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THE EVALUATION OF THE SOLAR ORIENTED ENERGY EFFECTIVE BUILDING DESIGN UNDER THE MEDITERRANEAN CLIMATE CONDITIONS IN TERMS OF WATER HEATING SYSTEM

Gizem **T**ET K

Department of Architecture, Istanbul Aydin Univesity, Florya, Istanbul, Turkey

E-mail: tetik_gizem@hotmail.com

Abstract- *Within the acknowledging of the fact that the half of the resources of the earth is being utilized for construction purposes; in this dissertation, which aims to lower this rate for our country by raising the awareness of the society, it is asserted that the utilization of the solar energy, unlike the common belief, should be considered as a passive manner during the design phase, before utilizing it in an active manner and the types of utilization, in which the solar energy can be benefitted at its full, is further demonstrated. Within this context, the analyses of the solar energy systems were conducted, the variables according to the climate and building types were discussed and the current suggestions for the improvement were presented along with the relevant literature reviews and case studies.*

Keywords: Sustainability, Solar Architecture, Solar Power, Mediterranean Climate, Solar Energy Systems

1. INTRODUCTION

The need for energy rises in the world with an ever increasing pace and this results in various problems in terms of social, economic and environmental aspects. The aforementioned problems raise the significance of the energy needs to be met by the clean and renewable energy sources each day. The share of the energy that is consumed for the heating and cooling of the living spaces in order to maintain comfortable living conditions has a significant place in the total consumption. In European countries, %40 of the primary energy consumption goes for meeting the energy requirements of the buildings [1]. Energy is the most important requirement of the mankind in every aspect of the daily life as well as in the activities it performs. The sources that are used for providing energy are varied. They are basically renewable and non-renewable sources of energy.
The thread of the depletion of the fossil resources and the increase in the energy requirement also increased the interest in the renewable energy sources.
The largest source of energy for earth is the sun. In addition to being a renewable energy source, its basic property of being an environment friendly source is what sets it apart from the other energy sources. Another reason for the increase in the studies on the solar energy is that it does not require complex technologies and it is not affected from price increases.

2. UTILIZING THE SOLAR ENERGY

While the solar energy can be directly utilized in passive systems, the active utilization involves solar powered systems, in which the hot or cold air or the liquid are managed / operated by the use of pumps and fans.

2.1. GENERAL UTILIZATION OF THE SOLAR ENERGY

Since the beginning of the world, the sun played the most important role in the emergence of life on earth as well as the in its course until today. Such that the first known religion is the heliolatry (worshipping to sun).
Sun is one of the renewable sources of energy. The sun conveys an amount of energy in a year which corresponds to an amount that 150 times the coal reserves have [1].

The methods of harvesting of the solar energy can be listed as follows;

The solar collectors **(Systems that generate hot water);** are the systems, used in the households,

workplaces and in industry and provide hot water. The collectors that congest the solar energy, heat up the water within its system. Such a system is supplemented by various pumps and valves. Different system capabilities are chosen based on different requirements. Such systems, which do not have further costs or expenses after the initial investment costs, are used in Turkey in regions with the Mediterranean Climate.

The thermal solar power plants**;** are the systems that generate electricity from the solar power. The meteorological data of the location of the plant should be taken into account when establishing such systems. The data include values such as the annual rate of rainfall, the duration under sunlight etc. These systems, with very large scale constructions, can be used to provide nationwide power.

The photovoltaic devices - the solar cells; are the applications that provide rather smaller scale energy generation and are generally used in various devices, vehicles, items and buildings, located in rural areas.

2.2. UTILIZING THE SOLAR ENERGY IN BUILDINGS

The solar energy, which is a clean, renewable and inexhaustible source of energy, is being used in architectural aspect with different possibilities. In recent years, such usage also demonstrated the changes in building designs as well. The current building today provide the conservation of the energy and they are becoming more and more the buildings that are able to generate solar power. Within this context, the structural envelope can be presented as one of the most suitable examples of contribution. Such contribution can be classified as the active and the passive contribution [2].

2.2.1. ACTIVE UTILIZATION

The active utilization can further be divided into two sub groups, comprised of the thermodynamic systems, that can be explained by the heat energy, obtained by the collector panels, and the photovoltaic systems that are used to harvest electricity from the solar energy using photovoltaic panels.

