

SOLAR WALL SYSTEM, THE SUN-CENTERED APPROACH TOWARD ECOSYSTEM

Masoud Valinejad Shoubi¹ and Mojtaba Valinejad Shoubi²

INTRODUCTION

Energy costs are continuing to rise as the Earth's fossil fuel resources diminish. In addition, the population of the earth is increasing, meaning that the use of these scarce resources will increase at a faster rate than in the past. Inevitably, the result will be continuing increases in the Earth's temperature, resulting in widespread climate change that could have devastating environmental impacts. Thus, as the Earth is moving rapidly toward an energy crisis, sustainable architecture with enhanced energy efficiency takes on great importance in seeking to establish a reasonable balance between human needs and the environment. To achieve this balance, it is essential that we use every available means to manage and reduce people's basic needs—such as heating or cooling of living spaces—in order to minimize our use of non-renewable energy sources. The Sun is one of the largest and cheapest sources of energy. This tremendous resource has the ability to meet a large portion of human needs. In recent decades, solar energy has been used extensively to achieve environmental sustainability. One of these applications is the use of solar energy to provide warm air in buildings. The purpose of this paper is to investigate renewable energy sources, particularly solar energy and the solar systems currently in use around the world. By assessing their positive and negative attributes, we also intend to propose an alternative solar wall for producing warm air in buildings. Thus, in addition to addressing the weaknesses of previous products and approaches, we intend to augment the energy savings and decrease the costs associated with such systems by combining the positive attributes of several different systems to produce more efficient air heating, lighting, air circulation, and air purification.

KEYWORDS

renewable energy, solar energy, solar wall system, sustainable architecture, energy efficiency

1. BACKGROUND

The current emissions of greenhouse gases have resulted in many climatic changes and will continue to have significant effects on climate change in the future. The long lifetime of carbon dioxide in the atmosphere means that this gas will affect our planet for at least the

¹ Young Researchers and Elite Club, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

²Corresponding Author: Mojtaba_vlj256@yahoo.com. Young Researchers and Elite Club, Babol Branch, Islamic Azad University, Babol, Iran.

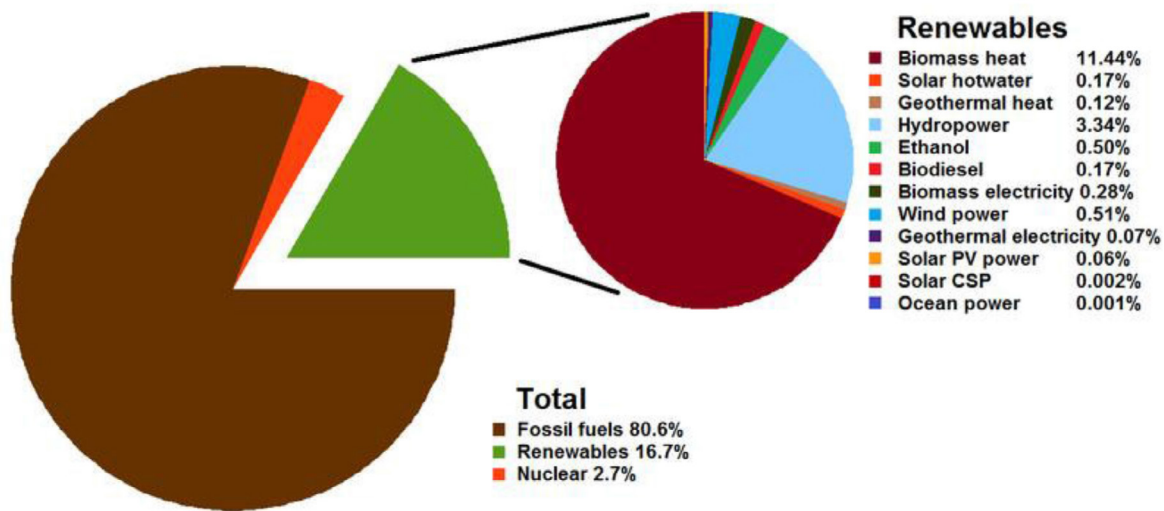
next 30 to 40 years. Many countries around the world are considering how they can reduce their greenhouse gas emissions [1]. According to the International Energy Agency (IEA) [2], improving energy efficiency in buildings, industrial processes, and transportation can reduce the world's energy needs by about 33% in 2050, which would contribute to the reduction of global greenhouse gas emissions. These changes will not happen without the development and implementation of appropriate policies related to energy consumption in the building sector. This can be achieved by using a sustainable design approach for buildings. Sustainable design can occur only if its definition is understood and builders have an appropriate, supportive attitude about it. If the goal of the project is to preserve the surrounding environment by identifying the environmental benefits of sustainable design, the most efficient solution would involve using renewable natural resources and reducing the use of non-renewable resources. Eco-design and sustainable development (SD) are considered as the key factors for sustainable living. This design must include the development of appropriate technologies in order to balance the environmental movement, and they must be considered as one of the main components of an environmentally-conscious lifestyle [3]. Thus, energy efficiency and renewable energy must be accepted as the main pillars of sustainable energy policies. The purpose of this study was to investigate solar energy as a renewable resource that can help us achieve sustainability. Specifically, the study was focused on an alternative solar wall that has ability to absorb solar energy and provide the heating required for the interior of buildings. This approach is especially advantageous in mountainous areas, where it is warm during daylight hours and cold at night.

2. RENEWABLE ENERGY

Probably the oldest source of renewable energy is using the wind to move boats across water. Ships on the Nile River about 7000 years ago used this technique to move from place to place [6]. This kind of energy is derived from the natural process of air movement across land and water. Renewable energy can be derived from various natural phenomena, such as sunlight, wind, tides, plant growth, and geothermal heat [4]. The Earth's non-renewable energy sources are concentrated in a limited number of countries, but renewable energy sources are ubiquitous and create significant opportunities to save energy over widely dispersed geographical areas [5]. The development and use of these resources could enhance the energy security of many countries by allowing them to rely on inexhaustible local resources while at the same time increasing their economic and social stability and reducing pollution and climate change. However, many countries, especially third-world countries, continue to use non-renewable energy, even with the associated risks to their economies and to the global environment in the future. Figure 1 shows the ratio of the types of energy consumption in the world and it clearly indicates that greater attention and investment should be made in developing sources of renewable energy.

