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A Study of Energy Efficiency Simulation Programs and Energy Saving Optimization Analysis of Building Envelopment Parameters in Turkey

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ABSTRACT

This study focused on optimizing energy consumption in buildings by improving the building envelope, which accounts for a significant portion of heating and cooling energy usage. The research took an existing building in the Konya-Meram region as an example and conducted experiments on insulation, window-to-wall ratio, and glass thickness. Simulations were performed considering the climate of the Turkey-Konya region for comparative analysis. Various programs, such as Revit, Ecotect, Hap, and the Izoder TS-825 calculator (the Turkish standard) were utilized to evaluate energy efficiency. The results of the comparative analysis indicated that the Ecotect program provides the closest match to the calculations, hence enabling optimization experiments throughout the study. The optimal insulation thickness was determined to be between 7–11 cm; implementing an insulation thickness of 11 cm results in a substantial 46.71% reduction in heating load and an overall annual energy savings of 3.896%. However, further increases in insulation thickness beyond 11 cm do not yield significant energy savings. Regarding window-to-wall ratios, the optimal ratio in Konya was determined to be 75%, resulting in savings of 5.04%. In conclusion, this study emphasized the importance of the building envelope for energy efficiency and presented optimized solutions for insulation, window-to-wall ratio, and glass thickness in Konya city. The results of this study make a valuable contribution towards achieving notable reductions in energy consumption and highlight the possibility of enhancing energy efficiency in the structures located in the study area.

Keywords: energy efficiency; optimal thickness; ecotect; window-wall ratio; simulation.

INTRODUCTION

Energy efficiency pertains to the optimal utilization of energy in order to attain a particular objective or accomplish a desired task. The concept entails reducing energy consumption while upholding or enhancing the calibre and efficacy of the task or system under consideration. The objective of energy efficiency is to mitigate energy wastage and curtail aggregate energy usage while ensuring that comfort, productivity, and functionality are not compromised. Energy efficiency practices can be implemented across diverse sectors, including residential, commercial, industrial, and transportation, to optimize energy consumption. The strategies that can be employed to reduce energy consumption encompass the utilization of energy-efficient technologies, upgrading of infrastructure and equipment, adoption of energy-saving habits, and implementation of energy management systems. There exist a multitude of advantages associated with the implementation of energy efficiency measures. The implementation of energy-efficient measures can result in a reduction of energy expenses, a decrease in the emission of greenhouse gases, an improvement in energy autonomy by decreasing dependence on external energy sources, the advancement of sustainability and environmental preservation, as well as the facilitation of economic expansion and employment opportunities.

There exist numerous incentives for enhancing energy efficiency. The reduction of energy consumption can lead to a decrease in energy expenses and potentially yield financial savings for consumers, provided that the cost of implementing energy-efficient technology is outweighed by the energy savings achieved. The mitigation of greenhouse gas emissions can be achieved through the reduction of energy consumption. Enhanced energy efficiency in buildings, industrial procedures, and transportation has the potential to curtail the global energy demand by a third in 2050, thereby contributing to the mitigation of greenhouse gas emissions on a global scale. An essential measure is to eliminate the state-sponsored energy subsidies that incentivize excessive energy consumption and ineffective energy utilization in over 50% of global nations [Indra Overland, 2010].

There are various methods for calculating the annual energy required for building climate control, including practical experimental methods that utilize real practical techniques and experimental methods. While the first method requires the construction of a few actual buildings, the second method involves making numerous changes to building materials and designs in order to create suitable conditions for energy efficiency calculations in buildings and to procure specialized equipment. Both methods result in high costs. There is a third approach that demonstrates the possibility of achieving results in a short time through the utilization of simulation programs characterized by their ease and cost-effectiveness in evaluating energy in conjunction with climate usage. Moreover, the phases of energy analysis can be conducted through the utilization of simulation programs. The energy consumed in buildings can be analyzed in three steps: 1) draft needs to be created in order to gather the necessary information regarding the specifications of the building to be examined, 2) The input of climate data for the construction site is required, 3) the simulation conduct and analysis of the obtained results are necessary. This study involved the simulation and optimization of a typical rural housing unit in a region characterized by hot summers and cold winters. The simulation was carried out using Ecotect, Rivet, and Hap software. The variables selected to establish a quantitative relationship between building shape parameters and energy consumption were the building shape coefficient, isolations thickness, window-wall ratio and thickness of glasses window. These factors were identified as influential in determining building energy consumption.

The average energy efficiency of rural homes is notably lower compared to urban homes, primarily due to their architectural design and the utilization of traditional biomass, which is known to be inefficient [Evans et al., 2014]. Han et al. {2009] revealed that rural occupants exhibit a greater tolerance for cold temperatures compared to their urban counterparts, which may be attributed to the suboptimal thermal efficiency of rural housing. Despite the fact that rural building energy efficiency has been a topic of interest for quite some time, progress in this area has been hindered by the challenges related to planning, design, and the effectiveness of heat preservation measures [He et al., 2014a]. Currently, the efforts to improve building energy efficiency have primarily centred on communal and commercial buildings on a large scale, as well as urban residential structures. However, there has been limited research conducted on enhancing the energy efficiency of rural residential buildings. In contrast to urban residential structures, rural buildings have historically been erected by farmers who have relied on their personal expertise rather than adhering to established building codes. Consequently, the standards of building design and construction in rural areas are comparatively inferior to those in urban locales [He et al., 2014b].

Over the period of the last ten years, there has been a significant advancement in simulation tools, resulting in notable progress in the realm of building energy efficiency. The veracity of these simulation tools has undergone rigorous examination and has been validated by multiple scholarly investigations [Toja, 2016 and Negendahl, 2016] and most of the studies conducted in the literature regarding environmentally friendly green buildings. The study conducted by [Huanget et al., 2016] centred on the optimization of building envelope design through simulation. Their findings indicate that single-objective optimization remains the general approach in this field. In their study, Liu et al. [2015] conducted extensive research across approximately 50 villages in five suburban counties in Jinan, China. The findings indicate that the U-value of the typical building wall and roof in the area exceeds the maximum value stipulated in national regulations by approximately six and four times, respectively. In a study conducted by Mirrahimi et al. [2016] it was found that a significant correlation exists between different building elements, including shading devices, external walls, external roofs, external glazing, as well as insulation, and the reduction of energy consumption. Ozturk [2015] provided information on green buildings and their evaluation standards of them, which are significant applications in terms of energy efficiency. Turker [2010] developed a method for green building rating systems and applied an analysis of global green building rating systems using the example of the Erzurum shopping centre. Erdede et al. [2016] conducted a comparative evaluation of green building assessment systems that are applicable worldwide. Said [2017] established a strategic technique to determine the best criteria for a Turkish green building certification system. That research used Analytic Hierarchy Process. The study found that cost, efficiency, overall assessment success, registration and certification costs, compliance, and reliability are the most important green building certification criteria.

