Optimization of Energy Consumption of an Office Building in Tehran Region

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ABSTRACT:
The continuous growth of urbanization, the emergence of megacities, and the subsequent increase in their population have had various consequences among which the increase in consumption and demand for energy resources can be mentioned. Energy consumption has increased dramatically in the last few decades, which has also caused an increase in the production of greenhouse gases. The importance of energy at the global level is something that has been paid attention to a lot, in Iran also due to the increasing statistics of fuel consumption, optimizing and saving consumption is vital. Therefore, in this research, by using previous studies and computer simulation, we tried to investigate the effect of the factors involved in the energy consumption inside the building. In this regard, a building with office occupancy has been investigated in terms of energy consumption. The considered building has been simulated in Design Builder software and analyzed in terms of energy consumption and other factors in this simulator. In order to optimize energy consumption, intelligent lighting systems, phase-changing materials on external walls, 3-pane windows with high sealing, and natural ventilation have been used. As a result of using these solutions, the optimal building compared to the original building has improved energy consumption from grade C to grade B.

KEYWORDS: Energy Consumption, Renewable Energy, Office Building, Design Builder, Optimization Of Energy Consumption

1. INTRODUCTION

Urban areas made up 2% of the earth's surface in 2009. These regions consume approximately 75% of the world's energy (Hong and Lee, 2017). In the case that today the concern about energy consumption is increasing and the inappropriate use of energy and raw materials causes irreparable damage, including the destruction of the environment, the destruction of fossil energy resources, economic and mental problems, and ultimately the loss of human comfort and health (Sanayeian et al., 2014). Currently, 50% of the world's population lives in urban areas, which will grow to 70% by 2050. (Algerini et al., 2012). The continuous growth of urbanization followed by the increase in the population of cities has various consequences. Among these consequences, we can point to the increase in consumption and demand for energy resources. Energy consumption has increased dramatically in the last few decades. On the one hand, this increase is an indicator of economic growth and the rotation of more industrial cycles followed by the displacement of industrial goods to different points, on the other hand, maybe due to the cheap price of energy, the industry owners and the private sectors consumers of the country have not sought savings and rational use of this blessing, and the energy demand for general electricity, heating, lighting, and ventilation has increased due to the increasing needs in society and construction. During the period from 1994 to 2016, energy demand in the construction sector increased by 11% (Statistical Pocketbook 2018). In contrast, this incremental change requires minimal energy consumption (A Martinez-Molina, P. Boarin, I. Tort-Ausina, & J. L. Vivancos,2017). Currently, most countries are moving towards energy-saving policies by working on energy-consuming sectors such as transportation, industry, houses and services, and agricultural sectors (R. Gupta, M. Kapsali, and M. Gregg,2017). Based on the information provided in the energy balance published by the Ministry of Energy in 2013, 40% of the total energy consumption in Iran, that is, more than one-third of the energy consumption is related to the building sector. Therefore, as mentioned in the 20-year vision document of the country, the appropriate design of buildings as a national necessity requires complementary studies that address this section beyond the guidelines and discussions that have remained at the theoretical level so far (Mirmoqtadai,

2013). In recent years, the annual growth of energy consumption in the world has been 1-2 percent and in Iran 5-8 percent, in other words, the growth of energy consumption in Iran is five times the average growth of consumption in the world. Also, energy consumption in Iran's buildings, as a non-productive sector, has allocated the largest share among all consumption sectors (Khodakarami & Qobadi, 2015). Among these buildings are office buildings, which are the largest indoor environment after houses and are important in terms of energy and indoor environment quality (IEQ) (Y. Allab, M. Pellegrino, X. Guo, E. Nefzaoui, & A. Kindinis, 2017). Such buildings need more attention due to the large number of people who can use these spaces for different purposes, also, the number of topics related to energy audit and indoor environment quality in office buildings are not comparable to the research that has been done for educational buildings, hospitals, and other buildings. Zomorodian et al. (Z. S. Zomorodian, M. Tahsildust, & M. Hafezi, 2016) showed that only 48 articles on the subject of thermal comfort in office buildings were published from 1969 to 2015. Even though our country is one of the exporters of non-renewable energy to different countries, proper culturalization has not been done in the field of its consumption, so consumers are not looking for savings or optimal use of it. In order to prevent the process of excessive consumption of energy in Iran, basic measures should be taken by the officials in the form of laws. One of the measures is the control of the structure of industries and new office buildings, which must be done under certain conditions in which the reduction of energy consumption is considered. For existing buildings that are currently in use and are not in good condition in terms of energy consumption, basic repairs should be done or principles should be implemented in them in order to energy consumption optimization.

2. Research Method

This research is a qualitative-quantitative study. These two types of study include sections of library study, field study, and software analysis. Documentary and library study forms the basis of expression, analysis, description, and interpretation of the materials in this research. Qualitative research interprets the conditions and has a special emphasis on the role of the researcher as a vital element in the result of the research (Groot & Wang 2010: 88). This research allows the researcher to interact with the subject, use flexible methods to collect, analyze, and interpret data, and consider the studied phenomena from a comprehensive point of view (Hariri 2011: 5).

The type of basic research and quantitative research method is the experimental research technique in an artificial environment (computer software) and the analysis of information and the evaluation of hypotheses by means of numerical models based on computer simulation. The method of collecting data and field studies includes observation and use of the processed data.

