ISTANBUL OKAN UNIVERSITY

INSTITUTE OF SCIENCE AND ENGINEERING

RENEWABLE ENERGY SOURCES IN BUILDINGS

Alican Şevki ÖZKAYA

THESIS FOR THE DEGREE OF MASTER OF ARCHITECTURE

IN ARCHITECTURE PROGRAM

ISTANBUL, May 2019

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ABSTRACT

The need for energy with changing living conditions is greater than ever. Increasing with the modern development movement, the urbanization and world population are growing rapidly. The fact that fossil-based fuels will soon be depleted led the countries to produce renewable energy whose source is found in nature. Furthermore, the damage to the environment in the production and consumption of these fuels has become irreversible. It has become difficult to leave a sustainable world for future generations. Therefore, there is a need for renewable energy resources with less impact on the needed biological environment. In this context, the key concepts and components were explained and the principles of benefiting from the solar and wind systems actively and passively were clarified, and applied systems were examined. As a result of these studies, the current solar and wind capacities in Turkey and abroad, in addition to the development of rainwater collection systems, application methods and incentives granted were explained with graphics. The data obtained from the researches and the samples regarding the use of renewable energy sources in Turkey and abroad were examined. Based on these examples, it was aimed to contribute to the design process by providing a housing sample which has an environment-friendly architectural design and low carbon emission to reduce the dependence of the country's economy on the foreign countries and to provide added value.

Keywords; renewable energy, sustainability, roofs, rainwater collecting systems

ÖZET

Değişen yaşam koşularında enerjiye olan ihtiyaç her zamankinden daha fazladır. Modern gelişim hareketiyle artan şehirleşme ve dünya nüfusu çok hızlı bir şekilde büyümektedir. Fosil bazlı yakıtların yakın zamanda tükenecek olması ülkelerin kaynağı doğada bulunan yenilenebilir enerji üretimine yönlendirmiştir. Ayrıca bu yakıtların üretiminde ve tüketiminde çevreye verilen zarar geri dönülemez bir hal almıştır. Gelecek nesillere sürdürülebilir bir dünya bırakmak zorlaşmıştır. Bu nedenle ihtiyaç duyulan yaşamsal çevreye etkisi daha az olan yenilenebilir enerji kaynaklarına ihtiyaç duyulmaktadır. Bu bağlamda çatı kavramları ve bileşenleri anlatılmış, güneş ve rüzgar sistemlerinden aktif ve pasif olarak yararlanma prensipleri açıklanmış uygulanmış olan sistemler incelenmiştir. Bu çalışmalar sonucunda Türkiye ve yurtdışında mevcut güneş ve rüzgar kapasiteleri buna ek olarak yağmur suyu toplama sistemlerinin gelişimi uygulama yöntemleri ve yapılan teşvikler grafiklerle açıklanmıştır. Araştırmalar sonucu elde edilen veriler Türkiye ve yurtdışında örneklerde yenilebilir enerji kaynaklarının kullanımına ait örnekler incelenmiştir. Bu örneklerden yola çıkarak mimari tasarımın çevreye duyarlı, karbon salınımı düşük ve ülke ekonomisinin dışa bağımlılığını azaltmak ve katma değer sağlayan yapılar üretmek için konut örneği verilerek tasarım sürecine katkı sağlamak amaçlanmıştır.

Anahtar Sözcükler; yenilenebilir enerji, sürdürülebilirlik, çatılar, yağmur suyu toplama sistemleri

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SYMBOLS

symbols	explanation
cm	centimetre
kw	kilowatt
kwh	kilowatthour
m	meter
km	kilometer
m^2	square meter
%	percentage
$	dollar
£	pound
/	division mark
ac	alternative current
dc	direct current
co2	carbon dioxide
rpm	revolution per minute
°x	degree
m/s	meter per second
mw	megawatt
gw	gigawatt

ACRONYMS

acronyms	explanation
A.D.	Anno domini
B.C.	Before christ
BRE	Building research establishment
EU	European union
KAKS	Floor space index
PV	Photovoltaic
TAKS	Building coverage ratio
TAKS	Thermal insulation standard in buildings
Btu	British thermal unit
Led	Light emitting diode
R&D	Research and development
IBB	Istanbul metropolitan municipality
TS.825	Thermal insulation standard in buildings
USA	United states of America
UK	United Kingdom
WCED	World commission on environment and development
IZODER	Association of heat, water, sound and fire insulators

I.INTRODUCTION

In today's world, the energy requirement has been continuously increasing with the technological developments started with the industrial revolution. The raw material used for supplying the increasing energy requirement has started to exhaust. The insensible use and processing of the raw material have started to damage the natural environment. The increase in the world's population brings along the rapid settlement. The devastation and destruction of forested land lead to the rising of seasonal temperatures, the melting of icebergs, the increasing of natural disasters, the disruption of the balance of nature and, to the global climate change.

For the sustainability of the progress of the countries, the used energy should be of high quality, continuous, cheap and environment-friendly. The fact that the fossil fuels used as energy resources cause environmental pollution and that these fuels may deplete have increased the tendency towards renewable clean energy sources.

The importance of energy-efficient designs is increasing day by day because of the use of non-renewable fossil-based fuels in the building sector as in other sectors. Nowadays, wind and solar energy have increasingly become among the renewable energy sources used in the field of architecture.

Wind and solar energy, which are utilized as passive and active systems in buildings, are used especially in designs in Europe, USA and Dubai. Although the renewable energy potential of Turkey is in a considerable amount, it have not been benefiting from wind energy adequately.

Renewable energy systems are used in many developed countries and Turkey's renewable energy potential is quite high compared to numerous other countries. Under these circumstances, in Turkey, the necessity of the use of wind and solar energy, which are the primary renewable energy resources, is inevitable. Especially in the building sector where a large part of the energy is consumed, the use of wind nergy should increase with the developing technologies.

1.1.Aim

The purpose of this study is to ensure the sustainability of energy resources in nature by using renewable energy resources; to emphasize the importance of the use of these resources. In this context, (i) to explain the principles of active and passive utilization of solar and wind energy among renewable energy resources in buildings; (ii) in addition to these systems, to investigate the use of rainwater collection systems on wooden, pitched and green roofs; (iii) to investigate the integration of these systems with buildings and, their usage, in order to provide added value to the existing buildings and the buildings to be made, by the examples from abroad and Turkey.

1.2.Scope

In the second part of the scope of the thesis study prepared, an overview of the subject is brought in and the subjects such as global energy problem, fossil-based energies and its environmental effects, the energy amount consumed in the building sector in Turkey are explained by tables. Besides, the need for renewable energy sources and the necessity of their use are discussed.

In the third part, first, renewable energy sources are defined in a general way and the incentives and tariffs applied in this context are examined. Inclined and green roof types, the utilization opportunities from solar and wind power which can be applied on roofs in this context are examined extensively; passive and active utilization opportunities are defined and types of application and storm water management systems and their usage areas are examined under sub-headings.

Then, in the fourth part, the samples from Turkey and the world are examined,the criteria that influence the structural design process are explained, Pendik region is chosen as a working area and the practices that can be made in housing design based on the acquisitions in the previous parts for the green and inclined roofs are exemplified.

In the conclusion part, all of the information presented is evaluated and the importance and necessity of using solar energy in buildings is emphasized, especially for our country.

1.3.Hypothesis

The main hypothesis of the study is that the on-site production of energy is economical in the long term. Turkey will quickly start the ecological sustainability practices within the EU integration process. These are valid concepts in accordance with the world green life principles, Turkey must take part in these activities.

1.4.Methodology

The main material of the study is the investigation of renewable energy sources and sustainability. Research techniques used in this study can be listed as follows:

- Literature research: It was conducted for collecting information. It is to reach written, drawn and visual sources and to reach previous studies and publications. A research method from general to specific is used.
- Field studies: The structural elements and applications concerning the subject of the study were observed on site by visiting the construction sites in the area.

- Evaluation of the information: The data obtained in the research were expressed in tables and graphs.

II.THE CONCEPT OF ENERGY AND SUSTAINABILITY

2.1. Concept of Energy

Energy use is one of the leading elements of the social development of countries. Energy resources are the most important vital inputs of our daily lives, energy, and industrial products are the most important vital inputs of our production. For this reason, those who undertake the governing of the country and the energy field have to supply the energy needed by the society and the economy in an uninterrupted, reliable, timely, clean and inexpensive ways and to provide them with the most affordable prices and to diversify these sources in terms of energy supply security.

Energy continues to be one of the biggest economic problems in terms of Turkey. This can be explained by giving several important figures. Turkey imports more than 70% of the energy it uses. Energy used in Turkey is distributed approximately equal in buildings, industry, and transportation and this is roughly one-third of the total energy consumption. For example, according to information of the World Energy Agency, the energy used in buildings in Turkey is around 27% of total energy in 2007, in addition, the use of energy in buildings in 2020 is estimated to be twice as high as 2007 values. In 2011 this amount is more than $20 billion according to IZODER data. It is estimated to be up to $25 billion in 2012. Three-fourths of this is also the funds to be exported. Energy savings in old buildings can reach up to 50%. At the same time, the use of innovative energy applications and the importance of energy savings in all new buildings will be important, as it will reduce the energy use required in the future. From this point of view, it is clear to what extent the applications to be made in buildings will reach an economic dimension. Of course, the construction and the use of these buildings in harmony with the environment will also make them economic in the long term. Basically, the concepts of 'green building' should be considered as the name given to the buildings that emerged at the end of these rational practices and it should be understood that the concept of 'green building' is a contribution to the whole country. (Mengüç, M.P. and Somuncu Y, 2012)

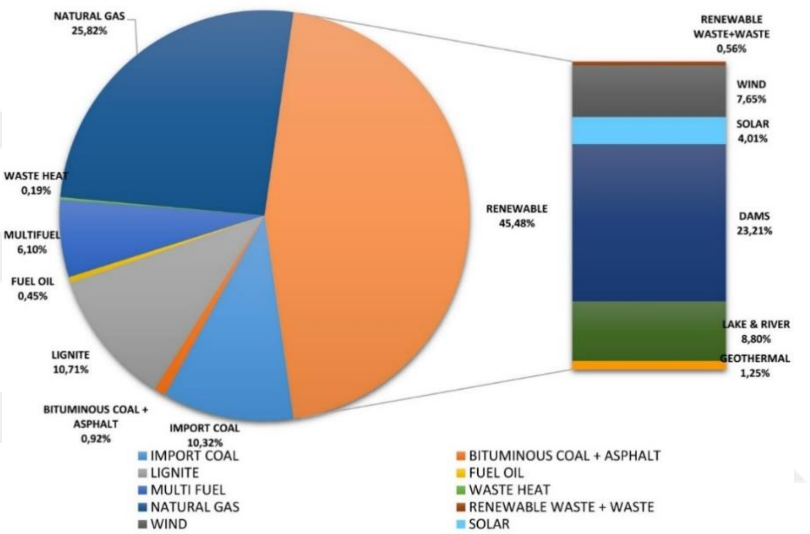


Figure 2.1. The distribution of electrical energy production in Turkey by the sources in 2017 [URL1]

2.2. Overview of Energy Situation in Architecture

In the building sector, which has an important share of total energy, the most suitable type of energy to be used to reduce the use of energy damaging the environment is solar and wind. It is possible to utilize solar and wind energy in heating, cooling, lighting, and ventilation of buildings with active and passive methods. The energy efficiency of buildings can be ensured by taking advantage of renewable energy sources with the help of some design measures, especially without requiring additional costs. In Turkey, which is suitable for sunbathing, these types of applications are scarce, but it is possible to encounter successful examples of these practices in many countries. The current energy problem forces countries to produce sustainable energy strategies aimed at ensuring efficient use of energy. That buildings rank first with the rate of 41% in the energy consumption of Turkey, shows that energies consumed by these buildings should be reduced with the help of energy-efficient designs based on physical environmental factors.

That most of the energy is still used for heating purposes, requires the utilization of factors such as the sun and the wind in a way that serves to the thermal comfort of spaces and increases the efficiency of energy in the use of energy in architecture.

2.3. Energy efficieny

Due to the deterioration of the ecological balance, the depletion of fossil resources in the near future, and excess consumption, energy efficiency should be given importance. Energy efficiency is the minimization of the amount of consumed energy without reducing the quantity and quality of production and without hampering the economic development and social well-being. It is the whole of the measures that increase efficiencies such as prevention of energy loss, recycling, and evaluation of waste or decreasing energy demand without reducing production of advanced technology, more efficient energy resources, advanced industrial processes, energy gains. (Yücer, N.S.2015)

Due to the fact that the energy resources to be used as an alternative to fossil energy sources are not yet economical, the inadequate domestic resources and importing them, the increase in consumer prices in response to the continuous increase in energy consumption raise the importance of energy efficiency in Turkey. It is required to give importance to savings and long-term use by reducing consumption.

Energy consumption in industrialized countries comes from industry, transportation, and construction sector, respectively. For this reason, it is necessary to use the energy effectively before construction, construction, and post-production phases of designing the building. In our country, 62% of the total final energy consumption in the industry and service sectors in 2017 was consumed in the manufacturing industry, 20.8% in transportation and storage sector, and 3.8% in the wholesale and retail trade sector.

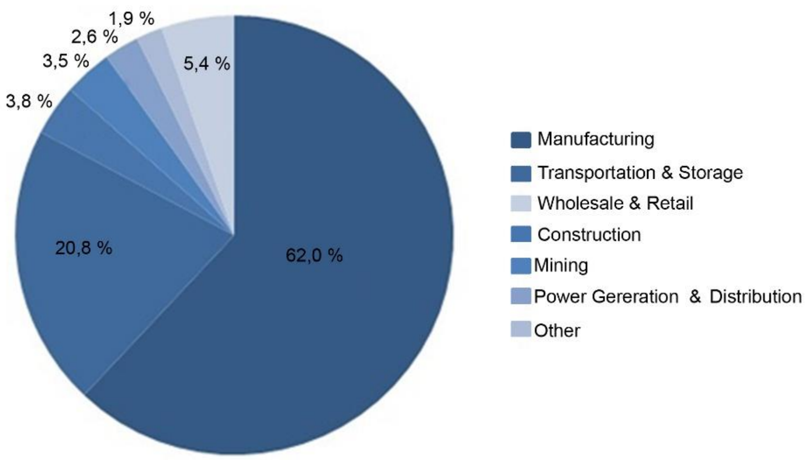


Figure 2.2. Distribution of final energy consumption by sectors, 2017 [URL2]

The energy used in residences corresponds to 31% of the total energy consumption and the electricity used corresponds to 43% of the total electricity consumption in Turkey. It is known that the heat losses caused by roof, glass, wall, and flooring in a building correspond to 60-70% of the total heat loss of the building. (Yüceer, N.S.2015)

Energy loss in buildings is caused by the use of air conditioning, ventilation, illumination, and electronic household appliances. Because this energy is obtained from oil, natural gas, and coal, it is necessary to use energy effectively in designs. To ensure energy efficiency in residential buildings;

- Energy waste should be evaluated and sustainability should be ensured by recycling.
- The roof, wall, floor, and facade of the buildings must be insulated against

energy losses.

- Building orientation, form, and shell should be designed according to the current climatic conditions.
- Passive energy systems should be used for heating, illumination, and cooling in the building.

The majority of energy consumption is realized in the industrial sector. Providing energy from renewable energy sources in the industrial sector, being recyclable and sustainable will contribute to the national economy. To ensure energy efficiency in industry;

- From where, how the raw material is provided, the source of the raw material should first be provided from domestic production.
- Wastes must be recyclable after the use of raw materials.
- In the industrial building design, it is necessary to provide passive energy sources according to current climatic conditions, directivity, lighting and thermal comfort.
- The energy used in the industry must be provided from renewable energy sources and energy wastes must be recycled.

Transportation sector comes second in terms of the size of energy consumed. With the realization of energy crises, efforts have been made in order to save money in the transportation sector. The development of rail, sea, and public transportation vehicles has been accelerated in freight and passenger transportation. Since the energy used in the transportation sector is petroleum, electrically driven railway and public transportation vehicles are under development. According to a study on energy consumption in Germany; in passenger transportation, while 1 unit of energy in the railroad, 3 units in the roadway, 5.2 units in the airway is consumed; it is determined that 1 unit of energy is consumed in the railroad and 3 units in the roadway in freight transportation. Approximately 20% of the energy consumed is used in the transportation sector in Turkey, 99% of this is composed of petroleum products.

The transport sector in Turkey relies heavily on outside financial sources. The energy problem in the transport sector can be solved by long-term solutions such as urban planning, increasing the share of public transport. (Yüceer.,N.S.,2015)

2.3.1. Energy efficient building design

Energy efficient building design can be defined as designing to use energy efficient and productive by taking advantage of physical environment variables data such as climate, direction, and prevailing wind in the architectural design process. The energy efficient structure design requires, by creating active and passive control facilities suitable for the building, requires improving the performance of the construction issues in the subjects of heating-cooling-ventilation-natural lighting and ensuring audit towards energy conservation, determining design criteria and making architectural designs in this context. (Özmehmet, E. 2007)

Energy efficient structure design includes the following criteria.

- Forming and positioning of structure shell and form according to physical environment data,
- In the design of the structure, using the forms that will control the inside air by taking it from outside and will distribute the controlled air, and will create a buffer zone between the inside and outside of the structure,
- In order to take atmosphere conditions into the structure by softening, making designs that will include nature and green into the structure,

- Supporting the building design to provide optimum utilization of solar energy and using energy efficient exterior systems on the structure,
- Selecting the materials and components of the structure from materials that use renewable energy sources, energy conservative, environmentally friendly, and require low-maintenance,
- It can be defined as the use of passive and active systems to provide energy efficiency within the structure (Utkutug. G.S.1999).

The most important features that distinguish the energy efficient building design process from the traditional design processes are:

- In all stages of architectural design process, production of all materials and components forming the structure, usage, maintenance, operation, and handling the air conditioning systems in a large spectrum up to the selection and management,
- Reducing the amount and cost of energy inputs towards individual and social benefit without reducing the standard of the structure and
- Ensuring harmony of the building environment, use of renewable energy sources and taking measures to protect the energy used.

2.3.2. Energy efficient building design criteria

The design parameters which affect the energy efficiency of the building, which takes maximum advantage of natural resources and consumes minimum energy to provide thermal (climatic), visual and auditory comfort conditions, in other words, which will be effective in creating an energy efficient sustainable environment as a passive system are listed below. (Lakot.E.,2007)

- Location selection of the structure

- Distance and positioning of the structure to other structures,
- The direction of the structure,
- Form of the structure,
- Physical properties of structure shell affecting heat transfer,
- Outdoor lighting level,
- Obstacles that may affect the climatic and visual comfort outside the structure,
- Physical properties of the structure internal volume,
- Dimensions and structural properties of structural elements such as window and glass,
- Properties of the components of artificial lighting system and
- Solar control and natural ventilation systems

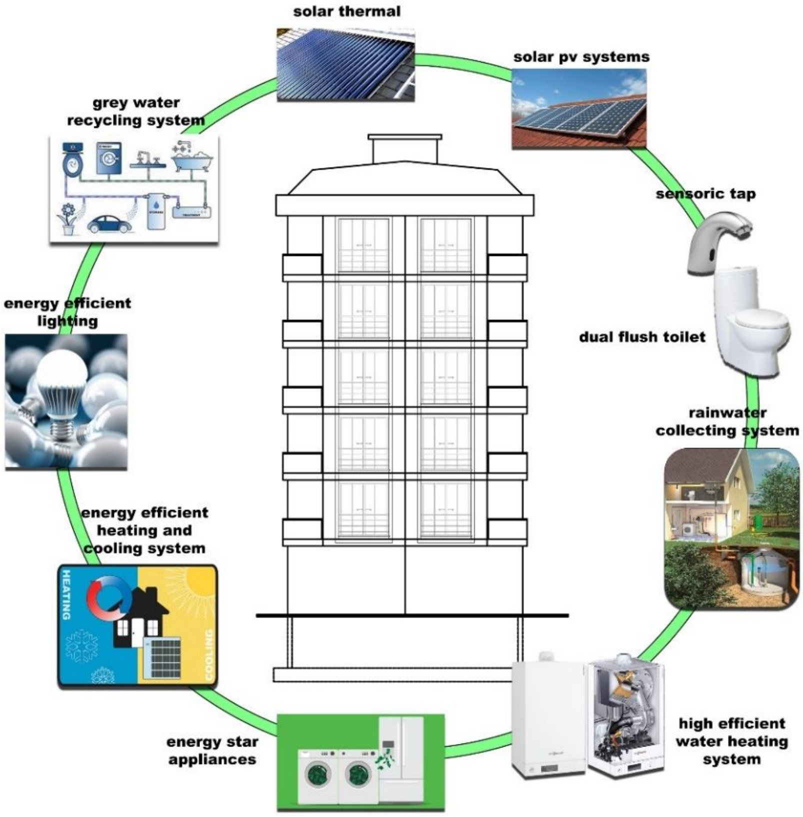


Figure 2.3. Example of Energy Efficient Structure Design [URL3]

2.4. Concept of Sustainability

Sustainability is one of today's important phenomena used together with concepts such as ecology, environment, and energy. Sustainability is defined on the one hand as continuing to use natural resources, on the other hand as the protection of these resources to ensure that they can be used by future generations. (Renda.Y., 1995).

The concept of sustainable development was first used by the World Environment and Development Commission (WCED) in its report titled “Our Common Future” which was published in 1987 by the Norwegian Prime Minister Gro Harlem Brundtland and it was defined as ‘meeting today's needs without taking away the means to meet their own needs of future generations.

‘The Common Future’ report, has generated worldwide echoes by bringing a wide initiative in environmental issues and the concept of sustainable development, has greatly influenced the knowledge and ideas on the environment. The deterioration of the ecological structure due to the environmental problems, together with the poor quality of our living environment, the importance of designs that can meet the needs of healthy living of future generations is also increasing. In this context, the concept of ’sustainable architecture' is emerging.

(Canan.F,2003)

Sustainable architecture while offering safe and comfortable spaces to its residents, defines the building design which respects the environment by minimizing the use of natural resources. In this case, architecture needs to be addressed in the dimension of sustainable development. The contribution of the architect to sustainable development will be realized by designing sustainable buildings, constructing, following the principles of sustainability in every stage of building, and continuing the process at the end of usage.

Sustainability in architecture is based on the use of renewable resources, energy efficient technologies, use of reputable materials, recycling and reuse activities, considering ecology in all phases of design and construction

The projects that revealed as ecological and sustainable approaches, guide the understanding of today's and future housing and set an example in this field, are in general terms based on five main principles.

- Healthy Artificial Environment becomes compatible with topography, the old natural life of the environment is revitalized, working with the consciousness of creating an artificial ecosystem. Construction materials and building systems containing non toxic raw materials and harmless gases are used.
- Adequate and Efficient Energy Systems: Necessary measures are taken in order to minimize the energy used when creating suitable living conditions. Heating, illumination, and cooling systems are made up of methods and products that use little or no energy.
- Environmentally Sensitive Building Materials: Building materials and products that require less energy in production, application, and use, which do not give hazardous waste to the environment and which are recycled are used.
- Environmental Sensitive Form: The building form and living space organization are designed according to the structure of the place and the climate characteristics of the region. Be respectful to the ecological structure. In-house comfort conditions are provided by the rational and efficient use of energy.
- Intelligent Design: Place use, circulation, building form, mechanical systems and construction are designed to work efficiently, quickly, harmoniously, and

with long life. (Koçhan.A., 2003)

In line with these principles, it is clear that sustainable design is intertwined with energy resources and energy use.

Providing sustainability in the field of energy is also based on three main principles:

- Efficient use of energy and energy saving;
- Development of environmentally friendly energy strategies to minimize the negative impacts and pollution of energy production and use in the environment;
- Increasing the use of renewable energy sources and increasing the technological capability in this field.

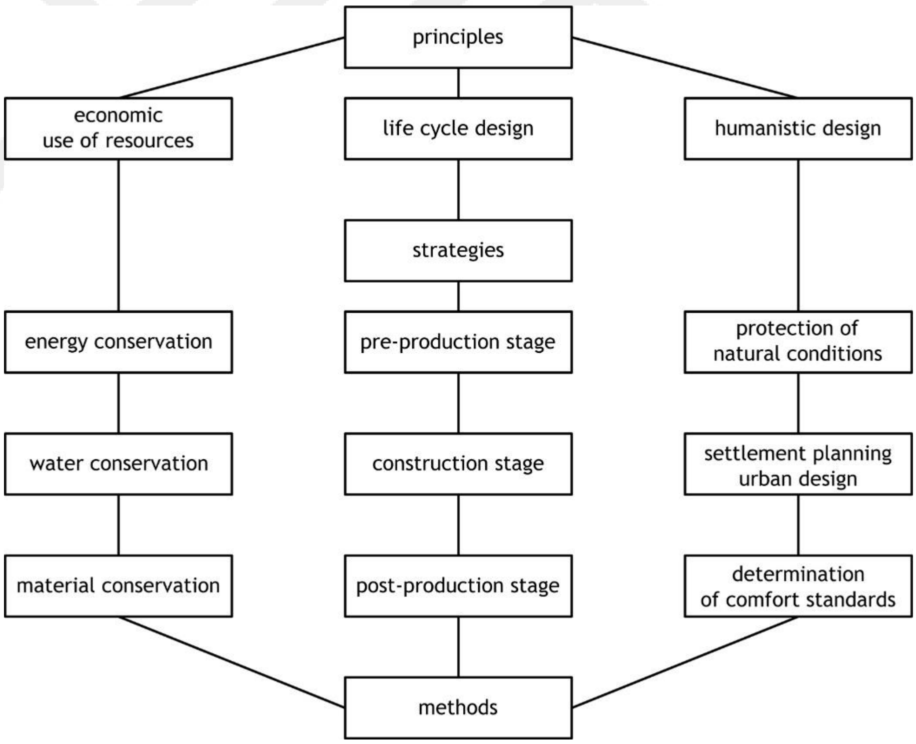


Figure 2.4. Example of Energy Efficient Structure Design (Kim and Rigdon,1998)

In terms of energy savings, significant gains can be achieved in many buildings by using small measures (like orientation, size, and placement of windows, etc.) that can be taken without any additional expenditure during the design phase.

III. RENEWABLE ENERGY SOURCES AND USAGE IN ARCHITECTURE

3.1. The Concept of Renewable Energy

Renewable energy can be defined as "in the evolution of nature itself, the energy source that may be present in the next short period.(Uyar, 2004) It is the energy that is never ending and can renew itself, and not a conventional energy source (coal, petroleum, natural gas, uranium, etc.). Compared to the fossil and nuclear sources, the negative effects on the environment are very low. Combined with the burning of fossil fuels, the carbon dioxide is combined with other gases in the atmosphere, thus preventing the reflection of the sun's rays, thus creating a greenhouse effect. Carbon monoxide, methane, nitrous oxide and sulfur dioxide, which are produced by the combustion of fossil fuels, are dangerous for the environment and living things. With industrialization, rapid population growth and developing technology, energy is demanded more in all sectors. Total energy needs are increasing in all over the world. The decline in energy resources of fossil origin has also directed countries to use renewable energy sources.

Renewable energy sources can be used directly or transformed into another type of energy. Problems related to environmental pollution, fossil fuels will soon be depleted and their tendency towards renewable energy sources is increasing. It is estimated that oil reserves in the world will be exhausted in 40 years, natural gas reserves are in 67 years, and coal reserves will be depleted in 227 years. Approximately 64.5% of the world electricity consumption is produced from fossil fuels (38.7% coal, 18.3% natural gas, 7.5% oil), 7% nuclear energy, 16.5% hydraulic energy, and 13% other renewable energy sources. These figures indicate that renewable energy sources will be more important in the future and investments in this area will increase rapidly. (Eniş, 2005)

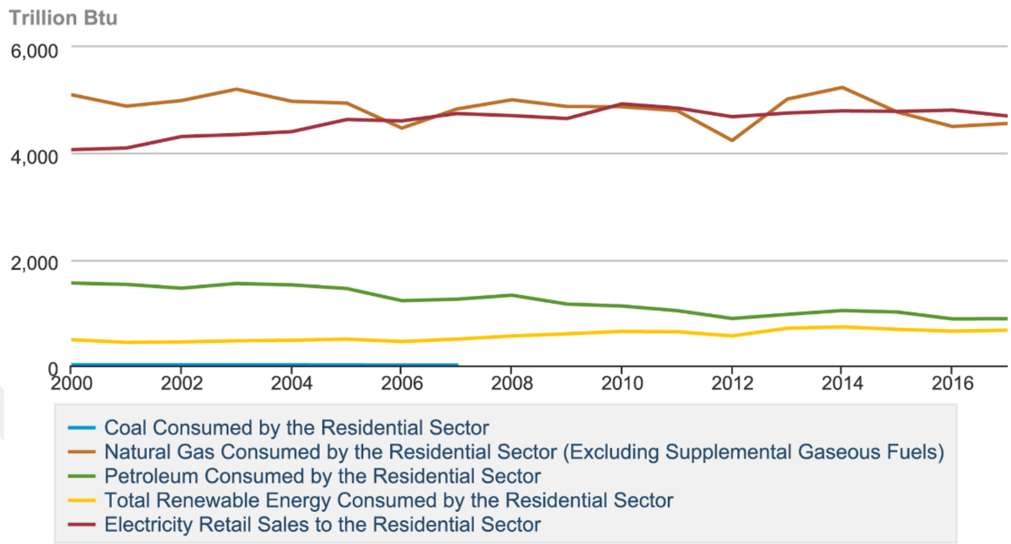


Figure 3.1. Residential sector energy consumption, 2000-2016 [URL4]

The apparent environmental impacts of global and local energy use by traditional resources and their relationship with global warming have led to an environmentally important source of renewable energy sources that cause almost zero emissions. (Altuntaşoğlu, 2003)

Since renewable energy sources are domestic sources, they also reduce the dependence of foreign countries on energy. "In developed countries, modern or transformed forms of renewable energy, in particular wind, solar, processed biomass and organic wastes, in which technology is heavily used, are generally used." In less developed countries, direct use of biomass and animal wastes is important in rural areas for heating and cooking purposes.

