REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

IMPACT OF DIFFERENT TRANSPARENCY RATIOS OF BUILDING ENVELOPE ON BUILDING ENERGY PERFORMANCE IN VARIOUS CLIMATIC ZONES

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MSc. THESIS
DEPARTMENT OF ARCHITECTURE
PROGRAM OF BUILDING PHYSICS

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İSTANBUL, 2016

REPUBLIC OF TURKEY

YILDIZ TECHNICAL UNIVERSITY

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ACKNOWLEDGEMENTS

I would first like to thank my thesis advisor Prof. Dr. Gülay ZORER GEDİK and all other instructors of the Department of Architecture, Building Physics Program in Yıldız Technical University. The office door of Prof. GEDİK was always open whenever I ran into trouble or had a question about my research.

I would also like to thank my academic family and grandmother: My father, Prof. Dr. Mahmut Aydınol, my mother Prof. Dr. Belkıs Aydınol, my brother, Dr. M. Mustafa Aydınol, and my grandmother Bedia Gözen.

Finally, I need to further thank my friends, particullary architect (MSc) A. Umur Göksu and mechanical engineer İ. Engin Şeker for their continuous encouragement throughout the process of researching and writing this thesis.

December, 2016

Fatma Azize Zülal AYDINOL

TABLE OF CONTENTS

Page

LIST OF ABBREVIATIONS vi

LIST OF FIGURES vii

LIST OF TABLES viii

ABSTRACT ix

ÖZET xi

CHAPTER 1

INTRODUCTION 1

1.1 Literature Review 3
1.2 Objective of the Thesis 9
1.3 Hypothesis 10

CHAPTER 2

THE CASE STUDY 11

2.1 Method 11
2.1.1 Determination of the Climate Types 12
2.1.2 General Description of the Modeled Blocks and Scenarios 12
2.1.3 Determination of the Orientation of Scenario Blocks 14
2.1.4 Properties of the Structural Elements and Material Selection 16
2.1.5 The System Selection 19
2.2 Energy Load and Surface Window Heat Gain/Heat Loss Energy Calculation of the Scenario Blocks 21

CHAPTER 3

ANALYZING OF ENERGY LOADS 25

3.1 Analyzing of Energy Loads and Surface Window Heat Gain/Heat Loss Energy of the Scenario Blocks 25
3.1.1 Findings for Antalya Province (South Sides) 25
3.1.2 Findings for Antalya Province (North Sides) 29

3.1.3 Findings for Erzurum Province (South Sides) 31
3.1.4 Findings for Erzurum Province (North Sides) 33
3.1.5 Findings for Istanbul Province (South Sides) 36
3.1.6 Findings for Istanbul Province (North Sides) 38
3.2General Analysis of Energy Loadsof the Scenario Blocks 41
3.2.1 A1, B1 and C1 Scenario Blocks (South) 41
3.2.2 A2, B2 and C2 Scenario Blocks (North) 42
3.3 Energy Saving Rates of the Scenario Blocks 45

CHAPTER 4

THE RESEARCH RESULTS OF THE SCENARIO BLOCKS 50

CHAPTER 5

RESULTS AND DISCUSSION 53

5.1 General Research Results 53
5.2Discussion and Recommendations 55

REFERENCES 57

APPENDIX-A

INTRODUCING OF THE DESIGNBUILDER PROGRAM 60

APPENDIX-B

EXTERNAL CLIMATE DATA FOR SELECTED PROVINCES 61

CURRICULUM VITAE 65

LIST OF ABBREVITIONS

ASHRAE	American Society of Heating, Refrigerating and AirConditioning Engineers
B.A.R	Building Aspect Ratio
BP	British Petroleum
C	Coated
ClO	Thermal Insulation Values of Clothes
CO2	Carbon Dioxide
DB	DesingBuilder
EU	European Union
IWEC	The International Weather Energy Calculation Data
KWh	Kilowatt Hour
MWh	Megawatt Hour
N	North
N.W.	North Window
PVC	Polyvinyl Chloride
S	South
S.W.	South Window
S.W.S.	South Window Size
TEIAS	Turkish Electricity Transmission Company
TMMO	Turkish Chamber of Mechnaical Engineering Association
TS 825	Turkish Standards
U_C	Heat Transfer Coefficient for Ceiling
U_G	Heat Transfer Coefficient for Ground
U_W	Heat Transfer Coefficient for Wall
U_w	Heat Transfer Coefficient for Window
UK NCM	United Kingdom National Calculation Method
WBCDS	World Business Council for Sustainable Development

LIST OF FIGURES

Page

Figure 1.1 The Share of the Buildings Energy Usage in Turkey 2
Figure 1.2 Electricity Production in Turkey (MWh) TEIAS, 2015 3
Figure 2.1Orientations of the A1, B1 and C1 Scenario Blocks 14
Figure 2.2 A1, B1 and C1 Scenario Blocks 15
Figure 2.3 A2, B2 and C2 Scenario Blocks 15
Figure 2.4Changed Transparency Ratios of the Scenario Blocks 15
Figure 3.1Annual Energy Load Valuesof blocks for Antalya Province (South) 27
Figure 3.2 Surface Window Heat Gain/Loss Energy Values for Antalya Province (South) 28
Figure 3.3Annual Energy Load Values of blocks for Antalya Province (North) 30
Figure 3.4 Surface Window Heat Gain/Loss Energy Valuesfor Antalya Province (North) 31
Figure 3.5 Annual Energy Load Valuesof blocks for Erzurum Province (South)..... 32
Figure 3.6 Surface Window Heat Gain/Loss Energy Valuesfor Erzurum Province (South) 33
Figure 3.7 Annual Energy Load Values of blocks for Erzurum Province (North)..... 35
Figure 3.8 Surface Window Heat Gain/Loss Energy Results for Erzurum Province (North) 36
Figure 3.9 Annual Energy Load Values of blocks for Istanbul Province (South)..... 37
Figure 3.10 Surface Window Heat Gain/Loss Energy Values for Istanbul Province (South) 38
Figure 3.11 Annual Energy Load Valuesof blocks for Istanbul Province (North)..... 40
Figure 3.12 Surface Window Heat Gain/Loss Energy Valuesfor Istanbul Province (North) 40

LIST OF TABLES

Page

Table 2.1 The transparency ratiosofthe scenario blocks 13
Table 2.2 Determined U values of components of the structures for the selected provinces in degree-days regions of Turkey 16
Table 2.3Properties of the selected materials for transparent components with DB 16
Table 2.4Properties of the selected materials for opaque components with DB 17
Table 2.5The selected materials for building envelope of the structures with DB 18
Table 2.6Mutual system selections for structures with DB (Activity) 20
Table 2.7Mutual system selections for structures with DB (HVAC parameters) 20
Table 2.8Annual energy load values for Antalya province (kWh/m^2) 22
Table 2.9Surface window heat gain/heat loss energy values for Antalya province (kWh/m^2) 22
Table 2.10 Annual energy load values for Erzurum province (kWh/m^2) 23
Table 2.11 Surface window heat gain/heat loss energy values for Erzurum province (kWh/m^2) 23
Table 2.12 Annual energy load values forIstanbul province (kWh/m^2) 24
Table 2.13 Surface window heat gain/heat loss energy values for Istanbul province (kWh/m^2) 24
Table 3.1 Energy saving rates of the scenario blocks for Antalya province 45
Table 3.2Energy saving rates of the scenario blocks for Erzurum province 47
Table 3.3Energy saving rates of the scenario blocks for Istanbul province 48
Table B.1The hourly average weather temperature data for Antalya province 62
Table B.2 The hourly average weather temperature data for Erzurum province 63
Table B.3 The hourly average weather temperature data for Istanbul province 64

ABSTRACT

IMPACT OF DIFFERENT TRANSPARENCY RATIOS OF BUILDING ENVELOPE ON BUILDING ENERGY PERFORMANCE IN VARIOUS CLIMATIC ZONES

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MSc. Thesis

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Today, energy is more important than ever before, the rapidly growing population, excessive and unconscious use and depletion of natural resources, forces the need for new resources. New technologies are needed and studies are being done to decrease energy demand and reduce the energy consumption. Advances in technology have increased the need for more energy and technology is also used to develop methods to make energy efficient designs.

Openings in the structures are a major cause of energy loss and the major part of the openings are windows. Considering this information in this study; with DesignBuilder and EnergyPlus building energy simulation programs, one square form structure called block was designed and given a house function in different scenarios. They called A1, A2, B1, B2, C1 and C2. Each of them has four different altered transparency ratios in themselves. Transparency ratios of all facades of this four square blocks are as follows: 20% at north, 30% at east, 20% at west to be constant, and at south facade gradually changed as 20%, 30%, 40% and 50% for A1, B1 and C1 Scenarios. For A2, B2 and C2 scenarios all other transparency ratio kept same with A1, B1 and C1 scenarios except for north facades, it changes as 20%, 30%, 40% and 50% gradually. There are two different parameters within themselves blocks and scenarios. The first is changing window to wall area ratios, in other words, transparency ratios between the blocks of scenarios, and second used different window glass types between the scenarios. While

single glazing window was selected for blocks of A Scenarios, for B blocks double glazing window and for C blocks coated double glazing window has preferred. This study mainly evaluates depending effects of causing heat gains or heat losses of changing transparency ratios on building energy performance. Besides it is a study that carrying out effects of different glazing window types used in structures on heating, cooling and total loads (heating + cooling) conditions of structures with the same effect.A pilot province was determined in various climate zones of Turkey - Continental, Mediterranean and Marmara (transition) region climate types - energy load analysis of structures in each selected province were done. With the obtained data from the analysis, also energy saving rates of scenario blocks was calculated. In the light of these investigations, it is seen that changing transparency ratios on both north and south facades of structures have different influence on energy performance of structures in terms of heating, cooling and total energy load (heating + cooling) conditions. Also, there are big impacts of used different glazing types on energy performance. According to the resultscame up with using DesignBuilder program and its interface simulation tool EnergyPlus; with increased transparency ratios while due to heat losses from north facades of created scenario blocks oriented toward the north, heating and total loads increased. Due to solar heat gains from south facades of scenario blocks oriented toward the south, cooling and total energy loads increased. In the scope of limitations of this study, building energy performance was affected negatively with used 50% maximum transparency ratio. When observed effects of single, double and coated double glazing window types on the energy performance of the structures, the most energy saving came up with blocks with coated double glazing for all scenario blocks. The least energy saving came up with blocks with single glazing window types. The result was occurred that transparency ratios must be kept as minimum as possible, for this study by 20% at north facades. For Erzurum, located at cold climate, coated double glazing was effective on energy loads of increased transparency ratios of blocksoriented toward the north and with especially preventing major heat losses. When comparing the scenario blocks oriented to the same direction in the same provinces, for Antalya and Istanbul which are respectively located at hot climate and Marmara (transition) climate, there areeffects of double and coated double glazing on energy loads asmuch as creatinga marked difference. However, when comparing to scenario blocks oriented toward as north and south, there are not occurred notable differences on energy loads.

Considering transparent surfaces are the main reason for energy loss in structures, examining window to wall area ratio in relation with the structures in this study and further studies on this topic will be one of the very important steps for the future of development of energy efficient designs.

Key words: DesignBuilder, glazing type, transparency ratio, building energy performance

ÖZET

ÇEŞİTLİ İKLİM BÖLGELERİNDE BULUNAN YAPI KABUĞUNDAKİ FARKLI SAYDAMLIK ORANLARININ YAPI ENERJİ PERFORMANSINA ETKİSİ

Fatma Azize Zülal AYDINOL

Mimarlık Anabilim Dalı

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Tez Danışmanı: Prof. Dr. Gülay ZORER GEDİK

Günümüzde enerji her zamankinden daha fazla önem kazanmakla birlikte, hızla artan nüfus, doğal kaynakların aşırı ve bilinçsizce kullanımı, doğal kaynakların gün geçtikçe azalması, yeni teknolojiler ile yeni kaynaklara yönelişleri mecbur kılmış, ihtiyaç duyulan ve tüketilen enerji miktarlarını azaltmaya yönelik çalışmalar yapılmaya başlanmıştır. Teknoloji ilerledikçe ihtiyaç duyulan enerji daha da artmış ve bu yüzden yine teknolojiyi kullanarak enerji etkin tasarımlar yapılmaya, yöntemler geliştirilmeye çalışılmıştır.

Yapılardaenerji kayıplarının büyük bir kısmı yapılardaki açıklıklardan yani pencerelerden olmaktadır. Bu bilgiler gözetilerek bu çalışmada; binalarda en fazla enerji tüketimi kullanılan iklimlendirme sistemlerinin ısıtma ve soğutma enerji yükleri için olduğu bilinerek DesignBuilder ve EnergyPlus bina simülasyon programları ile, karesel formda, ev işlevi verilen ve blok diye adlandırılan bir yapı tasarlanmıştır. Bu blok ile A1, A2, B1, B2, C1 ve C2 diye adlandırılan farklı senaryolar oluşturulmuştur. Her bir senaryo bu kare yapının dört farklı saydamlık oranına sahip bloklardan oluşmaktadır. Bu dört yapının cephelerdeki saydamlık oranları A1, B1 ve C1 senaryolarında kuzeyde %20, doğuda %30, batıda %20 sabit olacak şekilde, güneyde ise sırasıyla %20, %30, %40, %50 olacak şekilde kademeli olarak değiştirilmiştir. A2, B2, C2 senaryolarında ise diğer yönlerdeki saydamlık oranları A1, B1 ve C1senaryosu ile aynı olup, sadece kuzey cephesinde %20, %30, %40 ve %50 olacak şekilde değişiklik yapılmıştır. Bloklar

ve senaryoların kendi içlerinde olmak üzere iki değişkeni vardır. Birincisi senaryo bloklarının değişen pencere/duvar alanı oranları başka bir deyişle saydamlık oranları, ikincisi senaryolarda kullanılan cam çeşitleridir. A senaryosunda tek cam, B senaryosunda çift cam ve C senaryosunda kaplamalı çift cam tercih edilmiştir. Bu araştırma öncelikle değişen saydamlık oranlarının, neden olduğu ısı kayıp veya kazançlarına bağlı olarak yapı enerji performansına olan etkisini değerlendirmektedir. Bunun yanında, yapılarda kullanılan farklı cam çeşitlerininde aynı etki ile yapıların ısıtma, soğutma ve toplam enerji yük (ısıtma + soğutma) durumuna etkisinin ortaya koyulduğu bir çalışmadır.Bu yapılar Türkiye'de görülen üç iklim türünde; Karasal, Akdeniz, Marmara (geçiş), belirlenen pilot illerde enerji yük analizleri yapılmıştır. Analizlerden elde edilen veriler ile senaryo bloklarının enerji tasarruf oranları da hesaplanmıştır. Bu araştırmaların neticesinde, yapıların kuzeyde ve güneyde değişen saydamlık oranlarının bina enerji performansını ısıtma, soğutma ve toplam enerji yük (ısıtma + soğutma)durumu açısından farklı etkilediği görülmüştür.Kullanılan farklı cam çeşitlerinin de etkisi büyüktür.Bu tez çalışmasında kullanılan DesignBuilder programınn arayüz simülasyon aracı EnergyPlus ile ortaya çıkan bazı önemli sonuçlara göre, saydamlık oranının artmasıyla tasarlanan kuzeye yönlendirilmiş senaryo bloklarında, kuzey cephelerdeki ısı kayıplarından dolayıısıtma ve toplam yük artmıştır. Güneyeyönlendirilmiş yapılarda ise, güney cephelerdeki ısı kazançlarından dolayı soğutma ve toplam yük artmıştır.Bu çalışmanın sınırlılıkları kapsamında, kullanılan maksimum %50 saydamlık oranı yapı enerji performansını olumsuz etkilemiştir. Senaryolarda kullanılan tek cam, çift cam ve kaplamalı çift cam çeşitlerinin enerji yüklerine olan etkisi incelendiğinde en büyük tasarrufun tüm senaryo blokları için kaplamalı çift camda olduğu görülmüştür. Tek camlı senaryo bloklarında ise en az olduğu ortaya çıkmıştır. Kuzeye yönlendirilmiş senaryo bloklarında kuzey cephelerde saydamlık oranının mümkün olduğunca minimum, bu tez çalışması için %20, tutulması gerektiği ortaya çıkmıştır. Kaplamalı çift camın özellikle soğuk iklim bölgelerinde kuzeye yönlendirilmiş blokların artan saydamlık oranında, büyük ısı kayıplarının önüne geçtiği için enerji yüklerinde etkili olduğu görülmüştür. Aynı yöne yönlendirilmiş senaryo blokları aynı il içinde, sıcak iklim bölgesinde olan Antalya ve Marmara (geçiş) ikliminde olan İstanbul için, karşılaştırıldığında,çift cam ve kaplamalı çift camın enerji yüklerindebelirgin bir fark yaratacak kadar etkisi olduğu, kuzey ve güney olarak karşılaştırıldığında iseenerji yüklerinde belirgin bir farkın oluşmadığı ortaya çıkmıştır.

Yapılardaki enerji kayıplarının başında saydam yüzeylerin geldiğini, ve ısıtma ve soğutma için harcanan enerjinin en fazla olduğunu düşünürsek; farklı pencere/duvar oranlarının ve cam çeşitlerinin yapılarda ısıtma ve soğutma yükleri ile ilişkili olarak bu çalışmada incelenmesi ve araştırmaların yapılması bina enerji verimliliği konusunda ileriye atılan çok önemli adımlardan biri olacaktır.

Anahtar Kelimeler: DesignBuilder, cam çeşidi, saydamlık oranı, yapı enerji performansı

CHAPTER 1

INTRODUCTION

In recent years, energy consumption in buildings has become an important issue. It is a serious concern for many countries, including Turkey, as causes and effects of energy consumption research, as well as study analyses,continues to increase. Construction activities consume 40% of the global energy each year [1]. In Europe, it is estimated that 40% of the energy is used for buildings. The World Business Council for Sustainable Development (WBCSD) reported that energy consumption by buildings constituted 30% to 40% of final energy consumption and CO2 emissions in many countries [2]. According to the World Energy Report, which is annually published by British Petroleum (BP), while world energy consumption has increased 2.4% (on average) compared to the previous year, this ratio has become 5% for Turkey [3] in 2007. Also, about 70% of the total energy consumed in Turkey is imported; this rate is progressively increasing. The energy import of Turkey is expected to be 73% in 2010 and 78% in 2020 [4]. Turkey has a high energy consumption ratio for buildings. For the residence/house sector, the share of energy consumption grew 2.7% between 1990–2000 and reached 34.5% in 2001 [4]. A large part of energy consumption is in buildings to ensure user comfort, i.e., thermal comfort, with heating-cooling, air conditioning, and lighting. This energy consumption ratio can be up to 40% in the world share [2].

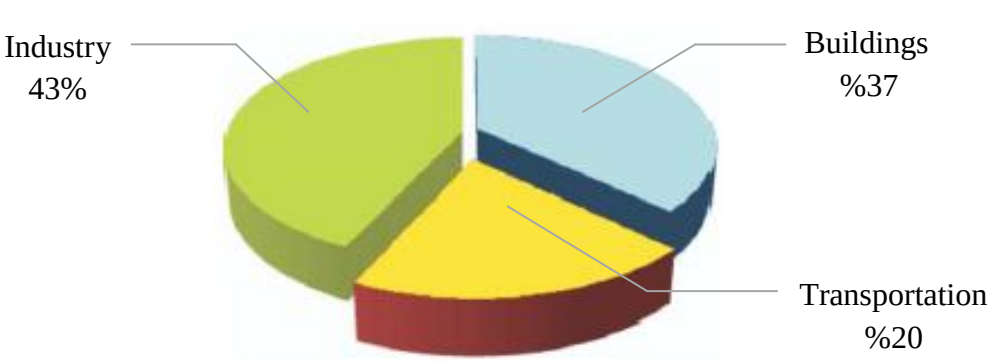


Figure 1.1:The share of the buildings energy usage in Turkey[2]

This ratio is important and cannot be underestimated. As every sector in the construction industry urgently needs to save energy, reducing this ratio should be considered.