The stages of conducting field studies and computer simulation are as follows:

1. Identification and collection of office building plans in Tehran region
2. Modeling of an office building in the Tehran region in DESIGN BUILDER software
3. Examination and identification of heating load - cooling load - electricity consumption of the group and laboratory equipment in the administrative building in the Tehran region
4. Modeling heating load - cooling load - electricity consumption of the group and laboratory equipment in DESIGN BUILDER software
5. Optimizing the building in terms of energy, using the suggestions and instructions available in the references.
6. Present solutions for energy supply from renewable energy sources, energy optimization, and increasing efficiency in office buildings in the Tehran region.

3.Definitions and Theoretical Principles And Foundations

Shah Hosseini et al. in their study focusing on the factors affecting energy consumption and waste in the building, found the efficiency of the interior spaces, the arrangement of heating devices, the transparent walls, the installation of the canopy, curtain installation, thermal bridges, insulation, prevention air penetration, sealing the building, installing springs on the doors, and filling vents and cracks are effective factors on energy consumption and its waste in the building (Shah Hosseini et al., 2014).

The studies that have been started in the world show that the physical characteristics of the building will be effective in the amount of energy consumption. Considering the role of the design pattern of buildings in optimizing energy consumption, rules and regulations have been prepared in other countries that include technical aspects related to buildings (Seyfi, 2014). According to the statistics published by the International Energy Agency, Iran is the ninth energy-producing country and the tenth energy-consuming country in the world (Khodakarami & Qobadi, 2015). Iran's total energy consumption is 3.5 times more than Turkey's, 14.5 times more than Japan's, and 5 times more than the world's average annual energy consumption, so that the average energy consumption per square meter in Iran is 2.6 times of average consumption in the industrial countries, and in some cities of the country, this figure reaches to 4 times (Zare Shah Abadi et al., 2013).

In a study conducted in Ilam City, it was shown that the main parameters affecting energy consumption in business entities include draught, lighting, cooling and heating, area, awning window, distance from the entrance, number per unit, and neighborhood. According to the results, the parameter of lighting with a correlation of 0.653 and p = 0.05 is the most effective factor in the energy consumption of business buildings in Ilam City, and the variables of draught, awning windows, heating and cooling devices, distance from the entrance, usage, area, and location of buildings are the next priorities, respectively (Qanbaran, Abdulhamid; Behrouz Salehi; Masoud Kaveh-Nezhad & Sima Ferdosian, 2016).

2.3. Energy Consumption in the Building Sector

One of the main topics that has been the focus of many developed and developing countries in the last few decades is the discussion of energy waste prevention (Khodakarami et al., 2015; Shah Hosseini et al., 2014). With the emergence of the energy crisis in the early 1970s, the importance of controlling the amount of energy consumption was revealed to everyone (Zhou et al. 2005). On the one hand, according to the reports of the International Energy Agency in 2012, fossil fuel has the highest function in energy consumption in the world (eia. u.s. energy information administration; & kazemi et al., 2013). This statistic shows that the production of carbon dioxide is the result of fossil fuel use. According to the statistics of the International Energy Agency, in the housing sector, energy consumption causes the production of 6 percent of carbon dioxide (Khodakarami et al., 2015). Also, the building sector in every country allocates more than one-third of the country's energy consumption, which is worth six billion dollars annually. The subject of the limitation of energy reserves in the world is not unknown to anyone anymore (Markos, 2013). Iran is one of the rich countries in the field of fossil energy and at the same time, it is also one of the indiscriminate consumers of energy (Haj Malik et al., 2015). In recent years, the growth of energy consumption has been 1 to 2 percent in the world and 5 to 8 percent in Iran. These statistics show the lack of attention to energy consumption in Iran compared to other countries in the world. Today, the change in the style of construction and the transformation of buildings into commercial goods has caused disregard for the principles of construction, the use of inappropriate materials, and as a result, energy wastage in the building sector. According to the statistics published in Iran, most of the energy in the building is used for heating in winter and cooling in summer, which is due to non-compliance of the building with the climatic conditions (Bahrpeyma et al., 2019).

Due to the cultural and structural problem that caused the value of energy to be less known, most of the country's buildings lack the known technical regulations to prevent the waste of cooling or heating energy. This high energy consumption in the building sector in Iran will cause problems such as a lack of energy and related credits in the future (Bahrpeyma et al., 2019). Therefore, buildings are considered to be one of the biggest sources of energy waste, and if they continue to consume too much energy, in addition to expanding the problem of energy crisis in the world, they also cause environmental pollution (Shah Hosseini et al., 2011). Improving energy efficiency in the building sector is one of the practical and sustainable measures with the aim of reducing the emission of greenhouse gases and the costs of energy consumption (Lower. R, 2000; & Hastings, 2004).

Energy consumption is different based on the types of buildings occupancy in the city. In residential buildings, space heating systems, domestic water heating, lighting, and cooking are among the activities that consume energy. Among the mentioned activities, the energy consumed for heating the indoor space of the house includes about 60 percent of the total energy consumption in these buildings and has assigned the largest share to itself (Steemers, 2003). In educational and administrative buildings, heating, lighting, cooling, fans, and pumps are among the main energy-consuming factors. The need for ventilation and lighting are two important and fundamental issues that determine the amount of energy consumption in such buildings (ibid).