Figure 1 shows that only about 17% of the world's energy usage comes from renewable sources. Only about 0.23% of the world's energy needs is met by solar energy. It is clear that, given the full availability and daily continuity solar energy, this source demands more serious consideration. Solar energy can become a significant source of energy worldwide, allowing us to make significant progress in solving some of the problems mentioned before [10]. So the essential research must be conducted that will allow this source to be recognized and utilized to a much greater extent in the future.

FIGURE 1. Sources of the world's current supplies of energy (2010) [7].



3. THE SUN AS A SOURCE OF RENEWABLE ENERGY

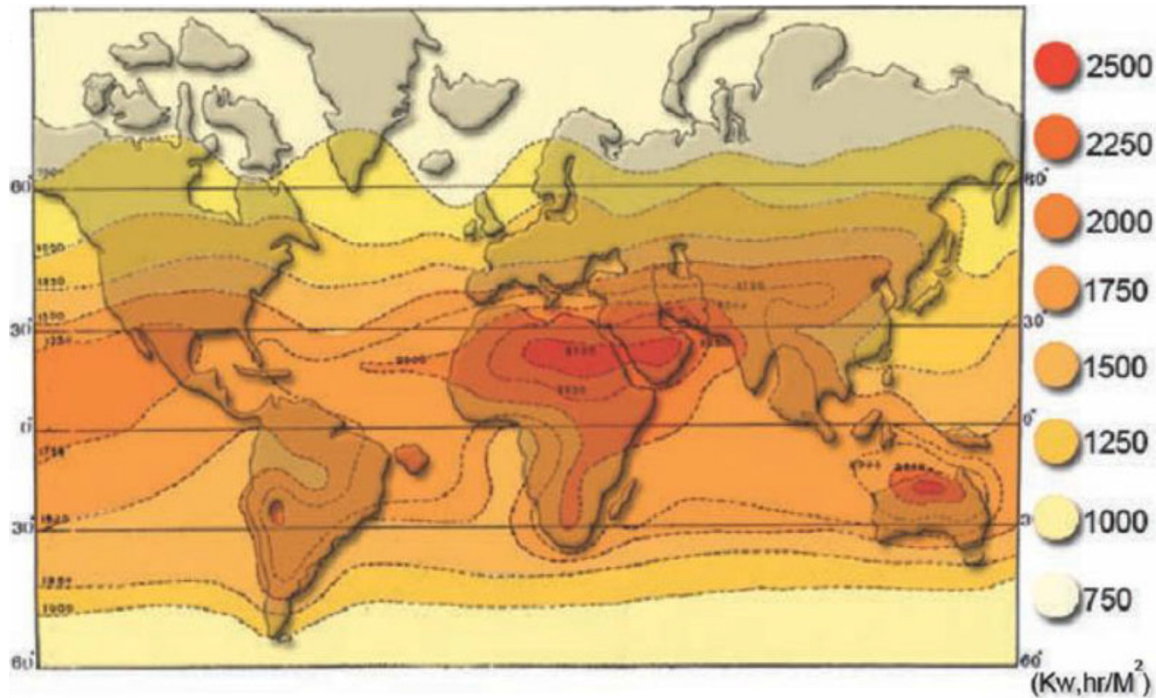
Solar energy is a 'free' source of energy and it is clean and free of adverse environmental impacts. Having been used extensively by our ancestors, the sun has radiative power equivalent to 1.4 kW/m^2 in the Earth orbit. The annual average of 24 hr of radiant energy is estimated to be about 0.2 kW/m^2 [8]. In other words, the energy produced from three days of irradiation of the Earth by the sun is equal to the energy produced by the combustion of all of the fossil fuels in the Earth. Therefore, it can be concluded that 40 days of solar irradiation—if the energy could be stored—produces enough energy to meet the Earth's needs for 100 years [9]. Generally, solar energy applications are limited to two aspects—lighting and solar heat; however, all sources of renewable energy—other than geothermal and tidal energy—originally obtained their energy from the sun. Although the available solar energy on the Earth is about 10,000 times the amount that is currently consumed, it has not been exploited to anywhere near its actual potential [8]. Figure 2 shows the amount of solar radiation in different parts of the world.

Both sunlight and heat have specific effects on our physical and mental well-being. Radiant light and heat from the sun have led to the development of a wide range of technologies [10] and ancient civilizations, with their knowledge of this matter, designed their buildings taking into account the light and heat from the sun to achieve maximum comfort and energy efficiency. The two categories—the roles of light and heat from the sun—are investigated below to determine how they were used to make living spaces more comfortable.

3.1. Light from the Sun

The sun is the main source of light and the reflection of this light is a sub-source [8]. The surrounding world can be detected by people due to the existence of light. Thus, light can truly be considered as the interface that people use to communicate with the surrounding world. People have devised ways to produce light during the hours of darkness when light from the sun is not available. Some examples are fires and lamps. But the lack of appropriate building design in the urban sector has led to the use of artificial light even when the sun is shining and

FIGURE 2. Annual solar radiation in different parts of the world (Kw.hr/M²).



this artificial lighting consumes a significant proportion of all energy consumed in the world. In residential and office buildings, 20 to 50 percent of the total energy consumed is due to lighting [11]. Eliminating the unnecessary artificial light usage in some buildings during daylight hours can reduce the energy consumption attributable to lighting by as much as 80% [12]. This saving cannot be achieved unless appropriate designs are used to allow sunlight to enter the building during the daylight hours.

In addition to saving energy, sunlight also kills germs and promotes the mental well-being of the occupants. According to studies conducted by Robert Urich (1972, 1981) [13] on 23 patients who had undergone surgery, there were fewer complaints from the patients when their rooms had windows that allowed the natural light to enter.

At the present time, various computer software programs are used to determine the appropriate amount of light for a given space. This approach reduces the incidents of incorrect decisions being made by architects and facilitates appropriate light planning. Calculations of the amounts of light in given locations are useful in preventing the excessive use of light sources. Excessive lighting wastes energy and can produce undesirable health effects, such as headaches, high blood pressure, and stress. In addition, workers' productivity can be diminished if the light is excessive and if they are sensitive to the light [14].

