IZMIR KATIP CELEBI UNIVERSITY ★ GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

EVALUATION OF PASSIVE BUILDING DESIGN PARAMETERS FOR IZMIR CITY

M.Sc. THESIS

İlker GÜÇÜ

Department of Urban Regeneration

Thesis Advisor: Assoc. Prof. Dr. Salih YILMAZ

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İZMİR KÂTİP ÇELEBİ ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

PASİF BİNA TASARIM PARAMETRELERİNİN İZMİR İÇİN DEĞERLENDİRİLMESİ

YÜKSEK LİSANS TEZİ

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TEMMUZ 2016

İlker Güçü, a **M.Sc.** student of **IKCU Graduate School of Natural and Applied Sciences**, successfully defended the thesis entitled "**EVALUATION OF PASSIVE BUILDING DESIGN PARAMETERS FOR IZMIR CITY**'', which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor : **Assoc. Prof. Dr. Salih YILMAZ** ....
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Date of Submission : 15 June 2016
Date of Defense : 14 July 2016

To my family,

FOREWORD

I would like to thank the following people who helped me building this study.

I would like to thank my parents Solmaz Güçü, Ali Güçü and my sister Müjde Aydın for their support and trust in every area of my life. In addition, I would like to thank my friends that I feel their support all the time.

And finally, I would like to thank my supervisor Salih Yılmaz for his leading, support and contribution to study.

July 2016

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(Architect)

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ABBREVIATIONS

TOKI	**:** Mass Housing Administration
TUIK	**:** Turkish Statical Institute

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EVALUATION OF IZMIR ENERGY DATA IN TERMS OF PASSIVE HOUSE DESIGN PARAMETERS

SUMMARY

The housing sector is one of the largest sector responsible for energy consumption in the world and Turkey. Sustainability is an emerging issue as energy related problems arises throughout the world. The sustainable sources are both clean energy sources and mostly renewable. Therefore, especially in terms of economy, these new energy sources are important opportunity for countries dependent on other countries energy. Turkey is rich in sustainable resources and especially Izmir province has good potential in terms of solar, wind and geothermal energy which are the most important sustainable sources.

Besides alternative sources, reducing energy demand is extremely important for sustainability and energy safety is not limited to renewable energy sources. An important share for housing energy is related to heating and cooling of buildings. Also, it is possible to provide the sustainability through the design of houses. Thus, the aim of this study is to describe the effect of passive building design parameters on energy consumption. Within the scope, a building model was developed through the computer-aided building design software and energy consumption values of this model were calculated by changing its design parameters. The results of the analysis were evaluated and tried to find the optimum passive design solutions for residences in the province of Izmir.

As a result of the analysis, the proper orientation of the building model was found in a north-south axis. In this orientation, energy savings of up to 7% have been observed. In addition, analyses were performed to find the appropriate street width for 3, 6 and 12-storey apartment models. As a result of these analyses, energy savings of up to 6% were observed in proper street width.

Keywords: Passive design parameters, Energy efficiency in buildings, Izmir, Ecotect Analysis

İZMİR İLİ ENERJİ VERİLERİNİN PASİF EV TASARIM PARAMETRELERİ AÇISINDAN DEĞERLENDİRİLMESİ

ÖZET

Konut sektörü Dünya ve Türkiye'de nihai enerji tüketiminden sorumlu en büyük alanlardan biridir. Sürdürülebilirlik konusu, enerji kaynaklı sorunların dünya çapında yükseldiği kadar gelişen bir konudur. Sürdürülebilir kaynaklar hem temiz enerji kaynaklarıdır hem de çoğunlukla yenilenebilir kaynaklardır. Böylelikle, özellikle enerji bakımından dışa bağımlı olan ülkeler için ekonomik açıdan önemli bir fırsattır. Türkiye sürdürülebilir kaynaklar bakımından oldukça zengindir ve özellikle İzmir ili sürdürülebilir kaynakların en önemlilerinden olan güneş, rüzgâr enerjisi ve jeotermal enerji bakımından iyi verilere sahiptir.

Ayrıca alternatif kaynakların enerji talebini düşürmesi sürdürülebilirlik için çok önemlidir ve sürdürülebilirlik sadece yenilenebilir enerji kaynaklarıyla sınırlı değildir. Tüketilen enerjinin büyük kısmı binaların ısıtma ve soğutması için harcanmaktadır. Sürdürülebilirliği sağlamak enerji tüketiminden büyük ölçüde sorumlu konutun, tasarımıyla da sağlamak mümkündür. Bu tez çalışmasının amacı da böylelikle, konut tasarımındaki parametrelerin İzmir ilindeki enerji tüketimine olan etkisini açıklamaktır. Bu amaç kapsamında bilgisayar destekli yazılımlar aracılığıyla bir bina modeli oluşturulmuş ve bu bina modelinin tasarım parametreleri değiştirilerek enerji tüketimleri hesaplanmıştır. Analizlerden çıkan sonuçlar değerlendirilmiş ve İzmir ilindeki konutlar için optimum pasif tasarım çözümleri bulunmaya çalışılmıştır.

Yapılan analizler sonucunda, oluşturulan apartman modeli için en uygun yönlenme güney-kuzey aksında bulunmuştur. Bu yönlenmede %7'ye varan enerji tasarrufu gözlemlenmiştir. Ayrıca, 3,6 ve 12 katlı modellerin en uygun sokak genişliklerini bulmak için de analizler gerçekleştirilmiştir. Bu analizler sonucunda da uygun sokak genişliklerinin apartmanlara %6'ya varan enerji tasarrufları sağladığı izlenmiştir.

Anahtar kelimeler: Pasif tasarım parametreleri, binalarda enerji verimliliği, Izmir, Ecotect Analysis

1. INTRODUCTION

1.1 Problem Definition

Demand for housing and energy are increasing with the population growth. The housing is one of the largest sectors responsible for energy consumption throughout the world [Url-1]. According to TUIK data, housing sector with a 37% share is the most energy consuming sector after industry in Turkey [Url-2].

A large part of the energy consumed today is derived from fossil fuels. As a result of synthesis of these fuels, gases such as carbon dioxide and methane are released to atmosphere. The rays from the sun warms the Earth through the atmosphere. Gases in the atmosphere keep a portion of the earth temperature and prevent the loss of heat from the earth. In recent years, there is an increase in the amount of gases such as carbon dioxide and methane harming ozone layer. This increase leads to the accumulation of gases in the atmosphere. All of these gases have the ability to retain heat. Thus, Earth’s temperature increases. This process is called greenhouse effect and this effect is the most important reason for forming global warming [Url-3]. Therefore, the measures to be taken to reduce energy consumption is of great importance.

In addition, it is important for the economy and politics to reduce energy consumption in Turkey which is dependent on foreign countries for its energy need.

Looking at the vast majority of buildings constructed in Turkey, it is seen that the conservation of energy efficiency and climatic suitability are ignored. This situation can be understood from the same type housing to be seen all over the country. With measures to be taken in the building design, the energy demand can be reduced and environment friendly buildings can be constructed. Developing policy and plans on this, significant environmental and economic gains can be achieved.

1.2 Objectives & Scope

Energy efficiency in building can either be achieved by providing an efficient insulation system or by introducing passive design principles.

The main objective of this study, is to determine how passive design parameters affect the building energy consumption in terms of heating and cooling loads. For this objective, focused on different design parameters such as the orientation of buildings, street widths and building height. It has also benefited from software products to monitor the change of the heating and cooling loads. So the variables were examined in an only virtual environment and be able to have some prior knowledge about design.

The scope of this study is to investigate the effects of design parameters that affect building energy consumption by computer simulations.

An apartment building models were designed to examine the impact of determined design parameters. Revit Architecture 2014 software has been used for modelling. Heating and cooling energy demand analysis is carried out by Ecotect Analysis 2011 software. Climate data of Izmir were introduced to this software and energy consumption of the buildings were analyzed by the changes made in the models design parameters.

1.3 Structure of the thesis

In line with this aims, the study consists of 5 chapters. The aim, scope and method of study are mentioned in the first chapters. Also, the literature study is included in this section.

In the second chapter, design parameters that have an impact on building energy consumption are described in the environment and building titles. In the third chapter, design parameters determined in the previous section and adaption of the building model is mentioned. In the fourth chapter, the results of analysis are presented and discussed. Conclusion and suggestions will take place in the last chapter.

1.4 Previous Studies

The topic attracts researchers interest especially for the last few decades. Finding of some important studies in the literature are explained below:

Berköz et al. [1] aimed to create handbook for convenience and flexibility in the selection of appropriate values to the architect in the design. For this purpose, the determination of these values and the methods applied in the design process. In the study, five different climatic regions of Turkey were examined for passive building design and the results were discussed for these five regions. The parameters analysed in the study are followings:

- Optical and thermodynamic properties of the building envelope
- Orientation of the building
- The form of the building
- Building ranges
- Natural ventilation scheme
- Location

Feuermann and Novoplansky [2] investigated reversible low solar heat gain windows. This window types usually double glazed with the exterior pane tinted or selectively absorbing and refuse a portion of the absorbed solar radiation and reduce solar heat gain. Thus they educe solar heat gain. this effect is undesirable in the winter. However, this windows are 180° reversible. So that this window will collect more solar radiation and helps to warm up in winter. For the study, seasonal energy savings estimated with the computer. The analysis results revealed that significant savings can be achieved via proposed windows.

Bouchlaghem [3] presented a new computer model. This computer model both analyzes the thermal performance of the building and applies numerical optimization techniques to determine the optimum design variables. The main program was supported by graphical model fit the design window tools. While the model was analysed, it was showed that standard numerical optimization could be applied to thermal design to optimize the thermal performance of buildings. It was concluded that the models offer precious decision for designers at an early design state.

Aksoy [4] investigated the effect of building orientation and building forming in terms of climatic comfort to building heating costs. In this study, building envelope temperature distribution for different building alternatives which have the same base area and three different form factors, is calculated according to nine different orientation conditions, three different surface ratios and five different building envelope details. Also, advantages and disadvantages of building alternatives discussed according to the cost of heating and passive design strategies. The study was conducted for Elazığ province of Turkey. According to analysis results, it was observed that building orientation angle, physical properties of building envelope and thermal insulation properties are the most important parameters.

Prianto and Depecker [5] studied the effects of naturally ventilated building design parameters on providing thermal comfort in tropical humid regions. The applicability of some architectural elements such as balcony placement, window type and location, and internal partitioning evaluated by using numerical simulations. According to analysis results, it was showed that balcony, window configurations and internal partitioning were the most important design parameters governing indoor thermal comfort.

Ozdemir (2005) [6] addressed the process of designing the building as energy efficient passive system for a sustainable environment. Energy efficient passive building design process steps in the study were as follows:

- Compilation of meteorological data
- Depending on the climate zone where the building is located deciding on the design principles
- Determination of suitable values for design parameters
- Creating alternative models of building depending on determined design parameter values and drawing of architectural project
- Performing the least energy cost project for the designated purpose among the alternatives and drawing of application projects

Canan and Bakır [7] performed analysis for rehabilitation and energy analyses of two existing buildings in Konya city using the method of sun shell. According to the results, not to have shade, it was found that in all blocks reduce volume substantially as 73% and showed that ignored the potential benefit from the sun of the residential buildings in existing applications. As a result, it was announced that sunbathing is not contained in the regulations and design.

Soysal [8] examined the relationship between energy consumption in residential buildings and design parameters. For this purpose, the effects of design parameters such as orientation in housing blocks, thermal conductivity of building envelope, exposed wall area to the window area ratio, the total exposed area of the shell, the effect of the buffer zone of enclosing balconies vertical zoning and unheated volumes in heated apartments was analysed. According to the simulation results, it was concluded that following measures may reduce the heating load: reducing the exposed area, reducing the window area in the western, eastern, northern facade and increase the window area in the southern façade, application of glass balconies and be located on the intermediate floors of apartments.

In another study by Çetiner et al. [9] energy and cost effective models of window for houses in different climatic zones of Turkey were selected. In consequence of evaluations of energy and cost performance of different window options, researchers found that climatic conditions, building typology, orientation, transparency rate and solar control tools have an effect on the performance of the window systems.

Wong et al. [10] investigated the effects of urban air temperature change on energy consumption of buildings in tropical climate of Singapore. For this purpose, the building simulations and numerical calculations were conducted. A total of 32 cases were evaluated to understand the impact of urban form according to density, height and greenery density. It was concluded that amount of existing green areas is the most important factor having an impact on building energy consumption. In addition, if urban elements (buildings, greenery and pavement) are used effectively, up to 4.5% reductions in energy consumption can be achieved.

Shrestha and Kulkarni [11] conducted research on the use of natural gas and electricity in 30 homes in Nevada. These homes were built in 2001, 2005 and 2008. The studied parameters and the effect of these parameters on electricity and natural gas usage is shown in Table 1.1:

Table 1.1 : Parameters effect on electricity and natural gas usage.

Factors	Annual Electricity Consumption	Annual Natural Gas Consumption
Construction Year	No relationship	Positive relationship
Type of Window Glass	Negative relationship	No relationship
Age of Air Conditioner	Positive relationship	NA
Frequency of Air Conditioner Use	Positive relationship	NA
Temperature Set in Summer	Negative relationship	NA
Age of Clothes Washer	Positive relationship	NA
Frequency of Clothes Washer Use	Positive relationship	NA
Room Temperature Set in Winter	NA	Positive relationship
Frequency of Clothes Dryer Used	NA	Positive relationship

Faizi et al. [12] investigated the level of energy consumption of Maskan Mehr residential complexes in Iran. Energy analyses performed by Ecotect software. Different types of residential complex were analysed in four areas: shadows and overshadowing, lighting access simulation, solar radiation and thermal analysis. Later, regarding current methods for minimum energy consumption in buildings, the optimum pattern of orientation described. In conclusion, it was observed that the pattern should have the following properties:

- The lowest ratio of width to length along the North
- Having the maximum level of south-facing walls
- Design the most translucent layers in respectively South, East, West and North side.

Jaber and Ajib [13] worked on the design of housing that will take place in Mediterranean Region. It was aimed that designed house had to be energy efficient, economic and aesthetic. Building orientation, window size, thickness of thermal insulation factors were taken into consideration. According to the results, 27.59% of the annual energy consumption can be reduced with the best orientation, the best window size and shading elements and thickness of insulation.

Song and Choi [14] examined the effects of government regulations permitting the remodelling of the balconies. In this regulation, it was intended to become a living spaces for the balconies. However, with this arrangement, while the balcony is becoming a place within the house, it has lost the property of being a buffer zone between the outside and inside of the house. With the field measurement and simulation, the effects of new regulation were investigated. According to measurement results, the indoor temperature of the room with a balcony was 0.8°C higher than that without a balcony. In addition, it was found that heating and cooling loads of a room without balcony were respectively 39% and 22% higher than a room with balcony.

Yasan [15] aimed to ensure energy efficiency through appropriate building design parameters which affect energy consumption. In the study, as a reference project 'Urfa Agriculture Village Project' has been a subject. By developing alternative shell, sun control elements and the orientation of the building, heating, cooling and lighting loads are calculated. According the analysis results, it was observed that redirection of the building to the south, the brick of opaque component and PVC triple glazing provide lowest heating, cooling and lighting load.

Energy analysis on bungalow houses in Malaysia conducted by Sabouri et al. [16]. For these analysis, Bungalow houses were modelled by Design Builder software. Then different components of houses such as wall, roof, floor and their influence were explored by simulation. Results showed that cooling energy of naturally ventilated raised floor in first floor with 19 mm wooden material decreased by 9.4%. White painted steel instead of concrete tile could save up to 16% of cooling energy. In total, the proposed components presented 28.3% saving in cooling energy.

Akyol [17] researched the effect of the passive house criteria on the thermal performance of a low-rise building. In hot humid climate zones, for example Antalya, the impacts of passive house design parameters, such as optical and thermodynamic properties of the building envelope, window size, regional use of shading element were analysed for energy performance using Design Builder v3 energy analysis software.

Granadeiro et al. [18] investigated the effect of building envelope shape on energy performance and presented a new method. Basically, this method calculate the energy needs of each design. The main purpose of this study was to show effect of different geometries at the design stage. For this study, Frank Lloyd Wright's prairie house was used as a concept and successful results were obtained.

Fahmawee [19] researched the effects of different building orientation and floor heights on atrium daylighting levels. Studies were conducted in Taj Mall Shopping Centre (Amman) which has three large atriums. These atriums have a circular shape of different sizes, orientations and heights. Results showed that there is a relationship between floor height and daylight performance inside the atrium. Also, south side has the highest daylighting performance among the three atriums.

Sadeghifam et al. [20] aimed to find role of walls, windows, roofs, floors and ceilings in the energy savings and aimed at the effective integration between these elements and air quality factor. The study was performed in Kuala Lumpur, Malaysia. Two-storey house was modelled in Revit software and energy analysis of this model was performed with Design of Experiment (DOE) technique. According to the results, the walls, ceilings and temperature appeared to be the most influential factors. Besides, temperature-wall and temperature-ceiling were found to be the most important compounds for energy consumption.

Heravi and Qaemi [21] aimed to determine and evaluate the design and construction measures related to building energy efficiency in Iran and evaluate these measures. These measures and systems were evaluated by the opinions of experts and simulations. According to analysis results, it was seen that passive solar energy is the most appropriate renewable energy source for Iran. Then, twenty-three design and construction measure were defined and divided into twelve groups. Finally, these groups are divided into three levels according to their importance.

Türktaş [22] aimed at housing design suitable climatic conditions for the hot humid climate zones and investigated the effects of thermal performance of different design parameter values in the form of housing proposals. It is observed that the biggest factors effecting thermal performance level shown by the spaces; with the facade opening, change of the amount of volume, height of the ceiling and ventilation system. It was emphasized that factors such as the orientation of the structure, building envelope stratification detail and solar control have an effect on building thermal performance. However, periodically replaceable parameters have also been found to positively affect thermal performance in the different seasons in space.

Mangan and Oral [23] aimed at choice of energy-efficient solutions for energy consumption and reducing costs. Different energy-efficient heating and cooling scenarios developed for the settlements made by TOKI (Housing Development Administration of Turkey). Model and energy analysis were carried out by Design Builder. As a result, energy-efficient and cost-effective solutions were presented for each region. NPVs (Net Present Value) were achieved for all climatic zones by adding insulation layer and replacement of existing window type.

Asfour and Alshawaf [24] examined impact of housing density on energy efficiency of buildings located in hot climates. For this purpose, different configurations were compared in Ecotect Analysis and Design Builder. As a result of the analysis, it was found that energy consumption has a very close relationship with building density. Also, it was observed that the compact horizontal housing showed better performance than vertical configuration and the row houses configuration offers a decrease in energy consumption that reaches 28% compared to the other residential buildings.

Zhao et al. [25] studied the parameters affecting the energy consumption of housing in China by means of the climatic basis. According to the simulation results, heating load is dominant in the cold and severe cold regions, cooling load is dominant in hot summer, warm winter and warm regions. In addition, heat transmission coefficient of the windows plays an important role in severe cold regions. With the help of dynamic simulations, airtightness and insulation thickness of the outer wall were found as the most sensitive parameters in the severe cold and cold zone. The heat transmission coefficient and transparency ratio (window and door area) of the outer walls was found to be important in hot summer and severe cold regions.

Abanda and Byers [26] investigated the effects of orientation on energy consumption in the small-scale buildings by facilitating BIM (Building Information Modelling). The modelled building in Revit was exported to Green Building Studio. Effects of changing the orientation of the building are studied in this software. As a result of analysis, it was found that total electricity use difference of 17 056 kWh and total gas use difference of 27 988 MJ is possible between the best (+180°) and worst (+45°) orientation.

