The Effect of Orientation on Cooling Load in Hot Dry Climate Regions; Diyarbakır Şilbe Mass Housing Example

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ABSTRACT
The share of the housing sector in the world's total energy consumption has reached 20%. In recent years, the construction sector has turned its face to an environmentally friendly design. This method, also known as energy efficient design, has become widely used today in the world. Which has a wide network in the housing sector in Turkey and many shares the annual energy consumption of mass housing settlement houses produce every year is very high. Therefore, it is thought that more energy efficiency will be provided by using energy efficient building design methods in residential units such as Mass Housing rather than single buildings. In this context Şilbe I. Stage Mass Housing settlement area located in the city of Diyarbakır was chosen as the study area. 100 m2 housing plans, which offer different orientation alternatives among the housing typologies, were selected. Within the scope of the study, Design Builder Energy Simulation Program was used to analyze the energy loads. This study has been carried out due to the limited number of studies emphasizing the optimal building orientation of the buildings relative to each other after the pre-design energy costs are calculated for each climate zone through simulation programs, especially in the production of social housing unit in Turkey.
Keywords: Mass Housing, Energy Efficient Design, Optimum Direction, Design Builder Simulation Software, Cooling Load.

1. INTRODUCTION
A dramatic increase in the use of fossil-based energy sources was observed with the industrial revolution. The consumption of fossil fuels has been shown as the biggest agent of climate change, especially global warming. As a result of industrial activities, it is claimed that approximately 20 billion tons of carbon dioxide, 100 million tons of sulfur, 2 million tons of lead and other chemical compounds are released into the atmosphere every year (Kadıoğlu and Tellioğlu, 1996). The increase in this ratio has increased the greenhouse gas components that are constantly present in the atmosphere, and accelerated the global warming threat causing extra warming of the earth's surface. It is thought that many sectors such as industry, agriculture, transportation and energy, especially the building sector, have tragically accelerated global climate change. Heating the building 36% of the total energy consumed in Turkey for cooling and illumination is used. In this way, the annual energy cost of the buildings exceeds $ 14 billion. However, it is stated that approximately 25% savings in total energy consumption can be achieved by using energy efficiently. The building sector accounts for 40% of global energy consumption; buildings in developed countries account for 35–40% of total energy consumption, 30–60% of which is used to regulate the indoor environment of buildings (Zhang at all., 2022; Wang at all., 2021; Jannat at all., 2020). It is stated that 45 million tons of carbon dioxide gas emission can be prevented annually if the buildings' energy efficiency is increased by 22% (Eicker, 2009). Energy efficiency improvements are an

important element to ensure sustainable development, however, there is a concern that global energy efficiency is on the decline, the 1.2% improvement in 2018 was around half the average rate is seen since 2010 (IEA 2019).

Mass housing settlements, which contain many houses and host many people, are widely accepted as an energy consumption line. It has been noted that during the construction and use phase of mass housing, it consumes almost 16% of the fresh water resources in the world, 25% of the flora population, and 30% of natural energy and material resources. Therefore, it is more rational to take measures from the construction of the building to the recycling of the building within the energy efficient design parameters of the houses that are produced by the Mass Housing Administration (TOKİ), which will produce many houses and will affect thousands of users simultaneously, rather than the measures taken according to the energy conservation and energy consumption of the buildings on a single residence basis. it is considered a solution.

Within the scope of the study, it is considered as the first mass housing settlement in Diyarbakır, which is located in the hot-dry climate zone, and is located in Şilbe 1st Stage Mass housing settlement, which is home to 2050 residences that started in 1994. housing type is handled. It is aimed to determine the optimum orientation for the hot-dry climate regions after determining the heating-cooling load expenses of the different orientation forms in the settlement texture by making numerical comparison and analysis through the Design Builder Energy Simulation Program. In addition, the fact those building design parameters will provide significant energy savings if environmental factors are considered in the first phase of the design is another purpose of the study. As a result of this study, it aimed to be a guiding source for the construction of buildings that are more climate and environment based and that can use energy more effectively through the measures taken in the first step of the building design process in the mass housing settlements to be produced later in the hot-dry climate region.

2. LITERATURE REVIEW

2.1. Energy Efficiency Design

Energy efficient building design can be defined as designing to use energy effectively and efficiently by using variable physical environmental data such as climate, direction and prevailing wind in the architectural design process (Pacheco at all., 2012). Energy-efficient building design requires the creation of active and passive control facilities suitable for the building, providing control to increase the performance of the building and provide energy conservation in heating-cooling-ventilation-natural lighting issues, determining the design criteria and making architectural designs in this context (Dikmen, 2011; Ashmawy, R.E., 2015; Ashmawy ve Azmy, 2018). In this context orientation, building forms, building materials, passive design strategies that researchers are trying to optimize in order to reduce energy consumption (Nguyen, Truong, Rockwood, & Tran Le, 2019; Abanda & Byers, 2016; Rashdi & Embi, 2016; Motealleh, Zolfaghari, & Parsaee, 2018; Kohansal at all., 2021). Energy Efficient Design Parameters are given in Figure 2. The user-related parameters are design parameters that aim to provide climatic comfort within the structure and are based on a certain standard and acceptance. Considering the user health, climatic comfort conditions should be handled first in the building design. The structure includes physiological factors such as user’s age, gender, race, heart rhythm, body temperature, sweating rate, and parameters that vary according to the quality and condition of the user. In Figure 1, energy efficient design criteria are given with sub parameters.

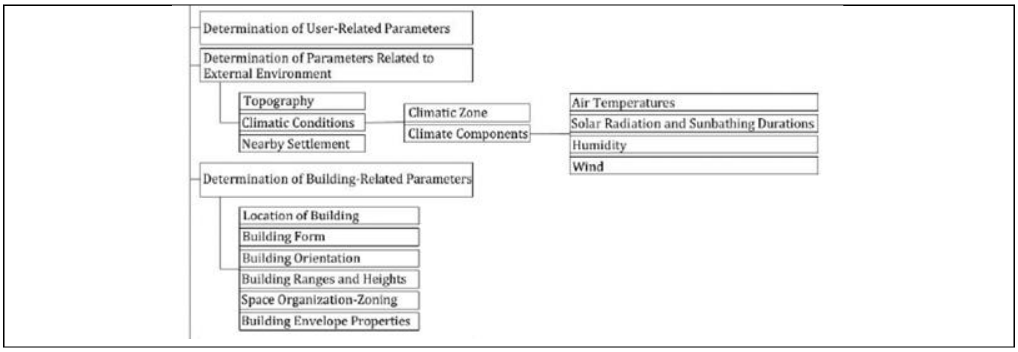


Figure 1. *Energy Efficient Design Parameters* (Ziya Yakut M, Esen S. 2019)

Energy-efficient design parameters are divided into three parameters for the user, the external environment and the building. Energy-efficient systems are divided into passive and active systems (Geetha ve Vadraj, 2012; Rodriguez-Ubinas, 2014; Goldman, 2016; DOE, 2022). Accordingly, a reference building was established as an example of application in the hot-humid climate zone so as to demonstrate the effect of energy-efficient design parameters on energy consumption. The reference building was designed to meet a building's energy requirements at a minimum in terms of the type of climate in which it is located. The parameters considered when creating the reference building are shown in Figure 1.

