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Design And Energy Optimization For Building In Tehran Province

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***Abstract*—The infrastructure industry is growing at the rate of 12.5%. The development of new infrastructure results in the increase of energy consumption, in particular electrical power consumption. Energy efficiency is a mandatory requirement and integral part of green and sustainable buildings. Energy efficient design optimization is a practical technique that has been proposed and used by architects and other scientist for several decades, especially in the past few years. Considering that in zero energy building, architectural designs, structures, mechanical installations, electrical and lighting, use of renewable energy, comfort of residents, etc… are considered, its design and construction requires deep knowledge and useful experience in design of this building. In this research a zero energy building, which is located in Tehran, has been designed. The energy optimization of this building is done from different perspectives as mentioned above.**

Keywords—component; energy optimization, green building, zero energy building, renewable energy

I. INTRODUCTION (*Heading 1*)

Global warming is one of the most controversial science issues of the 21st century, challenging the very structure of our global society.The problem is that global warming is not just a scientific concern, but encompasses economics, sociology, geopolitics, local politics, and individuals lifestyle choice. Global warming is caused by the massive increase of greenhouse gases, such as carbon dioxide, in the atmosphere, resulting from the burning of fossil fuels and deforestation. There is clear evidence that we have already elevated concentrations of atmospheric carbon dioxide to their highest level for the last half million years [1].

In addition to the limitations of non-renewable energy sources, Energy generation is always accompanied by economic and environmental issues too. A significant amount of World total energy is consumed by buildings Therefore, the optimization of energy consumption in this sector will cause. a significant effect on its side economic and environmental issues[2]. At the heart of the ZEB concept is the idea that buildings can meet all their energy requirements from low-cost, locally available and renewable sources [3]. Buildings have a significant impact on energy use and the environment. Commercial and residential buildings use almost 40% of the primary energy and approximately 70% of the electricity in the United States [4].

Report indicates that the energy consumption of Iran has been increasing continuously since 1971. Given that a zero energy building takes into account the utmost considerations in architectural design, structure, mechanical installations, electrical and lighting, use of renewable energy, comfort of residents, etc. in an integrated complex, its design and construction need Deep knowledge and having useful experience in designing and executing such buildings [6]. In recent years, many documents about the design and construction of these buildings have been provided to researchers in this field. Energy transfer and calculating the amount of energy entered into the system and how it is produced is one of the most important design parameters [7].

Optimal and efficient design will require accurate knowledge of the site and its surroundings. So during the visits to the site, several issues, including the slope of the site, the presence of green spots and the presence of an artificial lake in the southern part of the site were considered by the design team. Man's relationship with nature in architecture oversees architectural design in interaction with nature. Nature means comfort and tranquility. If the building is designed to behave in a nature-like and relaxing way, it can be said that we have reached an interaction between architecture and nature[8].

Regarding the relationship between man and the environment, Andrew Brennan also develops the idea of ecological humanism and believes that “Because we are part of nature, we must have contact with it in order to become a perfect human being “ . He considers our identity to be related to nature and introduces it as the first step towards environmental

ethics and believes that “Ethics and aesthetics are as intertwined as truth and beauty, so it does not make sense to recognize the direct benefits of our contact with nature. but not to care about it, that is, what we are doing now”[9].

II. DESIGN OF BUILDING

From the past until now, Iranians have had a special interest in building gardens and orchards in yards and around buildings. Iranians believe that human beings have lived in nature throughout history and have evolved and coexisted alongside it. Therefore, this idea can be considered as the source of the formation of buildings among gardens in Iran. In examining the site of the studied building, the presence of sycamore trees, boxwoods that were several years old, as well as the high dependence of the employees who were stationed in the current building, should be considered.