Nabonia et al. [27], used genetic algorithms for optimization of heating, cooling and lighting demands of different building designs. In the study, over 25 million different buildings constitute search space, and the most energy efficient solutions were researched for 8 different climatic zones. The best solutions were searched for all climatic zones and compared with the Olgyay's (Design with Climate) data. In the last stage of study, the energy saving potential were evaluated and compared with Lechner's findings. Finally, it was concluded that the peak impact could be achieved by strategizing the elements such as orientation, form and materials according to Olgyay and Lechner findings.

Bajsanski et al. [28] proposed an algorithm to mitigate absorbed heat in urban areas. Parking areas was the main focus of the study. The algorithm proposed optimizes tree locations, aiming to provide optimized shadowing of the parking lots, while leaving the useable parking area and the parking lot form intact. Simulations of algorithms were modelled in Ecotect software. As a result of analyses conducted, tree locations estimated by the algorithm increased shadowing of the parking area and heating was reduced significantly.

1.5 Evaluation of Previous Studies

It is observed from the studies that passive design parameters yielded very good results in reducing the energy demand of the building. It is observed from the studies that selection of doors and windows, wall, floor, ceiling materials, shading element design, distance of buildings, building orientation, trees around the building are the most commonly used parameters.

Optimum use of passive design options were studied for several locations and different climatic conditions. On the other hand, studied for Turkey is very limited and mostly focusing on cold climatic zones.

Izmir is a highly populated and rapidly growing city of Turkey. Therefore, it is selected as a case study for optimum passive design solutions in hot climatic zones of Turkey.

2. PARAMETERS AFFECTING ENERGY DEMAND OF BUILDINGS

2.1 Introduction

Energy related problems became one of the most important issue between countries that increase the importance of energy policies in the last few decades. In steadily developing countries like Turkey, the need for energy is constantly increasing. This increase results in significant damages to economy and environment. Because of these, an issue emerged as important as existence of energy: Energy efficiency.

Energy efficiency can be achieved in all areas and one of them is the housing sector as it is one of the most energy consuming areas. Significant energy savings can be achieved via proper building designs. In this part of the study, the most important parameters in housing design are described in terms of energy efficiency.

Mentioned design parameters are divided into two groups: Environmental and building design parameters.

2.2 Environmental Parameters

Building design cannot be separated from the environment and the first stage of building design is to set up a harmonic relationship between building and environment. There are many environmental parameters that affect building design such as, site selection, topography, climatic data, construction density around the buildings and surrounding plants.

2.2.1 Site selection

Site selection is one of the most crucial factors affecting the building's energy demand. At the beginning of planning stages, it should be determined whether the land is suitable for any intervention or not. Yeang [29] has categorized suitable and unsuitable settlement areas. This classification is summarized in Figure 2.1.

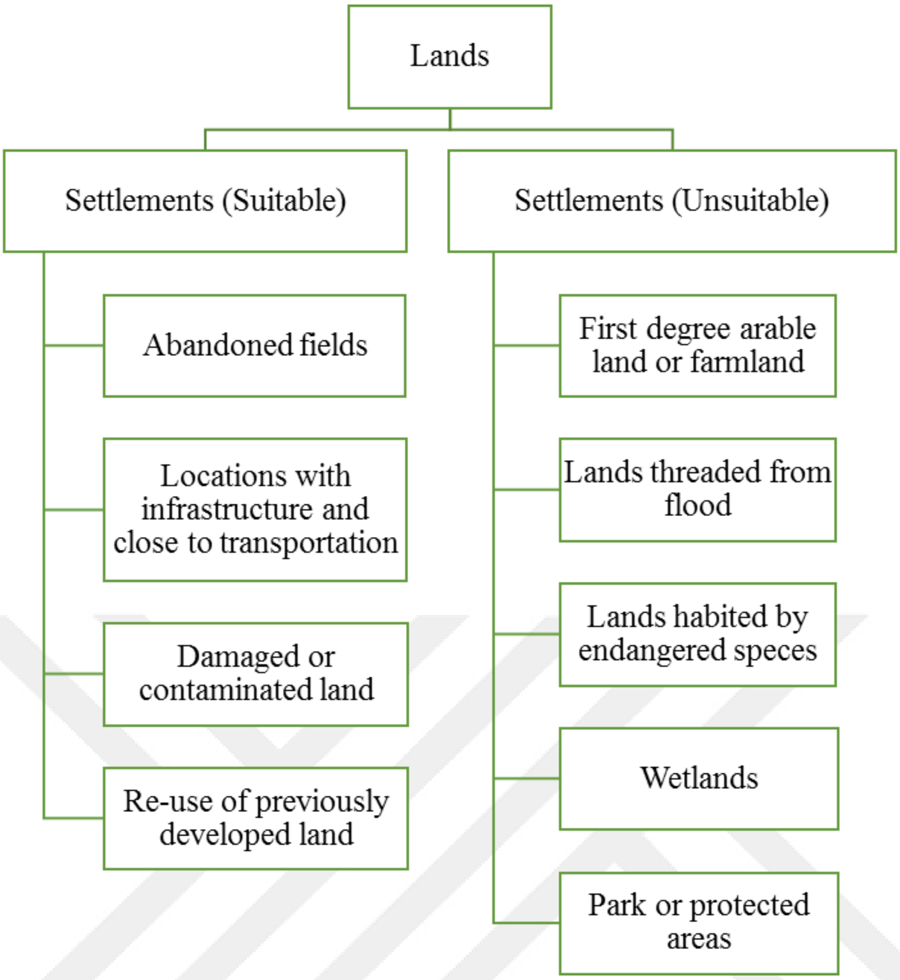


Figure 2.1 : Classification of lands.

Many factors might play a role in site selection. Climate, geotechnical properties, transportation, disaster risks, building shape and topography can be considered as the most important factors. Lechner [30] described land selection principles for residential and small office buildings in different climatic zones. According to this, south slopes maximize solar collection in cold climates and are shielded from cold northern winds. Avoid the windy hilltops and low-lying areas that collect pools of cold air.

On the other hand, build in low lying areas that collect cool air is suitable in hot and dry climates. If winters are very cold, build on the bottom of the South slope. If winters are mild, build on the north or east slope, but in all cases avoid the west slope.

In case of hot and humid climates, maximization of natural ventilation by building on hilltops instead of west side of hilltops is extremely important because of the hot afternoon sun. These site selection principles are illustrated in Figure 2.2.

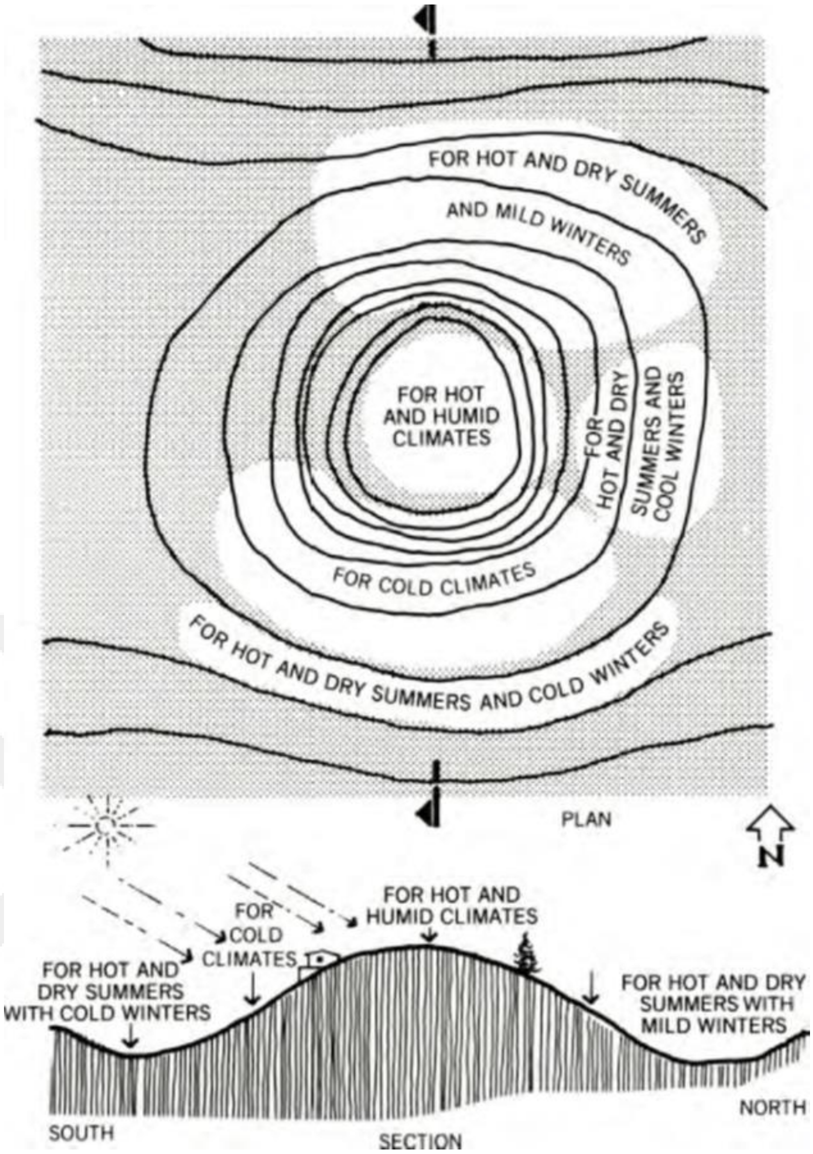


Figure 2.2 : Residential areas for different types of climate [30].

2.2.2 Topography

Topography is the first decisive element of the structure as it directly affects, solar collection, wind and humidity. Design method should be based on identified characteristics of topography in order to achieve energy effective solutions.

Each building is a part of environment where it was built and therefore building cannot be considered standalone. Protection of aboveground and underground wealth is important and interventions to the environment should be as limited as possible.

Characteristics of sloppy or flat terrain should be considered at the beginning of the design of ground and basement floor [31].

An effective solution for a sloppy terrain is shown in Figure 2.3. In this solution, it was obtained from slope of the terrain, therefore, half of the garage located under the ground.

Figure 2.3 : Using the slope of land [Url-4].

2.2.3 Climatic data

The successful design of buildings relies on an appropriate understanding of the climate. Buildings are increasingly being designed to utilise passive techniques and have evolved so that they adapt to the climate [32].

Climate is defined as the weather conditions prevailing in an area, in general or over a long period [Url-5]. Climate is the most important parameters for the building envelope characteristic. Especially in the traditional buildings, the importance of suitable climatic design is observed. For example in Figure 2.4, due to climatic reasons, brick domes were built in Harran traditional houses.

Figure 2.4 : Traditional Urfa-Harran Houses [Url-6].

The climate is formed by an annual average of specific meteorological events. These meteorological events are shown in Figure 2.5. Climatic conditions should be used as data in design. The task of architect is to use this data in the most effective way. For example, heat transmission coefficient of building envelope should be formed by climatic data of location.

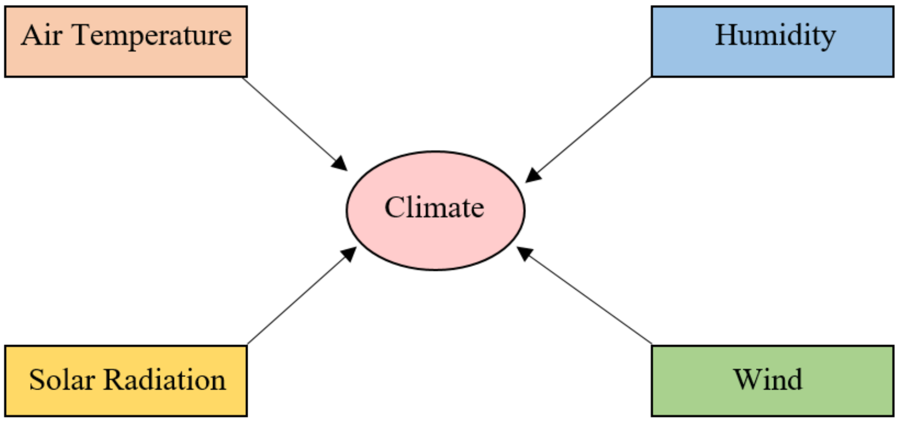


Figure 2.5 : Meteorological events forming the climate.

Four different climate types are observed in Turkey. These climate types and Climatic regions of Turkey are shown in Figure 2.6.

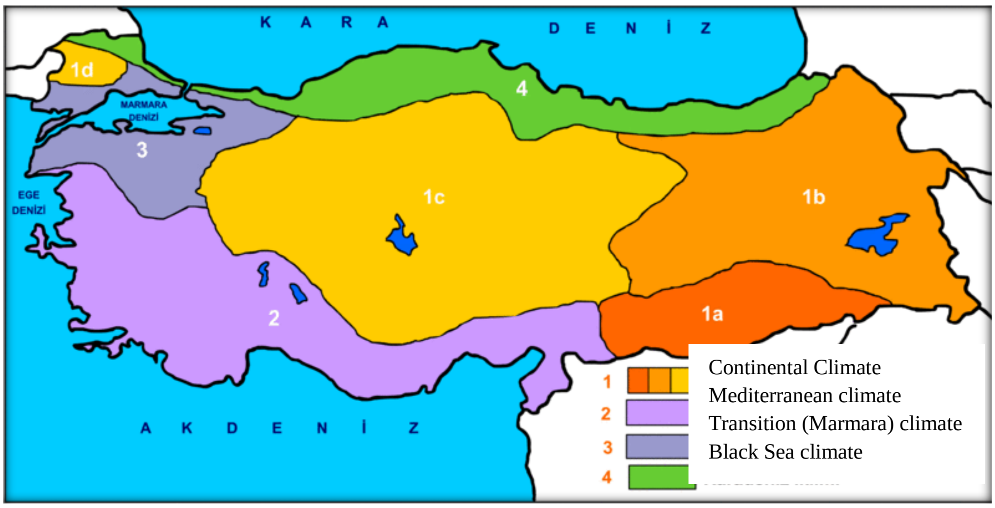


Figure 2.6 : Climate regions of Turkey [33].

Izmir, case study area of this study has Mediterranean climate. According to Turkish State Meteorological Service; summers are hot and dry, winters are mild and rainy in Mediterranean Climate. Snowfall in the coastal zone and frosts are rare. Winters are cold and snowy in mountainous areas. January is the coldest month and the average temperature is 6.4°C. July is the warmest month and the average temperature is 26.8°C. The average annual temperature is around 16.3°C. Average annual rainfalls are 725.9 mm and most of the rainfalls are precipitated in the winter season. Average share of summer rainfall is 5.7% of total annual rainfall. This area is dominated by the summer drought. Annual average relative humidity is around 63.2% [34].

2.2.4 Construction density around the buildings

Buildings and surrounding structures are in interaction with each other’s energy consumption. For this reason, especially building design in densely constructed areas has an impact on environmental design.

There are differences in terms of energy consumption with respect to building location in rural or urban area. In urban areas, there are more factors affecting building than the rural areas. Change in wind speed and occurrence of heat islands can be given as examples. Apart from these, noise and air pollution can be originated from nearby construction sites.

2.2.5 Surrounding plants

Green areas distribute polluted air over the city and prevent pollution by providing a gate to the winds and air flow in the urban fabric. Accordingly, green areas serve as ‘’Urban Lung’’ in real sense [1].

Tönük [31] expressed contributions of the green texture to the ecological balance. According to this study, green texture cleans air and adjust humidity and temperature. Besides, it provides acoustic insulation, wind protection. It protections against sun rays.

Besides, green texture of building environment has an impact on building energy efficiency. Trees and bushes around the buildings can reduce the effect of wind and sunlight on the building (Figure 2.7).

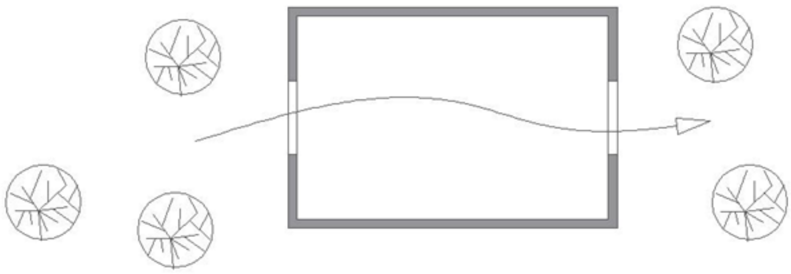


Figure 2.7 : Redirecting of wind by trees.

The deciduous trees while protecting the building from the sun in summer, do not prevent sunlight from heating the building in the winter. Thus, cooling energy can be saved in summer without an increase in heating energy loads of the building (Figure 2.8).

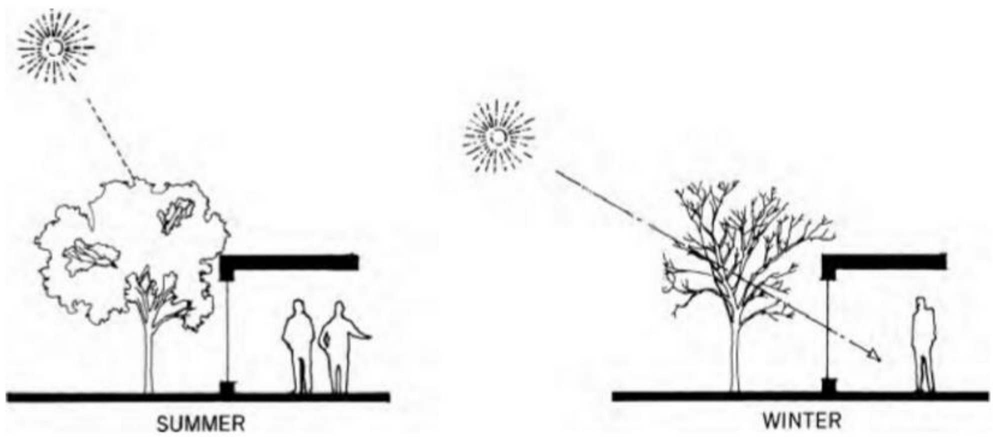


Figure 2.8 : Deciduous tree in winter and in summer [30].

Above all, the locations of trees around buildings should be well positioned. Trees should not damage the foundation of the building when they grow up and should not be too close to buildings acting as a view barrier. In addition, considering the properties of the tree and the location climate, the best tree alternative should be selected.

2.3 Structural Parameters

Parameters related to building itself, effecting energy consumption are extensively. These parameters have an impact on aesthetic and design of building as well as energy consumption. Some of those parameters are building geometry, building orientation, space arrangement and building materials.

2.3.1 Building geometry

Building geometry has a direct impact on the building's energy consumption.

Tönük [31] stated some considerations about building shape and has showed in Figure 2.8 and 2.9.

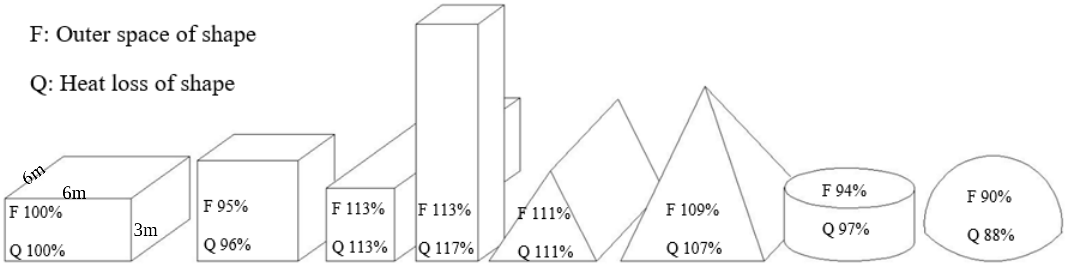


Figure 2.9 : Heat loss rate of geometric shapes which have the same volume, different base area and outer surface [35].