Certainly, this situation affects Turkey negatively. With this awareness, the adoption of renewable energy sources and providing energy efficient design concepts for economic, social and environmental areas is very important [5].

For these reasons, regarding energy efficiency in Turkey, the Energy Efficiency Law was adopted during the country's accession into the European Union (EU), in 2007 [6].

Also, a wide range guide called "Energy Performance of Buildings Regulations" was put in place in 2009 to improve the energy efficiency of buildings [7]. In the near future, Turkey is expected to join the Kyoto Protocol. To fulfill the terms of the Protocol, Turkey should considerreducing its carbon content and usingrenewable energy sources [8].

Actually, Turkey is a great country in terms of renewable energy resources. For example; Turkey's solar energy potential is equivalent to the sum of the potential of all European countries [9]. According to a study conducted by the EIE, the average annual sunshine duration is 2640 hours, and the average annual solar radiation is 1311 kWh/m²-year [10]. In light of this information, Turkey has the advantage of using solar energy to power buildings. This energy can also be used (in both passive and active systems) for the residence-housing sector. Some examples of its use include a solar water heating system, a solar heating system, and a photovoltaic panel system. Another potential renewable source for buildings is geothermal energy. Turkey ranks seventh in the world in terms of its geothermal energy capacity. According to this statistic, 30% of

the heating needs of houses can be afforded from this energy. Wind, hydrogen, and biomass energy can also be used as other optionsin areas where there is an energy demand. [11]. Figure 1.2, which describes the electricity situation in Turkey, shows that the total electricity production was 194.357.244 mWh in 2015.

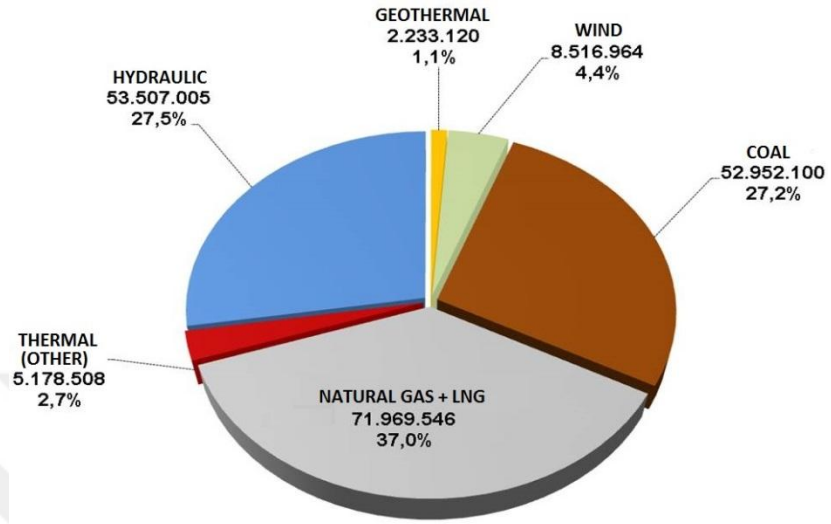


Figure 1.2: Electricity production in Turkey (mWh) TEIAS, 2015 [12]

Although Turkey has great renewable sources,its populace needs to be aware of this deplorable situation. If the country were to use these sources effectively in all sectors, it could become one of the leading countries in terms of efficient energy usage.

1.1 Literature Review

Throughout Turkey (and the world), many studies similar to this one have been carried out. Below are some examples of studies related to making changes in buildings according to different standards and window issues regarding energy efficiency.

"A case study of evaluation of energy efficient development of a primary school indifferent climatic zones[1]" (2009),studied by Yılmaz [13], for a primary school energy efficient improvements were suggested in different climatic zones of Turkey.The selected provinces in different climatic zones are Istanbul, Ankara, Antalya, Erzurum and Diyarbakır. First, climates were analyzed according to regions, and energy efficient forms and orientation, as well as building envelope and energy efficient placement, were sought.Then, the primary school was introduced through plans and sections.

[1] Org. name of the thesis in Turkish language is "Farklı İklim Bölgelerinde Bir İlköğretim Tip Projesinin Enerji Etkin Geliştirilmesine Yönelik Uygulama Örneği".

For the application, the building was modeled using the DesignBuilder program.Creating alternatives by using different materials and orientations, a comparison of energy costs was made. While calculating energy costs, on/off days of school were considered. For five provinces and eight directions, heating, cooling, and lighting energy loads were calculated separately. The TS 825 Turkish Standard was considered and, with changes in material selection, the optimum condition in terms of energy load was sought. According to results, for Erzurum and Ankara, which are located at a cold climatic zone in Turkey, there was no need to use sun shading elements; whereas, for Antalya, using these elements could potentially save energy by 532 kWh per year. Also, region-specific structural materials, such as basalt and camber stone, which are generally used in Erzurum and Diyarbakır, are better than vertically perforated brick.Compared to brick, stone provides better insulation. It is also better in terms of energy cost. By using region-specific structural materials, it is possible to save energy by 120 kWh in Diyarbakır and by 2880 kWh in Erzurum per year. For these three provinces(Erzurum, Istanbul and Antalya), 4 cm insulation is suitable for walls at north facades.By doing this, the energy consumption for Istanbul decreases, with a value of 16596 kWh. For Diyarbakır, energy saving becomes 1260 kWh, and for Erzurum, it becomes 11323 kWh [13].

The study “Evaluation on energy and thermal performance for residential envelopes in hot summer and cold winter zone of China” (2009) by Yu et al. [14],used the Equest program in the scope of the EETP parameter based on JGJ134-2001 to make energy and thermal performance calculations of standard residential buildings for four provinces in China (located at both hot and cold climates):Shanghai, Changsha, Shaoguan, and Chengdu. With the help of these results, the main aims of the study are designing sustainable houses with low energy and helping the Chinese government for energy saving issues[14].

“Calculation of cooling energy load of non- residential buildings with usingtransfer function method[1]” studied by Eskin and Türkmen [15] uses different energy load calculation methods and programs to make and compare the energy load calculations of office buildings.

[1]Org. name of the study in Turkish language is “Konut Dışı Binaların Soğutma Yüklerinin Transfer Fonksiyonu Yöntemi ile Hesaplanması”.

During calculation, the main parameters climatic condition, insulation, heating capacity, color, shadow, ventilation ratio, and control strategies were taken into consideration. Also, the study focused on the effects of the transparency ratio; window types were considered firstly. For four provinces in Turkey (Antalya, Izmir, Istanbul, and Ankara), different energy load calculation methods were used to ensure accurate results and calculate the heating, cooling, and lighting energy loads [15].

According to the study "Analysis and modeling of window and glazing systems energy performance for a well insulated residential building"(2010),by Gasparella et al.[16],uses simulation progam TRN-SYS software and its multi-zone building simulation subroutine called Type 56, to calculate energy performance of one residential building.. For calculation, different kinds of glazing systems (two double and two triple glazings),and window size (from 16% to 41% of window-ground area ratio) were used. As a climatic data, Europe was considered: Paris, Milan, Nice and Rome. Internal gains on winter and summer energy need and peak loads were calculated. They started with simple building envelope. With the help of simulation program the building was transformed to a well-insulated building. After selection of orientation and other futures simulation was done. According to research results, the use of large glazings enhances winter performance but worsens the peak of winter loads, use of windows with low transmittance in winter is useful but higher solar transmittance worsens summer performance. Window surface appears to be of minor importance for winter energy needs [16].

Similar study about calculation of buildings in energy performance of buildings "Energy efficient buildings designusing sensitivity analysis" (2006), by Tavares and Martins [17], in Portugal by VisualDOETM simulation tool, tried to approach large, comfortable and energy efficient office building. By making changes those parameters HVAC system, glazing of window types, building envelopes (materials) etc., various alternatives were created. One of the important result of this study is that triple glazing window types do not improve energy performance so much in winter time as they do in summer [17].Considering the energy retrofit and the conversation measures implemanttion for a large commercial building in Saskatoon, Canada similar conclusions came Carriere et al. [18].

In their study called “Thermal performance optimization of building aspect ratio andsouth window size in five cities having different climatic characteristics of Turkey” (1998),Inanici and Demirbilek [19]considered the optimum building aspect ratios and south window sizes of residential buildings from the thermal performance point of view. In this study, the effects of six different building aspect ratios and eight different south window sizes for each building aspect ratio were analyzed for apartments, which were located at the intermediate floors of buildings. Using the SUNCODE-PC thermal analysis program, this calculation was done in five cities in Turkey, including Erzurum, Ankara, Diyarbakir, Izmir, and Antalya. The aim was to calculate the annual energy consumption and explore the optimum values. Comparisons of optimum values and total energy consumption rates were made among the analyzed cities. The results of the study on the building aspect ratio (B.A.R.) have shown that maximum elongation on the east-west axis (1:2) is preferable in hot climates (Diyarbakir, Izmir, and Antalya). For cold climates, buildings with a compact form and a B.A.R. of 1:1.2 are the optimum case. Deciding on the south window size (S.W.S.) of residential buildings depends on the effect of windows on heat gain and loss values. A building that has a conventional S.W.S. (25%) is preferable in hot climates (Diyarbakir, Izmir, Antalya) because of the need to decrease heat gain in the summer. In cold climates, a larger S.W.S. (up to a certain size) is preferred due to the need to increase heat gain in the winters [19]. In terms of used methods, topic, usage of a simulation program to calculate heating and cooling energy loads,analyzing effects of changed south window sizes on energy loads of building in different provinces, this literature survey is similar with this thesis study. For this study at the end it is aimed to find optimum B.A.R. for buildings. If we mentioned some highlighted results of this reseacrh (Inanici and Demirbilek, 1998), for cold climatic region, by 25% S.W.S., optimum B.A.R.for Erzurum is 1:1.2, for Ankara 1:1.2, for Diyarbakır 1:1.2, for Izmir 1:2 B.A.R., for Antalya 1:2. On the other hand, optimum S.W.S. values are for provinces in all B.A.R. 90% for Erzurum, 90% for Ankara, 25% for Diyarbakır, 25% for Izmir and 25% for Antalya. It is obviously seen that for hot climates, S.W.S. value should be less than cold climates. If doing so, energy consumption of building for heating and cooling energyreach optimum condition. Deciding on the S.W.S. of residential buildings depends on the effect of window on heat gain and loss values [19].

Comparing with this thesis study and study above, some similarities were appeared in terms of research topics and results were seen. For instance, in this thesis study, it is also observed that effects of surface windowheat gain /heat loss situation of a created block (giving a house function) within the different scenarios based on four different transparency ratios and three different window types on energy loads.While these used transparency ratios respectively are 20%, 30%, 40% and 50%, used window types are single, double and coated double glazing window types. With Design Builder simulation program for these selected provinces of Turkey; Antalya, Erzurum and Istanbul, heating, cooling and total energy loads(heating + cooling) of blocks were observed. Some results came up with this thesis study,it is found that with increased transparency ratios at south sides (with maximum 50%) cause huge amount of heat gains, so cooling load values increase too for especially blocks with single glazing in Antalya (hot climate). Although usage of double and coated double glazing at blocks suppliesa small amount of energy efficiency for cooling load, it is still very less. For that reason, transparency ratio at south side of blocks in Antalya should be minimizing. On the other hand, for Erzurum (cold climate), although blocks oriented toward the north with coated double glazing provide more energy efficiency at all energy loads, because of huge amount of heat losses from north facades,it is found that while 50%transparency ratio is not good, 20% transparency ratio is much better. As much as possibleto minimize window/wall area ratio at north side of blocks is good for energy efficiency especially in Erzurum. Besides, transparency ratios at south facades should be increased at block oriented toward the north to benefit solar heat gains to decrease demand for heating energy.

The study is called “Energy-efficient window systems” by Below-Hübe (2000) isa detailedinvestigationof energy efficient window systems [20].In this thesis, energy efficient windows of residential and office buildings in Sweden were studied. The Derob-LTH simulation program was used to measure the indoor climate and energy values of terraced houses for two years. This thesis was studied in two ways. First, using a super-insulated glass daylight transition room, view perceptions were observed. Second, as it was carried out in a full range laboratory with a natural climate using shading tools, the satisfaction of daylight was observed. With help from new technology, the development, types, and psychological and physiological effects of windows were discussed.For a single family, a house was designed: the window-ground

ratio was kept at 15%, windows were insulated and U values of them were determined to be less than 1.0 W/m^2K which is below Sweden's average standard. The study also explained that, according to 1960's, insulated window types of houses can be 1.6 W/m^2K.In part of "Cost efficiency of window replacement", according to 1960s and 2000s, for a house which is supposed at three different regions of Sweden (Lund, Stockholm and Luleå) to show ways of energy saving, use better types of windows, and replace old windows. Also, for one person's office room, the window ratio was gradually changed from 10% to 50%, and the heating and cooling energy loads were calculated at both south and north facades for five different window-wall ratios. In general, this study tried to explore which type of window is best. As a result, the best type of window changes according to the situation. Windows with the lowest U values are not the best, and for Sweden, there is a big difference between the best values of north and south windows. These values depend on different factors, such as the insulation of the house or orientation of the windows. According to other results, to increase the building's energy efficiency, the U values of windows need to drop.Swedish house with further north, need to have low U values of windows compared to southern ones. With using energy efficient windows, thermal comfort has increased. However, at super insulated houses and high glass office buildings overheating problems were occurred. For this reason, with very low U (heat transmission coefficient) and g values (window solar factor) were needed. If there is no need high energy efficiency, it revealed that using coated glass is enough [20].

This study, by using simulation program Derob-LTH, researched that effects of different window types with based on different transparecny ratios on energy load situations of houses and office buildings for different regions of Sweeden.According to highlighted results,at super insulated houses and high glass office buildings overheating problems were occurred. For that reason there is a need to use with very low U window types, that is coated glass. In this thesis study, for created scenario blocks, one of the selection was using coated double glazing window types for created scenario blocks and observed its effects on energy loads; heating, cooling and total (heating + cooling). The similar result came up with this thesis study, that is, usage of coated double glazing window type provides energy efficiency with decreasing heating or cooling loads both blocks oriented toward the south and north. These window types decrease amount of heat gains and heat losses throughout the windows too.Shortly, they are the best for

energy efficiency. Other similar result with this thesis study, during the cooling season, glazing size and solar energy transmittance are important parameters, while heating season glazing size and U value of windows are important [20].Although for this thesis study energy loads were calculated as annual, nevertheless, this result is valid.

1.2 Objective of This Thesis

When the general structure of the buildings is examined, it is seen that most part of energy is lost from openings. When energy efficiency design criteria, such as window to wall area ratio, orientation, and the heat transmittance coefficient of building materials, are not taken into account, it causes a huge increase in energy costs. Therefore, controlling the amount of energy consumed by buildings is very important. Also, ratios of energy loss for parts of buildings are different. Regarding the heating loss of a structure, 25% is from the roof, 35% is from the outside wall, 15% is from the floor, and 25% is from both doors and windows (namely, openings). In this study, observing the heat energy gains and losses for openings is the main subjectand scope of this study regarding with changed transparency ratios. With using DesignBuilder program and its interface simulation tool EnergyPlus, one square form building was designed as a house, and four different alternatives, which have different transparency ratios, were created [21]. (Appendix A)These alternatives generate scenarios and were studied for chosen provinces belonging to the different climatic zones of Turkey.

The main aims of this study are as follows:

- Understanding which transparency ratio (in other words, window to wall area ratio) is optimum or best for selected provinces in determined climatic zones in terms of energy efficiency;
- Understanding how increasing transparency ratio of south and north facades affects heating, cooling and total energy load(heating +cooling) values of thehouse (heating not include energy consuming for domestichot water);
- Understanding the how heat gain/loss from the openingsaffects energy load values (heating and cooling loads) of the house;
- Understanding how changing the window type affects the energy load situation of the house;

- Understanding which orientation is the best for modeled structures in terms of energy saving and how orientation affects changes in energy loads; and
- Understandingweather changing transparency ratio or window types is more effective on changes in heating, cooling and total energy loads of the structure.

1.3 Hypothesis

When the general structure of this thesis is thought, there are two main parameters; usage of different glazing types and different transparency ratios. The main aims of the thesis as mentioned before, observing effects of those parameters on building energy performance. At the process of energy performance calculation of these scenario blocks with DB, research question in other words hypothesis automatically came out:

“Change of transparency ratio of south and north sides of structure effects building energy performance more than change of glazing types of windows.”

Beside this hypothesis, as a sub research topic;“Transparency ratio increase at bothsouth and north facade of structures is proportional to energy load increase” tried to be researched.

CHAPTER 2

THE CASE STUDY

As mention before for this thesis study; with usingDesignbuilder and EnergyPlus software programs, one square form structure called block was designed and given a house function in six different scenarios. They called A1, A2, B1, B2, C1 and C2. Each of them has four different altered transparency ratios in themselves.There are two different parameters. The first is changing transparency ratios between the blocks of scenarios at south and north facades, and second used different glazing and window types between scenarios. While single glazing type of window was selected for blocks of A Scenarios, for B blocks double glazing window type and for C blocks coated double glazing window type has preferred.

This work mainly evaluates effects of changing transparency ratios accordingly both south and north sides of structures on building energy performance and besides carrying out effects of changing glazing and window types. Moreover, it is also aimed that with calculating energy saving rates of scenario blocks, evaluate to energy efficient condition.

2.1 Method

For this study, first of all, a pilot province was determined in various climate zones of Turkey and modeled with using DesignBuilder software program. Secondly,after orientation decision of buildings; parameters related to heating, cooling, ventilation, condensation and building envelope materials have been selected considering based on Turkish Standards TS 825 [7]. Thirdly, same system selection was done for each province. Lastly, energy loads of buildings in each selected province are calculated via EnergyPlus simulation tool.When modeling buildings, the interior climate comfort data set in accordance with UK NCM [22] and it has been adapted to Turkey based on

temperature threshold [23] byTurkish Chamber of Mechanical Engineering Association TMMOB [24]. For selected provinces which are Antalya, Erzurum and Istanbul, external climate data are taken from ASHRAE/IWEC which belongs to year 2002 [25] (Appendix B).

2.1.1 Determination of the Climate Types

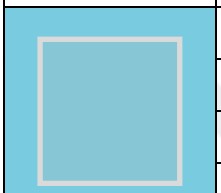
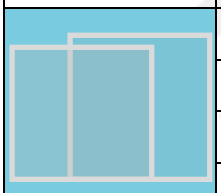
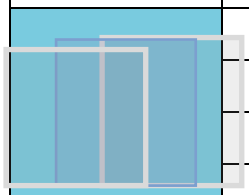
Turkey is located between subtropical zone and temperate zone and have four climate occurs; Mediterranean climate, Continental climate, Marmara (transition) climate, Black Sea climate [26]. This study is done in three climate zones.Selected pilot provinces are Antalya for Mediterranean climate, Erzurum for Continental climate, and Istanbul for Marmara climate. For the selection of these provinces and climate types their unique charecteristics have great importance.Continental climate has high temperature difference between summer and winter, rainfall usually occurs in the winter and spring, and summer is dominated by drought.Briefly if we are going to talk about these climates; Mediterranean climate is effective in a large part of the Aegean region, in the western part of Central Anatolia, and the segments of the Taurus mountains facing south in the Mediterranean region.Summers are hot and dry, winters are mild and rainy. Snow and frost are very rare at coast line. Continental climate has high temperature difference between summer and winter, rainfall usually occurs in the winter and spring, and summer is dominated by drought. Marmara climate; is seen from northern Aegean to the southern part of Marmara region. Winters are not warm as Mediterranean climate; summers are not as rainy as Black Sea climate. Winters are not cold and summers are not too dry as continental climate. Due to these characteristics, Marmara climate shows transition between Continental, Black Sea, and Mediterranean climates [27].