On the other hand, due to the slope of the site, in case of leveling, excavation is required, which in addition to cost, will destroy the natural environment and visually affect it. Another problem facing the current society is the lack of water, which is one of the most important and vital issues that must be addressed. Therefore, not cutting down trees that have spent a lot of water on their growth so far can save water. The use of natural light can also greatly affect the performance of space users. The quality of natural environments is not limited to the health and well-being of people, but also meets their mental and psychological needs. If the quality of natural environments is not good, it will cause residents anxiety, anger, disability, fear, panic and pessimism. In order to be mentally healthy, human beings have a special need to be close to nature and communicate with it in various forms. Relying on the above and maintaining the green spaces on the site, the main lines of the plan were designed. The design of the spaces around the green space draws the outside environment inwards and connects the two, so that the person will not feel entering the closed space and will not be separated from the natural and open environment.

By converting these spaces into uncontrolled spaces, in addition to reducing the amount of heat transfer, it also provides the required light to the spaces naturally. On the other hand, the moisture produced by the green space can humidify the dry air of Tehran and also purify and improve the amount of pollutants emitted by the activities of people and equipment, which can ultimately reduce the amount of air conditioning load.

In the design of this building, an attempt has been made so that the structure of each section can operate separately and during the development of the building section, the space design work will not be a problem and will not interfere with the performance of the building. Due to the location of the city of Tehran on the fault, an attempt has been made to reduce the effect of the earthquake on the building and have less destructive effects. As mentioned, the separation of the building structure can also move more freely and each structure will behave differently in the event of an earthquake.

The issue of fire is also one of the most vital points that should be considered in the design of the building. The presence of central Atrium due to the separation of different spaces from each other can to some extent prevent this fire and prevent its spread. One of the most important ideas in designing this space is to use natural light in all spaces. Maintenance of green spaces on the site, in addition to saving water consumption and improving indoor air quality, will cause light and also soften the interior space.

Therefore, the proximity of all spaces with green paths that have glass surfaces and light transmitters, will cause them to have natural light and there will be a uniform distribution of light inside the space. On the other hand, broken surfaces that will be created due to the use of land slope and height differences will lead to the creation of vertical surfaces on the southern front, which can provide part of the space lighting.

Figure 1-Design taking into account the slope of the site

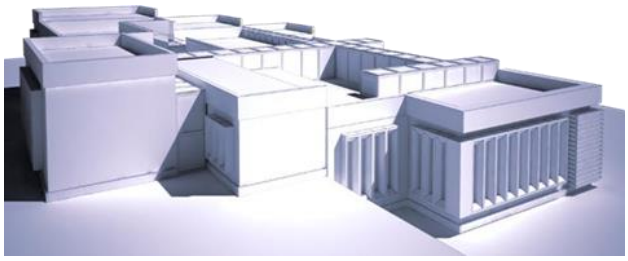

Figure 2-Schematic of design on the slope

The presence of middle ATRIUM, in addition to providing indoor light, can become uncontrolled spaces that are heated and cooled by sunlight and natural ventilation. In the selection of building materials, as much as possible, efforts were made to prioritize materials that do not violate the goals and values of sustainable architecture and do not have a detrimental effect on the natural environment. Leaving aside the benefits of using concrete structures, in addition to creating debris during construction,

disturbing the natural environment and environmental degradation is another problem that will be in conflict with the values of sustainable architecture, and will not be ignored. Therefore, in selecting the type of structure, the metal type was selected so that in addition to high execution speed, reducing the cross-sectional area of the columns, reducing the seismic coefficient of the steel structure, it can be recovered after the life of the building and does not leave an adverse effect on the ground.

The materials used in the structure of the wall and facade of the building will be clay blocks and wooden and metal timber, which not only do not have any contradiction with the natural environment, but will be compatible with it. In the selection of wall filling materials, due to the fact, that non-clay blocks are not compatible with the natural environment and cause its destruction and are irreversible to the natural environment, so the use of clay blocks was considered by the design team to be able to some thermal inertia Compensated by internal walls and stored part of the energy.

To build the external wall, a new generation of porcelain blocks (Porotherm) will be used, the technology of which has recently been imported to Iran. The heat transfer of the building will be less compared to ordinary blocks. Other materials used are wooden beams that will be used in the facade, which will have the role of shading the walls and windows and glare control. Despite the green wall that will be placed on the facade can be useful in associating the natural environment and introducing the building as a building under energy.