3.3.Optimizing Energy Consumption In The Building Sector

Energy efficiency in the entire life cycle of a building is the most important goal of sustainable architecture. Architects use many different passive and active techniques to reduce the energy needs of buildings and increase their ability to capture or generate their own energy (M. DeKay & G. Z. Brown, 2014). To minimize cost and complexity, sustainable architecture prioritizes passive systems to use building sites with integrated architectural elements and renewable energy sources and then provide fossil fuel only if necessary (Bielek, Boris, 2016). Targeting energy consumption consists of planning (including audit, goal setting, and project definition prioritization), organization, recruitment, guidance and monitoring to achieve optimal energy consumption so that the system uses new technologies and the service level of the system does not decrease. At the same time, it will reduce energy consumption and related costs (Technology Studies Center 5831: 44).

4. Literature Review

4.1. Studies Conducted In The Field Of Energy Consumption In The Building Sector

In 2013, Hajipour et al. studied the effect of various factors on energy consumption in Shiraz city. They

found a direct relationship between housing patterns and energy consumption, although this relationship is not simple and is influenced by other variables. As a result of this research, it can be said that the central courtyard houses with an average of 65 gigajoules per square meter have allocated the highest annual energy consumption and therefore are considered the most inefficient type of residence in terms of functional energy consumers, and in this regard are one of the two types of villa houses or urban decays with consumption of 8 and 4 gigajoules per square meter, respectively (Hajipour et al., 2013). Several studies on this subject are mentioned in Table1.

Table 1. Studies done in the field of energy consumption in the building sector

Research Title	Authors	Year	Results
Evaluation of building energy consumption	X. Wang, C. Huang, and W. Cao	2010	- Air conditioning in the building has the highest energy consumption. -Lighting energy consumption is less than 10% -Energy consumption between 2005 and 2008 was 1130 tce.
A review of home energy consumption, policies, guidelines, and standards	M. Lu and J. H. K. Lai	2019	In developed countries, the consumption of fossil fuels is much higher than in developing countries. - Developed countries should put the policy of using new energy on their agenda. - Developing countries should adopt a policy to optimize energy consumption. - Developed countries should follow the policy of using energy standards in their buildings.
Energy audit in an educational complex in a hot summer climate	A. Alajmi	2012	- There are many opportunities to save energy; It is expected to save 6.5% of the building's annual energy consumption, witha return on investment period of 0.48 per year (due to the cost of the audit team). - 52% of the total energy can be saved if all recommendations made by EAT are implemented. CO2 emissions due to building electricity consumption will be reduced by 648 tons per year.
Energy audit, thermal comfort, and indoor air quality (IAQ)	A. Merabtine, C. Maalouf, A. Al Waheed Hawila, N. Martaj, and G. Polidori	2018	- The first step of this work was to determine the different amounts of energy consumption; As a result, the program analysis was conducted to include three years of data collection from 2015 to 2017. In one bill, more than 19,000 tons of electricity per year is the main electricity and it accounted for 52% of the total bill in 2015.
Residential building energy consumption: review of availability prediction methods, characteristics, and energy performance prediction methods	H. Do and K. S. Cetin	2018	The review points to the need for more access to residential building energy sources and non-energy data sources to improve energy performance prediction models and the need for a comprehensive and relatively accurate study of these models for residential buildings in the range of data frequencies.
Building performance evaluation of a "sustainable" community center and a public library building	R. Gupta, M. Kapsali, and M. Gregg	2017	Lack of delivery, guidance, and training, inadequate commissioning of systems, and poor calibration of meters. Despite these issues, the community center works well and is appreciated by users who are satisfied with their environmental conditions, comfort, and energy use. On the other hand, library users have complaints about indoor temperature and air quality and control over their environment.
Relationships in the layers of residential buildings	Biddulph	2007	Paying attention to the effect of wind will reduce the amount of energy consumption in cold climates by 3 to 5 percent. Therefore, the use of a dense pattern, orientation of roads in the opposite direction of the prevailing winter wind, appropriate height change and form of the blocks, and planting trees as an obstacle in front of the buildings facing the wind, are among the effective measures.
Comparative evaluation of ventilation and thermal behaviors in native residential buildings in Iran's temperate and humid climate (case study: Kolbadi House and Aghajan Nasab House)	Pourmusa, Shemirani, and Zarandi	2016	The climatic design of residential buildings in the past was such that it responded to their climatic needs. In their research, Shemirani et al. investigated the thermal behavior of two residential buildings (Kolbadi House, and Aghajan Nasab House) using Ecotech and Design Builder software. The results have shown that these two residential buildings were 40-42% comfortable and as a result, reduced energy consumption for cooling and heating. Finally, the authors have extracted effective design solutions.