There is a disconnect between building energy-saving design and program design within the realm of architectural design. Typically, architects devise the program based on their professional expertise or established energy efficiency guidelines, relegating energy consumption analysis to a later stage of the design process. The irreversibility of the design process poses a challenge to the effectiveness of energy-saving design as a guiding principle in program design. Furthermore, most studies on energy-efficient design for residential buildings have focused on multi-story and high-rise structures in urban and suburban areas. Conversely, there has been a dearth of research on energy-saving design strategies for rural buildings. This paper studied the quantitative relationship between the design parameters of building shape and envelope structure and building energy consumption in the Konya-Meram rural area in hot summer and cold winter. The aim of implementing this approach was to facilitate the development of rural residential structures in the regions characterized by hot summers and cold winters, to achieve a reduction in energy consumption over the year.

The aim of the present study was to calculate the annual energy consumption of a building by experimenting with various building energy simulation software programs, namely Ecotect, Revit, and HAP, through the assessment of cooling and heating loads for indoor climate control. The impact of variations in passive and envelope materials used in a building on energy calculation analysis has been investigated to determine the contribution ratio of each parameter and the optimal state of each parameter group.

MATERIALS AND METHODS

Study area and data used

An 80 m^2 residential building was used in this study (Fig. 1). The building was designed using the most appropriate software to optimize parameters, such as windows-walls in the building envelope. Through experimentation, the study calculated the energy-saving contribution of the total shell parameters used in the building and proposed an energy-efficient building envelope design for the Turkish climate. The energy

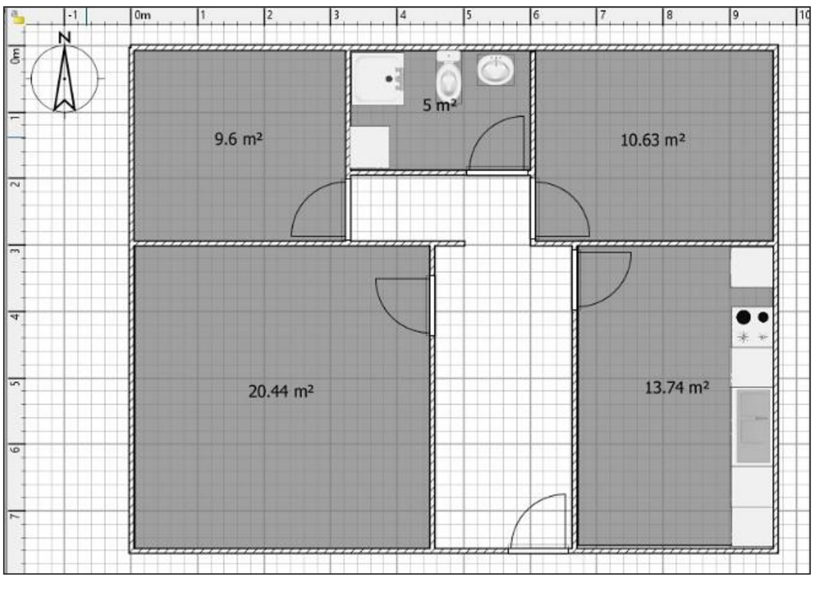

Figure 1. Map of the study building

performance analysis of the building in the study was conducted using the most suitable and efficient program that has been validated. Following the analysis of data containing the project specifications of the building in a simulation environment, a comparison was made between the energy performance of the building based on the ASHRAE version and the energy loads for heating and cooling as well as lighting loads, as outlined in the preliminary design of the building.

Table 1. Architectural inputs for building design

Structure features	Value
Total area of the building	80 m^2, it was chosen because the aspect ratio of the building is very close to 1:1 and it is the smallest and most suitable area in single house building designs in Turkey
Building height	3 m
Total exterior wall area	107.28 m^2
Window/wall reflected ratio	North/ South %30 East %50 West %10
Volume of the building	240 m^3 1:1.5 aspect ratio
Total window area	15 m^2
Number of floors	1 floor

Table 2. Window characteristics

Structural element	Material	Thickness	U value (W/m^2 K)	SHGC	SHGC
Window system	Ordinary glass, aluminum joinery	Glass 4 mm, Air gap 16 mm, Glass 4 mm	2.73	0.60	80%

Table 3. Thermal conductivity values (U-Values)

Structural element	Material	Thickness	U Value (W/m^2 K)
Roof	Matte porcelain granite	0.01	0.472
	Hollow brick filling	0.28	
	Slope concrete	0.05	
	Waterproofing	0.003	
Above ground walls	Brick wall	0.19	0.516
	Heat insulation XPS	0.05	
	Roughcast	0.01	
	Gypsum mortar plaster	0.01	
Underfloor walls	Brick wall	0.19	0.516
	Roughcast	0.01	
	Gypsum mortar plaster	0.01	
Mel floor	Lean concrete C-20	0.05	0.477
	Stamped concrete C-20	0.05	
	Aggregate	0.09	
	Protective concrete	0.1	
	Heat insulation	0.04	
	Bundling water izolation	0.003	

Table 4. Optimum trials and measurements conducted on parameters

Trials	Shell element	Parameter types	Measurements
1	Wall insulation thickness	TSE-825 proper insulation	1 cm, 2 cm, 3 cm, 4 cm
2	Glass measurement	Glass/wall ratio	25%, 50%, 75%, 100%
3	Glass thickness	Pure-glass SHGC 80%	2 mm, 4 mm, 6 mm, 8 mm

The system parameters identified for reducing the energy demand and improving the energy efficiency of the sample building are present in tables (1-4).

Methods

In this study, three pieces of simulation software were used. Ecotect is a three-dimensional high-performance simulation program utilized in building design and analysis, encompassing a broad range of thermal analysis, lighting, and acoustic domains. The design of buildings and their surrounding environment is referred to as engineering designs at the scale of simulation program models. In turn, Rivet is one of the programs developed by AutoCAD, a company specializing in the production of engineering programs for various engineering disciplines related to graphic interfaces. The program possesses the ability to define the boundaries of each area within a building and analyze the annual cooling and heating load for each space. The display of the table rows is determined solely by the location of the building based on the data provided to the program. Additionally, Hap is a program designed by Carrier Company to calculate thermal loads through building simulation and climate analysis, in addition to providing energy throughout the year. Its purpose is to compute the loads in spaces according to ASHRAE Association tables.

After selecting the location of the building through satellite in the Revit program, the building was automatically transferred to the program in the region where it is located in order to calculate the annual energy consumption per hour. In order to perform energy calculations in Ecotect and Hap software, it is necessary to prepare a climate file for analysis and optimization experiments in any region or climate.

The "Ecotect Weather" program (see Fig. 2) was utilized during the Ecotect program installation process in order to access the climate characteristics and data (such as temperature, pressure, wind, wind direction, etc.) of Konya city from the ACCU weather global climate website. Through these programs, the preparation of the annual climate files for Konya was done.

Inputs of the used software programs

After uploading the Konya climate file to the Ecotect program, the selected building was prepared for analysis using drawing tools in the Ecotect drawing interface, as shown in Figure 3.

Similar to the process in the Ecotect program, the building's envelope elements and thermophysical properties were identified and prepared for analysis, as shown in Figure 4, after the building was drawn using sketching tools.