Figure 3-material of façade and external wall

The type of insulation used in the external wall has been selected based on the cost and the amount of pollution and physical compatibility with nature. The use of south-facing windows with fixed canopies can meet part of the space heating needs and reduce energy consumption. On the other hand, the atriums in the space sharing season can also be preheated by the sun and cause preheat the air that entering the HVAC system then increase the Cop of the system.

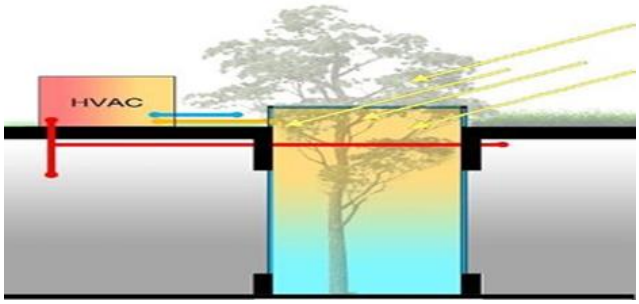

Figure 4-design of atriums in building

Other inactive systems include the use of external shading on the wall, which can play a significant role in preventing sunlight on surfaces in the summer. Use switchable glass on the upper surfaces of the atriums, which will be adjusted based on the indoor air temperature so that when the indoor air temperature exceeds the value specified for the sensor, the glass will act as radiation and reflect part of the sun's radiation. About 35% of heat absorption in summer is done by the roof, which can be used to create shade by using broadleaf trees and reduce the damaging effect of roof radiation.

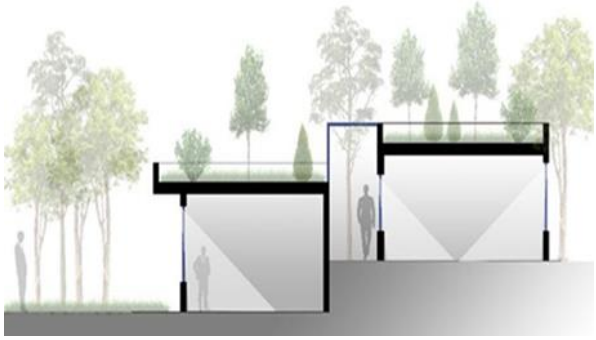

Figure 5-using broadleaf trees in design

In designing this space, an attempt was made to use the Iranian architectural model and to use the concept of the central courtyard of the past, which is still standing in the Dar al-Fonun and a few other houses.

III. THERMAL INSULATION AND OPTIMIZATION

In the design of thermal insulation according to the climate of Tehran and the type of use of the building, initially the design is based on a basic model as a basis, with surface heat transfer coefficients of external walls (0.88 W / m2k), ceiling (0.38 W / m2k), and was based on Section 19 of the National Building Code. Based on the simulations, the wwr was 40% for the southern front, 20% for the western front and 30% for the northern front. The operating temperature status in this mode is examined in 3 types of space on January 15 and July 15 and the effect of different elements in improving these conditions when the HVAC system is completely off is presented:

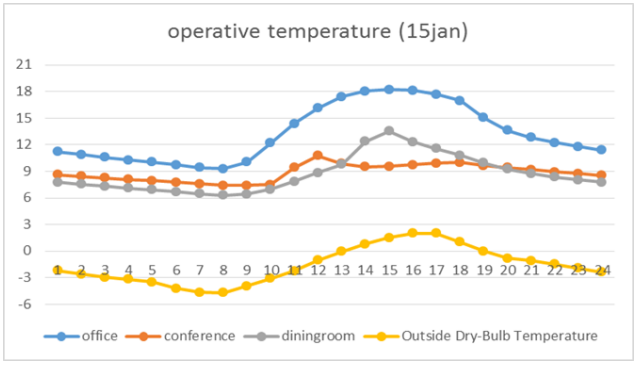

Figure 6- operative temperature for basic model in 15 jan

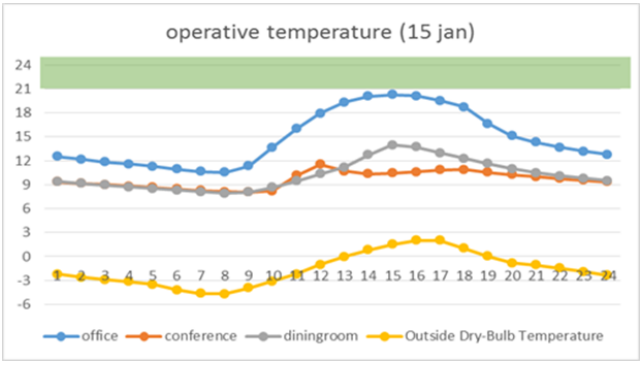

Figure 9-operative temperature after first step of optimization in 15 jan.