Below, we investigate two different types of designs for the control and efficient use of daylight in buildings.

Figure 3 shows that a small canopy can be used in the middle part of the window to control the daylight in various seasons. This canopy avoids direct reflection of sunlight to the residents and instead releases the sunlight indirectly into the space, which can lead to a decrease in the boldness of the light and the decentralization of the light. But in winter the

FIGURE 3. Use of a canopy for windows in different seasons [15].

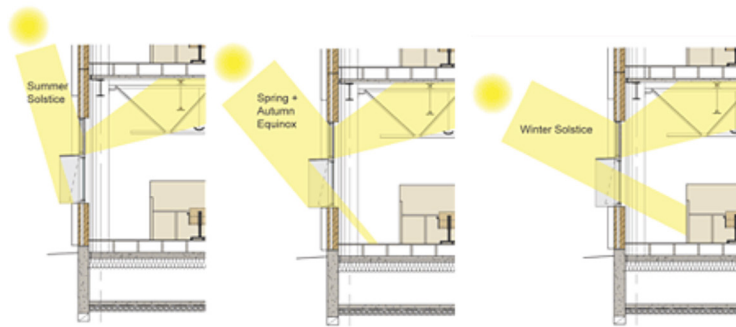


FIGURE 4. Sample of ceiling light [16].



canopy directs some of the light directly to the interior space to create a pleasant space in the cold winter months.

Sometimes, because of the close proximity of buildings, privacy policy, or special applications, inserting windows in the building may be impossible. By using the method outlined in Figure 4, designers conduct light from the roof to the inside the building. The system consists of a simple solar channel made by an aluminum tube, a glass or polycarbonate dome that is completely transparent, and an opaque glass container to be used for conveying the light to the inside the building.

3.2. Solar Thermal Energy

The temperature of an object actually represents the speed of its constituent particles. In other words, the higher the speed of the particles of an object, the higher the temperature of the object is. Therefore, it can be said that the increase of an object's temperature means the increase of the kinetic energy of its particles. The wavelength of the electromagnetic radiation from the sun is between 0.28 and 3.0 microns. Since glass is opaque to radiation with a wavelength of more than 4.0 to 10 microns (depending on the glass), when radiation from the sun shines through the glass it can easily pass through. It then collides with the air and other objects behind the glass, causing their temperatures to rise along with the emission of long-wavelength thermal radiation. Because of the properties of glass, the radiation accumulates in the space behind the glass and the temperature increases.

This property also exists in the atmosphere, which means a large portion of the radiation reflected from the surface cannot be removed from the atmosphere. This phenomenon causes the living space on Earth to increase in temperature; however, human activities—mainly burning of fossil fuels and deforestation—exacerbate this natural phenomenon and cause excessive warming of the Earth [17].

Designers have suggested different strategies for the optimal use of solar thermal energy and each one has various aspects that must be considered. Below, some examples of these strategies are discussed.

Figure 5 shows direct passive solar heating in the building. For passive solar heating, two primary actions occur—the use of glass on the south side and the use of thermal mass to absorb, store, and release the heat. The thermal mass used must have a high heat capacity so that it can absorb heat during the day and release the heat during the night. The size and

FIGURE 5. Direct passive solar heating.

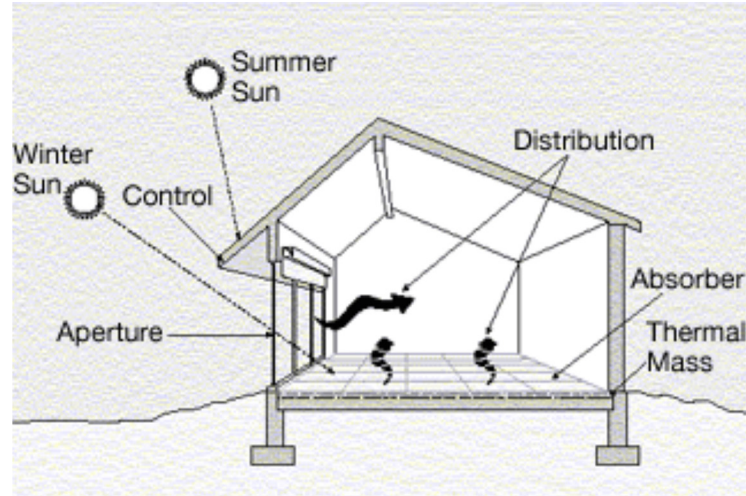
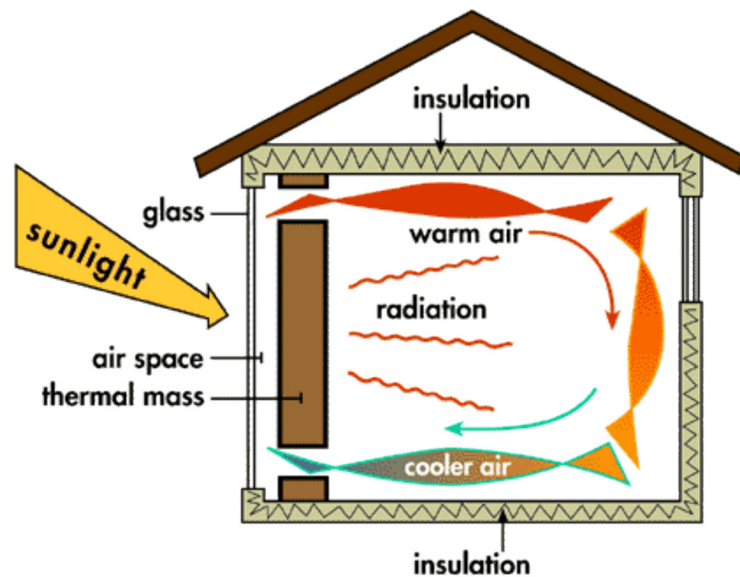


FIGURE 6. Indirect passive solar heating.



placement of the thermal mass depend on various factors, including climate, day lighting, and shading. If the mass is placed properly, it will maintain the room temperature in the comfort zone and will reduce the need for additional heating and cooling equipment [18].

Figure 6 shows indirect passive solar heating in a building. This system is formed by a thermal mass near the window placed some distance from the glass. The sunlight causes the thermal mass and the air between the glass and thermal mass to be warmed. The less dense hot air goes to the top, enters the room, and is replaced by cold air from the room. The convective flow is continued until a balanced temperature is attained in the room.

