light shelves can be classified into three groups as light shelves placed inside the window (inner light shelf), outside the window (outside light shelf) and placed on both sides (Figure 5.33). Interior light shelves direct daylight passing through the window into the interior space. Exterior light shelves have an impact on the architecture of the building since they are placed out of the building (Erel, 2004). An exterior light shelf shadows the window, while an interior light shelf provides illumination to the depths of the space. In addition, the material (matte, glossy or specular), smoothness (rough or smooth), color (light or dark), and slope of the ceiling cover affect the diffusion of daylight into the space.

Figure 5.33. Examples of interior and exterior light shelves (Ofluoğlu, 2017)

The depth of a light shelf must be increased to protect the interior space from excessive daylight. However, deep light shelves will reduce the external field of view provided through the window. This problem can be solved by covering the light shelf with moving reflective film (Figure 5.34). The reflective film can be adjusted appropriately depending on the different solar incidence angles (Şahinoğlu, 2012).

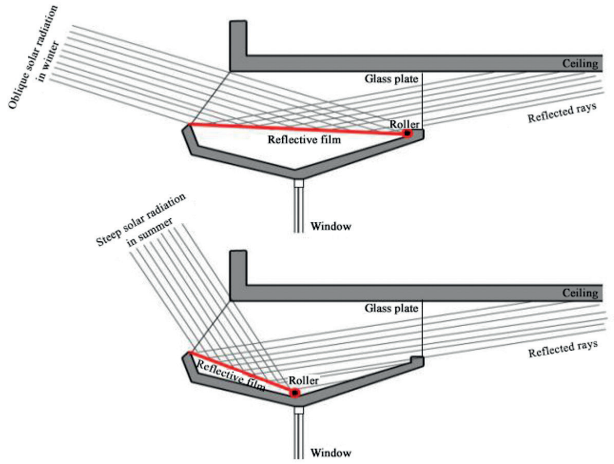


Figure 5.34. Working principles of light shelves with moving reflective film (Şahinoğlu, 2012)

5.1.14. Light Pipes

Light pipes are systems used to direct daylight to deep volumes. These are the elements where the sunlight taken from the small roof skylights is carried to the ceiling of the space by reflective pipes. The distribution of the light in the space is provided by the internal emitter elements. The daylight sensitive lighting element placed in the pipe or emitter element may operate in connection with daylight. Their performance is better when direct sunlight is available. A suitable system for the illumination of small spaces and if the grid layout is provided in large spaces, a smooth distribution of daylight can be obtained (Deparsolar, 2019) Figure 5.35 shows a light pipe application.

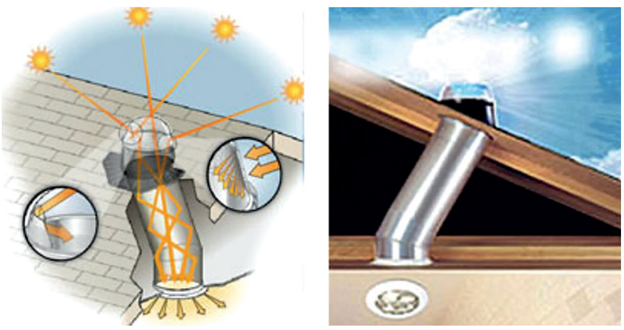


Figure 5.35. Working principle of light pipes (Inhabitat, 2019)

Light pipes are designed in 2 different ways; *end-lit* and *side-lit* light pipes.

End-lit light pipes consist of three parts. The first part of end-lit pipes is a transparent dome made of polycarbonate or acrylic. The dome formed by this injection molding method has high light transmittance and is resistant to weather conditions. It is mounted on a bright plate in such a way that it refracts the daylight at the correct angle (Yener, 2008). The external collector unit, which is formed by this dome, prevents the penetration of dust and water into the pipe while keeping the ultraviolet rays out. Collectors are generally two types. These are the dome-shaped elements that capture the light coming from all directions or the "sun followers" aiming to provide the highest efficiency by following the sun in the sky (Tokuç and Yıldızber, 2009). The second part, the light pipe itself, consists of intertwined tubes. The inner surface of the light pipe is covered with a reflective film. The third part forms an illumination device or diffuser unit which allows the light to diffuse indoors. The external collector unit is generally placed on the roof of the building. Thus, the light is transmitted by the collecting element with full internal reflection along the light pipe and is distributed in the internal space by the emitter element (Erel, 2004). As seen in Figure 5.36, the level of luminosity and visual comfort in the volume is increased with natural lighting.