Associating Renewable Energy Sources and Building Sector

As the buildings have an important share in total energy consumed in the world and in Turkey, the efficient use of energy types, especially the ones that do not harm the environment, will be beneficial in terms of preventing environmental problems for the building sector, as for all sectors. (Esin, 2007).

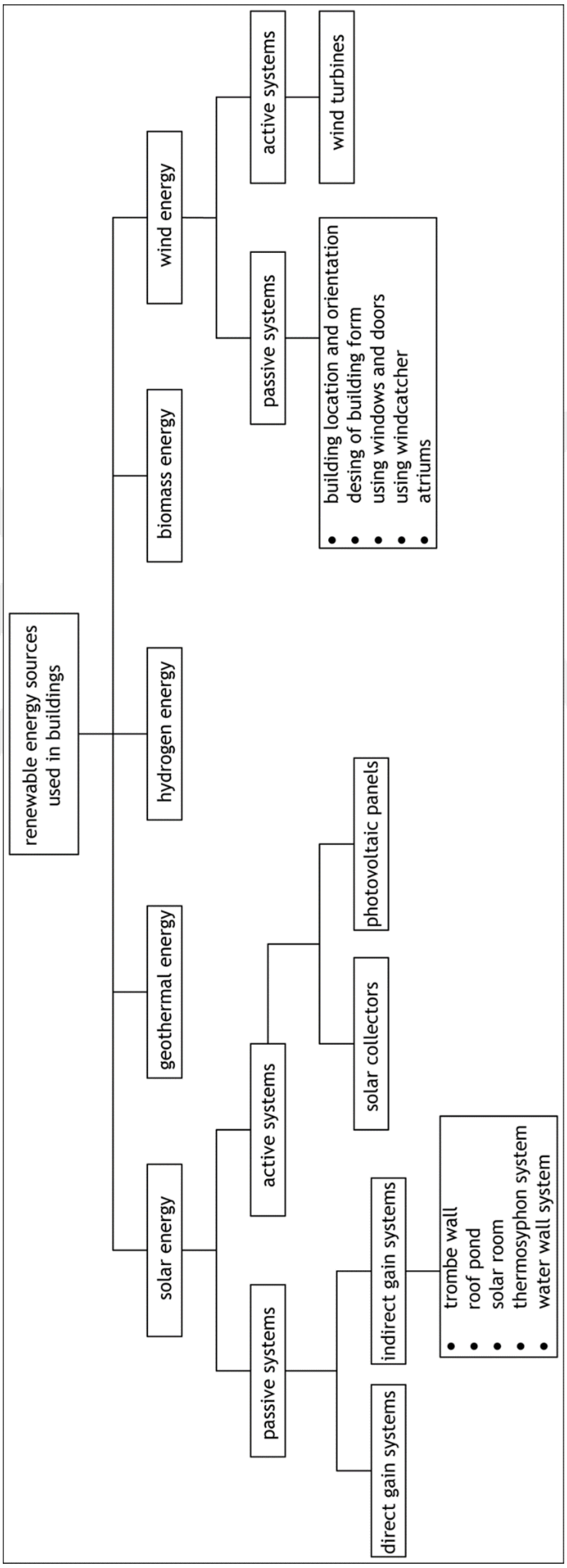
In Turkey, a very important ratio of total energy is used in the areass uch as heating, air conditioning, ventilation and lighting, as in the rest of the world in order to provide user comfort in buildings.

Renewable energy sources are an environmental, economic alternative to classical energy sources and a necessity when considering that classical sources are running out. Energy saving and conservation, adopting the principle of minimum and proper energy use is also a matter of importance for classicalenergy sources, which are rapidly depleted, such as the use of renewable energy. In the face of high energy consumption in the building sector, less heating, cooling, ventilation will be needed, and practices to reduce the energy use need are becoming important for the optimization of climatic data. The integration of renewable energy sources such as the sun, the wind, etc. which are crucial within the framework of macro and micro climate implicitly, through design and in a way that will minimize the energy need of the building, the shaping of the building in accordance with these determinants is positive within the scope of an architecture that complies with the climate and is sustainable, in terms of energy efficiency.

Therefore, this study is performed to shed light on the energy conservation problem used in buildings.

In Table 3.1. the main renewable energy sources used in buildings are grouped.

Table 3.1. The main renewable energy sources used in buildings



Types of incentives applied for using renewable energy;

The only reason for the promotion of renewable energy sources is not to reduce the damage caused by fossil fuels to the environment. Beyond that, there are political and economic reasons. They are as follows: Ensuring the energy supply security, environmental sustainability and combating climate change, sustaining competitiveness. In order to increase the use of renewable energy sources in the world, the authorities take various measures. These measures are implemented in different ways. Some of these are:

- **Tariff Guarantee (Feed-in Tariff);** In the tariff guarantee system, the state requires the energy authorities to obtain electricity from renewable energy sources for 20-25 years on the market price. The authorities can reflect this cost overrun on the utility bills of consumers. Thus, this system can operate independently from the economy and consumers who do not want to pay more bills will invest in renewable energy sources. (EPIA; 2009).
- **Investment Support;** Investment supports are a system applied to all types of goods and services. Solar energy is not an exception to these investments. A certain portion of the investment costs is provided by the fund organization. Compared to other support mechanisms, it remains weak. Since the actual production is not supported, it may be desired to keep investment costs low by using poor quality products.
- **Quota Systems;** Quota systems can be implemented in different ways but the basic principle is that the state forces manufacturers, suppliers, and consumers to obtain a certain portion of the energy used from renewable energy sources.

When the quota is implemented, the price arises from the competition among different projects and technologies. The quota system does not need to be used with other support tools.

Roofs

Before proceeding to the practices of renewable energy, this part describes the roof and components of the building which are the first elements to contact with external factors. In accordance with the current building bylaws, since the distance between buildings is short and it is appropriate for the usability of renewable practices as surface area in the current urban housing, the utilization of roof areas is important.

Roof is a structural element that is built to protect a structure from external influences such as rain, snow, wind, hot and cold weather. Roofs can be made of wood, steel, and reinforced concrete materials.

The concept of the roof has existed throughout human history that is protecting the structure and thus the people living in it from climatic effects and various dangers caused by nature. In the past, only performing protection function, roof with developed product technologies and by going out of classical roof molds, also to the aesthetic requirements become one each building element to respond. (Figure 3.2.)

Therefore the roof, though it is a structural element covering the top of the building, is one of the main elements of architectural integrity, is complementary to the concept of structure. (Figure 3.3.)

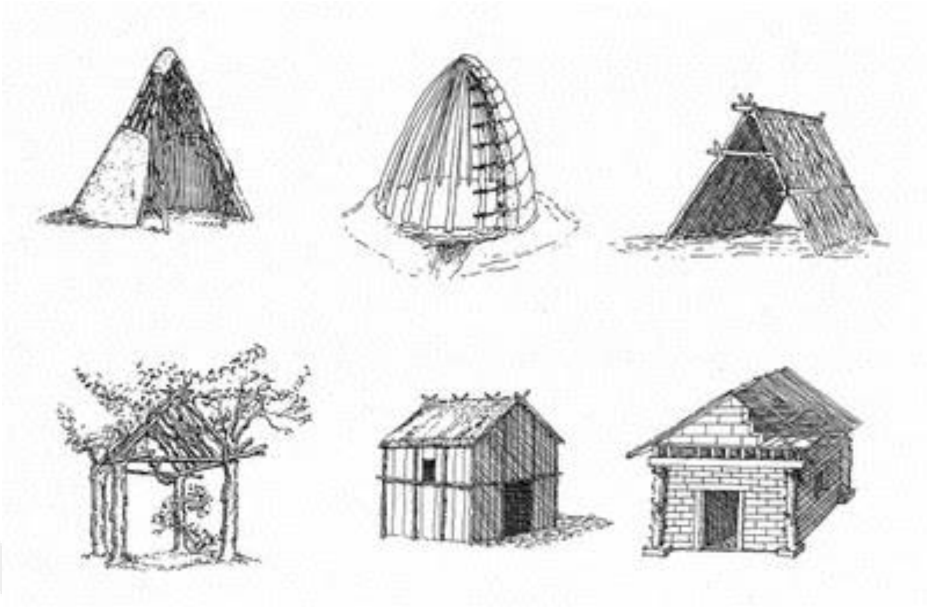


Figure 3.2. Examples of roofs that carry out the task of protection [URL5]

Figure 3.3.Examples of roofs with architectural integrity and aesthetics [6],[7],[8]

Roof coverings the top of the building and completing the structure, cover and carrier two sub-consist of system. Cover that protects the roof against external influences, also form a carrier portion to place the cover layer undercover system where the cover can place while consisting of the top part of the roof. (see Figure 3.4.)

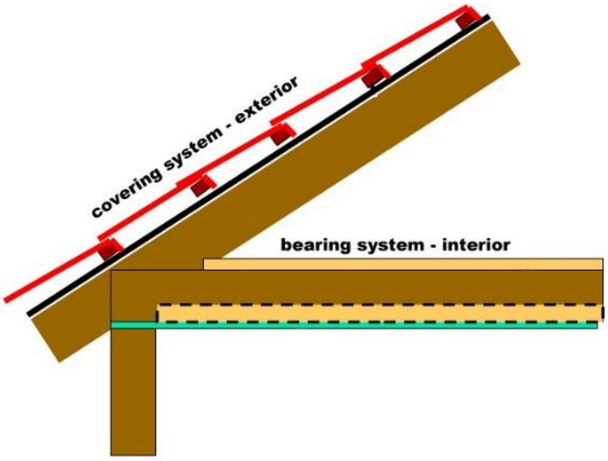


Figure 3.4. Inside and outside layers on pitched roof [URL 9]

Roofs are usually divided into two as terrace and sloping. Terrace roofs are considered to be roofs with a slope less than 5%. The terrace is very advantageous because it allows easy installation of various apparatuses and activities on the roof. Inclined roofs are roofs with a slope greater than 5%. Inclined roofs are often preferred in cold climates where snowfall is high. It is of great importance to remove rainwater from the roofs in rainy rainfall and in climatic zones where precipitation is high. For this reason, roofs are made very inclined to remove rain water from the surface. In addition, the roof covering products in this region is in the form of large pieces of products instead of small pieces, that makes it more useful to prevent water leakage from the joints. In climatic zones where the amount of rainfall is low, the roofs of the building are made as flat, terrace roof. Southeast and Central Anatolia region in Turkey this type of roof can be seen. In climatic zones where snowfall is high, the roof slope is increased in order to prevent the snow weight from forcing the roof, In addition, the products that have the feature of keeping the snow from the covering products are preferred. In the world, it is possible to come across very slanted roofs in Central Europe and eastern Anatolian climate zones of Turkey.

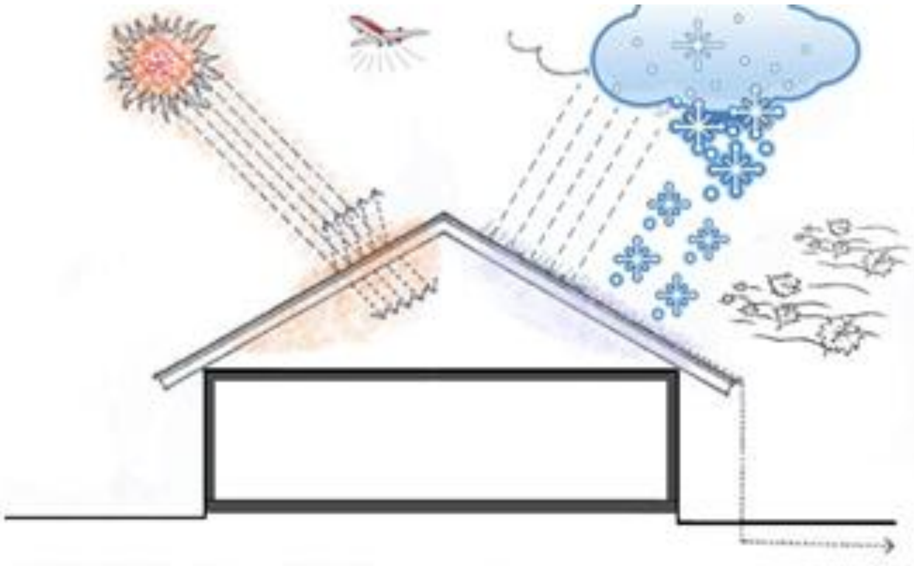


Figure 3.5. External effects on pitched roofs [URL10]

Wood is the common choice in roof construction. However, because of their high strength, reinforced concrete or steel roofs are preferred in large span business place, garage, factory etc. Roofs while protect the structure against adverse environmental conditions that may come from outside on the other hand, it helps to create suitable life conditions in the interior environment. Therefore, some criteria should be taken into account when planning sloping roofs. Considering these criteria should be kept;

- Regional conditions
- Bearing
- Features of roof covering
- Aesthetics
- Insulation
- Roofing conditions,
- Regulations can be listed as.

Wooden Pitched Roofs

Wood is preferred for structural purposes since prehistoric period with its advantageous features. The use of the roof is also based on these periods. They are important features of the material, which have a visual diversity, are resistant to corrosion, are resistant to strength/weight ratio, are economical and easy to form. Technological developments throughout history have led to developments and changes in roofs.

The first shelters were constructed by excavating 40 - 45 cm of the soil, placing wooden pillars at certain intervals, and tying these studs by bending together at the hill. Therefore, it can be said that the first timber roof system were covered by materials such as animal skin and plant. In the following period, wooden elements were placed on the walls formed of adobe, stone, or wood and covered with earth or plants. (As.N., Koca.G., 2016) Today, the roofs are divided into two as with cold and warm roofs. Cold roofs used before the Industrial Revolution, are produced as cold slopes. Warm roofs were started to be used after the technological developments and building dimensions of the Industrial Revolution. Difficulties of covering large-sized structures with pitched roofs require different solutions and low-pitched roofs have emerged. In spite of this, cold roofs are still preferred in small sized buildings. The structure formed on cold roofs has always been wood since the past. (Toydemir N., Bulut Ü., 2004)

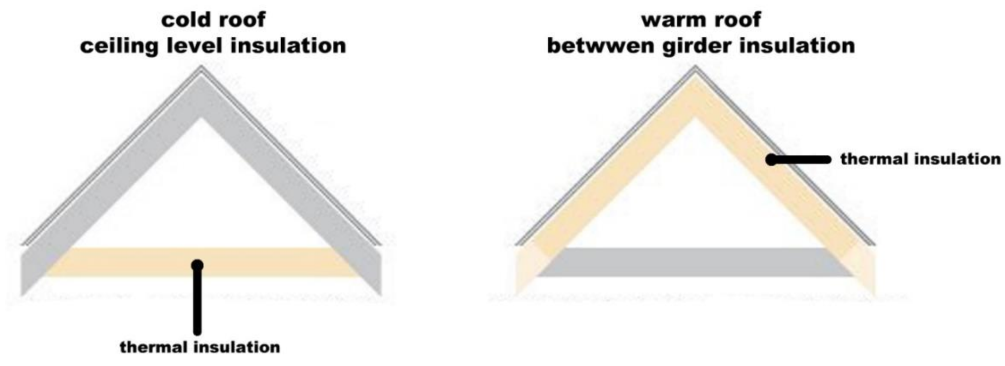


Figure 3.6. Cold and warm roof [URL11]

Layers in pitched roof systems;

- Roof covering
- Ventilation space
- Water insulation
- Heat insulation
- Vapour barrier
- Bearing layer

Components of wooden pitched roofs

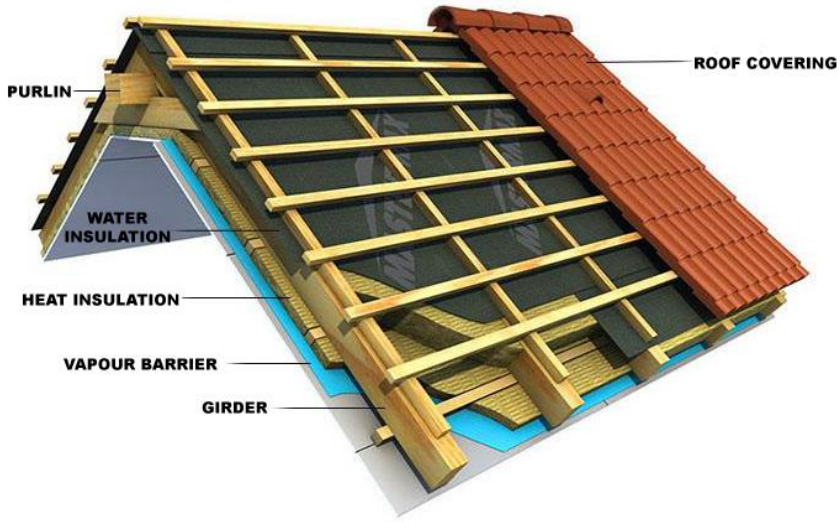


Figure 3.7. Curved Roof Section Layers [URL12]

Purlins; are the support beams which form a bearing to the beams and sit down on the roof shears and convey loads from the rafters to the posts. They are generally placed parallel to the building axis and are named as mahya, and fringe (dropper) purlin according to their location. Depending on the specific climate, inclination and load conditions, the dimensions of the purlin can be as 10/14, 10/16 and 12/16 cm. (Toydemir N., Bulut Ü., 2004)

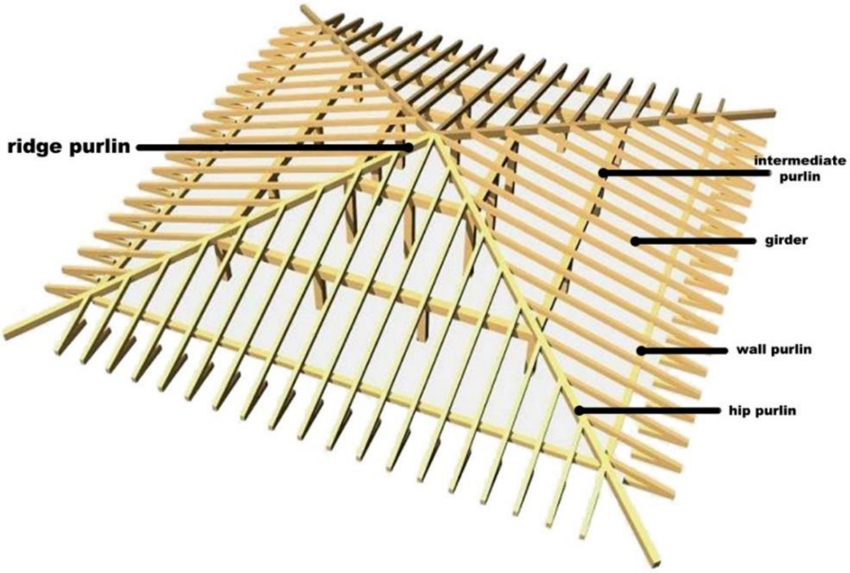


Figure 3.8. Roof Elements [URL13]

Girder; is the element that transmits the burden on the undercoat to the purlins. The cross-sectional dimensions of the element are determined depending on the distance between purlins and the current loads. Girder size ranges 50-90 cm and the optimal range is 55-65 cm. Girders are usually used with a rectangular cross section and are 5/10 or 6/12 cm in size.

(Toydemir N., Bulut Ü., 2004)

Ridge; is a cross-section where the curved roof surfaces on cradle and broken roofs are intersecting along a horizontal line. If the ridge is on a horizontal right ridge purlin on a sloping straight is called hip purlin. (see Figure 3.9.)

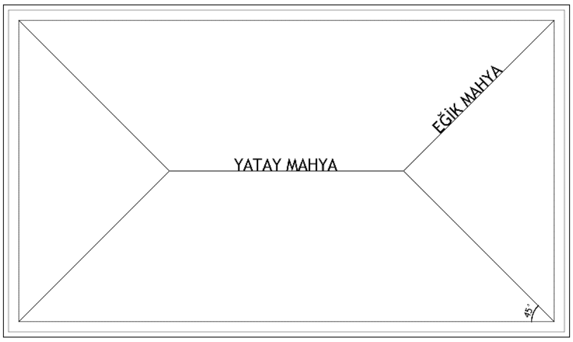


Figure 3.9. Ridge purlin and hip purlin on sloped roof

Roof covering; on pitched roofs, under the roof cover and cover product it is a coating on which it rests. This coating is on the girders in perpendicular direction sits. (Toydemir et al., 2006)

Roof coverings, 2 to 2.5 cm in thickness; the planks can be formed by placing the planks at regular intervals of 20 cm in width, they can be placed side by side in a continuous manner or in the same thickness plate-like osb, plywood products can also be formed by mounting on rafters. (see Figure 3.10.)

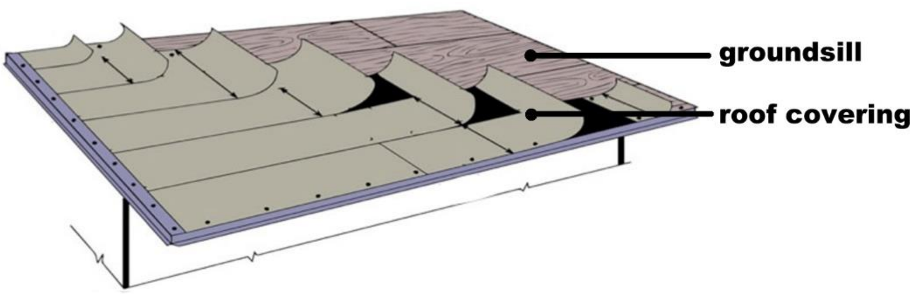


Figure 3.10. Roof covering in pitched roofs [URL14]

Eaves; The roof is the part of the roof surface outside the building. The main task of the eave is, the water to protect the structure from the sun to flow away from the base. (Çelebi, 2001) Eaves bottom surface it can be sloped and can be applied straightly (see Figure 3.11.)

The width of the eaves determined by the Istanbul zoning regulation dated 20.05.2018 is 0.60 m, if there is an sponson in the structure is 0.50 m. The fringes should be arranged so as not to exceed this specified size. [URL15]

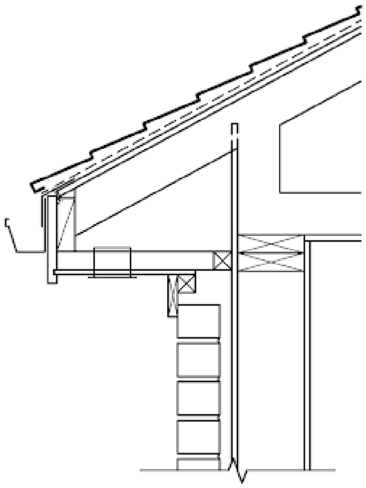


Figure 3.11. Roof eaves

Vapour barrier; In general, it is a cover-shaped material produced from polymer and bituminious materials in order to prevent water and steam flows. (Toydemir et al., 2006), (see Figure 3.12.)

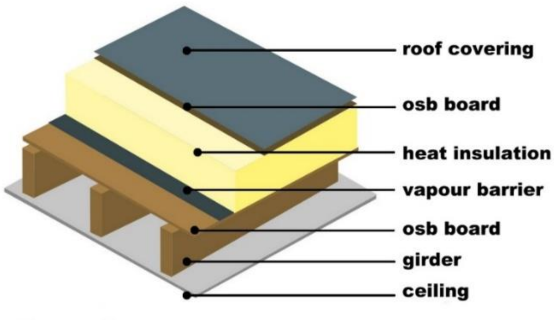


Figure 3.12. Roof covering in pitched roofs [UR16]

Thermal insulation; Is an organic and non-organic insulation product which contains stagnant air and used to reduce the flow of heat energy out space. (Toydemir et al., 2006), (see Figure 3.13.)

Figure 3.13. Use of thermal insulation [URL17], [URL18]

Waterproofing cover; Is a water impermeable insulation product which is produced from Polymercopolymer and bituminous products in order to prevent water from entering the structural element in the roof (Toydemir et al., 2006), (Figure 3.14)

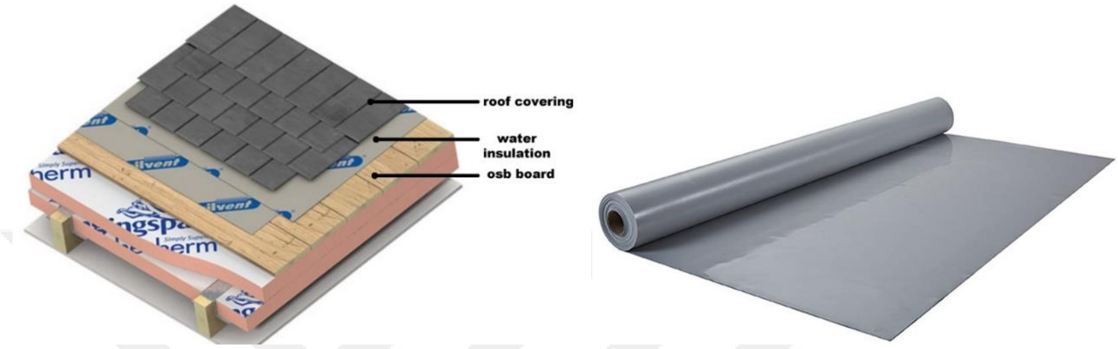


Figure 3.14. Use of water insulation [URL19], [URL20]

Besides; other additional support elements such as impregnation, bonding, lateralizing, release beam, tensioning beam are also used, in roof construction.

Green Roofs

Green roofs make the urban environment more livable, comfortable, and sustainable. It represents an innovative approach to urban design using "living materials." Green roof, with the simplest definition, is planting on the roof of the building. According to a scientific description, the green roof system is expressed by various definitions like ecological roof, living roof, brown roof, roof garden. The terms "ecological roof" and "living roof ” are often used in the European and the United States literature. The term "brown roofs" is a commonly used term in England. Moreover, the roof garden can be defined, in oldest and common term, as a space considered and designed for people to reside. (Erkul, E. and Sönmez, A., 2014)

The term roof garden is actually quite different from the concept of the green roof. However, the two terms can be used interchangeably. The roof gardens are used for recreation and entertainment purposes in general, including automatic irrigation and lighting systems that include dining and living areas, and are places that reunite people and nature. (Tohum, 2011)

The concepts of eco-roof and living roof are related to hot and cold. Therefore, these concepts are an expression of an ecological situation. These two terms are used in the west USA. (Coffman, 2007) Green roofs, unlike the roof garden, prioritize sustainability and aim to cover the building area with green texture 18 in the most economical and efficient way possible. In this way, the heating and cooling loads are reduced throughout the building. (Tohum, 2011)

It is believed that the first examples of green roofs date back to the BC. The first examples used were the temples and temples that resembled the Ziggurat pyramid (see Figure 3.15.) in the city of Ur, built in the 2000s BC. (Magill, 2011)

Figure 3.15. Green garden in the Ziggurat pyramid [URL21]

Since then, these structures have been preferred since they provide positive effects on people, environment, and structure. The Romans planted trees over institutional structures such as the tombs in Augustus and Hadrian, while the Vikings planted the walls and roofs of their houses to protect them from wind and rain.(Peck et al., 1999)

Figure 3.16. Use of green roof in Iceland [URL22]

After these applications, famous architects have started to use this system. Many architects, including Le Corbusier and Frank Lloyd Wright, have used green roofs in their buildings.