The reason for describing the building in the HAP program analysis is due to the undivided nature of the drawing interface. To perform this

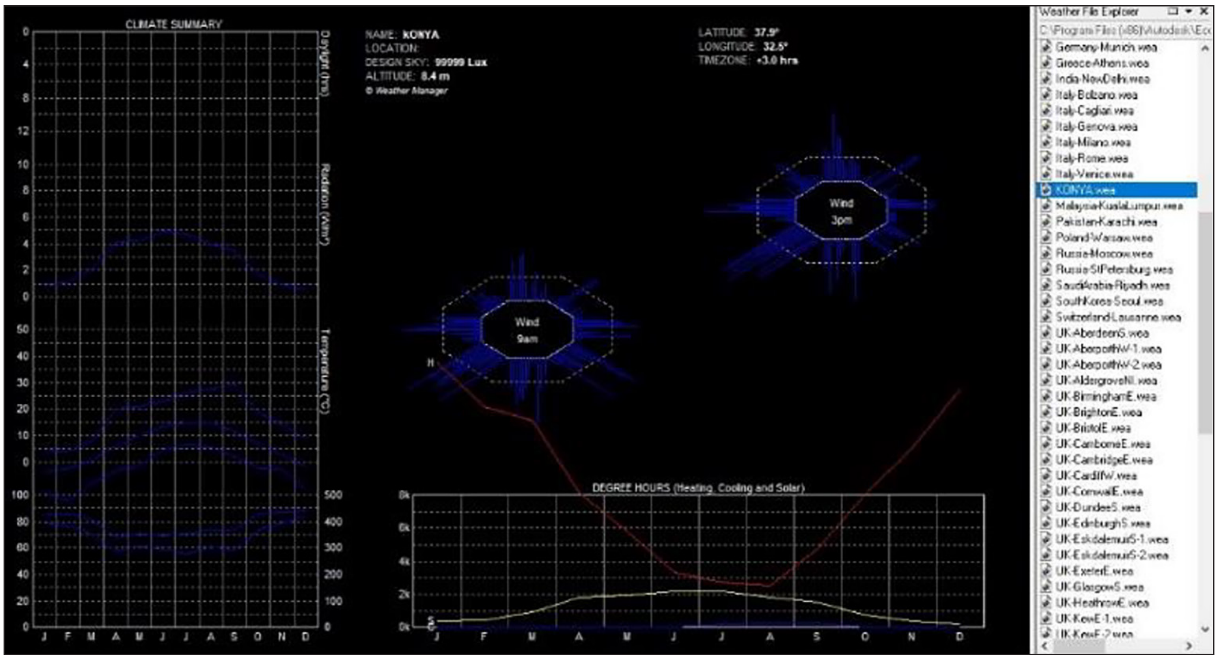

Figure 2. The view of the Ecotect Weather program during the preparation of a climate file

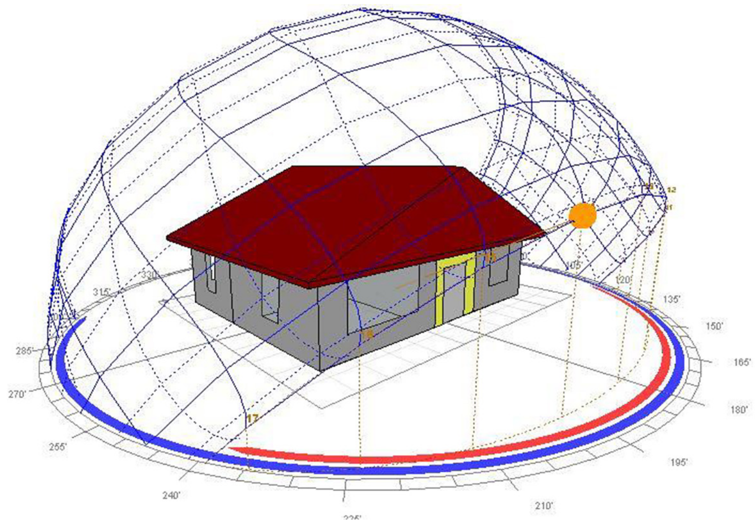

Figure 3. View of the building using Ecotect

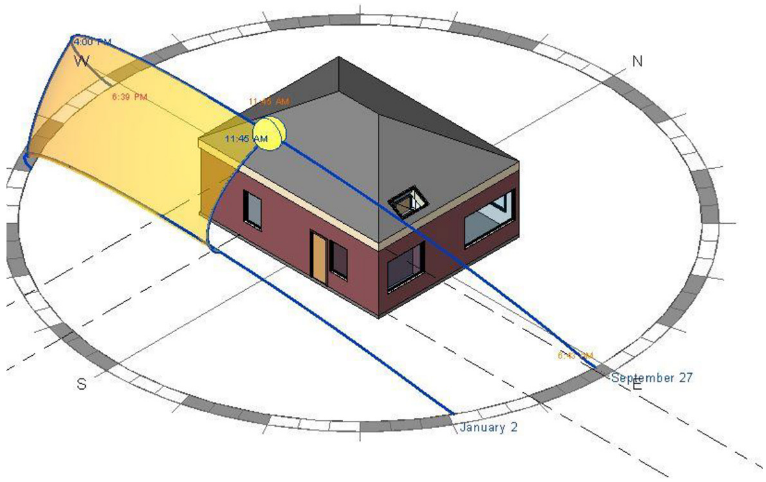

Figure 4. View of the building using Revit

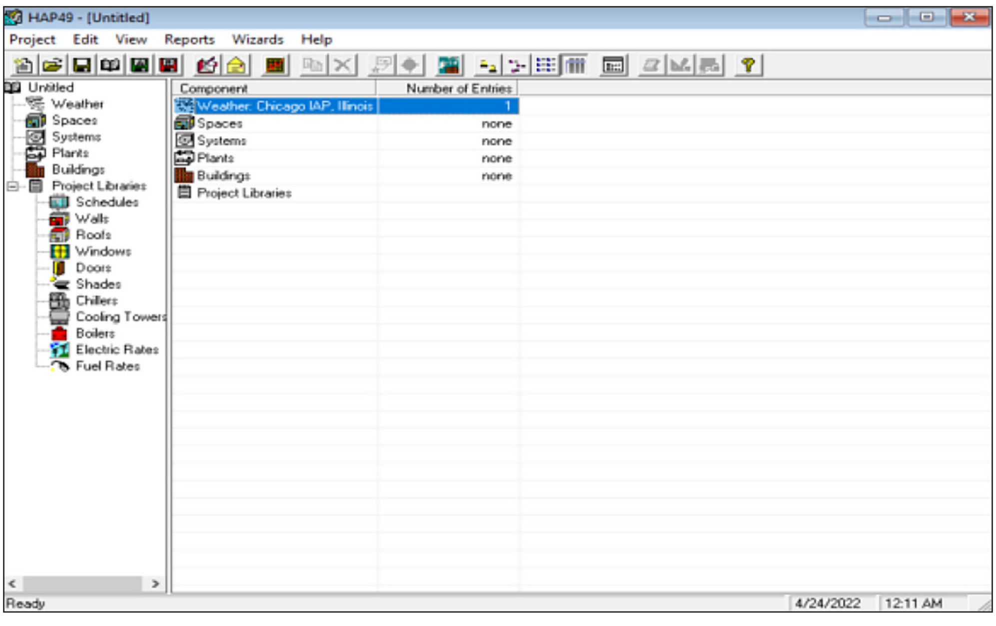

Figure 5. The interface for describing the building in the HAP program

procedure, the climate location was selected in the Weather window, and subsequently, each window of the building (walls, roof, windows, and floors) was individually included in the program through coding (Fig. 5).