4.2. Studies Conducted In The Field Of Energy Consumption Optimization

In the research done by Rafiyan et al. in Hashtgerd City in 2013, they found a 30 to 45 percent reduction in energy consumption, achieved only by making changes in the arrangement form, height, dimensions, and size of the parts and the orientation of the buildings in the urban planning and design process. It should be noted that the research was conducted only in the area of 35 hectares of the new city of Hashtgerd and resulted in a cost reduction of about 700 million tomans. Therefore, in the case of applying guidelines based on reducing energy consumption in existing buildings in the whole country, this figure is very huge and it shows the importance of paying attention to this issue more than ever. By now, many studies have been conducted in the field of energy consumption of buildings and the reduction of environmental pollution caused by it and optimization of energy consumption in Iran and the world (Table 2). In 2017, Eliasi and his colleagues investigated the role of new energies in the architecture of green buildings with the approach of reducing energy consumption. During this research, they found out that efforts to promote the use of these systems, especially in electricity distribution, while reducing the problems caused by the development of the network and fuel supply in these areas, can be a solution to reduce the consumption of fossil fuels and have a significant effect in reducing the emission of greenhouse gases, and in the future by increasing the production of these systems and reducing construction costs, better use of them will be possible (Eliasi et al., 2017). Nayara et al. in 2014 investigated the obstacles to the construction of green buildings in Brazil. They stated the purpose of their research to be the technical and economic analysis of the construction of green buildings in Brazil and to identify the existing obstacles (Nayara et al., 2014). Yongheng et al. in 2013 analyzed the construction of green buildings from an economic perspective. In their study, they tried to compare the initial cost required for the construction of a green building with a normal building and finally calculate the duration of return on investment for these buildings (Yongheng et al., 2013). In 2015, Queena et al. simulated the building and calculated its construction costs (Queena et al., 2015).

In 2015, WeihongGuo et al. conducted a numerical simulation of a natural air conditioning system using computational fluid dynamics inside a green building. They stated that the use of natural air conditioning systems has less environmental pollution and also a higher level of thermal comfort, and therefore they are very suitable for greenhouses (WeihongGuo et al., 2015). In 2010, Bedir et al. investigated the design of a zero-energy building in terms of economic issues using Homer software. The system investigated by them consisted of wind and solar renewable sources (A. Bedir et al., 2010). Khodakarami et al. in 2015 investigated the optimization of energy consumption in an office building with an intelligent control system. They found that by carrying out proper planning in the field of energy management and consumption in a smart office building, it is possible to reduce energy consumption from 35% to 40% per year, and the greatest saving in energy consumption is in the cooling and lighting sectors (Khodakarami et al., 2015). Rahimzadeh has investigated the simulation of the effect of the external window dimensions of the building on the annual heating and cooling load in residential houses in the Iran region (Rahimzadeh et al., 2011). Nasrollahi et al. analyzed energy efficiency in young cities (Nasrollahi et al., 2013). M. Rashidi et al. have also investigated the effect of the orientation of buildings on the amount of solar energy absorption (Rashidi et al., 2016). The elements of the urban form affecting the energy consumption of the building include the type, dimensions, and size of the house, density (including the physical compactness of building units and population), the layout of buildings (including the direction of the street and the configuration of buildings), and the level of permeability of the surface and green space and other factors which affects the efficiency of the heating and cooling systems of the building. Also, despite the methodological challenge of investigating the effects of the external and internal environment of the building (Agrini et al., 2012), it is necessary to pay more attention to this issue.

Indoor energy simulation software is not enough to predict the energy needs of buildings in urban areas (Kubiak & Kolokotsa, 2017). For example, Kubiak and Kolokotsa in their research (2017) combined the microclimate simulation software with the indoor energy simulation software (Figure 3-2). Finally, the combination of these two software led to a 40% difference in the calculation of the building's heating and cooling needs.

Building height and density are among the very important things that are determined in the urban planning and design process. If there is no control and coordination of the height of the buildings in the city or a part of it, the access of residential buildings to sunlight, as one of the renewable sources of energy, and the shading of the buildings on each other will change. As a result of this change, residential buildings use more energy to provide lighting and heat the space inside the house (Rafiyan et al., 2010).

Building density, which is related to the amount of land use and the height of the building, affects the amount of energy consumption in the building. In fact, as the building density increases, the amount of land covered decreases and the microclimate of the area gets better conditions. It should be noted that if the building density increases too much in the city, the height of the

buildings will increase and this will cause the formation of wind draught around the building and as a result, the temperature will decrease. Therefore, more energy in the building is used for heating the space of the house (ibid).

Table 2. Studies conducted in the field of energy consumption optimization in buildings