Green roofs are now widely used in Europe and worldwide. However, green systems have become a fully sustainable roof design alternative in modern Germany. These systems have evolved as a result of trial and error, repeated material testing and the development of industry standards and principles.(Velazquez, 2005)

Fundamental layers of green roof systems

Green roof systems are composed of various layers. If we consider the bottom layer as the roof construction, the other layers are respectively;

- waterproofing
- root retainer layer
- moisture retainer layer
- filter and drainage layer
- plant carrier layer
- plants

Plants; The choice of the plant to be used in the planting roof varies according to the type of roof system. In densely planting roof systems, while it is aimed to gain an aesthetic value by using big trees and bushes, it is aimed to provide ecological benefit by choosing self-catching and sustainable plants in sparse plant textured green roof systems. (Tokaç, 2009)

Substrate (plant carrier layer); Lava, bims-based products used in green roof systems, recyclable, durable products help keeping the selected plant alive by providing living requirements of them. (Erkul and Sönmez, 2014)

Filter and drainage layer; It stores the rain water from the upper layers and also drains and discharge the water to prevent the decay of the plants. (Erkul and Sönmez, 2014)

Protective and moisture protection against mechanical effects; Protective root retention layers, waterproofing membranes, roof construction and other layers against corrosion and mechanical effects. (Erkul and Sonmez, 2014)

Root holder layer; It is the layer used to separate the plant roots from other layers and is used to prevent damage to other layers.

Waterproofing and roof construction; One of the most important layers in the green roof is waterproofing and it is a solid infrastructure.

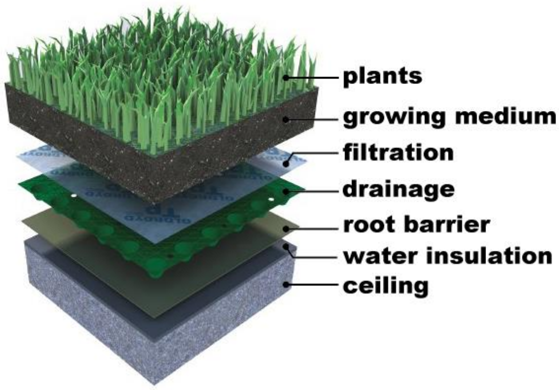


Figure 3.17. Fundamental layers of green roofs [URL23]

Classification of green roofs

Green roofs are examined as extensive(sparse), intensive and semi-intense green roofs considering the depth of the habitat, plant species, planted surface area and vertical loads.(Lanham, 2007)

Extensive (sparse) green roofs

Maintenance of preferred plant species in sparsely planted roof type are natural species that can grow naturally. These roofs approximately 8-10 cm in depth and such roofs are only accessible for maintenance.(see Figure 3.17) Modular, continuous and some of the loose-layered systems various plants. Although it has been proven to hold species, it is very shallow green to create more plant diversity. It may be a challenge for roofs.(Tolderlund, 2010)

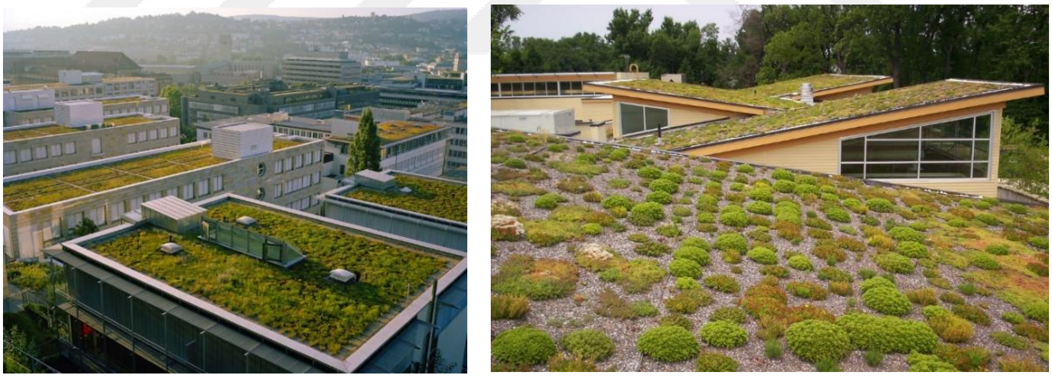


Figure 3.18 Extensive green roof applications [URL24,25]

Plants used in sparse planting green roof type high temperature, should be tolerable against drought, wind and frost. Common misconception, green about the roof where the roof environment will be provided should be flat. But on flat roofs a soft slope of 1.5-2% is natural on these roofs, as drainage problems will arise provides drainage. (Velazquez, 2005)

Extensive green roofs have both advantages and disadvantages. (see Table 3.2.)

Table 3.2. Advantages and Disadvantages of Extensive Green Roofs (Peck et al., 1999)

Advantages of extensive green roofs;
-There is no support required due to it's low weight
-It's generally used in areas which have bigger space
-This type of roof systems are preferred for roofs with slope between 0 - 30 degrees
- Easy maintenance
-Often watering and drainage is not required
-Comparing to other roof systems, extensive roofs can be handled with minimum amount of technical knowledge, less complexity.
-Plants can be easily left alone to grow up by themselves
-Prices are more economic rather than other roof systems.
Disadvantages of extensive green roofs;
-The amount of chosen plant types are limited
-Not usually preferred for recreational areas

Extensive green roof systems are often made for ecological purposes. The built roofs are generally not available for use on human. There are blocking elements that do not allow it to walk. Big trees and shrubs are used rather than single annual stunted plants. (see Figure 3.19).

Because there is no dense plant texture on, aesthetics or social contribution is less than the intensive planting system. (Doug et al., 2005)

Figure 3.19. Extensive green roof [URL26]

From Turkey, in Istanbul Maslak 'ITU Metro Station' and 'Garanti Bank Technology Campus' examples can be given for the extensive green roof. (see Figure 3.19) and (see Figure 3.20)

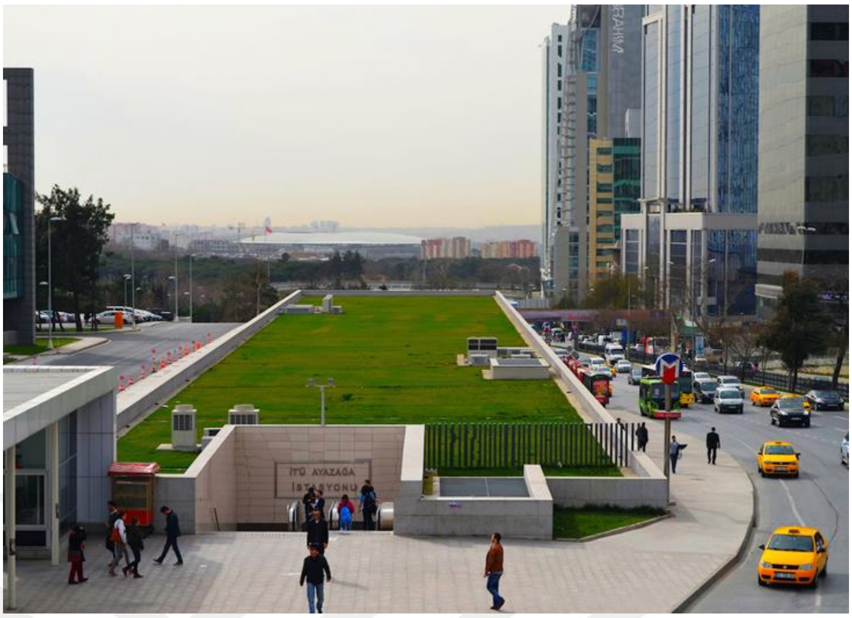


Figure 3.20. Extensive green roof - ITU Ayazağa metro station [URL27]

Figure 3.21 Extensive green roof - Garanti bank tech campus

The layers of extensive green roof are;

- Planting
- Substrate (Plant carrier layer)
- Filter and drainage layer
- Polymer bitumen waterproof coating
- Insulation layers
- Vapour barrier
- Ceiling (see Figure 3.22.)

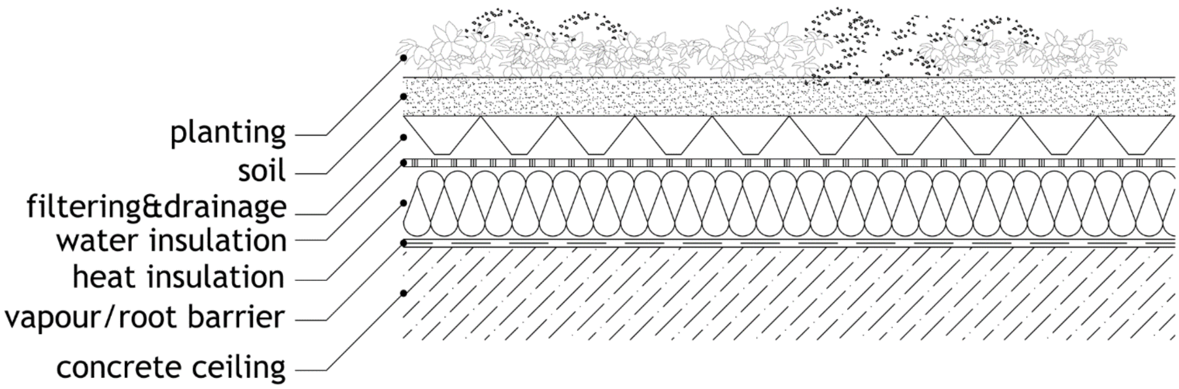


Figure 3.22 Extensive green roof layers (Aytin and Ovalı, 2016)

Intensive (frequent) green roofs

Intensive green roof systems plant growth more than 15 cm and therefore need more care green roofs.(Getter et al., 2009) This type of roofs of a thick plant soil and traditional garden plants are incurred. They are designed according to human traffic and therefore frequent maintenance needs. Environment, combined with walkways and terrace applications to made human comfort. (see Figure 3.23)

Figure 3.23. Intensive (frequent)green textured plant - Kensington Roof Gardens [URL28]

Using as a recreation area as it can be walk on the intense roofs we can see as the biggest advantage. On this type of roofs plants with a wider variety than extensive roofs (flowering bushes, vegetables, even trees) can be used. But these systems require a lot of maintenance after construction and it is quite costly. (see Table 3.3.)

Table 3.3. Advantages and Disadvantages of Intensive Green Roofs (Peck et al., 1999)

Advantages of intensive green roofs;
-Provides high variety of plant types
-Very good insulation properties
-Attractive visuality
- It is possible to show the system as earth ground
-Often watering and drainage is not required
-Provides roof to be used for many purposes (plant production or creating spaces intended for different usages)
Disadvantages of intensive green roofs;
-Creates excessive weight on the roof
-Requires additional watering and drainage systems
-High cost
-Qualified labour is needed due to the complex system

The layers of green roof with the textured plant textured are;

- Planting
- Substrate (Plant carrier layer)
- Filter and drainage layer
- Separator layer
- Polymer bitumen waterproof coating
- Insulating layers
- Vapour barrier
- Ceiling (see Figure 3.23)

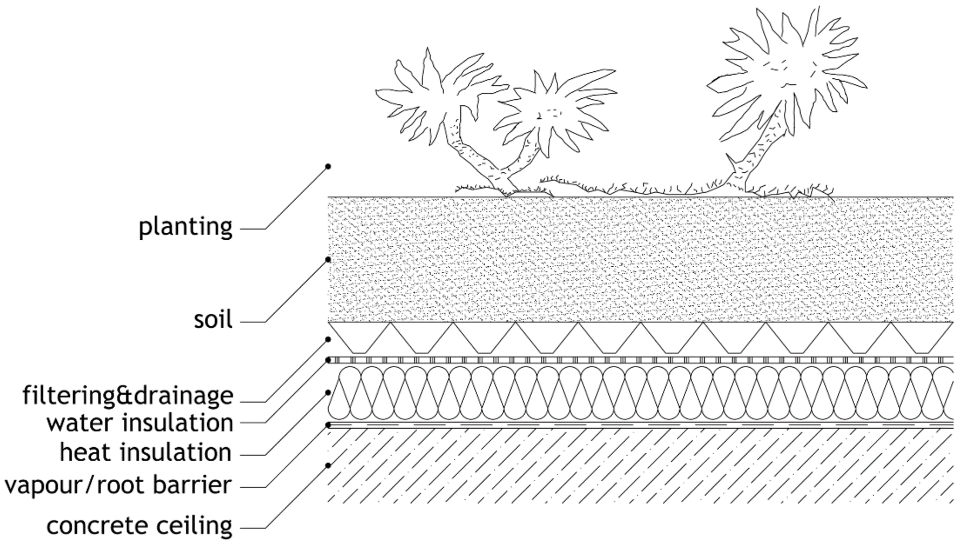


Figure 3.24. Intensive green roof layers (Aytin and Ovalı, 2016)

Semi-intensive (semi-dense) green roofs

Semi-intense green roofs; created by mixture of extensive and intense green roof systems. (see Figure 3.25.). Its prevalence is very low. Therefore, it is not fully known (Lanham, 2007).

Figure 3.25 Semi-intensive green roof [URL29]

Zorlu Center Shopping Center in İstanbul is an example for semi-incentive green roofs can be given. (see Figure 3.26.)

Figure 3.26. Semi-intensive green roof [URL30]

Comparison of green roof types

The advantages and disadvantages of each known roof type. While the cost, maintenance, and irrigation of the extensive roofs are low, plant growth depth is low. It is also a type of roof that cannot be walked on. Other than this disadvantages is that all kinds of plants cannot be used. The cost of construction in intensive green roofs is high.

Needs much more maintenance and irrigation. Advantageous aspect is that it can be walked on and the plant breeding depth is high. Therefore, all kinds of plants can be preferred on these roofs. The comparison of these species is shown in more detail below. (see Figure 3.27.)

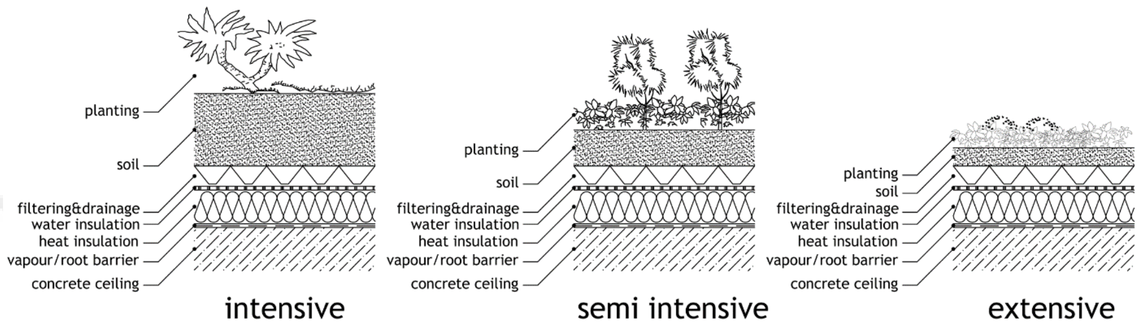


Figure 3.27. Comparison of green roof systems

Table 3.4. Comparison of green roof systems(Peck et al., 1999)

	Intensive (heavy) green roofs	Semi Intensive green roofs	Extensive (sparse) green roofs
purpose of use	functionally and aesthetically; living space,gardening etc.	-	functionally; ecologic protection layer
accessibility	always accesible	semi accesible	unaccesible; just for maintenance
maintenance	high level of maintenance	periodic maintenance	low maintenance
expenditure	high level	semi level	low level
structural requirement	extra support needed	-	can be carried by existing structure
watering	high level	-	low level
plant diversity	high level (types of turfs, boskets, trees etc.	semi level (floor covering species, types of turfs, boskets etc.	low level (floor covering species, types of turfs, water based plants etc.

3.2. Solar Energy

As long as life continues in the world, it is the energy source that will never be exhausted. If utilized, it is able to meet the energy needs of the countries in the world. It can eliminate external dependence. Hazardous gas emissions, such as fossil energy sources, are incomparably low does not harm the environment.

The share of the building sector in our country constitutes a significant percentage of the total energy consumption. Depending on the conditions of the country and the characteristics of the building, it is possible to cover a significant portion of this consumption for heating purposes from solar energy. (Çelebi, 2002) In addition, solar energy is used for cooling, air conditioning, and ventilation of buildings. Solar energy is one of the most important alternative energy sources due to the lack of production costs in order to save energy.

It is possible to use two kinds of solar energy. First, the passive systems, consisting of various elements to collect, store and distribute energy using heating systems. The second is to create the building system with the values determined by the design parameters such as directionality, building form, building shell, thermophysical properties by providing optimum benefit from solar energy by keeping the active systems out of the work. (Özemir, 2005)

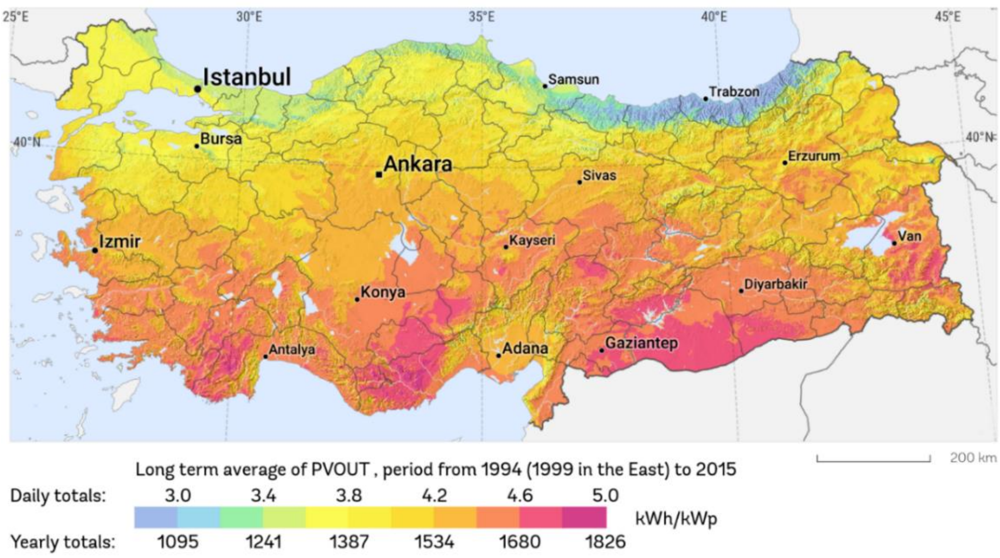


Figure 3.28. Photovoltaic power potential of Turkey [URL31]

Table 3.5. Installed solar power capacity by countries

Installed solar power capacity and prospects (mW)			
country	Total Capacity	Total expected Capacity by 2022	Growth rate (%)
Germany	42,973	63,237	10%
Italy	19,392	26,924	7%
France	7,999	19,702	20%
UK	12,676	14,742	3%
Spain	5,627	14,460	21%
Turkey	3,420	14,320	33%
Egypt	80	11,750	171%
Saudi Arabia	19	7,070	227%

The use of solar energy in architecture can be examined under two main headings.

3.2.1. Passive systems

Passive solar systems are the simplest ways to get energy from the Sun. It is based on the principle that by using the design features of the structure and appropriate material, the solar energy is taken into the structure and obtaining heat energy. (Boduroğlu, 2010) It is one of the oldest methods used in cooling and heating of building. In passive systems, the wall openings in the south-east and southwest axis or the winter gardens and greenhouses are used to enter solar energy into the living space and are spread through the building components. (Bekar, 2007)

There are three main functions in passive systems;

- Collecting: Solar energy is taken into the living area by the south-east and south-west axis of the windows opened, winter gardens and atrium.
- Storage: It is the storage of the heat received into the living area, after using some the other part, for later use on floors and walls.

- Distribution: It is the distribution of stored heat to the living area. This process can be done by means of radiators or conveyors as well as by means of fans. (Bekar, 2007)

Passive systems are examined under two headings as direct gain systems and indirect gain systems. (Bozdoğan, 2003)

3.2.1.1. Direct gain systems

Sunlight is taken directly to the structure. Solar energy; it is taken inside from windows designed on the southern facade of the building during daylight hours, from greenhouses, from winter gardens, and from windows on the roof. The heat energy taken into the space is used all day long, the unused energy is stored in the building components such as walls, ceilings, and upholsteries. The stored energy is used during the night. In order to benefit from direct solar energy, there are some considerations when designing the building;

- For maximum utilization of solar energy, it is important that the buildings are correctly positioned. By the openings on the southern facade, it is possible to benefit from the sunlight in the day.
- Buildings should be designed according to the climatic data of the land. The building forms and the materials used should be shaped according to the climatic and topographic characteristics of the region.
- The climate-friendly models and size, windows that provide natural lighting and ventilation are important elements for the building in terms of energy saving and conservation. From the windows intended to be utilized as far as possible to the south, it gains importance to make use of the necessary ventilation and lighting

in the north, east, and west directions, in terms of protection from the sun rays sinking in the east and afternoon in the west and in the winter the winter winds in the north. (Bozdoğan, 2003)

- In order to preserve the heat gain from the sun in winter, double-glazing must be used. After the sunset, it is protected from heat losses by moving insulating elements such as shutters, shades, blinds, or at least by closing the blinds tightly. In the summer, in order to be protected from the sun rays during the daytime, sun shading, curtains and eaves should be used on the windows. (Bozdoğan, 2003)
- Greenhouses, also called winter gardens, have the ability to collect heat from the sun. The facade where the buildings are positioned, the slope of the roofs, the cover materials used in their roofs and the materials used in their skeletons should be chosen in such a way that the light is best transmitted.
- When the facade of the building cannot get the necessary sunlight, the building windows should be designed and the daylight should be taken to the interior. It also provides natural ventilation of buildings. Dirty air heated in the interior environment is thrown out of the roof windows.

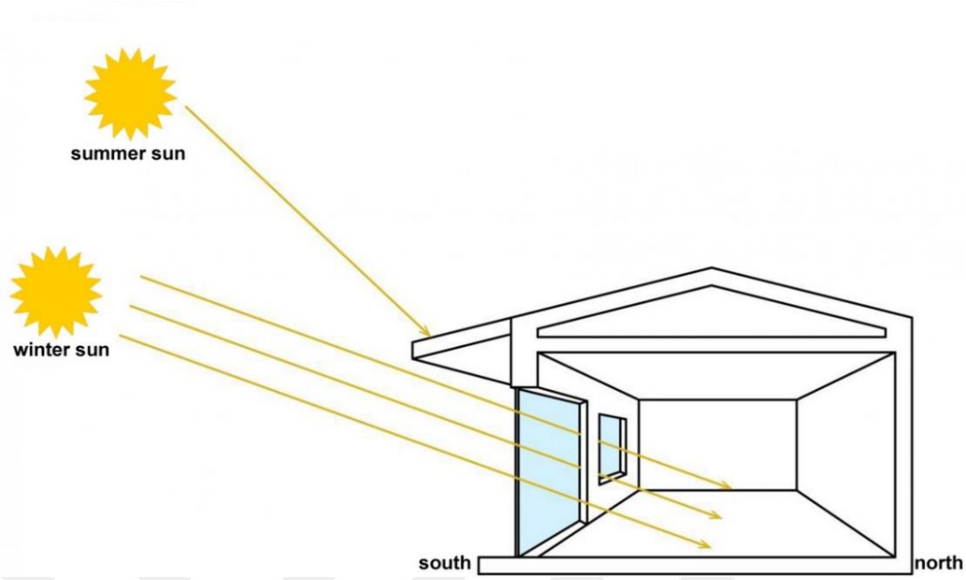


Figure 3.29. Direct Solar Gain [URL32]

Passive systems can achieve the desired level of energy savings with little investment.

3.2.1.2. Indirect gain systems

Indirect systems consist of elements suitable for absorbing and storing sunlight. On a dark colored or selective surface of concrete, filled bricks, stone mass walls of stone (trombe wall, water wall, remote storage wall), elements that absorb sunlight like roof pool system, by using the indirect system, sunlight can be stored and be used in desired places when needed.

Trombe walls; The facade which receives the sun rays most, it is made to the southern front for Turkey, leaving a gap behind the sun's rays directly from the glass surface is made of thermal wall to create a thermal storage space.

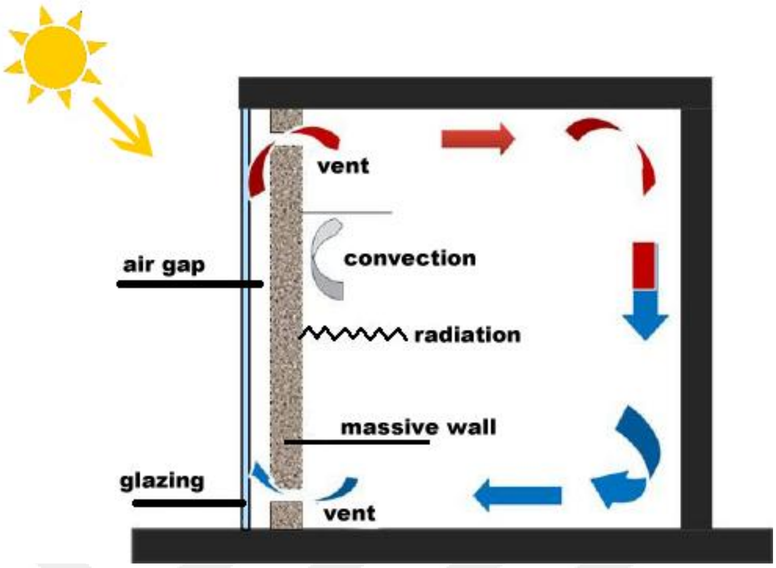


Figure 3.30. Trombe wall [URL32]

Trombe walls can be used for both heating and cooling. It is economical, also maintenance-free. However, there are also disadvantages of the thrombotic walls. On prolonged cloudy days, heat loss occurs on the outer walls. In the non-insulated thrombotic walls, the heat loss at night is high. Prevents natural lighting. [URL33]

Advantages of trombe wall;

- Indoor temperatures are quite stable for a passive system.
- Since the sun rays don't go directly to the place, problems arise in very sunny weathers are not encountered.
- The cost is quite low, especially when it is made of bricks.
- It is easy to apply to existing structures. (Tokuç, A., 2005)

Water trombe wall; It allows the transfer of the sun rays to the space. The difference between the trombe walls is not massive, the interior of the wall is filled with water. In this way, heat retention is high and it has the feature of being used as thermal mass.

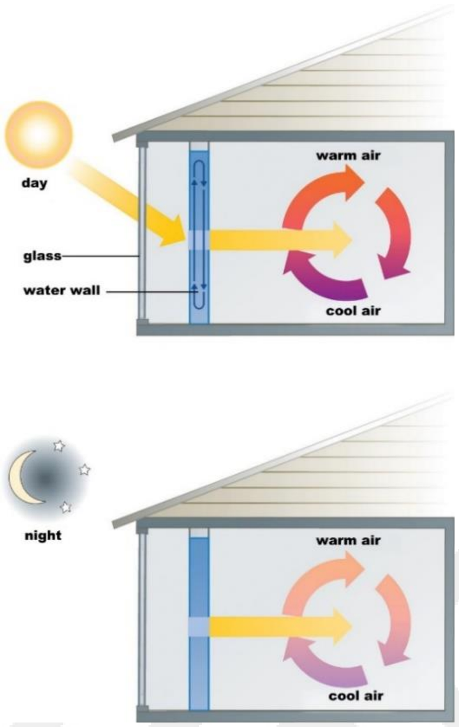


Figure 3.31. Water Wall System [URL32]

Advantages of water trombe wall,

- Isothermal property of the heat tank prevents the formation of very high temperatures on the outer surface. Thus, the heat losses to the outside and to the sky at night are reduced.
- Glare, privacy, and sun-wearing effect are not problems.
- Heat emissions in the living space are less than other passive systems.
- The storage remains warm until late in the night and continues to provide heat to the interior.

Sunroom; They are places with intense glass surfaces, which are directly connected to the places to be heated, designed on the southern facade where the sun rays are effective. Also called greenhouse. More radiation is taken with the winter garden. In some cases, heat dissipation is ensured by placing the thermal mass without being in contact with the spaces. In some cases, heat dissipation is ensured by placing the thermal mass without being in contact with the spaces.

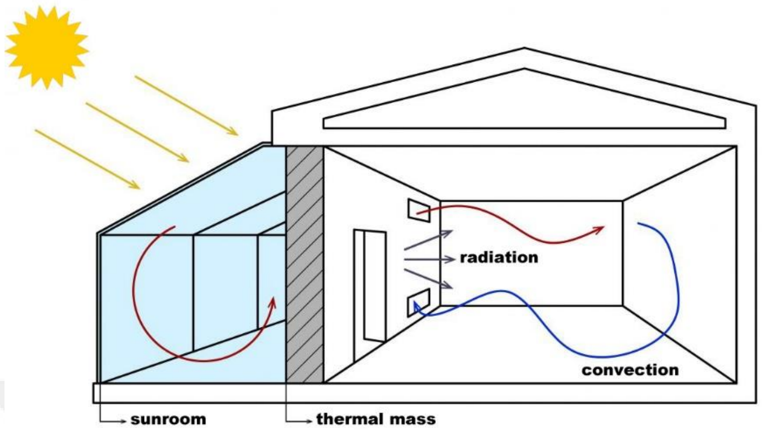


Figure 3.32. Sunroom [URL34]

Roof pond; It is a water filled thermal mass in the roof which is used as heating in winter and as cooling in summer months. The top cover must be well insulated. There is a cover with insulation material on the top that can be opened during the day in winter, be closed at night, it can be closed during the day in summer, be opened at night.