Figure 5.36. Examples of light pipes (Günışığı Aydınlatma, 2017)

Side-lit light pipes consist of three parts, a heliostat unit mounted on the roof or outside of the building to follow the sun and used to intensify the sunlight, a secondary mirror placed at the entrance of the tube to transmit the collected light, and a light pipe used to transmit the light. (Figure 5.37). Since these tubes serve each floor, it is important to intensify and strengthen the transmitted light. Therefore, movable side elements such as a heliostat and a secondary mirror support the system (Yener, 2008).

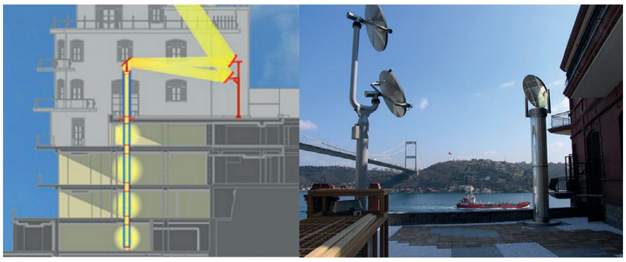


Figure 5.37. Heliostat unit with side-lit light pipe system (Borusan Holding Management Center-Istanbul) (Heliobus the Daylight Company, 2016, l)

5.1.15. Heliostats

Heliostats are systems that collect light outside and transmit it into the building. Heliostat is an integrated system that follows the sun with its automatic tracking system and consists of one or more mirrors and a lens and collects the sun's rays. This system is not a daylighting system alone, it transmits the collected solar rays to a light carrier system, mostly light pipes. The sunlight carried in the light pipes is then diffused into the building with a distributor outlet unit. An artificial light source (lamp) is also added to this system and can be used in times of insufficient daylight. The purpose of the heliostats is to illuminate spaces without windows or natural lighting with daylight and with a supplementary lamp (International Energy Agency, 2000). Figure 5.38 shows an example of a heliostat.

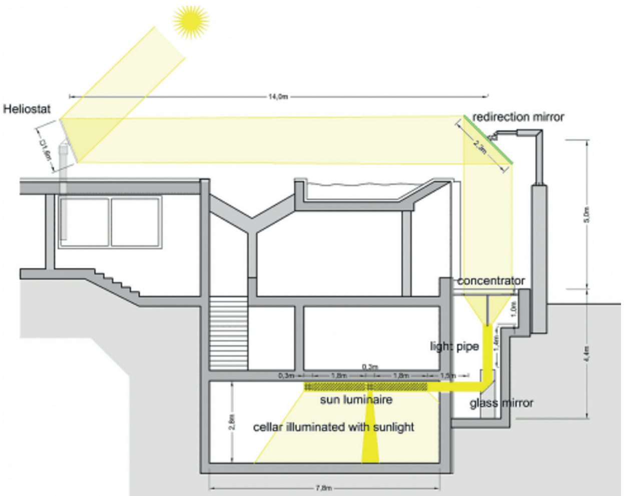


Figure 5.38. Working principle of heliostats (Clear Comfortable Low Energy Architecture, 2019)

5.1.16. Anidolic Ceilings

Anidolic ceilings are systems that collect diffuse daylight using the optical properties of parabolic collectors. These systems are mostly used in the regions where overcast weather conditions prevail, to direct the diffuse light in the sky to the depths of the spaces (Uyan and Yener, 2011).

The system consists of a light channel and reflectors located at the beginning and end of this channel (Figure 5.39). The first reflector on the façade surface collects diffuse light and transmits it to the light channel. The inner surface of the light channel is highly reflective, and the light is transmitted along the channel according to the full internal reflection principle. The parabolic reflector at the exit of the light channel distributes diffused light neatly into the space (Ünal, Çetegen and Enarun, 2005). There is a glass unit at the entrance of the system which is at an angle of 25° with the horizontal plane. This unit directs the daylight on the light channel. There is also a glass unit at the exit of the system to ensure safety and reduce system maintenance costs. All external components in the system must be insulated to prevent condensation and thermal bridges. An example of an anidolic ceiling is shown in Figure 5.39.