2.1.2General Description of the Modeled Blocks and Scenarios

One square form block was designed as a single zone and given a house function in different scenarios. 100 $m^2$and 3 meters height each block was studied separately. Scenarios are presented in Table 2.1. As seen Table 2.1, each scenario has divided in two groups. Each group has four subgroups according to changing transparent ratio at south and north sides of structures. Based on the results of previous research, in terms of utilizing daylight transparency ratio kept minimum 20% and with 10% of the range step it is gradually changed up to 50%.Transparency ratios of all facades of this four square

blocks are as follow: 20% at north, 30% at east, 20% at west to be constant, and at south facade gradually changed as 20%, 30%, 40% and 50% for A1, B1 and C1 scenarios. For A2, B2 and C2 scenarios all other transparency ratio kept same with A1, B1 and C1 scenarios except for north facades, it changes as 20%, 30%, 40% and 50% gradually. Within scenarios, blocks with increasing window/wall area ratios on the south side are called A1, B1 and C1 and on the north side are called A2, B2 and C2 scenario blocks. Their names are given below.

Table 2.1: The transparency ratios of thescenario blocks

Single Glazing	**A1 Scenario Blocks**	Transparency Ratio *(South)*	**A2 Scenario Blocks**	Transparency Ratio *(North)*
	Block 1	S20%	Block 1	N20%
	Block 2	S30%	Block 2	N30%
	Block 3	S40%	Block 3	N40%
	Block 4	S50%	Block 4	N50%
Double Glazing	**B1 Scenario Blocks**	Transparency Ratio *(South)*	**B2 Scenario Blocks**	Transparency Ratio *(North)*
	Block 1	S20%	Block 1	N20%
	Block 2	S30%	Block 2	N30%
	Block 3	S40%	Block 3	N40%
	Block 4	S50%	Block 4	N50%
C. Double Glazing	**C1 Scenario Blocks**	Transparency Ratio *(South)*	**C2 Scenario Blocks**	Transparency Ratio *(North)*
	Block 1	S20%	Block 1	N20%
	Block 2	S30%	Block 2	N30%
	Block 3	S40%	Block 3	N40%
	Block 4	S50%	Block 4	N50%

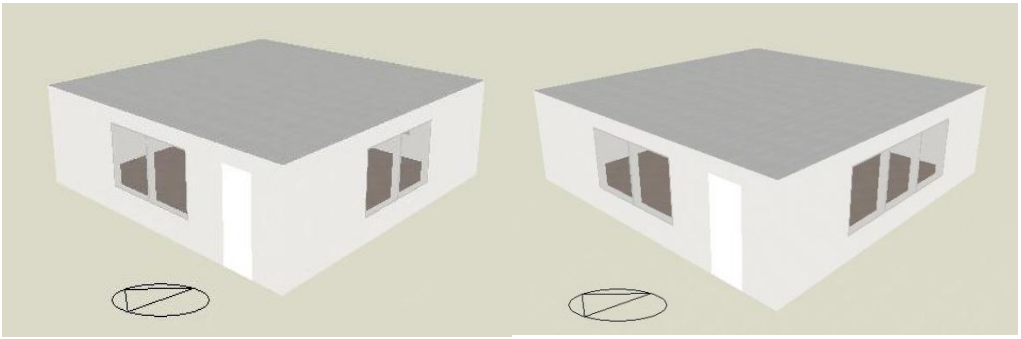
A1 Block 1 - B1 Block 1 - C1 Block 1 [(A1.1.S20%) - (B1.1.S20%) - (C1.1.S20%)]
A1 Block 2 - B1 Block 2 - C1 Block 2 [(A1.2.S30%) - (B1.2.S30%) - (C1.2.S30%)]
A1 Block 3 - B1 Block 3 - C1 Block 3 [(A1.3.S40%) - (B1.3.S40%) - (C1.3.S40%)]
A1 Block 4 - B1 Block 4 - C1 Block 4 [(A1.4.S50%) - (B1.4.S50%) - (C1.4.S50%)]

A2 Block 1 - B2 Block1 - C2 Block 1 [(A2.1.N20%) - (B2.1.N20%) - (C2.1.N20%)]
A2 Block 2 - B2 Block 2 - C2 Block 2 [(A2.2.N30%) - (B2.2.N30%) - (C2.2.N30%)]
A2 Block 3 - B2 Block 3 - C2 Block 3 [(A2.3.N40%) - (B2.3.N40%) - (C2.3.N40%)]
A2 Block 4 - B2 Block 4 - C2 Block 4 [(A2.4.N50%) - (B2.4.N50%) - (C2.4.N50%)]

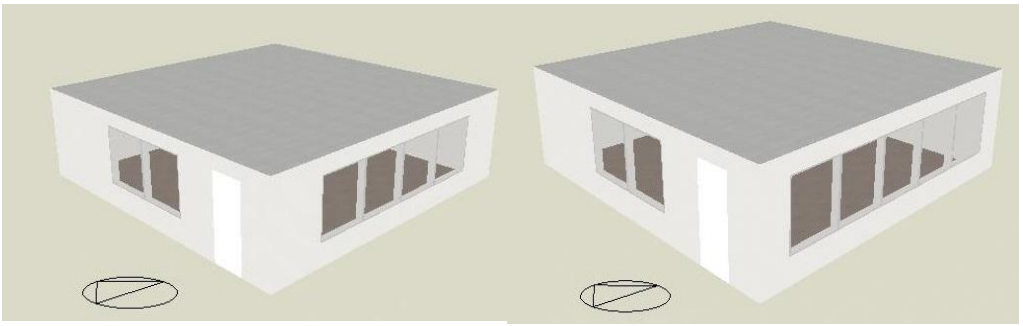
2.1.3Determination of the Orientation of Scenario Blocks

Orientation selection for scenario blocks was determined according to considering this information: For northern hemisphere, the winter sun is horizontal and the summer sun is steep. For this reason, more solar heat can be taken in winter time from faces at south. In summer time, south faces are easily protected from solar energy. Therefore, in architecture south facades of buildings are emerging as the most valuable facades [28]. Considering this information and location of Turkey on the earth, north facades are the worst for buildings in terms of heat gains and heat losses. For this study created scenario blocks oriented toward the both south and north, and transparency ratios of them gradually were increased. In doing so, it is aimed that observing effects of increased transparency ratios on energy loads as heating, cooling and total energy loads (heating + cooling) for both the blocks oriented toward the south and the north.

In the below, with given perspective views of A1, B1 and C1 scenario blocks orientation is explained. The only difference with A2, B2 and C2 scenario blocks is being gradually changed transparency ratios at south facades. (Table 2.1) Door of blocks is located at west side for all scenarios. Ratios were gradually changed as 20%, 30%, 40% and 50%.



S20% BlocksS30% Blocks



S40% Blocks S50% Blocks

Figure 2.1 Orientations of the A1, B1 and C1 scenario blocks

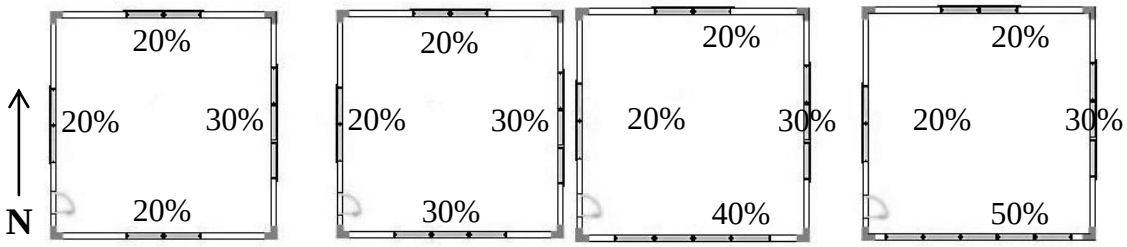


Figure 2.2 A1, B1 and C1 scenario blocks

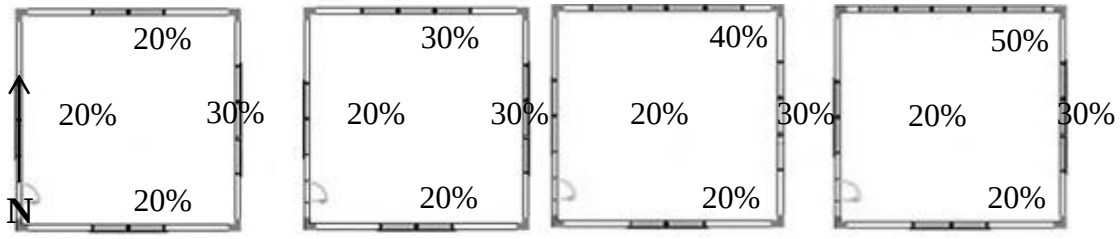


Figure 2.3A2, B2 and C2 scenario blocks

In the below, A1, B1 and C1 scenario blocks were given which have changed transparency ratios at south sides. A2, B2 and C2 scenario blocks' changed transparency ratios at north direction.

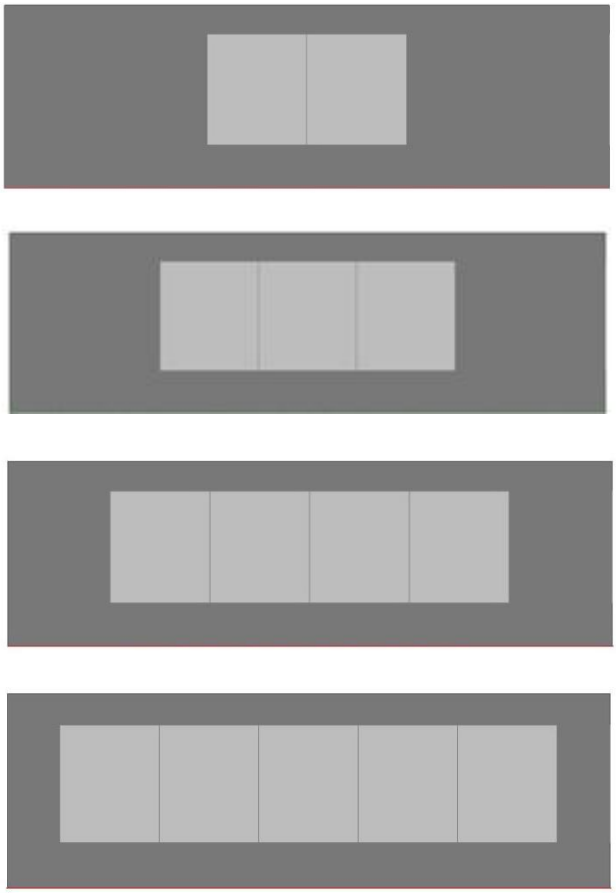


Figure 2.4 Changed transparency ratios of the scenario blocks

2.1.4 Properties of the Structural Elements and Selection of Materials

According to TS 825 standard, in Turkey there are four different degree-days regions. These are Antalya is from region 1, Istanbul is from region 2, Ankara is from region 3 and lastly Erzurum is from region 4 [21].For this study scope, Antalya, Istanbul and Erzurum were studied. Material selection was done mainly with reference to this standard. Referenced U values of building envelope sections are as a result of geographical locations of these provinces. Used both materials and thermal insulation materials were selected from DesignBuilder program. Their characteristics are given at Tables 2.2, 2.3 and 2.4.

Table 2.2Determined U values of components of the structures forthe selected provinces in degree-days regions of Turkey [21]

	U_W(W/m^{2}K)	U_C(W/m^{2}K)	U_G(W/m^{2}K)	U_w(W/m^{2}K)
1.Region(Antalya)	0,70	0,45	0,70	2,4
2.Region(Istanbul)	0,60	0,40	0,60	2,4
3.Region(Ankara)	0,50	0,30	0,45	2,4
4.Region(Erzurum)	0,40	0,25	0,40	2,4

Table 2.3 Properties ofthe selected materials for transparent componentswith DB

	Light Transmittance W/m/ºC	**Direct Solar Radiation Transmittance (τ)**	**Total Solar Radiation Transmittance(τ)**	**U value W/m^{2}k**
Single clear glazing window Pane type: 4mm generic clear glass	0,892	0,816	0,847	5,871
Double glazing window (16mm air) 2 layers Pane type: 4 mm generic clear glass	0,801	0,670	0,742	2,73
Coated double glazing window (16mm argon) 2 layers Outermostpane type: 4mm generic low-e glass Innermost pane type: 4mm generic clear glass	0,761	0,509	0,587	1,303

Table 2.4Properties ofthe selected materials for opaque components with DB

MATERIALS	Thermal Conductivity Value W/mK	Specific heat J/kgK	Density Kg/m^3
Brick (Aerated)	0,300	840	1000
Concrete-Reinforced (with 1 %Steel)	2,300	1000	2300
Concrete (High density)	2,0000	1000	2400
Etylene Propylene Diene Monomer (EPDM)	0,2500	1000	1150
Underlay, Cellular Rubber or Plastic	0,1000	1400	270
Cement/Plaster/Mortar-Cement Screed	1,4000	650	2100
Timber Flooring	0,1400	1200	650
Plaster (Dense)	0,5000	1000	1300
Plaster (Lightwieght)	0,1600	1000	600
XPS Extruded Polystyrene-CO2 Blowing	0,0340	1400	35
Wooden Floor	0,1400	1200	650
Painted Oak	0,1900	2390	700
0.1 in. Depth Wood framing R-3.8 Insulation, Expanded polystyrene, Molded Bleads	0,0355	1470	10
Polyvinlychloride(PVC)	0,1700	900	1390

- Used painted door and its frame are both wooden with EPS insulated. Door is considered as an opaque component because of its low U value.
- Used frames for windows are PVC.
- For insulation, materials with low thermal conductivity value tried to be used.
- Windows were created as a modular. For 20% windows/wall area ratio two pieces, for 30% three pieces, for 40% four pieces and for 50% five pieces glasses were used.
- Dimension of each pieces are 1.65m -1.82m as length and width.

Table 2.5The selectedmaterials for building envelope of the structureswith DB

Antalya	**U_W=0,70 W/m^{2}K wall**	**U_G=0,70W/m^{2}K ground**	**U_C=0,45 W/m^{2}K ceiling**
	4 layers **Outermost layer:** Plaster(dense)0,02m **Layer 2**: XPS Extruded Polystrene-CO2 Blowing 0,0178m **Layer 3**:Brick aerated 0,19m **Innerrmost layer:**Plaster (lightweight) 0,01m	**8 layers** **Outermost layer:** Soil-earth,gravel based 0,1m **Layer 2:** Concrete (high density) 0,1m **Layer 3:** Ethylene propylene diene monomer (EPDM) 0,001m **Layer 4:** XPS Extruded Polystyrene- CO2 Blowing 0,0167m **Layer 5:** Vapor, seal, 2 layers of mopped 0.73 kg/m^2 felt 0,002m **Layer 6:** Cement/plaster/ Mortar-cement screed 0,05m **Layer 7:** Underlay, cellular rubber or plastic 0,002m **Innermost layer:**Timber flooring0,03m	**7 layers** **Outermost layer:** Roofing - asphalt shingles 0,005m **Layer 2:** Ethylene propylene diene monomer (EPDM) 0,003m **Layer 3:** XPS Extruded Polystrene-CO2 Blowing 0,0558m **Layer 4:** Vapor, seal, 2 layers of mopped 0.73 kg/m^2 felt 0,002m **Layer 5:** Cement/plaster/ Mortar-cement screed 0,05m **Layer 6:** Concrete, reinforced with 1% steel0,1m **Innermost layer:** Plaster (lightweight) 0,01m
Erzurum	**U_W=0,40 W/m^{2}K wall**	**U_G=0,40W/m^{2}K ground**	**U_C=0,25 W/m^{2}Kceiling**
	4 layers **Outermost layer:** Plaster (dense) 0,02m **Layer 2**: XPS Extruded Polystrene-CO2 Blowing 0,0542m **Layer 3**: Brick aerated 0,19m **Innerrmost layer:**Plaster (lightweight) 0,01m	**8 layers** **Outermost layer:** Soil-earth,gravel based 0,1m **Layer 2:** Concrete (high density) 0,1m **Layer 3:** Ethylene propylene diene monomer (EPDM) 0,001m **Layer 4:** XPS Extruded Polystyrene- CO2 Blowing 0,0532m **Layer 5:** Vapor, seal, 2 layers of mopped 0.73 kg/m^2 felt 0,002m **Layer 6:** Cement/plaster/ Mortar-cement screed 0,05m **Layer 7:** Underlay, cellular rubber or plastic 0,002m **Innermost layer:** Timber flooring 0,03m	**7 layers** **Outermost layer:** Roofing - asphalt shingles 0,005m **Layer 2:** Ethylene propylene diene monomer (EPDM) 0,003m **Layer 3:** XPS Extruded Polystrene-CO2 Blowing 0,1162m **Layer 4:** Vapor, seal, 2 layers of mopped 0.73 kg/m^2 felt 0,002m **Layer 5:** Cement/plaster/ Mortar-cement screed 0,05m **Layer 6:** Concrete, reinforced with 1% steel 0,1m **Innermost layer:** Plaster (lightweight) 0,01m

Table 2.5The selected materials for building envelope of the structures with DB (cont'd)

Istanbul	U_W=0,60 W/m^{2}K wall	U_G=0,60W/m^{2}K ground	U_C=0,40 W/m^{2}K ceiling
	4 layers **Outermost layer:** Plaster (dense) 0,02m **Layer 2**: XPS Extruded Polystrene-CO2 Blowing 0,0259m **Layer 3**: Brick aerated 0,19m **Innerrmost layer:**Plaster (lightweight) 0,01m	**8 layers** **Outermost layer:** Soil-earth,gravel based 0,1m **Layer 2:** Concrete (high density) 0,1m **Layer 3:** Ethylene propylene diene monomer (EPDM) 0,001m **Layer 4:** XPS Extruded Polystyrene- CO2 Blowing 0,0248m **Layer 5:** Vapor, seal, 2 layers of mopped 0.73 kg/m^2 felt 0,002m **Layer 6:** Cement/plaster/ Mortar-cement screed 0,05m **Layer 7:** Underlay, cellular rubber or plastic 0,002m **Innermost layer:** Timber flooring 0,03m	**7 layers** **Outermost layer:** Roofing - asphalt shingles 0,005m **Layer 2:** Ethylene propylene diene monomer (EPDM) 0,003m **Layer 3:** XPS Extruded Polystrene-CO2 Blowing 0,0652m **Layer 4:** Vapor, seal, 2 layers of mopped 0.73 kg/m^2 felt 0,002m **Layer 5:** Cement/plaster/ Mortar-cement screed 0,05m **Layer 6:** Concrete, reinforced with 1% steel 0,1m **Innermost layer:** Plaster (lightweight) 0,01m

According to Turkish Standards TS 825 determined U values of components of structures are different each other for each province. It is based on degree-days regions of Turkey. (Table 2.1) Although same structural elements were used for each province, thicknesses of these elements and insulation materials are different to supply determined threshold value.

2.1.5The System Selection

The main purpose of this study is to observe the changes in the energy by changing the window/wall area ratios and keeping the materials and systems in modeled structure constant. For this aim, after all materials selection, system selection was done with DB program according to Tables2.6 and 2.7. Because of the possibility of interaction between buildings and shadowing effects of buildings, each block in the scenario is evaluated separately in their own building envelope. After system selection simulation was done.