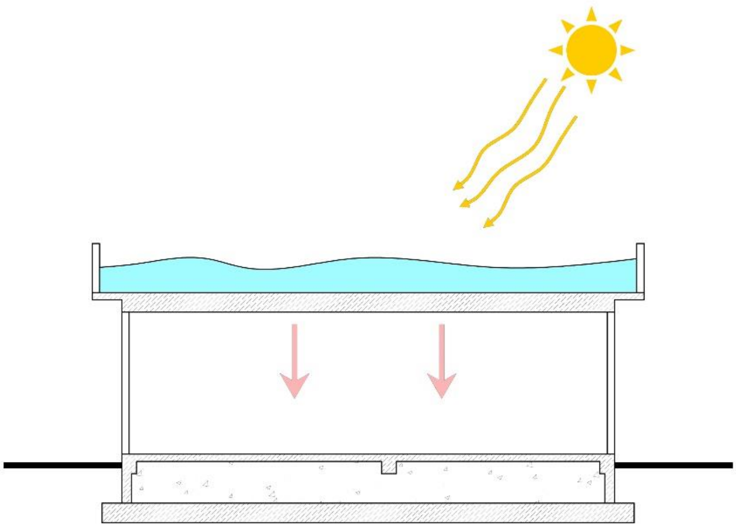


Figure 3.33. Roof Pond [URL35]

Thermosiphon system; The sun rays consist of a thermal mass system located outside the building to be conveyed to the place by an collector outside the space. In the need of heat, solar collectors collect the sun rays and transform them into heat energy. The energy stored in the thermal mass area spreads into the space.

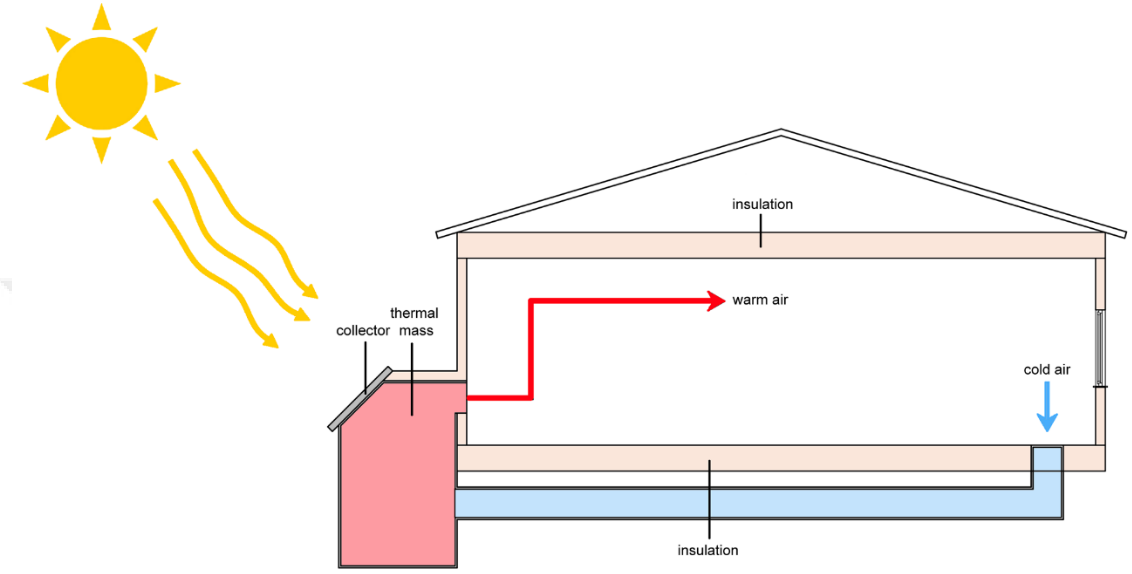


Figure 3.34. Thermosiphon System [URL36]

3.2.2. Active systems

Active solar systems are the total of various mechanical and electronic systems used to convert solar energy into desired form of energy. (Yüksek,İ., Esin, T., 2009) It is used for heating, cooling, and electricity generation purposes. The use of active solar energy in architecture is in two ways.

- Solar Collectors (Solar Heating Systems)
- Photovoltaic batteries (systems generating electricity)

3.2.2.1. Solar collectors

Solar collectors are the systems used for heating and water heating of solar energy from solar radiation in buildings. The solar collectors consist of a double glass top surface, a space left over the absorbent layer with glass, a metal or an absorbent layer, an insulating layer at the back and sides, and the enclosure enclosing all these sections.(Yüksek, İ., Esin, T., 2009) The solar radiation coming to the glass surface of the collector is taken on the absorbent surface side and the liquid in the pipes connected to the absorbent surface is heated and the heated water is transferred to the water tanks by means of the pump and the water of the building is heated. In addition, hot water can be transferred to thermal generators of air conditioners. The solar collectors can be applied to the building, the roof, the wall, and the floor at a lower level.

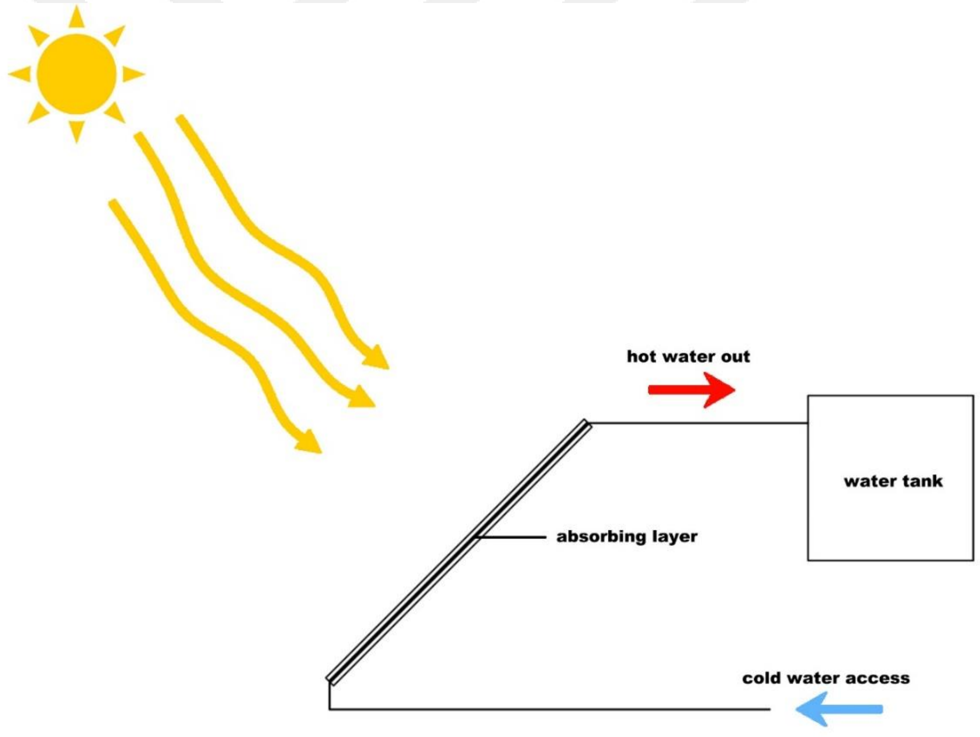


Figure 3.35. Working principles of solar collectors [URL37]

3.2.2.2. Photovoltaic batteries (solar cells)

Photovoltaic batteries are semiconductor systems that convert incoming sunlight directly into electrical energy. It provides the electricity needed by many systems especially for heating and lighting in buildings. However, they don't have storage property of the obtained energy. There are batteries to store unused energy to be used in cloudy weathers and nighttime.

In the modern sense, the first solar cells began to be used as a power source in 1954 to supply electricity to the satellite receivers. Later, due to the development in technology, industrialization, and increasing demands, in street lamps, in watches, in calculators and on building surfaces their use has become widespread since the 1970s. (Moral U., 2006)

Main components of photovoltaic system;

- Photovoltaic modules
- Inverters
- Batteries
- Charge control units
- are other system components.

The production of photovoltaic current is provided by square, rectangular, or circular shaped solar cells made of specially machined semiconductor materials. (Çelebi,G.,2002)

Photovoltaic modules; Photovoltaic cells are formed by parallel, serial, or mixed connection. These cells are produced from semiconductor materials that are suitable for this transformation. The cells consist of two layers of electrical energy, one of which is positively charged and the other consists of two negatively charged layers. When the sunlight falls on the cell, some photons that carry the light energy are passed through this semiconductor material.(Eke, R., Oktik, Ş., 2000)

Transducers; They are the units that convert the direct current energy produced by PV cells into the alternative energy flow.

Batteries; Pv is the units in which the electrical energy produced by the cells is stored when it is not used.

Charge control units; These are units used to prevent excessive energy loading and discharge during the transmission of electricity generated by PV cells to the battery.

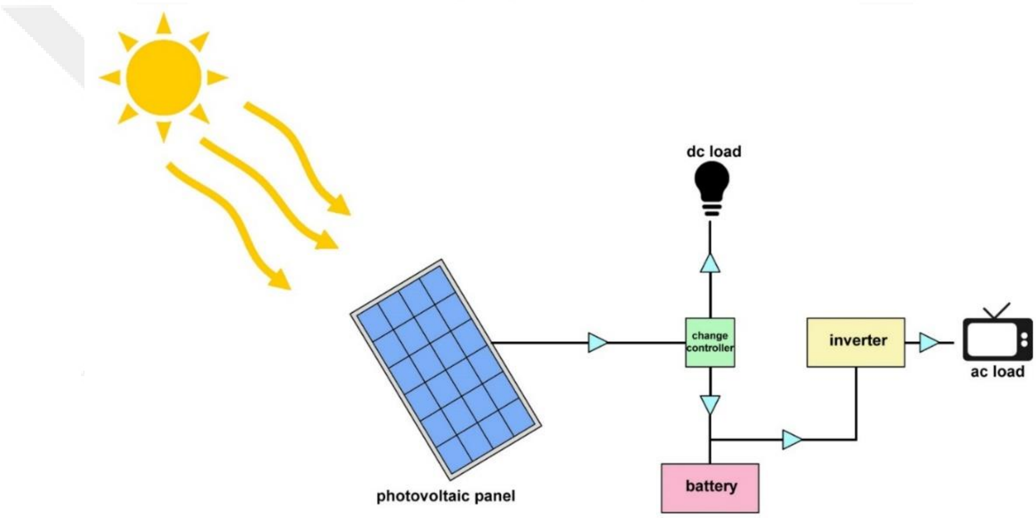


Figure 3.36. Components of photovoltaic system [URL38]

Table 3.6. Advantages of photovoltaic systems

Advantages of photovoltaic systems;
-Admissable transformation efficiencies
-Integration on the apartments without damaging it visually
-Modularity and statistical characteristics
-High strength and long working life
-Low service costs

3.2.2.3. Use of photovoltaic panels in buildings

The use of photovoltaic panels in buildings must be considered as an inseparable whole from the building during the design phase, and must be integrated into the building. The use of photovoltaic panels, which are in the form of a later addition to the roof of the building existing in the first time, have started to be used in the vertical walls of the buildings by understanding the importance of the sun as an alternative energy source. The options to use photovoltaic composite systems in buildings are;

- Vertical or inclined curtain walls
- Facade systems
- Fixed or shading elements
- Mounting on inclined and flat roofs
- Roof lighting systems (with translucent PVs)
- Can be used with building elements such as eaves and parapet. (Keleş, 2008)

Photovoltaic cells can be used in a modular basis as ready-made elements in panel-shaped frames or as laminated between two glass layers in curtain wall systems prepared according to the architect's design, or in the form of shingle or mounted on thin metal plate roofing material. Photovoltaic panels are preferred because they do not leave any harmful waste to the environment and use direct sunlight. (Çelebi, 2002)

Figure 3.37. The use of photovoltaic panels in buildings [URL39,40]

Table 3.7. Incentives applied by countries for solar energy

country	regulations	encouragement
Germany	The Renewable Energy Resources Law (Erneuerbare Energien Gesetz, EEG) issued in 1991 made the purchase of the electricity generated from renewable energy sources obligatory. In Germany, incentives such as fixed price guarantee, investment incentives, and tax exemption are applied.	As of 2009, the mains supply tariffs applied for the photovoltaic systems are as follows: • Systems less than 30 kWp: 0.3194 Euro/kWh for solar PV systems installed on the ground; 0.4301 Euro/kWh for solar PV systems installed in buildings • Systems between 30-100 kWp: 0.3194 Euro/kWh for solar PV systems installed on the ground; 0.4091 Euro/kWh for solar PV systems installed in buildings
France		As of 2009, according to the Incentive Law for Renewable Energy Resources, mains supply tariffs are as follows: • 0.32223 Euro/kWh for the systems installed on the ground on the French mainland; 0.42 Euro/kWh on the islands such as Corsica • 0.60176 Euro/kWh for roof-mounted or building-integrated systems throughout France
UK	Including incentives such as quota, green certificate practices, and tax advantage, Renewables Obligation was put into practice in 2002 in England.	As of 2006, the situation in renewable energy incentives is as follows: The funding mechanism, also known as the Energy Saving Trust, provides £2,000 per kW in the installation of solar energy systems. The maximum incentive amount is £2500 and does not exceed 50% of the total installation costs.
Spain	Since 2008, the legal framework has been determined by the legal regulation of renewable energy sources, also known as Real Decrato (Royal Decree), which was renewed in 2008.	In the systems installed in buildings: • For systems less than 20 kWp: 0.34 Euro/kWh • For systems more than 20 kWp: 0.32 Euro/kWh • For systems installed on the ground: 0.32 Euro/kWh
Greece	Incentive Law for Renewable Energy Resources	There are renewable energy resource financing systems covering 40% of investment incentives and tax cuts in Greece
Turkey	In Turkey, the law related to the incentives planned to be given to solar energy investments was prepared in 2005. Afterward, the energy efficiency regulations in buildings were also issued and the regulation for efficient use of energy in buildings was introduced.	Turkey plans to provide 28 Euro cents per kWh of electricity obtained as a result of the electricity production from solar energy investment activities in the first 10 years and 22 Euro cents in the next 10 years. Although the law has been prepared, it has not been put into practice yet.

3.3. Wind Energy

It is important to know the types of wind formation and in which regions it is effective to obtain maximum efficiency from wind energy. Firstly, wind formation and its types are mentioned.

Wind formation and Types: The source of the wind is the sun. Wind energy is an indirect form of solar energy. 1-2% of the sun rays are transformed into wind energy. The wind is the result of the interaction of the low and high pressure of each region of the earth since every part of the earth does not heat up evenly resulting in the.

Atmospheric pressure and temperature changes of air.

- Rising and descending air currents
- Horizontal air currents

It leads to movement in two ways. In addition to these currents, irregular distribution of the oceans and continents, irregular terrain, daily temperature changes, and seasonal changes also affect the weather events, causing the formation of wind. (Şen, Ç., 2003)

Meteorological aspects of wind formation;

- Places where pressure gradient (change in two points) is high
- High, uneven hill, and valleys
- Coastlines
- The mountain range, where the canal effects occur, are valleys and hills. (Durak, M., Özer, S.,2008)

Topography data is very important in the formation of winds. For example, hills, ridges, cascading land structure, grooves, valleys have an additional effect on the wind.

Wind is divided into four parts: continuous, seasonal, local and tropical winds.

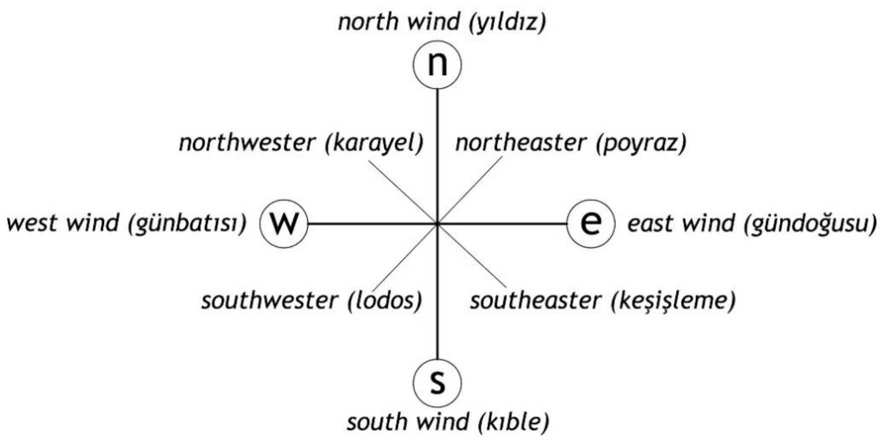


Figure 3.38. Main winds in Turkey (Akman, Y.,1999)

Wind energy is an increasingly updated and rapidly expanding energy source. The world energy reserve is decreasing day by day. As countries became aware of the problems related with fossil fuel, nuclear power, and wasteful use of energy, they started to move towards more efficient technologies and energy production in the natural environment.

As a result of their past experiences, industrialized countries have focused on taking measures to ensure the effectiveness of energy production and use and to support the use of renewable energy technologies.(Yerebakan,M., 2001)

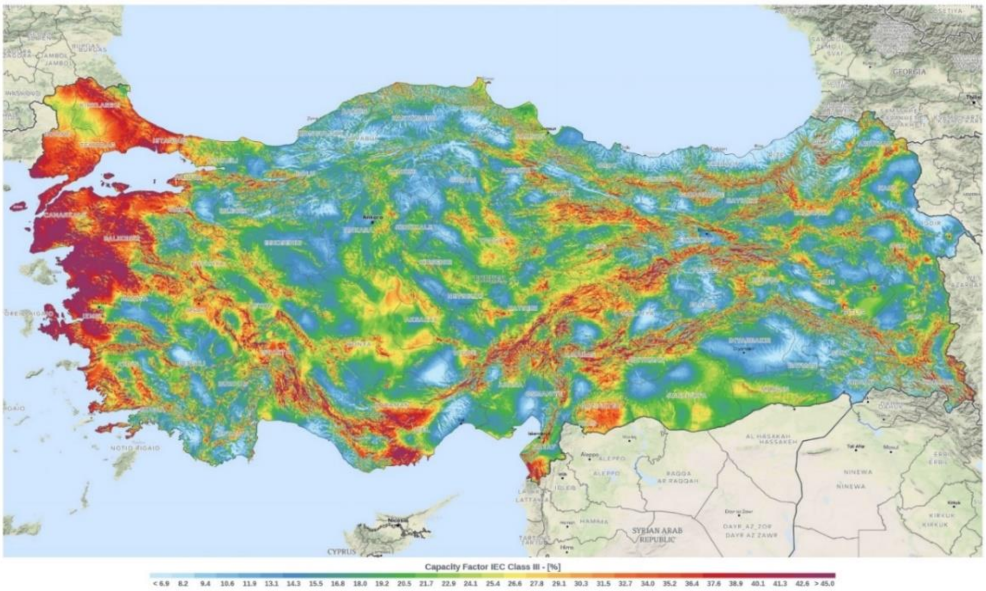


Figure 3.39. Turkey’s wind map [URL41]

Mechanical and electrical energy generation, inexhaustible wind energy developed and commercial is a favorable source of renewable energy. Significant wind energy benefits;

- Be renewable
- Not resulting pollution
- Cheap
- Increasing the size of the business

- Can be installed anywhere
- Increasing compatibility of major manufacturers with subsidiary industry terms
- An alternative to fossil fuels
- Never ending
- Environmentally friendly
- Does not adversely affect agricultural activity
- Protecting ecological balance
- Low investment and relocation costs. (Yerebakan,M., 2001)

Figure 3.40. Life of fossil energy sources [URL42]

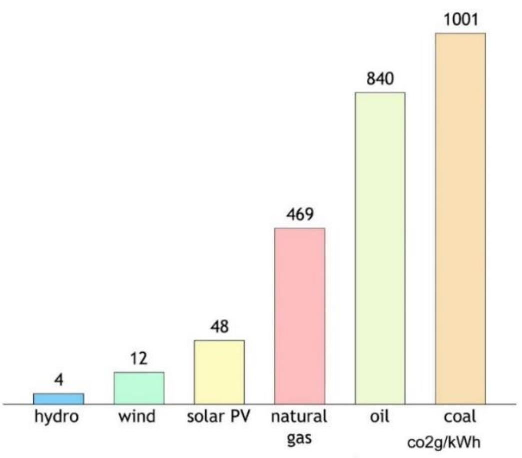


Figure 3.41. The carbon emission of electric generation [URL43]

3.3.1. Utilization of wind energy in buildings

Nowadays, the use of wind power, which are generally used in wind power plants, is increasing day by day to produce energy in buildings. Most of the developed countries reflect on the project by paying attention to building-wind relations.

Wind energy is used in two ways in architecture. In the buildings, wind energy systems are examined in two groups as passive and active systems.

3.3.2. Passive wind systems

The character of the air flow around the building creates pressure differences around the structure. Regular air currents in parallel fibers have a positive or feed effect on the wind open surfaces of buildings, or negative or suction force on the back, side and wind under back surfaces. (Ok, 2008)

Positive and negative pressure on buildings are effective in the design parameters used in the cooling and ventilation of buildings. The main strategy in the passive utilization of wind energy is to provide natural ventilation in buildings.

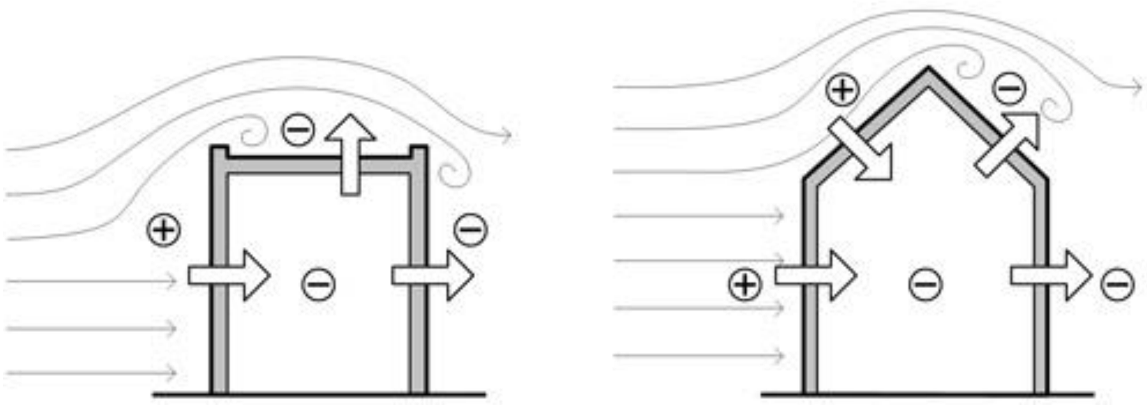


Figure 3.42. Wind pressure effects on buildings [URL44]

Clean air used in a closed place to replace the dirty air used; that being said, replacement of low quality air containing pollutants with high quality, non-polluting air is called ventilation. (Balanlı,2007) Natural ventilation is defined as taking atmospheric air into the building without using mechanical systems and removing the used air from the structure.(Durak, M., Özer, P. 2008)

In order to provide ventilation, there must be an air flow through the space. Air pressure, the obstacles in the space, the speed of the air flow and the path in the space are the factors that determine the quality of the ventilation. (Darçın, P.,2008)

Temperature difference between the indoor and outdoor environment causes density difference, thus, a pressure difference occurs which causes airflow.(Öztürk, H. et al.,2005) Used air is contaminated and becomes hot. The warming air expands, heats up, and rises. Rising air goes up from the top of the building. Cold air enters the building from the bottom of the building. Thus, the interior is ventilated. In the design phase of the building natural ventilation is not given the necessary importance mechanical systems for ventilation of the building will be utilized. This will increase the cost and energy consumption. In buildingsNatural ventilation is provided by various methods. These methods,

- Structure location and orientation
- Design of the building form
- Using windows and doors
- Using wind chimneys, wind shovels
- Designing atriums by creating mutual wall openings

Building Location and Routing: In the interaction structure with the wind, location between building groups, and the angle between the direction of the wind are important.(Akyel, D., 2007)

In addition to natural factors such as land use, topography, and wind speed in an urban area, the speed of the wind is affected by the geometry and dimensions of the structures, the height of the building, the differences between the height of the building (artificial unevenness), spaces between buildings (street, street), street geometry, and trees, in short, urban landscape. [URL45] Dense housing in the city reduces the speed of the wind. In addition, the construction of high buildings in the cities is increasing day by day, have a significant impact on the change of wind speed and direction with their heights.

The wind, which hits a high structure, is directed downwards in the direction of flow and causes undesirable wind circulation and speed increase in the vicinity of the surface. In the rear part of the high structure, wind speed decreases. As the building height increases, the effect area of the wind motion on the rear expands, the wind speed is further reduced. This also increases the quiet area take place at the rear.(Kural, M., 2007) The high-rise buildings in the city prevent fresh air from entering the city and the city's ventilation.

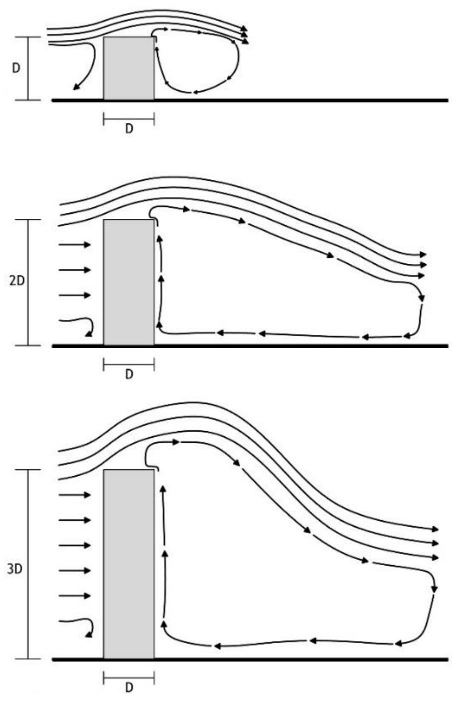


Figure 3.43. Construction height and effect area at the rear (Ok, V., 1997)

In addition to the height of the structures in the city, the wind movement is also affected the distance between structures. When there is a gap between two buildings next to each other, because the structures block the wind, the air is squeezed from the unobstructed section and passes rapidly and excessive wind speeds occur. This event is called funneling. It is important to locate structures at appropriate intervals to prevent funneling.

In the positioning of the structures, the angle of the wind to the building walls is also important. When the wind blows perpendicular to the building wall, the pressure is highest. At a 45-degree angle, the resulting pressure is minimal, but the resulting wind shade is higher.

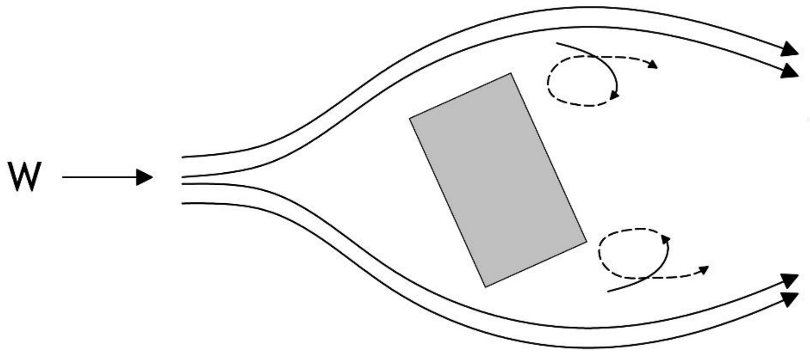


Figure 3.44. A rectangular structure with a wind angle of 45 degrees

In the case of air movement and formed wind shade. Where wind is not desired (in cold and hot-dry climatic zones), the structures must be placed in the shadow of each other or adjacent and dense. Structures where winds are to be desired (in hot humid and mild humid climates); the structures should be placed in such a way that they will make the smallest wind shadow and not in the shadow of each other. (Özdeniz, M., 1979)

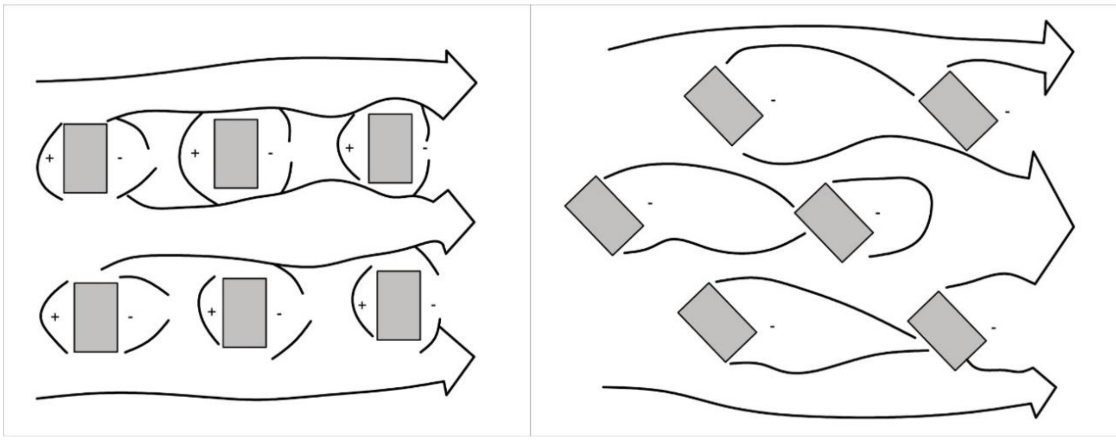


Figure 3.45. Protection with shade formed in the layout of the building groups [URL46]

One of the most important criteria for the passive utilization of wind energy in buildings is, especially in hot and humid climates settlements, positioning the long structure of the structure and the shell of the gaps in the direction of the dominant direction of the wind.