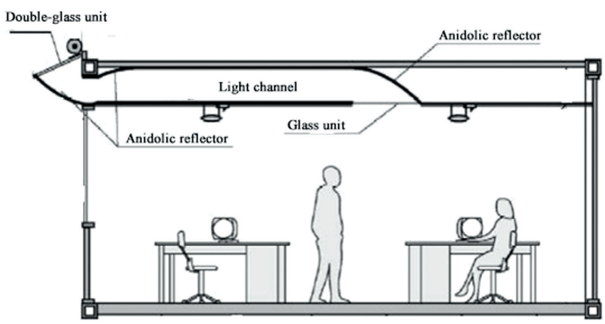


Figure 5.39. Working principle of anidolic ceilings (SPIE, 2019)

The main features of anidolic ceilings are to direct the daylight to the area of usage without glare, providing a proper illumination and increasing the level of illumination in the parts of the spaces which are not illuminated adequately by traditional systems. Anidolic ceilings can be used in commercial, industrial or educational buildings (International Energy Agency, 2000).

5.1.17. Labyrinth Systems

The labyrinth system was developed in order to take advantage of the natural coolness that exists at night in regions where the temperature differences between day and night are high during the summer months. The system was used for the first time in The Turkish Contractors Association Headquarters in Turkey (Figure 5.40). In this building, a concrete labyrinth was designed under the basement car parks in order to minimize the energy consumption in heating and cooling by using the temperature difference between day and night, which is the most significant indicator of typical continental climate conditions in Ankara.

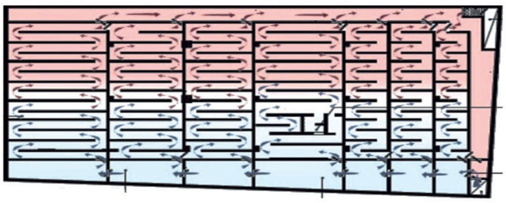


Figure 5.40. Labyrinth system plan of Turkish Contractors Association Central Building (Emporis, 2017)

During the night in summer, the outdoor cold air circulates through the chimneys and circulates through the labyrinth, helping to cool the dense concrete mass and trapping it as a battery. The hot air outside during the day is passed through this battery and cooled by the cold concrete mass and directed to the areas of usage.
In winter, the temperature is constant throughout the year at a certain depth below ground level. In this way, during the winter months, the outdoor air labyrinth circulates and warms up and reaches the air handling units. In order to contribute to the warming of the air in winter, friction surfaces were increased (Figure 5.41). Thanks to this cycle, the minimum load is placed on air conditioners and energy consumption is prevented (Emporis, 2017).

Figure 5.41. View from the labyrinth system of Turkish Contractors Association Central Building (Emporis, 2017)

5.2. Active Systems

Active systems are the whole of mechanical and electronic systems used to produce heating, cooling and electricity in buildings by making use of solar energy, wind energy and geothermal energy. Supporting applications with mechanical equipment and additional heat storage measures in order to benefit from solar energy, wind energy and geothermal energy in buildings, automatic control of heat distribution, application of water-air collectors, use of high efficiency collectors and solar cells, generation of electricity with wind turbines, heat pumps and heating and cooling and generating electricity are defined as “active systems.

5.2.1. Solar Collectors

Solar collectors are used to meet the hot water requirements of buildings. The solar collectors that provide the heating of the cold water are systems that operate with the logic of collecting and intensifying the radiation emitted from the sun. The most important problem with this system is the freezing risk during the winter time. This problem is solved by insulated collectors, pipes and storage units. The efficiency of the collector is defined as the ratio of the amount of energy collected to the amount of energy received (Özdoğan, 2005).

Solar collectors are classified as planar solar collectors, vacuum tube collectors and condenser collectors. The most commonly used collector type in the construction sector is planar solar collectors. There are high levels of heat losses by convection from planar collectors through the glass cover. On the other hand, a vacuum is created between the transparent glass tube outside the vacuum tube collectors and the black painted tube inside, reducing transport losses. Therefore, the efficiency of vacuum tube collectors is higher than that of planar collectors. Vacuum tube collectors are used in hot water production, industrial processes, heating and cooling of buildings (Alparslan, 2010). In Figure 5.42, planar and vacuum tube solar collectors are represented schematically.