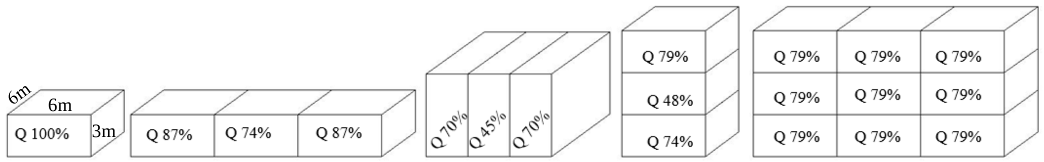


Figure 2.10 : Heat loss rate of different combinations of the same size geometric shapes [35].

In order to prevent heat loss that will occur through the outer surface, reducing the building's exterior area and compact building shape should be taken into consideration in ecological design. Building shape and surface area play an important role in the building's heat sealing. Considering the thermal resistance of different geometric shapes that have the same volume, different base area and outer surface, heat loss of spherical and dome-shaped geometrical objects was found to be less than that of others (Figure 2.8). Similarly, building structures adjacently may result in extra energy-efficiency. Heat loss rate of adjacent and multi-storey buildings is given in Figure 2.9. If buildings' surface area with respect to its volume increases, consequently heat loss of building will increase, as well.

2.3.2 Building orientation

Building orientation must be well defined at beginning of the design. After examining features such as climate, dominant wind direction, sun position, the most suitable direction for the building's energy consumption should be determined.

The main objective of building orientation is to increase the energy efficiency by optimizing the impact of climate and ensuring comfort conditions. Periodically, while avoiding the heating effect of the sun, it is necessary to take advantage of the cooling effect of the wind in summer. Contrary to that, in winter, it should benefit from the heating effect of the sun and protected from cooling effect of the wind [36].

Burdick [37] stated his perspective on this subject as follows: The orientation of the building must be considered in the cooling load calculations due to changing of solar heat gains at various times of the day (Figure 2.10). North, Northeast, East, Southeast, South, Southwest, West, Northwest or North are typically the orientations used for undertaking load calculations for construction, although the exact cardinal orientation can be used for buildings specifically located on a given lot. The orientation of the building can significantly affect heat gain depending on the ratio of windows to opaque walls and the degree of shading from the sun.

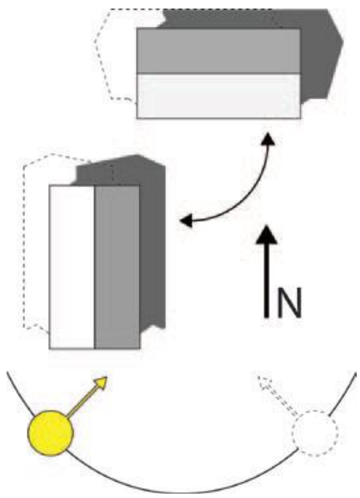


Figure 2.11 : Location of the sun at various times of the day [37].

Besides effect of building energy consumption in building orientation, factors such as views, privacy and confidentiality must be taken in to consideration, and it should be kept in mind that selection of optimum direction may not be possible always because of these factors.

2.3.3 Space arrangement

External space surface area of building is defined by space arrangement. If open shell area to climatic conditions increase, heat transfer occurs from the surface of opaque and transparent shell that will be less. In determining the position in space planning organizations, function and user needs constitute the main factors [36].

Collecting a combination of volume and comfort conditions indicating a common feature in energy-conscious design, to be a buffer zone of cold thermal zone and pay attention to the movement of air, help saving energy spent on heating, cooling and lighting. With using unheated volumes, services and circulation area as a buffer zone, other spaces (heating need is more than the others) will be protected. These buffer zones are also important to extend the duration of the cooling of the interior space in the winter and prevent high temperatures by the shadows in the interior space. Volumes such as bathroom and toilet to be placed near to the external walls, by this arrangements living spaces become more protected in terms of energy efficiency[8].

2.3.4 Building materials

The materials used in the construction of buildings, thermal insulation and frames are one of the most effective parameters in terms of energy consumption. Thermophysical properties of the materials are governing factors in terms of energy performance. Materials should be used appropriately, for the climate and should not be harmful to the environment.

It may cause damage to scarce natural resources in the choice of natural materials. At this point, selection of artificial materials has become a need. A selection of artificial materials respectful to nature also depends on a number of criteria. These criteria are briefly; durable, low maintenance cost materials, less energy-consuming materials during the manufacturing process, materials containing substances which give less damage to the environment as much as possible in the production process, usage of materials respectful of the nature in the stage of construction, usage and demolition of building and destruction, especially materials which can be suitable for recycling after the demolition of the building [31].

In energy efficient housing design, after obtaining environmental factors and microclimate control, another important issue to be addressed is the control of the thermal performance of the building envelope. The building envelope, which is of importance in terms of climatic comfort, are required to provide protection against primarily wind, heat and cold. Thermal conduction properties of the layers forming the envelope, the envelope airtightness level, positioning of windows, frames, colour and reflectivity of glass used are important inputs to building energy consumption[8].

Optical and thermophysical properties of the building envelope, play an active role in determining the amount of heat lost or gain from the unit area of the building envelope, the outside air temperature and solar radiation effects. Thus, optical and thermodynamic properties become determinant characteristics of interior comfort and heating and cooling loads [38].

The most important optical and thermodynamic properties affecting the heat transfer of the building envelope;

- Overall heat transmission coefficient of opaque and transparent components (a)
- Transparency rate,
- The amplitude reduction factor of opaque component / extinction ratio,
- The time delay of opaque component,
- Absorbing, transmittance (invalid for opaque components), reflectance coefficients (a, t and r) of opaque and transparent components against solar radiation.

Walls

Walls are one of the most important components providing the connection between the internal environment and the external environment. Optimum value of external walls coefficient of thermal conduction should be selected to create the necessary internal surface temperature in interior spaces. By considering heat gains and losses in the external wall, the total thermal conductivity must be identified as required. According to the priority of protection or benefit, the texture of the opaque component should be considered [39].

Floors

Heat loss of the ground-contact surfaces depends on especially tile material, size and the characteristics of the ground. The insulation of the floor is a good solution to prevent heat loss and uncomfortable air movement. Heat transfer in the mezzanine floor depends on the thickness of the floor and materials. Heat loss is generally caused by cracks and corners [40].

Windows

Windows are structural component, that enable use of daylight, provide visual connection with the external environment and natural ventilation. For this reason, window size, location, direction and window materials should be determined by climatic conditions of the region. While the south windows provide maximum benefit from the sun in winter, it should be protected by use of shading devices from the direct sunlight and heat gain in summer. Windows on the east and west facades must be smaller than the windows on the south facade and must have a good summer shade. The north windows are not exposed directly to the sunlight and, therefore they have least effect in terms of heat gain [41].

3. MATERIALS AND METHOD

3.1 Introduction

In this chapter, studies conducted for the thesis is explained in detail. First of all, a typical apartment building in Izmir city was modelled in Revit Architecture. Afterwards, energy analyses of this model were performed by changing the design parameters. Then, building model was developed in Revit Architecture 2015 software (Figure 3.1). Finally, this model was transferred to Ecotect Analysis 2011 software to conduct energy analysis.

Figure 3.1 : 3D perspective of created apartment model.

3.2 Studied Passive Design Alternatives

In the study, the building design parameters have been changed in order to understand their effects on energy consumption. Firstly, building orientation parameter was analysed. Revit Architecture model was rotated at 45° angle increments and annual energy consumption was calculated. Secondly, it was examined the effect of street width on building energy consumption. For this analysis, 3, 6 and 12 storey versions of designed apartment model were prepared.

3.3 Apartment Model Designed for Izmir Province

A typical apartment model was designed to represent common practice in Izmir. For this purpose, three rooms with a saloon configuration has been selected. Additionally, two dwellings in each floor is preferred as a common typology. The reason for this is to understand the difference in energy consumption between the dwellings located on the same floor.

Firstly, different building types were investigated and appropriate apartment type was selected for the analyses. For the study, Izmir province which has a huge potential in terms of urban regeneration projects is selected. Aim of the analysis, is to contribute to urban regeneration projects in terms of planning. It was assumed that selected building sits on a flat terrain and adjacent building.

Designed apartment model was considered for elementary family with 1 or 2 children. It was intended to benefit from daylight in every room except bathroom, toilet and cellar. Therefore, rooms are spread over three facades, other spaces are located in the interior space of the dwellings.

Each dwelling consists of living room, kitchen, family room, bedroom, kid’s room, bathroom, toilet and cellar. Also, each dwelling has three 1-5 m long balconies. These balconies can be reached from the living room, family room and bedroom. Since kitchen, living room and family room are frequently used, they were positioned near to the entrance of dwelling. Private spaces are located at the back sideof the dwelling Room legend of the designed model is given in Figure 3.2. Building roof is flat roof with 1% sloping.

Revit Architecture software is used for architectural design because of its easy use and compatiblity with Ecotect Analysis software. Revit Architecture is a commonly used Building Information Modelling (BIM) software produced by Autodesk Company. It delivers BIM tools for architectural design, MEP (Mechanical, electrical and plumbing) engineering, structural engineering, construction and enables coordination between disciplines [Url-7]. It allows users to design a building, structure and its components in 3D, annotate the model with 2D drafting elements, and access building information from the building model's database [Url-8] User interface of the software is shown in Figure 3.3.

The software has a material library in itself. Many objects such as window, door, furniture are located in the material library. These objects can be changed in desired sizes, colours and materials. In addition, the details of wall, floor, roof are available in the material library and these details can be changed by request.

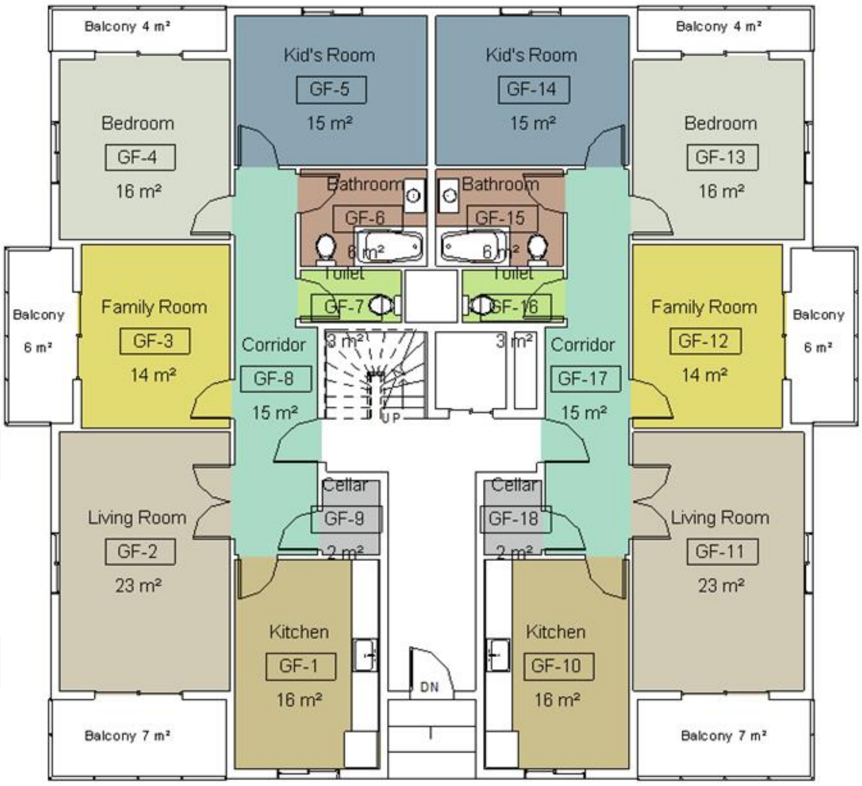


Figure 3.2 : Room legend of created apartment building.

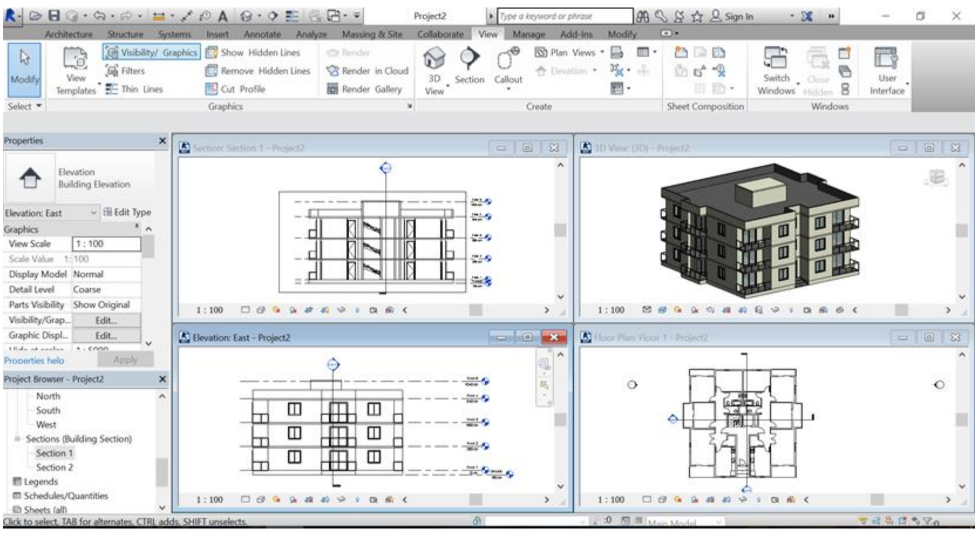


Figure 3.3 : Revit Architecture interface.

The width of each floor is 17.4 m and the length is 17.6 m (Figure 3.4). Inner area of each dwelling is 110 m^2 and increases to 127 m^2 with balconies. Construction area is 279 m^2 for each floor. The total construction area comes into 837 m^2 for three floors as the same plan has been applied at all. Cantilever slab was used only as a balcony. Dimensions of rooms and dwellings can be seen in Figure 3.4. Area of rooms are given in Table 3.1.

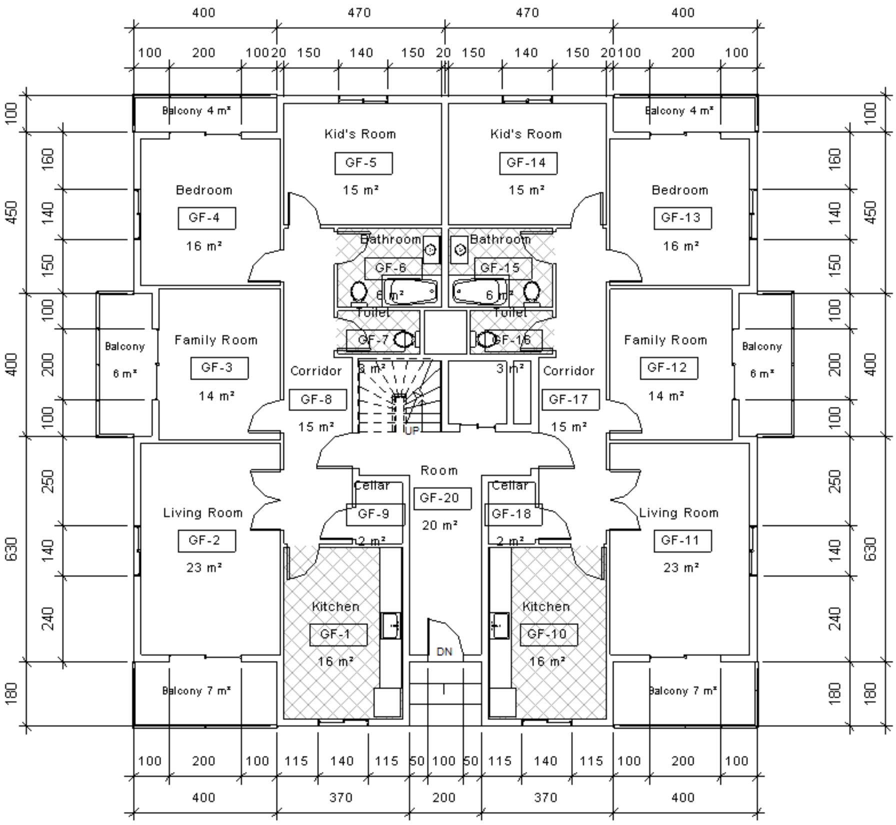


Figure 3.4 : Plan dimensions of selected apartment building.

Table 3.1 : Area of dwelling rooms.

Room Name	Size(m^2)
Living Room	23
Kitchen	16
Family Room	14
Bedroom	16
Kid’s Room	15
Bathroom	6
Toilet	3
Cellar	2
Corridor	15
Total	110

Storey height is selected as 280 cm keeping up with common practice and height of subbasement is designed as 50 cm. Slab thickness is 12 cm (Figure 3.5).

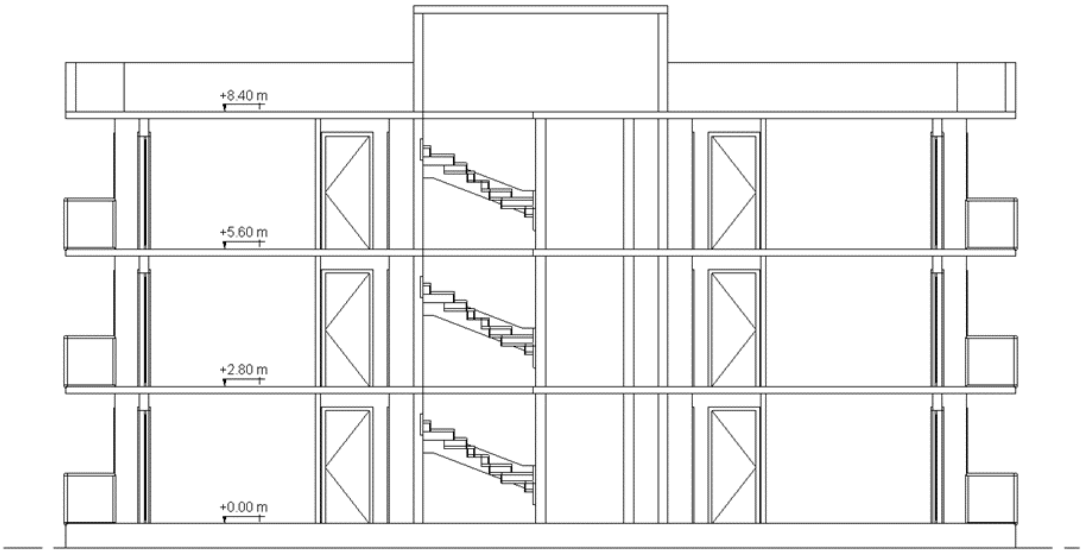


Figure 3.5 : Section of apartment.

Front view and side view of selected apartment models are shown in Figure 3.6 and Figure 3.7.