Design of building form; Depending on the form of the building shell that covers the living areas and separates it from the outside environment, the ventilation of the interiors varies. The structure form is also important since the air currents change in direction and intensity according to the shapes of the three dimensional objects they meet. Rectangular and L structured wind movements differ (see figure 3.46.)

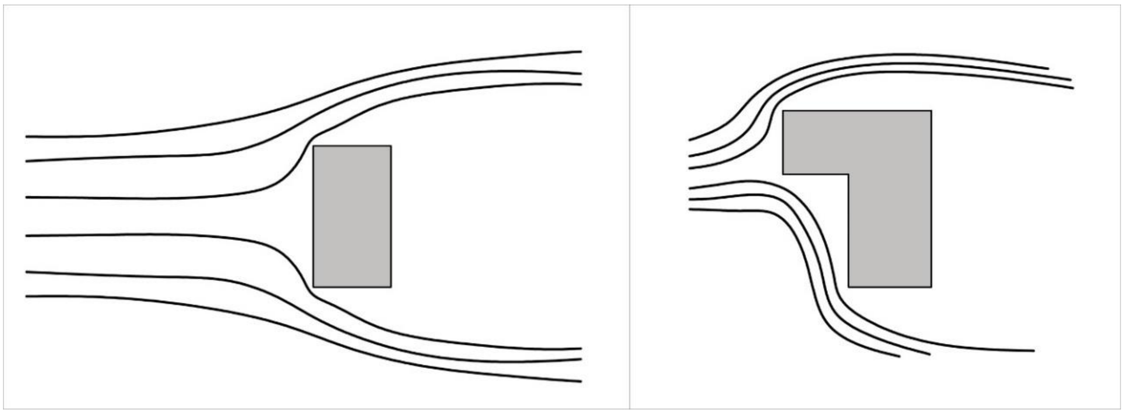


Figure 3.46. Wind movements in rectangular and l shaped buildings (Olgyay, 1992)

The form of the structure must be in accordance with the characteristics of the climate zone in which it is located. Indoor and courtyard buildings, For example, to obtain shady and cool living areas in the hot-dry climate zone, to obtain the long facade that allows cross ventilation in hot-humid climatic zones, to minimize the heat loss in cold climatic zones, thin structures, directed towards to the dominant wind direction compact structures are built. More wind in buildings can be provided with building elements other than the form of the building. As the wind speed increases as the height of the building rise, more wind uptake can be achieved by raising structures on the column. This method is generally applied in hot climatic zones. Also in high-rise buildings to reduce the burden on the building of the wind in the design phase precautions should be taken. Examine the effect of building form on wind energy The best method used is the wind tunnel test. Under the influence of weather aerodynamic forces and moments on high buildings experiments determine the shape of the design. Thinning of the building form as it rises, giving a sculptural look at the top of the building, created in the structure openings change the effect of wind on structures. “If the building form is limited only by the rectangular prism, this form is exposed to the lateral wind effect. Cylinder, ellipse, triangle, and other forms of structure have less lateral force than the structures of rectangular prism. (Ali, M., Armstrong, P., 1995)

Wind pressure acting on structures in cylindrical (elliptical) or elliptical form decreases by 20-40% compared to the rectangular prism of the design load. (Schueller, 1977) In addition, the openings on the building facade, especially close to the roof, are the aerodynamic response of the structure, which reduces the negative effects of the wind load on the structure.

(see Figure 3.47.)

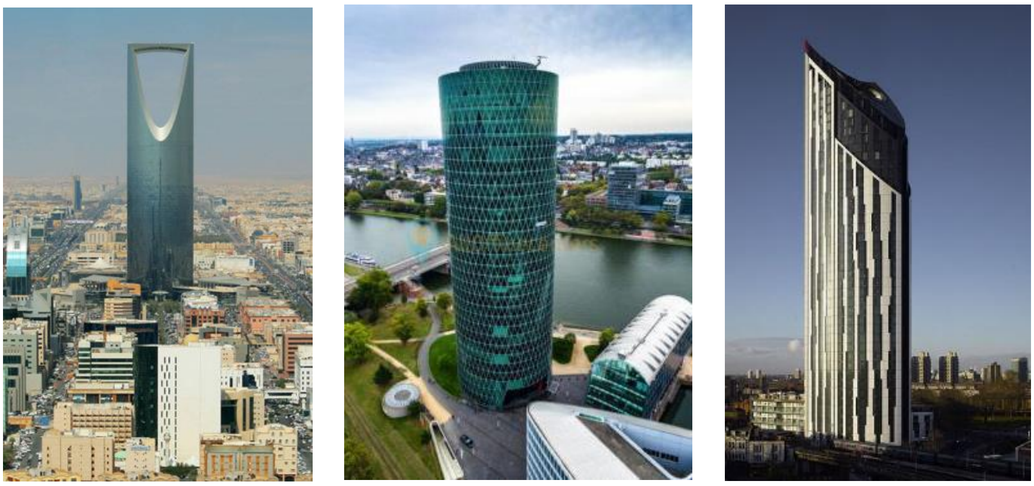


Figure 3.47. Kingdom Center[URL47] Westhafen Tower[URL48] Strata SE1[URL49]

Windows; Introduction to the building and output gaps air circulation inside the building It provides. Entering to the building emptied from the air outlet cavities taken from the cavities. The dimensions, forms, and positions of the openings created in the design phase of the buildings in providing natural ventilation in the building is important. The windows used in buildings are structural elements used for natural ventilation. Through airflow from windows the internal temperature changes and the internal air is removed. The opening of the window frame, its position in the wall, its shape, and its size change the quality of the air taken in. Providing natural ventilation in places for window openings. The most appropriate sequence from the opening to the unsuitable angles are shown. The vent sash type windows used above and below the window opening allow the fresh air coming from the interior to get out of the lower window, while the heated air is thrown out of the upper glass. Continuous air circulation provided indoor. For this reason, it is a window type which is more suitable for ventilation of the interior environment than other window types. (see Figure 3.48.)

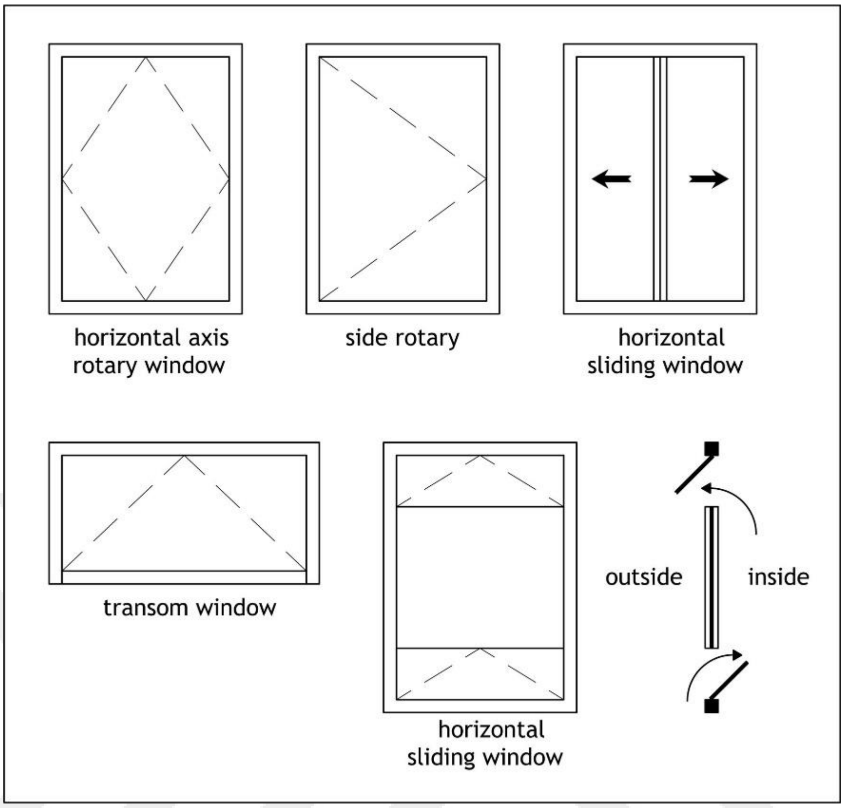


Figure 3.48. Window types

Roof windows; Exterior of rising air in the indoor space disposal the principle of natural ventilation It provides. Roof on these windows slope Placing it in parallel or upright position is important. Roof parallelto slope windows placed outside outdoor air directly taken inside as they provide more ventilation than windows placed upright.

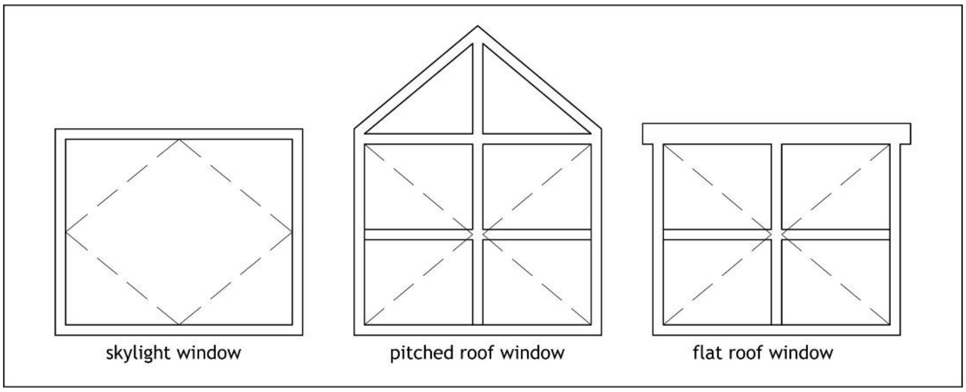


Figure 3.49. Roof window types

Double glass applications; Double layer used in buildings It is an effective method for providing natural ventilation in facade applications. Especially in high-rise buildings due to the high wind pressure in buildings double glazing application choice windows are provided for natural ventilation gains openable feature.

Double layer In the curtain wall systems, the air taken from the lower part of the facade into the space becomes hot and rises. Air heated in space, temperature in cold season losses It works as a preventive thermal buffer zone. If desired, the heated air can be introduced into the space by mechanical means. In hot seasons, the air heated in the air space must be vented through the ventilation ducts. Double layer curtain wall systems according to the way of ventilation;

- Floor height with ventilation duct double layer systems,
- Building height with ventilation duct double layer systems,
- Shaft cladding facade systems can be divided into three groups.

(Begeç, H., Savaşır, K. 2004)

Floor height with ventilation duct double layer In systems, the air is taken from the opening in the lower part of the facade into the air gap, the heated air is the same. Floor outlet channel out with expurged. (1) (see Figure 3.50)

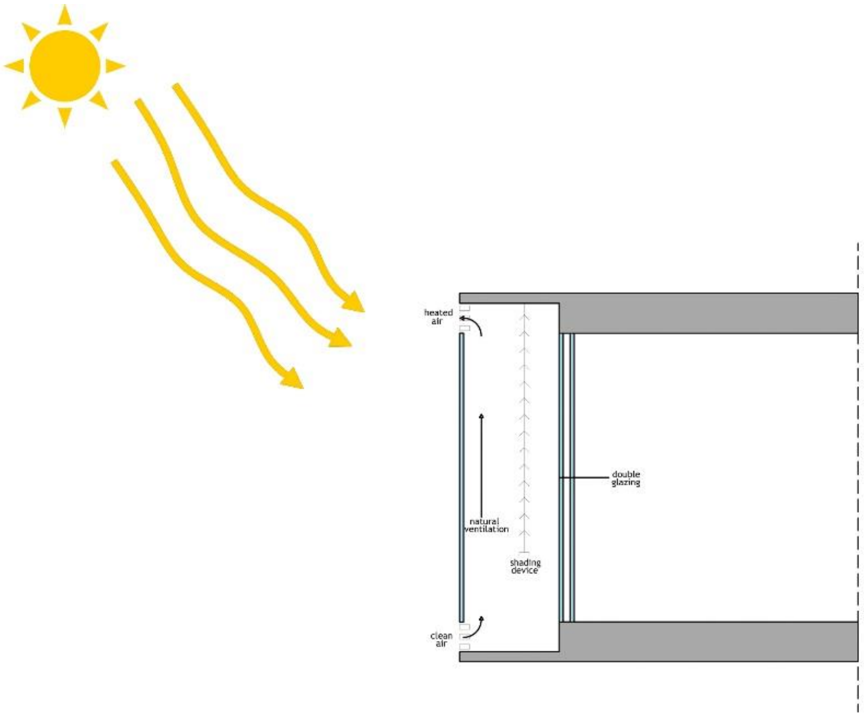


Figure 3.50. Double skin facade [URL50]

In double-layered systems with ventilation ducts at the building's height, the air entering from the lower part of the facade is warmed up and thrown out from the air outlet opening at the upmost of the facade. (2) (see Figure 3.51.)

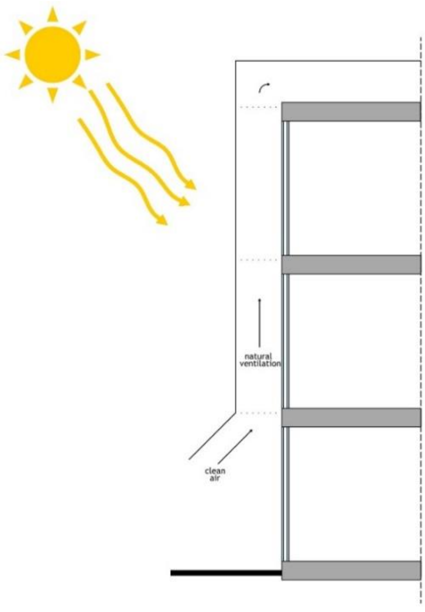


Figure 3.51. Multi storey type [URL50]

Shaft cladding facade systems are "the systems which are formed by the concomitant use of the double-layer systems with ventilation ducts at the storey height with the double-layer systems with ventilation ducts at the building height. The building has an air gap (shaft) that is continuous in the vertical along the facade height.

The transfer of the heated air to the shafts is achieved by means of the horizontal openings between the two facade layers. (Begeç and Savaşır, 2004) The shaft causes the heated air to be thrown out. Each floor has air intake, but the air release is only provided through the opening on the shaft. (3) (see Figure 3.52.)

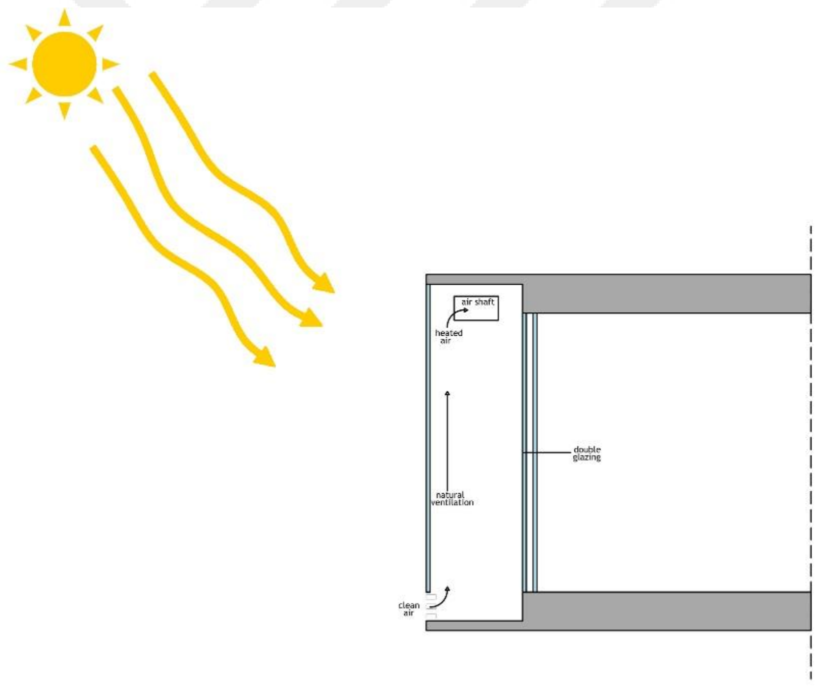


Figure 3.52. Shaft-box type [URL50]

Doors; Doors are other building elements used to provide natural ventilation in buildings. By means of the doors, the air taken from the building shell into the interior reaches to the places with no connection to the external facade. (Balanlı, 2007)

Windcatchers; The ventilation of the interior is very important in ensuring healthy and comfortable living conditions. Windcatcher is the mechanisms which can be used in all kinds of buildings. The blowing wind is accelerated as it passes through a funnel-like machinery. The entrance of this blow to the interior as clean and cool air is provided by windcatcher in the vertical direction (see Figure 3.53.)

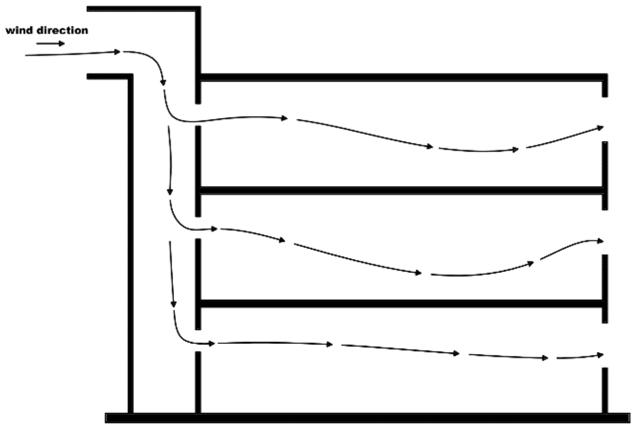


Figure 3.53. Working principle of windcatcher [URL51]

Wind chimneys are the elements used for indoor air conditioning. They provide natural ventilation of the interior. Wind chimneys work in two ways:

1. Air circulation between high and low pressure zones
2. Temperature difference between indoor and outdoor (Ali and Özer, 2011)

The working principle of the wind chimney is based on the principle that the heated warm air rises and is thrown out of the chimney. Because of the resulting pressure difference, air circulation is enabled inside. (see Figure 3.54.)

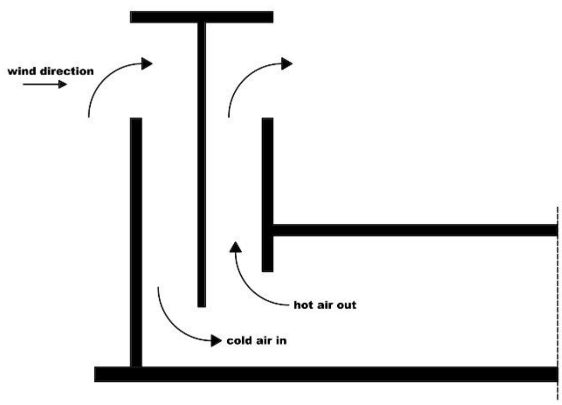


Figure 3.54. Working principle of windcatcher [URL51]

In the daytime, the southern side of the chimney warms up and throws out the air inside it, the cool air enters into interior from the northern openings. In the night, by the setting of the sun, the air cools, while the heated air from the interior is being thrown out, the air circulation in the interior is provided through the chimney. (Ali and Özer, 2011).

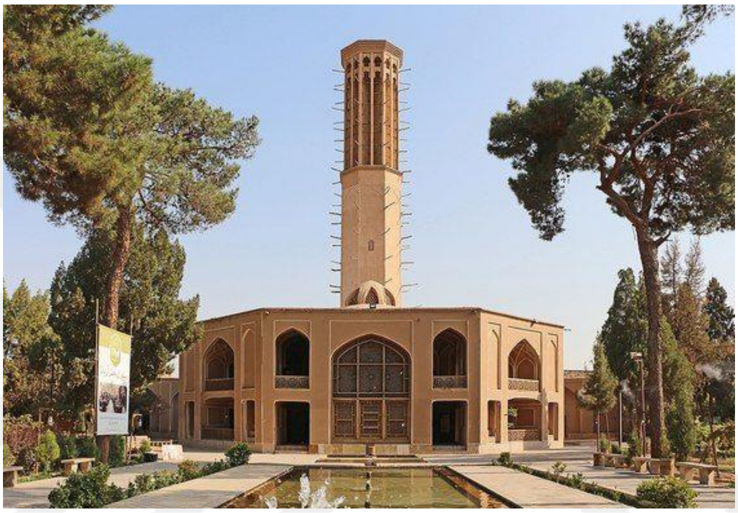


Figure 3.55. Dolat abad windcatchcer Yazd, Iran [URL52]

Atrium; In buildings with atrium, the cold air taken inside the building provides circulation in the place through the reciprocally opened wall gaps, while the heated air is taken into the atrium. The air that expands and rises in the atrium is thrown out of the building from this natural circulation tower. (see Figure 3.56.)

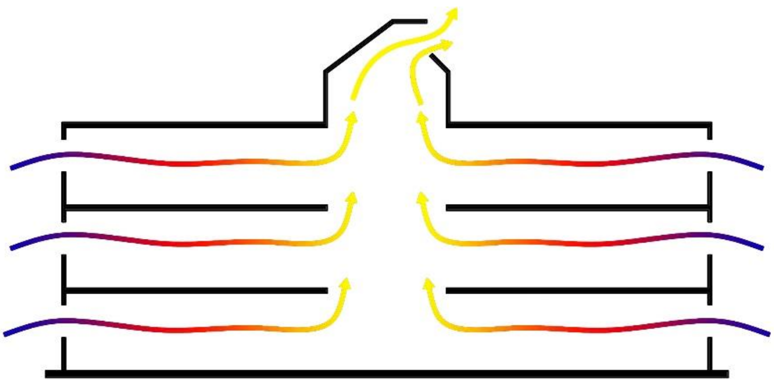


Figure 3.56. Atrium [URL53]

3.3.3. Active wind systems

The process of producing electrical energy and water pumping from the air flow which is free in nature is carried out with the active system. In order to take advantage of the active system, wind turbines are used.

3.3.3.1. Wind turbines

Wind power is known to be used in the oldest settlements such as Mesopotamia since 2000's B.C.(Uyar,1997) The wind was used in windmills, sailboats and water pumping systems. The first examples of windmills were used in China. This technology used in the years of AD 640s in Iran transferred to Turkey and then to Europe by means of wars. In the 18th century the Dutch technician Adrew Meikle and in 1772 Captain Stephen Hooper made the first examples of wind turbines (Anon, 1984) Nowadays, electrical energy is commonly produced with wind turbines.

The first facility which produce electricity by means of turbines was established in 1891 in Denmark. With the oil crisis between 1973-1979, the use of wind energy has started to increase. During this period, many state-funded research and development programs were initiated. Over time, the private sector has emerged at a slow pace. The first major commercial market emerged in California between the years of 1980-1986 and helped the international wind energy industry develop.Yerebakan, 2001) Germany, India, UK, Netherlands, Spain and Sweden have become important names in this sector since 1990s.(Günel, Ilgın and Sorguç, 2007)

Figure 3.57. Windmill (Durak ve Özer,2008) URL[54]

Due to energy requirements and increased environmental awareness, wind turbines have been mass-produced and wind energy power plants have been established. The development of modern wind turbines is rapidly increasing. With the development of propeller diameters and turbine dimensions, wind power is increased and more energy is produced.

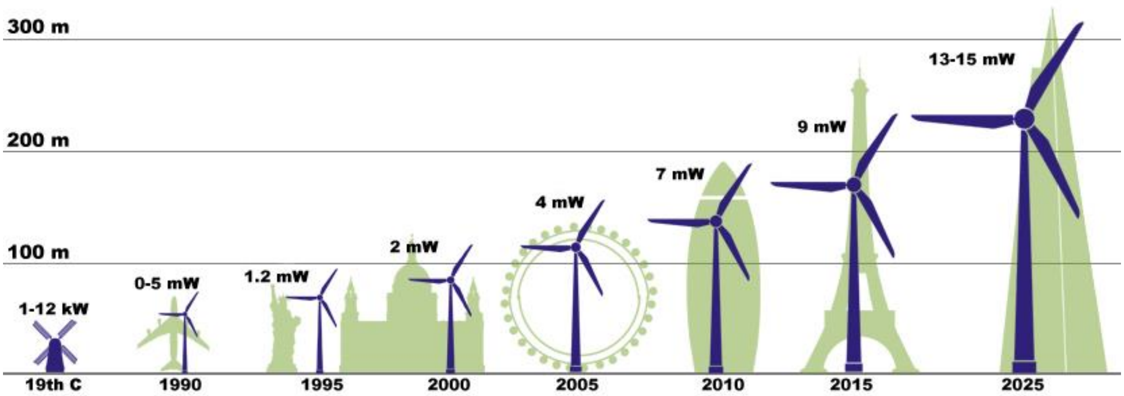


Figure 3.58. Development of wind turbines by years [URL55]

In developed countries, one of the most important reasons for the proliferation of the energy production by using wind turbines instead of power plants using traditional energy sources is that the turbines produce clean energy. "It is seen that the wind turbine with 1.5 MW installed power, generating 80 million kWh of clean energy during its 20 years of economic life is equal to the energy generated by 9000 tons of brown coal." (Durak and Özer, 2008)

The development of wind turbines in Turkey is in a low level. The first wind turbine in Turkey was founded in 1998 in the Çeşme, Germiyan region. Alize Çeşme power station has a power of 17.4 MW. While its share in electricity consumption in Turkey in 2000 is about 0.5%, it is estimated to be about 3.35% in 2025. (Öztürk, 2013).

Table 3.8. Installed wind power capacity by countries

Installed wind power capacity (mW)			
country	Established end of 2007	Established in 2008	Established end of 2008
Germany	22,247	1,665	23,903
Spain	15,145	1,609	16,754
Italy	2,726	1,010	3,736
France	2,454	950	3,404
UK	2,406	836	3,241
Denmark	3,125	77	3,180
Greece	871	114	985
Turkey	147	286	433

3.3.3.2. Wind turbine elements

The system of the active use of wind energy is the wind turbines. Wind turbines are the systems that convert the kinetic energy of the wind into electric and motion energy. The rotational movement of the rotor shaft is transferred to the generator on the body. Electrical energy generated from the generator is used directly or transferred to the batteries and stored. Wind turbines consist of the tower, the generator, the wings, the rotor and the power shaft. The electrical energy produced can be transferred to the networks.

Tower: It is the pole, generally as pipe-sectioned, which enables the turbine to be placed on the top plane.

Generator: The systems that convert mechanical energy into electrical energy.

Blades: After receiving the wind, they transmit this power to the motor hub.

Turbines consist of one, two or three blades with fixed or variable angles. In blades, the glass fiber reinforced with polyester or wood-epoxy and other composite materials are used, as ingredients. (Günel, Ilgın and Sorguç,2007)

Rotor: It turns the kinetic energy of the wind into mechanical energy.

Low speed shaft: It is defined as the shaft which makes approximately 30 to 60 revolutions per minute to which the blades are connected.Günel, Ilgın and Sorguç, 2007)

High speed shaft: The shaft that drives the generator. (Günel, Ilgın and Sorguç,2007)

Gearbox: It transfers the low speed rotation load from the propeller to the generator as high-speed rotation.

Wind turbines catch wind energy by means of two or three blades placed on a head. The blades act like an airplane wing, the low-pressure air pushes the blades upward and since the force is much more than the power generated by the oncoming wind, the blades begin to rotate like a propeller by means of the product of these two forces, and the kinetic energy is converted into electrical energy." (Bozdoğan, 2003)

Wind turbines can be divided into two groups as horizontal and vertical axis wind turbines.