The reference buildings are located in a hypothetical topography in Diyarbakır province, which is in the hot-humid climate zone. In this type of climate, the consumption of cooling energy is more important than the consumption of heating energy. It was acted on by accepting that the building, which was located in a field exposed to intense solar radiation throughout the year, was not shaded by other buildings or obstacles.

Environmental factors have a direct impact on energy efficient design. In other words, many climatic components have an impact on annual energy costs, from climate to topography, topography to temperature and temperature to humidity. Perhaps the most important input of energy efficient design is the correct analysis of the external environment data during the preliminary design phase. Relationship parameters to the external environment; It is possible to classify as climate, solar radiation, outside temperature and humidity, wind, topography, landscape. Since the variables related to the inner environment directly affect the climatic comfort, they are shown among the important parameters. Climatic comfort is defined as the state of providing maximum environmental adaptation with minimum energy (Olgyay 1963). Therefore, the suitability of the parameters related to the internal environment has a direct effect on the climate comfort level of the user of the space. Parameters related to the internal environment; It is possible to classify it as indoor surface temperature, indoor air temperature and humidity and indoor air movement. The design parameters related to the construction environment, on the other hand, bring together an integrated design approach that includes many parameters from formal feature to building orientation, building envelope and space organization. If we detail the building design parameters of the built environment.

2.2. Design Parameters for Artificial Environment

A comparison of energy efficiency with non-energy-efficient buildings was carried out to evaluate the performance of buildings having a difference in orientation, construction materials, and architecture height (Khaliq and Mansoor, 2021). The location of the building; plays a decisive role on energy costs. Optimal building orientation is a very low-cost solution in architecture that can significantly reduce energy consumption in the building sector (Albatayneh, Alterman, Page, & Moghtaderi, 2018). Many studies highlight the impact of building orientation on energy saving. According to some researchers, the orientation of the design of the buildings has a significant impact on fuel consumption and cost reduction (Wong and Fan, 2013; Mardookhy at all., 2014; Abanda and Byers, 2016; Hashemian and Etemad, 2018). Research by some researchers suggests that proper orientation in buildings impacts on the fuel consumption in buildings up to 20% and in some cases to 36% (Fallahtafti and Mahdavinejad, 2015; Spanos at all., 2005).Building form is another parameter that directly affects energy costs. The form and size of a building have a sufficiently significant influence on energy consumption (Hachem at all., 2011; Joelsson, 2012; Catalina at all, 2011). As stated in the study of Kocagil et al. [4], the building Form and the envelope complexity directly impact the total heat loss and gain and consequently the energy consumption (Kocagil and Oral, 2015). In other words, the building form is effective on energy losses. The value obtained as a result of the proportion of the building envelope that protects the spaces from external factors by limiting the spaces to the building volume is highly effective in heat gain or loss (Göksal and Özbalta 2002; Fallahtafti and M. Mahdavinejad, 2014). In other words, as the building surface area increases, an increase in heat losses will be observed, that is, an increase in the surface / volume ratio will cause an increase in energy costs. As seen in Figure 2, the heat loss in the mass with the cubic building form is the least but the heat losses in the mass with the amorphous building form are the highest.

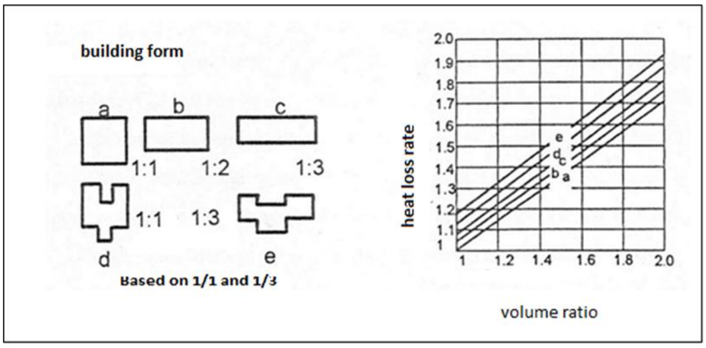


Figure 2. Changing Heat Loss Rate According to Different Plan Types (Burberry, 1999)

The results of the "left-air" orientation theory are used in the orientation of buildings or cities. This theory is defined as: 'When it comes to the optimum direction for any region, this direction is such a direction that it will receive a lot of solar radiation in a period when a facade facing that direction is not desired, and it will be optimally benefited from solar radiation at any time. (Berköz, 1973). In other words, after determining the climatic conditions of the place where the building will be built, it is prevailing that the annual heating-cooling load values will decrease if it is designed to provide maximum benefit from the solar radiation in the winter and the minimum in the summer.

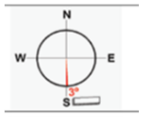
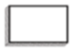
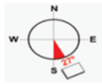
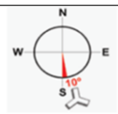
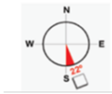
CLIMATE REGION	BUILDING FORM	BUILDING ORIENTATION
HOT-HUMID CLIMATIC REGION	 Surface open to the wind, close to a long rectangular	
HOT-DRY CLIMATE REGION	 Courtyard, Square surface	
DRY-TEMPERATE CLIMATIC REGION	 Closed to the wind when heating is required, compact form	
TEMPERATE-HUMID CLIMATE REGION	 Large surface to the wind in the period when heating is not desired,rectangular or free plan	
COLD CLIMATE REGION	 Compact or square plan, giving little surface to the wind	

Figure 3. Building forms and orientation situations according to different climatic regions (Zeren 1987)

After determining the climatic conditions of the region where the building will be built, the building orientation and form should be decided. In other words, when designing buildings in hot dry climatic regions, the courtyard and compact building form should be chosen. In this way, the undesirable effect of solar radiation will be minimized. In cold climate regions, compact forms providing heat gain should be preferred and the building surface should be exposed to a minimum wind effect. For mild humid areas, forms that will form as wide surfaces as possible to the wind should be designed. Likewise, building orientation should be designed in accordance with climatic conditions. It has been stated that the optimum orientation for the hot dry climate zones has an angle of 18^{o} from the north to the northeastern direction, and the directions that apply to this climate type may be the south, southwest and southeast directions. The slope of the local part suitable for the hot dry climate region ranges from 0^{o}-6^{o}. In the cold climate regions, the optimum orientation is determined to have an angle of 22^{o} from north to northeast direction, and it is stated that the valid directions may be south, southeast and southwest directions. In mild humid regions, the optimum orientation is determined to have an angle of 10^{o} from north to northeast direction and it is stated that valid directions may be south, southeast and southwest directions (Figure 3).