The IZODER TS-825 calculation software, which is based on standard institute preparation in Turkey, is utilized as a standard for heating load and monetary return and to calculate error rates of other energy programs. All cities located in the Republic of Turkey contain pre-prepared climate files for almost all regions. The main screen of the system provides the opportunity to record information regarding the characteristics and features of the building in addition to the climate of the region. The IZODER TS-825 program incorporates the building details in a data format, and compatible components (walls and roof) are combined to load the building's characteristic features into the program. After transferring the wall and roof data into the program, each facade was included separately based on the window areas in order to accurately express the rate of solar energy utilization of the building. Upon transferring all details of the building into the program, the system presents analyses or data reports in the form of comprehensive reports, graphs, and sectional images through the recycling and reporting section (see Figure 6).

Application procedure of the programs

The programs utilized in this study are subjected to testing. By utilizing the TS-825 program, the whole work was analyzed, and the necessary system was determined for the research. Firstly, based on the building information provided, the shape and region of the building were specified in the programs. The information provided above is implemented as follows:

A building in the form of a residential structure located in the Konya region with a property and size of 8.9×8.9 = 80 m^2 was considered. After identifying all of the information in the program, the calculation table is prepared. On the basis of the gathered information, the final solar energy amount, by taking into account the thickness of the wall (wall thickness) and the properties of the roof, as well as the window ratios and orientation, was calculated. Once all of the information had been configured within the program, the annual thermal energy within the resulting chart was determined. The obtained result reveals the total amount of heat loss. As a result, the programs used were compared, and the most appropriate one for the optimization process was selected.

Best fitting program

The three used programs (Ecotect, Rivet, and Hap) were compared to determine the most

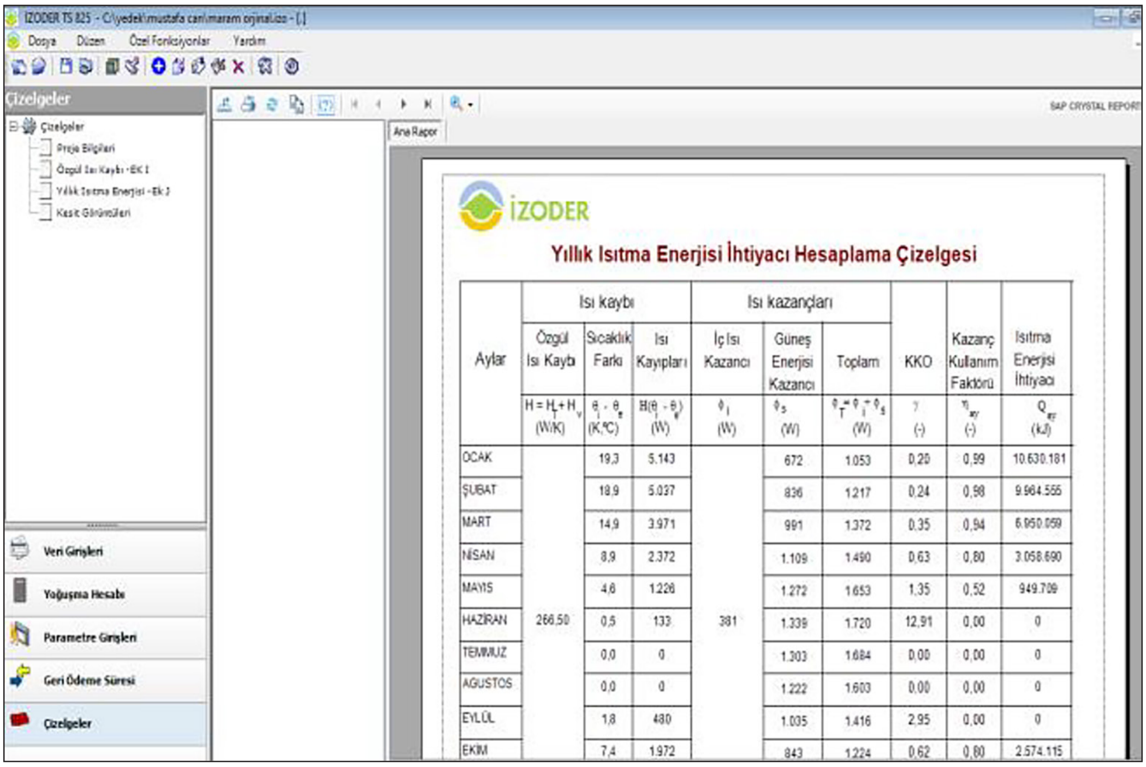

Figure 6. The energy consumption calculation window which obtained from the İzoder TS-825 program

Table 5. Comparison results of programs

İzoder Max heating W	ECOTECT Max heating W	Revit Max heating W	HAP max heating W
50,563	49,196	77,759	11,700
	ECOTECT Max cooling W	Revit Max cooling W	HAP Max cooling W
	31,314	62,982	4600
İZODER Total max load W	ECOTECT Total max load W	Revit Total max load W	HAP Total max load W
50,563	71,039	140,741	16,300

suitable program for the study. Similarly, simulations of an 80 m^2 building located in the Konya region were determined using Ecotect, Revit, and Hap programs. After conducting a simulation of the same building without insulation according to Turkish standards, the value was determined to be 15.071 kW of air. Thus, the closest program was chosen to be Ecotect software. When comparing with the Ecotect program, the results obtained from the Revit program exhibit an increase of approximately 22%, whereas the increase observed in the Ecotect program is not more than 1%. The Hap program obtained a result that is significantly distant. After conducting all of these comparisons, the Ecotect program was determined to be the most suitable program for the purposes. This is attributed to the fact that it enables us to achieve the closest results in terms of heating and cooling. As demonstrated in the thesis provided by Yıldız Technical University, the program utilized, particularly in the cooling aspect, enables us to arrive at the aforementioned conclusion through a comparison of calculations conducted in the Antalya and Diyarbakır regions of Turkey for cooling purposes. Similarly, the Ecotect program was chosen, as it is designed to obtain the closest results based on the cooling load factor (CLF), as shown in Table 5.

Optimization testing

Following the determination that the Ecotect program is the most effective program in the experiments mentioned above, an analysis of the parameters in three distinct groups was conducted by optimizing the building envelope.