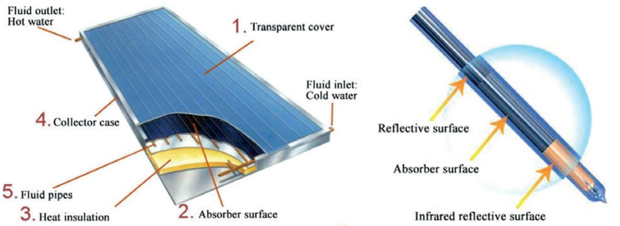


Figure 5.42. Planar and vacuum tube solar collectors (Güneysan Solar Energy Systems, 2019)

5.2.2. Solar Cells

Solar cells are used to meet the electricity requirement of buildings for heating, cooling and lighting. Among the renewable energy sources, it is one of the most effective ways of generating electrical energy from the sun, which is the easiest to access, abundant and clean. With the rapid growth of the solar energy industry, the importance of solar cells has increased greatly in recent years. These batteries, which are used to convert solar energy into electrical energy, are considered as one of the most important renewable energy technologies in energy efficient building design (Alparslan, Lee, Manthapuri, Yi and Deb, 2014). Being environmentally friendly during use and not causing greenhouse gases are among its most important advantages (Said, El-Shimy and Abdelraheem, 2015). This technology used for electricity generation in buildings and solar farms in many countries, has recently begun to attract attention in Turkey. However, it has not become widespread due to the high initial investment costs and the lack of necessary information. Figure 5.43 shows an example of the application of solar cells to the roof.

Figure 5.43. Solar cells (Deparsolar, 2019)

5.2.3. Wind Turbines

Wind turbines are systems that convert kinetic energy from wind into mechanical energy and then into electrical energy. A wind turbine generally consists of a tower, a generator, speed converters (gearboxes), electrical-electronic elements and a propeller. The electrical energy obtained from the generator is stored by batteries or delivered directly to the receivers (Elibüyük & Üçgül, 2014). The lifespan of wind turbines varies according to turbine quality and local climate characteristics. The average lifespan is 20-25 years (General Directorate of Electrical Power Resources Survey and Development Administration, 2016). Wind turbines are classified according to their axes of rotation, speed, power, number of blades, wind effect, gear characteristics and installation positions.

Wind turbines used in buildings are classified into three groups:

Building-independent wind turbines: Wind farms are examples of building-independent wind turbines that are independently designed apart from the building.

Building-integrated wind turbines: The design phase of the building is based on the use of wind energy. The aim is to transform the building into a mechanism that collects the wind and directs it to the turbine.

Building-mounted wind turbines: The building is used as a kind of tower (Günel and Ilgın, 2008). The main purpose of all wind turbine uses is to provide some of the building's electricity requirement from wind energy.

On the roof of the Munich Neues Technisches Rathaus Administration Building, a Darrieus-type vertical axis wind turbine was used. This turbine has a power of 40 kW (Figure 5.44).

Figure 5.44. Wind turbines in Munich Neues Technisches Rathaus Administration Building (Emporis, 2017)

Savonius-type vertical-axis wind turbines were used in the Oklahoma Medical Research Foundation (OMRF) building (Elibüyük and Üçgül 2014). 18 wind turbines with a height of 5 m are placed on the roof of the building and 4.5 kW power generation is provided (Figure 5.45).

Figure 5.45. Wind turbines in Oklahoma Medical Research Foundation Building (Wind Turbines, 2017)

12 Savonius-type vertical-axis wind turbines were used in Chicago Greenway Self Park Building (Figure 5.46). The turbines are six meters high and made of aluminum. It is placed vertically in the southwest corner of the building, and the energy produced is primarily used for the exterior lighting of the building. Excess energy is supplied to the grid.