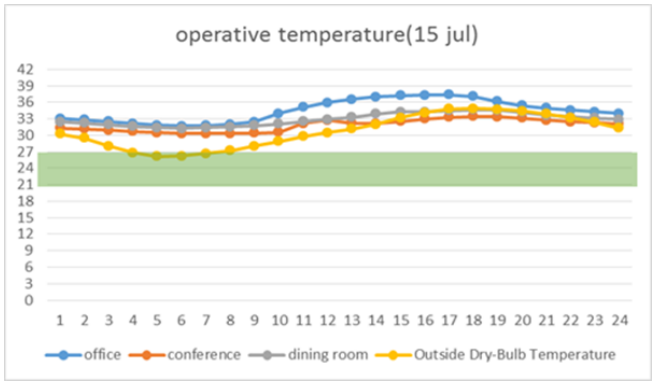

Figure 7-operative temperature for basic model in 15 jul.

According to the above two diagrams, the temperature of all spaces is outside the comfort range, which will be optimized in the following ways. Initially, by changing the material of the glass and changing the heat transfer coefficient from 2.75 to 1.96, also changing the roof glass of the atriums to the electro chromic type (acting as a reflection when the indoor air temperature reaches 24 degrees Celsius), which is due to high light and overheating They will prevent that by applying these changes, its greatest effect can be seen in improving the internal conditions in summer.

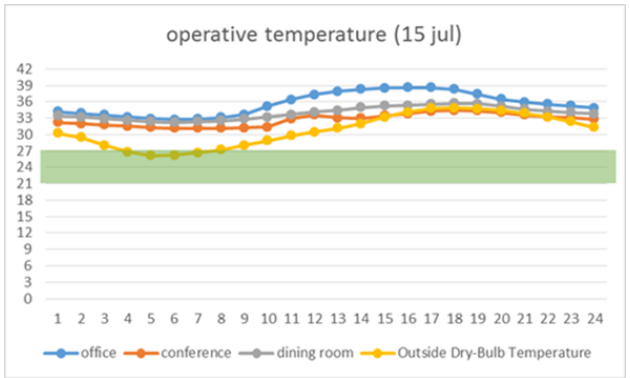

Figure 8-operative temperature after first step of optimization in 15 jul.

In the second stage of optimization, by placing the canopy on the windows, the indoor temperature conditions improved about 2 to 3 degrees.

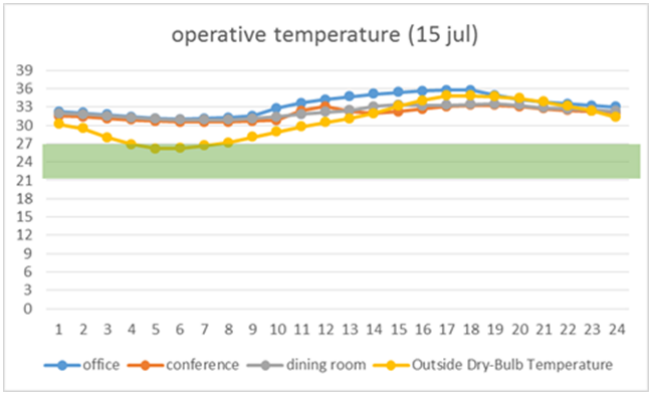

Figure 10-operative temperature after second step of optimization in 15 jul.