Research Title	Authors	Year	Results
Determining the optimal pattern of the central courtyard in Dezful traditional housing	Taban et al.	2013	The authors have investigated the effect of the shape and design of the open space of the building on climatic comfort and have presented an optimal model the use of which will increase the received shade, reduce the temperature of the walls, reduce the cooling load of the building and increase the number of residents.
Evaluation of thermal performance in the design process of a building using simulation	Abolhasani and Bateni	2013	The authors have evaluated the thermal performance by computer modeling and by using building energy simulation software during the design process, they have tried to improve the design in terms of energy consumption in the initial steps by spending less time and money. In this case, we can have high-quality and low-energy-consuming buildings.
New standards for comfort and energy use in buildings	Nicol JF, Humphreys MA	2009	New standards are required to build stable and thermally comfortable buildings. It is the right way to define the conditions compatible with the low carbon goal. Such standards are building-based rather than environment-based, leading to greater design freedom to achieve sustainability.
Building energy performance: evaluation of design and construction-related dimensions related to building energy efficiency in Iran	Heravi and Ghaemi	2014	The design and dimensions of the construction have been identified and evaluated according to their impact on the energy performance of the building based on energy simulation. The preliminary result of the research has shown that passive solar energy is the most practical renewable energy system in urban buildings in Iran.
Optimizing the architectural design of school buildings to reduce energy consumption in the hot and dry climate of Iran	Zomorodian and Nasrollahi	2013	To achieve the purpose of the article, a specific elementary school has been selected and modeled, and various design criteria (direction, wall-to-window ratio, spatial organization, creating shadows) have been analyzed using energy simulation software. The results show that with the optimal architectural design, the primary energy consumption in the studied case is reduced by 31%, while its thermal comfort is maintained.
	Saroni et al.	2010	By evaluating and comparing energy consumption in normal and optimized buildings, the result of the research showed that the difference in energy consumption is due to the difference in the design and construction operation of the building.
Thermal comfort standards for the 20th century: upgrading high-energy buildings	Roaf S, Nicol F, Humphreys M, Tuohy P, Boerstra A	2010	In this study, new thermal comfort standards were used, which allow residents to choose and control their desired temperature. In the future, buildings will increasingly be classified based on energy use and carbon impact.
The relationship between users' thermal perception and building thermal performance in naturally ventilated school buildings	Liang HH, Lin TP, Hwang RL	2012	Setting the clean energy of the building naturally has a significant effect on the level of thermal comfort. The compatibility comfort model is built and suggested to be compatible with design variables in the energy regulation of other buildings.

The arrangement form of the buildings also has different types such as attached and separated, linear, central courtyard, and tall blocks. Each of these forms has its own characteristics and due to the difference of each of them in terms of access to sunlight and exposure to wind, it creates changes in the amount of energy consumption of the building. For example, if residential buildings are attached to each other, the free surface of the buildings is reduced and as a result, the heat exchange of the building with the environment is reduced and less energy is needed to heat the building (Biddulph, 2007). The central courtyard forms, due to creating confinement for residential buildings, reduce the negative effect of wind in winter, and as a result, the energy required for heating is reduced.

Taleghani et al. in their research (2013) compared the three parameters of temperature, light, and hours of thermal comfort in summer in three different types of urban block configurations in the temperate climate of the Netherlands, this configuration includes single

building, linear building, and central courtyard. The obtained results have shown that the effect of the surface-to-volume ratio of the building is the most important factor in high annual energy efficiency and summer thermal comfort, and buildings with a central courtyard in the Netherlands climate have the least need for energy consumption and the most hours of heat comfort in summer, and single buildings have the most need for energy consumption. Mehdizadeh and Nasrollahi (2012) have studied the effect of the arrangement of neighborhood units on the amount of energy consumption inside the building and compared six common conditions of building blocks in Tehran in terms of thermal energy consumption in winter as well as the amount of energy needed for lighting, by means of simulation methods. The results of the surveys have shown that the central courtyard buildings are the best choice for access to daylight, while the linear models are the best choice in terms of heating and cooling energy consumption.

In their research conducted in 2017 in Iran, Zomorodian and Nasrollahi found that through an efficient architectural design, primary energy demand can be reduced by 31% while maintaining visual and thermal comfort compared to the existing buildings (Zomorodian & Nasrollahi, 2017).

In the present era, the role of these energies in solving environmental problems, especially air pollution, is clear. In Iran, due to the new policies of the regime in the energy sector and due to the benefits of various renewable energies, prioritizing the development of these clean energies, which have various economic and bio-environmental benefits, has been provided. This orientation makes it necessary to give priority to the development of renewable and clean energies. At the global level, conscious sustainable development is taking shape in recent decades. With the attention and desire of the world, especially the people of developed countries in Europe and America, to become aware of environmental issues and the efforts of some wealthy and influential people to respect environmental issues in industries, awareness of the developing countries and the third world about the dangers of environmental crises, and the development of Eco-friendly technologies in today's societies, conscious sustainable development is becoming more acceptable and emerging among societies every day (Aslani, 2018). As can be seen from the previous studies, the most important factors affecting the energy consumption of buildings include the climate in which the building is located, the neighborhoods and how it is located in the urban fabric, materials, height, form of the building, type of building occupancy, type of heating and cooling systems, insulation, type and the percentage of awning windows, the orientation of the building, the behavior of the residents, the curtain, the lighting system and the canopy, and things like these. Also, the findings indicate that the Design Builder software with the Energy Plus calculation engine is the most suitable simulator for the energy consumption of buildings. Therefore, in this research, this software is used to simulate building energy. Therefore, this software is used to simulate building energy in the present research. Most of the studies done in the field of energy in the construction industry have been in the field of residential buildings or the study of building complexes. The study of educational buildings is a study gap. Therefore, the present study analyzes the energy consumption of the building of the Faculty of New Sciences in Tehran and presents strategies to optimize the consumption of this building.

5. Knowing The Plan Platform

5.1. Analysis Of Climatic Parameters Of Tehran

According to the comparison chart of dry temperature and wet temperature in summer, air humidity is low in this region. Therefore, it is better to use cooling and humidifying systems in the interior of the building.