Figure 7 shows one solar thermal technology responsible for heating the air and providing the building's heat supply. This process consists of a free-glaze, metallic, adsorbent bed, that is responsible for conducting the solar energy to the air [19]. The metallic absorbent is usually made of aluminum or steel and placed every six to ten inches to create an air space between the walls and the cladding, which is far from the available ordinary walls [20]. The cladding has small holes on the surface and a fan is used to draw the fresh air in where it can

be absorbed [21]. The air heated by the absorbent is about 75 degrees warmer than the ambient temperature. This hot air can also be utilized as a direct heating system for the building [22].

3.3. Advantages and Disadvantages

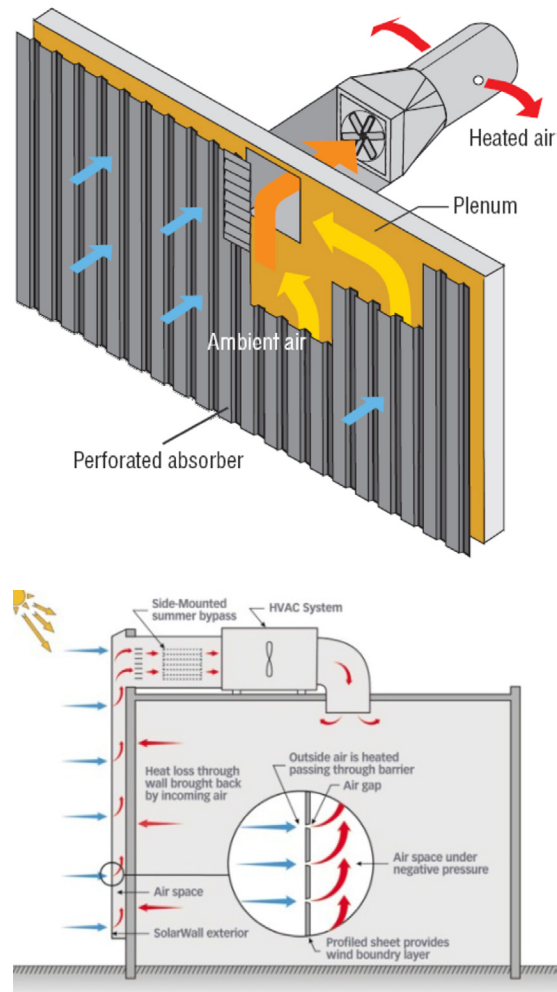
In the system shown in Figure 5, a larger absorbing surface is required to absorb the heat due to the lack of separation between the light source and the provision of heat. On days when the heat is not needed, an insulating surface can be placed on the window, allowing the light to enter but reducing the heat. Its passivity feature can be noted as an advantage, and it can be constructed and operated in any location and circumstances.

In the system shown in Figure 6, placing an absorbent in front of the place where the light enters the building provides light and brightness in the system, but the fact that the system must occupy an interior part of the building can be noted as a disadvantage. However, the combination of both radiation and convection flows for heat transmission and the system's simplicity are definite advantages.

The system shown in Figure 7 has gained acceptance for use in factories, office buildings, and other large buildings, but the lack of sunlight entering the interior space of the building can be considered as a disadvantage of the system. The positive aspect of this system can be air conditioning of the interiors of buildings and its integration with the cooling system.

In the United States, more than 25 percent of the energy used in commercial buildings and almost half of the energy used in residential buildings are attributable to air conditioning and ventilation. Solar heating, cooling, and ventilation technologies can be used to offset a portion of this required energy [23]. The future well-being of cities around the world depends on the ability of people to develop and utilize environmentally-friendly technology. To achieve this, the use of multi-functional systems with minimum complexity is recommended. Multi-functional systems can provide better performance with minimum cost

FIGURE 7. Sample of solar thermal technology.



and minimum complexity, as evidenced by the use of such systems by the indigenous people of various regions all over the world.

If a space is defined by floor, shell, and roof, the shell and roof elements are always heated by direct solar radiation. But the sun's radiation in the afternoon or in cold seasons of the year has a greater effect on the building's exterior shell. Because of that, the thermal energy should be reflected on the roof and saved in the shell, especially in the parts of the building that do not receive direct sunlight.

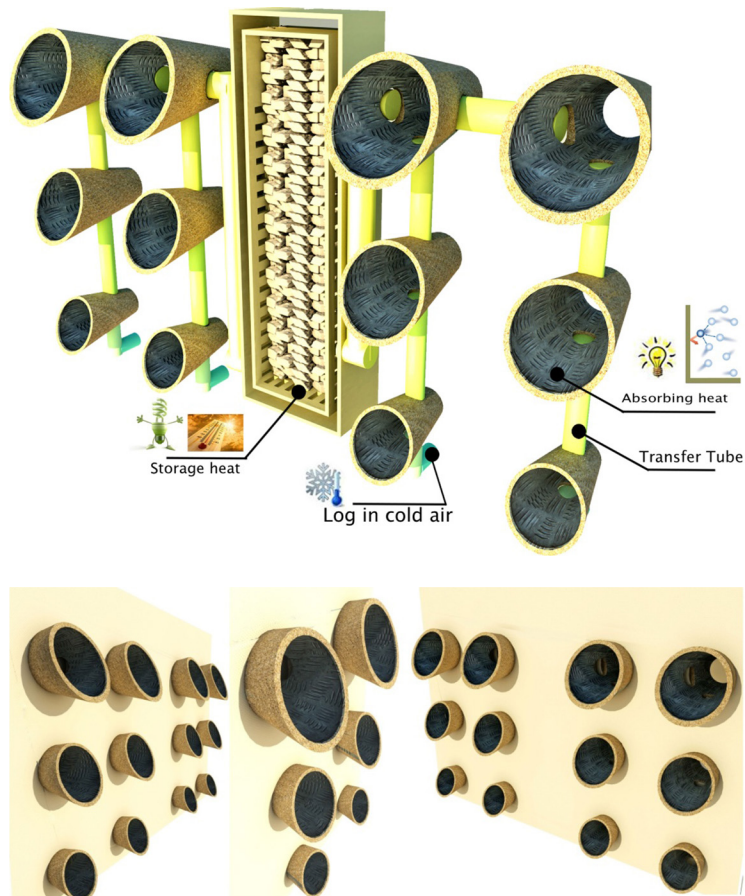
So, the proposal to use a solar wall is focused on three key issues:

1. Functional integration of the proposed system: The three functions of light, heat, and ventilation must be provided.
2. Passivity: This system, as a part of the building, offers a combination of absorption, heat storage, and heat distribution that works appropriately.
3. Simplicity: To encourage and stimulate indigenous people to use this system, the easiest technology was used in its structure.