Wall thickness

The original building walls have poor or no insulation. However, XPS insulation of 15 thicknesses (1–15 cm) was tested due to its affordability and low K factor (thermal conductivity factor). After drawing the original building envelope using the Ecotect program, an energy efficiency analysis was conducted of the insulation

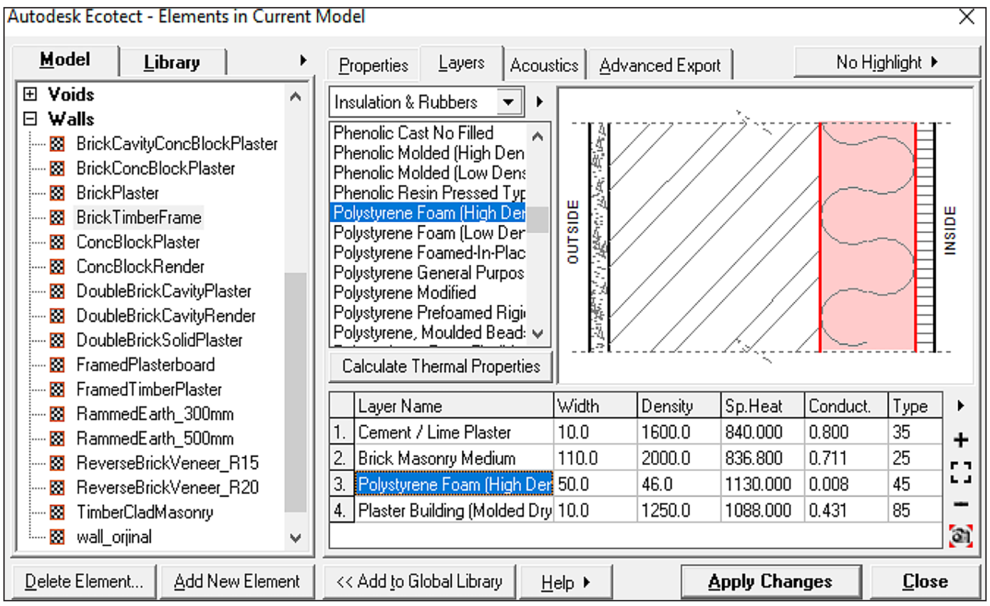

Figure 7. Examples of shells in insulated walls

envelope in the climate of Konya. The annual hourly climate files of Konya were loaded for trial in the Ecotect Weather program format. Following the preparation of the climate files, the wall insulation thickness of the building shell was modified in each trial by replacing the original uninsulated shell with 15 shells, as depicted in Figure 7, accessed through the wall–window properties. Before performing an energy analysis in the software, the thermal properties panel was employed to designate a building that is entirely air-conditioned. The temperature settings of the air conditioning system in Konya city were chosen to range from 18–22 °C for the set point, owing to the region's cold climate.

Analysis of window-to-wall ratio

After conducting an optimization analysis of the thickness of wall insulation, the next stage involved analyzing the window-to-wall ratio (at ratios of 25%, 50%, 75%, and 100%) (see Fig. 8–11) for all directions of the building in Konya, with the aim of achieving an optimal outcome.

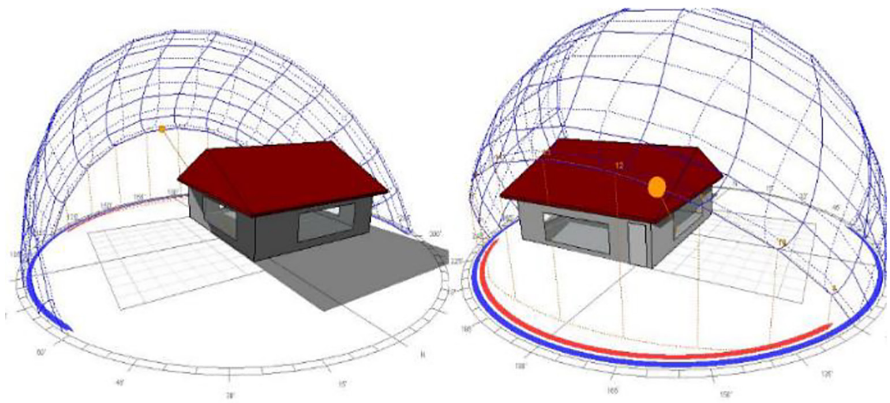

Figure 8. View a four-sided visual representation of the 25% window-to-wall ratio

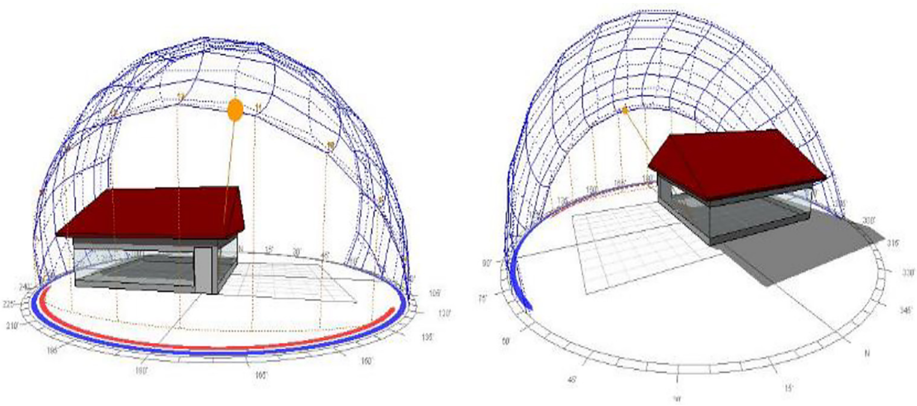

Figure 9. 50% window-to-wall ratio

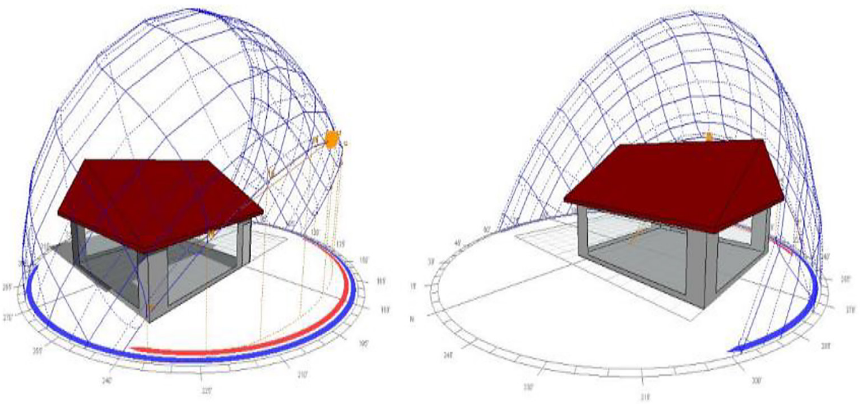

Figure 10. 75% window-to-wall ratio

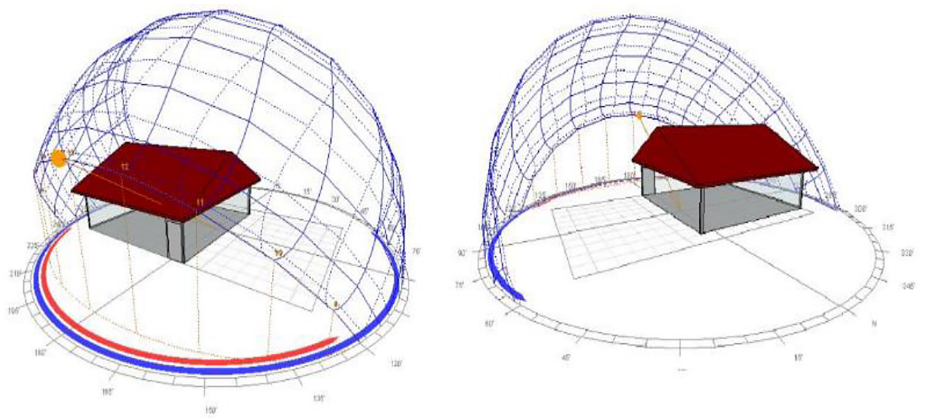

Figure 11. 100% window-to-wall ratio

Table 6. Window-wall ratios, area and dimensions

Direction	Area (m²)	Dimension (m)
North	0.3 × 889 × 3 = 8.01	5.34 × 1.5
South	8.01 – 2 = 6.01	4 × 1.5
East	0.5 × 8.9 × 3 = 13.35	8.9 × 1.5
West	0.1 × 8.9 × 3 = 2.67	1.78 × 1.5

The window-to-wall ratios depicted on all four facades of the building were calculated in terms of their total area and measurements, as shown in Table 6. Equation 1 was utilized to derive the values presented in Tables 7 and 8, which were subsequently employed in the optimization experiments for window design.

$$WWR = \frac{Window\ area}{Wall\ area} \quad (1)$$

where: WWR is a wall-window ratio.