Depending on the actions to be taken in it, appropriate directions should be given to the spaces. The primary purpose of directing the building is to maximize solar gain in winter and to minimize in summer. In this way, climate cooling comfort will be provided and a decrease in cooling-heating loads will be observed. According to the climate zone in which it said will allow Turkey to take place optimization direction south and south directions are close. Since nearly 90% of the solar radiation that comes during the day in the fall period reaches the earth at around 9:00 am and 3:00 pm, there should be no obstacles on the solar radiation to make maximum use of solar energy. The control of solar radiation from the east and west is difficult compared to the south. The basic principle of the design is the proper solar control on these facades, and the planning of the building to form a wider facade on the east-west axis (Soysal 2009; Shick, 2009; Ashmawy and Azmy, 2018).

It is possible to classify the degrees of suitability of the volumes in terms of direct solar radiation. Locations such as living, bedroom, dining room, which are the most frequently used functionally, where the number of users are high and their usage times are spread over a large time period, should be located in the places close to south or south. On the other hand, it is possible to classify secondary degree places as wet spaces such as bathrooms and toilets. In Figure 5. degrees of suitability direction are classified. 1st degree suitable direction south, 2nd degree is determined as east-west directions. The most unfavorable direction in terms of suitability for the settlement was determined as the north direction (Figure 4)

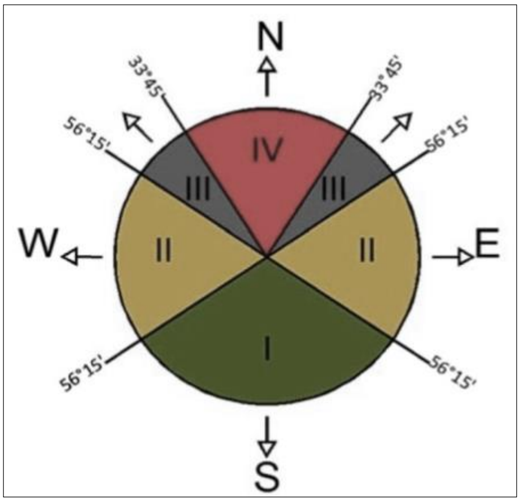


Figure 4. Space Organization and optimum direction classification (Berköz at all., 1995)

3. Study Area: Location and Climatic Features of the Province of Diyarbakır

Diyarbakir, separated by a sphere located on the northern hemisphere and the seventh is a city located in the geographic region of Turkey Southeastern Anatolia (Figure 5). Its position on the world is located 55 minutes North of the 37th latitude circle and 13 minutes east of the 40th Longitude circle.

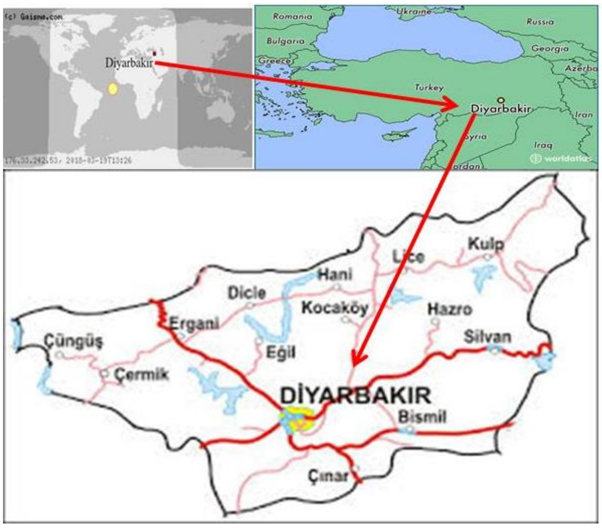


Figure 5. Location of Diyarbakir on the World(URL 1)

It is possible to categorize Diyarbakır province where the study area is located according to the climate classifications developed by different scientists. For example, according to Köppen Climate Classification Diyarbakır province: hot and dry climate CSA (Mediterranean Climate) is located in the dry climate region of Aydeniz climate classification. According to the classification made by Lütfi Zeren, Diyarbakır located in a warm-dry climate zone. Considering all the climate classifications, it is concluded that the terrestrial-arid climate, where the average temperature is high and the rainfall is low, is dominant in Diyarbakır.

Table 1. Climatic Data of Diyarbakır Province between 1957-2018(URL 2)

	MONTHS											
	January	February	March	April	May	June	July	August	September	October	November	December
Temperature	7 °C	8 °C	13 °C	20 °C	26°C	32 °C	38 °C	37 °C	33 °C	25 °C	16°C	9°C
Precipitation	68mm	62mm	63mm	59mm	32mm	12mm	3mm	3mm	4mm	44mm	46mm	62mm

As a result of the findings obtained from meteorological data, it was the hottest month of July with an average temperature of 38°C between 1957 and 2018, and it was the coldest month of January with an average temperature of 7°C. While the most rainfall was observed in winter and subsequently in spring, it was recorded as the driest August in the year (Figure 7).

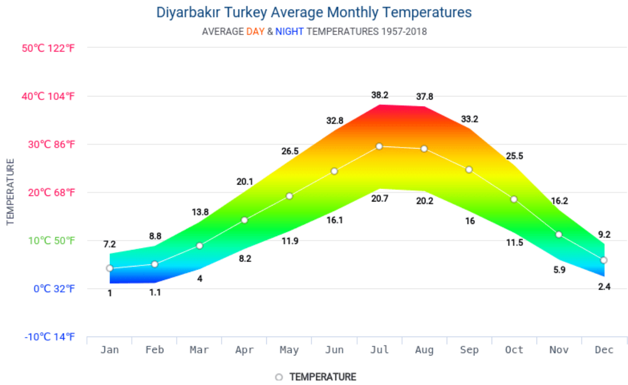


Figure 6. Average Monthly Temperatures for the years 1957-2018 of Diyarbakır (URL 2)

Diyarbakir is a city of sun, both in terms of duration and sunny day on average in Turkey. It was determined that it received the most solar radiation in 2008-2016 (Figure 7). The hottest or coldest period of the region where the dwelling to be designed should be analyzed correctly. The desired period periods of cooling for Diyarbakır provinces obtained by using the climate comfort graphs are shown in Figure 6;

According to the graph, it is concluded that the hottest circuit in Diyarbakır takes much longer than the coldest circuit (Figure 7). The hottest period, which covers the period, covers the range between 12.30-14.30 on April 19 and 12.00-14.00 on November 1 (Zeren, 1967). Briefly, the period when cooling is desired is more than five times than the time when heating is desired. In order to provide thermal comfort in building design and to minimize thermal inputs, the need for mechanical cooling systems increases dramatically during these periods when the hottest circuit is dominant. This will also increase cooling load expenses and will appear as residential units that consume more energy.