The solar collectors convert the incoming solar energy into the heat energy and transfer this heat energy via the liquid, stored within the system. The collected solar energy is used directly in the form of hot water for the heating of the building or being used at night after being stored. There are two solar collectors in general;

- Fixed Solar Collectors
- Sun Tracking Solar Focusing Collectors

The fixed solar collectors have the same area to stop and absorb the sun rays. However, the focusing solar collectors usually have a concave surface in order to increase the flow of radiation and by focusing the solar rays onto a small area, they provide high temperatures. The water, air or heat transfer oil can be used in the solar collectors as the heat transfer fluid.

Figure 1. Collector Samples [3]

The solar collectors vary depending on the fixed, moving or water circulating systems. The fixed collectors always remain at the position they are situated at and do not track sun. The sun rays pass through the transparent surface and are absorbed by the black absorbent surface with a high level of absorbance capacity thus transferred to the conveyor liquid, stored inside the fluid tube. The transferred energy is then conveyed by the conveyor liquid in order to be used or stored.

The solar energy plants are large scale plants that generate electricity from the solar energy. The power generation in such plants are large enough to enable energy distribution to the cities or countries.

The photovoltaic systems; there are PV modules with different system characteristics, which are replacing the conventional roof and siding elements by being designed as a new breed of construction shell that function as the traditional shell. The functions of the shell are multi dimensional. The shell, regarded as a construction component, create venues inside the structure that provide the comfortable living conditions. The main reasoning behind the concepts of "interior" and "exterior" is that there is a separating element present in between. The shell, in addition to being a separating surface, also has to undertake various functions.

2.2.2. PASSIVE UTILIZATION

The main principle in passive utilization of the solar energy is to benefit from the radiation in maximum level by the measures, taken in the shell of the structure as well as by the additional systems to be installed to the shell.

2.2.2.1. Direct Yield

The direct systems works by directing the sunlight directly to the areas by the glass surfaces. In such systems, the sunlight is converted into the heat by radiation. Because of the fact that all structures contain glass, the direct systems are the most commonly used and least costly heating systems. Due to its transparency, it increases the area temperature from time to time.
If they have windows, facing to South, many houses have this direct yield. In a direct yield system, the sun radiates within the area directly. First the air of the room, the walls, floor and other heat able bodies are heated up by the sun and hot air. The living areas begin being overheated and significant temperature fluctuations may occur.

2.2.2.2. Indirect Yield

In indirect systems, the solar radiance is converted to the heat outside the room and then conveyed to the room by transfer or radiation.
The generated energy can be transferred to the area in nighttime. However, due to having an inadequate level of insulation, such systems are deemed disadvantageous in terms of heat loss.
The greenhouse application or heated rooms are the methods, used in the structures through passive heating systems. This method is obtained within a heat storing wall system by enlarging the space between the glass surface and side well thus surrounding the structure with a greenhouse. The purpose behind the greenhouse application is reducing the heat loss in living areas. Most of the greenhouses are made of glass and the heating up of the ceiling is performed through the sun.
The trombe wall application is a system that is built from a transparent surface on the southern side of the building and a dark colored and heat storing wall, thickly built around 10 cm inboard of a high density material. The sun rays, passing through the glass, are absorbed by the wall and subsequently stored within. Therefore, the air between the glass and the wall is heated and is distributed to the interior areas. The wall, being thick, ensures the heat storage and enables the heat to be distributed to the interiors at night with a lag. The chimney effect is present in this system thus while the air between the wall and the glass is ejected by the natural transference, it is replaced by the fresh air, coming from the opened windows on the northern side and as the result, the interior is ensured to be cooled at all times.

2.3. THE DESIGN PHASE OF THE STRUCTURES THAT UTILIZE THE SUN VIA PASSIVE SYSTEM

Heating up the spaces via solar energy by the planning decisions, taken during the planning phase and the materials, chosen within the scope of such decisions, is called passive systems. Apart from using passive systems for the utilization of the solar energy, the ecological building design can also be complemented by integrating mechanical hardware to the structures as well.

3. ASSESSING THE SOLAR POWERED HOT WATER SYSTEM IN BUILDINGS IN MEDITERRANEAN REGION

3.1. THE CLIMATE CHARACTERISTICS OF THE MEDITERRANEAN REGION

The Mediterranean climate prevails in most of the Aegean as well as in the innermost parts of the Central Anatolian Region in addition to the parts of the Mediterranean Region that face to the Toros Mountains. The summers are hot and dry while the winters are mild and rainy. The snowfall or frost rarely occur within the coastal line.
While the mean temperature in January is 6.4°C; the mean temperature in the hottest month, June is 26.8°C and the average annual temperature is around 16.3°C. The annual total rainfall is 725,9 mm and the most of the rainfall occurs in winter. The share of the summer rainfall within the total is %5,7. This region is dominated by the summer drought. The annual relative humidity %63,2 [4].