4. PROPOSED SOLAR WALL

Solar wall technology allows the balanced achievement of thermal comfort by heating air with renewable solar energy. This system can be considered one of the most affordable solar technologies. Using solar radiation for heating the surface of an absorber, transferring the

FIGURE 8. Overall structure of the proposed solar wall.



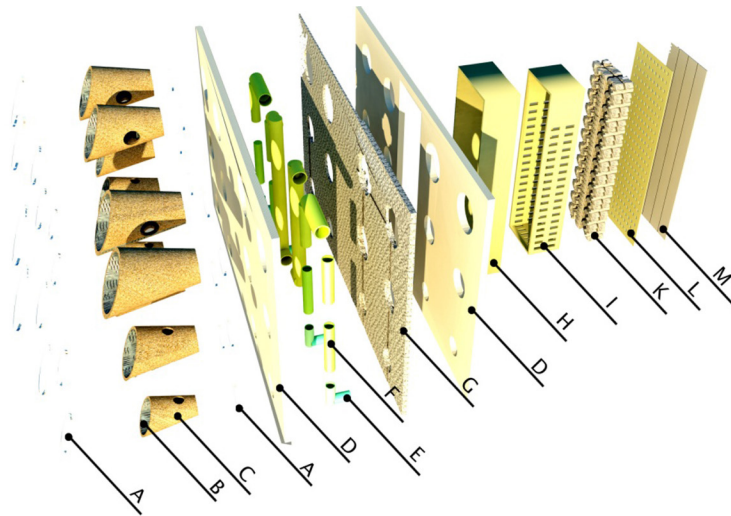


FIGURE 9. Structural components of the proposed solar wall.

heat to the fluid interface (air), storing the thermal energy, and using the stored heat in the building when necessary describes the complete workings of the system. Collectors are actually part of the building and they can be installed as a window or skylight. Figure 9 shows the layers of the proposed solar wall, and these layers are explained in the following section.

A) Glass (3 mm thick) with a Nano Coating

As demonstrated in physics, when waves reach surfaces, three situations can occur. Some of the waves pass through the object, based on its degree of transparency; some of the waves are absorbed by the object; and some of the waves are reflected. Figure 10 shows the percentages of the waves that are transmitted, absorbed, and reflected.

These numbers are fairly accurate if the glass is clean. Dirty glass reflects more of the incoming light than clean glass and colorless glass. Dirty glass can reduce the light entrance level into the building by as much as 70% [8]. Table 1 shows the amount of light that passes through glasses with different colors.

To achieve maximum energy absorption in solar collectors, the amount of light that passes through the glass must be increased by reducing the percentage of reflected light. Nano-technology has made it possible to achieve anti-reflection glass. It can be achieved by using a

FIGURE 10. Percentages of the waves that are transmitted, absorbed, and reflected after reaching a surface.

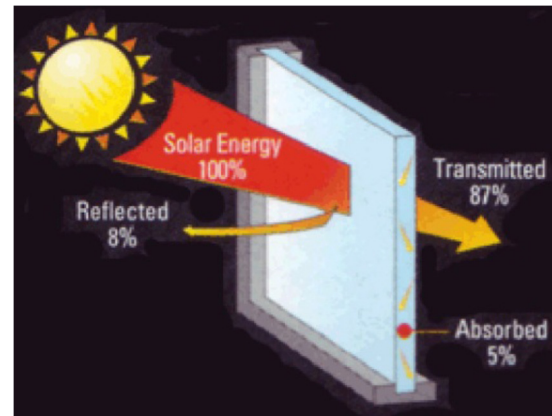


TABLE 1. Percentages of light that pass through various colors of glass.

Color of 6-mm-thick glass	% of Light that Passes Through the Glass
Colorless	87
Very bright green	73
Very bright blue	76
Clear or dark bronze	52
Light gray	44

layer of anti-reflection (AR) coating composed of a very thin layer of silica with large pores. By using this method, we can improve the transparency of glass up to 98% and, in addition, the glass also has anti-static properties and the efficiency of the collector can be increased by as much as 15% [24].

B) Metallic, Energy-Absorbent Surfaces

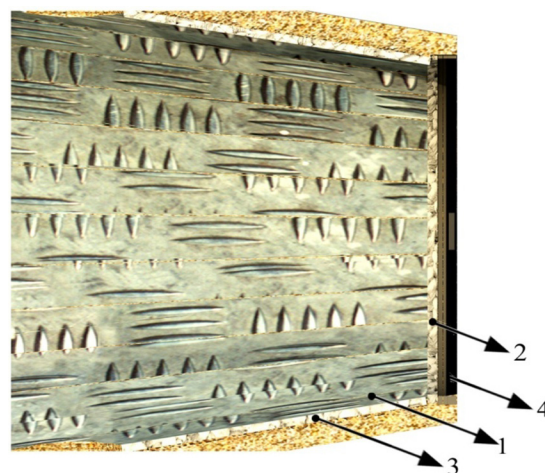
For maximum solar thermal energy absorption and transfer to the air inside the container, a layer of metal can be used on the inside of the container. A dark metal surface is used in the system because the dark surface will be about 39 °C warmer than a reflective white surface due to the absorption of solar energy [25]. Figure 11 shows the metallic layer that is used inside the concrete container.

Metals used for the absorber plate are primarily copper, white iron, galvanized layer, and aluminum, but brass and steel also are used to some extent. Copper has a higher thermal conductivity than most other metals and its corrosion easily can be prevented. For these reasons, we used copper as an energy absorber in our system. To prevent the loss of the collected energy, the absorber plate is covered with a suitable insulation material.