Table 2.6 Mutual system selections for structures with DB (Activity) [24]

Activity Level:	Residential Space
Density:	0,04 people/ m^2(24 hours usage)
Metabolic Activity:	Sitting/Standing
Type of Activity:	Various Works/Eating/Drinking
Clothing:	Winter 1,00 clo, Summer 0,50 clo
Usage of Domestic Hot Water (DHW):	0,72 l/m^2-daily
Environmental Control:	
Heating Setpoint Temperatures:	Heating 20°C, Set Back 12°C
Cooling Setpoint Temperatures:	Cooling 26°C, Set Back 28°C
Minimum Fresh Air Requirement:	10 l/s-Person
Lighting:	
Target Illuminance:	300 lux
Internal Gain:	6 W/m^2Miscellaneous (On at 12.00 pm - off at 11.00 pm)

Table 2.7: Mutual system selections for structures with DB (HVAC Paremeters) [24]

HVAC Template:	Fan-Coil Unit (FCU) – 4 Pipe Air Cooled Chiller
Mechanical Ventilation:	Off
Heating:	On
Fuel/ Heating System Seasonal CoP:	Natural gas/ 0,8
Supply Air Condition:	
Maximum Supply Air Condition Temperature:	35°C
MaximumSupply Air Humidity Ratio:	0,0156 g/g
Heating Limit Type:	Limit Capacity
Operation:	On at 6 am - off at 11 pm (7 days-winter only)
Cooling:	On
Fuel/ Cooling System Seasonal CoP:	Electricity From Grid/ 1,670
Supply Air Condition:	
Maximum Supply Air Condition Temperature	12°C
Maximum Supply Air Humidity Ratio	0,0077 g/g
Operation:	On at 6 am - off at 11 pm (7 days-summer only)
Domestic Hot Water Usage:	On
Type/ fuel/ DHW CoP:	Instantaneous Combi/ Natural Gas/ 0,85
Water Temperatures:	
Delivery Temperatures/ Mains Supply Temperatures	55/ 10°C
Operation:	24 hours/ 7days
Natural Ventilation:	On - By zone
Outside Air/ Air Temperature Distrubition:	1,5 ac/h/ Mixed
Outdoor Minimum /Maximum Temperature Control:	-100/ 100°C
Operation:	24 hours / 7 days

2.2 Energy Load and Surface Window Heat Gain/Heat Loss Energy Calculationof the Scenario Blocks

Openings in the structures have major importance in terms of heat gain and heat loss. Although a substantial amount of heat is lost through the windows, there is also heat gain from the windows. Considering this information in this part, for created each scenario blocks, heat gain and heat loss situation of most windowed surface areas for both south and north sides were calculated.

In first stage, annual heating, cooling and total energy load (heating + cooling) values of A1, B1, C1 and A2, B2, C2 scenario blocks were calculated separately for selected provinces. They were given below in Tables 2.8, 2.10 and 2.12.

Second, surface window heat gain and heat loss energy situation was observed and result tables were formed for scenario blocks.

Lastly, according to results, their energy loads comparison within the same province separately was done. Comparison partially was mentioned in this part, and in detail results part with their graphic displays. In doing so, aimed that easily perceive effects of used different window types together with changed transparency ratios on building energy performance.

As mentioned before, there are two different parameters for this thesis study. Beside used of changed transparency ratios on both south and north facades of scenario blocks, used of three different glazing window types (single, double and coated double glazing) for blocks is other parameter. Data given below are results of this parameter and it is seen that directly affects results of energy load situation of scenario blocks. These detail statistics given below are supportive and necessary for research results. (Tables 2.8, 2.10, 2.12)

- **Antalya Province**

Table: 2.8 Annual energy load values for Antalya province (kWh/m^2)

Single Glazing	**A1 Block 1**	**A1 Block 2**	**A1 Block 3**	**A1 Block 4**	**A2 Block 1**	**A2 Block 2**	**A2 Block 3**	**A2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	11,06	9,72	8,78	8,16	11,06	11,84	12,61	13,38
Cooling	75,19	80,42	85,68	90,92	75,19	77,99	80,77	83,50
TOTAL	86,25	90,14	94,46	99,08	86,25	89,83	93,38	96,88
Double Glazing	**B1 Block 1**	**B1 Block 2**	**B1 Block 3**	**B1 Block 4**	**B2 Block 1**	**B2 Block 2**	**B2 Block 3**	**B2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	6,92	5,55	4,59	3,94	6,92	7,06	7,21	7,35
Cooling	69,29	74,13	78,99	83,87	69,29	72,16	74,97	77,78
TOTAL	76,21	79,68	83,85	87,81	76,21	79,22	82,18	85,13
C. Double Glazing	**C1 Block 1**	**C1 Block 2**	**C1 Block 3**	**C1 Block 4**	**C2 Block 1**	**C2 Block 2**	**C2 Block 3**	**C2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	5,96	4,58	3,59	2,87	5,96	5,77	5,62	5,48
Cooling	59,83	63,82	67,81	71,87	59,83	62,28	64,77	67,25
TOTAL	65,79	68,40	71,40	74,74	65,79	68,05	70,39	72,73

Table 2.9Surface window heat gain/heat loss energy values of scenario blocks for Antalyaprovince (kWh/m^2)

ANTALYA	**A1 Scenario Blocks (Single Glazing)**		**B1 Scenario Blocks (Double Glazing)**		**C1 Scenario Blocks (C. Double Glazing)**	
South Windows	Heat Gain kWh/m^2	Heat Loss kWh/m^2	Heat Gain kWh/m^2	Heat Loss kWh/m^2	Heat Gain kWh/m^2	Heat Loss kWh/m^2
Block 1 S20%	50,90	9,97	44,23	5,84	35,58	2,90
Block 2 S30%	75,54	15,29	65,88	8,99	53,16	4,50
Block 3 S40%	99,67	20,80	87,24	12,29	70,60	6,15
Block 4 S50%	123,34	26,46	108,34	15,69	87,92	7,88
North Windows	**A2 Scenario Blocks (Single Glazing)**		**B2 Scenario Blocks (Double Glazing)**		**C2 Scenario Blocks (C. Double Glazing)**	
Block 1 N20%	16,70	10,33	15,64	5,95	13,37	2,95
Block 2 N30%	24,84	15,44	23,33	8,95	19,99	4,45
Block 3 N40%	32,85	20,51	30,93	11,95	26,56	5,96
Block 4 N50%	40,75	25,54	38,45	14,97	33,09	7,50

- **Erzurum Province**

Table 2.10Annual energy load values for Erzurum province (kWh/m^2)

Single Glazing	**A1 Block 1**	**A1 Block 2**	**A1 Block 3**	**A1 Block 4**	**A2 Block 1**	**A2 Block 2**	**A2 Block 3**	**A2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	113,04	112,39	111,99	111,85	113,04	118,73	124,40	130,10
Cooling	19,30	22,30	25,42	28,60	19,30	20,06	20,81	21,54
TOTAL	132,34	134,69	137,41	140,45	132,34	138,79	145,21	151,64
Double Glazing	**B1 Block 1**	**B1 Block 2**	**B1 Block 3**	**B1 Block 4**	**B2 Block 1**	**B2 Block 2**	**B2 Block 3**	**B2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	86,05	83,02	80,26	77,77	86,05	88,40	90,77	93,12
Cooling	18,02	21,10	24,05	27,30	18,02	19,10	20,17	21,26
TOTAL	104,07	104,12	104,31	105,07	104,07	107,05	110,94	114,38
C. Double Glazing	**C1 Block 1**	**C1 Block 2**	**C1 Block 3**	**C1 Block 4**	**C2 Block 1**	**C2 Block 2**	**C2 Block 3**	**C2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	74,91	71,25	67,82	64,59	74,91	75,52	76,14	76,77
Cooling	13,99	16,40	19,01	21,78	13,99	15,09	16,19	17,30
TOTAL	88,90	87,65	86,83	86,37	88,90	90,61	92,33	94,07

Table 2.11Surface window heat gain/heat loss energy values of scenario blocksfor Erzurum province (kWh/m^2)

ERZURUM	**A1 Scenario Blocks (Single Glazing)**		**B1 Scenario Blocks (Double Glazing)**		**C1 Scenario Blocks (C. Double Glazing)**	
South Windows	Heat Gain (kWh/m2)	Heat Loss (kWh/m2)	Heat Gain (kWh/m2)	Heat Loss (kWh/m2)	Heat Gain (kWh/m2)	Heat Loss (kWh/m2)
Block 1 S20%	41,91	21,60	38,12	12,55	31,91	7,01
Block 2 S30%	62,24	32,59	56,79	18,99	47,67	10,62
Block 3 S40%	82,18	43,66	75,22	25,52	63,32	14,29
Block 4 S50%	101,73	54,81	93,42	32,14	78,84	18,03
North Windows	**A2 Scenario Blocks (Single Glazing)**		**B2 Scenario Blocks (Double Glazing)**		**C2 Scenario Blocks (C. Double Glazing)**	
Block 1 N20%	9,62	23,64	10,42	13,22	10,09	7,29
Block 2 N30%	12,80	31,51	13,87	17,69	13,46	9,78
Block 3 N40%	16,94	41,79	18,38	23,55	17,87	13,05
Block 4 N50%	21,02	51,97	22,83	29,40	22,24	16,34

- **Istanbul Province**

Table 2.12Annual energy load valuesfor Istanbul province (kWh/m^2)

Single Glazing	**A1 Block 1**	**A1 Block 2**	**A1 Block 3**	**A1 Block 4**	**A2 Block 1**	**A2 Block 2**	**A2 Block 3**	**A2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	52,38	52,27	52,02	52,09	52,38	54,31	56,25	58,18
Cooling	47,51	53,05	58,52	64,00	47,51	50,13	52,71	55,24
TOTAL	99,89	105,32	110,54	116,09	99,89	104,44	108,96	113,42
Double Glazing	**B1 Block 1**	**B1 Block 2**	**B1 Block 3**	**B1 Block 4**	**B2 Block 1**	**B2 Block 2**	**B2 Block 3**	**B2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	39,21	37,79	36,54	35,49	39,21	39,62	40,03	40,46
Cooling	44,08	50,01	54,83	60,28	44,08	47,00	49,93	52,90
TOTAL	83,29	87,80	91,37	95,77	83,29	86,62	89,96	93,36
C. Double Glazing	**C1 Block 1**	**C1 Block 2**	**C1 Block 3**	**C1 Block 4**	**C2 Block 1**	**C2 Block 2**	**C2 Block 3**	**C2 Block 4**
T.R.	S20%	S30%	S40%	S50%	N20%	N30%	N40%	N50%
Heating	33,78	31,82	30,25	28,72	33,78	33,41	33,04	32,70
Cooling	36,17	40,62	45,22	49,87	36,17	38,80	41,48	44,18
TOTAL	69,95	72,44	75,47	78,59	69,95	72,21	74,52	76,88

Table 2.13Surface window heat gain/heat loss energy valuesof scenario blocks for Istanbul province (kWh/m^2)

ISTANBUL	**A1 Scenario Blocks (Single Glazing)**		**B1 Scenario Blocks (Double Glazing)**		**C1 Scenario Blocks (C. Double Glazing)**	
South Windows	Heat Gain (kWh/m2)	Heat Loss (kWh/m2)	Heat Gain (kWh/m2)	Heat Loss (kWh/m2)	Heat Gain (kWh/m2)	Heat Loss (kWh/m2)
Block 1 S20%	40,03	12,69	35,68	7,09	29,29	3,51
Block 2 S30%	59,44	19,22	53,18	10,78	43,78	5,35
Block 3 S40%	78,47	25,86	70,45	14,57	58,16	7,24
Block 4 S50%	97,13	32,60	87,51	18,44	72,45	9,18
North Windows	**A2 Scenario Blocks (Single Glazing)**		**B2 Scenario Blocks (Double Glazing)**		**C2 Scenario Blocks (C. Double Glazing)**	
Block 1 N20%	17,22	13,11	16,76	7,18	14,61	3,52
Block 2 N30%	25,58	19,63	24,98	10,80	21,84	5,32
Block 3 N40%	33,78	26,11	33,09	14,44	29,01	7,14
Block 4 N50%	41,83	32,56	41,11	18,10	36,13	8,97

CHAPTER 3

ANALYZING OF ENERGY LOADS

In this thesis study, annual heating and cooling energyloads were calculated with DesignBuilder software program and its interface simulation tool EnergyPlusby according to the characteristics of the generated buildings. Energy analysis was done with selected materials and determined sides of scenario blocks and observed energy efficient conditions.As a consequence of the results obtained from the computer simulation program were given in chapter two. Analysis of research results were given below.

3.1Analyzing ofEnergy Loadsand Surface Window Heat Gain/Heat Loss Energy of the Scenario Blocks

When analyzing research results, characteristic of each province should be taken into account together with impact of changed transparency ratios at determined sides as well as used different glazing window types for scenario blocks. There is a benefit to remember, while single glazing type of window was selected for A scenario blocks, for B scenario blocks double glazing window type and for C scenario blocks coated double glazing window type has preferred.

Within these analyses, effects of changing values as percentage at those parameters heating and cooling loadsof scenario blocks and heat gains and losses from windows were given in this part.

3.1.1Findings for Antalya Province (South Sides)

A1, B1 and C1 scenario blocks have changed transparency ratios at south sides. Analysisresults of these scenario blocks were given in this part.

- **Heating Energy LoadAnalysis**

Antalya is located at south part of Turkey. As a consequence of this, energy consumption of blocks for heating energy is lower than for cooling energy. A1, B1 and C1 scenarios blocks with increased transparency ratio heating energy load values decrease. Besides changed transparency ratios, the impact of used different glazing and window types between the scenarios on heating loads is clearly seen. Amount of reduction at heating energy loads of for these scenarios depends on used glazing types too. Amount of these decreases as percentage were found from Table 2.8.Valuesare respectively from A1.1.S20% to A1.4.S50% blocksby 27%,from B1.1.S20% to B1.4.S50% blocks by 43% and from C1.1.S20% to C1.4.S50% blocks by 50%.

According to these results, increasing transparency ratio at south sides of C1 scenario blocks causes decreases for heating energy by 50% for Antalya province. Because of characteristics of Mediterranean climate, in Antalya province, heat gaining from south facades of blocks is very high. (Table 2.8, Figure 3.2) These gains compensate partially heat losses and in this manner heating energy demand decreases. With increased transparency ratio demand for heating energy decreases goes down to 50% for blocks with coated double glazing, namely, C1 scenario blocks.

Used glazing types with low U value are more effective to decrease heat losses comparing to other glazing types. So, it can be said that energy efficiency for total and individual heating energy loads is mostly seen at blocks with coated double glazing windows. It follows blocks with double glazing and lastly blocks with single glazing window types.

- **Cooling Energy LoadAnalysis**

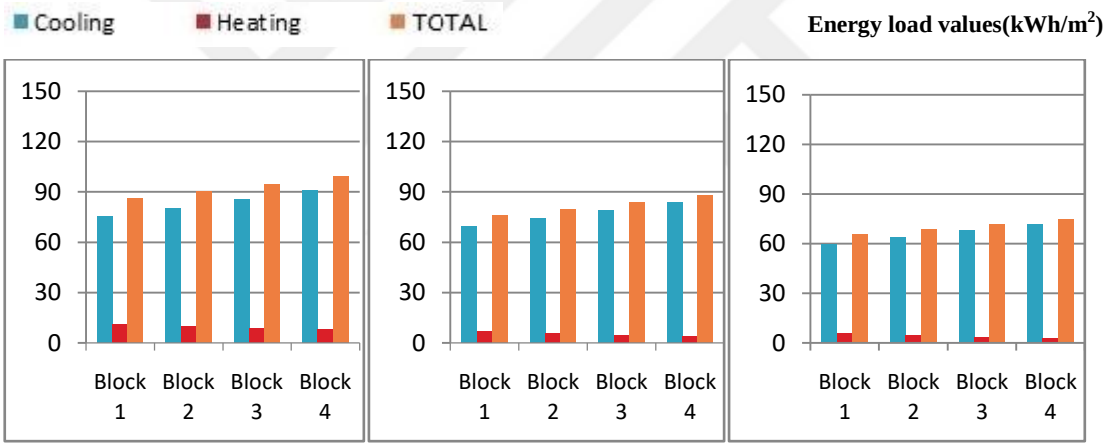
As a result of climatic characteristics of the Mediterranean, energy consumption for cooling energy is higher than for heating energyof scenario blocks for Antalya province. (Table 2.8, Figure 3.1) As mentioned before, high amount of heat gains are seen for these blocks. Although, usage of double and coated double glazing window types at scenario blocks affects both total and individual cooling energy loadsof scenario blocks on the downward direction compared to single glazing window type according to Table 2.8. However, with increasing transparency ratios for the same scenarios cooling energy loads of blocksincrease for Antalya province. However when look backed to Table 2.8these increases as percentage between the scenarios are very close each other for all

window types. Even, these values for double glazing window and single glazing window types are same from S20% to S50% blocks by 17.3%. For blocks with coated double glazing, this value is from C1.1.S20% to C1.4.S50% blocks by 16.8%.

As a result, in general impacts ofchanged transparency ratios on cooling energy loads is less than usage of different glazing window types when compared to heating energy loads.

According to Table 2.8, it can be said that impacts of changed transparency ratios on cooling energy loads is the least for blocks with coated double glazing. The values are given above show that this impact is same for blocks with single and double glazing window types.

For total and individual cooling energy loads of between the scenario blocks, it is found that withused of glazing types with low U value, cooling energy load decrease.These decreases are less than heating load decreases.



A1 Scenario Blocks (S)B1 Scenario Blocks (S)C1 Scenario Blocks (S)
(Single glazing) (Double glazing) (C. Double glazing)

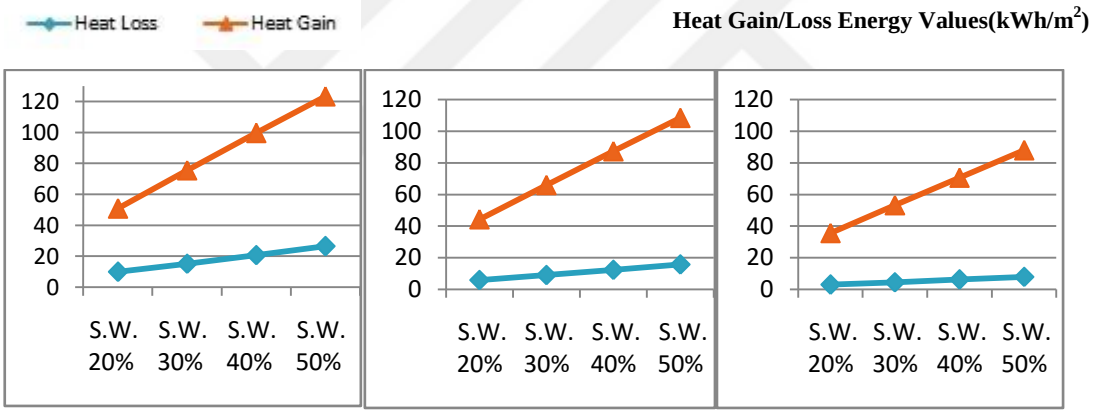
Figure 3.1[1] Annual energy load values of blocks for Antalya province (South)

As a result, increased transparency ratios cause to decrease heating energy loads and increase cooling energy loads for scenario blocks oriented toward the south in Antalya province.It is seen that with increased transparency ratios, total energy loads increase for all scenario blocks.

[1]Figure 3.1 is partially graphic display of Table 2.8

- **Surface Window Heat Gain/Heat Loss Energy Analysis (South)**

Increasing window areas at southern side of blocks allows to coming more solar gain from the sun into the house. This is valid for all scenario blocks with changed transparency ratios at south sides at Antalya province. These gains compensate partially heat losses and in this manner heating energy demand decreases.The most solar heat gain from window is seen at single clear glazing window type because their solar transmittance(t) values are higher than other used window types. (Table 2.2) The least is seen at coated double glazing window type. On the other hand, it can be said that with increasing transparency ratio heat losses from window surfaces increase too as like heat gains. However these increases with changed transparency ratio are very less. (Table 2.8, Figure 3.2) So that, it can be said that impact of changed transparency ratios are less effective on heat losses compared to heat gains. Used different window types are more effective on heat losses.



A1 Scenario Blocks (S)B1 Scenario Blocks (S)C1 Scenario Blocks (S)
(Single glazing) (Double glazing) (C. Double glazing)

Figure 3.2[1]:Surface window heat gain/lossenergy valuesfor Antalya province (South)

As a result, while changed transparency ratio effects on heat gains more than heat losses, changed glazing types effects on heat losses more than heat gains. This situation is seen predominantly in blocks oriented toward the south.