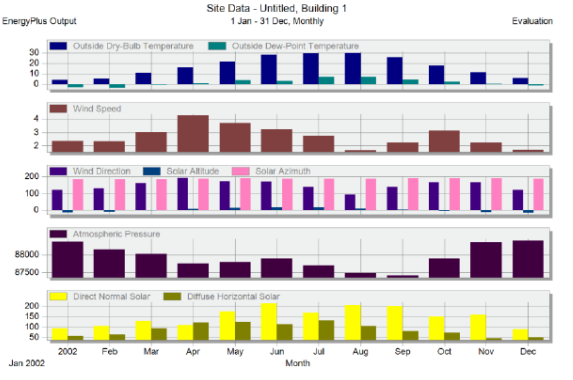

Fig 1. Site information diagram

As shown in the wind speed diagram (Figure 3), the highest wind speed in Tehran belongs to the months of March, April, May, September, and October.

- The wind direction is mainly between 100 and 200 degrees relative to the geographical north.
- The elevation of the sun is in the range of -10 degrees to +10 degrees.
- The solar azimuth angle is 180 degrees.
- Atmospheric pressure varies between 875 and 880 millibars. The highest atmospheric pressure is in December and the lowest in August.
- The biggest difference between direct solar radiation and scattered horizontal radiation is in the month of May.

As can be seen from the picture below, in the months of September, October, November, December, January, and February, there is the biggest temperature difference between the air inside and outside the building. This temperature difference of 15 degrees centigrade on average causes a heating load to be imposed on the building. The average temperature difference between outside and inside the building is less in the hot season, so in this climate, to achieve thermal comfort, the heating load is more than the cooling load. According to the Asher standard, the comfortable temperature range is 18 to 23 degrees centigrade (Asher Standard, 2015). The analyzed building does not need cooling or heating in the months of March, April, and September when the outside air is within the comfort range.

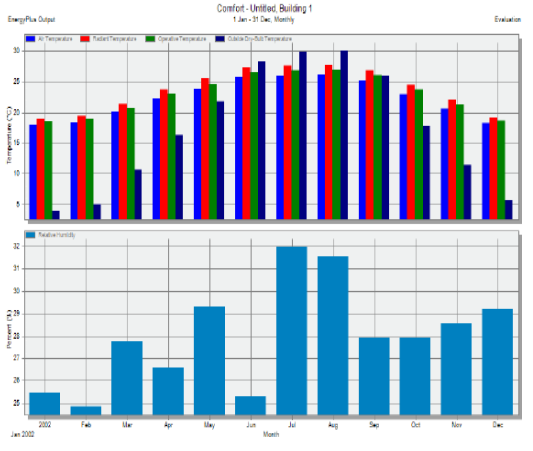

Fig 2. Comparison of thermal comfort parameters

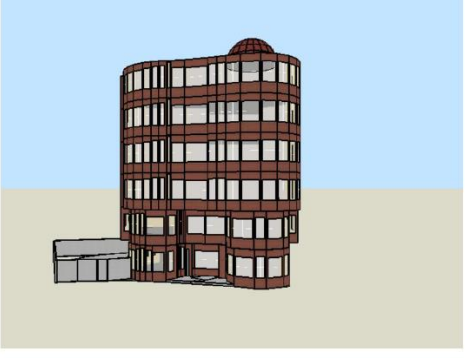

Fig 16 . South view

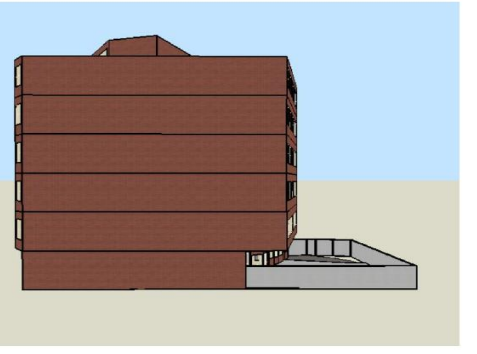

Fig 17. North view

Figure 18 . Western view

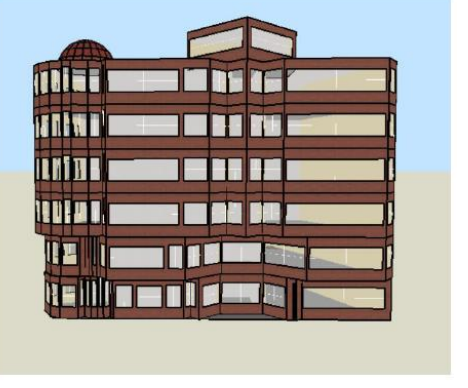

Fig 19 . Eastern view

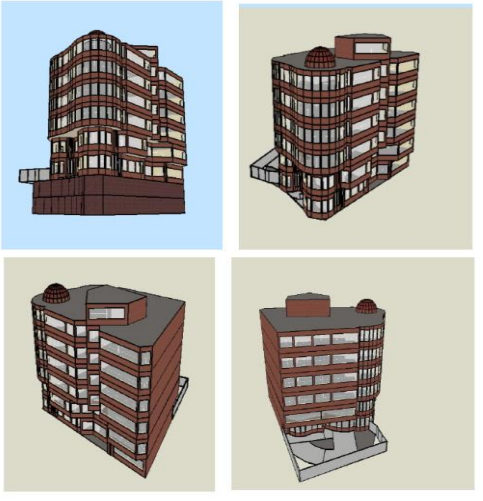

Fig 20. Perspective of the building in Design Builder

6. Energy Analysis of the Primary Building

6.1. Energy Obtained From The Sun And Internal Factors:

According to the image below, the energy obtained from the sun by the external windows of the building is 42029.98 kWh/m²/year. Lighting system with a total of 4.50618 kWh/m², electrical equipment with a total of 43125.3 kWh/m², and people with a total of 18329 kWh/m² are among other factors that cause the ambient temperature increases, and causes 102525.2 kWh/m² energy to be imposed on the building for cooling. In the winter, the total factors have a heating load of 2996.5 kWh/m², which are added to the building's heating system load to reach the appropriate temperature.