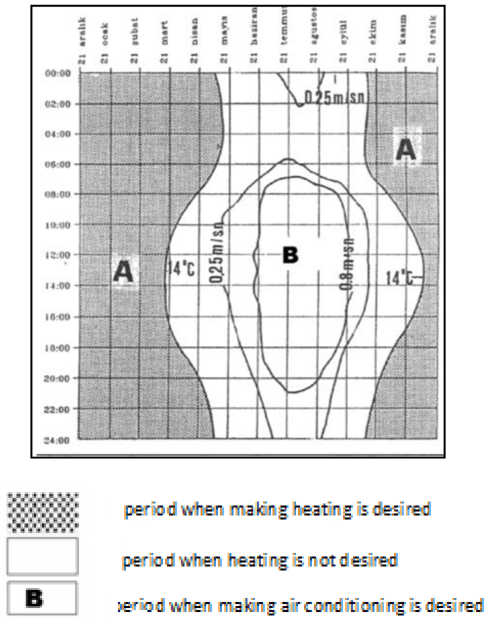


Figure 7. Heating-Cooling Periods Required in Diyarbakır (Berköz etc. 1995)

3.1. Case Study of Diyarbakır Şilbe Mass Housing

Diyarbakır Şilbe Mass Housing settlement is located in the Şilbe region, located at the north-west of the city, located at the intersection of Silvan-Elazığ highway, 4-5 km away from the city center (Figure 8).

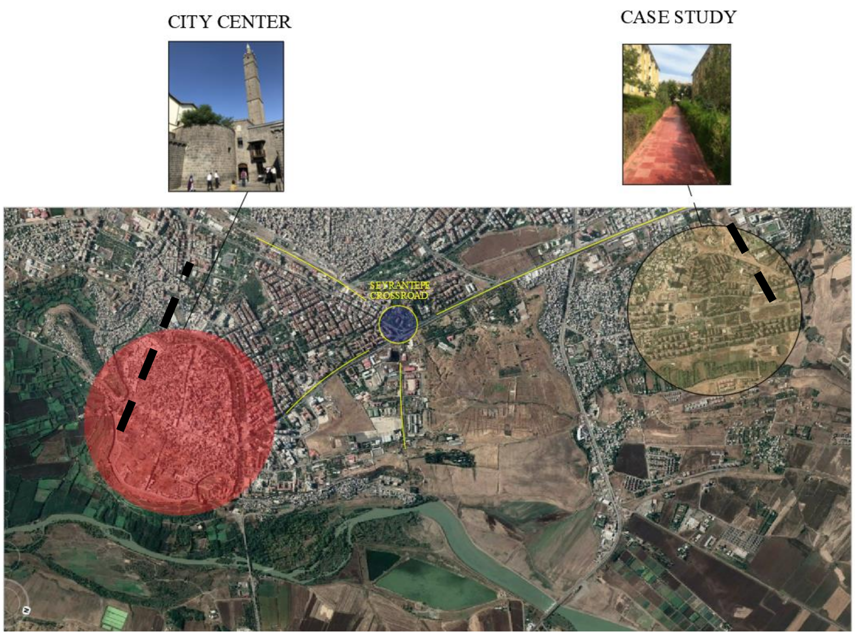


Figure 8. Location of the Şilbe Mass Housing and the Connection to the City Center (Google Earth Space Image)

The study was carried out in Şilbe 1st Stage Mass Housing settlement in Diyarbakır, located in the hot-dry climate region. In the study, 100 m^2 housing type was chosen which offers more orientation and angle alternatives.

Figure 9. 1 Şilbe 1st Stage Mass housing plan and placement of 100 m^2 houses (Case Study and chosen mass housing)

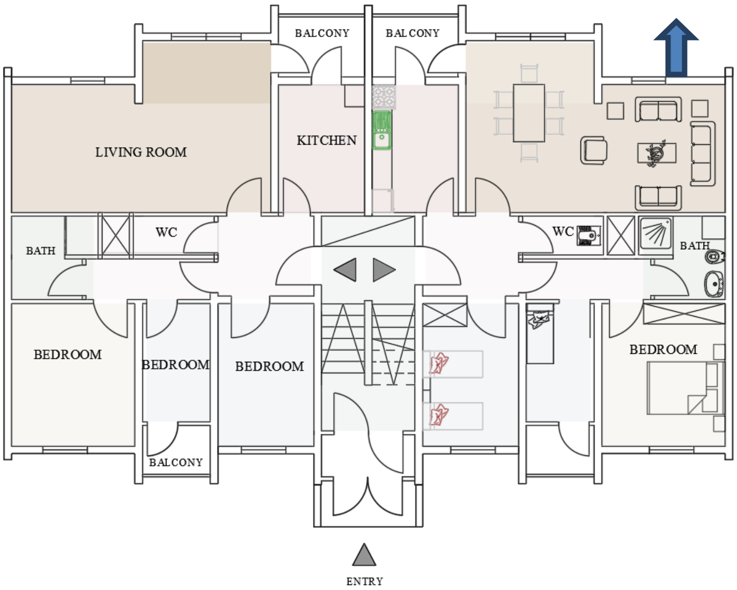


Figure 10. 1st Stage Mass Housing Ground and Normal Floor plan of 100 m^2

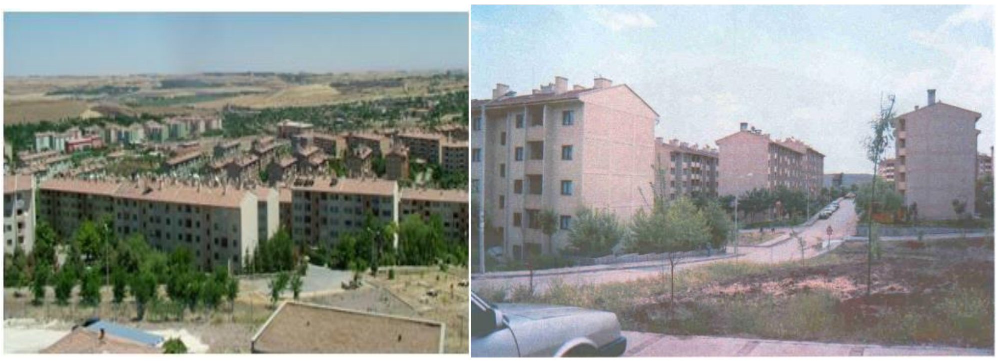


Figure 11: The location of the randomly placed buildings in Şilbe Mass housing

3.2. Volume Organization and Orientation Status of Şilbe Mass Housing Buildings

It is very important to find the proper orientation in the design for Diyarbakır, located in the hot-dry climate region. In order to reduce annual energy loads, the building should be designed at the right angle along with the appropriate direction. Especially for Diyarbakır, where the hottest circuit is dominant, it is necessary to follow the way to take measures to minimize the cooling loads during the building design process. Considering the Şilbe 1st Stage Mass Housing settlement, the distribution of the houses to the land did not occur homogeneously. This block type was chosen within the scope of the study, since there is an orientation towards all intermediate and main directions in the 100 m^2 residential type. There are 127 blocks of the 100 m^2 plan type blocks those of 64 are located in the northeast-southwest direction, 34 in the northwest-south-east direction, 25 in the east-west direction and 4 in the north-south direction. The directions of the 100 m^2 block type are shown in Table 2 and Figure 12.