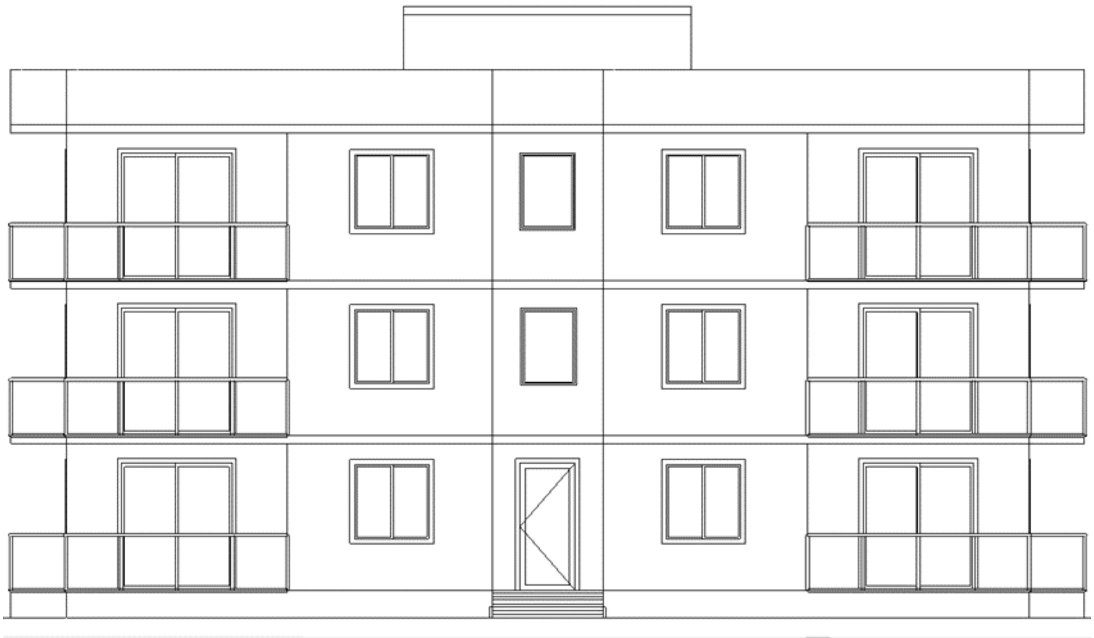


Figure 3.6 : Front view of apartment.

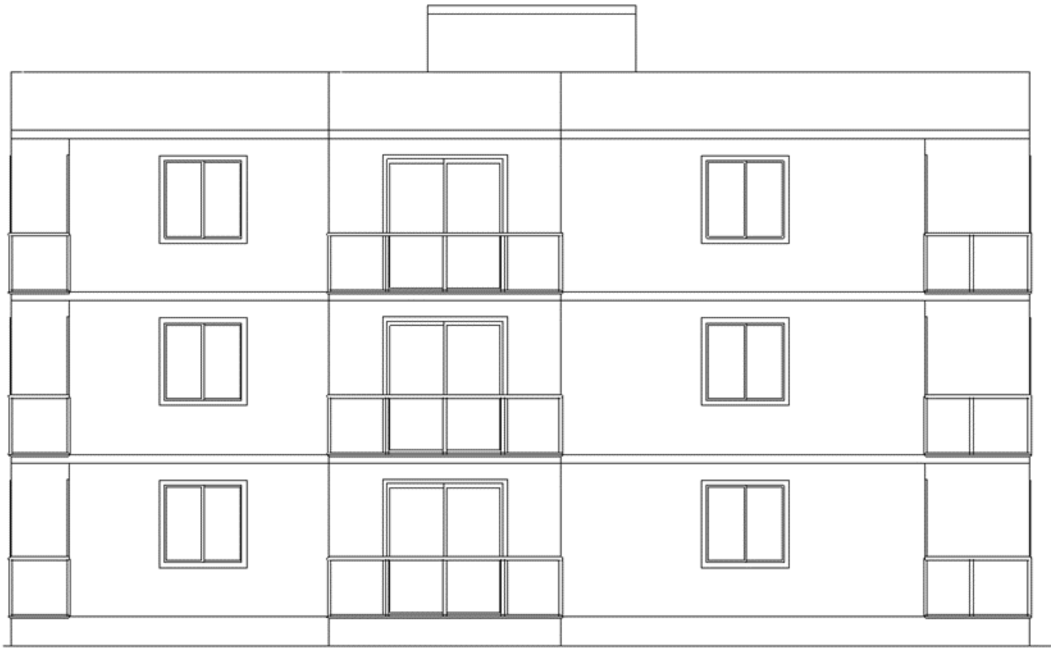


Figure 3.7 : Side view of apartment.

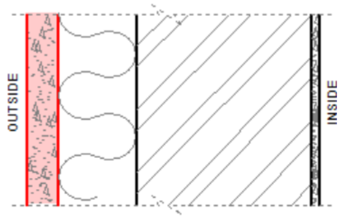
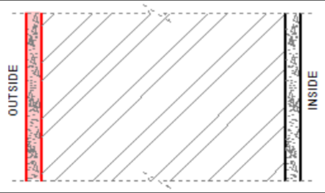
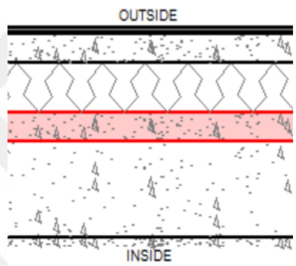
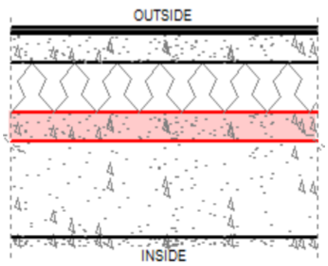
Living room, kitchen, family room, bedroom and kid's room were designed as thermal zone and for the other spaces, heating and cooling does not considered.

3.3.4 Data of building envelope

The apartment model is a reinforced concrete structure. According to TS 825 [Turkish code for thermal insulation requirements for buildings], heat transmission coefficient of the building envelope must be smaller than 0,7 W/m^{2}K. Outer walls, ground floor slab and roof of the apartment were designed according to that limitation.

According to these, stratification belonging to the building shell is given in Table 3.2.

Table 3.2 : Details of the building envelope.

Layer Name	Material	Width (mm)	Thermal Conductivity (W/m.K)	U Value (W/m^2K)	Section
Outer Walls	Plaster Wool Brick Plaster	20 50 110 5	0.520 0.038 1.297 0.520	0.610	
Enwalls	Plaster Brick Plaster	5 80 5	0.520 1.297 0.520	3.860	
Roof	Ceramic tile Mortar Protective concrete Water proofing Heat insulation Levelling concrete Concrete slab Plaster	5 2 30 - 50 30 100 5	1.200 2.000 0.800 0.5 0.038 0.209 1.046 0.520	0.440	
Foundation slab	Soil Lean concrete Foundation Screed	1500 100 500 50	0.837 0.1 2.2 1.4	0.700	

Windows and balcony doors in the building are monotype and frames of them are aluminium (Figure 3.8, Table 3.3). Typical windows size is 140x140 cm and size of balcony doors is 200x230 cm. Wood panel doors are used as interior doors and their size is 90x210 cm.

Figure 3.8 : Section of window and balcony door glasses.

Table 3.3 : Properties of windows and balcony doors.

Property	Values
Heat transmission coefficient (W/m^{2}K)	2.700
Solar heat gain coefficient (0-1)	0.81
Thickness (mm)	42
Visible transmittance (0-1)	0.639

Transparency rates were investigated according to thermal zones in the building. The results are given in Table 3.4.

Table 3.4 : Transparency ratio of thermal zones.

Zone Name	Total Outer Wall Area (m^2)	Transparent Area (m^2)	Transparency Rate (%)
Kitchen	20.44	1.96	9.6
Living room	30.24	6.56	21.7
Family room	11.2	4.6	41.1
Bedroom	25.2	6.56	26
Kid's room	15.96	1.96	12.28

3.4 Ecotect Analysis and apartment model properties

Ecotect Analysis is a green building software provides comprehensive analysis tools for any kind of sustainable building [Url-9]. It is produced by Autodesk Company. Energy, water, daylight, carbon analysis of the whole building can be done using this software. The climate and annual weather information of 92 cities are located in the software library.

After modelling building and thermal zones, energy analysis were conducted in Ecotect Analysis which requires a location to perform the analysis. In scope of this thesis, climatic data of Izmir province was defined.

3.4.1 Climatic data and modelling

Izmir is located in Mediterranean climate region which has mild and rainy winter, hot and dry summer. Months of spring are connection between summer and winter seasons. Because of mountains run perpendicular to the coastal line and plains extend threshold of West Central Anatolia, marine impacts are spread far inland. The average annual temperature is 17.9 ° C. Total annual average rainfall is 689.0 mm. Average monthly precipitation and air temperature of Izmir province for many years are given in Figure 3.9.

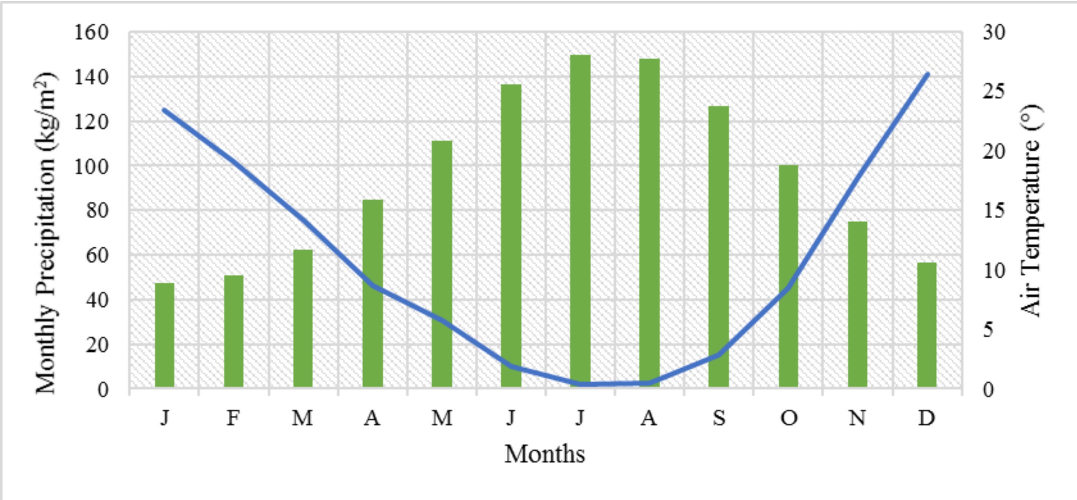


Figure 3.9 : Monthly temperature and precipitation chart of Izmir.

Average wind speed in Izmir is 3.0 m/sec. Izmir's dominant wind direction is south-southeast, depending on seasonal changes secondary, dominant wind direction is west-northwest. Izmir also has huge potential in terms of renewable energy sources.

In order to perform the analysis in the software, it is necessary to select a location found in the software library. However, climatic data of Izmir province is not found in Ecotect Analysis. That’s why is necessary to provide these data to the software.

A software called Meteonorm was used for this task (Figure 3.10, 3.11, 3.12). Thorough this software, the climatic data can be obtained from the weather stations. Firstly, location of Izmir was found in the Meteonorm software and climate data was saved in the desired format. Then, climate data was introduced to Ecotect Analysis through convert weather tool in the software (Figure 3.13).

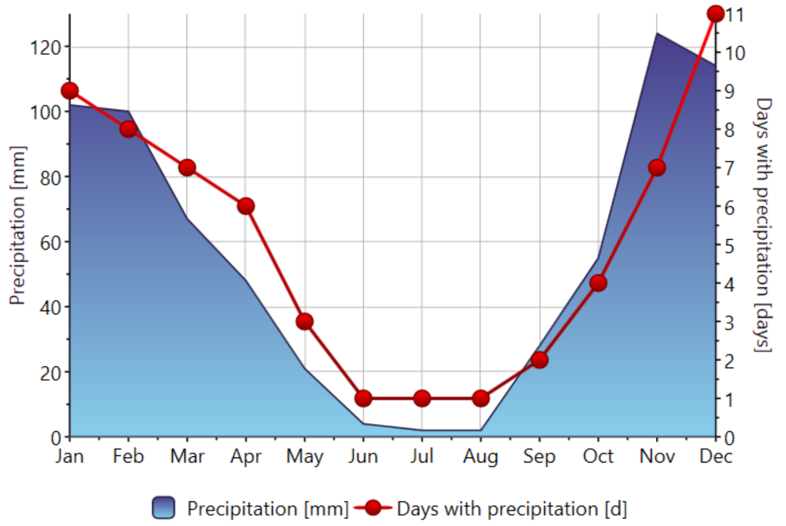


Figure 3.10 : Precipitation data of Izmir city in Meteonorm software

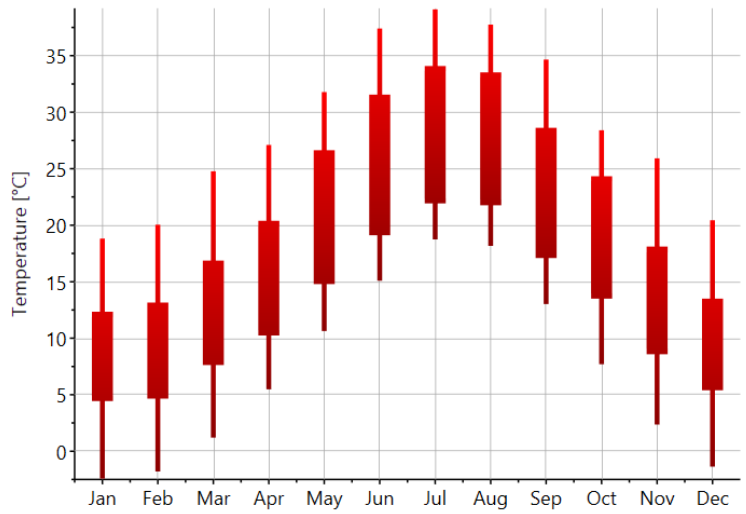


Figure 3.11 : Temperature data of Izmir city in Meteonorm software

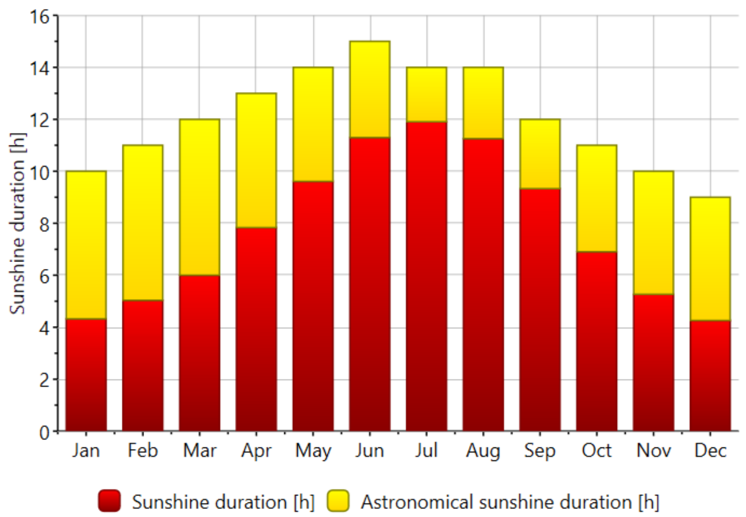


Figure 3.12 : Sunshine duration of Izmir city in Meteonorm software

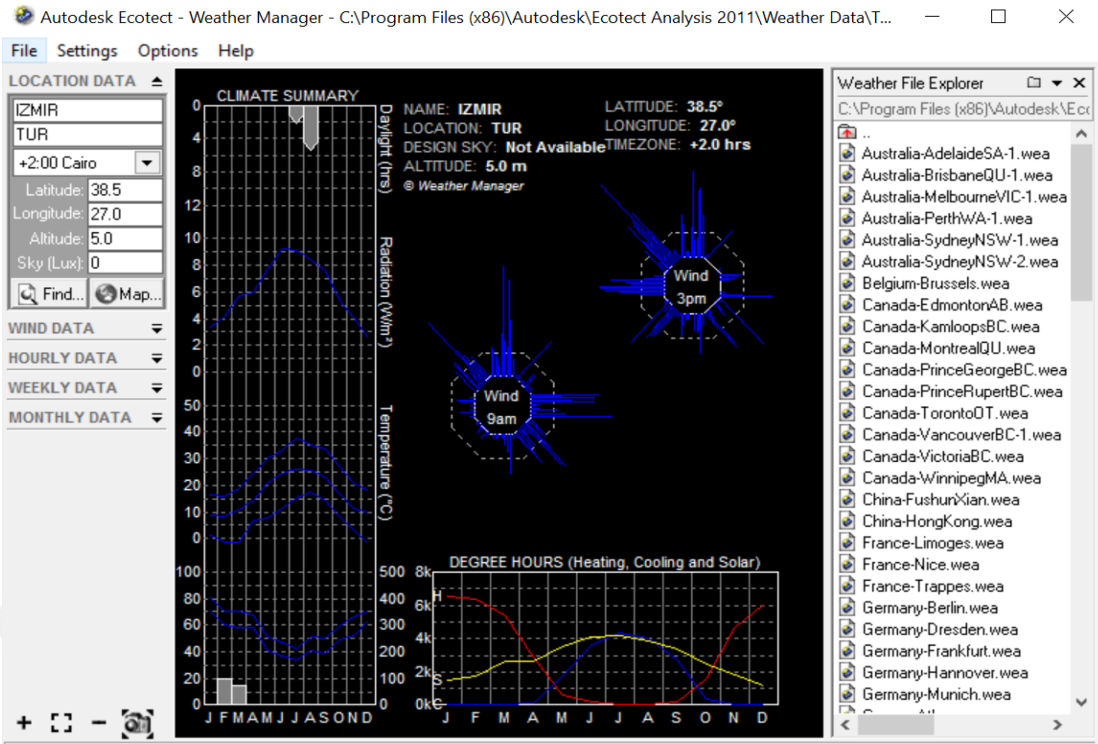


Figure 3.13 : Climate data of Izmir province in Ecotect Analysis.

3.4.2 Analysis parameters for Ecotect Analysis

The model created in Revit Architecture was transferred to Ecotect Analysis 2011 in order to calculate annual heating and cooling loads. For this, the model created in Revit Architecture was exported to Ecotect Analysis in gbXML format. In order to conduct thermal analysis in the software, rooms of apartment must be defined as thermal zone. These zones are formed according to the width, length and height of the space.

Ecotect Analysis has a material library in itself. It has different door, wall, ceiling, windows and roof materials and new material can be added. The software calculates values such as coefficient of heat transmittance, admittance, thermal lag of the materials and uses these values in analysis (Figure 3.14). Wind, acoustic, lighting analysis can be performed by the software as well.

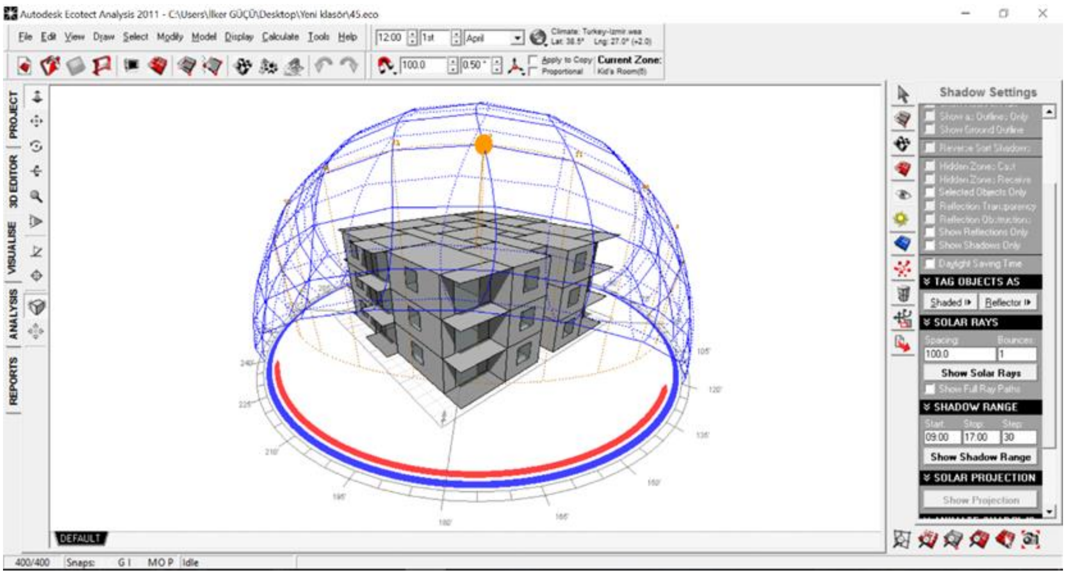


Figure 3.14 : Ecotect Analysis interface.