Metal expands as its temperature increases, and this could cause damage to other components. To solve this problem, a gap was placed at the beginning and end of energy-absorbing, metallic surface. This gap separates the metallic surface from the glass and the steel frame. A flexible thermal insulator, such as a cork, is used to fill this gap. Layer number 2, shown in Figure 11, indicates this kind of insulator.

Since metallic surfaces that absorb solar energy do not transfer the heat to the concrete surface, insulation can be used between them to prevent the loss of heat energy. Layer number 3 in Figure 11 indicates this kind of insulator.

FIGURE 11. Metal layer and surrounding layers used in the container.



C) Concrete Container to Collect Hot Air

The container is made of concrete that was prefabricated in a factory. In the pre-fabrication stage, a metallic absorber is placed in the interior part of the container. The air inside the container is heated by the metallic absorber. When a substance is heated, it expands and its density decreases. Light air is transferred through the tube to the next container. Figure 12 shows how the air circulates in the containers.

To create better air circulation, the upper containers were made larger to heat greater volumes of air so that each row of the concrete container is 1.5 times larger than the container below it. This is shown more explicitly in Figure 13.

The container, with its two layers of glass and the air between them, prevents the occurrence of annoying noises. The sunny side of the container was cut at a 30-degree angle in order to get maximum light energy from the sun during different hours of the day. This angle is the best angle for a solar absorber to absorb the maximum amount of sunlight. Each container has

two holes that hold the pipes through which the heated air flows. The holes are located at the top and bottom of the container, except for the top row of containers, where the holes are placed at the bottom and sides. Grooving action is considered for holes so that the transmission tube can easily be screwed inside them. The dimensions of this container and all of the other components of the system can vary. The dimensions of the components of this product vary based on the space used and the amount of heat storage required. Figure 14 shows the proportions of the components that we used. Although the sizes can change, the ratios are always fixed.

D) Double Wall

Double walls have been used with a layer of thermal insulation to minimize heat dissipation in the interior of the building. This wall can be made of any type of material, including bricks and blocks. But it must also be kept in mind that the solar system must be constructed during the construction of the wall. This is important because installing this system would be very difficult to accomplish after the wall has been completed. The insulation placed between the two layers of the wall prevents the transfer and dissipation of heat from inside the building to the outside, thereby facilitating the process of space heating.

E) Cold Air Transmission Pipe

Due to the higher density of cold air, it is always located in the lower layers of the air. By putting the pipe at the bottom of the system, the cold air from the room is absorbed into the system through a suction caused by the warm air in the container.

F) Transmission Pipes

The PVC transmission pipes are covered with insulation and transfer the heated air from the absorber container to the thermal storage container.

FIGURE 12. Air circulation process and heat diagram of the system.

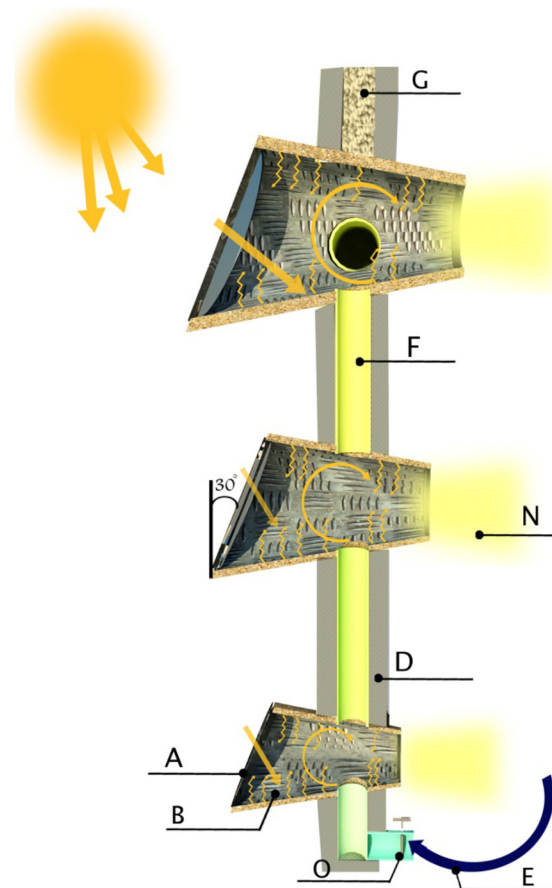


FIGURE 13. Various sizes of concrete containers in a vertical row.

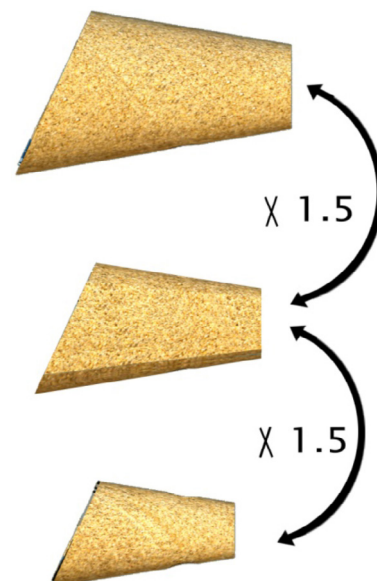
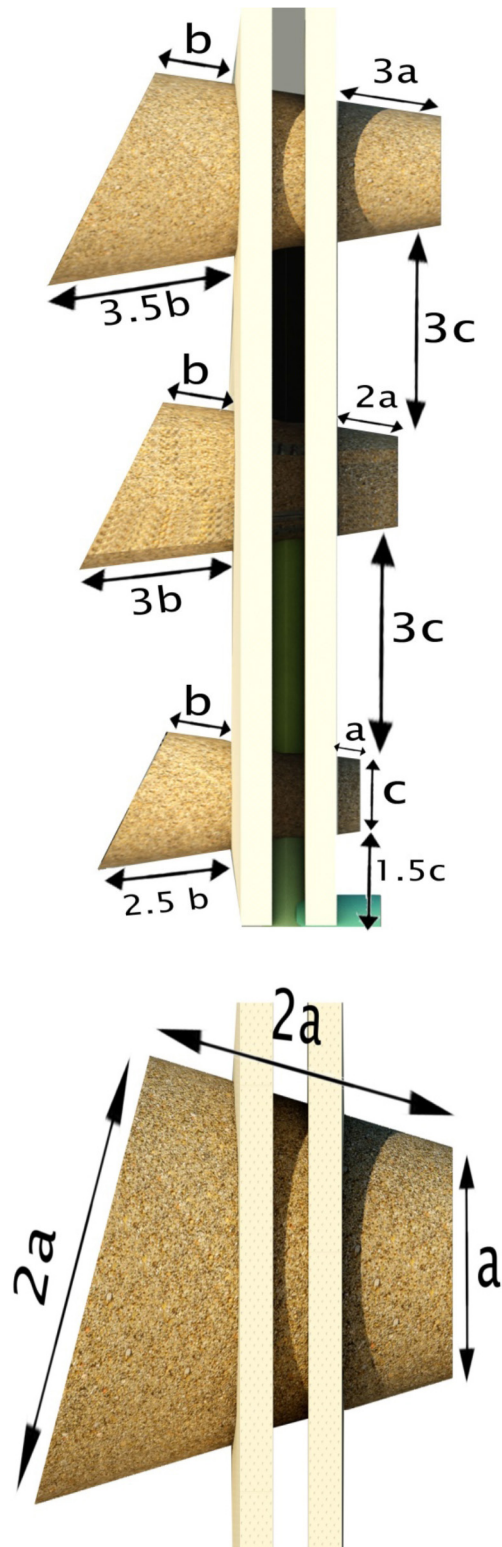