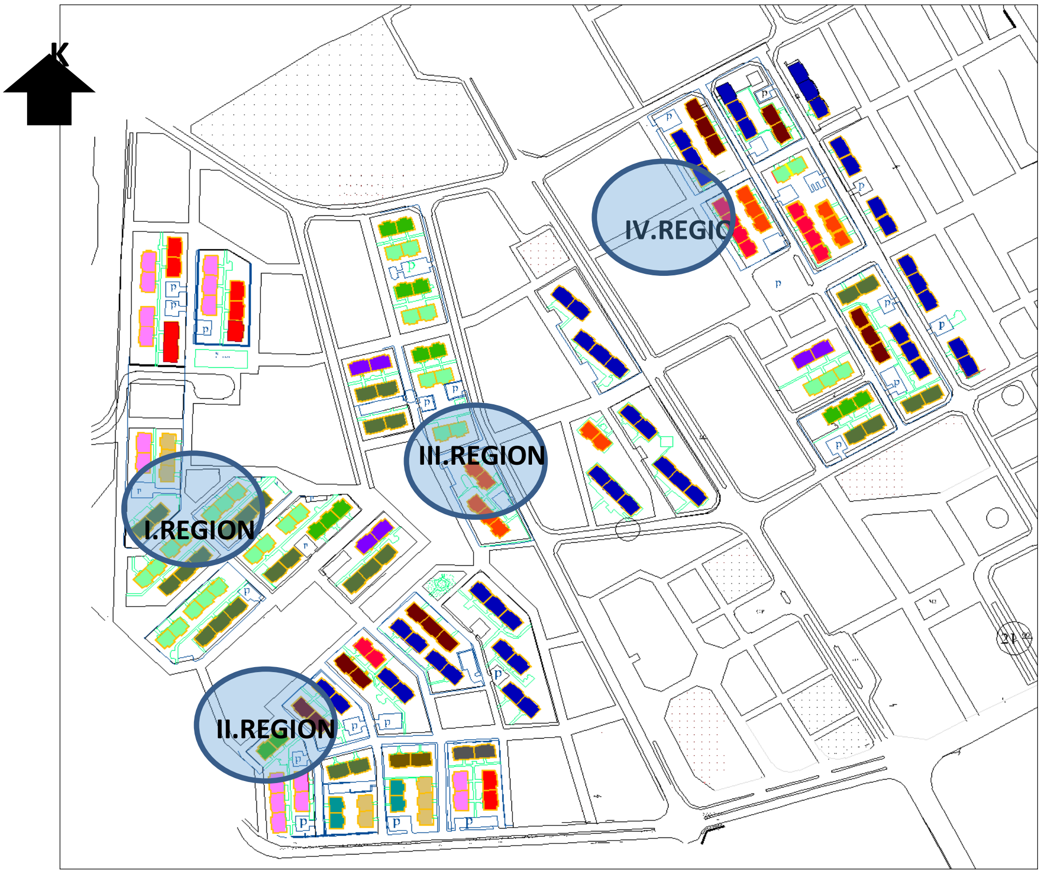


Figure 12. Distribution of the Regions in the Mass Housing Settlement different replace position of houses (Akalp, 2018)

In the organization of the space, there are 4 different orientations and 8 different housing types pertaining to 100 m2 of housing. In addition, it was determined that the living area and kitchen sections of 15 out of 64 houses located in the northeast-southwest direction in the 100 m2 houses are located in the southwest, while the bedrooms are located in the northeast direction, while 49 of them are located in the northeast and the bedrooms in the southwest. While the living space and kitchen of 28 of the 34 residences located in the northwest-southeast direction are located in the southeast direction, the bedrooms are located in the northwest direction, while the remaining 6 are located in the southeast direction and the living areas and the kitchen part are located in the southeast direction. In addition, among the 25 houses located in the east-west direction, 16 of them are located in the west and the living areas and kitchens are in the east, while the remaining 9 are located in the east and the bedrooms in the east. Finally, the living area of 2 of the 4 flats directed in the north-south direction is in the north and the bedrooms are in the south direction, while the other 2 are the opposite (Table 2 and 3).

Table 2.1. Stage 100 m^{2}Plan Types Located in Mass Housing Settlement (Orientation of Spaces)

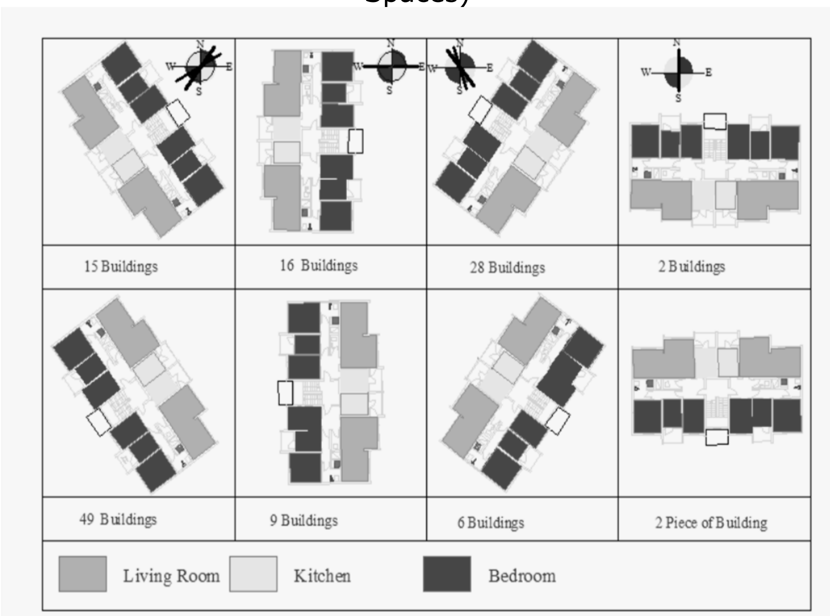


Table 3. Orientation and plan types of Şilbe Mass Housing (100 m^2 plan types)

	Building Types and Orientation (N, W, E, S)				
15	Building Type1A NE-SW			Building Type1A$_1$ NE-SW	49
28	Building Type 1B NW-SE			Building Type 1B$_1$ NW-SE	6
16	Building Type 1C E-W			Building Type 1C$_1$ E-W	9
2	Building Type 1D N-S			Building Type 1D$_1$ N-S	2
61	Total Building				66
127 BUILDINGS					

4. Material and Methods

What will be the energy efficient design of mass housing, which has been brought to the agenda with a large number of houses, will be determined by the Design Builder Energy Simulation Program, and the suggestions will be made by making the most appropriate orientation in the positioning of the houses with the data obtained in terms of cooling load (Akalp, 2018). Energy efficient design parameters will be examined while starting to work (Figure 13).