[1]Figure 3.2 is partially graphic display of Table 2.8.

3.1.2Findings for Antalya Province (North Sides)

A2, B2 and C2scenario blocks have changed transparency ratios at north sides. Analysis results of these scenario blocks were given in this part.

- **Heating Load Energy Analysis**

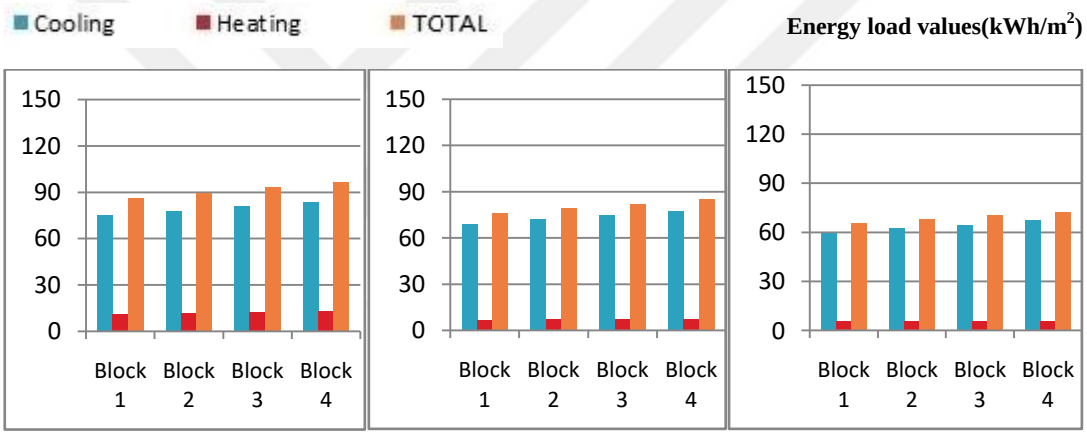
Energy consumption of blocks for heating is lower than for cooling. The reason is considering all facades, with increased transparency ratios heat gains and heat losses increase too. Because of heat gains, heating load values decrease for blocks with coated double glazing.For blocks with single and double glazing these values increase because amount of heat losses are more than blocks with coated double glazing.

According to Tables 2.8 percentages of these increases for heating load values are respectively from A2.1.N20% to A2.4.N50% blocks by 17.4% and from B2.1.N20% to B2.1.N50% blocks by 0.6%. Percentage of decrease value for blocks with coated double glazing window types is from C2.1.N20% to C2.4.N50% blocks by 0.8%.Although decreases of heating load were seen at that scenario blocks amount of these decreases are very less. Nevertheless, energy efficiency for heating is mostly seen at blocks with coated double glazing windows. It follows blocks with double glazing and lastly blocks with single glazing window types.Considering these results, it can be said that although there are less amount of changes in heat gains by window types, it is seen huge amount of heat losses changes by different window types especially at blocks with coated double glazing window types. Effects of increasing transparency ratios are less than effects of used high efficient window types which have low U value on heat losses. Especially, usage of high efficient window types at blocks oriented toward the north is more effective.

- **Cooling Load Energy Analysis**

Energy consumption of blocks for cooling is higher than for heating. With increased transparency ratios cooling load values increase too. The reason is although heat gains from north facades of blocks is quite lower than south facades (Figure 3.4), still there are heat gains throughout other facades of blocks (especially from south facades) and this causesincreasing cooling energy demand. However these increases for cooling loads within same scenario blocks and window types are not too much with increased transparency ratios compared to cooling loads of A1, B1 and C1 blocks (South).

According to Tables 2.8, percentages of these increases for cooling loadvalues are respectively from A2.1.N20% to A2.4.N50% blocks by 10%,from B2.1.N20% to B2.4.N50% blocks by11% and from C2.1.N20% to C2.4.N50% blocks by 11%. According to these results, for all window types at north facades these increase values are close to each other. However considering both total and individual cooling energy load of blocks in scenarios, energy efficiency for cooling is mostly seen at blocks with coated double glazing. It follows blocks with double glazing and lastly blocks with single glazing. Besides, the occurrence of this result, small amount of heat gains both from north and other facades are also effective. Especially for blocks with coated double glazing (low U value) heat loss values decrease. Considering cooling and total energy loadstogether, blocks oriented toward the north have advantage for Antalya province.



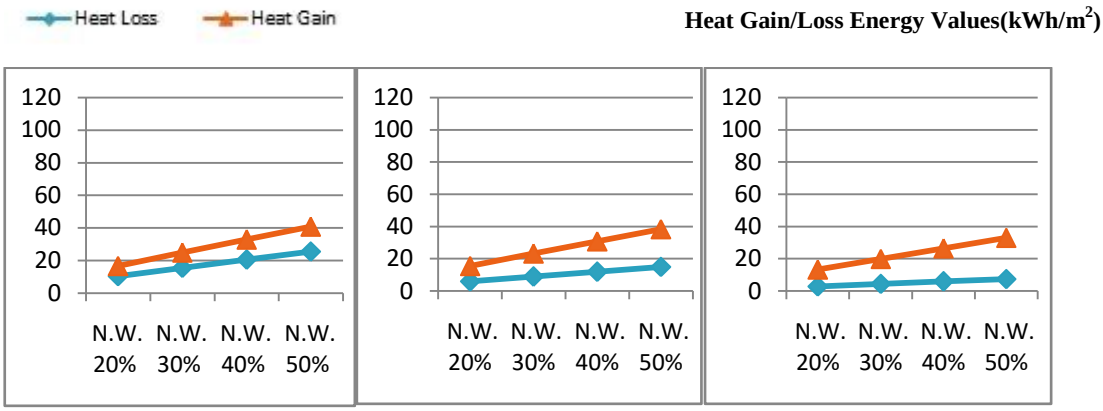
A2 Scenario Blocks (N) B2 Scenario Blocks (N) C2 Scenario Blocks (N)
(Single glazing)(Double glazing) (C. Double glazing)

Figure 3.3[1] Annual energy load valuesof blocks for Antalya province (North)

- **Surface Window Heat Gain/Heat Loss Energy Analysis (North)**

With increasing window areas at northern side of blocks both heat gains and heat losses increase. It is valid for all scenario blocks oriented toward the north. (Table 2.8, Figure 3.4) However these increases are different because of used different windows types. Whereas blocks with single glazing with increased transparency ratio is the most, blocks with coated double glazing is the least. Besides, considering these increases, heat losses are less than heat gains. In other words, while used of coated double glazing window type at blocks has great influence to decrease both heat gains and losses; effects of increased transparency ratio are less effective to change heat losses.

[1]Figure 3.3 is partially graphic display of Table 2.8



A2 Scenario Blocks (N) **(Single glazing)** B2 Scenario Blocks (N) **(Double glazing)** C2 Scenario Blocks (N) **(C. Double glazing)**

Figure 3.4[1]: Surface window heat gain/loss energy valuesfor Antalya province (North)

3.1.3 Findings for Erzurum Province (South Sides)

A1, B1 and C1 scenario blocks have changed transparency ratios at south sides. Analysis results of these scenario blocks were given in this part.

- **Heating Load Energy Analysis**

Erzurum is located at east part of Turkey. As a consequence of this, energy consumption of blocks for heating energy is quite higher than for cooling energy.A1, B1 and C1 scenarios blocks with increased transparency ratio demand for heating energy needed decreases too because of heat gaining from the sun. (Table 2.11, Figure 3.6)Besides, used different glazing window types and changed transparency ratios have same impact on heating energy loads. They are both decrease heating energy demand. While the least heating load values belongs to scenario blocks with coated double glazing, the most is belong to blocks with single glazing.

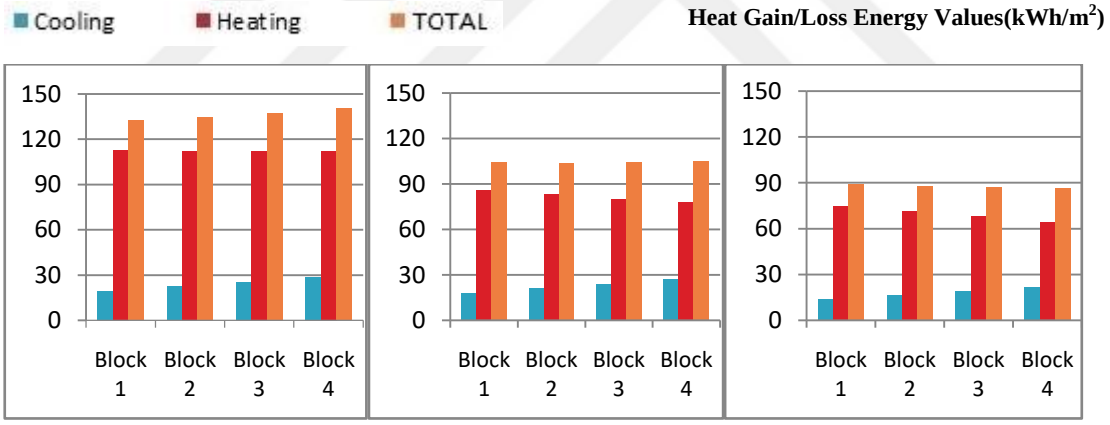
Amount of these decreases as percentage were found from Table 2.10. Values are respectively from A1.1.S20% to A1.4.S50% blocksby 5.5%, from B1.1.S20% to B1.4.S50% blocksby 9% and from C1.1.S20% to C1.4.S50% blocks by 13%. According to these results, decreases for heating energy mostly are seen C1 scenario blocks,by 13%for Erzurum province. It means energy efficiency for heating is mostly seen at blocks with coated double glazing windows types. It follows blocks with double glazing and lastly blocks with single glazing window types.

[1]Figures 3.4 is partially graphic display of Tables 2.11.

- **Cooling Load Energy Analysis**

Energy consumption for cooling is lower than for heating of scenario blocks of Erzurum. Amount of this gap is quite a lot. Because of characteristics of Continental climate, it is seen huge amount of heat losses throughout facades. Although there are huge amount of heat losses throughout facades, heat gains are also seen from south facades. With increased transparency ratio, solar gains increase. As a result of this with increased transparency ratios cooling energy load values increases too. According to Table 2.10, percentages of these increases for cooling load values are respectivelyfrom A1.1.S20% to A1.4.S50% blocksby 32.6%, from B1.1.S20% to B1.4.S50% blocksby 34% and from C1.1.S20% to C1.4.S50% blocksby 35.8%.

According to these results, for all window types at south facades these increase values are close to each other. However considering both total and individual cooling load of blocks in scenarios, energy efficiency for cooling is mostly seen at blocks with coated double glazing windows. It follows blocks with double glazing and lastly blocks with single glazing window types.



A1 Scenario Blocks (S) **(Single glazing)** B1 Scenario Blocks (S) **(Double glazing)** C1 Scenario Blocks (S) **(C. Double glazing)**

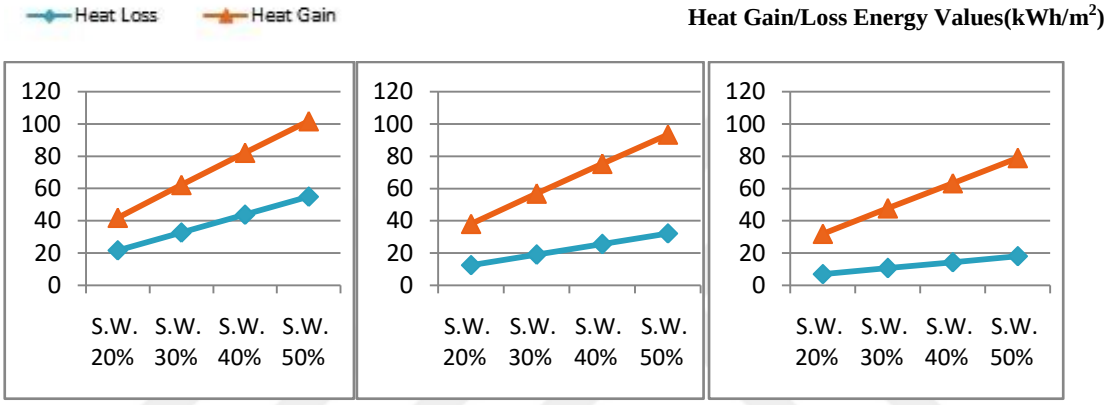
Figure 3.5[1] Annual energy load values of blocks for Erzurum province (South)

As a result, increased transparency ratios cause to decrease cooling energy loads and increase heating energy loads for scenario blocks oriented toward the south in Erzurum province. It is seen that with increased transparency ratios, total energy loads of blocks with coated double glazing decrease too.

[1]Figure 3.5 is partially graphic display of Table 2.10.

- **Surface Window Heat Gain/Heat Loss Energy Analysis (South)**

Because of characteristics of the Continental climate, with increased transparency ratios huge amount of heat losses from openings are seen. (Table 2.11, Figure 3.6) This causes high amount of heating energy consumption. With used high efficient window types which are double and coated double glazing these heat losses decrease. Usage of these types of window is more logical than single glazing because they provide remarkably energy efficiency for blocks. Blocks with coated double glazing is much better for preventing heat losses from window surfaces compared to blocks with double glazing. Usage of single glazing is the worst for the blocks in terms of energy efficiency.



A1 Scenario Blocks (S) **(Single glazing)** B1 Scenario Blocks (S) **(Double glazing)** C1 Scenario Blocks (S) **(C. Double glazing)**

Figure 3.6[1]Surface window heat gain/loss energy valuesfor Erzurum province (South)

As a result, while changed transparency ratio effects on heat gains more than heat losses, changed glazing types effects on heat losses more than heat gains. This situation is seen predominantly in blocks oriented toward the south.

3.1.4 Findings for Erzurum Province (North Sides)

A2, B2 and C2 scenario blocks have changed transparency ratios at north sides. Analysis results of these scenario blocks were given in this part.

[1]Figure 3.6 is partially graphic display of Table 2.11.

- **Heating Load Analysis**

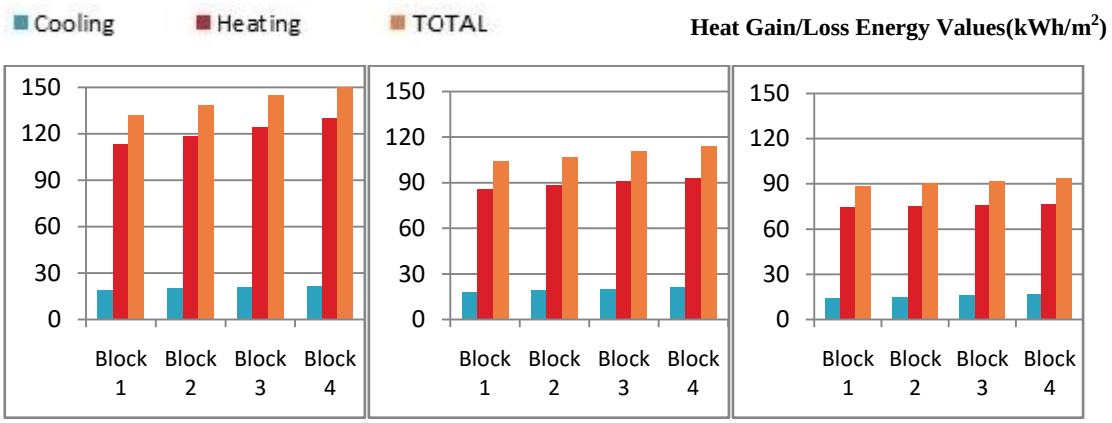
Energy consumption of blocks for heating energy is higher than for cooling energy for all A1 B1 and C1 scenarios blocks in Erzurum province. According to Tables 2.10, percentages of these increases are respectively from A2.1.N20% to A2.4.N50% blocks by 17.4%, from B2.1.N20% to B2.4.N50% blocks by 0.6% and from C2.1.N20% to C2.4.N50% blocks by 0.8%. With increased transparency ratios heating energy load values of blocks increase too.

According to results, amount of these increases are mostly seen at blocks with single glazing, second blocks with coated double glazing and thirdly blocks with double glazing. Considering for all scenario blocks oriented toward the north in Erzurum energy efficiency for heating is mostly seen at blocks with coated double glazing windows. It follows blocks with double glazing and lastly blocks with single glazing window types.

- **Cooling Load Analysis**

Energy consumption for cooling energy is lower than for heating energy for scenario blocks in Erzurum.(Table 2.10)According to Figure 3.8, heat losses from the openings with increased transparency ratios increase too. Even, these increases are more than heat gains increases for blocks with single and double glazing window types. On the other hand, heat losses values under the heat gains values at blocks with coated double glazing window types.

According to Table 2.10, percentages of increases for cooling energy load values are respectively from A2.1.N20% to A2.4.N50% blocks by 10.4%, from B2.1.N20% to B2.4.N50% blocks by 15.3%and from C2.1.N20 %to C2.4.N50% blocksby 19.2%. These results shows that thanks to blocks with high efficient window types with considering other facades of within same blocks heat losses values decrease, and heat gains and heat losses are nearly equal for blocks with coated double glazing. (Figure 3.8) Also, with increased transparency ratios, there is total energy load balancing for blocks with coated double glazing. Considering total cooling energy load values, energy efficiency for cooling is mostly seen at blocks with coated double glazing types. It follows blocks with double glazing and lastly blocks with single glazing types. Besides, usage of high efficient window types which are double and coated double glazing window types are more effective at blocks oriented toward the north compared to blocks oriented toward the south for Erzurum province.



A2 Scenario Blocks (N) **(Single glazing)** B2 Scenario Blocks (N) **(Double glazing)** C2 Scenario Blocks (N) **(C. Double glazing)**

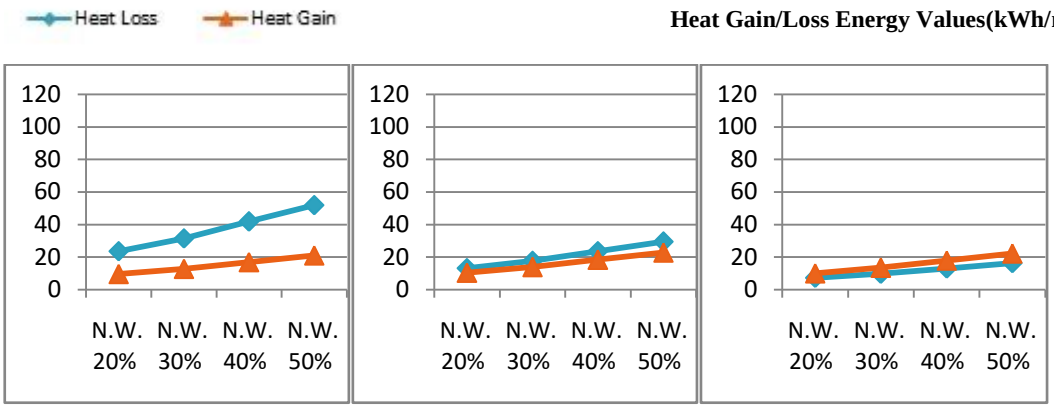
Figure 3.7[1] Annual energy load values of blocks for Erzurum province (North)

As a result, usage of high efficient window types (low U value) which are double and coated double glazing window types provide high amount of energy saving for scenario blocks. With increased transparency ratios, usage of double and coated glazing types at blocks affects heating energy load results in a small scale.

- **Surface Window Heat Gain/Heat Loss Energy Analysis (North)**

With increasing window areas at northern side of blocks both heat gains and heat losses increase. However these increases are different because of used different windows types. According to Figure 3.8, first of all it can be said that used of double and coated double glazing window types are more effective at north facades compared to south facades for Erzurum province. Thanks to these window types values of heat gains and heat losses were dramatically decreased.Amount of these decreases for heat losses are more than heat gains. Especially blocks with coated double glazing window types heat losses values under the heat gains values. This helps to decreasing energy consumption especially for heating loads. According to results usage of different window types has more influential effect on heat losses than changed transparency ratios.

[1]Figure 3.7 is partially graphic display of Tables 2.10.



A2 Scenario Blocks (N) **(Single glazing)** B2 Scenario Blocks (N) **(Double glazing)** C2 Scenario Blocks (N) **(C. Double glazing)**

Figure 3.8[1]Surface window heat gain/loss energy values for Erzurum province (North)

3.1.5Findings for Istanbul Province (South Sides)

A1, B1 and C1 scenario blocks have changed transparency ratios at south sides. Results analysis of these scenario blocks were given in this part.

- **Heating Load Analysis**

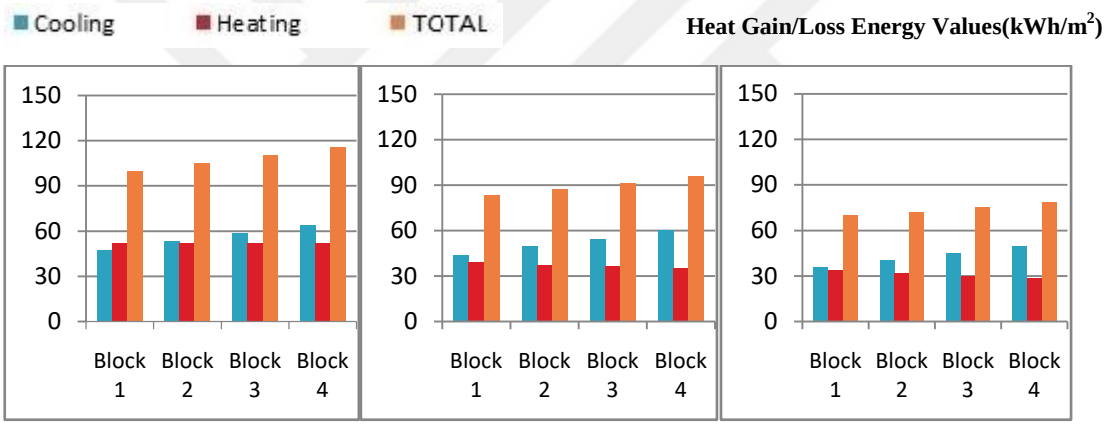
Istanbul is located at northwest part of Turkey. Because of climatic characteristic of the Marmara (transition) climate, energy consumption of blocks for heating energy is lower than for cooling energy except A1.1.S20% block. With increased transparency ratio in other words window/wall area ratio at south facades, demand for heating energy needed decreases too because of high amount of solar gain from the sun. (Table 2.12, Figure 3.10)

According to Table 2.12, percentages of these decreases for heating load values are respectively fromA1.1.S20% to A1.4.S50% block by3%,from B1.1.S20% to B1.4.S50% blocks by 9.5%, andfrom C1.1.S20% to C1.4.S50% blocks by 15%. These results show that, energy efficiency for heating is mostly seen at blocks with coated double glazing windows types. It follows blocks with double glazing and lastly blocks with single glazing window types.

[1]Figures 3.8 ispartially graphic display of Table 2.11.

- **Cooling Load Analysis**

Energy consumption for cooling energy is higher than for heating energy for scenario blocks in Istanbul except A1.1.S20% block. With increased transparency ratios cooling energy load increases too. (Table 2.12, Figure 3.9) The reason is heat gains increase with increased transparency ratios. (Figure 3.10) According to Tables 2.12, percentages of increases for cooling load values are respectively from A1.1.S20% to A1.4.S50% blocks by 26%, from B1.1.S20% to B1.4.S50% blocks by 26.9% and from C1.1.S20% to C1.4.S50% blocks by 27.5%. According to these results, although with changed transparency ratios amount of increase values as percentage at cooling energy load is mostly seen at blocks with coated double glazing window types, it has the greatest impact to decrease cooling energy loads. For blocks with oriented toward the south in İstanbul province, energy efficiency is mostly seen at blocks withcoated double glazing.



A1 Scenario Blocks (S) **(Single glazing)** B1 Scenario Blocks (S) **(Double glazing)** C1 Scenario Blocks (S) **(C. Double glazing)**

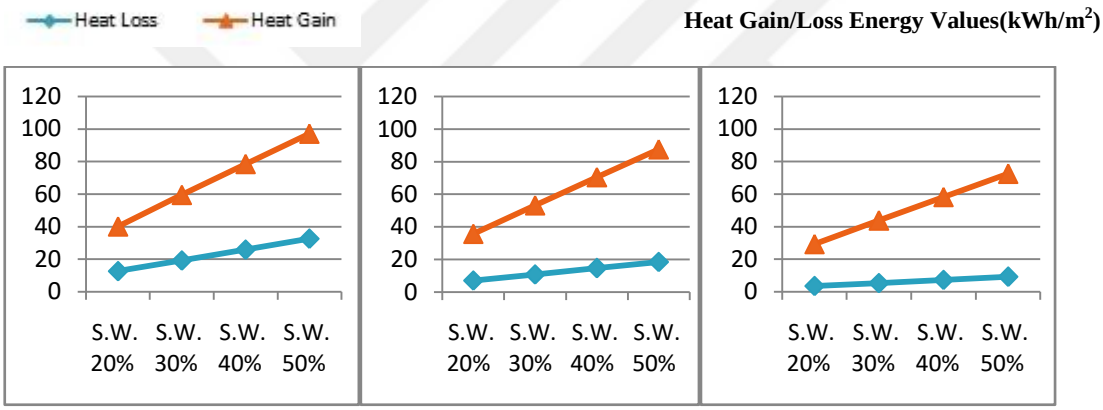
Figure 3.9[1] Annual energy load values of blocks for Istanbul province (South)

As a result, usage of high efficient window types (low U value) which are double and coated double glazing window types provide certain amount of energy saving for scenario blocks. With increased transparency ratios, usage of double and coated glazing types at blocks affects both heating and cooling energy load results. Coated double glazing affects energy loads more than double glazing.

[1]Figure 3.9 is partially graphic display of Table 2.12.

- **Surface Window Heat Gain/Heat Loss Energy Analysis (South)**

Increasing wall/window area ratio at southern side of blocks allows to coming more solar gain from the sun into the house. These gains compensate partially heat losses and in this manner with increased transparency ratios both heating energy demand and heating energy loads decrease. (Table 2.12, Figure 3.10) Heat losses decrease with increased transparency ratios at all scenario blocks. These decreases are mostly seen at blocks with coated double glazing, second blocks with double glazing and lastly blocks with single glazing window types.(Table 2.12, Figure 3.10) However effects of changed transparency ratios on energy loads are very less for blocks with coated double glazing. So, according to Figure 3.10, it can be said that usage of high efficient window types decreases heat losses and provides energy efficiency in a certain amount for blocks oriented toward the south.



A1 Scenario Blocks (S) **(Single glazing)** B1 Scenario Blocks (S) **(Double glazing)** C1 Scenario Blocks (S) **(C. Double glazing)**

Figure 3.10[1]Surface window heat gain/loss energy valuesfor Istanbul province (South)

As a result, while changed transparency ratio effects on heat gains more than heat losses, changed glazing types effects on heat losses more than heat gains. This situation is seen predominantly in blocks oriented toward the south.

3.1.6 Findings for Istanbul Province (North Sides)

- **Heating Load Result Analysis**

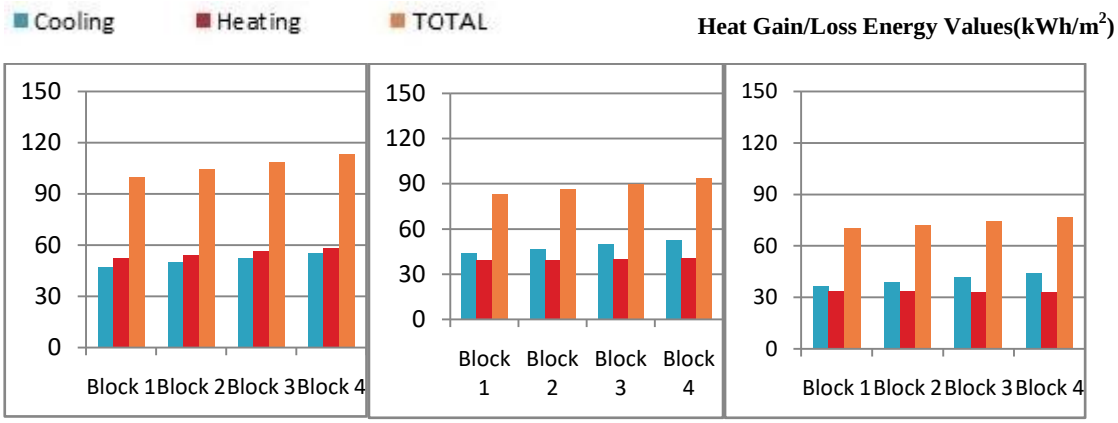
While energy consumption for heating energy is higher than for cooling energy for scenario blocks with single glazing, for blocks with double and coated double glazing this is vice versa. (Table 2.12)

[1]Figure 3.10 is partially graphic display of Table 2.13.

Although heat losses decrease with used of high efficient window types (Table 2.13, Figure 3.12), with increased transparency ratios demand for heating energy needed increases too. With increased transparency ratios, heating energy load increases blocks with single and double glazing window types. These increases are more for blocks with single glazing and less for blocks double glazing window types. According to Table 2.12, percentages of these increases for heating energy load values are respectively from A2.1.N20% to A2.4.N50% blocks by 17.4%, from B2.1.N20% to B2.4.N50% blocks by 0.6%. However, with increased transparency ratios, heating energy loads decrease for blocks with coated double glazing. According to Table 2.12, percentage of this decrease for heating energy load value is from C2.1.N20% to C2.4.N50% blocks by 0.8%.Usage of high efficient glazing types at blocks is very effective to decrease heat gains. For that reason, demand for heating energy decreases. According to these results, clearly, energy efficiency for heating energy is mostly seen at blocks with coated double glazing. It follows blocks with double glazing and lastly blocks with single glazing.Besides, usage of double and coated double glazing for blocks oriented toward the north is more effective in terms of energy efficiency when compared to blocks oriented toward the south in Istanbul province. This result is vice versa for block with single glazing.

- **Cooling Load Analysis**

Energy consumption for cooling energy is higher than for heating energy for scenario blocks in Istanbul except for blocks with single glazing window types (Table 2.12). Because of huge amount of heat losses from the north facades with single glazing (high U value) heating energy loads are more than cooling energy loads. Heat losses with used of high efficient window types that are double and coated double glazing, decrease. Both these decreases and a small amount of heat gains from south facades cause to domestic heat increasing. Coated double glazing is very effective to decrease heat losses. However, it is not very effective to decrease heat gains for blocks. For that reason with increased transparency ratios, cooling energy load increases. (Figure 3.11) According to Table 2.12, increases for cooling load values as percentages are respectively from A2.1.N20% to A2.4.N50% blocks by 14%, from B2.1.N20% to B2.4.N50% blocks by 16.7% and from C2.1.N20% to C2.4.N50% blocks by 18.2%. According to Table 2.12 and Figure 3.11, while for cooling energy loads the best result came up blocks with coated double glazing in terms of energy efficiency, the worst result belongs to blocks with single glazing.

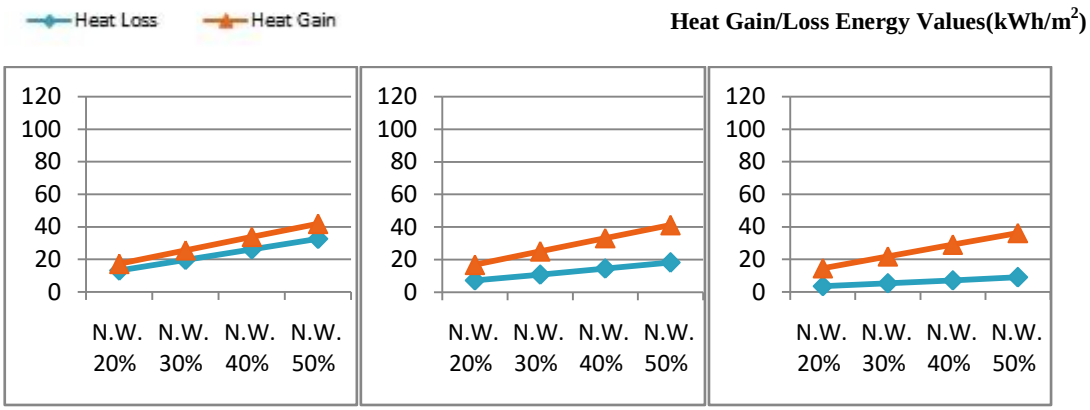


A2 Scenario Blocks (N) B2 Scenario Blocks (N) C2 Scenario Blocks (N)
(Single glazing) **(Double glazing)** **(C. Double glazing)**

Figure 3.11[1] Annual energy load valuesof blocks for Istanbul province (North)

- **Surface Window Heat Gain/Heat Loss Energy Result Analysis (North)**

According to Figure 3.12, it can be said that although there are less amount of changes in heat gains by window types, there is huge amount of heat losses changes by different window types especially at blocks with coated double glazing window types. For this reason, high heating energy load values are seen at blocks with single glazing window types. (Table 2.12) For heat losses, effects of increasing transparency ratios are less than effects of used high efficient window types. Usage of glazing types with low U value is more effective for blocks oriented toward the north than blocks oriented toward the south.



A2 Scenario Blocks (N) B2 Scenario Blocks (N) C2 Scenario Blocks (N)
(Single glazing) **(Double glazing)** **(C. Double glazing)**

Figure 3.12[2]Surface window heat gain/loss energy valuesfor Istanbul province (N)

[1,2]Figures 3.11 and 3.12 arepartially graphic display of respectively Tables 2.12 and 2.13.

3.2 General Analysis of Energy Loadsof the Scenario Blocks

In previous part, annual heating and cooling energy load results of scenario blocks were evaluated separately for each province. In the light of these results, in this part general analysis of A1, B1, C1 (South) and A2, B2, C2 (North) scenario blocks were given.Besides heating and cooling energy load results, total energy load (heating + cooling) results were evaluated too. Also, common results were highlighted for scenario blocks oriented toward the south and the north in each province.

3.2.1A1, B1 and C1 Scenario Blocks (South)

In general, total energy load (heating + cooling) order is A1 > B1 > C1 for Antalya, A1 > B1 > C1 for Erzurum and A1 > B1 > C1 for Istanbul for each scenario block.For A1, B1 and C1 scenario blocks heating and cooling energy load order is cooling > heating for Antalya and Istanbul (except A1.1.S20%), for Erzurum heating > cooling for each scenario blocks.

Heating Load Results: Heating energy load values of S20% scenario blocks arehighest for all provinces.

For Antalya, these values are A1.1.S20% by 11,06 kWh/m^2 > B1.1.S20% by 6,92 kWh/m^2 > C1.1.S20% by 5,96 kWh/m^2. (Table 2.8)

For Erzurum these values are A1.1.S20% by 113,04 kWh/m^2 > B1.1.S20% by 86,05 kWh/m^2> C1.1.S20% 74,91 kWh/m^2. (Table 2.10)

For Istanbul these values are A1.1.S20% by 52,38 kWh/m^2> B1.1.S20% by 39,21 kWh/m^2> C1.1.S20% 33,78 kWh/m^2. (Table 2.12)

According to these results, because of high amount of solar heat gain from south facades of blocks, blocks of Antalya have the lowest heating load values. On the other hand, blocks of Erzurum have the highest heating energy load values. With increased transparency ratios, heating energy loads decrease for all scenario blocks.

As a common result for all scenarios and provinces while blocks with single glazing window types are the least effective to decrease heating energy loads with increased transparency ratios within the same province, blocks with coated double glazing are the most effective. As a second common result for all scenarios and provinces minimizing window/wall area ratios (20%) at south sides is not suitable in terms of energy efficiency for heating energyloads of scenario blocks. However, considering for

totalenergy loads (heating + cooling) there is an energy efficient situation is observed. This is reverse for cooling energy loads.

Cooling Load Results: Cooling energy load values of S50% scenario blocks are highest for all provinces.

For Antalya, these values are for A1.4.S50% block by 90,92 kWh/m^2 > for B1.4.S50% block by 83,87 kWh/m^2 > for C1.4.S50% block by 71,87 kWh/m^2. (Table 2.8)

For Erzurum these values are for A1.4.S50% block by 28,60 kWh/m^2 > for B1.4.S50% block by 27,30 kWh/m^2> for C1.4.S50% block by 21,78 kWh/m^2. (Table 2.10)

For Istanbul these values are for A1.4.S50% block by 64 kWh/m^2> for B1.4.S50% block by 60,28 kWh/m^2> for C1.4.S50% block by 49,87 kWh/m^2. (Table 2.12)

With increased transparency ratios solar heat gain from south facades of blocks increases too. Depending on it and according to results given above, cooling energy loads increase with increased transparency ratios too and with 50% window/wall area ratio they reach to the highest value for all scenario blocks in provinces. Although usage of double and coated double glazing window types at scenario blocks provides decreases for cooling loads, still with increased transparency ratios cooling loads increase.

As a common result for all scenarios and provinces, decreases for cooling loads are mostly seen at blocks with coated double glazing, second with double glazing and lastly blocks with single glazing window type.

As a second common result for all scenarios and provinces maximizing window/wall area ratios (50%) at south sides is not suitable in terms of energy efficiency for both cooling and total energy loads (heating + cooling) of scenario blocks.

3.2.2 A2, B2 and C2 Scenario Blocks (North)

In general, total energy load (heating + cooling) order is A2 > B2 > C2 for Antalya, A2 > B2 > C2 for Erzurum and A2 > B2 > C2 for Istanbul for each scenario block. For A2, B2 and C2 scenario blocks heating and cooling energy load order is cooling > heating for Antalya, heating > cooling for each scenario blocks in Erzurum and for Istanbul heating > cooling for A2 scenario blocks, cooling > heating for B2 and C2 scenario blocks.

Heating Load Results: According to Table 2.8, for Antalya N50% blocks have the highestheating energy load values in A2 and B2 scenarios. For C2 scenario heating energy load value of C2.1.N20% block is highest. For Erzurum heating energy load values of N50% blocks are highest for all scenarios. (Table 2.10) For Istanbul heating energy load values of N50% blocks are highest for A2 and B2 scenarios. For C2 scenario heating energy load value of N20% block is highest. (Table 2.12)

For Antalya, these values are for A2.4.N50% block by 13,38 kWh/m^2 > for B2.4.N50% block by 7,35 kWh/m^2 > for C2.4.N50% block by 5,48 kWh/m^2. As mentioned before, C2.1.N20% block has the highest heating energy load value by 5,96kWh/m^2.(Table 2.8)

For Erzurum, these values are for A2.4.N50% block by 130,10 kWh/m^2 > for B2.4.N50% block by 93,12 kWh/m^2> for C2.4.N50% block by 76,77 kWh/m^2. (Table 2.10)

For Istanbul, these values are for A2.4.N50% block by 58,18 kWh/m^2> for B2.4.N50% block by 40,46 kWh/m^2 >for C2.4.N50% block by 32,70 kWh/m^2. As mentioned before,C2.1.N20% block has the highestheating energy load value by 33,78 kWh/m^2. (Table 2.12)

As a common result, with increased transparency ratios heating energy loads of scenario blocks with single and double glazing window types increase too for all provinces.

As a highlighted result, for scenario blocks oriented toward the north usage of double and coated double glazing window types provide energy efficiency at a certain scale both heating and total energy loads (heating + cooling) comparedwith blocks with single glazing window types for all provinces. When compared this result with result of blocks oriented toward the south for same scenario blocks in same provinces, there is no energy efficiency at certain scale for Antalya and Istanbul provinces.This can be explained that; because of huge amount of heat losses from north facades, heating energy demand increase for blocks oriented toward the north. For that reason, heating energy load values of scenario blocksoriented toward the north increasemore than blocks oriented toward the south. According to Figure3.8, amount of heat gains from the north facades of blocks decrease especially at blocks with double and coated double glazing oriented toward the north in Erzurum province. These decreases cause increasing heating energy load values for A2, B2 and C2 scenario blocks more than A1, B1 and C2 scenario blocks. Although coated double glazing is more effective to

decrease heat gains compared with double glazing, it is also effective to decrease heat losses more than double glazing. For that reason, heating energy load values are still the least for same scenario blocks with coated double glazing oriented toward the north in same provinces. This result is also valid for other provinces with same scenario blocks.