We can list the characteristics of the Mediterranean climate as follows;

- The average annual temperature is 15 - 18 degrees.
- The average temperature in July exceeds 25 degrees.
- The average temperature in January is around 10 in southern parts while being 7-8 degrees in Aegean coastline.
- Due to the fact that it enters into the influence of the desert climate from South during summer months, no rainfall occurs.
- Almost half of the rainfall occurs between November – April depending on the frontal effects. (1000 mm.)
- The mountains, stretching in parallel to the coast lead the humid air subsiding on the coastal area in winter thus render the rainfalls last long [5].

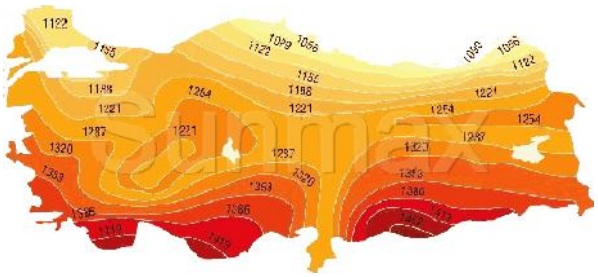

Figure 2. Solar Energy Radiation Map Of Turkey[1]

3.2. THE SOLAR POWERED HOT WATER SYSTEMS, IMPLEMENTED IN MEDITERRANEAN REGION IN TURKEY

By its simplest context, the solar powered systems and its branch, the solar powered boiler systems are being used as the means of harvesting the solar power.

3.2.1. SIMPLE SOLAR ENERGY SYSTEMS

In a solar power system, working at its most basic principle, the type of utilization is water heating.

Figure 3. Sample Building Analysis

As it is seen from the structure, in which the sample building figure 3 review shall be conducted, this system is prefferred in regions, where the Mediterranean climate prevail and this scene is a common one at all. As the coating material; aluminum foil or galvanized metal sheet are preferred.

Figure 4. Solar Energy System Analysis [6]

In the system, seen in the image, the tank on the bottom is the cold water tank and the pipe, coming out from the tank is the transfer pipe, which is used for balancing the atmospheric pressure. Hot water is stored in the tank, located on the top side. Due to the difference in density between the hot and cold water, the density of the water decreases as its temperature rises. This renders the hot water rising to the top. There is no connection between the cold water tank and the collector. The pipe, coming out of the collector, sends the heated water to the upper tank, there is a direct connection between those two.
The hot water in the upper tank is distributed to the users directly via the distribution grid. Even if the hot water is not used, it is transferred to the fixtures of the consumption areas, standing ready to be used.

3.2.2. SOLAR POWERED BOILER SYSTEMS

In boiler systems there is a circulation pump in addition and there are also differences in storage systems. Especially in multi, storey structures; the presence of a circulation pump is a necessity as sometimes a circulation pump is required to be placed within few floors.

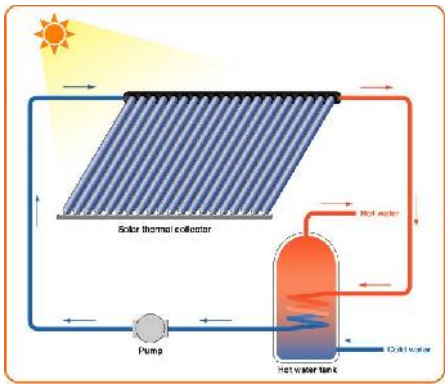

Figure 5. Solar-Powered Hot Water Supply System Analysis [7]

The hot water, coming in by being heated up at the solar energy collectors, descends and the descending

water loses heat. The serpentine is located within the boiler tank. The serpentine is made of a material with high heat insulation. Within the serpentines; the water, which is never mixed with the water within the tank, is constantly circulated. The usage water is the water that is accumulated within the tank and the aim of the serpentine is to heat up the water inside the tank. The boiler is the point of exit of the grid, located on the upper side of the tank, where the distribution of the outgoing hot water is performed. By the cold water intake, located on the bottom part of the tank, the water, which shall be prepared to be heated up, is taken inside the tank. Inside the boiler, the hot water ascends due to the difference in density between hot and cold water. However, this is also valid until all the water inside the boiler is heated up. This process is also included into various calculations such as the tank and collector size and their quantity etc.