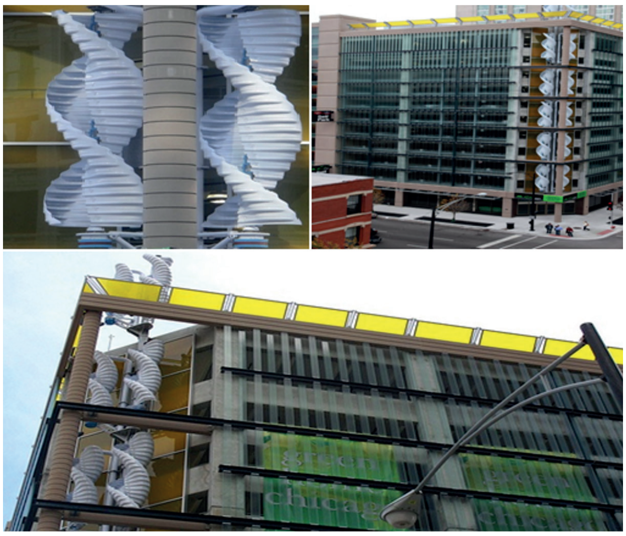


Figure 5.46. Wind turbines in Chicago Greenway Self Park Building (Greenway Self-Park / HOK, 2019)

Horizontal axis wind turbines are mostly commercial turbines. These turbines have high production efficiency, aesthetic appearance, quieter and causing less bird death. Portland Twelve West Building is an example of horizontal axis wind turbines (Figure 5.47). There are 4 wind turbines with a total installed power of 9.6 kW on the roof of the building.

Figure 5.47. Wind turbines in Portland Twelve West Building (Malin, 2017)

5.2.4. Underground Heat Pumps

A heat pump is an electrically powered system that transports heat energy from one medium to another as befits its name. The underground source heat pump system is based on the fact that the temperature of the earth remains constant throughout the year at a certain depth. The working principle of this system for the winter months is to carry the heat stored in the soil layer or groundwater to the building; while its working principle in summer is to transport the heat inside the building to the underground. Briefly, underground acts as a heat source in winter and as a heat pit in summer (Develioğlu, 2012).

Underground source heat pumps have been widely used in recent years owing to their usability as a single device for both heating and cooling purposes, being more functional than traditional methods, providing significant savings in energy consumption, having an integrated structure and adapting to high control technology (Arslan, 2014). It consists of three main sections:

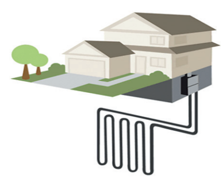
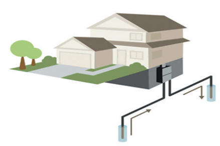
- A heat pump system that transfers heat between the building and ground connection,
- Soil heat exchanger required to transfer heat from the soil,
- Heating-cooling system for heating and cooling the building.

The high-performance coefficients of underground heat pumps reduce the operating cost of the system. The energy savings provided by the energy obtained is higher than the energy consumed, both for the user and for the national economy. However, in the use of soil as a heat source, there is a soil heat exchanger which increases the initial investment cost. In order to reduce this cost, first of all, temperature and heat storage load of soil geological units, soil structure, thermal properties, humidity and ground water level and its variation according to climatic conditions should be examined. Using the abovementioned indications, the optimum operating conditions of the heat pump should be determined (Acar, 2009).

Two systems, the open system and the closed system, are used in underground heat pumps. In the open system, wells, lakes, rivers and sea are used as heat sources. Water taken from the source is drawn into the heat pump unit to be pumped back in a manner that does not harm the environment and nature by taking its heat. The closed system consists of heat exchangers, closed circuit and polyethylene pipes underground. In the closed system, the liquid is circulated in a continuous manner in the pipe under pressure (Yerlibucak, 2007). There are four different underground pipe laying options depending on the location of the building and land where underground heat pump systems will be installed. These are called horizontal closed circuit, vertical closed circuit, "from water well-to water well" (open circuit), "from lake" closed circuit (Principle of Heat Pumps, 2016).

Horizontal closed-circuit pipe laying systems are preferred in wide soils that are easy to dig and not arid. It requires wider soil area than other systems, and the pipes are buried at a depth of 1.7-3 meters of the soil. Vertical closed-circuit pipe laying systems are suitable for buildings with limited soil area. The temperatures are higher in deeper soil. Therefore, less pipes are used than horizontal circuit systems. Vertical drilling is carried out with a diameter of 13-18 centimeters and a depth of 20-100 meters with 3-6 meters distance from each other. Drilling depths and number of drillings vary according to heat demand and ground layers. Open circuit pipe laying systems are suitable for buildings with abundant and high-quality water wells. These systems draw heat directly from well water. The well water is pumped from the source well to the heat pump, and the water from the heat pump is pumped into the return well. In general, the incoming water temperature in such systems is 6° C higher than closed circuit systems, which makes the geothermal heat pump system work more efficiently. High saline, chloride or mineral waters can damage the system or prevent it from working efficiently. Closed circuit systems from the lake are suitable for buildings on the lake shore. The pipes are placed directly at the bottom of the lake water. The transfer fluid passing through the closed-circuit pipe takes the heat of the lake (Table 5.3).