Then, by reducing the heat transfer coefficient of the wall from 0.88 to 0.25, the temperature changes of the spaces will be as follows:

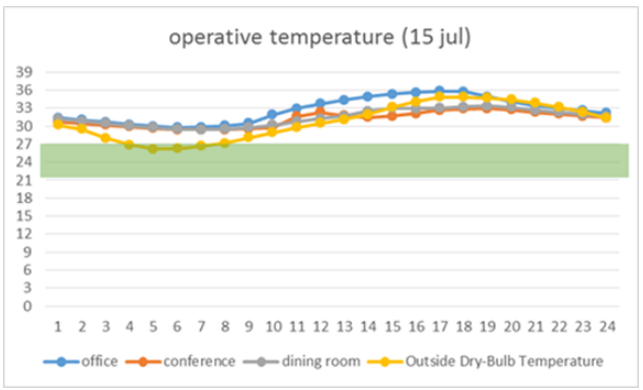

Figure 11-operative temperature after second step of optimization in 15 jan.

By insulating the walls, the temperature conditions in the office section, which is located in the south, are in the comfort zone in a few hours, and another spaces will feel higher temperatures.

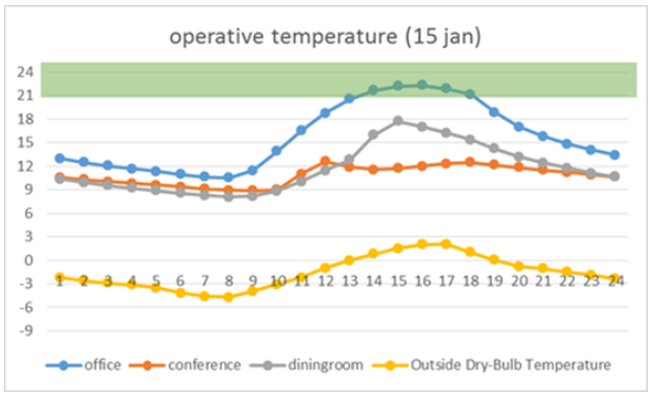

Figure 12-operative temperature after insulating the wall in 15 jan.

In the fourth stage, the coefficient of conductivity of the roof was changed from 0.38 to 0.3 and in fact the roof is designed as a green roof and the results will be as follows.

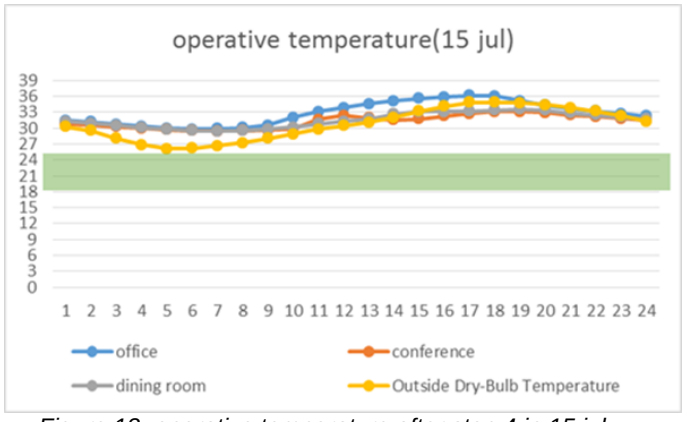

Figure 13- operative temperature after step 4 in 15 jul.

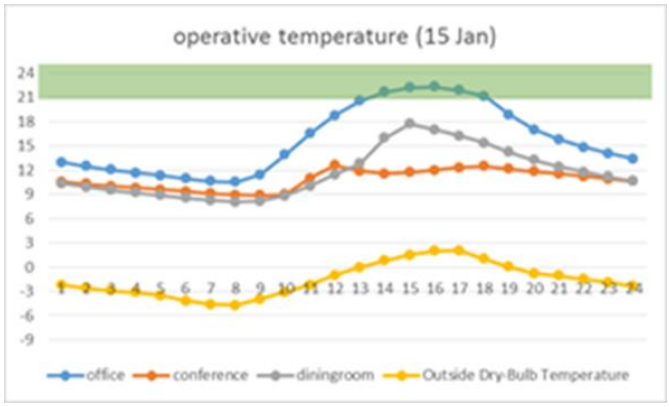

Figure 14-operative temperature after step 4 in 15 jan.