FIGURE 14. Proportions of the components of the concrete containers.



G) Thermal Insulation

Insulation placed between the two layers of the wall prevents the transfer and dissipation of heat from the interior to the outside.

H) The External Layer of the Storage Tank

The storage tank is composed of two layers. The outer layer makes the rotation of the hot injected air easier, and the second layer keeps the gravel in the tank. The outer layer is made of PVC with an exterior layer of insulation. It is used to collect the air that has been heated by the absorbers and transfer it to the central storage tank.

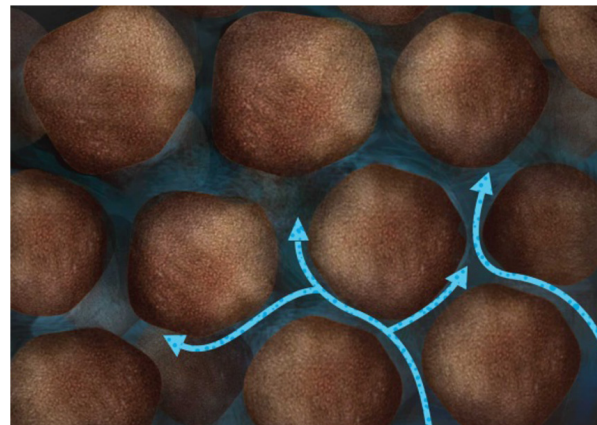
I) Internal Layer of Storage Tank

This container with holes in its body absorbs the hot air collected in the outer container and heats up the small and big stones that have the role of heat conservation. This tank is made of PVC to prevent the loss of heat resulting from the gravel.

K) Gravel

By placing the small and large gravel with high porosity, the temperature of the gravel is increased and the hot air is kept in the voids between the pieces of gravel. Figure 15 shows the movement of warm air in the voids between the gravel.

FIGURE 15. Movement of warm air between the gravel.



L) Exit Valve

The exit valve is composed of two parts—a shell with holes for heat transfer to the environment and an insulated cover to close it so that heat cannot be transferred to the environment and remains stored in the tank. This fenestrated metallic valve transfers the heat stored in the tank into the environment in two ways: 1) by introducing hot air to the space by the embedded holes and 2) by absorbing the heat from the gravel in the storage tank by a metal grille and transferring the heat into the space.

Insulating coatings are carefully composed of thermal insulation like a movable sealed door. When the hot air is no longer needed in the space, these insulating coatings are placed on the outlet valve of the storage tank to store the heat in the tank.

M) Insulation Coating

This movable door—which is carefully seamed—is formed of the thermal insulation. When the hot air is not needed, it is stored in the storage tank.

N) Interior Lighting

In addition to heat generation, this system also provides interior lighting. But the amount of sunlight that reaches the interior space is reduced by about 30 percent due to space between the two glasses. In this project, we increased the efficiency of solar energy collection by appropriately dividing the lighting levels. Figure 16 shows the comparison of the level of transparency between the conventional windows and the holes on the designed solar wall.

O) Control Key

When there is no need to provide hot air to the interior space, this key can be turned to block the entrance space of cold air into the system, thereby stopping air circulation in the system. Figure 17 shows this process.

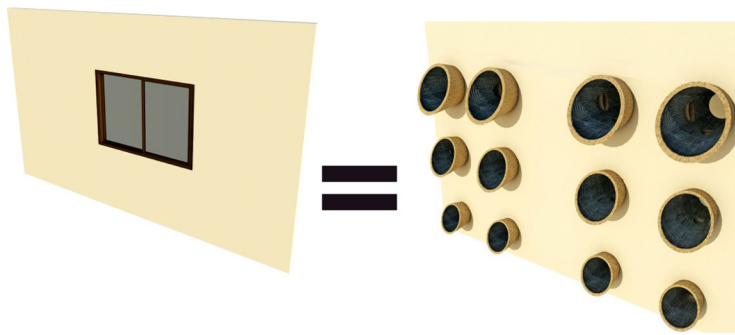


FIGURE 16. Comparison of the concentration levels of transparent surface.

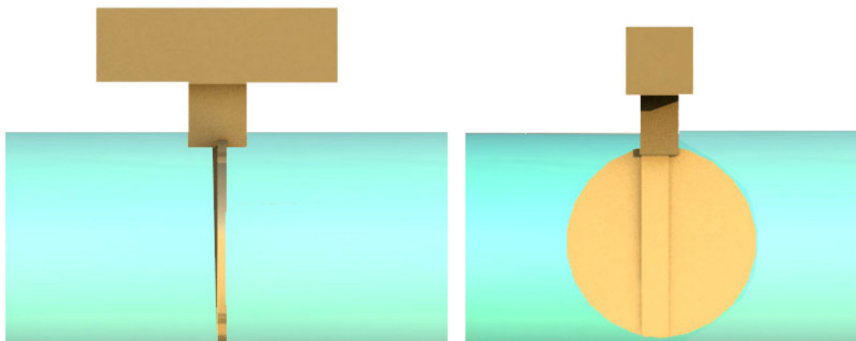


FIGURE 17. Opening and closing the control key in the pipe.