In order to achieve exact equality in calculations based on the southern window area due to the presence of a door on the southern facade, the dimensions shown in the table below were used by reducing the ratio, as shown in Table 7.

Window thickness

At this stage, simulations were conducted on the (2-4-6-8) mm thicknesses of windows commonly used in building envelopes to analyze their highest energy efficiency potential.

Table 7. The ratios and dimensions of windows and walls on the southern facade

WWR	Area (m²)	Dimension (m)
25%	6–675	4.45 × 1.5m
50%	13–35	8.9 × 1.5m
75%	20–025	2.5 × 8.01
100%	267	3 × 8.9

RESULTS AND DISCUSSION

Before commencing experiments in this section, the outcomes obtained from each of the three programs were analyzed utilizing the Turkish Standard Code, Izoder TS-825. Throughout the optimization process, the outcomes of individual parameter groups were analyzed and endeavoured to determine their optimal states. After including the data of the selected building with three different programs (in the form of figures or data), the cooling, heating, and total annual energy consumption figures were obtained, and then these results were compared with the TS-825 standard established by the Turkish Standards Institute to select the most suitable or realistic program. When the same building was included in the Izoder program and calculated the results, it was found that the Ecotect program ranked first in terms of the heating load. On the other hand, it has been determined that there is a discrepancy rate of 17.1% when comparing the heating energy calculated using the HAP calculator, which is used to calculate the capacity of the Carrier air conditioning devices, and the data provided by Izoder (Fig. 12).

In cooling load calculations, different results have been obtained in each program. There is currently no published cooling load calculation code or standard in Turkey for accurately determining

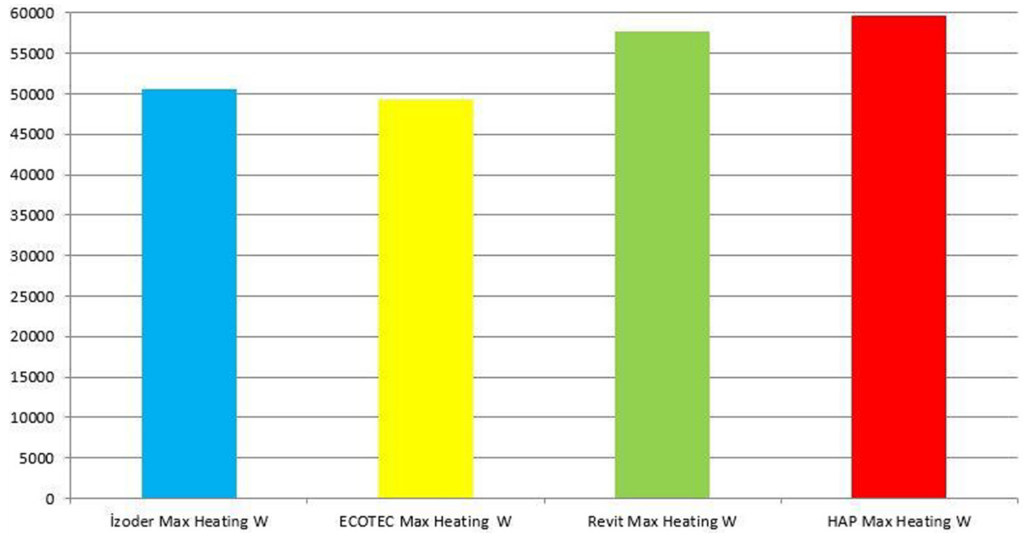

Figure 12. Energy consumption for heating which calculated for the example building

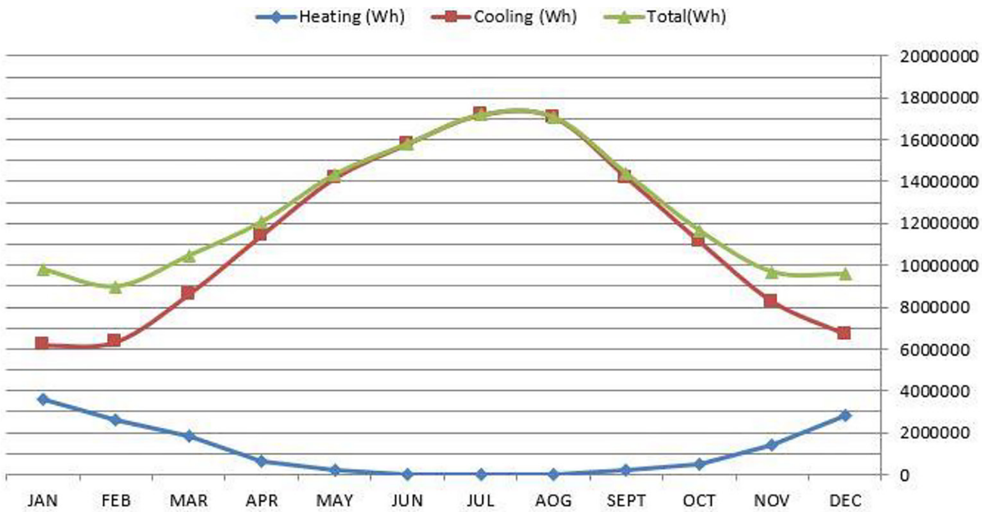

Figure 13. The distribution of heating, cooling, and total air conditioning energy calculated for each month in the Ecotect program

the error rate of each program in the cooling direction. However, in the study conducted at Yıldız Technical University, the Ecotect program was used to calculate cooling loads for Turkey. Thus, based on the calculations, it was determined that Ecotect is the best program that can be used for this purpose. Figure 13 shows the heating, cooling, and total air conditioning energy distribution calculated using the Ecotect program.