4.CONCLUSION

The energy is required for the continuity of the daily life. Today, the renewable energy sources are getting into prominence. The ever depleting reserves, increasing costs and the environmental factors are the reasons of this. It was concluded that Turkey holds a great potential in terms of solar radiation and thus energy requirements should be met with the solar powered systems and the economic benefits should be obtained from this as well. By analyzing the potentials that Turkey has; it was extrapolated that one of the most useful resources is the solar energy. The recommendations for improvement for the current systems were presented over the sample building cases. Popularizing the solar energy systems in Turkey should be adopted as a state policy.

4.1. SAMPLE BUILDING CHARACTERIZATION

Figure 6. Sample Building

The sample building, seen in image 6 and 7 is a residential structure, located within the Mediterranean climate conditions in Turkey. Solar powered water heating system is present in the structure. The insulation of the system is insufficient and there is no circulation pump present.

Although the solar energy systems are gradually being generalized due to the fact that they are the sources of clean energy in addition to the low costs, the misapplications, summarized below result in;

- The obtained energy is dissipated throughout the day,
- Since the expectation of instant hot water is not met, an electrical heater is added to the system and this renders the solar heating system investment meaningless.

However, such systems lack the technological advancements and contain shortcomings. In solar powered water heating systems, as it seen from the image, the pipes outside the building, which are subjected to the outdoor conditions, should be insulated. The material of choice for the insulation is glass fiber and since glass fiber shall be worn off rapidly due to its structure and texture, coating materials are used for additional protection.

If hot water waits for a long period, without being used, it loses its heat in the bank. That's why the water is not at the temperature that we want when we initially open the fixtures. If there had been a circulation pump to maintain the perpetuity of the system, the hot water shall always be present during the sunny hours. Although the fact that such a system exists in solar powered boiler systems; the circulation pumps can also be integrated into the simple solar energy systems as well.

4.2. THE RECOMMENDATIONS OF IMPROVEMENT FOR THE SAMPLE BUILDING

The insulation of the pipes, outside the structure; the currently fitted service pipes outside the structure should be protected by heat insulation in order to prevent the daily and seasonal temperature changes in the water inside the pipes (including the prevention of freezing during winter months) and to ensure that the hot water reaches to the user rapidly.

The insulation of the pipes, inside the structure; in the traditional systems, no insulation is applied to the in-structural installment pipes. As the result of the insulation to be applied as a part of the building improvement, the still standing water inside the pipes shall maintain its temperature.

Space organization; since installing the main pipe that performs in building distribution, next to the spaces, where the hot water usage is heavy, shall decrease the amount of the water that wait inside the grid and shall keep the process of running the mild water that is cooled within the grid pipes, short; this shall be an implementation to be taken into consideration. The designer, within the scope of the

principle of the space designing, should make the plans in a way that insures the shortest distance between the spaces with the heaviest hot water demand and the distribution lines.

The grid system; as an alternative for using a single distribution pipe; independent grid networks can be established by allowing the entry of the hot water, waiting in the tanks, to each one of the areas of usage. In single pipe method; the top floor, which is located as the closest to the tanks, is the space, which utilizes the system in the most comfortable way. The utilization of the user drops in a linear manner when descending from the upper floors to the lower levels. By establishing a multi grid line, the independence of the users in a building will be achieved and the obtaining hot water for the users will be eased. In addition, this system shall make great contributions to avoid wasting water.

Insulation of the tanks; in case there is no insulation in the tanks, due to the daily temperature differentiation, the energy, obtained in sunny hours shall be lost during the time, when there is no sun present. In such cases, the purpose of setting up a solar system would fail. Undertaking heat isolation in such cases shall be most beneficial for both the hot and cold water tanks. The heat loss of the water, brought up to the intended temperature but being kept in the tank, that will occur in case the water is not used, shall be kept at a minimum level as the result of the insulation of the tank. And by the insulation of the cold water tank, the temperature of the water to be heated up shall be at a higher level and this shall fasten the operation of the system and shall prevent situations caused by the un-heated water, reaching to the freezing point, which will hinder the operation of the system.

The circulation pump; in order for the water, circulating within the distribution grid to be hot during the usage, the circulation is necessary. Otherwise, until the hot water in the tanks reach to the fittings, the cooled water within the pipes shall run for waste. This shall render the energy collection system useless and shall lead to water waste.

The image of the simple solar energy system; as seen from the images, the solar collection systems, installed on the roofs, are the systems that disrupt the architectural identity and that create visual pollution for the city and the residents. Placing the tanks inside the building when installing the solar energy systems shall avoid the visual pollution and in addition; since the only system components that can be seen outside the building shall be the collectors located on the roof, the visual pollution shall be further limited.

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