Some definitions and assumptions are required for energy analysis in Ecotect Analysis software. These definitions and assumptions are related to zone management. Occupancy, internal gains, infiltration rates, thermal settings are determined in this menu. Settings about heating and cooling system of apartment, thermostat values, duration of use of the rooms can be determined from zone management menu (Figure 3.15).

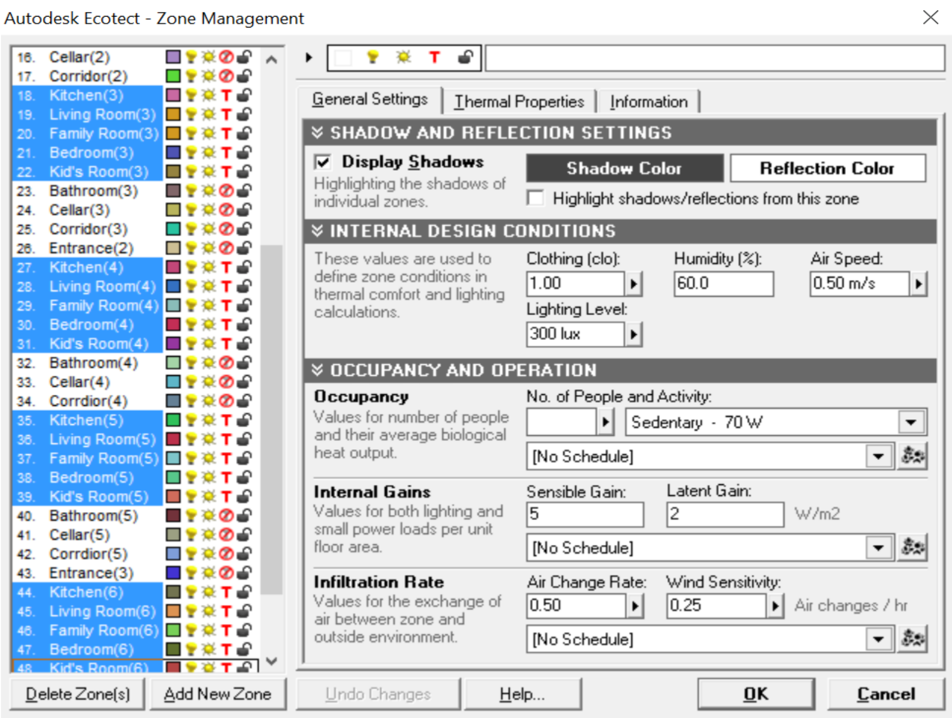


Figure 3.15 : Zone management menu.

For this study, the settings and assumptions used in the model are as follows:

- Kitchen, living room, family room, bedroom and kid's room was defined as thermal zone in the model. In other areas (corridor, bathroom, toilet, cellar), it is assumed that heating and cooling is not performed, therefore they were not included in the analysis.
- The number of users has been determined for all thermal zones. The number of users for kitchen, living room and family room were determined as 4, for bedroom and kid's room were determined as 2. Originating from internal gain value, from the number of users was accepted as 70w/people (sedentary).
- It was defined that heating and cooling were performed in all thermal zones. Thermostat range is set to the lowest 22°C, the highest 26°C. During initial attempts for analysis, room temperatures were set exactly 23°C. However, it was revealed that keeping room temperature at a constant level requires continuous heating/cooling activity and it was an inefficient approach. Besides, user practices are showing a range of comfort for the room temperatures. Therefore, in the analysis, the range of 22-26°C is set for heating/cooling control.
- Clothing value (clo), humidity (%), air speed (m/s) were assumed to be 1.00, 60 and 0.50, respectively, in all zones.

Hours of operations were determined for all thermal zones. This operation is related to the room occupancy duration of people. Accordingly, the hours of operation specified in this model are given in Table 3.5:

Table 3.5 : Hours of operation according to thermal zones.

Zone Name	Weekdays	Weekends
Kitchen	07.00-23.00	07.00-23.00
Living room	All day	All day
Family room	All day	All day
Bedroom	21.00-09.00	23.00-10.00
Kid's room	18.00-08.00	All day

3.5 Investigated Parameters

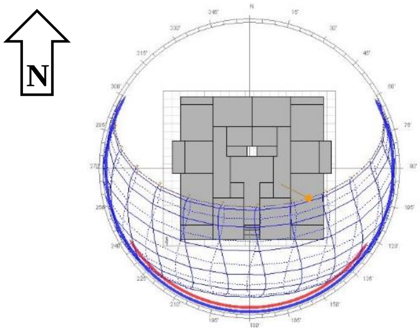
In the study, the effect of two diffirent parameters on energy performance of buildings were analyzed. Firstly, the effect of building orientation on annual energy consumption of the buildings was investigated. Then, the effects of street width and clear spacing between buildings on heating and cooling performance was studied.

Orientation of buildings, depending on the facade transparency, affects the annual heating and cooling loads of buildings. In order to study the effects of building orientation, designed 3-storey apartment model was oriented in 8 different angles and annual heating and cooling energy costs of these alternatives were measured. These alternatives are shown in Figure 3.16.

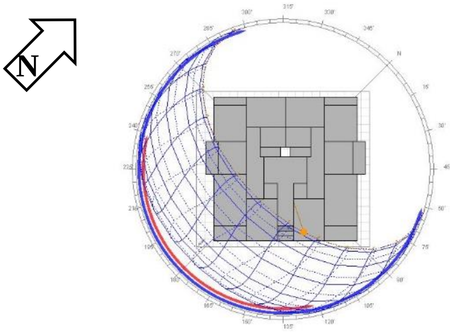
Analyzes were conducted to investigate the effect of street width or clear spacing from other buildings on the building's annual heating and cooling energy. For this analysis 3, 6, 12 storey models were designed (Figure 3.17, 3.18). All models have the same floor plan for the first analysis. Barriers were placed in front of the buildings to represent buildings on the other side of the street. Barriers have the same height with buildings. The only function of these barriers is to provide shading to the buildings for which analysis are conducted.

These barriers are located in front of the building. Therefore, the heating and cooling loads were calculated only for living room and kitchen as they are the most affected zones of building. Every building in the study were evaluated at different street width. Evaluated widths are reported in Table 3.6. The first barrier was placed 20 cm away from each building as a reference point representing adjacent building case without any positive insulation effect.

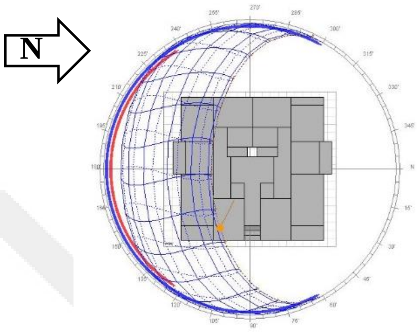
For these analysis related to street widths, the cases representing a street on south, east and west façade of the building are considered. Analyzed façade of the building a faced towards the street. North side streets did not considered as it would have almost no effect. South side streets are necessarily in east-west direction, whereas east or west side streets are directed along south-north axis.



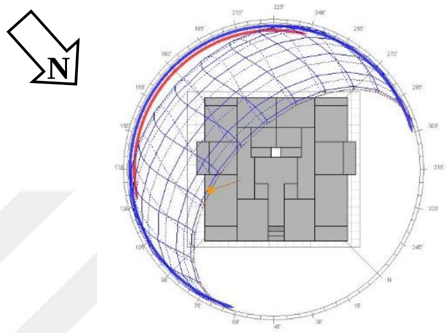
Condition 1: Entrance towards the south



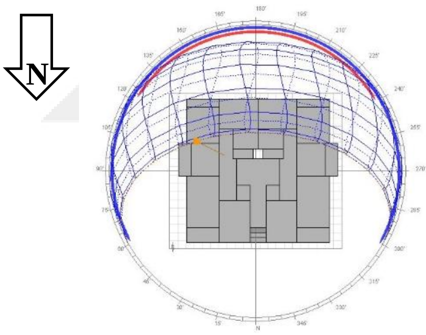
Condition 2: Entrance towards the southeast



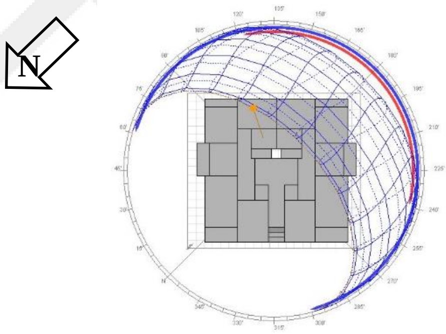
Condition 3. Entrance towards the east



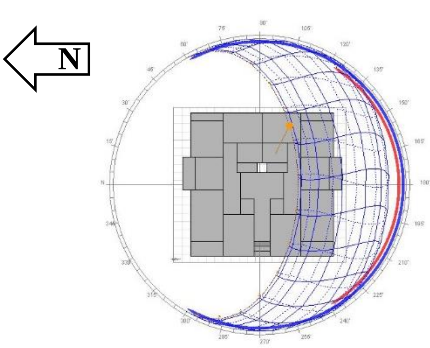
Condition 4. Entrance towards the northeast



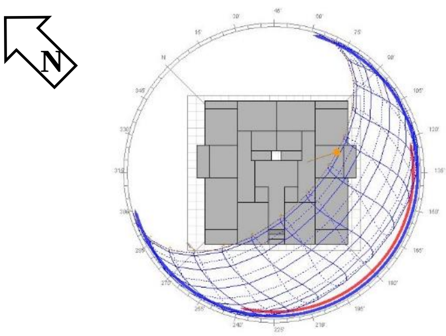
Condition 5. Entrance towards the north



Condition 6. Entrance towards the northwest



Condition 7. Entrance towards the west



Condition 8. Entrance towards the southwest

Figure 3.16 : Orienations of the model

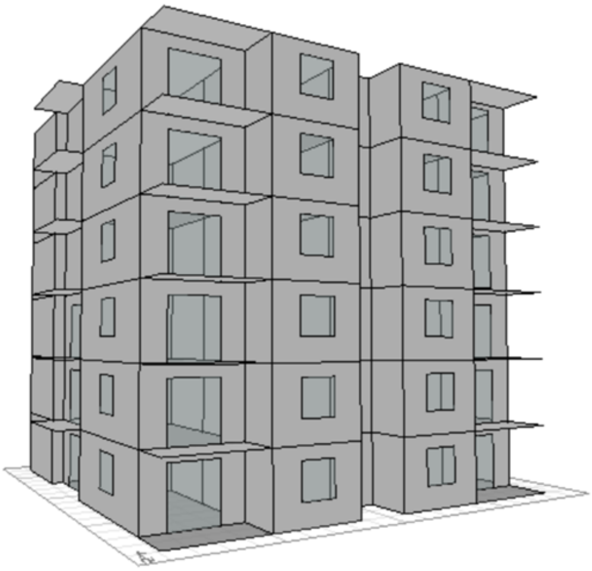


Figure 3.17 : Designed 6 storey model.

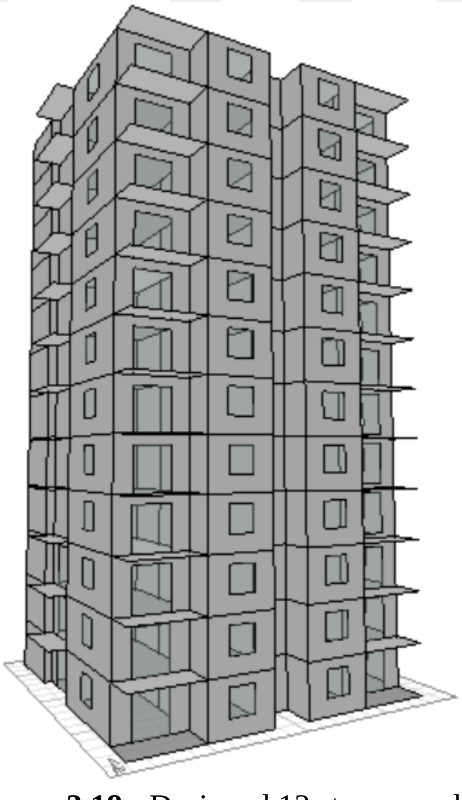


Figure 3.18 : Designed 12 storey model.

Table 3.6 : Evaluated street widths.

	0.2	3	4.5	6	9	12	15	18	24	30	36	42	50	66
3-storey	x	x	-	x	x	x	x	x	x	-	-	-	-	-
6-storey	x	-	x	x	x	x	-	x	x	x	x	x	-	-
12-storey	x	-	-	x	x	x	-	x	x	x	x	x	x	x

4. ANALYSIS RESULTS

In the thesis, a total of 8 analyses for building orientation and 51 analyses for street width were performed. According to the scope of the thesis, analyses were divided into 3 parts. Results of all analyses are explained in this chapter.

4.1. Building Orientation Analysis Results

In order to observe the impact of orientation on building energy consumption, the selected apartment model was rotated in 8 different directions. For the orientation angles 0° corresponds to south-faced case. The other orientations are obtained by clockwise rotation of building plan. Basically, the results were compared in 3 different ways:

- Annual heating energy
- Annual cooling energy
- Annual total energy (heating and cooling energy).

3-storey model was used in the study. 6 dwellings for a better understanding of the analysis results were defined with different names. Figure 4.1 shows the coding system of the apartment model. Basically, this coding was done according to the followings:

1. Letter 'L' is used for the dwellings to the left side of building entrance façade, letter 'R' is used for the dwellings to the right side of building entrance façade.
2. Letter 'G' is used for the dwellings on the ground floor, number '1' is used for the dwellings on the first floor, number '2' is used for the dwellings on the second floor.

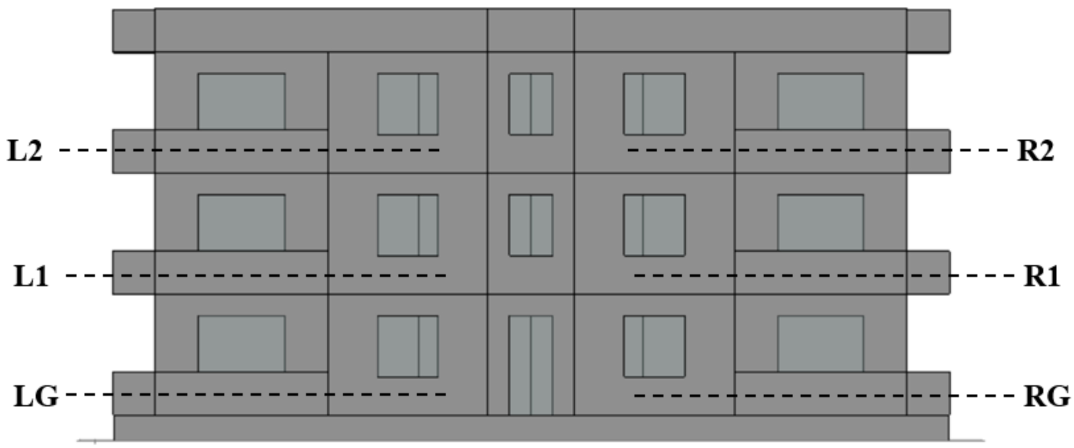


Figure 4.1 : Apartment Coding.

Changing the building orientation, annual heating, cooling and total energy consumption of apartments changed significantly are given in Table 4.1, 4.2 and 4.3 for heating, cooling and total consumption respectively.

Table 4.1 : Annual heating energy consumption of all dwellings.

Orientation Angle (°)	LG (kWh)	RG (kWh)	L1 (kWh)	L2 (kWh)	R1 (kWh)	R2 (kWh)	Total (kWh)
0	2038	1951	1939	1939	2258	2202	12327
45	2048	2019	1974	1990	2256	2229	12516
90	2119	2152	2081	2108	2309	2275	13044
135	2166	2247	2133	2211	2344	2495	13596
180	2204	2237	2172	2203	2455	2485	13756
225	2234	2191	2202	2161	2495	2422	13705
270	2209	2182	2181	2153	2467	2323	13515
315	2196	2111	2164	2081	2454	2319	13325

Table 4.2 : Annual cooling energy consumption of all dwellings.

Orientation Angle (°)	LG (kWh)	RG (kWh)	L1 (kWh)	L2 (kWh)	R1 (kWh)	R2 (kWh)	Total (kWh)
0	1246	1302	1285	1331	1128	1165	7457
45	1291	1285	1317	1312	1188	1149	7542
90	1291	1245	1321	1275	1167	1110	7409
135	1284	1216	1314	1246	1152	1092	7304
180	1266	1223	1296	1252	1137	1098	7272
225	1278	1287	1307	1316	1148	1154	7490
270	1274	1322	1305	1352	1139	1183	7575
315	1273	1344	1302	1372	1138	1201	7630

Table 4.3 : Annual total energy consumption of all dwellings.

Orientation Angle (°)	LG (kWh)	RG (kWh)	L1 (kWh)	L2 (kWh)	R1 (kWh)	R2 (kWh)	Total (kWh)
0	3284	3253	3224	3270	3386	3367	19784
45	3339	3304	3291	3302	3444	3378	20058
90	3410	3397	3402	3383	3476	3385	20453
135	3450	3463	3447	3457	3496	3587	20900
180	3470	3460	3468	3455	3592	3583	21028
225	3512	3478	3509	3477	3643	3576	21195
270	3483	3504	3486	3505	3606	3506	21090
315	3469	3455	3466	3453	3592	3520	20955

In Figure 4.2, 4.3 and 4.4 comparison between heating, cooling, total loads and orientation angles.

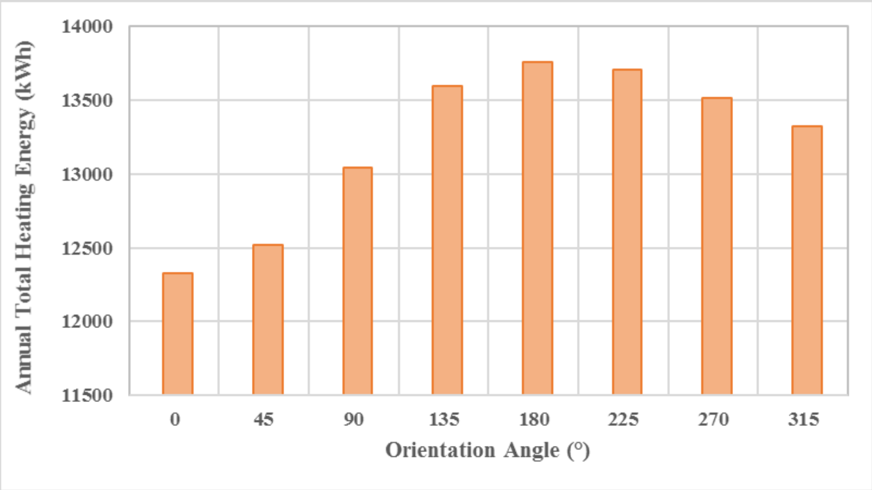


Figure 4.2 : Variation of heating energy loads with respect to orientation angles.