As a second highlighted result,minimizing window/wall area ratios (20%) at north sides is suitable in terms of energy efficiency for heating and total energy loads (heating + cooling) of A2 and B2 scenario blocks for Antalya and Istanbul provinces. Maximizing window/wall area ratios (50%) at north sides is better for heating energy loads of C2 scenario blocks for Antalya and Istanbul. Minimizing window/wall area ratios (20%) at north sides is better in terms of energy efficiency for heating and total energy loads (heating + cooling) for all scenario blocks for Erzurum province.

Cooling Load Results:Cooling energy load values of N50% scenario blocks are highest for all provinces.

For Antalya, these values are A2.4.N50% by 83,50 kWh/m^2 > B2.4.N50% by 77,78 kWh/m^2 > C2.4.N50% by 67,25 kWh/m^2. (Table 2.8)

For Erzurum these values are A2.4.N50% by 21,54 kWh/m^2 > B2.4.N50% by 21,26 kWh/m^2> C2.1.N50% by 17,30 kWh/m^2. (Table 2.10)

For Istanbul these values are A2.4.N50% by 55,24 kWh/m^2> B2.4.N50% by 52,90 kWh/m^2> C2.4.N50% by 32,70 kWh/m^2. (Table 2.12)

With increased transparency ratios solar heat gains from north facades of blocks increase too. Depending on it andaccording to results given above, cooling energy load values increase with increased transparency ratios too and with 50% window/wall area ratio they reach the highest values for all scenario blocks in provinces as like blocks oriented toward the south. Although usage of double and coated double glazing window types at scenario blocks provides decreases for cooling energy loads, with increased transparency ratios cooling energy loads increase. When compared coated double glazing with double glazing for same scenario blocks in same provinces, decreases for cooling energy loads are mostly seen at blocks with coated double glazing in Antalya. For Erzurum province the least cooling energy load values belong to blocks with double glazing in Erzurum province.For Istanbul province, blocks with coated double glazing have the lowest cooling energy load values.

As a common result for all scenarios and provinces, decreases for cooling energy loads are mostly seen at blocks with coated double glazing, second with double glazing and lastly blocks with single glazing window types. This result is also valid for A1, B1 and C1 scenario blocks.

3.3The Energy Saving Rates of the Scenario Blocks

Energy saving rate calculation ofeach scenario blocks with double and coated double glazing window types with based onenergy load results of blocks with single glazing types for each provinces is given below. When evaluated these results should be noticed that each province separately was compared within themselves as south and north facing blocks.Results mentioned before support these results.

Table 3.1 Energy saving rates of the scenario blocks for Antalya province

B1 Scenario Double Glazing	**Energy Saving Rates (South)**			**B2Scenario Double Glazing**	**Energy Saving Rates (North)**		
	Heating	**Cooling**	**TOTAL**		**Heating**	**Cooling**	**TOTAL**
Block S20%	37.5%	7.9%	11.7%	Block N20%	37.5%	7.9%	11.7%
Block S30%	43%	7.9%	11.6%	Block N30%	40%	7.5%	11.9%
Block S40%	47.8%	7.8%	11.3%	Block N40%	42.9%	7.2%	12%
Block S50%	51%	7.8%	11.3%	Block N50%	45.1%	6.9%	12.2%
C1 Scenario C. Double Glazing	**Energy Saving Rates (South)**			**C2 Scenario C. Double Glazing**	**Energy Saving Rates (North)**		
	Heating	**Cooling**	**TOTAL**		**Heating**	**Cooling**	**TOTAL**
Block S20%	46.2%	20.5%	23.8%	Block N20%	46.2%	20.5%	23.8%
Block S30%	52.9%	20.7%	24.1%	Block N30%	51.3%	20.2%	24.3%
Block S40%	59.2%	20.9%	24.4%	Block N40%	55.5%	19.9%	24.7%
Block S50%	64.9%	21%	25%	Block N50%	59.1%	19.5%	25%

According to table 3.1, for Antalya province, usage of double glazing at scenario blocks oriented toward the south provides more energy efficiency compared to single glazing window types. For total energy loads, rate result came up maximum by 11.7% for B1.1.S20% block. Usage of double glazing is more effective to decrease heating energy loads compared to cooling and total energy loads. With increased transparency ratios its effectiveness decreases for cooling loads. On the other hand, usage of coated double

glazing window types at scenario blocks oriented toward the south provide more energy efficiency compared to double glazing window types at total. For total energy loads, the rate result came up maximum by 25% for C1.4.S50% block. Usage of coated double glazing is more effective to decrease heating loads compared to cooling and total energy loads. It is least effective to decrease cooling loads. With increased transparency ratios its effectiveness decreases for cooling loads. In general usage of coated double glazing is the most effective to decrease energy loads and with increased transparency ratios its effectiveness increase too for total energy loads.

For scenario blocks oriented toward the north as like south facing blocks, usage of double glazing at scenario blocks oriented toward the north supplies more energy efficiency compared to single glazing window types. For total energy loads, the rate result came up maximum by 12.2% for B2.4.N50% block. Usage of double glazing is more effective to decrease heating loads compared to cooling and total energy loads. With increased transparency ratios its effectiveness decreases for cooling loads. It is same for blocks with coated double glazing window types. However, usage of coated double glazing window types at scenario blocks oriented toward the north provides more energy efficiency than double glazing at total. For total energy loads, the rate result came up maximum by 25% for C2.4.N50%. Usage of coated double glazing is more effective to decrease heating energy loads when compared with cooling and total energy loads. It is least effective to decrease cooling energy loads. As a result usage of coated double glazing is the most effective to decrease energy loads and with increased transparency ratios its effectiveness increase too for total energy loads.

Table 3.2 Energy saving rates of the scenario blocks for Erzurum province

B1 Scenario Double Glazing	**Energy Saving Rates (South)**			**B2Scenario Double Glazing**	**Energy Saving Rates (North)**		
	Heating	**Cooling**	**TOTAL**		**Heating**	**Cooling**	**TOTAL**
Block S20%	23.9%	6.7%	21.4%	Block N20%	23.9%	6.7%	21.4%
Block S30%	26.2%	5.4%	22.7%	Block N30%	25.6%	4.9%	22.8%
Block S40%	28.4%	5.4%	25.2%	Block N40%	27.1%	3.1%	23.7%
Block S50%	30.5%	4.6%	25.2%	Block N50%	28.5%	1.3%	24.6%
C1 Scenario C. Double Glazing	**Energy Saving Rates (South)**			**C2 Scenario C. Double Glazing**	**Energy Saving Rates (North)**		
	Heating	**Cooling**	**TOTAL**		**Heating**	**Cooling**	**TOTAL**
Block S20%	33.8%	27.6%	32.9%	Block N20%	33.8%	27.6%	32.9%
Block S30%	36.7%	26.5%	35%	Block N30%	36.4%	24.8%	34.8%
Block S40%	39.5%	25.3%	36.9%	Block N40%	38.8%	22.3%	36.5%
Block S50%	42.3%	23.9%	38.6%	Block N50%	41%	19.7%	38%

Energy Saving Rates: According to table 3.2 for Erzurum province, usage of double glazing at scenario blocks oriented toward the south supplies more energy efficiency compared to single glazing window types. For total energy loads, the rate result came up maximum by 25.2% for B1.3.S40% and B1.4.S50% blocks. Usage of double glazing is more effective to decrease heating loads compared to cooling and total energy loads. With increased transparency ratios its effectiveness decreases for cooling loads. On the other hand, usage of coated double glazing window types at scenario blocks oriented toward the south supply more energy efficiency compared to double glazing window types at total. For total energy loads, the rate result came up maximum by 38.6% for C1.4.S50%. Usage of coated double glazing is more effective to decrease heating loads compared to cooling and total energy loads. It is least effective to decrease cooling loads. In general usage of coated double glazing is the most effective to decrease energy loads and with increased transparency ratios its effectiveness increase too for total energy loads.

For scenario blocks oriented toward the north as like south facing blocks, usage of double glazing at scenario blocks oriented toward the north supplies more energy efficiency compared to single glazing window types. According to Table 3.2, the energy

saving rateresult for total energy loads came up maximum by 24.6% for B2.4.N50% block. Usage of double glazing is more effective to decrease heating loads when compared to cooling and total loads. With increased transparency ratios its effectiveness decreases for cooling loads. Even for B2.4.N50% block there is almost no energy efficiency for cooling energy load, by 1.3 %. Usage of coated double glazing window types at scenario blocks oriented toward the north supply more energy efficiency when compared to double glazing window types at total. For total energy loads, the rate result came up maximum by 38% for C2.4.N50%. Usage of coated double glazing is more effective to decrease heating loads when compared to cooling and total energy loads. It is least effective to decrease cooling energy loads. As a result, usage of coated double glazing is the most effective to decrease energy loads and with increased transparency ratios its effectiveness increase too for total energy loads.

Table 3.3 Energy saving rates of the scenario blocks for Istanbul province

B1 Scenario Double Glazing	**Energy Saving Rates (South)**			**B2Scenario Double Glazing**	**Energy Saving Rates (North)**		
	Heating	**Cooling**	**TOTAL**		**Heating**	**Cooling**	**TOTAL**
Block S20%	25.2%	7.3%	16.6%	Block N20%	25.2%	7.3%	16.6%
Block S30%	27.8%	5.7%	16.6%	Block N30%	27%	6.2%	17%
Block S40%	29.8%	6.3%	17.3%	Block N40%	28.8%	5.2%	17.4%
Block S50%	31.9%	5.9%	17.5%	Block N50%	30.4%	4.2%	17.6%
C1 Scenario C. Double Glazing	**Energy Saving Rates (South)**			**C2 Scenario C. Double Glazing**	**Energy Saving Rates (North)**		
	Heating	**Cooling**	**TOTAL**		**Heating**	**Cooling**	**TOTAL**
Block S20%	35.6%	23.9%	30%	Block N20%	35.6%	23.9%	30%
Block S30%	39.2%	23.5%	31.3%	Block N30%	38.4%	22.6%	30.8%
Block S40%	41.9%	22.8%	31.8%	Block N40%	41.2%	21.3%	31.6%
Block S50%	32.1%	22.1%	32.3%	Block N50%	43.8%	20%	32.2%

According to table 3.3 for Istanbul province, usage of double glazing at scenario blocks oriented toward the south supplies more energy efficiency when compared to single glazing window types. For total energy loads, the rate result came up maximum by 17.5% for B1.3.S40% and B1.4.S50% blocks. Usage of double glazing is more effective to decrease heating loads when compared to cooling and total energy loads. With

increased transparency ratios its effectiveness on cooling loads decreases. On the other hand, usage of coated double glazing window types at scenario blocks oriented toward the south provides more energy efficiency when compared to double glazing window types at total. For total energy loads, the energy saving rate result came up maximum by 32.3% for C1.4.S50%. Usage of coated double glazing is more effective to decrease heating loads when compared to cooling and total energy loads. With increased transparency ratios its effectiveness decreases for cooling loads as like double glazing. In general usage of coated double glazing is the most effective to decrease energy loads and with increased transparency ratios its effectiveness increase too for total energy loads.

For scenario blocks oriented toward the north as like south facing blocks, usage of double glazing at scenario blocks oriented toward the north supplies more energy efficiency when compared to single glazing window types. For total energy loads, the rate result came up maximum by 17.6% for B2.4.N50% block. Usage of double glazing is more effective to decrease heating loads when compared to cooling and total energy loads. With increased transparency ratios its effectiveness decreases for cooling loads. On the other hand, usage of coated double glazing window types at scenario blocks oriented toward the north supply more energy efficiency compared to double glazing window types at total. For total energy loads, the rate result came up maximum by 32.2% for C2.4.N50%. Usage of coated double glazing is more effective to decrease heating loads compared to cooling and total energy loads. With increased transparency ratios its effectiveness decreases for cooling energy loads as like double glazing. As a result, usage of coated double glazing is the most effective to decrease energy loads and with increased transparency ratios its effectiveness increase too for total energy loads.

CHAPTER 4

THE RESEARCH RESULTS OF THE SCENARIO BLOCKS

Within the scope of this thesisstudy, it isresearched that impact of changed transparency ratios and different glazing types on building energy performance for different climatic zones in Turkey. With using building energy simulation software programs DesignBuilder and EnergyPlus, annual heating, cooling and total energy load (heating + cooling) calculations were done for created scenario blocks.

Hypothesis of this thesis study is “Change of transparency ratio of south and north sides of structure effects building energy performance more than change of glazing types of windows.” Besides, sub research topic is“Transparency ratio increase at both south and north facade of structures is proportional to energy load increase.” After investigation of all results, reached research results with depending on these issues. In general, it is obviously seen that in some cases, change of transparency ratio is more effective than change of glazing types on building performance mostly on cooling energy loads of all scenario blocks with oriented toward the south in all provinces and blocks with oriented toward the north in Istanbul.

For blocks oriented toward the south in hot climate, especially high amount of solar heat gains is occurred as an unwanted energy parameter. With increased transparency ratios, these gains increase too. So that, glazing size in other words, transparency ratio have important role on cooling energy loads. On the other hand, changed glazing typesaffect heating and total energy loads (heating+cooling) more than changed transparency ratio. This situation is clearly seen at blocks oriented toward the north in Erzurum province. With usage of coated double glazing type (low U value) at blocks, energy loads decreased.

Research resultscan be summarized as follows:

- For A1, B1 and C1 scenario blocks oriented toward the south,because of high amount of solar heat gains from south facades of blocks, blocks in Antalya province have the lowest heating load values for all glazing types.
- For A1, B1 and C1 scenario blocks oriented toward the south, blocks of Erzurum have the highest heating load values.Considering these scenario blocks, while all scenario blocks by 20% transparency ratio have the highest heating load values, blocks by 50% transparency ratio have the lowest heating load values. In other words, with increased transparency ratios, heating energy loads decrease. All scenario blocks by 50% transparency ratio have the highest total energy load values.
- If considering cooling energy load values of A1, B1 and C1 scenario blocks, depending on solar heat gains from south facades, with increased transparency ratios cooling energy loads increase and by 50% window/wall area ratio they reach the highest value for all scenario blocks in provinces. Although usage of double and coated double glazing types at scenario blocks provides decreases for cooling loads, with increased transparency ratios cooling energy loads increase. With increased transparency ratios because of incremental demand for cooling energy, total energy loads (heating + cooling) increase.
- For A2, B2 and C2 scenario blocks oriented toward the north, depending on heat losses from north facades with increased transparency ratiosheating energy loads increased except for blocks with coated glazing types in Istanbul. It is seen that changed U values of glazing have great impact more than changed transparency ratios on heating energy loads both at blocks with single and double glazing in Istanbul and for all other blocks oriented toward the north.
- If considering cooling energy load values of A2, B2 and C2 scenario blocks even if they oriented toward the north, it is seen that solar heat gains from south facades of these blocks. Depending on it, cooling energy loads of scenario blocks with increased transparency ratios increase. Increased transparency ratios make only a small contribution to increase cooling energy loads for blocks in Antalya and Erzurum, blocks in Istanbul are more affected.
- Considering effects of used glazing types on the energy performance of the structures, the most energy saving came up with blocks with coated double glazing for all scenario blocks. By coated double glazing, heating energy load values

ofscenario blocks in Antalya province goes down by 50%. The least energy saving came up with blocks with single glazing window types. The result was occurred that transparency ratios must be kept minimum as much as possible, for this study 20% at north facades especially for blocks oriented toward the north. Besides, transparency ratios can be more increased at south facades for same scenario blocks.

- While changed transparency ratio effects on heat gains more than heat losses, changed glazing types effects on heat losses more than heat gains. This situation is seen predominantly in blocks oriented toward the south.
- For blocks oriented toward the north,double and coated double glazings areespecially effective for decreasing heating energy loads with preventing major heat losses throughout windows located at north facades. These effects are more clearly seen for blocks in cold climate.
- For blocks oriented toward the south, double and coated double glazing are especially effective for decreasing cooling energy loads with preventing major solar heat gains throughout windows located at south facades. Comparing same scenario blocks oriented toward the same directionwithin same provinces, these effects aremore clearly seen.Whencomparing same scenario blocks oriented toward as the south or the north within same provinces these effects are fewer.
- To increase building energy performance of structures, minimizing transparency ratio at south facades, for this study 20%, for blocks oriented toward the south except blocks in Erzurum, and minimizing transparency ratio at north facades, for this study 20%, for blocks oriented toward the north were came up as an energy efficient approach.
- It can be used more transparencyat south facades for blocks oriented toward the north in the cold climate. For blocks oriented toward the south in the hot climate, it can be used more transparencyat north facades.
- For all scenario blocks oriented toward the south in provinces, maximizing window/wall are ratios (50%) at south sides is not suitable in terms of energy efficiency for both cooling and totalenergy loads (heating + cooling) of scenario blocks.
- For all scenario blocksoriented toward the north in provinces maximizing window/wall are ratios (50%) at north sides is not suitable in terms energy efficiency for total energy loads.

CHAPTER 5

RESULTS AND DISCUSSION

When indicate research results in this part, all tables, findings and results are considered together and each of them analyzed deeply. After totalevaluation of them finally general research results were investigated.

5.1 Genereal Researh Results

General research results can be summarized as follows:

- When north and south facades are compared among between themselves, while heat gains aregreater in south facades, heat losses are greater in north facades in general. This causes for changes in heating, cooling and total energy loads (heating + cooling) of designed structures.Another major reason of changes in energy load values is used different glazing types for scenario blocks.
- In general, when compared A1, B1 and C1 scenario blocks within themselves total energy load values of blocks with single glazing are higher than other blocks. The lowest energy load values belong to blocks with coated double glazing. This result was also occurred for A2, B2 and C2 scenario blocks. Used different glazing types affected energy load results very clearly.
- Increase in window/wall area ratio on the north facade causes both cooling and heating energy loads increasing for blocks oriented toward the north, and it is not an energy efficient approach in general, as it significantly increases the heating energy loads.
- Especially window/wall area ratios of buildings in cold climate should be as minimal as possible and windows should be placed on south side to reach optimum heat gain and heat loss situation.

- In terms of energy saving, usage of coateddouble glazing type is more effective on energy loads especially for decreasing heating energy loads at cold climatic region which is in this study Erzurum, and using it at north side of structure is more logical.
- Changed transparency ratio effects on heat gains more than heat losses. However, changed glazing types effects on heat losses more than heat gains. This situation is seen predominantly in blocks oriented toward the south.
- In terms of energy saving, usage of coated double glazing type came up as the most effective glazing type on energy loads for all scenario blocks in provinces.
- It has been observed that, each region has a unique climate zone, and structures should be designed according to these properties. Beside the importance of window/wall ratio, in other words, transparency ratio, selected regions, used insulation materials and general materials, as well as orientations also have big impacts on energy loads and building energy performance.

5.2 Discussion and Recommendations

With this thesis study, it is created an example study for those energy issues parameters; energy loads and surface window heat gain/loss energy. Those parameters were analyzed for created scenario blocks and reached research results. One of the aims of this study was exploring the best conditions for scenario blocks in terms of building energy performance. For created scenario blocks with used three different glazing types and selected two orientations these conditions were given in research results part. However, in terms of used glazing types, these scenario blocks created completely just with single, double or coated double glazing window types. It is just estimated that, if blocks were designed mixed glazing types, building energy performance would be increase. If we give an example, for block oriented toward the north in Erzurum province by 50% transparency ratio with coated double glazing, namely C2.4.N50%, instead of using coated double glazing for whole block, for south and west side double glazing could be used. So that combining glazing types could be more effective in terms ofenergy performance. Besides, if heat gain/loss energy situation was not just calculatedfor south and north facades of blocks, effects of east and west facades could be seen and this could be provide an ease tounderstandresearch results.In the future, who wants study on similar issues; it is highly recommended that those issues mentioned above for their study. Besides, it is recommended that not working with just one simulation program,two or more developed one is better.