Result of optimization of wall insulation thickness

In this study, where insulation thicknesses ranging from 1–15 cm with very low or no insulation were used in the wall materials of a sample building, it was observed that there was an increase in energy savings with an increase in insulation. This was evidenced by a reduction in energy loads associated with heating, cooling, and overall energy consumption. Due to the climate in Konya city, the optimum insulation thickness for XPS insulation is between 7–11 cm (as per the optimal thickness in Turkey). It has been observed that after exceeding the insulation thickness of 11 cm, there is a decrease in energy savings in the heating load. It was determined that the cooling load was located after approximately 11 cm of insulation thickness in close proximity to zero. While examining the total annual energy savings, it was observed that the energy savings associated with 11 cm insulation were 3.896%, which was lower than the energy savings observed under the same heating conditions with insulation greater

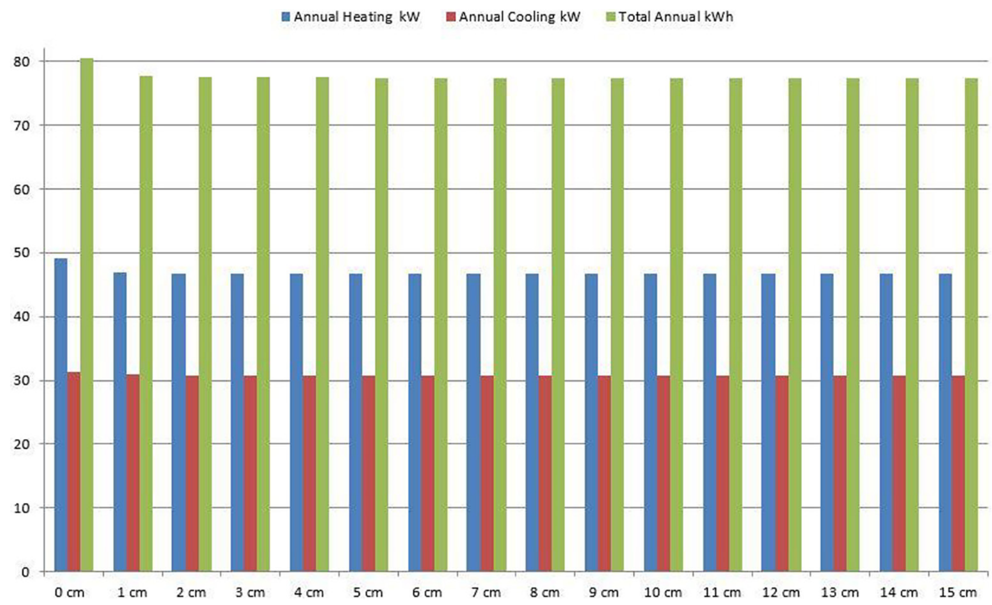

Figure 14. The energy consumption diagram of the building through the insulation on its walls

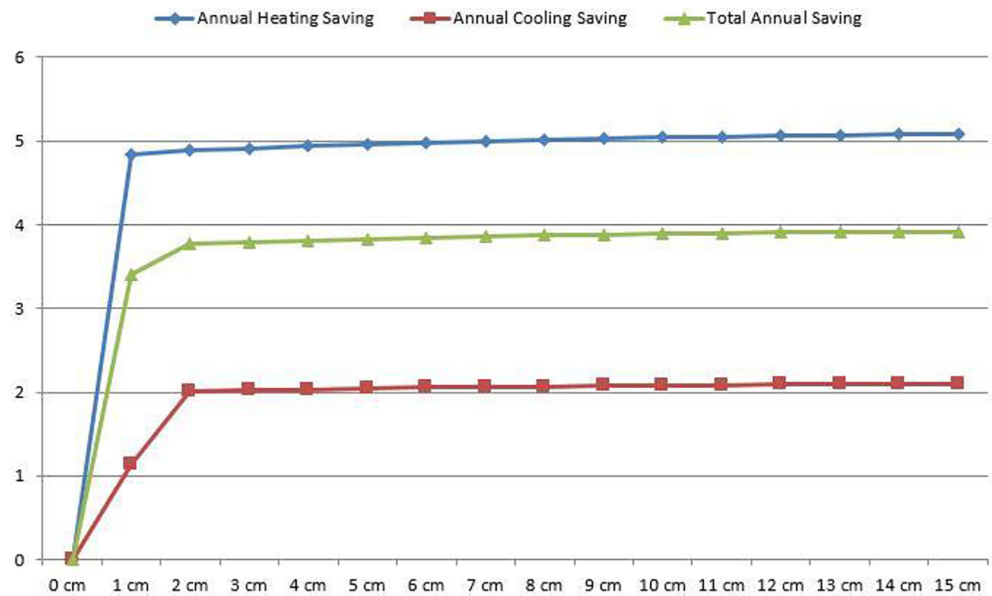

Figure 15. The saving rate in air conditioning energies in the building with the increase in wall insulation thickness

than 11 cm. Furthermore, a comparison of energy savings between insulated structures ranging from 15 cm and uninsulated buildings resulted in a savings range of 3.398–3.920 cm (Fig. 14 and 15).

The result of wall-window ratio optimization

In the study building envelope, four different window-to-wall ratios (25, 50, 75, and 100%) were presented, and it was varied for all four facades while calculating the cooling loads using the Ecotect program. In Konya city, the results demonstrated that the optimal window-to-wall ratio for heating purposes is 75%, which results in a 5.04% energy savings. It is the most effective in terms of cooling load, resulting in savings of 1.13% and a total annual conditioning load of 3.522% (Fig. 16 and 17).

The result of window thickness optimization

From the results (shown detailed in Table 8), it was observed that the Konya region, being a cold area with a significantly higher annual heating load than cooling load, has resulted in an increase in annual heating savings ranging from 0.6 to 1.034 upon upgrading the thickness of the window's in

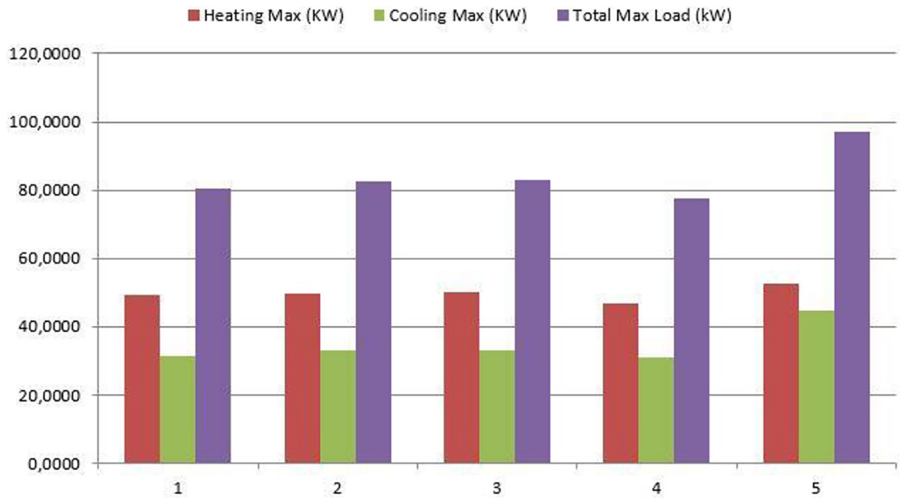

Figure 16. The energy loads for air conditioning in Konya's climate for four different window-to-wall ratios utilized