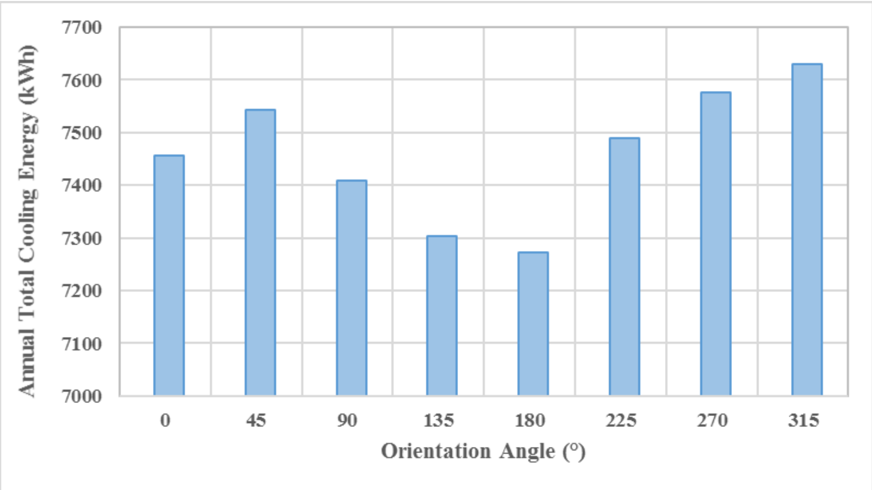


Figure 4.3 : Variation of cooling energy loads with respect to orientation angles.

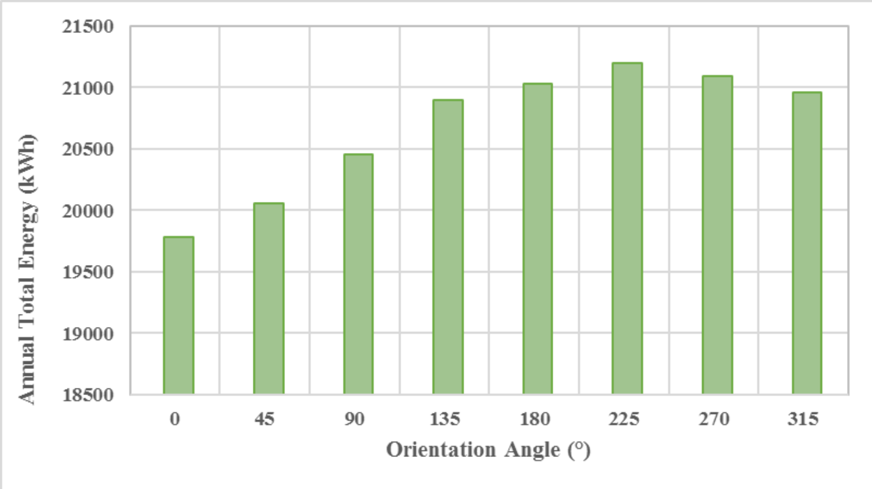


Figure 4.4 : Variation of total energy loads with respect to orientation angles.

The results of the annual heating analysis are as follows:

- The lowest load was observed at 0-degree orientation angle (reference apartment) corresponding to south-faced apartment case with 12327 kWh.
- Since most frequently used areas (kitchen, living room) benefit more from the sun in south-faced orientation, the heating load is lower than the other orientations.
- When orientation angle becomes 180° which stands for north-faced building case the highest heating load is obtained (13756 kWh).
- It was seen that there is an increase trend in heating load between 0°-180° orientation angle and a decrease trend in heating load between 180°-315° orientation angle.
- The lowest annual heating loads was observed in middle floor dwellings. The reason for this is that these dwellings have limited heat loss because of the top and bottom dwellings.
- In Table 4.4 and Figure 4.5, relationship between orientation angle and heating energy gain ratios of models are given. The highest gain ratio is obtained at 0° orientation angle with 10,39%.
- A significant difference in terms of energy gain was not observed especially between 135-315° orientation angles.

Table 4.4 : The heating energy gain ratios of apartments related to orientation angles.

Orientation angle (°)	The heating energy gain ratio (%)
0	10,39
45	9,01
90	5,18
135	1,16
180	0,00
225	0,37
270	1,75
315	3,13

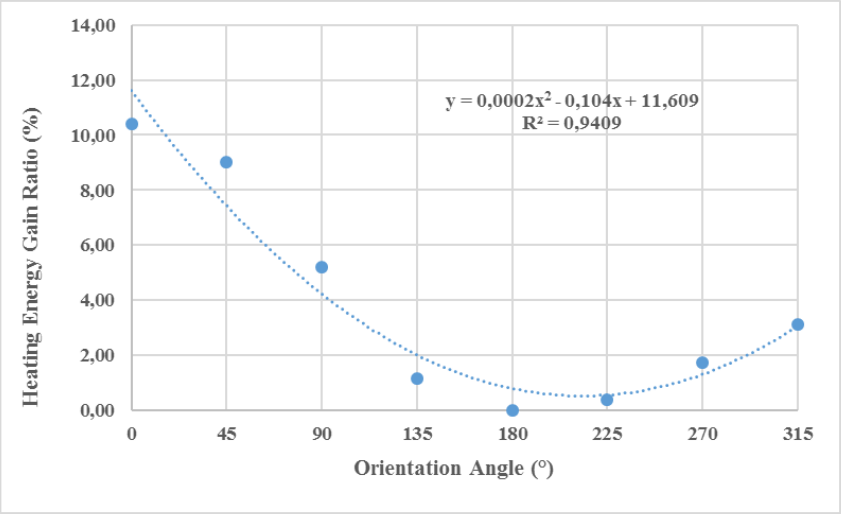


Figure 4.5 : Comparative heating energy gain ratios of apartments with different orientation.

The results related to annual cooling analysis revealed the followings:

- Change in annual cooling loads is smaller with respect to heating loads.
- The lowest load was observed at 180° orientation angle with 7272 kWh. In this orientation, the entrance of the apartment directed towards north. Since kitchen, living room benefit less from the sun in this orientation, the cooling load is lower than the other orientations.
- In Table 4.5 and Figure 4.6 are given relationship between orientation angle and cooling energy gain ratio of models in percentage. The highest gain ratio is obtained at 180° orientation angle with 4,69%.

Table 4.5 : The cooling energy gain ratios of apartments related to orientations.

Orientation angle (°)	The cooling energy gain ratio (%)
0	2,27
45	1,15
90	2,90
135	4,27
180	4,69
225	1,83
270	0,72
315	0,00

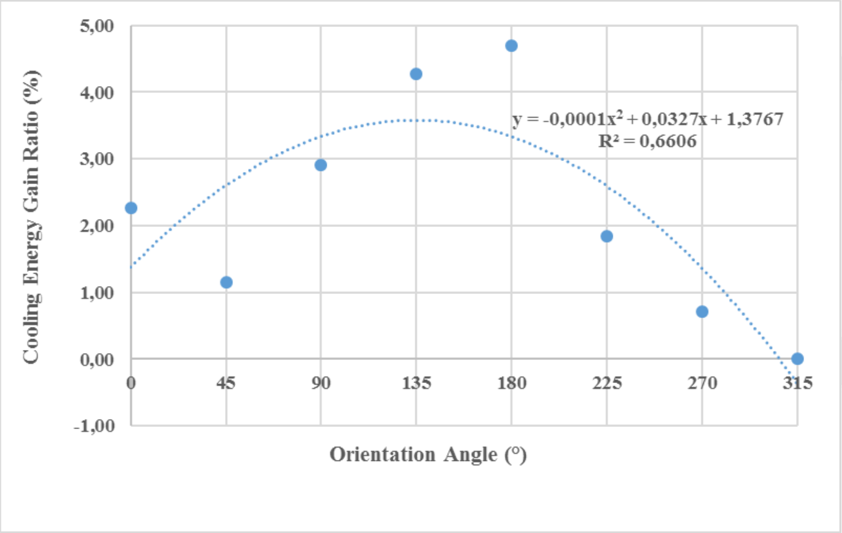


Figure 4.6 : Comparative cooling energy gain ratios of apartments related to orientations.

The results of overall energy demand analysis are as follows:

- On an annual basis, the lowest total energy load was obtained at 0° orientation angle with a value of 19784 kWh.
- It was seen an increase trend in total energy loads between 0°-225° orientation angles and a decrease trend in total energy loads between 225°-315° orientation angles.
- There is not a significant difference in total energy consumption between dwellings.

- In Table 4.6 and Figure 4.7, relationship between orientation angle and total energy gain ratio of models are given in percentage. The highest gain ratio is obtained at 0° orientation angle with 6,66%.
- A significant difference in terms of energy gain was not observed especially between 135-315° orientation angles.
- The contribution of cooling energy load is less than 40% of the total energy use. Besides, orientation of the building affects energy gains more clearly for heating case. Therefore, overall optimum directions are mostly compatible with optimum directions for heating.

Table 4.6 : Total energy gain ratios of apartments related to orientation.

Orientation angle (°)	Total energy gain ratio (%)
0	6,66
45	5,36
90	3,50
135	1,39
180	0,79
225	0,00
270	0,50
315	1,13

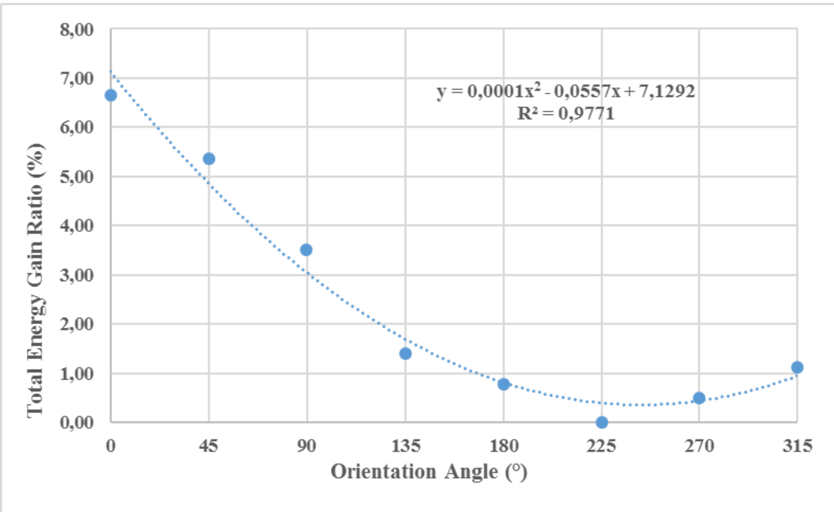


Figure 4.7 : Comparative total energy gain ratios of apartments with respect to orientation.

4.2 Street Width Analysis

In order to analyze effects of street widhts on annual energy performance, 6 and 12-storey apartment models were derived with the same plan as 3-storey model. The opaque barrier with the same height as apartments were placed in front of the façade of the apartment entrance. Figure 4.8 shows an example of barrier. The barrier is modeled as a continious element simulating several adjacent buldings, which results in partial shading of the analyzed building.

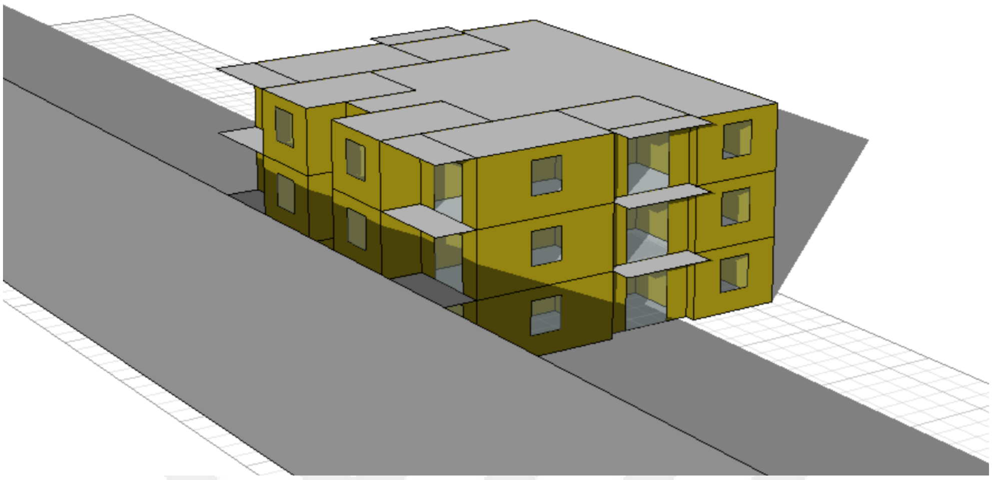


Figure 4.8 : The barrier shading 3-storey apartment model.

In order to calculate the highest heating load and lowest cooling loads, the first barrier was put 20 cm away from the building. This configuration will result in maximum shading and as it is not connected to building, it will not effect thermal conductivity.

For these barriers placed in the building's entrance facade, the energy consumption differences occurred only on living room and the kitchen. Therefore, for street widths analysis, energy demand of living room and kitchen located on front façade are taken into consideration. During this analysis, 0-degree south orientation angle is selected as the reference building orientation.

The results of analysis are described separately for 3, 6 and 12-storey apartment models. As in the previous analysis, heating, cooling and total loads are indicated.

4.2.1 Analysis results of three-storey model

For 3-storey model, the distance of the barriers to the building is increased gradually up to 24 meters. Since last barrier, which is 24 meters away from the building, does not a create a shadow effect on the building, the biggest distance of the barrier is selected as 24 meters (Figure 4.9).

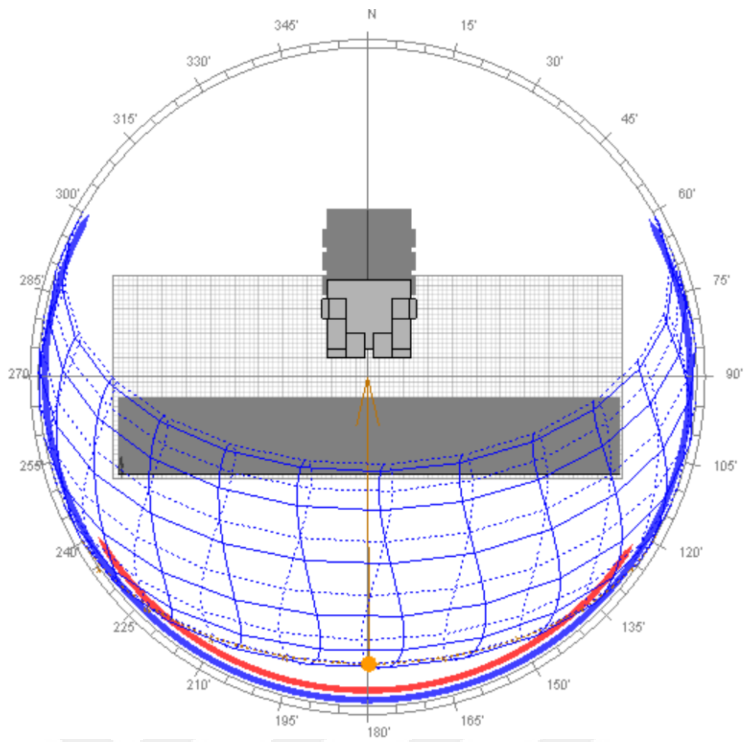


Figure 4.9 : Barrier 24 m away from the 3 three-storey model.

In front of the 3-storey model, barriers away from the building respectively 0.2, 3, 6, 9, 12, 15, 18 and 24 meters from the building and annual heating, cooling and total energy loads were calculated. Annual heating, cooling and total energy loads are given in Table 4.7. Heating, cooling and total energy loads for various barrier distance from the model are shown in Figure 4.10, 4.11 and 4.12.

Table 4.7 : Annual heating, cooling and total energy load of three-storey model.

Barrier Distance (m)	Annual Heating Energy (kWh)	Annual Cooling Energy (kWh)	Annual Total Energy (kWh)
0.2	5.474	1.912	7.386
3	5.384	1.951	7.335
6	5.283	1.984	7.267
9	5.180	2.005	7.185
12	5.096	2.020	7.115
15	5.050	2.029	7.079
18	5.003	2.038	7.041
24	4.955	2.072	7.027

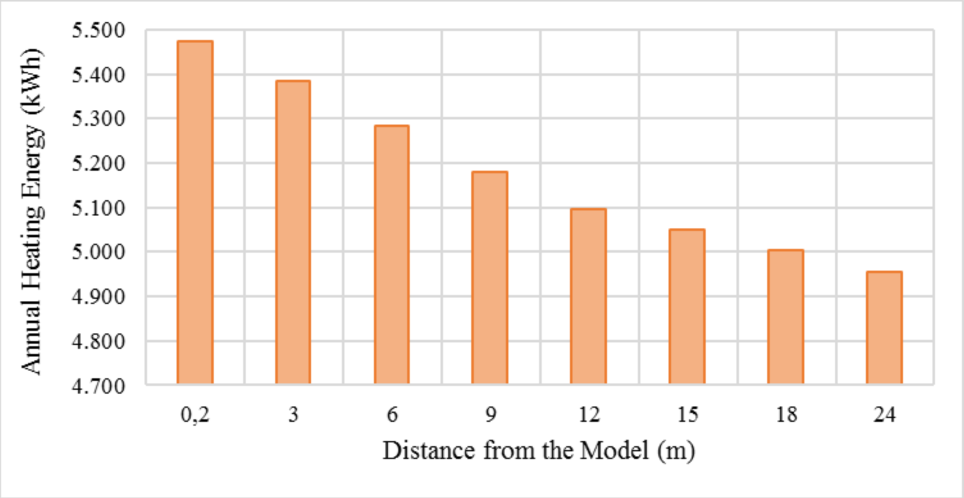


Figure 4.10 : Annual heating energy load of three-storey model.

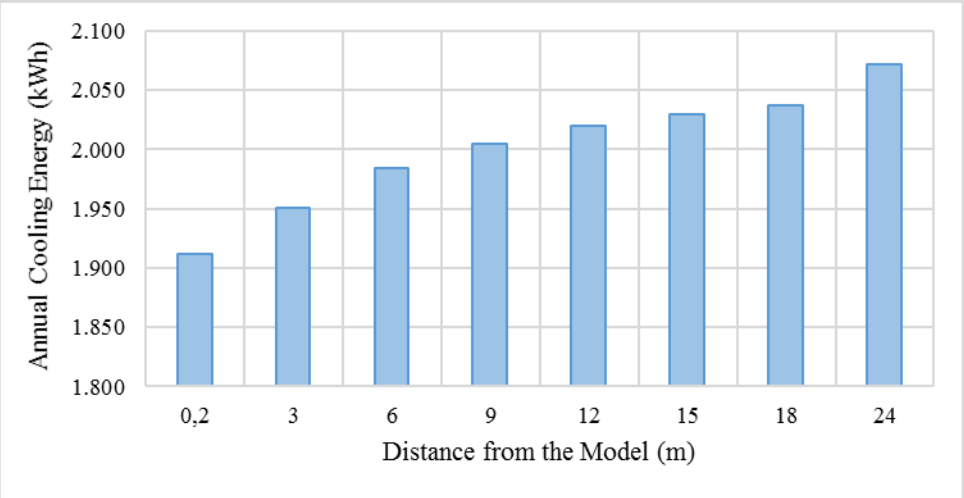


Figure 4.11 : Annual cooling energy load of three-storey model.