Table 5.3. Underground pipe laying systems (Principle of Heat Pumps, 2016)

UNDERGROUND PIPE LAYING SYSTEMS	
Horizontal closed circuit	
Vertical closed circuit	
Open circuit	
Closed circuit from the lake	

REFERENCES

Acar, Ş. G. (2009). Denizli havzasındaki jeolojik formasyonlarda sıcaklık ve ısı depolama kapasitesi değişiminin incelenmesi ve ısı pompası uygulamalarının araştırılması (Doctoral dissertation, Pamukkale Üniversitesi, Denizli, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Alakavuk, E. (2010). Sıcak iklim bölgelerinde çift kabuk cam cephe sistemlerinin tasarımı için kullanılabilecek bir yaklaşım (Doctoral dissertation, Dokuz Eylül Üniversitesi, Izmir, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Alamy. (2017, May 25). Retrieved from http://www.alamy.com/stock-photo/bedzed.html

Alparslan, E. M., Lee, S. E., Manthapuri, S., Yi, W. & Deb, C. (2014). PV (Photovoltaics) Performance Evaluation and Simulation-Based Energy Yield Prediction for Tropical Buildings. Energy, 71, 588-595

Alparslan, B. (2010). Ekolojik Yapı Tasarım Ölçütleri Kapsamında Ankara'da Örnek Bir Yapı Tasarımı ve Değerlendirmesi (Master's thesis, Gazi Üniversitesi, Ankara, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Arslan, A. E. (2014). Toprak kaynaklı ısı pompası ile doğal gazlı kombi birleşik sisteminin enerji verimliliği yönünden araştırılması (Master's thesis, Trakya Üniversitesi, Edirne, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Autodesk. (2017, January 05). http://sustainabilityworkshop.autodesk.com/buildings/stack-ventilation-and-bernoullis-principle

Ay, İ., & Khanları, A. (2015). Güneş duvarı sisteminin çalışma prensibi ve Türkiye'deki uygulanabilirliği. Gazi Üniversitesi Fen Bilimleri Dergisi, 3(3), 525-533

Baer, S. (2009). Some Passive Solar Buildings with a Focus on Projects in New Mexico. Retrieved from: http://docplayer.net/28788605-Some-passive-solar-buildings-with-a-focus-on-projects-in-new-mexico.html

Bekar, D. (2007). Ekolojik Mimarlıkta Aktif Enerji Sistemlerinin İncelenmesi (Master's thesis, Yıldız Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Center for the Built Environment. (2016, May 15). Retrieved from https://cbe.berkeley.edu/mixedmode/images/carnegie/Carnegie_cool_tower.html

Clear Comfortable Low Energy Architecture. (2019, November 9). Retrieved from https://www.new-learn.info/packages/clear/visual/buildings/options/core/mirror_heliostat.html

Dangermond Keane Architecture. (2016, May 15). Retrieved from dangermondkeane.com/Project-e

Deparsolar. (2019, October 30). Solar Power and Lighting Systems. Retrieved from http://www.deparsolar.com

Develioğlu, M. (2012). Yer kaynaklı ısı pompalarının teknolojik gelişimi ve Türkiye'deki uygulanabilirliği (Master's thesis, Hacettepe Üniversitesi, Ankara, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

General Directorate of Electrical Power Resources Survey and Development Administration (Elektrik İşleri Etüt İdaresi Genel Müdürlüğü). (2016, May 23). Retrieved from http://www.eie.gov.tr/eie-web/turkce/YEK/ruzgar/ruzgar_turbin.html

Elibüyük, U., & Üçgül, İ. (2014). Rüzgar Türbinleri, çeşitleri ve rüzgar enerjisi depolama yöntemleri. Süleyman Demirel Üniversitesi Yekarum e-Dergi, 3(2), 1-14