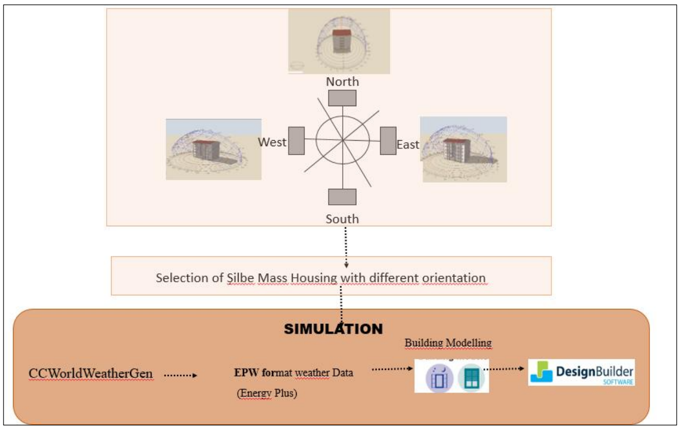


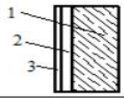
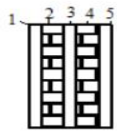
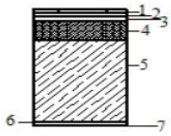
Figure 13. Research process

Design Builder Energy Simulation program was used in this study. Design Builder is a dynamic simulation tool that calculates all building energy, lighting, carbon, and comfort performance analyses (Zhang, 2014). The program is preferred because it has a user-friendly interface and the simulation results are realistic. Design Builder simulation program is used in many disciplines because it is reliable software. It can be used actively in architecture, building physics, mechanical engineering, heating and cooling systems modeling. In addition to heating-cooling load modelling, lighting hasthe ability to calculate daylight and model computational fluid dynamics (CFD) (Riahi Zaniani, etc 2019). IWEC (International Weather for Energy Calculations) climate data of the province of Diyarbakır, located in the hot-dry climate region, which was selected as the study area, was introduced to the program. Comfort conditions were determined by making certain constants and assumptions to carry out analyses through the Design Builder Energy Simulation Program. Building heating and cooling systems were used as a reference in the mass housing settlements used in the region, the building heating system was introduced as natural gas, and the cooling system was introduced as electric energy to the program. In order to provide climatic comfort, seasonal differentiation was preferred. Furthermore, to provide internal climatic comfort, the indoor air temperature comfort value was set to 21 °C and the heating-setback setting was set to 16 °C in winter. For the summer season, the indoor air comfort value was 25 °C and the cooling set back temperature was 25 °C. In addition, the number of residential users was determined to be four. User activity level 0.9 MET (metabolic equivalent of task) winter garment insulation value was accepted as 1 Clo (Clothing Insulation) and summer garment insulation value was accepted as 0.5 Clo.

4.1. Building Envelope and Thermophysical Properties

The building shell and thermophysical properties of the blocks in the Şilbe 1st Stage Mass Housing settlement, which was produced with tunnel formwork reinforced concrete system, are shown in Table 4:

Table 4. 1. Stage Building Shell and Thermophysical Properties of Houses in Mass Housing Settlement (Author-TOKI)

U-Value (W/m²K)	Reinforced Concrete Exterior Wall	BUILDING ENVELOPE PROPERTIES
0,814	Reinforced Concrete Precast Wall (15 cm) Glass Fiber Insulation (3cm) Gypsum Plastering (3cm)	
0,651	Brick exterior Wall External Plaster (3cm) Air Brick (8,5 cm) Glass Fiber Insulation (3cm) Air Brick (8,5 cm) Internal Plaster (3cm)	
0,466	The Ceiling Dividing Garret Bitumen Sheet (2 mm) Heat Insulation (2 cm) Bitumen Sheet (2 mm) Reinforced Concrete Precast Wall (15 cm)	
0,545	Tilling on the Floor Terrazzo Tile (3 cm) Levelling Concrete (4 cm) Blind Concrete (10cm) Clinker Filling (10 cm) Concrete Fundament (60 cm) Insulation (3 mm)	

When the transparency ratio of the building is examined, there are transparent surfaces on the east-west facade, and windows on the north-south facade surfaces. Space enlightenments are not dispersed homogeneously. Window sizes used in the building of 100 m2 have been determined as 120x120 and 180x120. In addition, balcony door dimensions with glass surfaces are designed on a scale of 80x210 and 120x120 cm. In Table 4, the heat permeability coefficients of the materials used in the building shell are given.

Table 5. 1. Stage Transparency rates of housing types in mass housing settlement (by author-TOKI)

Housing Type	Total transparency %	*North front*	*South front*	*East front*	*West front*
100 m²	10,275	21,63	19,47	-	-

After the building modeling was done through the Design Builder Energy Simulation Program, the building envelope properties specified in Table 5 were transferred to the program and thus modeled in accordance with the original of the simulated building.

5. Analysis of Cooling Energy Loads of Different Oriented Blocks in Şilbe I. Stage Mass Housing Settlement

100 m^2 housing type, located in Şilbe 1st Stage Mass Housing settlement and offers more orientation alternatives, was chosen for the study. The energy efficient design method is both an integrated reflection of the environmental components to the building as well as the measures taken during the building design phase. In this step of the study, the effect of the building orientation status, which is among the building design parameters, on the energy costs was examined. For this purpose, numerical comparisons were evaluated

after the cooling load of each of the blocks with different orientation and plan types in the settlement were calculated with the Design Builder Energy Simulation Program. In this way, the number of blocks that perform optimum orientation between 100 m^2 blocks in Şilbe 1st Stage Mass Housing settlement unit is determined.

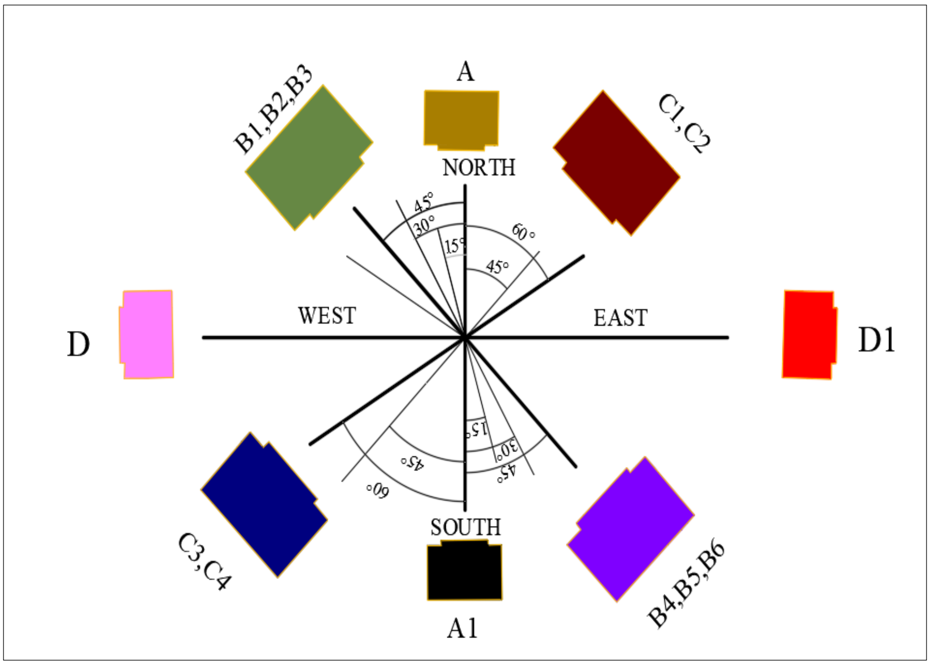


Figure 14. Şilbe 1. Stage Routing Status of Blocks in Mass Housing Settlement

Different building orientation alternatives are calculated through the Design Builder Energy Simulation Program.