Horizontal axis wind turbines;

Turbines whose rotors are running in the direction of wind flow on the horizontal axis are horizontal axis turbines. They are commercially more preferred than vertical wind turbines. These turbines are divided into two according to the wind direction as upwind and downwind turbines. The upwind turbines, which are not affected by the shading formed by the tower, have been widely used for years. In these turbines, a mechanism called yaw is used to rotate the rotor against the wind, and the blades must be made of a very hard material. In the downwind turbines, there is no need for the yaw system and the blades are flexible and light. Its disadvantage is the power fluctuations that occur when the blades pass through the tower." (Günel, Ilgın and Sorguç, 2007)

Vertical axis wind turbines;

They are the wind turbines whose blades operate on the vertical axis and that can take the wind from all directions. Since the turbine is not placed on the tower, the advantage of vertical axis wind turbines is that they do not need a rudder to turn to the tower and the direction of the wind. However, their yield is quite low compared to the horizontal axis wind turbine. They are usually produced for experimental purposes.

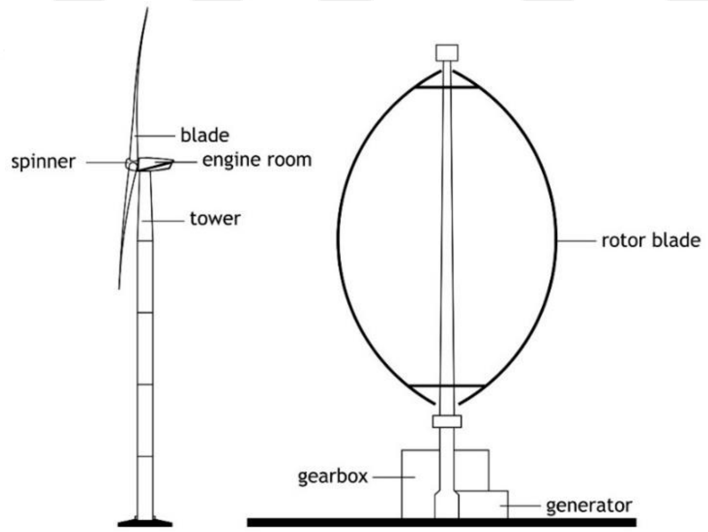


Figure 3.59. Horizontal and vertical axis wind turbines URL [56]

Table 3.9. Comparison of horizontal and vertical axis wind turbines

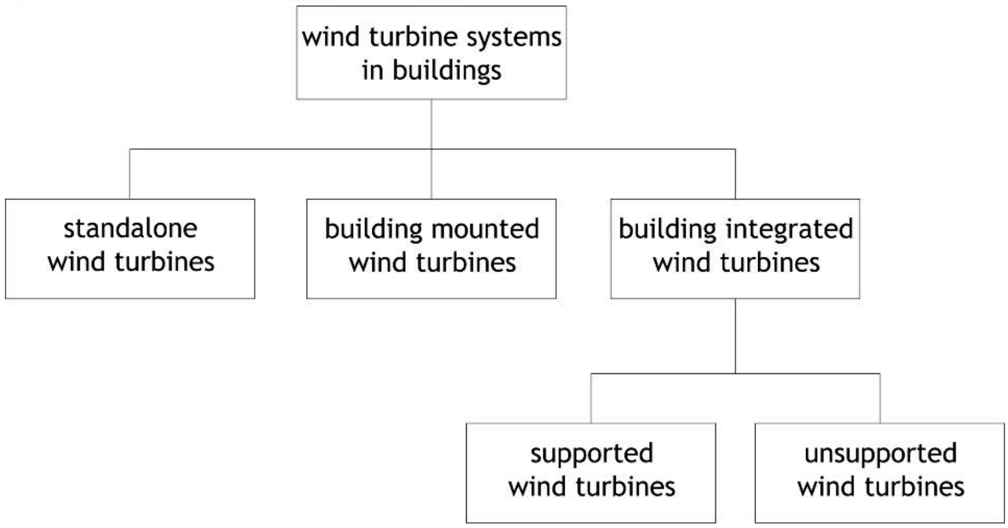
horizontal axis wind turbines	vertical axis wind turbines
main rotor shaft in the horizontal direction	main rotor shaft in vertical direction
small generators are pointed into the wind by a simple wind vane	operates with wind from any direction
requires a relatively high wind speed	designed for low wind speed
operates at a high RPM	operates at a low RPM
higher vibration levels	lower Vibration levels
high noise levels	low noise levels

3.3.3.3. Wind turbine use in buildings

The rapid depletion of resources and the consumption of a large part of the energy in the construction sector have led to the development of new technologies regarding the use of energy in buildings. Wind energy, as one of the fastest growing and cheapest energy sources in the world, which does not cause environmental pollution, is widely used in developed countries with the provision of the necessary technical infrastructure and the national wind energy program. "Nowadays, in the high buildings which are intended to build especially in European countries and the USA, the weight of wind energy efficient designs is increasing."(Günel, Ilgın, Sorguç, 2007) The technological developments in the wind turbines used increased the rate of utilization of wind power. The current situation of turbines has eliminated the disadvantages caused by wind energy in the past years. For example, while the wind turbines in the past years were more noisy, the current wind turbines are quite silent. In order not to cause bird deaths, wind turbines must be established in places away from where birds live or use as the migratory path. The wind turbines that convert the kinetic energy of wind into electric or motion energy produce electricity for buildings or the produced electricity is sold to the public service. The wind turbines are divided into two as on-grid and battery powered.

On-grid systems transfer the generated electrical energy to the main supply. Energy production may not show continuity for the reason that the winds are not regular. Generally, wind turbines with a power of 1-30 kilowatts are classified as battery powered systems. These turbines store the electrical energy they produce by transferring them to the batteries. In cases where the wind does not blow at sufficient speed, energy production is not realized. In this case, it is ensured that the electricity demand is met by storing the electricity produced in the batteries.

Table 3.10. Wind turbine systems in buildings (Günel, Ilgın and Sorguç, 2007)



3.3.3.4. Building Independent Wind Turbines

Building Independent Wind turbines are the turbines which are considered as independent from the buildings in terms of architectural design and structure, and in which the buildings are not effective in changing the wind speed, direction or density. Wind plants and wind farms are examples of this group.Günel, Ilgın and Sorguç, 2007)

Figure 3.60. Soma wind power plant (Capacity: 240 mW) [URL57]

Researches show that the seas are richer than the lands in terms of wind energy potential. The studies on wind energy in the seas started after the world energy crisis in the early 1970s and were included in the scope of the international energy agency program in the early 1980s. For the first time, Sweden realized the offshore wind energy project in 1990. Then Denmark established the Vindeby Offshore Wind Farm offshore of the Lollad Island, and later, the floating wind turbines on the water-gauges were installed in the seas with the studies of countries such as the USA, the Netherlands and the UK. In 59 wind atlas prepared for the European Union, it is stated that the wind speed at 10m height of the Aegean Sea is between 7-8 m/sec and it remains valid up to the other shores of Turkey. In the Irish Sea of the UK, the wind farms which will provide energy to 50,000 housings are seen. (see Figure 3.61.)

Figure 3.61. Wind farm at north atlantic sea (Capacity: 6.800 mW) [URL58]

3.3.3.5. Building-Mounted Wind Turbines

Building-mounted wind turbines are turbines which are mounted to the building at the design stage or later on and which do not need any adaptation to the form of the building and do not use the form to change the wind flow. They usually use buildings as towers. Horizontal and vertical wind turbines can be mounted in building. The wind angle around the building is important for getting the maximum yield from the turbine. The dominant wind direction of that area and the location of the building determine the surface of the turbine to be mounted on the building.

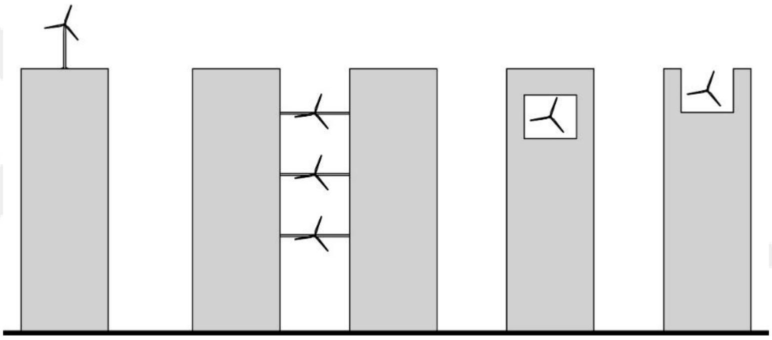


Figure 3.62. Building mounted wind turbine strategies (Günel, Ilgın and Sorguç, 2007)

Figure 3.63. Building mounted wind turbine URL[59,60]

3.3.3.6. Building-Integrated Wind Turbines

Building- integrated wind turbines, which are examined in two classes as building-supported and building-unsupported, are the turbines which are designed for the aims of maximizing the generated energy by means of changing or increasing the wind direction, speed or density by being supported by the form of the building and included in the process during the architectural design. (Günel, Ilgın and Sorguç, 2007) Wind turbines have a great impact on the architectural form and the main purpose in the design of building is to use wind energy.

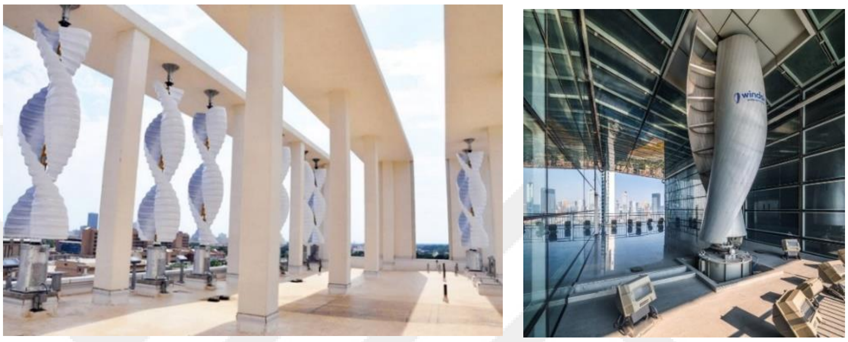


Figure 3.64. Building integrated wind turbine URL [61,62]

Building- integrated wind turbines are divided into two as building-supported wind turbines and building-unsupported wind turbines. Building-supported wind turbines produce energy using the building structure. In Figure 4.39, an example of a building-supported wind turbine is seen. Building-unsupported wind turbines can be defined as turbines which can operate near building and which can potentially use the wind flow caused by the building. (Günel, Ilgın and Sorguç,2007)

Figure 3.65. Building supported wind turbine URL [63]

Bahrain World Trading Center has wind turbines that connect two skyscrapers. It is the first building to produce electricity with wind power.

Table 3.11. Advantages and disadvantages of wind turbines in buildings

Wind turbines in buildings	
Advantages	**Disadvantages**
-Provides the building to be self sufficent on energy	-Because of the turbines there is an extra weight on buildings structural system
-Uses clean energy, helping out lowering the co2 emission	-Turbine designs need to be more durable than the ones used in rural areas
-Energy is consumed where it is produced, therefore it costs less	-Without proper noise isolation, it may possibly disturb the residents
-Contribute the economy of the country	-Turbines need a routine check up
-When the building itself is used as both tower and foundation, extra expenses will be saved up instead	-Designs without precautions may result in deaths of birds
-Visually, they represent an environmental approach and creates a postive effect on public	-If compartments of the turbine were picked without care, as a result the mechanism may cause vibration
-They can produce energy even when the sun is set or in a cloudy day	-Because of the irregularities of the winds, there are observable interruption on production of the energy.

Table 3.12. Incentives applied by countries for wind energy

country	incentive type	encouragement
Denmark	Basic Incentive Mechanisms	Fixed price and the premium guarantee for onshore wind farms; tenders for offshore power plants Wind farms on land: total tariff is around €57/MWh
Germany	Fixed Price Guarantee	Wind farms onshore: €83/MWh for at least 5 years; €52.8/MWh for the remaining 15 years Wind farms at offshore: €91/MWh for at least 12 years, €61.9/ MWh for the remaining 8 years
Spain	Choice between the fixed price guarantee and premium tariff	The premium guarantee system with maximum and minimum price application is implemented. Fixed price tariff: €68.9/MWh for <5 MW and >5 MW Premium Price tariff: €38.4/MWh for <5 MW and >5 MW
UK	Quota obligation, Green certificate practices, Tax exemptions Electricity suppliers have an obligation based on the green certificate. In addition, there are tax exemptions to renewable energy source producers.	
Finland	Tax Exemptions and Investment Subsidies	A mixture of tax exemptions and subsidies. €6.9/MWh tax refund for wind; investment subsidies up to 40%.
Bulgaria	Compulsory purchase price	Prices valid for 12 years for power plants established after 1 January 2006: €79.8 /MWh for effective operating time > 2250 hours/year; €89.5/MWh for effective operating time < 2250 hours/year
Turkey	Fixed promotion price	$7.3 cents/kWh for 10 years for the electrical energy generated from wind energy by licensed and unlicensed enterprises.

In order to ensure the consumption of the electrical energy generated from these sources, there is an obligation for suppliers selling electricity to consumers to purchase the electrical energy generated from wind energy.

As a result of the implementation of support systems, the installed wind power in the world increased from 6100 MW in 1996 to approximately 198 GW at the end of 2010.

3.4. Rainwater Collecting Systems

Although rainwater collection systems are being implemented in many countries of the world today, in our country which is in the category of water-scarce countries, developments related to this subject are not yet sufficient. However, it is known that the solutions such as the precipitation water being collected during the appropriate seasons and used when they are needed were widely applied in our traditional buildings. There are necessarily water wells around historical buildings. In traditional houses, the use of cisterns for collecting rainwater beside the water wells is quite common. However, the application of collecting the rainwater, which has been maintained for centuries in the territory of our country, has lost its presence in today's buildings in parallel with the developing technology and living conditions. The problem of drought frequently encountered by the world and our country in recent years makes it inevitable to bring forward these traditional practices in our buildings again.

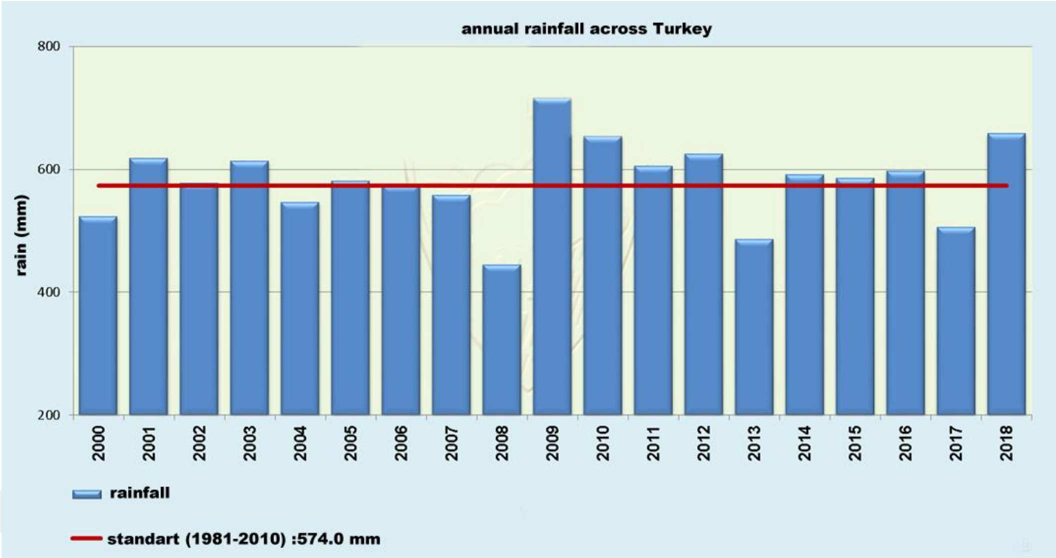


Figure 3.66. Annual rainfall across Turkey 2000-2018 URL [64]

With small additions to modern equipment and machinery, the use of mains water will reduce, the installation for this will be minimized, and it will be ensured that the water requirements are met on demand. Re-dissemination of rainwater collection systems in our country requires firstly rising the awareness of the employees working in the building sector and sufficiently introducing the importance and benefits of these applications. Nowadays, the use of potable mains water for the requirement for irrigation water is an important loss in terms of both environmental and economic aspects. Thus, although in some public housing areas, there are attempts to recycle and reuse the wastewater, these are still insufficient. However, with other water-efficient applications, it is clear that the use of rainwater collection systems in appropriate rainfall areas will provide with multiple benefits.

In the past times, rainwater was collected and used by cistern systems which were seen especially in areas where water shortage was felt. Nowadays, the use of rainwater in the irrigation of gardens, which has a large proportion of total water consumption in arid regions which have the water problem, greatly reduces water consumption. The cistern application is a very effective method for this type of use. Cistern applications are offered as an ideal solution for places where underground and surface water resources are limited, where there is sufficient rainfall and where there is no central water supply infrastructure. Among the places where the cisterns can be used, there are rural areas, coastal areas, arid, semi-arid areas, islands, and scattered settlements.

A typical cistern system consists of four components.

- Collecting rainwater from the roofs of the buildings or from the ground,
- Providing its transmission by the waterspout system,
- Collecting it in the rainwater storage,
- Transmitting it into the building while being purified. (Alpaslan et al., 2008)

The waters collected from roofs, terraces and clean concrete courtyards are provided to the cistern. The rainwater provided to the cistern has to be filtered through sand (filter) and silica sand and gravel are used for this purpose. A sand filter, which 1/3 part of it's made out of gravel and the upper part is that of fine sand, yields good results. (see Figure 3.67.)

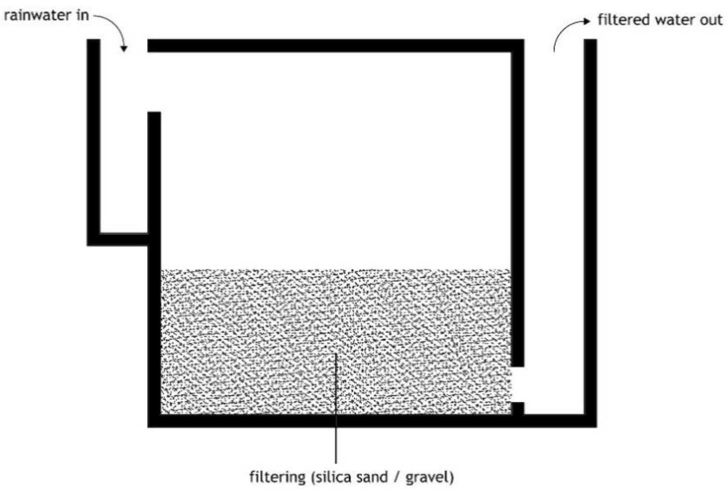


Figure 3.67. Vertical section of typical cistern (Şahin and Manioğlu, 2011)

However, if the sand filter is built into the cistern, the cistern volume may be redundantly large since about 40% of the sand layer is empty. To overcome this drawback, it is necessary to place the filtration sand around the delivery pipe or the water intake tube, to replace the sands that have been contaminated over time, or at least to wash the contaminated sands. In more advanced cisterns, rainwater passes through a resting and filtering process. The 1.40 m height sand filter made of gravel and fine sand filters the floating substances and the hanging dirt in the water and ensures the passage of cleaned water to the water intake wells. In order to keep the water clean, it is appropriate to take the water from the cistern with pumps not with buckets (Şahin and Manioğlu, 2011). (see Figure 3.68.)

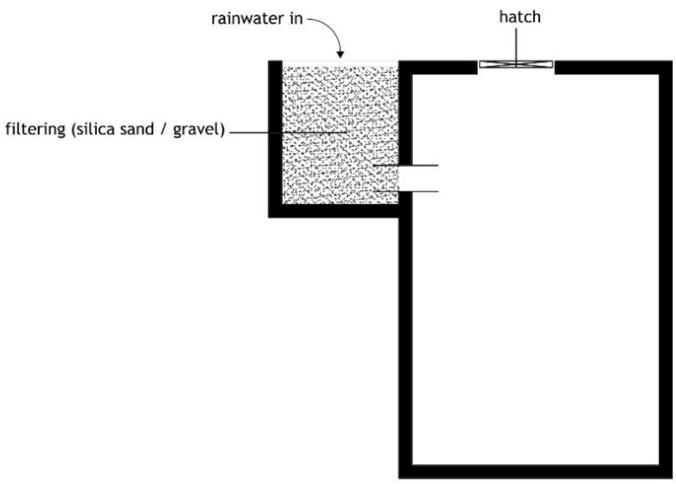


Figure 3.68. Filtration and storage of rainwater (Şahin ve Manioglu, 2011)

There are many examples of traditional cisterns in Istanbul, where water shortage is frequently seen and which fed by various waterways to meet the increasing population needs. The most well-known examples of the cisterns are the Emperor Cistern (Yerebatan Sarayı), Pileksenus Cistern (Binbirdirek) and Acımusluk Cistern (Avcı, 2001).

3.4.1. Use of rainwater collection systems in buildings

Use of rainwater collection tanks provides many benefits. In this way, the efficiency of rainwater usage increases, ground water resources are protected, rainwater is prevented from being polluted by hindering its entrance to the sewage system, flood and overflow risks are reduced, surface water pollution is avoided.

According to the need for usage in buildings, the quality of water is divided into two as drinking water and running water (water without drinking water quality). Areas where there is need for running water are where house cleaning, fire extinguishing, laundry, garden watering, pool filling, toilet washing, car washing, water-cooling towers and industrial operations are carried out. The areas where drinking water is needed are cooking, bath-shower, dish washing. Rainwater can be used inside or outside the building for running water purposes. With a simple rainwater tank, operations, such as car washing, filling of swimming pool or ornamental pool, irrigation with additional piping, use in toilet reservoirs, and after careful controls for water quality and, purification, use in washing machines and the shower/bath, are carried out.

In houses, the amount of running water constitutes 78% of the domestic use. 59% of this rate is used in the garden irrigation and 19% within the housing. The cost of plumbing within the house makes the use of rainwater outside the housing more suitable. For this reason, it is more common to collect the rainwater in a simple way and used for garden irrigation. [URL65]

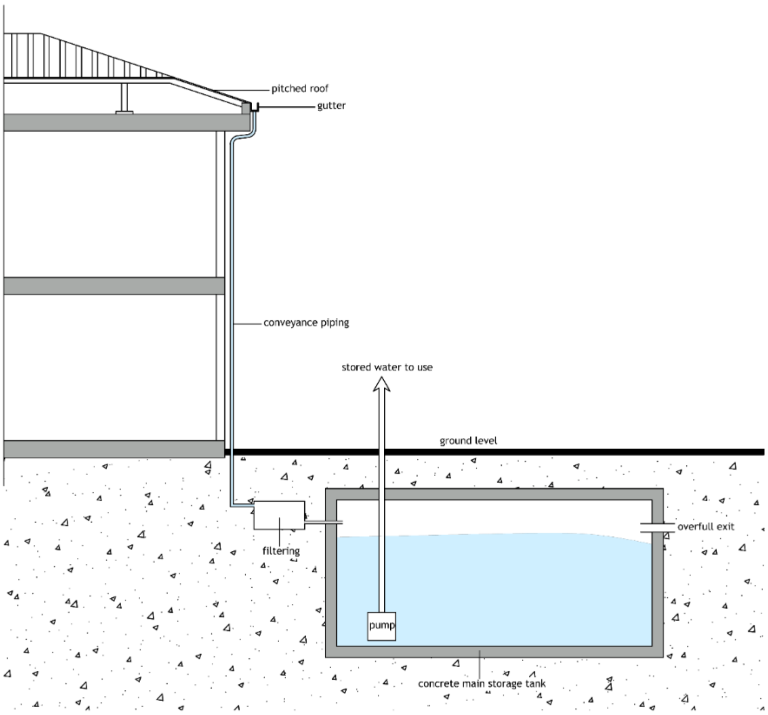


Figure 3.69. Pitched roof rainwater collecting system [URL 66]

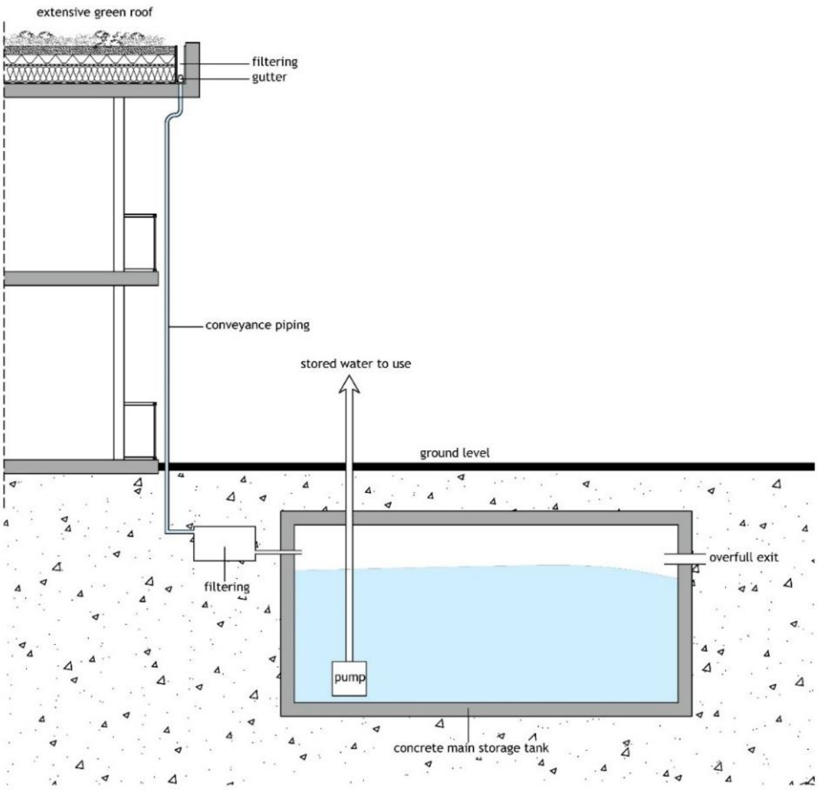


Figure 3.70. Extensive green roof rainwater collecting system [URL 66]

3.4.2. Installation of rainwater system in building

The systems where the rainwater installation is used in the housing are various.

(1) Single system,

(2) Systems in which the network feeds the rainwater installation,

(3) Double system, are different application options. (Şahin, N.İ.,2010)

3.4.2.1. Single system

The rain water collected from the roof comes to the rainwater store reservoir after passing through the filter holding large pieces. The water is pumped from the rainwater store reservoir to the areas needed in the housing, such as the washing machine or the toilet reservoir. In this system, apart from the first setup cost of the system, no charge is paid for rainwater. However, in times when the rainwater is few or there is any problem in the rainwater collection system, the water shortage which will arise in the building is the weakness of this system. (see Figure 3.71.)

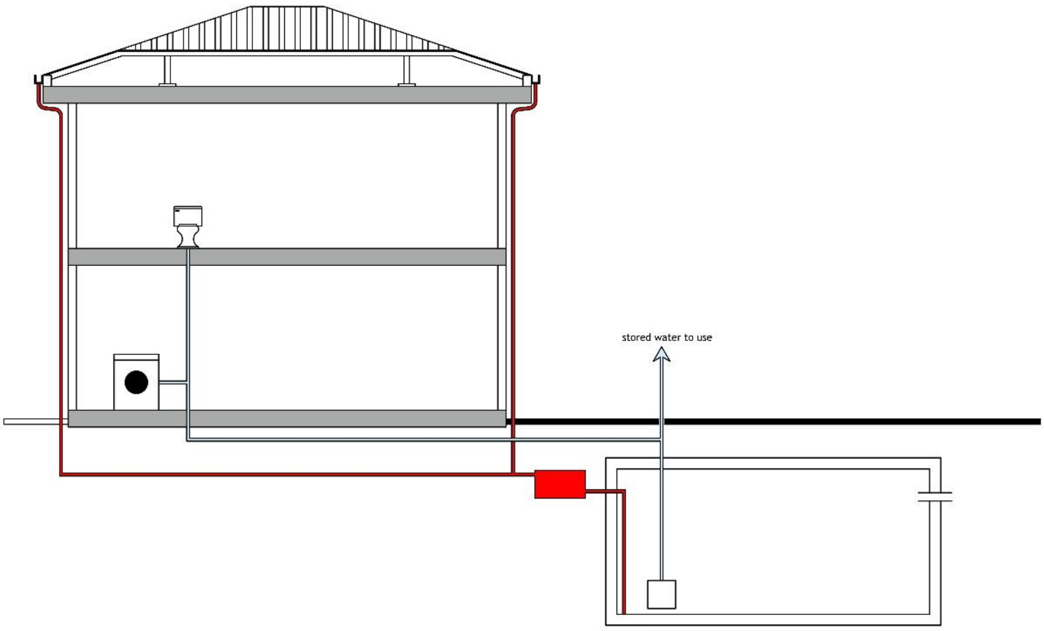


Figure 3.71. Single system (Şahin, N.İ., 2010)

3.4.2.2. Systems in which the network feeds the rainwater installation

These are the systems where the rainwater installation is supplied by the network. These systems are more costly than the systems using only rainwater installations. In such systems, the rain water coming from the roof is collected in the reservoir after it passes through the grooves and filters and is pumped into the usage places such as washing machines or toilet reservoirs in the building. The distribution of rainwater within the building can be done in two different ways.