The following is the study of the operating temperature of the building in the two models of optimal and basic in 12 months of the year. The building in the optimal model will be in a better condition in the cold months of the year, and in the warm months, the temperature should be in the comfort zone day and night due to natural ventilation.

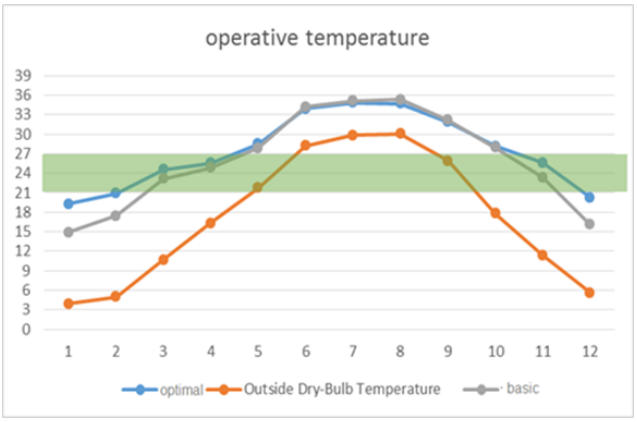

Figure 15-operative temperature 12 months.

	Room Electricity	Lighting	Heating (Gas)	Cooling (Electricity)	DHW (Electricity)
	Wh/m2	Wh/m2	Wh/m2	Wh/m2	Wh/m2
Optimal model	19122.91	4528.295	22106.8	18673.84	7274.736
Basic model	19493.93	4056.027	26611.04	27635.93	5654.713

Figure 16-energy consumption by section in basic and optimal model.

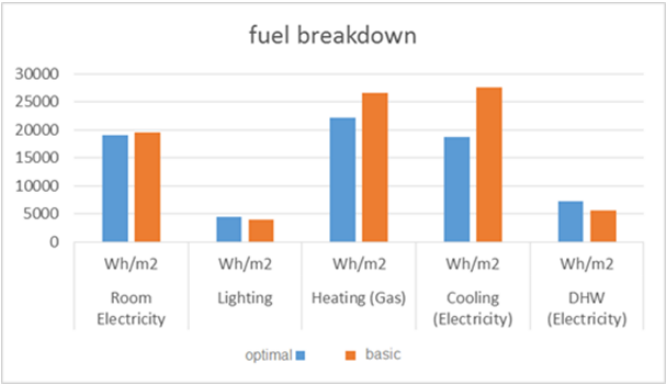

Figure 17-fuel breakdown

In fact, by insulating the walls, we reduced energy consumption by 16.9% in gas consumption and by 12.7% in annual electricity consumption.

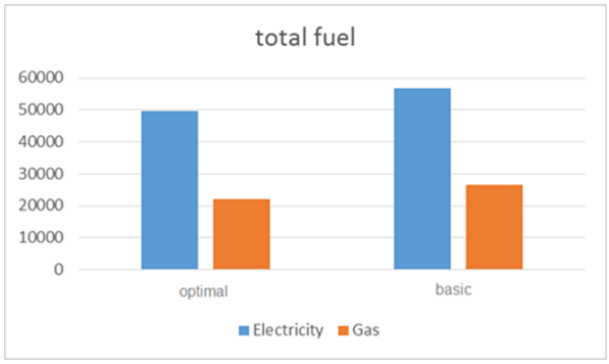

Figure 18- total fuel consumption for basic and optimal model.

IV. CONCLUSION

In this article, the zero energy building located in Tehran weather conditions is designed. In this design, an attempt has been made not to ignore the connection between nature and architecture. In addition, by using inactive systems, an attempt has been made to optimize energy consumption in the building. Then, after reviewing and simulations, the effect of proper insulation in optimizing electricity and gas consumption is studied. The results indicate that in designing a zero energy building from the initial stage of design, measures should be taken to optimize energy. This indicates the high importance of the design phase in achieving this type of building. In the study in this paper, the result of using thermal insulation and passive and stable systems in the design resulted in a significant reduction in total energy consumption in the building.

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