Cooling Loads
Cooling load values are specified in Table 7. Different building orientation alternatives are calculated through the Design Builder Energy Simulation Program.

Table 6. Cooling loads of blocks with different layout.

X	Y	Z
A **(North)**	45.838	0-5
A1 **(South)**	45.076	0-5
B1 **(Northwest)**	46.412	10-15
B2 **(Northwest)**	48.123	25-30
B3 **(Northwest)**	51.237	40-45
B4 **(Southeast)**	45.607	10-15
B5 **(Southeast)**	47.593	25-30
B6 **(Southeast)**	50.917	40-45
C1 **(Northeast)**	52.163	40-45
C2 **(Northeast)**	54.782	55-60

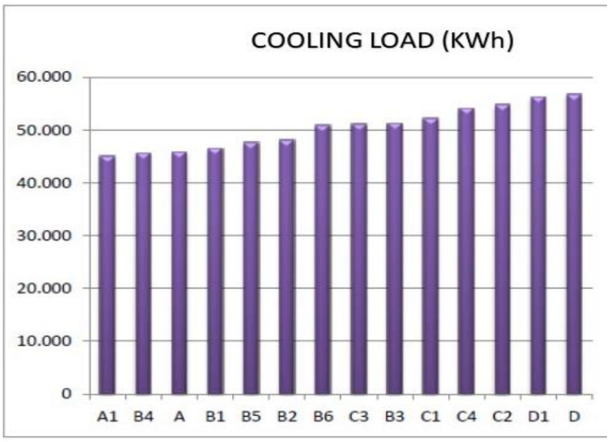


Figure 15. Cooling loads

C3 **(Southwest)**	51.134	40-45	
C4 **(Southwest)**	53.999	55-60	
D **(West)**	56.793	85-90	
D1 **(East)**	56.163	85-90	

X: Direction **Y**: Cooling Load (Kwh)

If the total cooling loads of the blocks with different orientation and angle alternatives are compared, it is determined that the lowest cooling load value is in the north-south orientation (A, A1). However, it was determined that the southeast orientation (B4) located in the northwest-southeast direction is very close to the north-south orientation in terms of cooling load. The highest cooling load value was found to be in the western (D) orientation (Table 6).

After the obtained numerical values were listed from small to large, Figure 15 was obtained. It has been determined that the southern (A1) steering has a minimum cooling load per year with very little difference (Table 6). As seen in Figure 15, the highest cooling load per year belongs to D (west).

6. Conclusions and Further Research

Nowadays, a large proportion of energy sources are spent to optimize heating-cooling energies in order to provide climatic comfort in buildings. Therefore, the share of the construction sector in energy consumption is undeniably high. In Turkey, many public housing authorities in the residential housing sector produces each year are of great importance. It is thought that minimizing the energy consumed in residences in Diyarbakır, which is one of the provinces with the highest population in the Southeastern Anatolia region, will ease the burden on the country's economy. Therefore, within the scope of the study, Şilbe I. Stage Mass Housing settlement in Diyarbakır province was chosen.

Energy efficient design is an integrated method. It consists of many components from climate to building design parameters, from recycling to the use of renewable energy sources. In this study, the effect of building design parameters on annual total heating-cooling load values is examined. In other words, the effect of the orientation resulting from the positions of the buildings relative to each other on the energy loads was examined. In this context, the heating-cooling load values of each of the 100 m2 plan type with different layout in the housing estate, independent of the settlement texture, were calculated with the help of the Design Builder Energy Simulation Program, and the minimum annual total heating-cooling load among the houses in this settlement texture The optimum direction with the value has been determined.

As a result of the numerical analysis carried out using 100m2 residential type with different layout in Şilbe I. Stage Mass Housing settlement. Consisting of 127 blocks of 100 m2, there are only 4 blocks in Şilbe I.Stage Mass Housing settlement that are suitable for building orientation. If we express the current situation with a percentage value, it is concluded that only 100% of the building design suitable for its orientation has been realized in the 100 m2 residential type in the Mass Housing settlement. It is concluded that a significant proportion of the remaining 97% is designed arbitrarily, ignoring the energy efficient building design criteria.

It was determined that the optimum direction is the north-south direction and the south direction in the direction. The type of orientation, which has the highest cooling load value, was found to be in the east-west direction.

• It was concluded that the western orientation, which has the highest annual total cooling load value, is the most unfavorable direction for the hot-dry climate region.

As a result of the obtained results, annual energy losses due to orientation have been determined in Şilbe I. Stage Mass Housing settlement. In addition, Zeren et al. The optimum orientation of the hot-dry climate region made by the province was determined as 18o from the south or to the north.The optimum direction determined as a result of this study was determined by Zeren (Zeren et al., 1990). It was found in the range of optimum orientation value found in the study conducted by. This proved to be verifying the analysis results made through the simulation program.

As a result of the analyzes carried out with the help of the Design Builder Energy Simulation Program, it was understood that the building design criteria, which are among the energy efficient design parameters, directly affect the cooling load value.

As a result, within the scope of this study, the data provided by the Design Builder Program in Mass Housing shows how the energy expenses in a building have changed depending on the layout scheme and the orientation effect in parallel.

Feasibility studies in the construction process of the buildings, taking into consideration the energy efficiency of the buildings, correct orientation, correct layout, selection of the right material in transparent areas will reduce the load on heating by minimizing heat losses through transmission. With the right guidance, expenses spent for lighting energy can also be reduced.

Annual energy losses will decrease if the buildings are designed in accordance with the climatic design parameters in every step from the design process to the construction process. In this way, a sustainable future will be possible where natural resources are used efficiently. In addition to this, this study also showed that if passive systems are used in the housing design phase in cities located in the hot dry climate region, they can save annual energy. As a result of the study, if this study is taken as reference in the residential areas of the buildings that are produced in the hot-dry climate regions of the Mass Housing Administration, which has an important place in the annual housing production rate, this study will contribute to the economy of the country.

7. REFERENCES

Akalp, S., 2018, Toplu Konutlarda Farklı Yerleşim Düzenlerinin Enerji Etkinliğinin Karşılaştırılması: Diyarbakır Şilbe Örneği, D.Ü.FBE Ylisans tezi, Diyarbakır.

Albatayneh, A., Alterman, D., Page, A., & Moghtaderi, B. (2018). The impact of the thermal comfort models on the prediction of building energy consumption. Sustainability, 10(10), 3609.

Ashmawy, R.E., (2015), Establish a sustainable strategies for low energy building. Master thesis, faculty engineering. Tanta University.

Ashmawy, R. E., & Azmy, N. Y. (2018). Buildings orientation and it's impact on the energy consumption.

Berköz, E., Küçükdoğu, M., Yılmaz, Z., Kocaaslan, G., Ak, F., ve ark. 1995. Enerji Etkin Konut ve Yerleşme Tasarımı, TÜBİTAK- İNTAG 201, Araştırma Raporu. İstanbul.