Emporis. (2017, May 25). Retrieved from https://www.emporis.com/images/details/879194/top

Engin, N. (2012). Enerji etkin tasarımda pasif iklimlendirme: doğal havalandırma. Tesisat Mühendisliği Dergisi, 129, 62-70

Erengezgin, Ç. (2001). Enerji mimarlığı. Yapı 2(234), 82-89

Erel, B. (2004). Gün ışığı ile aydınlatma alanında geliştirilen yeni teknolojiler hakkında bir araştırma (Master's thesis, Istanbul Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Erkınay, P. U. (2012). Yenilenebilir enerji kaynaklarından rüzgâr enerjisinin Türkiye'de binalarda kullanımı üzerine bir inceleme (Master's thesis, Çukurova Üniversitesi, Adana, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Göçer, Ö. (2006). Atrium tipi binalarda enerji tüketiminin azaltılması ve kullanıcı konforunun sağlanması için uygun camlama ve denetim sistemi modeli (Doctoral dissertation, Istanbul Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Greenway Self-Park / HOK. (2019, October 30). Retrieved from http://www.archdaily.com/74468/greenway-self-park-hok

Gültekin, A. B. & Demircan, R. K. (2015). Binalarda pasif ve aktif güneş sistemlerinin incelenmesi. In 2nd International Sustainable Buildings Symposium, Ankara, Turkey.

Gültekin, A. B. & Demircan, R. K. (2017). Binalarda Pasif ve Aktif Güneş Sistemlerinin İncelenmesi. TÜBAV Bilim Dergisi, 10(1), 36-51.

Günel, M. H., & Ilgın, H. E. (2008). Bir mimari tasarım kriteri olarak rüzgar enerjisi kullanımı. Ege Mimarlık Dergisi. 2(65), 6-15

Güneşevi. (2016, May 15). Retrieved from http://www.gunesevi.org/index.php/2012-09-24-11-54-40/gunesevi-teknik

Güneysan Solar Energy Systems. (2019, October 30). Retrieved from http://www.guneysangunesenerjisi.com.tr/?pnum=15&pt=Vakum+T%C3%BCpl%C3%BC+G%C3%BCne%C5%9F+Enerji+Sistemleri

Günışığı. (2019, September 10). SkyBox Shelf Series. Retrieved from http://www.gunisigiaydinlatma.com/Product/SkyboxShelf

Günışığı Aydınlatma. (2017, May 25). Elit Mühendislik. Retrieved from http://www.elitmuh.com.tr/gunisigiaydinlatma.html

Heliobus The Daylight Company. (2016, May 10). Retrieved from http://www.heliobus.com/en/products/lightpipe

Inhabitat. (2019, November 5). Solatube Skylights. Retrieved from http://inhabitat.com/solar-tube/

International Energy Agency. (2000). Daylight in Buildings, Report IEA SHC Task 21

Principle of Heat Pumps. (2016, May 25). Benko Clean Energy Systems. Retrieved from http://benkoltd.com/enerji/toprak-hava.asp?sayfa=calisma-prensibi

Malin, N. (2017, May 25). Twelve West. Retrieved from http://www.solaripedia.com/13/297/3341/twelve_west_clouds.html

Middle East Sustainable Cities. (2016, May 15). Retrieved from http://www.carboun.com/sustainable-design/passive-cooling-responding-to-uae%E2%80%99s-soaring-electricity-demand/

Ofluoğlu, S. (2017). Güneş Kırıcıları ve Rafları. [Powerpoint slides]. Retrieved from http://sayisalmimar.com/kurslar/aydin/gunes_kiricilar.pdf

Ok, V. Çakan, M. Özgünler, M., & Kavurmacıoğlu, L. (2009). Gölgeleme elemanlarının rüzgar üstü bina yüzeyindeki basınç katsayılarına etkileri. İstanbul Teknik Üniversitesi Dergisi, 8(1), 28-40

Oral, G. K. (2005). Sağlıklı binalar için enerji verimliliği ve ısı yalıtımı. In VII. Ulusal Tesisat Mühendisliği Kongresi (pp. 253-264)