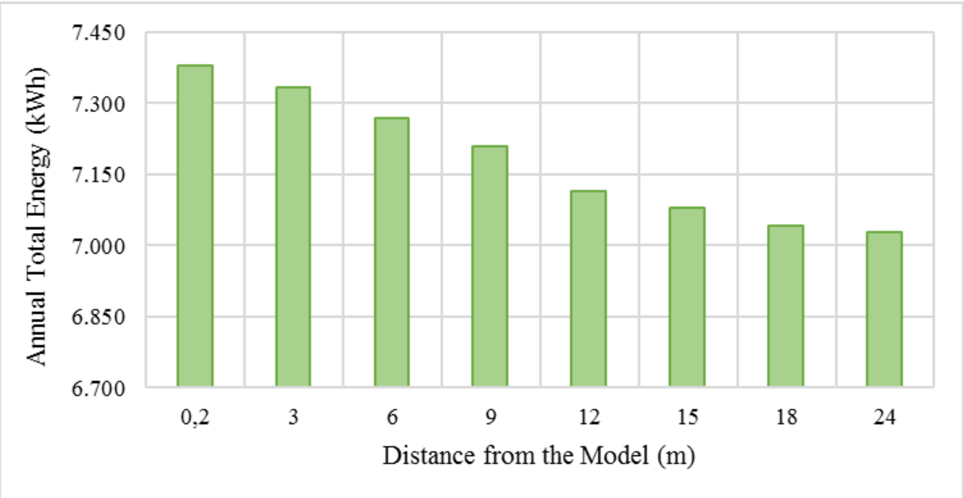


Figure 4.12 : Annual total energy load of three-storey model.

The highest heating load was observed at 0.2 m distance from the building with a value of 5.474 kWh, the lowest heating load was observed at 24 m with a value of 4.955 kWh. Barrier was put a distance 0,2 m from building to create a shadow. That's why building cannot benefit from sun energy. Thus the heating energy requirement was increased.

The highest cooling load was observed at 24 m distance from the building with 2.072 kWh, the lowest cooling load was observed at 0.2 m distance from the building with a value of 1.912 kWh.

As can be seen from the analysis, when barrier distance was increased from the building, cooling load increased, but heating load decreased.

According to analysis results, it seems that the most suitable street width for three-storey model is 15 meters.

In Table 4.8 and Figure 4.13 are given relationship between distance and total energy gain ratio of model in percent. The highest gain ratio is obtained at 24 m distance from the building with 4,79%. Up to 15 m distance considerable changes observed. However, after this distance further energy gain is minimized.

Table 4.8 : The total energy gains ratios of apartments according to distance of barrier from the model.

Distance (m)	Total energy gain ratio (%)
0,2	0,00
3	0,63
6	1,53
9	2,31
12	3,60
15	4,09
18	4,61
24	4,79

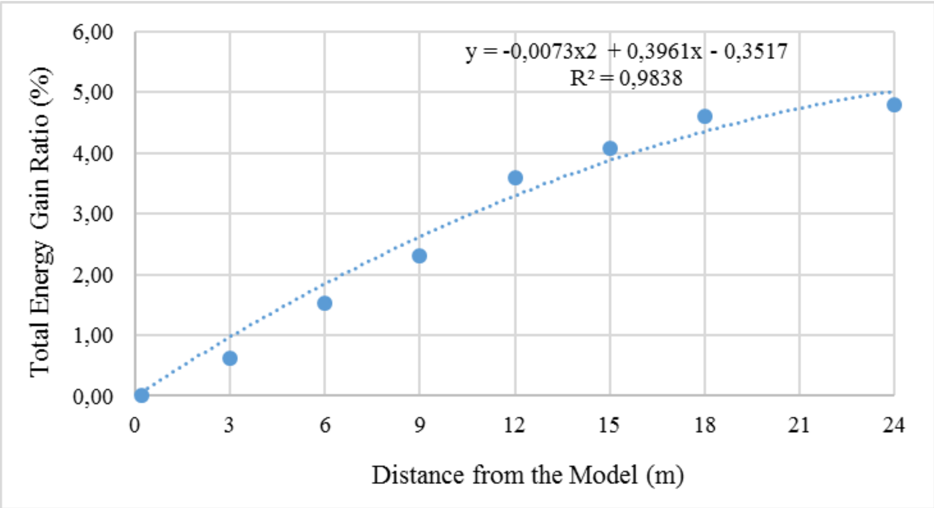


Figure 4.13 : Comparative total energy gaining ratios of apartments with respect to barrier distance.

4.2.2 Analysis results of six-storey model

For six-storey model, the distance of the barriers to the building is increased gradually up to 42 meters. Since last barrier, which is 42 meters away from the building, does not a create a shadow effect on the building, the biggest distance of the barrier is selected as 42 meters (Figure 4.14).

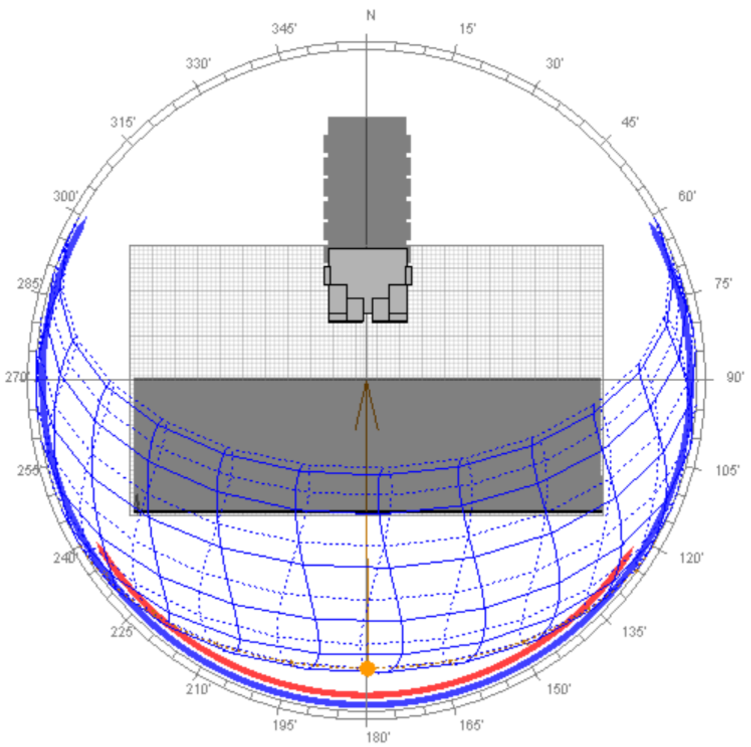


Figure 4.14 : Barrier 42 m away from the six-storey model.

In front of the 6-storey model, barriers were located away from the building respectively 0.2, 4.5, 6, 9, 12, 18, 24, 30, 36 and 42 m and annual heating, cooling and total energy loads were calculated. Values of annual heating, cooling and total energy loads are given in Table 4.9. Heating, cooling and total energy loads for various barrier distances from the model are shown in Figure 4.15, 4.16 and 4.17

Table 4.9 : Annual heating, cooling and total energy load of six-storey model.

Barrier Distance (m)	Annual Heating Energy (kWh)	Annual Cooling Energy (kWh)	Annual Total Energy (kWh)
0,20	10.694	3.933	14.627
4,5	10.605	4.018	14.623
6	10.454	4.041	14.495
9	10.268	4.081	14.349
12	10.138	4.111	14.249
18	10.001	4.132	14.133
24	9.899	4.167	14.066
30	9.750	4.199	13.949
36	9.686	4.214	13.900
42	9.602	4.240	13.842

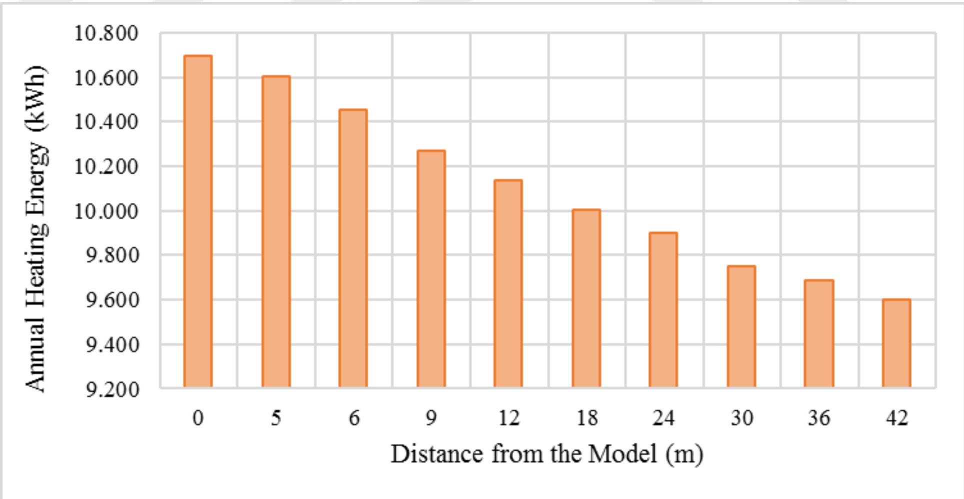


Figure 4.15 : Annual heating energy load of six-storey model.

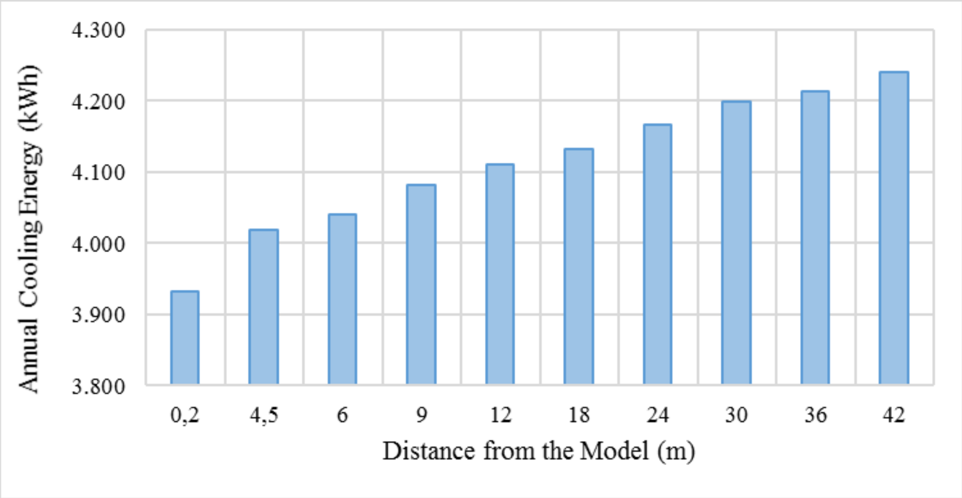


Figure 4.16 : Annual cooling energy load of six-storey model.

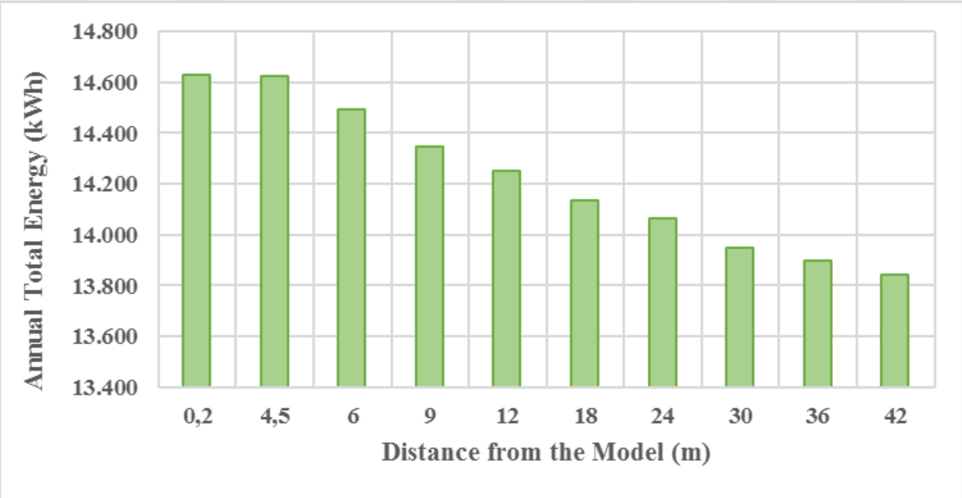


Figure 4.17 : Annual total energy load of six-storey model.

The highest heating load was observed at 0.2 m distance from the building with a value of 10.580 kWh, the lowest heating load was observed at 42 m with a value of 9.947 kWh. Barrier was placed at a distance of 0,2 m from building to create a shadow. That's why building cannot benefit from sun energy. Thus the heating energy requirement was increased.

The highest cooling load was observed at 42 m from the building with 4.223 kWh, the lowest cooling load was observed at 0.2 m from the building with 3.976 kWh.

As can be seen from the analysis, when the distance was increased from the building, cooling load increased, but heating load decreased.

According to analysis results, it seems that the most suitable street width for six-storey model is 30 meters.

Relationship between distance and total energy gain ratio of model in percentage are given in Table 4.10 and Figure 4.18. The highest gain ratio is obtained at 42 m distance from the building with 5,37%. Up to 30 m distance considerable changes observed. However, after this distance further energy gain is minimized.

Table 4.10 : The total energy gains ratios of apartments with respect to barrier distance from the model.

Distance (m)	Total energy gain ratio (%)
0,2	0,00
4,5	0,37
6	0,90
9	1,90
12	2,58
18	3,38
24	3,84
30	4,64
36	4,97
42	5,37

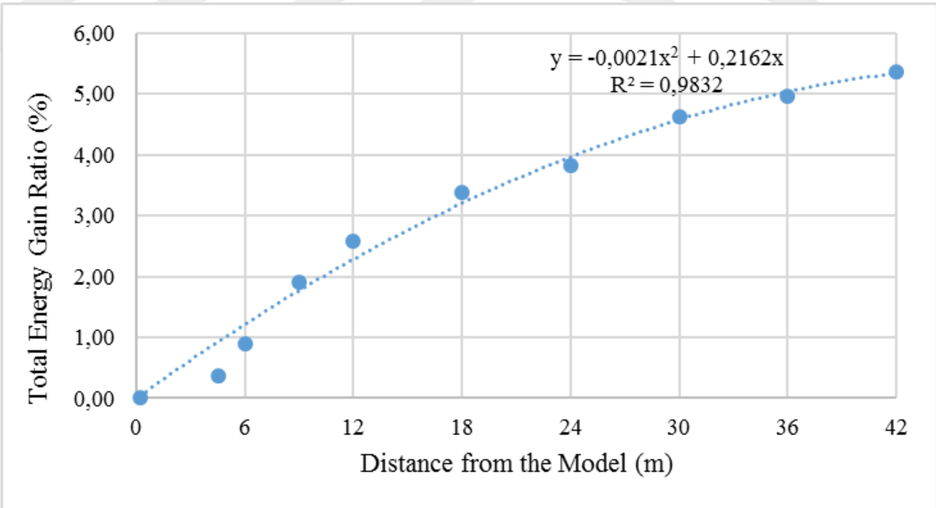


Figure 4.18 : Comparative total energy gain ratios of apartments with respect to barrier distance.

4.2.3 Analysis results for twelve-storey model

For 12-storey model, the distance of the barriers to the building is increased gradually up to 66 meters. Since last barrier, which is 66 meters away from the building, does not a create a shadow effect on the building, the biggest distance of the barrier is selected as 66 meters (Figure 4.19).

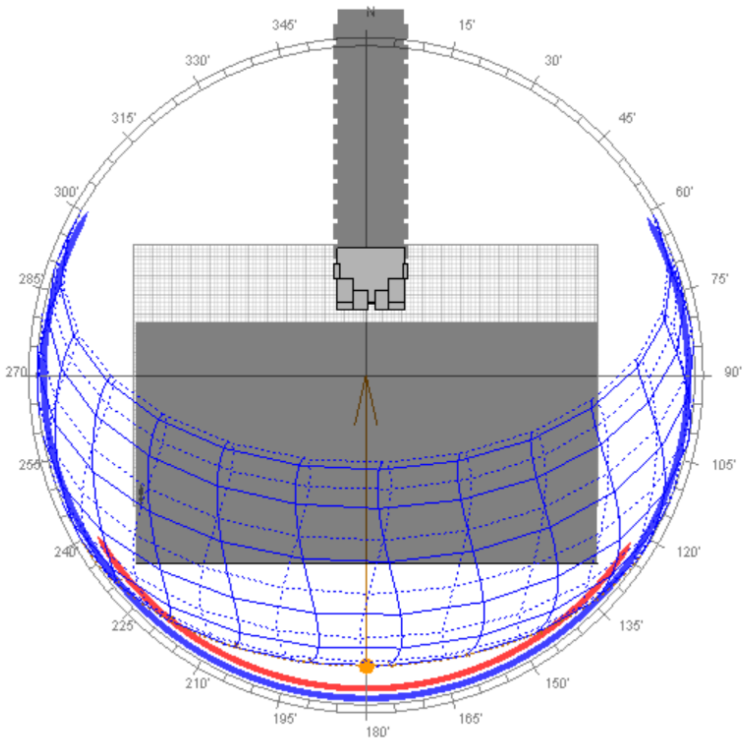


Figure 4.19 : Barrier 66 m away from the twelve-storey model.

In front of the twelve-storey model, barriers away from the building respectively 0.2, 6, 9, 12, 18, 24, 30, 36, 42, 50 and 66 from the building and annual heating, cooling and total energy loads were calculated. Values of annual heating, cooling and total energy loads are given in Table 4.11. In Figure 4.20, 4.21 and 4.22 are shown relationships between heating, cooling, total loads and barrier distance from the model.

Table 4.11 : Annual heating, cooling and total energy load of twelve-storey model.

Barrier Distance (m)	Annual Heating Energy (kWh)	Annual Cooling Energy (kWh)	Annual Total Energy (kWh)
0,20	20909	8061	28.970
6	20714	8107	28.821
9	20410	8165	28.575
12	20263	8213	28.476
18	20087	8296	28.383
24	19922	8364	28.286
30	19779	8410	28.189
36	19541	8448	27.989
42	19313	8484	27.797
50	19103	8556	27.659
66	19041	8607	27.648

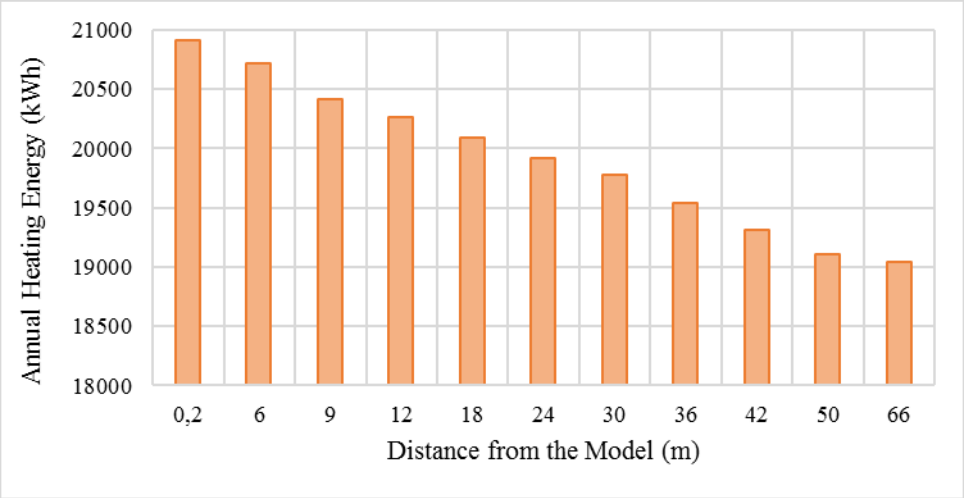


Figure 4.20 : Annual heating energy load of twelve-storey model.