Berköz, E., Küçükdoğu, M., Yılmaz, Z., Kocaaslan, G., Ak, F., ve ark. 1995. Enerji Etkin Konut ve Yerleşme Tasarımı, TÜBİTAK- İNTAG 201, Araştırma Raporu. İstanbul.

Burberry,P. 1999. Building For Energy Conservation, Architectural Pres, Sayfa: 17. Londra.

C. Hachem, A. Athienitis, and P. Fazio, "Parametric investigation of geometric form effects on solar potential of housing units," Sol. Energy, vol. 85, no. 9, pp. 1864–1877, Sep. 2011, doi: 10.1016/j.solener.2011.04.027.

D.Goldman,Progressive environmental design solutions,in: Environmental Architecture, 2016 (http://www.enviroarch.com/tiers.html

Dikmen, Ç. B. (2011). Enerji etkin yapı tasarım ölçütlerinin örneklenmesi. Politeknik Dergisi, 14(2), 121-134.

Eicker, U. (2009). *Low energy cooling for sustainable buildings*. John Wiley & Sons.

F.H. Abanda, L. Byers, An investigation of the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling), Energy. 97 (2016) 517–527.

Geetha, N. B., & Velraj, R. J. E. E. S. (2012). Passive cooling methods for energy efficient buildings with and without thermal energy storage–A review. Energy Education Science and Technology Part A: Energy Science and Research, 29(2), 913-946.

Göksal, T.,& Özbalta, N. (2002). Enerji korunumunda düşük enerjili bina tasarımları. *Mühendis ve Makina*, *43*(506), 26-32.

Hashemian, M. H., & Etemad, A. The Role of Orientation (Ron) in Climatic Attitude towards Traditional Iranian Architecture in the Orientation of Sustainable Monuments in the Contemporary Period (Case Study: ASP Tower).

I. E. Kocagil and G. K. Oral, "The effect of building form and settlement texture on energy efficiency for hot dry climate zone in Turkey," in Energy Procedia, Nov. 2015, vol. 78, pp. 1835–1840, doi: 10.1016/j.egypro.2015.11.325

I. Spanos, M. Simons, K.L. Holmes, Cost savings by application of passive solar heating, Struct. Surv. 23 (2005) 111–130.

IEA. 2019. International Energy Agency, World Energy Outlook 2019. Paris: IEA. https://www.iea.org/reports/worldenergy-outlook-2019

Jannat, N.; Hussien, A.; Abdullah, B.; Cotgrave, A. Application of agro and non-agro waste materials for unfired earth blocks construction: A review. Constr. Build. Mater. 2020, 254, 119346.

K. Wong, Q. Fan, Building information modelling (BIM) for sustainable building 10 design, Facilities. 31 (2013) 138–157.

Kadıoğlu, S.,& Tellioğlu, Z. (1996). Enerji Kaynaklarının Kullanımı ve Çevreye Etkileri'', TMMOB, 1. *Enerji Sempozyumu, ss*, 55-67.

Khaliq, W., & Mansoor, U. B. (2021). Performance evaluation for energy efficiency attainment in buildings based on orientation, temperature, and humidity parameters. Intelligent Buildings International, 1-17.

M. Mardookhy, R. Sawhney, S. Ji, X. Zhu, W. Zhou, A study of energy efficiency in residential buildings in Knoxville, Tennessee, J. Clean. Prod. 85 (2014) 241–249

Olgyay, V. (2004). Design with climate. 1963. *Richard Rogers+ Philip Gumuchdjian, Cities for a small planet, pp1-175 Moriyama*, 53-84.

Pacheco, R., Ordóñez, J., & Martínez, G. (2012). Energy efficient design of building: A review. Renewable and Sustainable Energy Reviews, 16(6), 3559-3573.

R. Fallahtafti and M. Mahdavinejad, "Optimisation of building Form and orientation for better energy efficient architecture," Int. J. Energy Sect. Manag., vol. 9, no. 4, pp. 593–618, Nov. 2015, doi: 10.1108/IJESM-09-2014- 0001.

R. Fallahtafti, M. Mahdavinejad, Optimisation of building shape and orientation for better energy efficient architecture, Int. J. Energy Sect. Manag. 9 (2015) 593–618.

Riahi Zaniani, J.; Taghipour Ghahfarokhi, S.; Jahangiri, M.; Alidadi Shamsabadi, A. Design and optimization of heating, cooling and lightening systems for a residential villa at Saman city, Iran. *J. Eng.2019).*

Rodriguez-Ubinas, E., Montero, C., Porteros, M., Vega, S., Navarro, I., Castillo-Cagigal, M., ... & Gutiérrez, A. (2014). Passive design strategies and performance of Net Energy Plus Houses. Energy and buildings, 83, 10-22

Soysal, S. 2008. Konut Binalarında Tasarım Parametreleri ile Enerji Tüketimi İlişkisi, Yüksek Lisans Tezi, Gazi Üniversitesi Fen Bilimleri Enstitüsü, Ankara.

T. Catalina, J. Virgone, and V. Iordache, "Study on the impact of the building form on the energy consumption," 2011.

U.S.Department of Energy (DOE), Passive Solar Home Design, U.S. Department of Energy (DOE), visited 2022 http://energy.gov/energysaver/passive-solar-home-design)

V. N. I. D. M. F. M. F. A. J. Anna Joelsson, "The Impact of the Form Factor on Final Energy Demand in Residential Buildings in Nordic Climates," 2012.

Wang, J.; Huang, Y.; Teng, Y.; Yu, B.; Wang, J.; Zhang, H.; Duan, H. Can buildings sector achieve the carbon mitigation ambitious goal: Case study for a low-carbon demonstration city in China? Environ. Impact Assess. Rev. 2021, 90, 106633.

Yakut, M. Z., & Esen, S. (2019). Impact of energy efficient design parameters on energy consumption in hot-humid climate zones.

Yakut, M. Z., & Esen, S. (2019). Impact of energy efficient design parameters on energy consumption in hot-humid climate zones.

Zeren, L. (1967). *Türkiye'nin tipik iklim bölgelerinde en sıcak devre ve en az sıcak devre tayini*. İTÜ Mimarlık Fakültesi

Zeren, L. 1978. Mimaride Güneş Kontrolü. İTÜ Yayınları, İstanbul.

Zeren, L. ve ark. 1990. Fiziksel Çevre Kontrolü Ders Notları, Fiziksel Çevre Kontrolü Birimi, İ.T.Ü, İstanbul.

Zeren, L. ve diğ. (t.y.). Fiziksel Çevre Kontrolü Ders Notları, Fiziksel Çevre Kontrolü Birimi, İ.T.Ü., İstanbul

Zhang, F., Shi, L., Liu, S., Shi, J., Ma, Q., & Zhang, J. (2022). Climate Adaptability Based on Indoor Physical Environment of Traditional Dwelling in North Dong Areas, China. Sustainability, 14(2), 850.

Zhang, L. Simulation analysis of built environment based on design builder software. *Appl. Mech. Mater.* 2014, *580*, 3134–3137.

URL 1: www.gaisma.com/en/location/diyarbakir.html)

URL 2: hikersbay.com