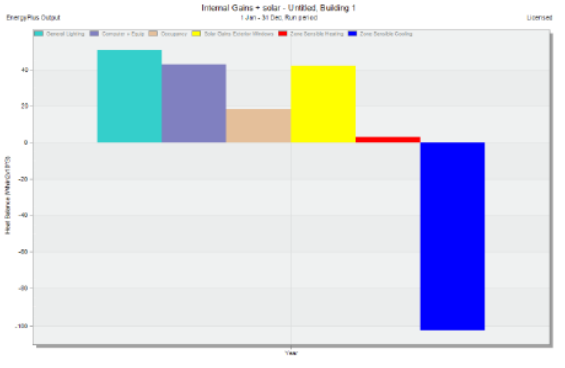

Fig 21 . Energy obtained by the sun, lighting system, electrical equipment, and human body

6.2 .Energy Bills Of The Primary Building:

The picture below shows the energy bill of the building. The most total energy consumption in the whole year is related to cooling with 187515.8 kWh/m², heating with 21585.4 kWh/m², and lighting with 50618 kWh/m². Consumable hot water with 4018 kWh/m², and electrical devices with 43125 kWh/m² are other energy-consuming items in the building. The total energy consumption of the building is 306864.1 kWh/m²/year.

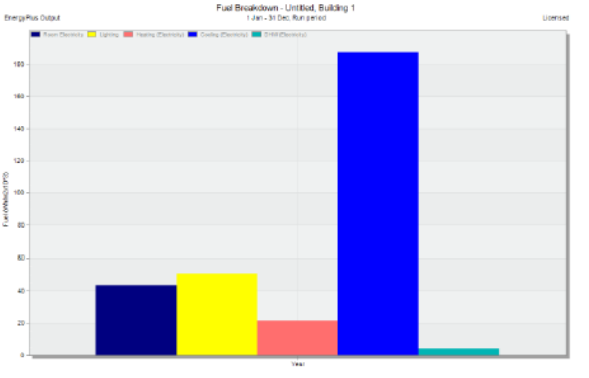

Fig 22 . Building energy bill

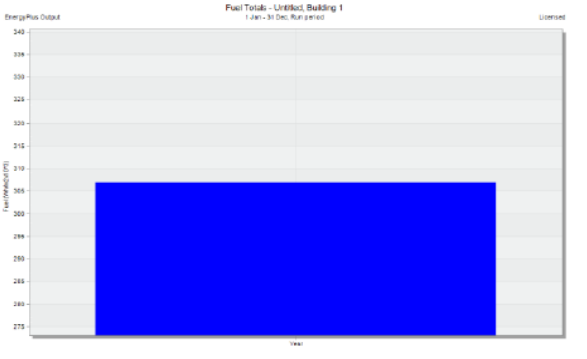

Fig 23 . Annual energy consumption

Based on the calculations provided by Iran's National Standard Organization for the private office building and the project climate, which is Tehran and is in the climate category number 5, and the project area which is 3071.35:

306864.1 * 3.7/ 3071.35 = 369.6
R = 369.6 / 124 = 2.98

This obtained value is in the range of 2.2 to 3.2, so the optimal building category is c.

7- Optimum Building Energy Analysis

In order to optimize energy consumption in this building, the following three solutions have been used:

Use Of Intelligent Lighting System

By equipping the house with smart lighting or lighting intelligentization, you can enjoy the benefits of a smart house with high-level management. A smart

lighting system with the ability to adjust and control remotely through a phone and tablet can help building owners in optimal energy consumption.

Using Insulated Walls With No Heat Transfer

Phase change materials can store heat energy in two forms, sensible and latent heat energy. In sensible energy storage, thermal energy is stored with the increase in temperature of a solid or liquid body. The amount of sensible energy stored in an object is a function of temperature, specific heat capacity, and the amount of the object. Thermal energy storage by the body is latent when the body changes phase from solid to liquid, liquid to gas, or solid to solid. Phase change materials store energy in the form of latent heat of fusion. As it has been said, heat storage is done by 3 ways of phase change, in the first case, when the phase change is from solid to solid, it is not suitable because the heat transfer is very slow and small. In the second case, i.e., changing the liquid phase to gas, it is not practical due to the need for high temperature and heat, as well as creating a high-pressure volume of the gas. But changing the phase from solid to liquid is more suitable because this feature exists in phase change materials, which are converted from solid phase to liquid at constant temperature by absorbing heat. These materials also release energy at approximately the same temperature as they absorb.

Use Of 3-Paned Windows With High Seams

You can use single-walled, double-walled, triple-walled glass, or even four-walled glass in upvc windows. The three-walled glass is composed of three single-walled glasses plus two spacers. In the empty space created by the spacer, argon gas equal to the outside air pressure is injected. The third glass in the three-paned window increases the role of insulation.