Ovalı, P. K. (2009). Türkiye iklim bölgeleri bağlamında ekolojik tasarım ölçütleri sistematiğinin oluşturulması "Kayaköy Yerleşmesinde Örneklenmesi" (Doctoral dissertation, Trakya Üniversitesi, Edirne, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Özdemir, B. B. (2005). Sürdürülebilir çevre için binaların enerji etkin pasif sistemler olarak tasarlanması (Master's thesis, İstanbul Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Özdoğan, H. P. (2005). Ekolojik binalarda bina kabuğunda kullanılan fotovoltaik panellerin tasarım bağlamında incelenmesi (Master's thesis, Yıldız Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Said, M., El-Shimy, M. & Abdelraheem, M. A. (2015). Photovoltaics energy, improved modeling and analysis of the levelized cost of energy (LCOE) and grid parity- Egypt case study. Sustainable Energy Technologies and Assesments, 9, 37-48

Sanchez, E., & Izard, J. (2015). Performance of photovoltaics in non-optimal orientations: an experimental study. Energy and Buildings, 87, 211-219

Ali, C., & Özer, Y. S. (2011). Sıcak iklimlerde bina içi iklimlendirme için geleneksel bir sistem: Rüzgâr bacaları. In X. Ulusal Tesisat Mühendisliği Kongresi. (2193-198)

Sayın, S. (2007). Yenilenebilir Enerjinin Ülkemiz Yapı Sektöründe Kullanımının Önemi ve Yapılarda Güneş Enerjisinden Yararlanma Olanakları (Master's thesis, Selçuk Üniversitesi, Konya, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Sharifi, A., Yamagata, Y. (2015). Roof ponds as passive heating and cooling systems: A systematic review. Applied Energy. 160, 336-357

Solar Wall. (2016, May 18). Retrieved from https://www.solarwall.com/technology/solar-wall-single-stage/

SPIE - The International Society for Optics and Photonics. (2019, October 10). Splitting up anidolic daylighting systems. Retrieved from http://spie.org/x36474.xml

Stack A., Goulding, J. & Lewis, O. (2002). Shading Systems – Solar Shading for the European Climates. Ireland: ENERGIE Programme of the European Commission

Şahinoğlu, S. (2012). Gölge elemanlarının pencerenin ısıtma/soğutma enerjisi ve görsel konfor performansına etkisinin değerlendirilmesi (Master's thesis, Istanbul Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Tokuç, A., & Yıldızber Z. E. (2009). Enerji etkin konut tasarımında tesisat bileşenleri ile birlikte kullanılabilecek yapı elemanlarının araştırılması. Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Mühendislik Bilimleri Dergisi, 5(3), 31-42

Uslusoy, S. (2012). Yenilenebilir enerji kaynakları kullanan enerji etkin binaların yapı bileşeni açısından irdelenmesi (Master's thesis, Dokuz Eylül Üniversitesi, İzmir, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Uyan, F., & Yener, A. K. (2011). Yeşil binalarda aydınlatma. Yeşil Bina Dergisi, 9

Ünal, G., Çetegen, G., & Enarun, D. (2005). Gelişmiş aydınlatma sistemleri. In III. Ulusal Aydınlatma Sempozyumu ve Sergisi Bildirileri

Wind Turbines. (2017, May 25). Retrieved from https://cityworksinc.files.wordpress.com/2012/10/wind-turbines-omrf.jpg

Yasan, A. S. (2011). Bina tasarım parametrelerinin enerji harcamalarına etkilerinin belirlenmesine yönelik bir çalışma. (Master's thesis, Istanbul Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Yedievli, U. H. (2009). Enerji etkin bina ve yerleşme birimlerinin iklimsel veriler ve gayrimenkul geliştirme açısından gerçekleştirilebilme olanakları (Master's thesis, Istanbul Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Yener, A. K. (2008). Gün ışığından yararlanma yöntemleri: çağdaş teknikler. In VIII. Ulusal Tesisat Mühendisliği Kongresi

Yerlibucak, Ş. M. (2007). Isı pompaları (Bachelor's project, Dokuz Eylül Üniversitesi, Izmir, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Yüre, T. (2007). Güneş enerjisinden edilgen sistem yararlanmada güneş odası ekleme yönteminin iç ortam sıcaklığına etkisinin incelenmesi İstanbul örneği (Master's thesis, Yıldız Teknik Üniversitesi, Istanbul, Turkey). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkez