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Effects of Exterior Wall Details and Building Locations on Energy Consumption of Residential Buildings in Turkey

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Abstract

The construction industry consumes energy throughout its life cycle. Countries that import most of the energy they consume are looking for ways to reduce the energy consumption of the construction sector. In this quest, the architectural design process and material decisions are important passive measures for reducing energy consumption. It is significant to determine the effects of external wall materials which have the largest surface area subjected to the climatic conditions where the buildings are located. In this study, by using the tracing technique, the external wall details of the residential projects in Ankara were examined, and effective parameters were used as input variables in energy modelling. The core materials used in the external walls were considered as the variables of this research since different types of materials were used according to geographical location despite being in the same climate zone. The energy consumption amounts were analyzed with the Green Building Studio program. In the analysis, the insulation materials and their thicknesses were kept constant. Results showed that while the wall details with the highest energy consumption were for the brick blocks in the Kızılcahamam region with the value 776,4 mJ/m^2/Year, the energy consumption for the pumice blocks in the Keçiören region was minimum with the value 618,9 mJ/m^2/Year. In conclusion, it is inferred that geographical location and wall core material type may increase energy consumption values up to 25%.

1. INTRODUCTION

Buildings are important in affecting our actions, emotions, and lives in the environment we live in. Because of the growing population in developing countries, there is a significant increase in building use stock. Therefore, the rate of energy consumption in the construction sector is also rising. The construction sector is a critical resource for the economies of developing countries in terms of future energy consumption and emissions. According to the 2020 evaluations of the Global Status Report for the Buildings and Construction Sector, published every year, the energy consumption originating from the building sector was calculated as 28%. Various legal regulations have ensured energy efficiency for buildings. Miscellaneous solutions were developed by environmental organizations and governments to reduce this ratio caused by the built environment. For example, Buildings Climate Tracker (BCT) system reduced energy emissions of the building sector in line with the study conducted by the International Energy Agency (IEA) (GlobalABC, 2020). Low-carbon, sustainable structures are at the forefront of these solutions. Alternative strategies are being developed to reduce the energy consumed from the production of the materials used in the buildings. Among the studies carried out, thermal performance is kept in the foreground in solutions for energy efficiency (Huberman & Pearlmutter, 2008).

As in the rest of the world, energy consumption rates are increasing in Turkey. According to the data, approximately 34% of the total energy consumption originates from the construction sector (Building Industry Energy Efficiency Technology Atlas, 2021). For this reason, studies for a sustainable built environment have gained great importance in recent years. In the studies, strategies for developing energy-

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efficient building applications, sustainable materials, and construction technologies are on the agenda. The energy-efficient materials are one of the methods used to reduce energy consumption in the building sector. As in the rest of the world, the regulations in Turkey also limit the application details used in the buildings.

Multidimensional improvement of residential buildings is possible by evaluating the building performance within the building life cycle. This situation leads to such results as the formation of structures that consume less energy during use but have very high financial costs, or structures with low financial costs but very high embedded energy. Hozatlı and Günerhan (2015) revealed that the reduction of embedded energies in buildings and the amount of energy consumed for heating, cooling, and hot water would decrease the amount of life cycle energy in buildings (Hozatlı & Günerhan, 2015).

Residential energy use depends mainly on the available amounts of local resources, which are closely connected with the present rural economy and living standards (Ozturk et al., 2004; Usta & Zengin, 2021). It has been revealed that the amount of energy was reduced to a minimum with the passive methods in architectural design. Architectural design involves decisions regarding the building features such as the type, size, location of the building, construction technology, materials, quality, etc. that affect the building cost and life cycle energy (Ilerisoy & Tuna, 2018). In terms of local resources, the most basic issue handled at architectural design stage is material decisions. Within the scope of the study, differences in energy consumption due to external wall material were focused. The total energy consumption of the residential building is affected by the temperature differences in the indoor and outdoor environment. Especially in cold and temperate climatic regions, heat transfer through the walls should be kept to a minimum (Djamila et al., 2018).

In the present study, to make reasonable analyses, the current situation was examined and buildings with the same concept were selected. For this reason, mass housing projects implemented in the different regions of Ankara, Turkey were chosen. According to a field study, it was determined that there were various external wall details in different districts within the same climatic conditions.

In the literature research, the prominent studies on energy consumption in the building sector are the subjects such as the differentiation of thermal insulation materials or the change of section thicknesses, material and system changes in the systems. However, studies on the regional variation of energy consumption are less. For this reason, this study aims to develop optimum relation between material type of external walls of residential buildings and location in terms of energy consumption. Residential building was selected as the reference among the other buildings, and energy analyses were made according to the difference in wall core material types and geographical location characteristics. With the comparative analysis, it is aimed to contribute to the country's economy by reducing the use of externally sourced energy for Turkey as a developing country.

2. LITERATURE

The inadequacy in the number of houses has been a problem in terms of quality and quantity, together with the intense migration from rural to urban areas and rapid population growth. In order to meet the increasing housing need after the 1980s, mass housing constructions started. However, because of the rapid implementation of the solutions by the state or private institutions, inadequacy in spatial and physical quality, environmental performance and psychosocial performance emerged (Özsoy, 2011). While the projects produced for lower-income groups, middle-income groups and upper-income groups differ in terms of materials used, the projects produced for the upper-income group have more qualified applications compared to the projects produced for lower-income groups (Bingöl, 2019). In addition to all these, because the energy used in the production and consumption phase is used from non-renewable energy sources, environmental problems occur in mass housing applications with dense housing units. Today, in line with increasing environmental awareness, the importance of residential building with low level environmental effects and sufficient in terms of design and functionality is increasing.

Buildings are considered as a priority area in studies to increase energy efficiency because of their high share in energy consumption, being the longest-lasting products in the economy sector, and a wide range of products and services. In his research, Karahan (2015) found that the energy consumption rate of the housing sector was 27% among all building structures when he lexamined energy consumption rates by sector (Karahan, 2015). Along with the housing production process, mass housing production and urban transformation applications also increase. With the rapid increase in mass housing production, improvements in the housing sector in energy consumption are of great importance (Karaca & Varol, 2012). Energy consumption rates in housing structure in Turkey are as follows: heating is 32%, hot water is 13%, lighting is 12%, cooling is 10%, and energy consumption for other uses is 33% (Çiftçi & Balyemez, 2020). Generally, considering the reasons for these consumptions, the decisions taken for the building envelope are effective in the architectural design process.

The building envelope, in its simplest form, comprises four elements: the external wall, the door/window, the roof, and the floor resting on the ground. Since these four elements are the components that separate the indoor and outdoor environments, they are in a structure containing many layers. Therefore, their complexity level is higher than the other parts of the buildings. The examination of heat losses in the energy consumption of buildings comes to the fore. Koçul and Dereli (2010) stated in their study that the heat losses in a single-storey house were 25% from the external walls, 22% from the roof, 20% from the windows, 20% from the basement, and 13% from air leaks. When mass housing was considered, they underlined that 40% of the total heat was from external walls, 30% from windows, 7% from roofs, 6% from basement flooring, and 17% from air leaks (Koçul & Dereli, 2010). Based on these data, it is revealed that the heat loss is mostly from the external walls. Therefore, the building envelope should protect environmental factors, such as reducing the heat losses required for the building and resistance to heat and cold. Benefiting from thermal mass, continuity of insulation, absence of heat and moisture bridges, and shell structure are the factors that are effective in providing thermal balance (Karaca & Varol, 2012).

The external walls, which are the focus of the study, are the elements with the largest surface area among the building envelope components. Details, which vary according to the characteristics of the building, are important for ensuring energy efficiency in constructions. In the literature, the most discussed issue in material decisions for external walls is related to the thermal insulation material and its thickness. Aktemur and Atikol (2017) made a comparative analysis of a sandwich-type wall for four cities by choosing six different insulation materials, which are extruded polystyrene, expanded polystyrene, glass wool, rock wool, polyisocyanurate and polyurethane, in order to find the optimum value of insulation thickness in buildings. In another study , the thermal insulation layer to be used in order to reduce energy consumption in buildings was decided by using the degree-day method for extruded polystyrene, expanded polystyrene, and cork insulation materials (Rachida Idchabania, Khyadb, and Ganaoui, 2016). Ertürk et al. (2015) performed energy analyses for buildings constructed in selected provinces in two different heat zones, including the use of rock wool, expanded polystyrene (EPS) and compressed polystyrene (XPS), including varying materials and thicknesses. Marwan (2020) made an innovative study in order to reduce energy consumption in buildings; a new composite brick material was produced by using styrofoam and earth binders, and it was revealed that energy consumption decreased in buildings produced with innovative brick material in the comparison of energy consumption between traditional brick and innovative brick. The classification of external wall applicationscan be done according to their different properties and in the light of heat losses (Marwan, 2020)

The energy performance in the usage phases of the selected application details is an important research area. Although the spaces to be created on the facade and the preferred windows differ according to the architectural designs (Koyun & Koç, 2017), the material preferences and application methods that affect the entire facade decision provide comfort conditions and play a leading role for an energy-efficient attitude. When external wall applications are considered within the scope of material decisions, (i) external coating, (ii) insulation, (iii) wall core material, and (iv) internal coating components come to the fore (Algın & Alkan, 2019).

3. METHOD AND CASE STUDY

The study analyzes the energy consumption of the details of the external walls of the mass housing projects in Ankara. By using data collection and tracking methods, which are two of the qualitative research methods, the energy consumption of the external wall details according to the varying material and location properties was examined. Modeling was done according to the determined variables. Analyses were made on the models. In order to obtain data for external walls, conventional design approaches and construction methods in housing production in Turkey, and to determine the detail types that are frequently used, information was obtained from experts about TOKİ Ankara projects. Then the details of the projects included in the scope were examined. The external wall details of 10 mass housing projects were analyzed and three types of details were determined. According to the data from the field study, the energy analyses regarding the detail types were carried out separately for each external wall core material. Afterward, these analyses were evaluated comparatively.

3.1. Analysis of the Current Situation in Mass Housing Projects in Ankara

Since the beginning of the 2000s, a rapid increase in the number of housing constructions has been going on in Ankara with the increasing population density and technological developments. The primary reason for this situation is the concentration of the increasing workforce in the region. Mass housing projects emerged in response to the increasing housing need, and mass housing projects were carried out by both the state and private companies (Yılmaz, 2016).

Ankara was selected as the region, and the houses were scanned to determine the current situation for the mass housing in Ankara, and the selection was made by considering the external wall systems among the mass housing projects made by TOKİ. The construction year range of the selected structures is 2000-2020. In the study, the architectural project system details and thermal insulation project of 10 residential buildings were reached. General information about the project and observational studies were presented. Selected buildings were listed chronologically according to their construction years (Table: 1).

Table 1. *Mass housing projects examined*

	T-1	T-2	T-3	T-4	T-5
Projects	**Kalecik TOKİ**	**Örencik TOKİ**	**Yapracık TOKİ**	**İncek 1.Etap TOKİ**	**İncek 2.Etap TOKİ**
Construction Year	**2007**	**2008**	**2009**	**2010**	**2014**
Number of Housing	112	756	732	1059	1585
Number of Floors of the Blocks	6	15	4,9,14	14	14,25
	T-6	**T-7**	**T-8**	**T-9**	**T-10**
Projects	**Mamak TOKİ**	**Saraycık TOKİ**	**Kuzeykent TOKİ**	**Varlık TOKİ**	**Kızılcahamam TOKİ**
Construction Year	**2016**	**2017**	**2018**	**2019**	**2019**
Number of Housing	519	1182	630	294	95
Number of Floors of the Blocks	11,12,13,14	6, 7, 8	8, 9	6,1 – 3, 5	3,5

According to the results of the data of the external walls from the projects of these structures, the tunnel formwork system was used in all the projects. Reasons for using this system are reducing labour cost, fast work completion, earthquake reliability, and providing a smooth concrete surface.

Wall systems of mass housing projects listed chronologically were examined and the results were presented (Table 2). It was observed that there was no guiding factor in material selection in the mass housing projects examined. In the projects shaped in line with the designer's decision, the material selection was also made with the design decisions. In addition, as a result of the chronological evaluation, it was observed that shear wall systems have been used in recent years. In the same way, it was revealed that there was no change in the material selection according to the projects examined chronologically. When the insulation materials were examined, it was seen that the use of rock wool material with high thermal insulation values was common. The reason for this is that stone wool is a good sound absorber and is fireproof. (Arslan & Aktaş, 2018). As a result, it was revealed that there was a wide range of materials because of the design decision with different uses, even in the same climate zone.

Table 2. *Summary of Field study*

Project	Region	Wall core material	External Wall System	External coating	Internal coating	Heat Insulation
Kalecik TOKİ	Kalecik	Brick	Paint	Acrylic Based Exterior Paint	Paint	Rockwool
Örencik TOKİ	Gölbaşı	Brick	Paint	Silicon-Based Exterior Paint	Paint	Rockwool
Yapracık TOKİ	Etimesgut	Brick	Paint	Silicon-Based Exterior Paint	Paint	XPS-EPS
İncek TOKİ	Gölbaşı	AAC	Curtainwall	Porcelain Facade Cladding	Paint	Rockwool
İncek 2. Etap TOKİ	Gölbaşı	AAC	Curtainwall	Ceramic Facade Cladding	Paint	Rockwool
Mamak TOKİ	Mamak	Brick	Paint	Acrylic Based Exterior Paint	Paint	Rockwool
Saraycık TOKİ	Sincan	Brick	Curtainwall	Fibre-cement Facade Cladding	Paint	Rockwool
Kuzeykent TOKİ	Keçiören	Pumice	Curtainwall	Fibre-reinforced Cement and Silicate Based Autoclaved Work Wall Board	Paint	XPS-EPS
Varlık TOKİ	Yenimahalle	AAC	Curtainwall	Double Glass with 16 mm Cavity Silicone	Paint	XPS-EPS
Kızılcahamam TOKİ	Kızılcahamam	Pumice	Paint	Acrylic Based Exterior Paint	Paint	XPS-EPS

According to the results of the site research, the masonry system was preferred for non-bearing walls, and it was determined that the building materials used were brick, aerated concrete (AAC), and pumice as the wall body materials. Thermal insulation materials used in buildings were EPS and mineral-based insulation materials. There were 3 different systems in exterior cladding; exterior paint, porcelain facade coating, fibre-cement facade coating. The coating materials used on the interior facades were the paint application on the interior plaster. Considering the wall body materials that emerged; brick was a building material that was commonly encountered in-wall systems. However, according to the research, the use of alternative materials is widespread because the environmental effects are high in the production and use of bricks (Khanve, 2014). The other wall material that emerged in the situation analysis was the wall types made with pumice wall blocks. Pumice blocks with a naturally porous structure produced from pumice stone are materials with high heat permeability resistance (Uzun, 2008). The third wall material was AAC blocks. AAC blocks are renewable and environmentally friendly materials, considering the necessity infrastructure for their production and the environmental factors that arise during the production phase (Usta & Zengin, 2021). In addition, since the raw material of AAC blocks is fly ash, which is one of the waste products formed in power plants, they are environmentally beneficial, green, long-lasting, and recyclable building materials. As they are light materials, they do not increase the dead weight of the buildings, while their CO2 emissions are also low (Kumar et al., 2021).

3.2. Determination of Wall Details and Location Limitations

While determining the type details for the modelling, the data obtained from the current situation analysis were taken into consideration. In the first stage, material diversity was considered in the external wall application. Here, the most effective difference was seen in the components of the exterior coating, insulation, and wall core material. Since thermal insulation materials are widely discussed in the literature, they are excluded from this study. In the process of modeling, thermal insulation was made with the use of materials of the same thickness in all types of details. The heat insulation material used here is extruded polystyrene foam and has a section thickness of 6 cm. While the thermal conductivity value (λ) of XPS material is 0.035 (W/mK), its thermal conductivity resistance (R) is 1.714 (m²K/W). Likewise, plaster material of the same thickness was used in all types of details. The cross-sectional thickness of the plaster material used is 2 cm and its thermal conductivity value (λ) is 0.51 (W/mK) and its thermal conductivity resistance (R) is 0.039 (m²K/W). In terms of exterior coating, there are both warm and cold wall applications (Knaack et al., 2014). However, because of the negligible effects of the application methods in the exterior coating materials in the research on energy consumption to be made, all models were applied with the warm wall technique. From this point of view, within the study, the wall core material was considered as a variable, and 3 types of models were determined as brick, pumice, and AAC (Figure 1).

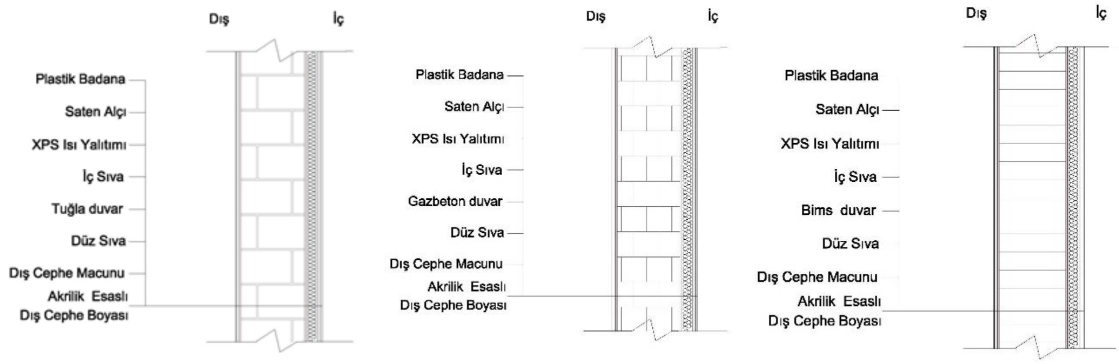


Figure 1. *The External Wall Cross-Sections*

Another issue that draws attention in the current situation is that the large mass housing projects in Ankara are in different locations and there are location-independent decisions on the external wall details. According to TS 825 Thermal Insulation Rules in Buildings, Turkey is divided into 4 heat zones (Heat Zones, 2015) (Fıgure 2). The thermal conductivity coefficient values (U value) that must be complied with in the buildings were determined for the regions where the distinction is made by considering the climatic characteristics. Considering the regions, the U values, which can have the highest thermal conductivity coefficients, are specified according to the climatic characteristics (TS-825, 2009). Ankara has a single heat zone and there is no difference in locations within the city. However, when the location of the materials with different thermal performances changes, their energy consumption also changes depending on the climate characteristics. In this context, to determine the differences in the energy consumption of wall systems, it was aimed to analyze according to three different locations in Ankara in the field study.

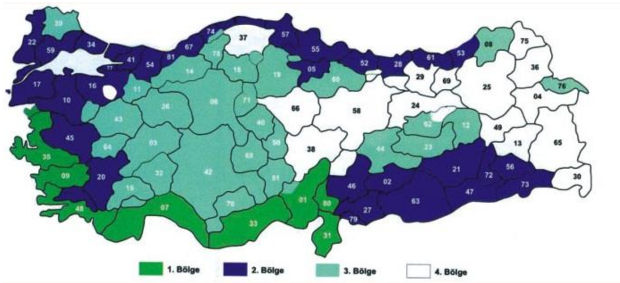
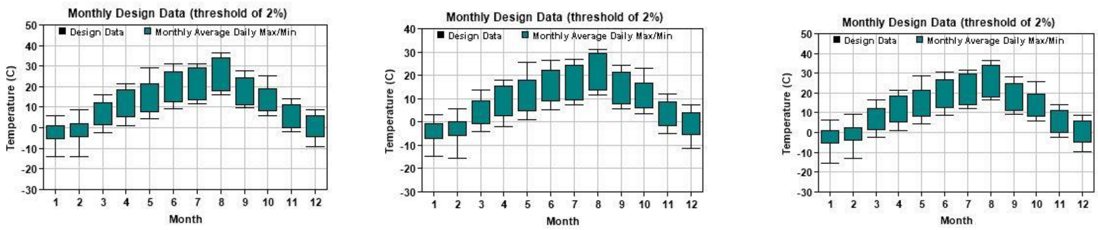


Figure 2. *Heat Zones (Isı bölgeleri, 2015)*

While making the analysis, Keçiören, Gölbaşı and Kızılcahamam regions, where three of the buildings discussed in the current situation analysis are located, were selected as the region in the province of Ankara, and the average temperature of these regions was taken as a basis for energy consumption. The thermal conductivity coefficients and usage phase energy amounts of the external wall details determined in the study were calculated. Since the 3 regions analyzed in the study are in Ankara, they are in the same heat zone. However, it was revealed that there were regional differences in climate characteristics and differences in energy consumption (Figure 3). Considering the temperature charts, for Keçiören district, the average temperature in winter is about -3 ◦C, the minimum temperature is -14 ◦C, and the maximum temperature rises to 35 ◦C in summer. For Kızılcahamam district, the average temperature in winter is -8 ◦C, the minimum temperature is -17 ◦C, and the maximum temperature is 29 ◦C in summer. Finally, considering the data for Gölbaşı district, the average temperature in winter is -5 ◦C, the minimum temperature value is -15 ◦C and the maximum temperature value is 32 ◦C in summer. When these three regions are compared, it is seen that the average temperature of the Kızılcahamam region is the lowest, while it is the highest in the Keçiören region. The temperature values of Gölbaşı region are between the values of the two regions.



(a) *(b)* *(c)*

Figure 3. *In Climate Characteristics (a)Keçiören, (b) Kızılcahamam, (c) Gölbaşı*

In the study, 9 different models were created with the data obtained from the current situation determination and material and region changes. The aim was to determine the differences by applying 9 different situation models to the same model. Models are classified according to their locations and material differences (Figure 4).

Location	Type Detail	Facade System
Keçiören	Type 1	Brick Wall
	Type 2	AAC Wall
	Type 3	Pumice Wall
Kızılcahamam	Type 1	Brick Wall
	Type 2	AAC Wall
	Type 3	Pumice Wall
Gölbaşı	Type 1	Brick Wall
	Type 2	AAC Wall
	Type 3	Pumice Wall

Figure 4. *Classification of Models*

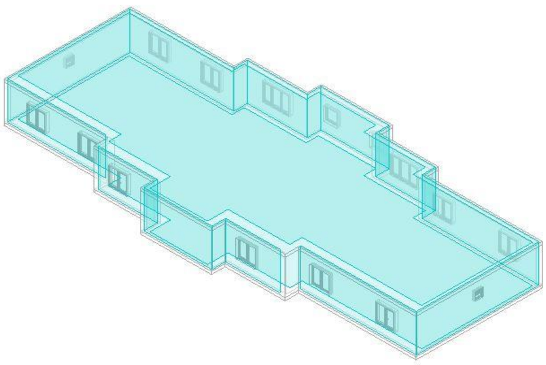
3.3. Determination of Architectural and Energy Modelling Process

In the architectural modelling process, as an application example, a floor plan with 2 flats was selected from the mass housing projects in Ankara and modelled in Revit, which is one of the Building Information Modeling programs produced by Autodesk, was used (Demchak et al., 2009). The building comprises two flats on each floor and the floor area is 275 m^2 in total (Figure 5a). In the scope of the study, external walls are created with 3 meters. The outer wall materials are added for each 9 types. The variables used in the program in the analysis are the core wall materials. Accordingly, the energy consumption of the materials changes with the thermal conductivity changes. The core wall material used in Type B is brick. The thermal conductivity value of the brick material is 0.5400 w/m.K. While the thermal conductivty value of pumice material used in Type P is 0.7600 w/m.K, the thermal conductivity value of AAC material used in Type AAC is 0.7400 w/m.K (Figure 5b).

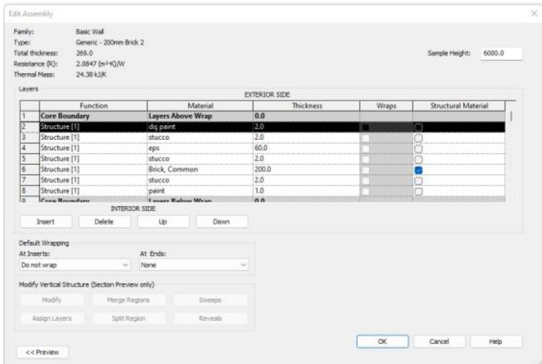
After architectural modelling, which contains both two-dimensional (2D) and three-dimensional (3D) drawing elements, energy modelling was created by checking the compatibility of the thermal conductivity values of the materials used in the systems (Figure 5b). Then, the Green Building Studio program is used to optimize energy efficiency. Green Building Studio is a flexible cloud-based service that allows to run building performance simulations to optimize energy efficiency and to work toward carbon neutrality earlier in the design process (GBS,2022).

Initial step of the energy analysis, information about the location of the projects, the type of building and the climatic conditions of the region are arranged. After the location data is entered, energy models are loaded into the system and energy values are analyzed. Results are shown with tables and graphics.

Since the study aims to calculate the energy consumption with the change of wall core material and location used in external wall applications in housing projects, some limitations can be mentioned. First, interior walls, roof, and floors were not included in the calculations, the floor plan was considered as a unit. Since it is crucial for the calculation of energy use density, the life of the building was determined for 20 years. Doors, windows, ceilings, and floors were not included in the calculations for all cases. The building was determined as a residential building in use 24/7 and it was assumed that the heating and cooling were made accordingly. It was also assumed that a water-cooled centrifugal chiller (COP 5.96) system was used for cooling, while a hot water boiler and the radiator-heated system were used for heating the building. For the ventilation of the housing structure, natural ventilation was considered. Finally, the effect of building direction is not covered in this study, but it is positioned linearly on the east-west axis of the building, keeping the south façade wide, making maximum use of solar radiation and energy and creating the least impact.



a



b

Figure 5. *Floor plan that is modelled*

4. FINDINGS AND EVALUATION

The energy consumption of the changing wall details in the buildings in different locations despite being in the same city presented in the study and the material decisions applied to the external walls of the buildings change the heat loss of the buildings and accordingly the heating load. The parameters examined in the study were Energy Use Intensity (mJ/m2/Year) and Annual Fuel Energy (MJ). Yang and Choi (2015) described the Energy Use Intensity (EUI) as a building's energy use in terms of its function, size and other characteristics, which is calculated by dividing annual building energy consumption in one year by the total gross floor area as kBtu/sf (Yang & Choi, 2015). Annual Fuel energy is the amount of fuel energy consumed in a year. In Table 3, the energy use intensity and annual fuel energy values, which are revealed as a result of the analyses for 9 different models, are given. The anaylsis data were evaluated in separate tables according to the material and region change.

Table 3. *Energy Quantities*

	Keçiören			**Kızılcahamam**			**Gölbaşı**		
	Type1; B	**Type2; P**	**Type3; AAC**	**Type1; B**	**Type2; P**	**Type3; AAC**	**Type1; B**	**Type2; P**	**Type3; AAC**
Energy Use Intensity mJ/m^2/Year	679,8	618,9	623,6	776,4	699,6	704,5	686,8	624,8	628,9
Annual Fuel energy (MJ)	102,495	86,182	87,182	134,671	113,675	114,693	104,201	87,653	88,518

First of all, the effect of the changing wall core material on the energy consumption performance under the same district was evaluated. According to the results, the values of the models using brick walls were the highest in terms of energy usage intensities, and the models using aerated concrete were the lowest. For example, in the Kızılcahamam region, where the average temperature is lower, the annual energy consumption is 699.6 mJ/m2/Year when AAC is used on the external walls, while this consumption amount has increased by approximately 7% with the use of pumice and reached 704.5 mJ/m2/Year, with an increase of 11% with the use of bricks, it has reached 776.4 mJ/m2/Year. Although this difference created by material change has a similar order in annual fuel energy amounts, the increase rates differ. At this point, in order to see the effects of material differences on annual energy performances, the percent increase obtained by accepting the AAC application in each region is calculated. Energy Use Intensity shows an average of 7% increase in pumice used models and 10% increase in brick wall usage. For annual fuel energy, these increases are 10% for pumice wall and 19% for the brick wall.

The second variable, the change of the regions, and the annual energy performance of the wall materials were examined. The lowest energy use density value was obtained in Keçiören region. The highest values belong to the models in Kızılcahamam. To see the effects of the changing regions, the models in Keçiören region, which has higher monthly average temperatures, were considered as a reference and the percentage increases obtained were calculated. In terms of Energy Use Intensity, an average of 1% increase was seen in the applications in Gölbaşı and 13% in the models in Kızılcahamam. For annual fuel energy, these increases were 1% in Gölbaşı and 30% in Kızılcahamam.

In the last stage, it was aimed to make a holistic evaluation by considering both variables. In order for all models to be evaluated on a single platform, the percentage increases in the amount of energy consumption among the models were calculated and compared with reference to the best performing Type-2 (Table 4). When the type detail made using the same material was analyzed according to the Kızılcahamam region, it showed an increase of 13%, while showing an increase of 1% in Gölbaşı region. Although the type 3 detail designed using AAC was proportionally close to the pumice block types, it was observed that there was an increase of approximately 1%. The energy consumption densities of the type detail made using brick wall material showed an increase of 9% for Keçiören region compared to the reference value, an increase of 25% for Kızılcahamam region and 10% for Gölbaşı region.

For the annual fuel energy data, similar rankings were seen, but the increase rates changed. When the type detail made by the same materials for Kızılcahamam region increased by %32, it was %2 for Gölbaşı region. When we compared type 2 and type 3 in Keçiören region, 2% increase shows that pumice material is close to brick material but more advantageous, while 19% increase in type 1 detail shows that energy consumption is high in brick material use. The annual fuel energy of the type detail made using brick wall material showed an increase of 19% for Keçiören region compared to the reference value, an increase of 56% for Kızılcahamam region, and 21% for Gölbaşı region. Similarly, type detail made using AAC wall material showed %33 increase for Kızılcahamam, while showing %3 increase for Gölbaşı region.

Table 4. *Energy Quantities According to Region*

	Keçiören			Kızılcahamam			Gölbaşı		
	Type1; B	**Type2; P**	**Type3; AAC**	**Type1; B**	**Type2; P**	**Type3; AAC**	**Type1; B**	**Type2; P**	**Type3; AAC**
Energy Use Intensity mJ/m^2/Year	111	100	101	125	113	114	110	101	102
Annual Fuel energy (MJ)	119	100	102	156	132	133	121	102	103

Additionally, the effect of meteorological data on the same outer wall structure in three different selected regions were evaluated. The details of pumice blocks, which have the lowest energy consumption values, were compared according to the regions. With the use of pumice materials, the energy usage density value obtained in the Keçiören region, where the average temperature is around -3 ◦C in winter, the minimum temperature is -14 ◦C, and the maximum temperature is 35 ◦C in summer, is 618,9 mJ/m2/Year, while the annual fuel energy value was found to be 86,182 MJ. In the Kızılcaham region, where the average temperature in winter is -8 ◦C, the minimum temperature is -17 ◦C, and the maximum temperature is 29 ◦C in summer, the energy usage density value is 699,6 mJ/m2/Year and the annual fuel energy value is 113,675 MJ. Finally, for Gölbaşı region the average temperature in the winter is -5 ◦C, the minimum temperature is -15 ◦C and the maximum temperature is 32 ◦C in summer, the energy usage density is 624,8 mJ/m2/Year and the annual fuel energy is 87,653 MJ. According to the results, the energy consumption values are the lowest in the Keçiören region, which has the highest average temperature in the analyzes made in different regions using the same materials. Accordingly, while the annual energy density in Gölbaşı region increased by 1% compared to Keçiören region, it increased by 13% in Kızılcahamam region. Similar changes were observed for annual fuel energy values.

5. CONCLUSION

The increase in the number of buildings with the increasing population has caused the rapid depletion of energy resources. When the energy consumption intensities taken into consideration, energy efficiency policies have gained importance in the housing sector, as the highest consumption is in the construction sector. In this context, energy-saving should be expanded by preventing heat losses in building. Within the current study, it was aimed to contribute to the country's economy by reducing the use of externally sourced energy in our country. To that end, energy analyses were made by considering different external wall types and energy consumption densities were compared. Exterior wall applications of mass housing projects built by TOKİ in Ankara were examined and the current situation analysis was made. There are brick, pumice and aerated concrete samples as core wall types, and acrylic paint, porcelain coating and fibre-cement coating samples are available for exterior cladding. However, there is no alternative other than paint as interior wall covering. Thermal insulation is provided with Rockwool, XPS and EPS sheets. After such diversity, it was intended to investigate the effect of wall core material on energy consumption in mass housing projects, especially in the variety of materials that can be selected by the architect. In this context, 3 different types of details were created on the same model, and each of them were analyzed according to 3 different regions. In the usage phase of the external wall details determined within the study, the energy use density values spent for heating and cooling were calculated.

According to the values obtained as a result of the analyses made by selecting three different locations in Ankara, the wall details with the highest energy consumption were the type details where brick wall blocks were used as 776,4 mJ/m^2/Year. The energy consumption of wall types made with pumice wall blocks is minimum with the result of 618,9 mJ/m^2/Year. As a result of the comparisons made according to the values obtained, there is an increase of 1% in the use of AAC blocks compared to pumice blocks in the Kızılcahamam region, and an increase of 11% when brick blocks are used. Similar values were obtained in other regions as well. While there is a 1% increase in the use of wood blocks compared to pumice blocks in the Gölbaşı region, there is an 8% increase when brick blocks are used. For Keçiören, there is a 1% increase in the use of aac blocks compared to pumice blocks, while there is an 8% increase when brick blocks are used. According to the results, considering the climatic conditions of the Ankara region, it was revealed that the use of pumice in the projects made was better in terms of thermal performance.

While the decisions taken for the material of the building envelope in buildings provide maximum comfort conditions for the users, energy and resources should be used effectively at the same time. Among the improvements made in the housing sector, studies to reduce energy consumption, cost and buried energy are very important. This study contributes to energy efficiency issues by reducing heat losses with building materials in a mass housing project. While the decisions taken for the material of the building envelope provide maximum comfort conditions for the users, it is also necessary to use energy and resources effectively. Among the improvements made in the housing sector, efforts to reduce energy consumption, cost and embedded energy are very important. This study contributes to energy efficiency issues by reducing heat losses with building materials in a mass housing project. According to the comparisons made in the study, the meteorological data of the regions affect the energy consumption. Since energy consumption can be reduced by the use of pumice material in regions where the average temperature is low, the use of pumice blocks is appropriate in these regions. On the other hand, since the energy consumption values are lower in regions with high temperature averages, the use of brick material may be appropriate.

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