This study and similar ones will help during the architectural design process and reconstruction of existing buildings as energy efficient.As the whole world has a mutual consciousness about energy saving, energy efficiency is now more important than ever before. Many studies and researches have continued in this field. With the help of technology, the scope of these studies will continue to increase. Thus, all advantages and opportunities of the technology should be used. Today, as mentioned before in the Literature Review section, there are a lot of similar programs to the DesignBuilder program. When choosing a method for this, the most important thing is that the program used should be reliable and qualified. With the help of thosekinds of energy simulation programs, understanding the climatic characteristics of a region and carrying out the design process (different than the standards in a more detailed way) has great importance.

Energy saving, with this awareness, should be done not just in the construction or architecture sectors where energy efficient design and related studies are carried out but in every sector. Trade associations, universities, companies, organizations, architects, engineers, utilities, students, building-related professionals, and individuals (in short, all of humanity) should work towards this aim and be aware of the importance of energy conservation.

REFERENCES

[1] Yelmen, B. and Çakır, M., T., (2011). "Yenilenebilir ve Etkin Enerji Kullanımın Yapılarda Uygulanması", 2nd National Energy Efficiency Forum and Fair, 13-15 January 2011, Istanbul.

[2] World Business Council For Sustainable Development (WBCDS), (2009).Transforming the Market: Energy Efficieny in Buildings, 2009,http://wbcsdpublications.org/project/transforming-the-market-energy-efficiency-in-buildings, 13 March 2016.

[3] British Petroleum (BP), (2007). Statistical Review of World Energy, June 2007,http://www.bp.com/statisticalreview, 15 March 2016.

[4] Tubitak, (2003).Vizyon 2023 Teknoloji Öngörüsü Projesi Enerji ve Doğal KaynaklarPaneli Ön Rapor, July 2003, Ankara, https://www.tubitak.gov.tr/tubitak_content_files/vizyon2023/edk/ekler.pdf, 12 March 2016.

[5] Uyar, T.S., (2004), Yenilenebilir Enerji Kaynakları, 2004, www.bugday.org, 10 March 2016.

[6] EECB, (2007). The Energy Efficiency Law No.5627 of Turkey, Energy Efficiency Coordination Board, Republic of Turkey Ministry of Energy and Natural Resources,Ankara.

[7] TS 825, (2009). Thermal Insulation Requirements in Buildings, Turkish Standards Institute, Ankara.

[8] Uğurlu, Ö. and Örçen, İ., (2007). "Küresel IsınmanınTürkiye'nin Enerji Kaynaklarına Olası Etkisi" TMMOB Türkiye VI. Enerji Sempozyumu: Küresel Enerji Politikaları ve Türkiye Gerçeği, 22-24 October 2007, Ankara.

[9] Gürsoy, U., (2004). "Enerjide Toplumsal Maliyet ve Temiz ve Yenilenebilir Enerji Kaynakları", Turkish Medical AssociationPublications, ISBN 975-6984-69-4, First Edition, Central Council of Turkish Medical Association, Ankara.

[10] General Management of Renewable Energy (EIE),Potential Renewable Energy Atlases, Solar Energy Potential Atlas of Turkey, www.eie.gov.tr, 20 March 2016.

[11] General Management of Renewable Energy (EIE), Hidroelectricity Energy Potential of Turkey, http://www.eie.gov.tr/hidroelektrik.htm, 10 April 2016.

[12] Turkish Electricity Transmission Company (TEIAS), 2015 Production Consumption Comparison, http://www.teias.gov.tr/,10 April 2016.

[13] Yılmaz, Y., (2009). Farklı İklim Bölgelerinde Bir İlköğretim Tip Projesinin Enerji Etkin Geliştirilmesine Yönelik Uygulama Örneği, Master's Thesis, ITU, Graduate School of Science Engineering and Technology, İstanbul.

[14] Yu, J., Tian, L., Yang, C. and Dan, L., (2008), Evaluation on Energy and Thermal Performance for Residential Envelopes in Hot Summer and Cold Winter Zone of China, Applied Energy, 86 (16): 1970-1985.,http://www.sciencedirect.com/science/article/pii/S0306261909000245,15 April 2016.

[15] Eskin, N. and Türkmen, H, (2003). "Konut Dışı Binaların Soğutma Yüklerinin Transfer Fonksiyonu Yöntemi ile Hesaplanması", VI. Ulusal Tesisat Mühendisliği Kongresi ve Sergisi, 8-11 October 2003, İzmir.

[16] Gasparella, A., Pernigotto G., Cappelletti F., Romagnoni P. and Baggio P., (2010). "Analysis and Modelling of Window and Glazing Systems Energy Performance for a Well Insulated Residential Building", 65th ATI National Congress, September 2010, Cagliari.

[17] Tavares, A., F. and Martins, O., G., (2007)."Energy Efficient Building Design Using Sensitivity Analysis-A Case Study", Energy and Buildings, 39 (1): 23-31., http://www.sciencedirect.com/science/article/pii/S0378778806001381,10 March 2016.

[18] Carriere, M., Schouenau, G., J. and Besant, R., W., (1999)."Investigation of Some Large Building Energy Conversation Opportunities Using the DOE-2 Model", Energy Conversion and Management, 40 (1999): 861-872.,http://www.sysecol2.ethz.ch/OptiControl/LiteratureOC/Carr_99_ECM_40_861.pdf, 10 March 2016.

[19] Inanici, M., N., and Demirbilek, F., N., (1998). "Thermal performance Optimization of BuildingAspect Ratio and South Window Size in Five Cities Having Different ClimaticCharacteristics of Turkey", Building and Environment, 35 (1): 41-52., http://www.sciencedirect.com/science/article/pii/S0360132399000025, 12 March 2016.

[20] Bülow-Hübe, H., (2001). Energy Efficient Window Systems, Doctoral Dissertation, Lund University, Lund Institute of Technology, Lund.

[21] Design Builder, Building Design, Simulation and Visualition, www.designbuilder.co.uk,5 March 2016.

[22] UK NCM, (2008). Energy Performance of Buildings Directive, United Kingdom National Calculation Method, London.

[23] Turkish State Meteorological Service, Official Statistics, Actual Average Values (1950-2015), http://www.mgm.gov.tr/veridegerlendirme/İl-ve_ilceler-istatistik.aspx, 3 March 2016.

[24] Uctea Chamber of Mechanical Engineers, (2009), Klimaları Tanıyalım, http://www.mmo.org.tr/genel/bizden_detay.php?kod=7735, 2 February 2016.

[25] ASHRAE/IWEC, (2002). The International Weather for Energy Calculation, AmericanSociety of Heating, Refrigereting and AirConditioning Engineers, Atlanta.

[26] Atalay, İ., (1997). "Türkiye Coğrafyası", Ege Üniversitesi Basımevi.

[27] Sensoy, S., Demircan, M. and Ulupınar Y. (2008). "Climate of Turkey", Climate of Turkey, (2007),Turkish State Meteorological Service, http://www.dmi.gov.tr/index.aspx, 18 April 2016.

[28] Demirbilek, F., N., and Irklı, D., (1999), Güneş Mimarlığı, Publications on Clear Energy, Habitat Association, http://www.habitatdernegi.org/tr/dl/yayin/TemizEnerjiYayinlari/Gunes_Mimarligii.pdf, 20 September 2016.

APPENDIX-A

INTRODUCING OF DESIGNBUILDER PROGRAM

DesignBuilder software is a building energy simulation tool in industry standard. With help of EnergyPlus software user interface program it provides access to all of the most commonly required simulation capabilities covering building fabric, thermal mass, glazing, shading, renewables, HVAC and financial analysis. Lots of parameters can be calculated such as heaitng, cooling, lighting, daylighting, surface temperatures etc. The software comes with UK NCM and ASHRAE construction, activity and schedule databases [20].

For this thesis study, first of all, structures were created as 3D with selected building envelopes and orientations via versions of Designbuilder 5.0.1.024 and EnergyPlus8.5 software programs.After, standard domestic activity was selected from ASHRAE standards for these created scenario blocks. Heating, cooling, ventilation, condensation and material selection have been selected considering based on Turkish Standards TS 825. When modeling buildingsthe interior climate comfort data set in accordance with UK NCM, and it has been adapted to Turkey based on temperature threshold determined by TS 825 and Turkish Chamber of Mechanical Engineering Association.

Lastly, for selected provinces which are Antalya, Erzurum and Istanbul, external climate data are taken from ASHRAE/IWEC which belongs to year 2002.

APPENDIX-B

EXTERNAL CLIMATE DATAS FOR SELECTED PROVINCES

For this thesis study, as mentioned before, external climate data are taken from ASHRAE/IWEC which belongs to year 2002. Data were selected from database of the DB program. For three provinces, Antalya, Erzurum and Istanbul of Turkey, where the application was made, hourly average temperatures data tables are given below.

Table B.1The hourly average weather temperature data for Antalya province

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0:01-1:00	9.8	8.8	10.7	13.9	18.2	21.6	24.2	25.0	22.6	18.4	14.8	10.9
1:01-2:00	9.6	8.4	10.4	13.3	17.7	21.0	24.0	24.5	21.9	18.1	14.4	10.8
2:01-3:00	9.5	8.1	10.2	13.0	17.6	20.6	23.6	24.1	21.3	17.8	14.3	10.7
3:01-4:00	9.3	8.1	10.0	12.5	17.4	20.2	23.3	23.7	21.0	17.6	14.1	10.5
4:01-5:00	9.2	8.1	9.8	12.3	17.2	19.8	22.9	23.3	20.6	17.3	13.9	10.3
5:01-6:00	9.3	8.1	10.5	13.0	18.7	21.5	24.5	24.5	21.8	18.6	13.7	10.6
6:01-7:00	9.5	8.2	11.2	14.9	20.3	23.4	26.4	26.2	23.2	20.0	14.0	10.8
7:01-8:00	9.6	9.5	12.0	18.0	21.9	25.3	28.3	28.1	25.5	21.3	15.4	11.0
8:01-9:00	11.4	12.2	13.4	19.6	22.6	26.0	29.1	29.0	26.9	22.7	18.2	13.1
9:01-10:00	13.1	14.0	14.7	20.6	23.3	26.8	29.8	30.0	27.9	24.2	19.8	15.1
10:01-11:00	15.1	15.2	16.1	21.5	24.0	27.5	30.5	30.8	28.8	25.7	20.9	17.1
11:01-12:00	15.1	15.7	16.2	21.6	24.1	27.7	30.8	31.0	29.1	25.7	21.0	17.3
12:01-13:00	15.2	15.8	16.3	21.5	24.4	27.9	31.1	31.7	29.3	25.7	21.2	17.5
13:01-14:00	15.5	15.8	16.4	21.5	24.6	28.1	31.2	32.1	29.6	25.8	21.4	18.0
14:01-15:00	15.0	15.7	16.0	20.9	24.1	27.9	30.7	31.6	29.2	25.2	20.8	17.2
15:01-16:00	14.4	15.4	15.6	20.8	23.7	27.7	30.3	31.0	28.7	24.6	20.2	16.5
16:01-17:00	13.9	14.7	15.3	20.2	23.2	27.5	29.9	30.4	28.2	23.9	19.3	15.8
17:01-18:00	13.0	13.7	14.4	19.4	22.5	26.6	28.8	29.5	27.1	22.9	18.6	14.8
18:01-19:00	12.1	13.0	13.5	18.2	21.8	25.7	27.7	28.5	26.2	21.8	17.7	13.7
19:01-20:00	11.2	11.6	12.6	17.2	21.0	24.7	26.6	27.6	25.4	20.7	17.0	12.7
20:01-21:00	10.9	11.0	12.0	16.4	20.4	24.1	26.1	27.0	24.8	20.2	16.1	12.2
21:01-22:00	10.5	10.3	11.6	15.6	19.8	23.5	25.4	26.4	24.1	19.6	15.7	11.7
22:01-23:00	10.2	9.7	11.3	14.9	19.2	23.0	24.9	25.9	23.5	19.0	15.4	11.2
23:01-24:00	10.0	9.1	11.0	14.4	18.7	22.4	24.5	25.5	23.0	18.6	14.9	11.1

TableB.2The hourly average weather temperature dataforErzurum province

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0:01-1:00	-11.0	-10.9	-7.4	3.2	10.3	14.2	16.3	14.2	9.3	4.4	-4.4	-8.0
1:01-2:00	-11.1	-11.1	-7.7	2.9	9.7	13.7	15.9	13.7	9.1	4.1	-4.6	-7.9
2:01-3:00	-11.2	-11.3	-8.0	2.5	9.1	13.3	15.5	13.3	9.0	3.9	-4.7	-7.9
3:01-4:00	-11.3	-11.6	-8.3	2.2	8.5	12.8	15.1	12.8	8.8	3.6	-4.8	-7.9
4:01-5:00	-11.4	-11.7	-8.4	2.2	9.1	13.6	16.0	13.0	8.9	3.4	-5.0	-7.8
5:01-6:00	-11.5	-11.8	-8.5	2.2	9.7	14.4	16.5	13.2	8.8	3.1	-5.2	-7.7
6:01-7:00	-11.5	-12.0	-8.6	2.1	10.3	15.3	17.1	13.5	8.8	2.9	-5.4	-7.7
7:01-8:00	-11.5	-11.5	-7.8	3.4	12.1	16.8	18.6	15.2	10.3	3.6	-5.2	-7.6
8:01-9:00	-11.5	-11.5	-7.1	4.7	14.0	18.4	20.1	17.0	11.7	4.3	-4.9	-7.5
9:01-10:00	-11.4	-11.2	-6.3	5.9	15.8	20.0	21.6	18.8	13.1	5.0	-4.7	-7.5
10:01-11:00	-10.8	-10.3	-5.3	7.0	16.8	21.0	22.4	19.9	14.1	5.9	-3.9	-7.3
11:01-12:00	-10.1	-9.3	-4.2	8.0	17.8	22.0	23.2	20.9	15.2	6.8	-3.1	-7.1
12:01-13:00	-9.4	-8.4	-3.1	9.0	18.9	22.9	24.0	22.0	16.2	7.8	-2.2	-6.9
13:01-14:00	-9.4	-8.0	-2.6	9.4	19.0	22.9	24.0	22.2	16.0	8.0	-2.1	-6.9
14:01-15:00	-9.2	-7.7	-2.1	9.7	19.1	22.9	24.2	22.4	16.2	8.2	-2.0	-6.9
15:01-16:00	-9.0	-7.4	-1.7	10.0	19.1	22.9	24.5	23.0	16.5	8.4	-1.9	-7.0
16:01-17:00	-9.3	-8.1	-2.2	9.6	18.7	22.5	24.0	22.2	15.7	7.8	-2.4	-7.3
17:01-18:00	-9.7	-8.8	-2.7	9.1	18.2	22.1	23.4	21.5	14.9	7.2	-2.9	-7.7
18:01-19:00	-10.0	-9.5	-3.3	8.6	17.7	21.6	22.8	20.7	14.0	6.6	-3.4	-8.0
19:01-20:00	-10.3	-9.8	-4.0	7.5	16.1	20.2	21.5	19.2	12.8	6.0	-3.7	-8.2
20:01-21:00	-10.6	-10.1	-4.7	6.4	14.6	18.9	20.2	17.7	11.6	5.5	-4.0	-8.3
21:01-22:00	-10,9	-10,4	-5.4	5.2	13.1	17.5	18.9	16.2	10.4	4.9	-4.2	-8.4
22:01-23:00	-11.0	-10.6	-5.8	4.7	12.2	16.4	18.1	15.5	9.9	4.6	-4.3	-8.4
23:01-24:00	-11.1	-10.9	-6.3	4.2	11.3	15.3	17.2	14.8	9.4	4.3	4.3	-8.3

Table B.3The hourly average weather temperature data for Istanbul province

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0:01-1:00	5.3	4.2	6.0	10.5	14.7	19.3	21.7	22.1	18.7	14.4	10.6	7.2
1:01-2:00	5.3	3.9	5.8	10.2	14.4	18.9	21.4	21.8	18.4	14.5	10.5	7.3
2:01-3:00	5.2	3.8	5.7	10.0	14.3	18.6	21.3	21.6	18.2	14.5	10.4	7.2
3:01-4:00	5.1	3.9	5.6	9.8	14.2	18.3	21.1	21.5	17.9	14.5	10.3	7.2
4:01-5:00	5.1	4.0	5.4	9.6	14.0	18.1	20.9	21.4	17.7	14.4	10.4	7.1
5:01-6:00	4.9	3.8	5.5	9.8	14.6	19.1	21.4	21.9	17.9	14.2	10.3	7.2
6:01-7:00	4.9	3.6	5.7	10.1	15.2	20.2	22.3	22.6	18.5	14.2	10.3	7.2
7:01-8:00	5.0	3.6	6.1	10.8	15.8	21.3	23.0	23.3	19.6	14.9	10.7	7.3
8:01-9:00	5.3	4.4	6.9	11.7	16.5	22.1	23.9	24.3	21.3	16.7	11.3	7.8
9:01-10:00	5.9	5.1	7.5	12.6	17.2	22.6	24.9	25.3	22.4	17.8	11.9	8.2
10:01-11:00	6.5	5.6	8.2	13.6	18.0	23.3	26.0	26.4	23.3	18.8	12.5	8.6
11:01-12:00	6.8	6.2	8.7	14.1	18.6	23.9	26.5	26.7	23.9	19.1	12.8	8.8
12:01-13:00	7.2	6.4	9.2	14.6	19.2	24.3	27.4	27.0	24.4	19.6	13.2	9.1
13:01-14:00	7.1	6.7	9.4	15.1	19.8	24.8	27.8	27.6	24.4	19.6	13.0	9.0
14:01-15:00	7.1	6.6	9.4	15.4	19.8	24.7	27.7	27.4	24.3	19.8	13.2	9.1
15:01-16:00	6.8	6.4	9.3	15.3	19.7	24.3	27.5	27.2	24.0	19.1	12.8	8.8
16:01-17:00	6.4	6.0	9.2	15.0	19.7	24.5	27.1	27.0	23.3	18.4	12.4	8.7
17:01-18:00	6.1	5.4	8.5	14.2	18.8	23.6	26.0	26.0	22.3	17.3	11.9	8.4
18:01-19:00	5.6	4.9	7.9	13.3	17.9	22.7	25.2	24.9	21.2	16.6	11.3	8.0
19:01-20:00	5.6	4.7	7.3	12.4	17.0	21.9	24.2	23.9	20.2	15.8	10.9	7.7
20:01-21:00	5.6	4.6	7.9	13.3	17.9	22.7	25.2	24.9	21.2	16.6	11.3	8.0
21:01-22:00	5.2	4.5	6.9	11.4	16.0	20.8	22.8	23.1	19.5	15.5	10.7	7.3
22:01-23:00	5.2	4.4	6.6	10.9	15.4	20.3	22.4	22.8	19.2	15.2	10.7	7.1
23:01-24:00	5.1	4.3	6.3	10.8	15.2	19.8	22.1	22.4	18.9	14.6	10.4	7.1

CURRICULUM VITAE

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EDUCATION

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Undergraduate	Interior Architecture and Environmental Design	Ihsan Doğramacı Bilkent University	2012
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WORK EXPERIENCE

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2013-2013	Tuhan Mimarlık	Interior Architect/Designer
2012-2013	Doğru Tasarım Mimarlık	Interior Architect/Designer

PUBLISHMENTS

Conference Papers

1.Aydinol, F.A.Z. and Gedik, G., Z., (2016). “Impact of Different Transparency Ratios of Building Envelope on Building Energy Performance in Various Climatic Zones”, 9th International Conference on Sustainable Energy & Environmental Protection (SEEP), 22-24 September 2016, Kayseri.