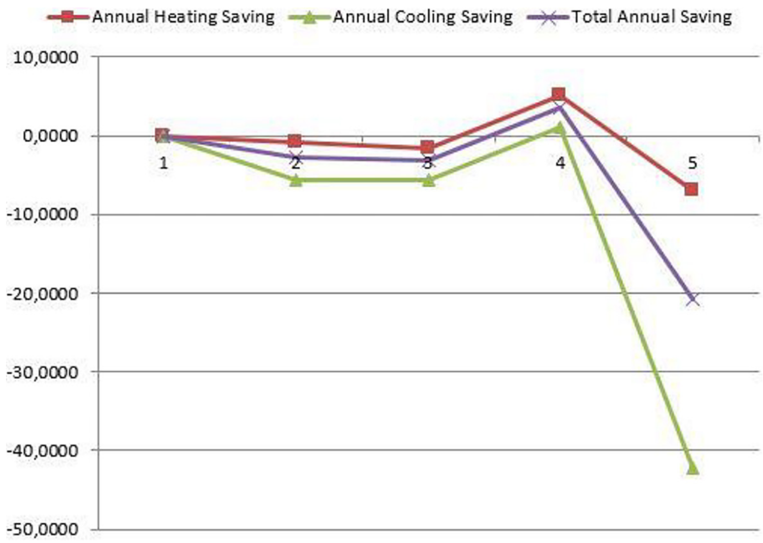

Figure 17. The correlation between the varying ratios of window-to-wall and the resulting increase in energy consumption saving

the building from 4 mm to 6 mm and 8 mm. On the other hand, it can be observed that increasing the thickness of the window from 4 mm to 6mm and 8mm results in a decrease in the annual cooling savings of the building, as it contributes to the cooling load. The ratio of energy consumption for cooling and air conditioning of the building has increased to a range of 0.55 to 1.15. However, the thickness of the window was reduced from 4 mm to 2 mm, and the annual cooling savings increased by up to 1%. Moreover, it has been observed that an increase in the thickness of the building's window results in a proportional increase in annual energy savings. The maximum achievable savings amount was 1.88% of the total annual energy consumption, as shown in Figure 18 and 19.

Table 8. Energy consumption and savings with window thickness

Thickness	Heating max (kW)	Cooling max (kW)	Total maximum load (kW)	Annual heating savings	Annual cooling savings	Total annual savings
2 mm	22.606	59.422	82.0280	1.2752	0.864	0.978
4 mm	22.898	59.9400	82.8380	0.0000	0	0
6 mm	22.973	59.217	82.1900	-7.5000	1.206	0.782
8 mm	22.998	59.134	82.1320	-10.0000	1.345	0.852

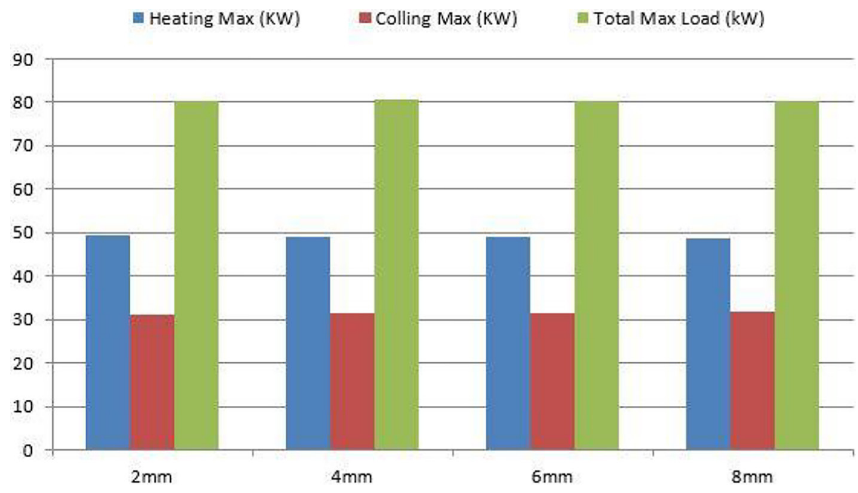

Figure 18. The relationship between window thickness and energy consumption in the climate of Konya

Figure 19. The correlation between the varying ratios of window thickness, and the resulting increase in energy consumption saving

CONCLUSIONS

The study was conducted in a residential building with an area of 80 m^2 with the aim of optimizing energy efficiency. The study was conducted with the aim of analyzing building energy performance and determining the most suitable programs for optimization processes, utilizing various pieces of simulation software such as Ecotect, Revit, and Hap. Architectural inputs such as total area, height, window-to-wall ratio, and building volume were determined for building design. The characteristics of building components such as windows, roofs, walls, and floors are determined by factors such as material, thickness, U-values (thermal conductivity values), and solar heat gain coefficient (SHGC). The simulation and analysis of building energy performance were conducted using selected software programs. The climate data for the Konya region was obtained from the Ecotect Weather programs. The annual energy consumption for heating, cooling, and total loads was calculated through modelling in Ecotect and Revit software programs. The results obtained from different programs were compared, and Ecotect was identified as the most suitable program for estimating heating and cooling loads in terms of accuracy.

After selecting the most appropriate programs, optimization tests were conducted on three different parameters, namely wall thickness, window-to-wall ratio, and window thickness. The energy efficiency of the building envelope was analyzed by altering the insulation thickness of the walls. The window-to-wall ratio has been adjusted for different facades to achieve optimal results. Furthermore, an analysis has been conducted on the energy efficiency potential of various window thicknesses commonly used in building envelopes. The findings and discussions of the study have focused on the energy performance of the building based on optimized parameters.

The effectiveness of the optimization process was evaluated by comparing the annual energy consumption for heating, cooling, and total loads with the Turkish Standard Code (İzoder TS-825). In general, research has utilized simulation software programs to analyze and optimize the energy efficiency of building envelopes.

The study aimed to propose an energy-efficient building envelope design for various climates by altering parameters such as wall thickness, window-to-wall ratio, and window thickness. The results obtained from simulations have revealed the potential energy-saving capabilities and overall energy performance impacts of optimized parameters. The scientific rationale and selection criteria for choosing software programs such as Ecotect, HAP, and Revit in our research emphasize the importance of utilizing more efficient, robust, and user-friendly programs that adhere to international standards. The authors opted for the Ecotect software to support the scientific approach of the study. The primary reason for this choice is the attainment of more efficient and closely aligned results in comparison with TS825 Turkish Standards Institute, as determined through our comparative analysis. The utilization of Ecotect enabled to obtain more comprehensive results in the calculation of heating and cooling loads, particularly due to its ability to perform more detailed and efficient calculations in comparison to TS825, which solely calculates heating loads. The utilization of these software programs enhances the scientific validity of the conducted analyses. The objective was to create designs with improved energy efficiency by conducting accurate analyses. This also enables the achievement of the set sustainability goals. The information presented in this scientific article constitutes the foundation of the study and elucidates the rationale behind the choices made. It is important to strengthen the scientific value of a study by focusing on topics such as research methods, accuracy of data, and validity of results.

According to the findings of the research, optimizing building components is of great importance for the energy efficiency of the building envelope. The optimization of parameters such as wall thickness, window-to-wall ratio, and window thickness has the potential to increase energy savings and improve overall energy performance. These findings emphasize the importance of considering the characteristics of building elements in addition to architectural entrances in building design. With regard to the formulated recommendations, it is essential to design energy calculation machines for buildings with reference to the Turkish standard TS-825. As a result, energy calculations can be performed in a standardized and accurate manner, leading to increased energy efficiency. Furthermore, it is recommended that the development of the İzoder TS-825 programs be undertaken to address the issue of disregarding window areas in recycling calculations. Thus, recycling calculations can provide more realistic results.

In addition, it is critical to calculating the efficiency of passive designs in buildings for Konya and their impact on the invoice amount. It is possible to construct sustainable buildings and promote energy efficiency by evaluating the impact of passive designs. These recommendations serve to identify the areas of focus for future research and studies. Optimization of building elements, enhancement of energy efficiency, and implementation of necessary measures for sustainable structures are of great significance in the field of building design.

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