P) The Way Hot Air Enters the Storage Tank

The reason for placing the entrance part of the warm air at the bottom of storage tank is that the heating process will be slow if we put it in the line of the last absorber container. This is because of the low density of warm air and the higher density of cold air, which would allow the input warm air to remain in the upper part of the tank and the cold air at the bottom. By placing the entrance part of the air in the lower section, we can improve the air circulation. The warm air that enters the bottom of the tank warms the gravels and mixes with the cold air as it moves toward the top of the tank. To create suction over the entire system, we used a small fan to make it easier to mix the hot air in the whole system. This fan acts based on the specific timing, which can be adjusted based on temperature of the air. At the indoor space, usually unpleasant airborne dust, toxic chemical fumes, harmful gases, microbes, viruses, and allergens, cause pollution and reduce the air quality levels. Figure 18 illustrates how the hot air enters and flows in the storage tank.

In this system, the next step after the fan is a filter that is used as an air purifier. The air is blown through the membrane filter by the fan, trapping the large contaminant particles. The membrane can be made of cotton, foam, fiberglass, or other synthetic fibers [24]. For this membrane, an efficient barrier filter was used that has the ability to prevent the passing of 99.97% of the pollutant particles larger than 0.3 micron [24]. However, nanotechnology has played a significant role in the quality and efficiency of filters. Figure 19 shows an example of a nano-filter membrane that can be used as an air treatment device in the system.

FIGURE 18. The entry of hot air into the storage tank and its flow directions.

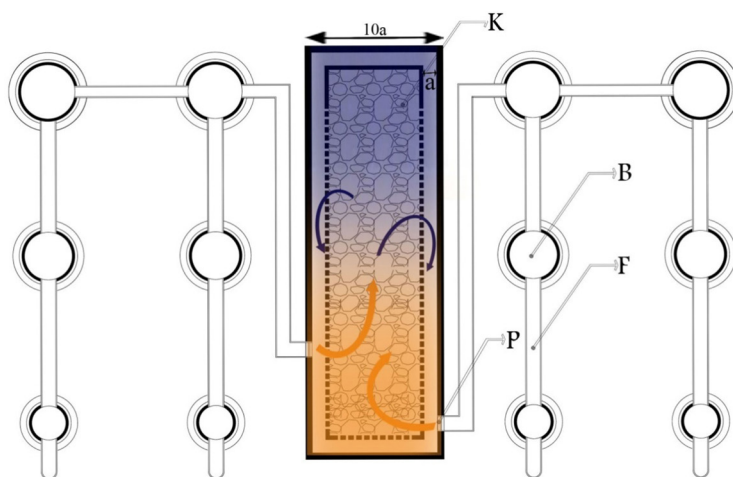
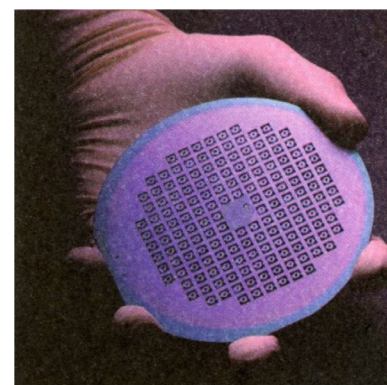


FIGURE 19. Nano-filter used in the system as an air purifier.



5. RESEARCH ANALYSIS

The proposed solar wall can be a kind of innovation in providing pleasant hot air for the building to increase thermal comfort of the occupants and reduce the use of non-renewable resources, such as fossil fuels. Optimum usage of solar energy will reduce the emissions of greenhouse gases and help reduce the rate of stratospheric ozone depletion over time.

The proposed solar wall has the following benefits:

1. This system is based on two aspects of light and heat and has led to combining them.

2. A large portion of this system is prefabricated in a factory, and so, by observing and measuring components, the problems that occur will be diminished.
3. This product will prevent air pollution caused by the use of fossil fuels by producing pleasant hot air with natural renewable energy. It will help families financially and its resource conservation aspects will lead to the enhancement of the national economy.
4. The system can be used as a space heating system in impassible and deprived areas.
5. The system is part of the building and does not occupy additional space; also it does not require a lot of space for its installation.
6. Due to its simple structure, the system can be built with little cost and used immediately.
7. In the United States, air conditioning systems use more than 25 percent of the energy in commercial buildings and almost half of the energy in residential buildings. The proposed system, with its ability to heat, circulate, and filter air, can be used to eliminate a significant portion of this energy usage.
8. By changing the structure of the system, it can eliminate the need for metallic guards on the windows of houses for security purposes.
9. This system has a balanced division of openings in the whole wall that allows light to reach all of the enclosed space without being so bright that it is uncomfortable for the occupants.
10. The two layers of glass used in the system and the space between them minimize heat and noise transfer from outside to inside or vice versa and provide thermal and sound insulation.

This system can be used in all areas that require heat to reach moderate ambient temperature due to heat generation and storage and also in the buildings that somehow need both aspects of solar heat, i.e., light and heat in their space. It can be utilized in the following buildings:

1. Residential buildings
2. Educational and service buildings. Because of the balanced distribution of light in the space and reduced light intensity, the system provides good performance in educational buildings, such as libraries and schools, and in service buildings, such as hospitals and factories.

6. CONCLUSIONS

People have always sought to create a comfortable atmosphere in which to live and work. To achieve this, many different methods and approaches have been used. This human endeavor to achieve the best comfort and tranquility continues today. Thermal comfort has always been one of the most important factors that have been considered. Since the industrial revolution, this comfort has been provided almost exclusively by using non-renewable resources and the consequences have been air pollution, destruction of ecosystems, and the high cost of locating, extracting, processing, and consuming these resources. The only solution at present to prevent further destruction is the use of renewable energy sources to achieve sustainable energy supplies. Such usage would also aid the economies of governments and individual households, while promoting its continued use by future generations. This wall was designed and proposed by utilizing one kind of renewable energy (solar). Its successful use involves the application of natural laws, such as the low density of hot air and the higher density of cold

air, to produce comfortable environments in homes and workplaces at greatly reduced economic cost while simultaneously providing significant reductions in the adverse effects on the environment.

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