Using The Natural Evaporation Facility

The natural ventilation system is based on heat and wind flow as driving forces and is not a new phenomenon or invention. The use of natural power for the purpose of ventilation has been for thousands of years for humans and animals among the things available to create suitable living conditions. During the 20th century, it was discovered to use mechanical engines such as fans for natural ventilation of the air along the ventilation channels. The mechanical air ventilation system provided a constant air flow, thus providing opportunities for air cleaning (e.g., air conditioning) and heat recovery. But despite the advantages of the mechanical ventilation system, the natural ventilation system has grown so well that it can even be called a renewal period in the late 1990s. In the meantime, especially the architects and engineers were interested in the use of a natural ventilation system with the use of air-moving power inside the building. They popularized the use of natural ventilation systems in buildings and drew more attention to this field. Of course, the backgrounds and motivations for this attention were different. Mechanical ventilation systems developed into complex systems with a large number of components that required space and consumed energy. As a consequence, the integrated use of these systems in buildings was challenging and required skill. In this case, achieving and creating a balance in both architectural quality and good breathing, as the functions of the ventilation system, is one of the important results of the work. A mechanical ventilation system has a short service life compared to the structure of the building. On the one hand, the reconstruction or renovation of the mechanical ventilation system reduces the life span of the building due to the presence of ducts that are involved with the building structure. As a result, the mechanical ventilation system includes a large part of the building costs. Mechanical ventilation systems produce a lot of noise (both inside and outside the building) and it is often difficult to clean, repair, and maintain them. In total, all these cases and the increase in awareness about the environmental consequences of consuming more energy and resources have led to more focus on buildings with low energy consumption.

7-1 Energy Obtained From The Sun And Internal Factors:

According to the image below, the energy obtained from the sun by the external windows of the building is 109958.5 kWh/m². Lighting systems with a total of 61791.8 kWh/m², electrical equipment with a total of 42774.2 kWh/m², and people with 18400.15 kWh/m² are among other factors that cause an increase in ambient temperature, which causes 156474.2 kWh/m² of energy for cooling the building. In the winter, the total factors have a heating load of 3359.4 kWh/m², which is added to the load of the building's heating system to reach the appropriate temperature.

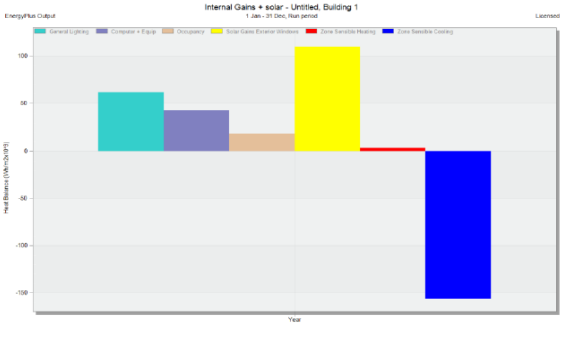

Fig 24 . Energy obtained by the sun, lighting system, electrical equipment, and human body

7.2. Optimal Building Energy Bill:

The picture below shows the energy bill of the building. The most total energy consumption in the whole year is related to cooling with 58760.3 kWh/m², heating with 2587.4 kWh/m², and lighting with 61791.8 kWh/m². Consumable hot water with 4175.4 kWh/m², and electrical devices with 42774 kWh/m² are other energy-consuming items in the building. The total energy consumption of the building is 170089.6 kWh/m²/year.

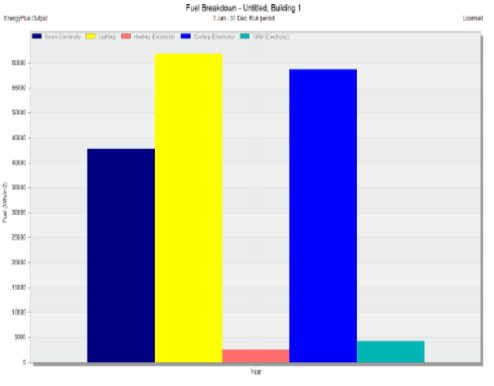

Fig. 25 . Building energy bill

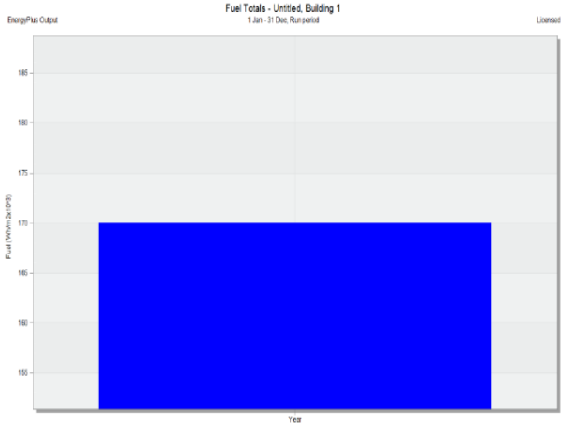

Fig 26 . annual energy consumption

Based on the calculations provided by the National Standards Organization of Iran for a private office building and the climate of the project, which is Tehran and in climate category number 5, and the area of the project which is 3071.35:

170089 * 3.7/3071.35 = 204.9
R = 204.9 / 124 = 1.65

This obtained value is in the range of 1 to 2.2, so the optimal building category is b.

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