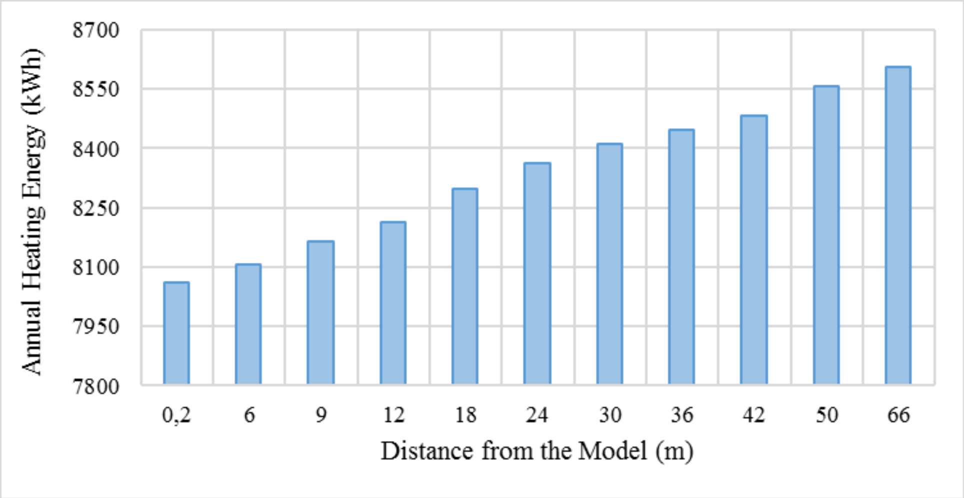


Figure 4.21 : Annual cooling energy load of twelve-storey model.

Figure 4.22 : Annual total energy load of twelve-storey model.

The highest heating load was observed at 0.2 m distance from the building with a value of 20.909 kWh, the lowest heating load was observed at 66 m distance from the building with a value of 19.041 kWh. Barrier was located at a distance 0,2 m from building to create a shadow. That's why building cannot benefit from sun energy. Thus the heating energy requirement was increased.

The highest cooling load was observed at 66 m distance from the building with a value of 8.607 kWh, the lowest heating load was observed at 0,2 m distance from the building with a value of 8.061 kWh.

As can be seen from the analysis, when the distance is increased from the building, cooling load increased, but heating load decreased.

In Table 4.12 and Figure 4.23 are given relationship between distance and total energy gain ratio of model in percentage. The highest gain ratio is obtained at 66 m distance from the building with a value of 4,56%. Up to 42 m distance considerable changes observed. However, after this distance further energy gain is minimized.

Table 4.12 : Total energy gain ratios of apartments related to distance from the model.

Distance (m)	Total energy gain ratio (%)
0,2	0,00
6	0,50
9	1,36
12	1,70
18	2,03
24	2,36
30	2,70
36	3,38
42	4,05
50	4,52
66	4,56

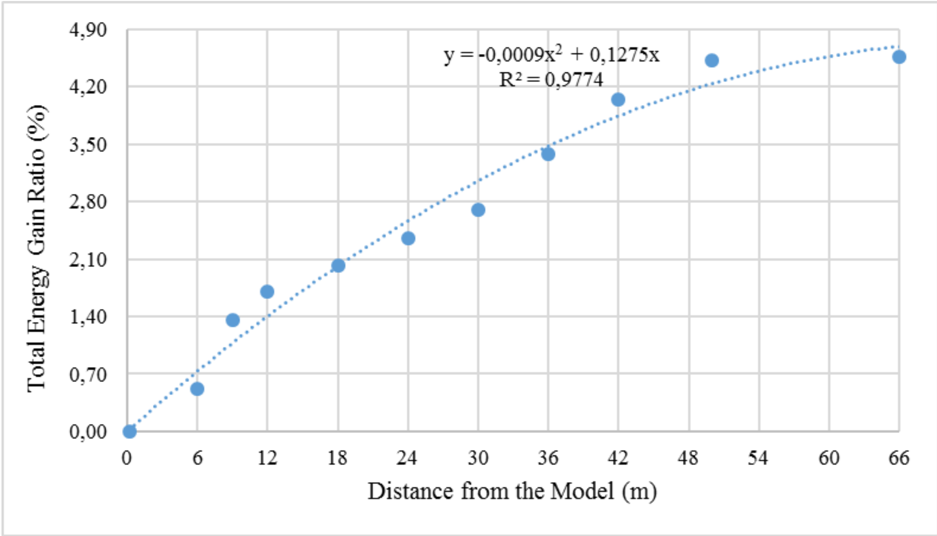


Figure 4.23 : Comparative total energy gaining ratios of apartments related to distance.

4.2.4 Energy consumption results of the north-south axis street

For street width analysis, 0-degree orentation was selected as the reference. Therefore street direction was formed in the east-west axis. As the last phase of the study, to obtain more meaningful results, energy analyses were conducted on north-south axis. For this, 12-storey model were rotated at 90 and 270 degrees (Figure 4.24). The obtained results were compared on heating, cooling and total annual energy load. Results of the analysis are seen in Table 4.13 and Figure 4.25, 4.26, 4.27.

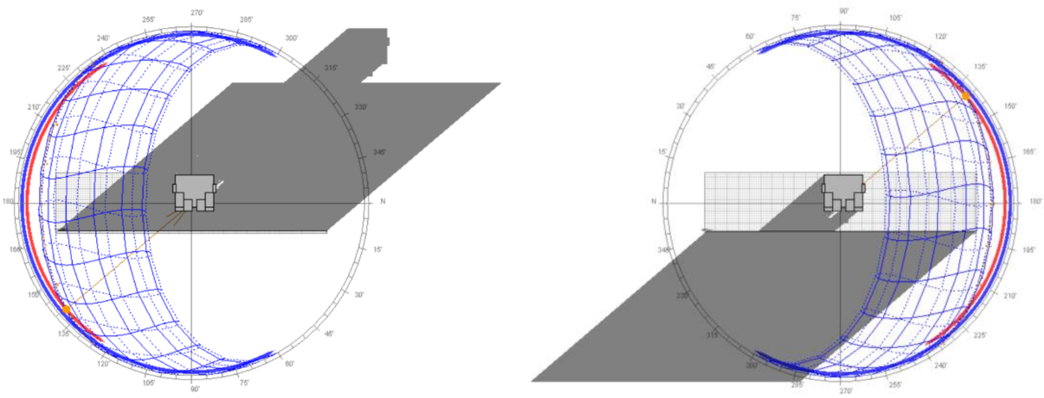


Figure 4.24 : 12-storey model at 90°(left) and 270°(right)

Table 4.13 : Annual heating, cooling and total energy load of 12-storey model.

Distance (m)	Heating kWh (270°)	Cooling kWh (270°)	Heating kWh (90°)	Cooling kWh (90°)	Heating kWh (0°)	Cooling kWh (0°)
0,2	22312	7670	21675	7904	20909	8061
6	22122	7755	21406	8064	20714	8107
9	22008	7801	21357	8111	20410	8165
12	21844	7921	21190	8163	20263	8213
18	21677	7988	21050	8231	20087	8296
24	21397	8048	20872	8293	19922	8364
30	21044	8088	20696	8344	19779	8410
36	20807	8132	20455	8381	19541	8448
42	20529	8266	20280	8456	19313	8484
50	20358	8301	20060	8522	19103	8556
66	20270	8358	19954	8609	19041	8607

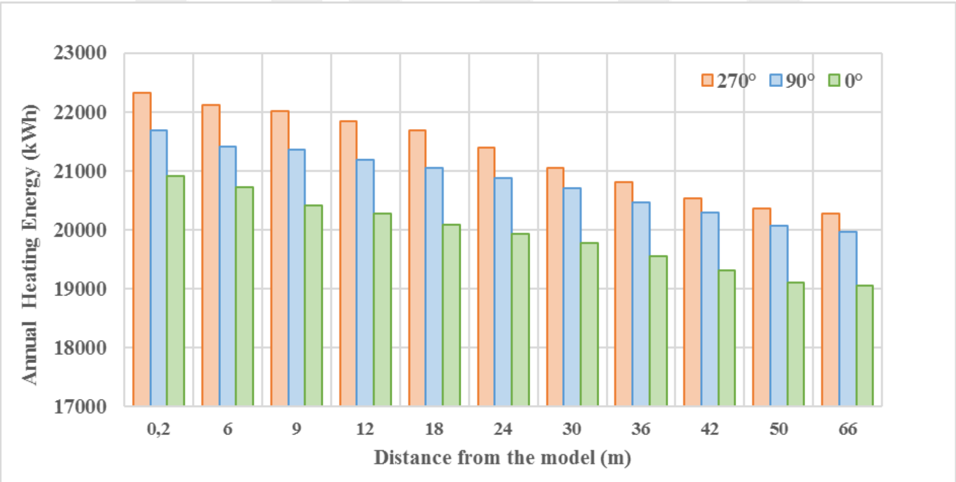


Figure 4.25 : Annual heating energy load of 12-storey model with respect to orientation angle.

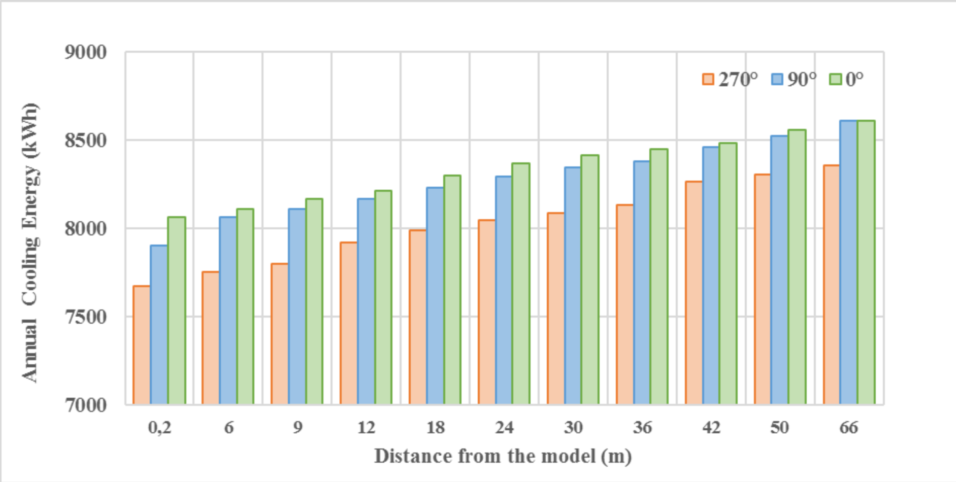


Figure 4.26 : Annual cooling energy load of 12-storey model with respect to orientation angle.

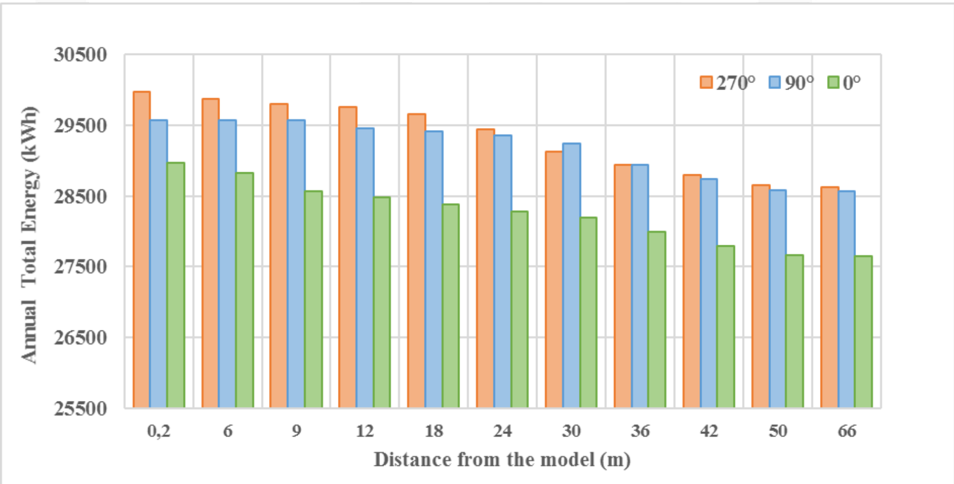


Figure 4.27 : Annual total energy load of 12-storey model with respect to orientation angle.

The highest heating and total energy loads were observed at 270°. However, total energy consumption results of 90° and 270° were close. Since most frequently used areas (kitchen, living room) benefit less from the sun in 90° and 270° orientations, the heating loads of these orientations are higher than 0° orientation.

The lowest cooling load was observed at 270°. Especially in the months of summer, barriers provide shade to model in the afternoon. Therefore, cooling energy load of 270° orientation is lower than the other orientations.

In Table 4.14 is given relationship between orientations and total energy gain ratio of model in %. As can be seen from the results, the most efficient orientation angle is 0° for 12-storey building in Izmir.

Table 4.14 : The total energy gain ratios of orientated models related to distance.

Distance (m)	Total Energy Gain Ratio (%) 270°	90°	0°
0,2	0.00	1.34	3.37
6	0.35	1.61	3.87
9	0.57	1.71	4.69
12	0.72	2.09	5.02
18	1.05	2.33	5.33
24	1.79	2.72	5.65
30	2.83	3.14	5.98
36	3.47	3.82	6.64
42	3.95	4.15	7.28
50	4.41	4.66	7.74
66	4.51	4.73	7.78

5. EVALUATION OF EXISTING SETTLEMENTS IN IZMIR

In the last stage of the thesis, existing settlements in Izmir were evaluated. For this purpose, four settlement areas were selected from Izmir city centre (Figure 5.1). Evaluation was conducted in selected areas according to following criteria:

- Building orientation
- Main streets and side road direction
- Street widths

Figure 5.1 : Selected areas from Gulf of Izmir.

These four areas were selected from Karşıyaka, Bayraklı, Konak and Narlıdere districts respectively. Regions of dense apartment buildings from these selected areas were investigated. Evaluations were done according to the plan view, and the results were discussed.

Karşıyaka District

The first settlement example is selected from Karşıyaka district. Lands of the district is mostly flat. It is located on the northern coast of the Gulf of Izmir. The marked apartments are good examples in terms of energy efficiency and can be seen in Figure 5.2. These apartment blocks were located towards south direction and main streets were directed along east-west axis.

Figure 5.2 : Settlement from Karşıyaka district

However, apartments marked in Figure 5.3 are inefficient examples for energy efficiency. These apartment blocks were located towards east or west direction. Façade of apartment entrance directed towards north, east and west directions. Main streets of apartments were located along north-south axis and the distance between apartment blocks is insufficient. Therefore, apartments are not benefiting enough from the sun. Especially in these areas, heating energy costs in winter and cooling energy costs in summer are expected to be higher than blue marked apartments.

Figure 5.3 : Inefficient apartments in Karşıyaka district

One of the main reasons causing problem in this area is the street highlighted in Figure 5.3. Because of this street was discontinuous due to by apartment blocks located in the middle. If the way was uninterrupted by these blocks, energy performance of apartment blocks in the middle would be better as they would be located towards south direction.

Bayraklı District

Bayraklı is the new city centre district of Izmir. The marked apartments are good examples for energy efficiency and can be seen in Figure 5.4. These apartment blocks were located towards south or south-east direction and the front façade of these buildings were located along east-west axis. Therefore, energy demand of marked buildings is lower than the other buildings.

Figure 5.4 : Settlement from Bayraklı district

The marked apartments in Figure 5.5 are poor examples in terms of energy efficiency. These apartment blocks were located towards east or west direction. Although apartment blocks labelled as ‘’1’’ directed properly, these blocks are examples for inefficient energy efficiency as distance of blocks from each other is very close. The left and right blocks create a shadow on the middle blocks, therefore especially energy performance of these two blocks are worse than left and right blocks.

Figure 5.5 : Inefficient apartments in Bayraklı district

Konak District

Konak is the central district and one of the historical districts of Izmir. Good examples can be seen in Figure 5.6 for passive energy design. These apartment blocks were located towards south direction and main streets were located along east-west axis resulting in significant open spaces in south facades. Therefore, energy consumption of marked buildings is lower than the other buildings.

Figure 5.6 : Settlement from Konak district

Within this examples area almost all buildings were located towards south, however main street widths of marked apartments in Figure 5.7 are insufficient and these buildings are directed towards north direction, which is the most unfavourable case for heating energy efficiency.

Figure 5.7 : Inefficient apartments in Konak district

Narlıdere District

This settlement example is from Narlıdere district. The marked apartments are good examples for energy efficiency because of open space design and orientation in Figure 5.8. However, the other places are inefficient example for energy efficiency. Because of unplanned settlement, distance of buildings is very close. Therefore, these buildings do not benefit enough from the sun.

Figure 5.8 : Settlement from Narlıdere district

6. CONCLUSION

Energy issue is of great importance for both the environment and economy. The growing population, especially in developing countries, has caused to environmental massacre and unplanned urbanization. This growth also, has led to the increase in energy demand. Studies are done recently, the people's interests and government policies have begun to focus on energy.

The conservation of the environment is associated with the reduction of energy demand. Building sector constitutes a large portion of this demand. Buildings consume great energy throughout their life cycle. Therefore, studies to reduce the energy consumption of buildings has become a need nowadays.

Studies on this subject has been increased too much in recent years. Wide range of issues are discussed in many disciplines such as architecture, engineering sciences and sociology. Some of these issues are construction materials, recycling, low energy consumption products and one of the most important issues is building design parameters. The importance of building design parameters is that they can be interrupted at the design stage and thus it can go to interventions without any financial loss.

Energy demand analysis software help the designer at building design stage. Ecotect Analysis and Revit are used in this study.

There are many design parameters that effect the energy consumption of the buildings. The most important of these design parameters were described in the scope of study. In the analysis, 2 of these parameters, building orientation and street widths has been studied.

Major results and conclusions of this study can be summarized as follows:

It should be paid attention to the position and orientation of the building at the design stage. The model used during analysis has no schematic and aesthetic features. Despite this, only by changing the orientation of the building, an energy saving was obtained up to 7%. As a result of the analysis, the proper orientation of the building model was found in a north-south axis. These gain can be increased further when more detailed project is developed.

It is difficult to make the new orientation proposal for the building with certain way and small size adjacent buildings.

Optimum orientation angle is found to be towards south direction for Izmir city. Therefore, new development areas or urban regeneration areas should be planned accordingly. Based on the results it is suggested to locate streets along north-south and east-west direction so that it might be highly possible to locate buildings in the desired orientation.

As for street widths, important energy savings were achieved. While the street width is increased, the heating energy consumption of buildings decreased. However, the cooling energy consumption of buildings increased. Because as long as street width is increased, the buildings can benefit from the sun. In addition, narrowness streets have an impact on the human psychology.

In performed analysis, it has been observed that street size made a significant contribution to energy saving in buildings. Related to this topic, up to 6% energy savings was achieved with studies performed on 3, 6 and 12-storey models.

For Izmir region, the most frequently used areas of buildings are located in east-west axis and buildings' entrance façade must look to the south. Wide streets especially between apartment blocks must be located on the east-west axis. Narrow streets must be located on the north-south axis. This will help to achieve more useful results in terms of energy savings.

With observations from several regions in Izmir, existing settlements were evaluated. According to observation results, most of the problems arise from squatters. In planned areas, it is observed that the orientation of the buildings is better than the squatter areas. However in squatter areas, orientation of buildings and main street direction and width were ignored. Additionally, street widths were ignored in most of the planned areas.

Finally, by changes done on legislations and standards by ministry and municipality, building design parameters will take more in consideration. Also, the building orientation and street width are evaluated along with region-specific design values and they should be integrated into the design. More importantly, city development plans should be prepared by considering energy design of structures.

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