Direct supply of the network with the rainwater system;

In such systems, the network and the rainwater installation are interconnected. In times when the rainwater is few, rainwater installation fed by the network is used in washing machines and toilet reservoirs in the building. Not requiring an additional space in the building is the strength of the system, on the other hand, the energy cost of the pump to pump the water in the network in times when the rainwater cannot be used, the costs of the pump maintenance, the expensive and complicated the control mechanism, operating of the pump whenever the water is used in the building, are the weaknesses of the system.(Şahin and Manioğlu, 2011). (see Figure 4.47.)

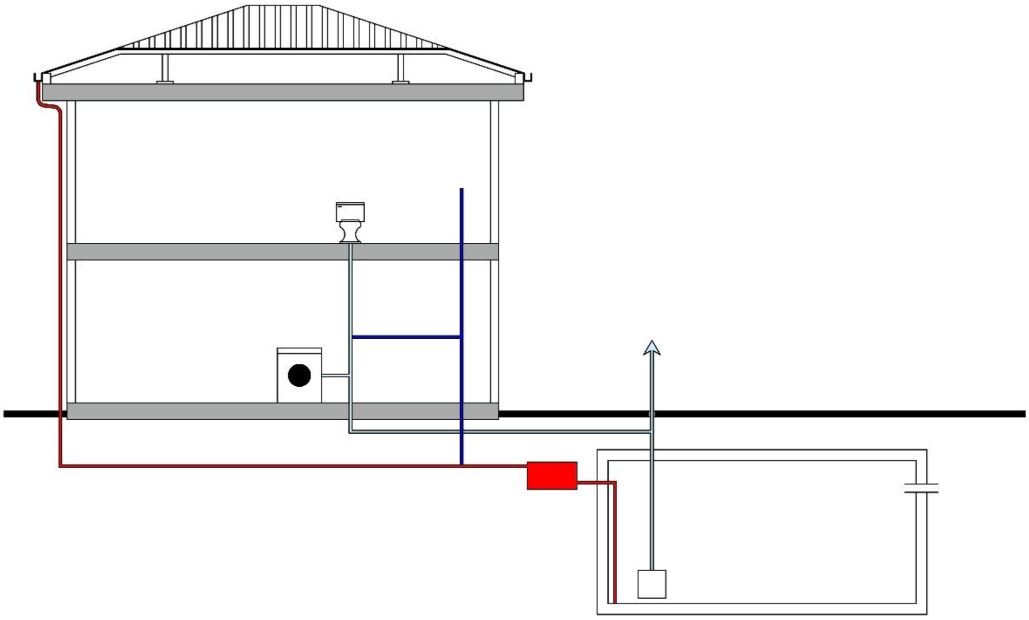


Figure 3.72. Direct supply of the network with rainwater system (Şahin, N.İ., 2010)

Gravity system distribution;

In this system, both the rainwater installation and the mains water come to the reservoir in the roof space. The system is in the form of filling the rainwater into the reservoir and then transferring it to the washing machines and toilet reservoirs by gravity without the need for a pump inside the building. (see Figure 3.73.)

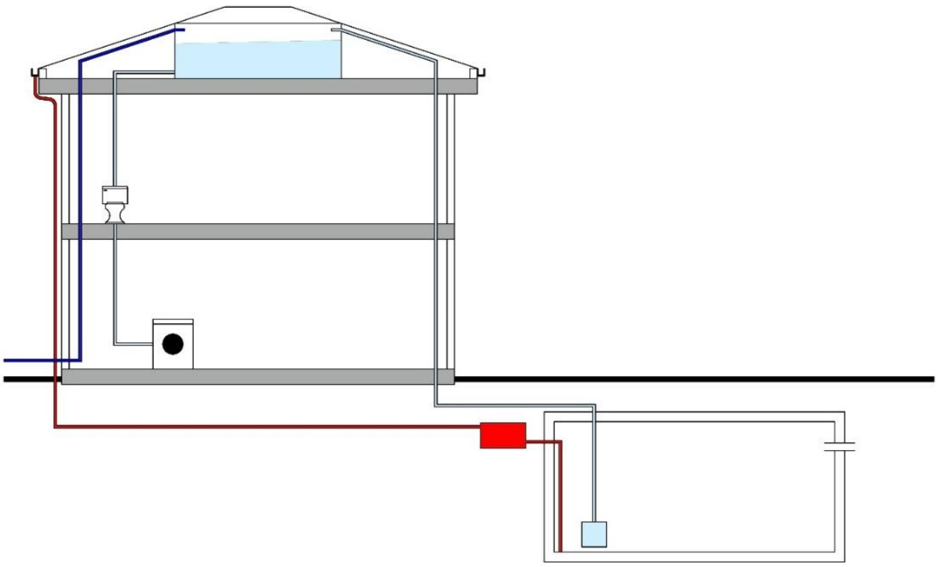


Figure 3.73. Gravity system distribution (Şahin, N.İ., 2010)

Being able to add water to the roof reservoir from the network, in case of a power outage in the building or the absence of water in the rainwater storage reservoir, having a simpler control mechanism and providing energy saving because the distribution within the building is provided by gravity are the strengths of the system (Şahin and Manioğlu, 2011).

Since the pump is not used, the pressure of the network may be too low for a modern washing machine and the garden irrigation, and the toilet reservoir can be filled slowly, and a space is required for the reservoir in the roof space, these are considered to be the weaknesses of the system. In our country, as "*Regulation on Buildings to be Constructed in Earthquake Areas 7.10.7. Reduction of Mass of Reinforced Concrete System*" item stated, the necessity of the installation weights in the roof such as water tanks etc. to be lowered to the floor is another important weakness of the system.

3.4.2.3. Double system

In such systems, the rainwater installation is not supplied by the mains, but instead, both systems (the rainwater installation and the network), are used independently in the toilet reservoir or in the washing machine. Since both systems are extended to the toilet reservoir or washing machine, there is no additional cost.

3.4.3. Regulations and incentives in the world and in Turkey on the use of rainwater in buildings

In European countries, before Turkey, various measures have been taken for the purpose of efficient use of water in buildings and the technologies have been developed. "*Green Building Certification Systems*" is an example of the developments and the importance given to this issue. With the developing technologies on reducing water consumption, each country has determined the way of using these technologies with guidelines, standard or scientific guidelines and has ensured its widespread use. Laws and regulations on the use of rainwater in various countries are summarized. (see Table 3.13.)

Table 3.13. Laws and Regulations on the Use of Rainwater (Şahin, N.İ. 2010)

country	law and regulations	encouragement
Germany	DIN 1989; This standard planning about rain water, covers plumbing, appliance and maintenance, filtering, reservoirs of rain water.	Due to high prices of water, there are more than 1.5 million rain water collecting systems. Depending on the region the system is applied on, there can be discounts up to 1200€
UK	BS 8515: 2009; Appliance standards of rain collecting systems. This standard is about the design on collecting rainwater to add it on usable reserves, plumbing and maintenance.	There is a 100% tax refund on appliance of the system in the first year.
Japan	Buildings that are larger than 30.000m2 has been legally forced to have gray water filtering systems as a must in Japan, by the ministry of development	
India	In New delhi all new buildings that have larger than 100m2 roof surface area and buildings that have larger construction surface than 1000m2, All official governing buildings in Gujarat In Indore all new buildings exceeding 250m2 construction surface In Hyderebad all new buildings exceeding 300m2 construction surface In Chennai all new buildings that are at least 3 stores All buildings in Mumbai exceeding 1000m2 area In Rajasthan all urban areas exceeding 500m2 that has infrastructure It has been made neccessary to use rain water	
Australia	Due to Basix, in Sydney and New South Wales, buildings need to reduce their usage of water by having an external tank inside or outside of the building according to regulations	In terms of "*National Rainwater and Grey Water Initiative*" programme, following january 2009, all families will be granted a $500 governmental payment to promote either the usage of rain water tanks or gray water filtering systems in their households. Promotional incentive will be $400 for 2000-3999 lts of rain water tanks, $500 for tanks larger than 4000 or more lts, $500 for permanent gray water filtering systems. In Queens land, government officials make offers to lower the installment prices of rainwater system up to $1500
USA	Illinois; in Illinois regulations were made, setting the minimum possible standards about collecting and usage of rain water systems in 1.1.2010 (SB 2549). Eventhough there are not many regulations about collecting and the usage of rain water, different states have their own respectful laws on the matter.	Eventhough the incentives to promote these systems that are available in the market since 1970's, each state also has their budget for promoting it Texas: There is a morgage aid for buildings that are used for industrial or commerce purposes that are using rainwater systems, also since 2001 there are tax discounts in buildings that use rainwater Austin: In 2008 government declared that they will be paying off $500 for rainwater system installments in households, this price goes up to $5000 if it is a non profit foundation or public buildings. Austin commercial incentive programme , may make a discount up to $40.000 for commercial appliances. Virginia: In state of virginia it is stated that as long as it does not exceed the half of the costs, there is a tax discount up to $2000
Turkey	There are regulations at hand issued by the official newspaper in 23.06.2017 about rainwater collecting, stocking and decharging systems. Aim of these regulations is to regulate the issues on rainwater collecting stocking and decharge systems planning, design of projects, construction of them and also running them as businesses. Regulations give detailed information on rainwater harvesting systems and steps on construction. Unfortunately there are no legal obligations to match in terms of usage of rainwater systems in buildings.	

3.5. Chapter Summary

In our country, the development of institutional policy, plan, program, and project on the production of renewable energy sources lacks basic legal and administrative infrastructure. Necessary legal arrangements should be made for the adoption of the use of solar and wind systems, which are renewable and clean energy sources.

The use of photovoltaic systems on roofs is more appropriate due to hours of sunshine and aesthetic concern.

The state should mobilize incentive mechanisms and implement legal arrangements in the short term. It should popularize the use of renewable energy systems in public institutions and organizations. Appropriate interest rate loans and long-term repayment plans should be implemented.

The ministry should provide local national and international financial incentives and support for the market formation of photovoltaic systems. Government procurement guarantee should be increased from 10 years to 20-25 years as in European countries. Income tax rates should be reduced if domestic production is used in systems used to promote home production. VAT and tax exemptions should be put into practice and cheap land and land allocation should be made for the installation of power plant.

Even though the potential of Turkey to generate electricity from solar energy is 380 billion kW, this potential can not be utilized even in a ratio of 1%. Turkey, which ranks among the top three in the use of solar energy for water heating, started the investment in the systems used for electricity generation only in 2007. To reduce the amortization periods of solar power plants, foreign exchange dependence should be prevented, the tax burden on photovoltaic imports should be increased and support should be given to industrial institutions for domestic production.

IV. USING RENEWABLE ENERGY SOURCES IN ARCHITECTURAL DESIGN

4.1. Investigation of Renewable Applications in Terms of Building Design

The energy used for the sustainable development of renewable energy resources in housing design can not be polluting the natural environment, must be used effectively and efficiently and must be recyclable.

In order for the designed housing to be sustainable, it is necessary to consider the climate data of the land, topographic land features, the use of renewable energy resources available in the area, the location of the design in the area, the position of the design according to other buildings, its form, direction, envelope, the choice of materials to be used, space organization, the materials used and whether the energy is recyclable.

4.1.1. Land and topography

When designing housing, natural environment data should be taken into consideration and should be integrated with the environment. When the structure is designed, the orientation, positioning, form, space organization, ventilation, cooling and heating load of the building are determined with the analysis of the land data.

It is necessary to know the topography of the land where the building will be located. Topography graphically shows the surface shapes, bumps, natural form that appear in the field. The existing topography must be protected in order not to damage the natural environment. (Kısa,Ovalı, 2009)

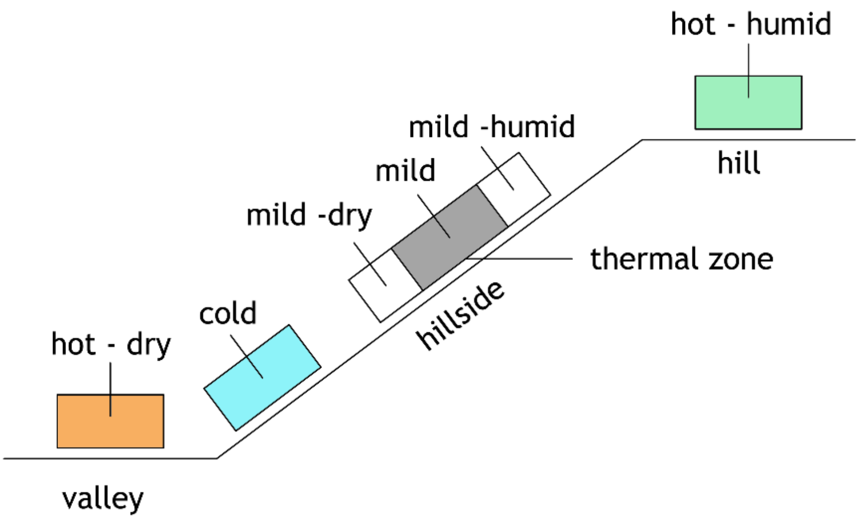


Figure 4.1. Site Selection (Kısa Ovalı, 2009)

4.1.2. Climate data

Climate data should be taken into account in building design. According to climate data, it plays an important role in the heat loss or gain of the building. In the design that is based on climate data, the energy efficiency is provided by determining the orientation, envelope, ventilation system, space cooling and heating methods, space organization and insulation material. Climate data varies depending on sunlight, wind, temperature and humidity.

4.1.3. Vegetation

In the processes of utilization or elimination of the dominant wind in a building, of solar control and of preventing noise pollution vegetation cover is used. It reduces the need for energy used for heating or cooling needs of the building. It reduces the air pollution by increasing the amount of oxygen in the environment. It provides continuity of natural environment. Erosion and floods are prevented by preserving natural vegetation in the construction of the building, the natural life is preserved. (Karaca, 2008)

4.1.4. Orientation

With the building orientation made by considering the current climate, land data, solar and wind effects, it is ensured that the natural ventilation, natural lighting, cooling and warming load is reduced.

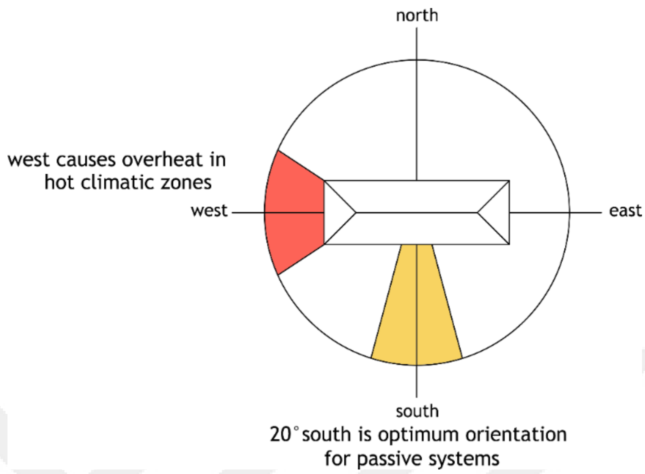


Figure 4.2. The appropriate orientation for the passive system element (Yüceer, 2015)

North: Provides high quality light and low heat gain. Since the indoor temperature is low, it creates heating problems. Since it gets sunlight at the very early hours of the morning and towards evening, the shadow elements are not much necessary.

South: It gives good light and heat. Shadow elements are easy planned on this facade.

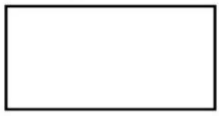
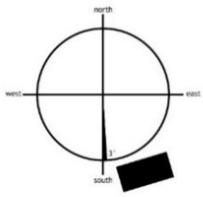
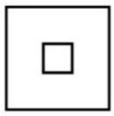
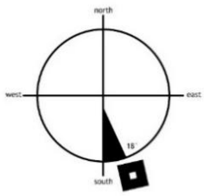
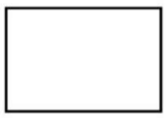
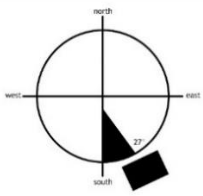
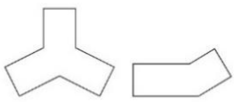
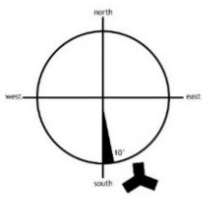
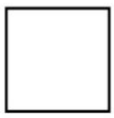
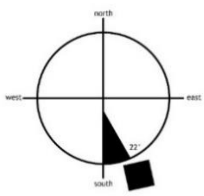
East and West: Since the lights coming from this direction go to infinity, they often cause visual and thermal disturbances in the interior. They are the directions which require a shadow element. (Yüceer, 2015)

4.1.5. The location and the building range compared to other buildings

By determining the location of the building and the openings between the buildings based on the sun's rays and the dominant wind direction, the natural illumination and ventilation are provided in the building and the load of heating and cooling is reduced. Existing renewable energy sources should be utilized from the location of the building and the energy should be used efficiently. The distance in the building openings varies according to the direction, the slope and the height of the terrain. In order to maximize solar radiation in hot climates, the building opening must be at least as long as building height. In cold climates, for the openings between buildings to be small or adjacently designed will reduce the surface area in buildings, thus reduces the heat loss. Landscape design is also important in the arrangement of openings between buildings. Plant communities used in landscape design and afforestation provide cooling and ventilation for buildings. (Yüceer, 2015)

4.1.6. Building form

Table 4.1. Building form and orientation according to climatic zones in Turkey (Yüceer,2015)

climatic zone	building form	orientation
hot-humid pilot city:antalya	windswept surface,rectangle 	
hot-dry pilot city:diyarbakır	atrium,square,open plan 	
mild -dry pilot city:ankara	close to square and compact 	
mild -humid pilot city:istanbul	rectangle, open plan 	
cold pilot city:erzurum	square 	

According to the results of the climate data, the building form is designed to provide the indoor heat comfort by using the formal components such as the ratio of the length of the building to the depth, the height, the type of roof, the slope of the roof, the inclination of the facade, the orientation, the ratio of the transparent and deaf surfaces. As these components will vary in each climate zone, building forms should be designed differently in each climate zone. Heat losses and gains in different building forms will be different. The determination of the heat losses and gains generated by the building forms affects the building cost. In order to ensure the use of natural ventilation and lighting, the building form must be designed according to the current climate data.(Yüceer, 2015)

4.1.8. Building envelope

The building envelope separates the external environment from the interior and provides energy efficiency and thermal comfort in the interior. Building envelope should be designed according to land, topography, climate, slope, orientation data. The ratio of deaf and transparent surfaces to each other, the materials used and the insulation systems affect the energy efficiency in the building envelope.

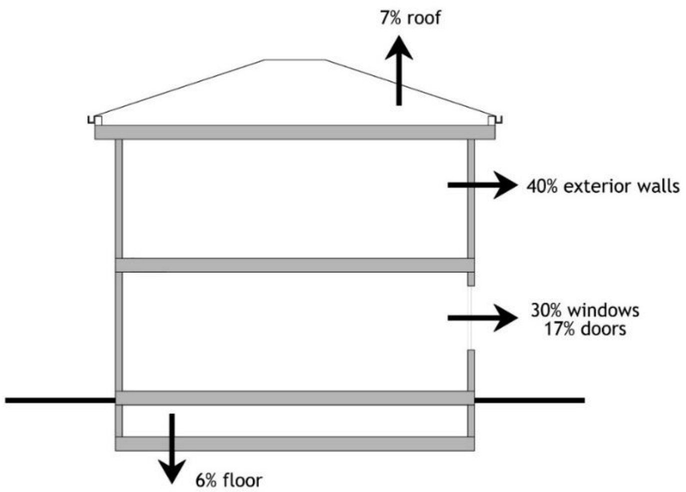


Figure 4.3. Energy loss in an uninsulated house [URL67]

Building elements in the building envelope;

- Exterior walls
- Roof
- Windows and Doors
- Tile
- Foundation

With the planting in the facades and roofs in the building envelope, it is ensured that the storage of the temperature of the space reduces the heating load by providing insulation and in hot climates, it absorbs the exterior temperature and reflect to the interior.

4.1.9. Place organization

While making place organizations in buildings, the energy efficiency should be provided, by considering the functions of the place, the purpose of the use of the place and how much energy is spent in the use phase.

In areas with warm climates, the living areas in building design where the user spent more time should be directed to the southern facade. The southern facade minimizes the energy to be used for warming and lighting by taking the sun's rays directly into the place. On the south facade, it is necessary to direct places such as rescue chamber, saloon, living room, bedroom, kitchen and to direct bathroom, wc, cellar and warehouse to the north facade.

4.1.10. Material selection

The materials used in the building should be selected so as not to damage the natural resources. The deterioration of the natural environment damages the living health. The use of materials which are high-tech and which consume high energy in their production and life cycle process, reveals environmental problems. Local materials which consumes less energy throughout the production and the life cycle should be preferred instead of materials consuming excess energy.

4.1.11. Zoning Status

Due to the fact that the zoning situation directly affects the design and direction of the building with some parameters that must be obeyed at the beginning of the design, it is binding in the formation of the micro-climate of the building. The location of the building is an important criterion in determining the energy efficiency.

Today, energy loss is experienced especially in apartment buildings as a result of disregarding the zoning status. The reason for this is that very little use is made of the sun and wind for heating and cooling buildings. In zoning plans the building's short edge is planned on the building's east-west axis. Generally, two flats are designed in middle-sized apartments and the apartment halls, in other words "much-used rooms," are located on the east or west side of the street on the short side of the land. While this is a cultural and social determinant, it directly affects the heat gain of the building and reduces it.

To review this situation, the planning in zoning plans of the large surface of the building lands in the north-south direction, the common use by these flats of the southern facade of the flats on the floors will make the building energy efficient.

By ensuring that the street facade is kept in the north and south while the zoning plans are being made, energy efficient design opportunities can be utilized by providing the settlement of much-used rooms in this direction. Since the orientation and design is affected by the situations of wide southern façade to buildings and the direction of street axles, the planning of building lands in the form of north-south or east-west in zoning plans is decisive in the formation of micro-climatic conditions in terms of passive utilization of renewable energy sources such as the sun and the wind.

4.1.12. Regulations

To prevent inefficient use of energy on the world, to improve the quality of construction, to minimize the harm of natural disasters thus to increase the comfort level of the places where people live, many regulations and standards have been set up. These regulations and standards

They all aim to improve the quality of life of people and to preserve nature.

Regulations, in the most general sense, are the rules of law which are made by the ministries or public legal persons regarding their respective fields of activity to ensure the application of

laws and regulations Standards in the building sector refer to the regulations which are agreed upon, approved by an accepted organization, which aim to establish the most suitable order in the present circumstances, which aim at the establishment of the product's features for common and repeated uses, processing and production methods, their related terminologies, symbols, packaging, marking, labeling and suitability assessment procedures, which point out one or more of these issues and which is mandatory to be complied with.

The main regulations and standards used in the construction sector are as follows;

- Zoning Law
- Zoning Regulations
- Regulation on Building Materials
- Regulation on Energy Performance of Buildings
- Regulation on Review and Management of Environmental Noise
- Regulation on Protection of Buildings from Fire

- Regulation on Thermal Insulation in Buildings
- TS 825: Standard for Heat Insulation in Buildings
- Regulation on the Buildings to be built in the Disaster Areas etc.

The following regulations are briefly described below.

Development Law; The purpose of this law is; to provide the organization appropriate for plan, science, health and environmental conditions of the residential areas and settlements in these areas. **(Development Law, 03.05.1985)** [URL68]

Zoning Regulations; with zoning plans and legislation provisions of the settlements and constructions within the border of the area of responsibility of the State Metropolitan municipality, the municipality and the adjacent area, they are prepared for providing the organization suitable for the social and technical infrastructure, science, health and environmental conditions. **(IBB Zoning Regulation, 20.05.2018)** [URL69]

Building Materials Management; The purpose of this regulation is; to determine the method and principles about the market surveillance, supervision procedures, the main requirements and the conformity assessment procedures to which the building materials produced to be used in all construction works including building and other works of civil engineering are supposed to be tied. **(Building Materials Regulation, 10.07.2013)** [URL70]

Regulation on Assessment and Management ofthe Environmental Noise; This regulation is intended to determine the principles and criteria for combating the effects of exposure to environmental noise and to take some research, information and measures to implement these criteria on the basis of noise sources, in order to develop an environment that will not disturb the physical and mental health, peace and tranquility of individuals with the noise. **(Regulation on Assessment and Management of Environmental Noise, 04.06.2010)** [URL71]

Regulation on the Protection of Buildings from Fire; It aims to provide organization, training and control with the measures to be taken before or during the fire which is extinguished by minimizing any kind of loss of life and property in the process of the design, construction, operation, maintenance and use of all kinds of buildings, housings, facilities and enterprises used by public and private institutions, foundations and real persons. **(Regulation on Fire Protection, 19.12.2007)** [URL72]

Regulation on Thermal Insulation in Buildings; The purpose of the TS 825, is to restrict energy amount used for the heating of buildings in Turkey thereby increasing energy savings and to determine the standard calculation methods and values to be used to calculate energy requirement. The standard can also be used to choose the design option which will provide

the ideal energy and performance by applying the calculation method and value to the various design alternatives of a new building, to determine the net heating energy consumption

of the existing buildings, to determine the amount of saving provided by energy saving measures which can be applied before applying a renewal project to an existing building.**(Heat Insulation Regulation in Buildings, 09.10.2008)** [URL73]

4.2. Examples from Turkey and World

4.2.1. Bedzed, Bill Dunster

location	London,UK	sustainable applications
architectural design	Bill Dunster	ecovillage application, PV systems, solar collectors, windcatchers
year of construction	2002	
intended use	residential	
roof type	extensive green roof	

Figure 4.4. Bedzed, Bill Dunster[URL74]

Bedzed, located in London, England, was completed in 2002. It consists of the building, office and social areas. In the design of the housing project, public transport, bicycle use, green pedestrian roads, electric vehicle use were encouraged, the parking space was limited. It is a housing complex that makes maximum use of renewable energy and produces its own energy consumed. Rainwater was collected and reused. Waste and garbage consists of recycled sources. In its design, ventilation is provided by the wind chimney head system on the roof [69].

It is designed according to zero energy system. Thanks to active and passive air conditioning throughout the year, it provides ventilation, heating and cooling. It meets the need of heating with solar energy and provides ventilation and cooling with passive techniques. With the wind chimney head system used in the roofs, the ventilation is ensured by taking fresh air in and throwing the used air out. The photo-voltaic panels on the roofs have produced electricity and have been the source of energy for electrically powered vehicles. Hot water is obtained by solar collectors on roofs. In the periods when the solar energy is insufficient, it is obtained by the bio-fuel system. During the construction phase, it is paid attention that the materials are insulated, recycled, locally produced and low-cost. Wood was chosen as an external facade material. The buildings are oriented towards the south facade and the solar gain is increased by large glass surfaces. Rainwater collected on roofs are used in garden irrigation and toilet flushes.

Figure 4.5. Bedzed, extensive green roof [URL75] Figure 4.6. Bedzed, windcatchers [URL76]

4.2.1. Solar site in Schlierberg, Rolf Disch Architects

location	Freiburg ,Germany	sustainable applications
architectural design	Rolf Disch Architects	natural lighting and ventilation, PV systems, solar collectors
year of construction	2005	
intended use	residential and commercial	
roof type	pitched roof	

Figure 4.7. Schlierberg, Rolf Disch Architects [URL77]

The Solar Site in Schlierberg is located in Vauban, a new ecological suburb of Freiburg, Germany, which is established as a sustainable model of living and its construction was completed in 2005. It used renewable energy sources such as solar energy instead of fossil fuels. It consists of a multi-functional trade and housing structure called Güneş Gemisi and a row of houses named Güneş Sitesi. Row houses are designed in the form of a Plus Energy House module. Plus Energy House module is an example of social and ecological sustainability which contributes to a sustainable lifestyle by producing more of the energy spent by users. In this region, which has the mild climate of Germany, heating is required in winter, and since the temperatures are not very high in the summer, there is no need for air conditioning due to the passive cooling. Narrow building depths provide mutual ventilation and illumination. (Guzowski, 2017) The windows of the southern facade and the large canopies perform passive heating and solar control functions according to the season. Photo-voltaic panels for solar energy production and solar collector for hot water were built on the wide roof. Highly efficient triple glazing and sun breakers contribute to both heating and cooling by providing control of the winter and summer sun. For car owners there is a car park whose roof was covered with photo-voltaic panels. (Guzowski, 2017)

Figure 4.8. Elevation of Schlierberg [URL78]

4.2.3. Lighthouse, Alan Shingler ve Martin Rose, Sheppard Robson

location	Watford ,UK
architectural design	Alan Shingler and Martin Rose, Sheppard Robson
year of construction	2007
intended use	residential
roof type	pitched roof
sustainable applications	
UK's first zero-carbon house, shading, natural lighting and ventilation, PV systems, solar collectors, rainwater collecting systems(flush)	

Figure 4.9. Lighthouse [URL79]

Lighthouse is located in the Innovation Park of the Building Research Establishment (BRE) in Watford, UK and its prototype house construction as the first net zero carbon in UK was completed in 2007. In order to provide the thermal comfort of the building located in the sea climate, moderate cooling in summer, heating in winter and relative heating or cooling in mid seasons are necessary. The height of the neighboring buildings and the solar criterion that determines the sitting direction of the building to the site ensure that the roof surface receives direct sunlight. The roof was designed to face south. There are photo-voltaic panels for energy production on the roof, solar collector for hot water supply, and wind trap (light chimney) for providing natural ventilation. The surplus electricity produced by photo-voltaic panels is exported to the city network. The wind trap provides passive cooling and natural ventilation. It takes the cool air inside to change the warmed inside air by creating a chimney effect. Thanks to the collapsible glass division, it provides instant cooling in very hot weather with mutual ventilation (Guzowski, 2017)

In order to reduce the heating period, a very well insulated, air impermeable and three-glazed building envelope with few windows is designed. In the Lighthouse, since the usual 25% -30% glass surface ratio was set as 18%, the period which requires heating during the year was reduced to four months. Gray water obtained by storing rainwater is used in toilet reservoirs (Guzowski, 2017)

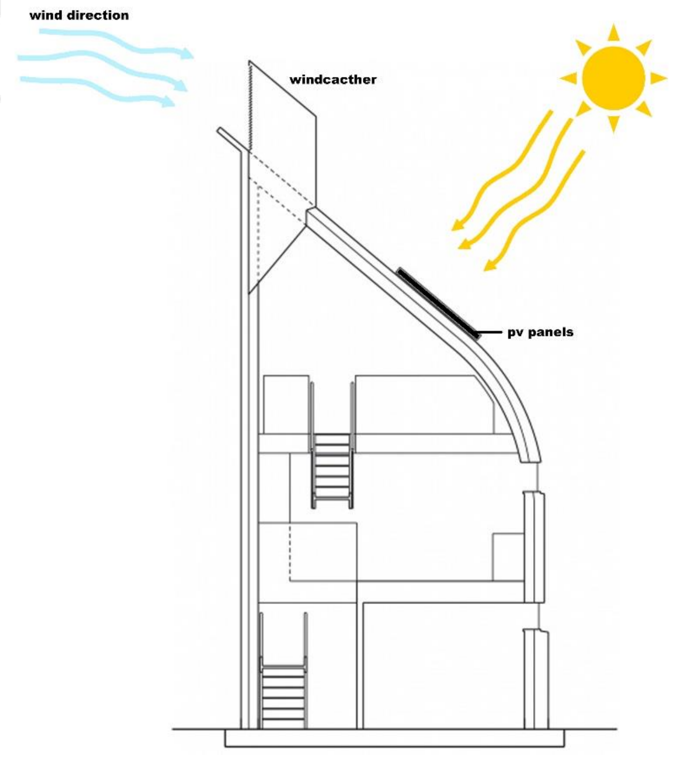


Figure 4.10. Section of lighthouse [URL80]

4.2.4. Gaziantep Ecological Building, Erden Güven

location	Gaziantep ,Turkey	sustainable applications
architectural design	Erden Güven	First Passivhaus certificated building of Turkey, natural lighting, PV systems,rainwater collecting systems(flush,gardening)
year of construction	2013	
intended use	conference hall	
roof type	extensive green roof	

Figure 4.11. Gaziantep ecological building [URL81]

Information and promotion center regarding renewable energy resources, environment-friendly structuring and self-energy systems that produce their own energy. A conference hall for 60 people and a foyer for information and exhibition were designed in the building. The building is oriented towards the southern facade to benefit from natural light. It was planned to obtain high efficiency from daylight with wide openings on the southern facade. In summer, the trees in front of the southern facade protect the building from excessive sun exposure. The artificial lighting in the building is a low-energy LED armatures. Green roof is used as roofing material. The green roof contributes to balance the amount of moisture and the level of carbon emission within the building, which is formed by planting green flowers and plants supported by insulation materials. 40 cm thick glass wool thermal insulation plates that surround the building envelope balance the heat inside the building. The three-glazed window systems used in the facade reduce heat loss.

The photo-voltaic solar cells in the garden of the building convert the solar energy into electrical energy and meet all the energy needs of the building. While the heat, humidity and air quality of the building are kept at an ideal level with the heat recovery ventilation plant, hot air ventilation in the winter and cool air ventilation in the summer is supplied with the pipes laid under the ground.

Rainwater was reused with storage and treatment systems. The gray water recovered by the treatment system is used in the toilet bowl reservoirs and the stored rainwater is used in the garden irrigation. [URL82]

4.2.5. Container Park, Workshop Labs

location	İzmir ,Turkey	sustainable applications
architectural design	Atölye Labs	recycling and reuse, natural lighting and ventilation
year of construction	2015	
intended use	commercial and office	
roof type	-	

Figure 4.12. Container Park, Workshop Labs [URL83]

The 1000 m² project, which was formed by transforming 35 second hand containers by Atelier Labs, was designed to carry out R&D in biotechnology, energy, materials and software related issues. With its permeable boundaries which ensure effective square meter usage by resetting the closed circulation area and increase the intersection points of shared courtyard design, the transparency have been prioritized. The project was built on a razed faculty area in idle form. The container modules, which make use of the shade by approaching the existing tree texture, are shaped by following the traces of the old building foundation except for the dominant wind direction and sun angles.

Sustainability was achieved through recycling and reuse of materials. Energy use is minimized by the use of active natural ventilation, shading with existing trees and the use of canopies and natural materials such as cork, local stone. In order to divide the place when desired, visible steel column and beam systems, modular design of the containers provided ease of use in the future. [URL79]

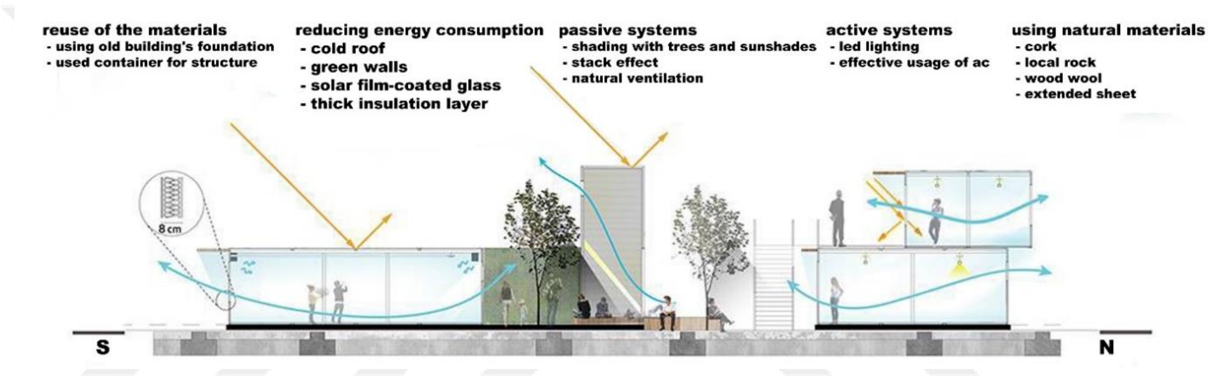


Figure 4.13. Horizontal section of Container Park [URL84]

4.2.6. Diyarbakır Solar House, Çelik Erengezgin

location	Diyarbakır ,Turkey	sustainable applications
architectural design	Çelik Erengezgin	trombe wall, PV system, solar collector,windcatcher natural lighting and ventilation, rainwater collecting systems(gardening)
year of construction	2008	
intended use	residential	
roof type	pitched roof	

Figure 4.14. Diyarbakir Solar House, Çelik Erengezgin [URL85]

In order to economically utilize solar energy, the country or region where the project is realized are supposed to receive an average of 2,000 hours of solar energy per year, while this project was implemented in Turkey, Diyarbakır, Turkey, where the longest sunshine hour average was 3,016 hours. It is a housing project that provides sustainability and renewable energy.

In the measurement made in the field, thanks to the energy getting stable as going down to two meters below the earth crust, the average temperature of the water in the vicinity of the well in the summer and winter days was found to be between 12-17 degrees. For this reason, this average 15 degrees of constant energy taken by means of water circulating through the pipes laid under three meters of ground is circulated in special green pipes at the ground floor flooring, ceilings and under the mezzanine floor, and transports energy from the water to the air and so the natural coolness of the house is provided in the summer. This natural coolness is taken into the interior by the natural method with the vacuum effect created by the tromp walls and greenhouse and the aspirator which is activated when needed.

Thermal comfort is ensured by providing heating and cooling with solar wall (thromb wall) and greenhouse area on the south side. Thanks to the outlets that can be opened at the bottom and top of the thromb wall, the place is heated by warming the cool air entering from the lower outlet and entering through the upper outlet. In addition, the upper outlet draws the cool air through the outflow opening and releases the air and shows a vacuum effect. Domestic wastes are used in garden irrigation by storing the water formed by biological treatment and the rainwater. [URL86]

4.3. A Case Study

As a result of obtained information from previous parts, housings were designed by using sustainable applications in accordance with reasons affect construction design process and current regulations of chosen area.

Pendik district of Istanbul, Çınardere neighborhood, G22A15B2B map, 0 island, parcel of 4841 was selected as the study area. It is a region that develops with rapid construction in the north of Pendik district. There are a shopping mall, a school, high-rise houses, hospitals and a metro station in this area. As an alternative to the existing residences in the study area, renewable energy is employed in the design of alternative housing by using active and passive systems in architecture.

The climate of this region is warm and humid in summers, warm and wet in winters. Summers are dry in terms of rainfall. Since it is close to the coast, the humidity is high. Heating in winter and cooling in summer is required. Shade elements are recommended for hot months. No shading during the cold months.

Figure 4.15. Pendik sub-province, Çınardere district [URL87]

4.3.1. Zoning Plan Notes of the Region

The revised zoning plan notes of the Çınardere neighborhood of Pendik district dated 13.12.2013;

(1) In Housing Areas;

In the parcels with parcel area of 0 m² - 300 m²;

KAKS = 1.25

In the parcels with parcel area of 300 m² - 1000 m²;

KAKS = 1.50

In the parcels with parcel area of 1000 m² - 3000 m²;

KAKS = 1.75

In the parcels with parcel area of 1000 m² - 3000 m²;

KAKS = 1.75

In the parcels of 3000 m² and above;

KAKS = 2.00

TAKS: 0.40

Maximum Building Height: 30.50 m (provided that it does not exceed obstacle plan criteria)

(2) In the parcels that will be formed as a result of the land amalgamation of the parcels of less than 1000 m² in the Residential Areas;

In the parcels with parcel area of 1000 m² - 2000 m²;

KAKS = 2.00

In the parcels with parcel area of 2000 m² - 3000 m²;

KAKS = 2.25

In the parcels of 3000 m² and above;

KAKS = 2.50

TAKS: 0.40

Maximum Building Height: 30.50 m (provided that it does not exceed obstacle plan criteria) (3) 20% of the parcel area will be allocated as a reinforcement area such as green field, religious facility area etc. in the implementations of the parcels larger than 3000 m² which were formed as a result of amalgamation in the housing areas. [URL88]

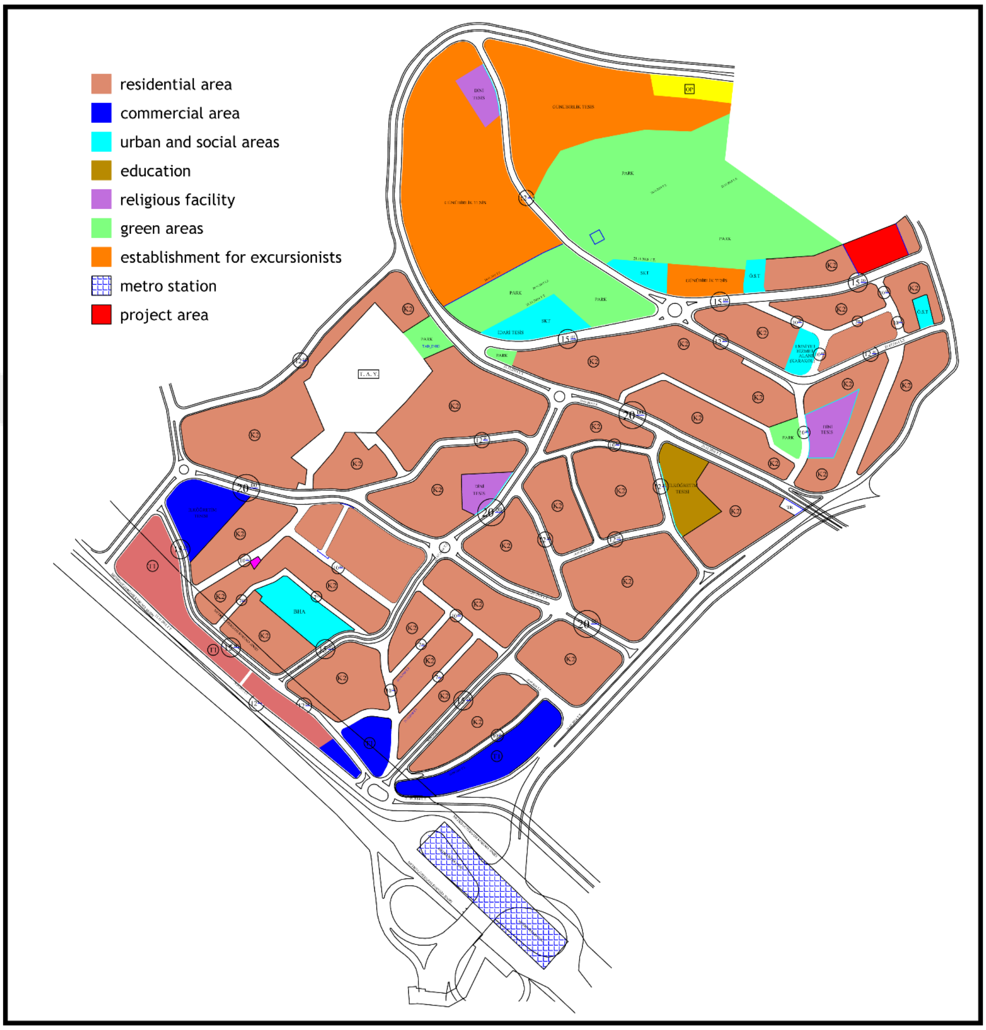


Figure 4.16. Implementary development plan of Çınardere district

4.3.2. Project Details

Housing design has been made in terms of sustainability concepts by using renewable energy sources. It is designed to be suitable for climate and terrain of the Pendik region. It is aimed to design a housing which can use the maximum amount of solar energy and make use of the fossil resources as little as possible and produce its own energy. Value-added has been created by making sustainable applications such as photo-voltaic panels on roofs and intensive green roof and it is designed as a living area to provide sustainability.

The building is designed in rectangular form because it is a mild and humid climate zone. It is a building consisting of 8 floors and 115 independent sections. The ground floor is 1378 m² and the first floor is 1521 m² and the total construction area is 16246 m². The building has been provided with parking space for each flat in accordance with the IBB parking regulation dated 22.06.2007. However, passive applications related to the orientation of the building and room settlements could not be utilized. The building is located in the parcel according to the drawing distances in the zoning status taken from the official institution.

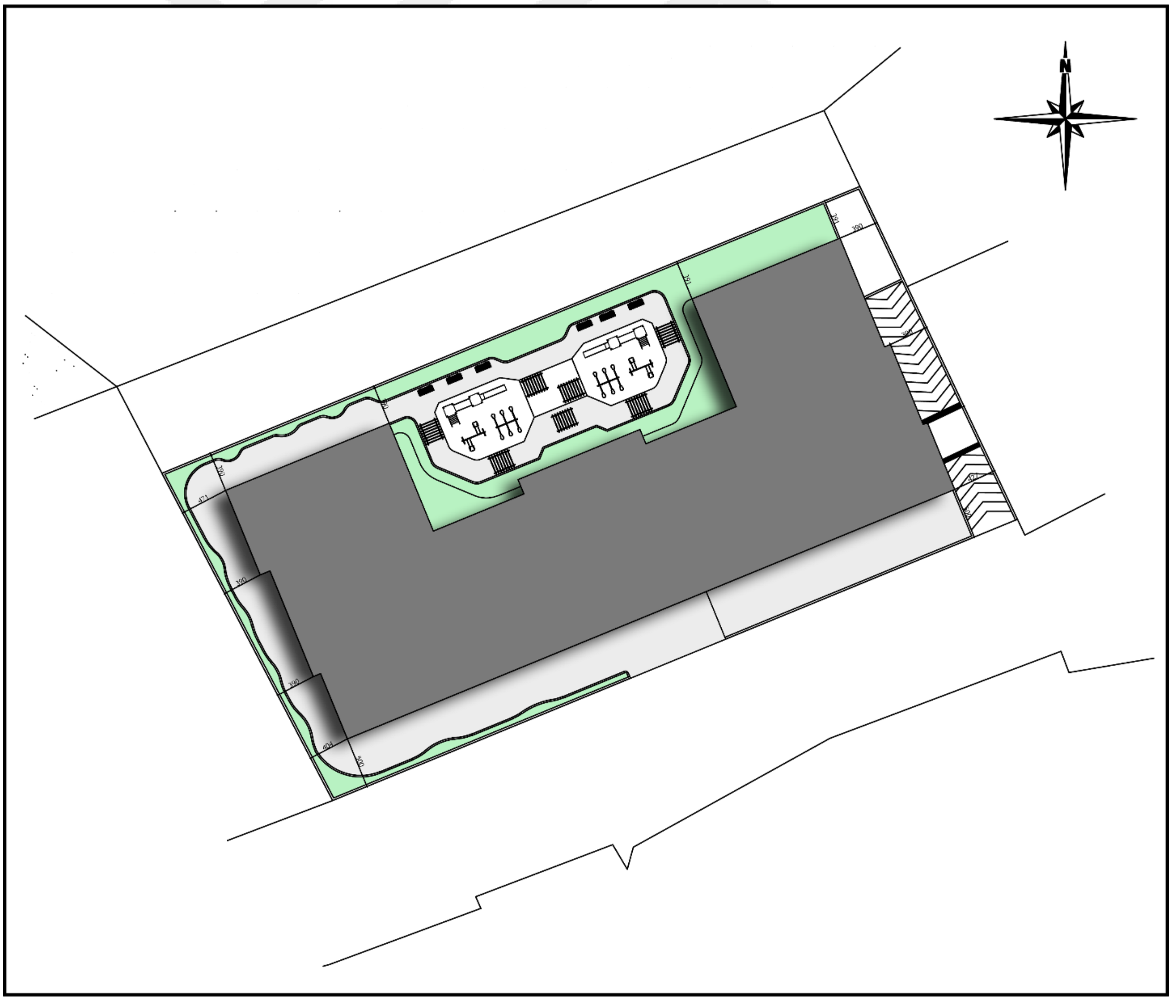


Figure 4.17. Location Plan

Natural lighting is provided by high and wide windows. There is no need for shading on the northern facade. The green roof absorbs the sun's rays in summer and reduces the effect of hot air. The window joinery is made of wood and the windows are double-insulated with the low-e system. Low-e prevents the sun's rays from directly passing through the place. As the insulation material, stone wool, which is available locally, has been used. Use of low-VOC paint and adhesive does not adversely affect human health.

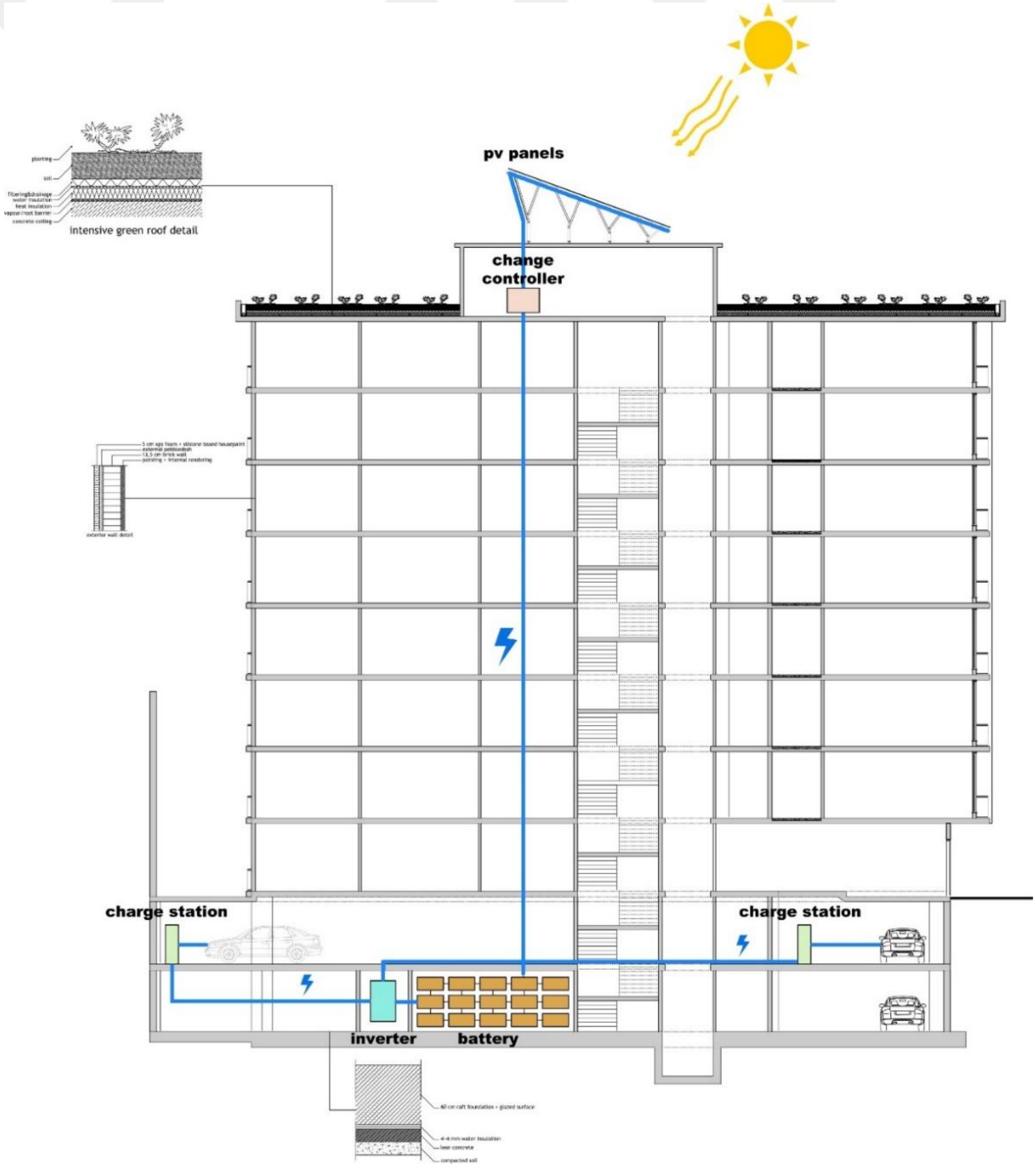


Figure 4.18. Pv system detail

The roof, tile, floor, wall, window, door components were insulated and the energy was protected. The electricity produced from solar energy with the photo-voltaic panels on the roofs are stored in batteries in electrical car park floors used in the building and in the electric vehicles.

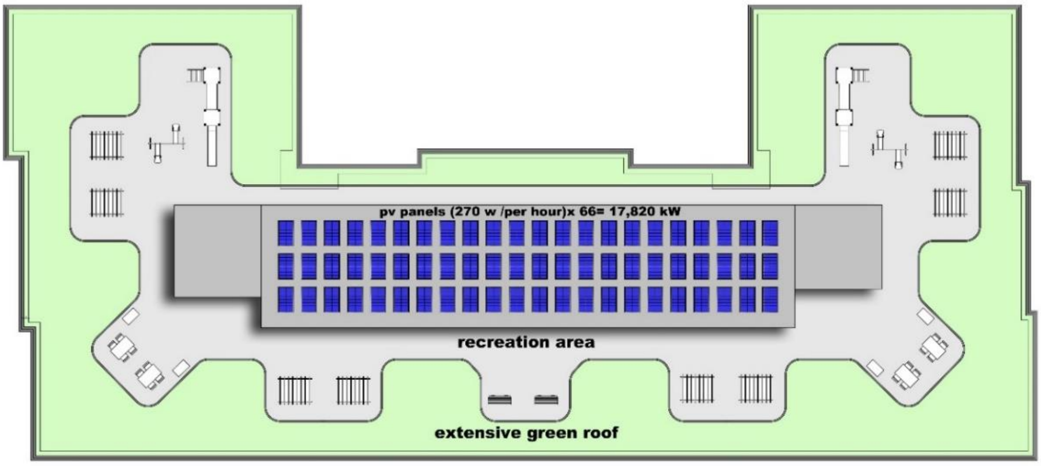


Figure 4.19. Roof plan

Figure 4.20. 3D model of roof

Minimizing the environmental effects of buildings by reducing energy consumption of the buildings is ensured by the active and passive application of energy efficient design principles. In many countries, the relationship between the building and the wind and solar energy are given the necessary importance. With the building systems and construction techniques developed in the recent years, it is seen that the energy efficient designs have started to be built.

Figure 4.21. 3D model of building

4.4. Chapter Summary

When the building samples are examined, it is observed that practices in Turkey are limited to individual samples and cannot be integrated into mostly built housing projects. The reason for this is that importing the systems used in the country's solar and wind energy and many building materials, lacking technical knowledge, avoiding high costs due to private sector building construction, designers ' aesthetic concerns, regulations, and so on. For economic reasons, Turkey is behind most countries in renewable applications.

If requested and initial investment costs are provided, as the building can become zero-energy with the fully efficient integral of the active energy systems in the energy efficient systems title. The building, which produces its own energy, can help the user make profit economically by selling the extra energy.

V. CONCLUSION

Several advantages of renewable energy resources in comparison with other energy resources, the wind and solar potential determined by the measurements made and the technological developments in the renewable energy sector all over the world, caused the related institutions and organizations, The Ministry of Natural Resources in the first place, to start the studies. Wind and solar farms were established and continue to be established. However, despite the high energy losses caused by the buildings in our country, the number of buildings actively benefiting from these energy sources is quite low. In Turkey, the rate of using the passive systems is more than that of using the active systems. Passive system parameters must be taken into consideration when designing and implementing the building. In the control of the architect who designs the building, apart from the sanctions determined by the regulations prepared by the relevant institutions and organizations, these parameters should be reflected in the architectural project, and a project that carries out the least energy cost together with the engineers with interdisciplinary work should be put forward. In our country, buildings created in this discipline are available but not enough.

The use of renewable energy sources in Turkey is planned to have a broad range of application areas in the very near future as it is in the developed countries. The EU has published directives and guidelines by generating a set of legal and binding targets for Member States to comply with the requirements for renewable energy sources. The developments experienced in wind and solar energy investments in recent years, in Turkey, which is in the European Union accession process,are promising. However, the utilization of the energy obtained in the wind and solar farms, in the buildings will reduce the energy consumption resulting from the construction sector and will contribute greatly to the national economy. The issues that Turkey need to do in order to progress in this platform and come to the level it deserves are listed below.

- Large portions of the photo-voltaic panels and wind turbines used in the wind and solar energy plant market in Turkey, are imported. Domestic production should be encouraged by the work of the state.
- Wind turbines in residential areas should be increased by design of the wind turbines with high performance at low wind speeds and by the decreases in unit costs.
- Building systems should be developed and the economic infrastructure for the application of wind energy based application methods should be matured.
- The effects of building-supported and building-integrated wind turbines on buildings should be detected by technical studies beforehand, to ensure that the necessary safety measures are taken in order to prevent the threats for public safety.
- It is necessary to ensure that renewable energy technologies and applications are introduced to different segments of the society, and to increase social awareness and sensitivity in this topic.
- The contribution of renewable energy technologies to the country's economy is not only to reduce dependence on foreign sources in energy. It should also be adopted as a state policy that will enable employment with new lines of business.

As a result; by raising awareness of the society and regulating the legal arrangements to promote the use of renewable energy resources, the studies similar to or more than the world examples can be developed in our country, as well.

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