İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

EVALUATION OF THE DESIGN PARAMETERS IN THE SETTLEMENT SCALE RELATED TO REGIONAL CLIMATIC DATA

M.Sc. Thesis by
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Department : Architecture

Programme : Environmental Control And Building Technologies

JUNE 2010

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Date of submission : **07 May 2010**
Date of defence examination: **11 June 2010**

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JUNE 2010

<u>**İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ**</u>

YERLEŞMEYE İLİŞKİN TASARIM PARAMETRELERİNİN YEREL İKLİM VERİLERİNE GÖRE DEĞERLENDİRİLMESİ

YÜKSEK LİSANS TEZİ

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Tezin Enstitüye Verildiği Tarih : 07 Mayıs 2010
Tezin Savunulduğu Tarih : 11 June 2010

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HAZİRAN 2010

FOREWORD

I would like to express my deep appreciation and thanks for all those who gave me the possibility to complete this thesis.

Firstly, I would like to express my appreciation to Prof. Dr. Gül Koçlar Oral for her both academically and morals supports. She always guides me, not only with her experience, valuable knowledge, important ideas, leading critics but also her good will and inspiring personality.

I would like to thank to all my colleagues at the Department of Building Physics of Hochschule fuer Technik Stuttgart for their friendship and being helpful for each issues. Special thanks are due to my supervisor in Stuttgart, Prof. Dr. Ursula Eicker, for being so generous to me with her time, patience, advice and valuable opinion.

I would like to gratitude to all my perfect friends who do not preserve their spiritual and material supports, both in Stuttgart and Istanbul. The list would be endless if I would like to write the all names here.

I would like to dedicate this thesis to my lovely parents, Hidayet Duran and Gülşen Duran and my dear brother and sister for their understanding, endless patience and encouragement, for the entire of my lifetime.

May 2010

Özlem Duran
Architect

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ABBREVIATIONS

PEE	**:** billion-ton gasoline energy
CO2	**:** Carbon dioxide
SO2	**:** Sulfur dioxide
NOX	**:** Nitrogen oxide
CLO	**:** Thermal resistance unit of clothing
Tg	**:** Globe temperature
M	**:** Metabolic rate
kW	**:** Kilowatt (power unit)
ac/h	**:** Airchange per hour
M/S	**:** Meter per second (airspeed unit)
MET	**:** Metabolism level
W/m²	: Watt per square meter (energy unit)
(Φ)	: Latitude angle
(L)	: Longitude angle
Ώ	**:** Profile angle
β	**:** Solar rising angle
γ	**:** Solar azimuth angle
CFD	**:** Computational Fluid Dynamics
U	: Total heat conduction coefficient
Ti,max	**:** Ratio of the highest temperature
Ti,min	**:** Ratio of the lowest temperature
Te,max	**:** Temperature difference on the inner surface to the highest
Te,min	: Lowest temperature difference on the external surface on one day
a	: Solar radiation absorbance
τ	**:** Transmittance
r	**:** Reflectance
k	**:** Coefficient of total heat conduction
x	: Transparency
EnEV	**:** Germany energy saving regulation
WSVO	: Germany thermal insulation regulation

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EVALUATION OF THE DESIGN PARAMETERS IN THE SETTLEMENT SCALE RELATED TO REGIONAL CLIMATIC DATA

SUMMARY

One of the most important responsibilities of architects is, to be aware of that affecting the world and natural sources while designing a built environment. To prevent energy and environmental problems, the objective of modern built environment design and construction is to provide a secure, healthy and comfortable environment, which at the same time addresses sensitive subjects such as energy conservation and impact on the natural environment.

In this context, in this study, energy efficient construction is focused on, energy efficiency parameters have been determined and the impacts of criteria that is related to settlement have been searched.

The study is consisting of 6 main chapters. In introduction chapter; the aim of the study, the research for the purpose and the example simulations are explained.

In second chapter; energy efficient building design methods are explicated.

In third chapter: energy demands in dwellings are searched. Comfort conditions that require energy usage are explained and the reasons that obligate to design energy efficient are determined.

In forth chapter; energy efficient design parameters are evaluated in detail and effects of these parameters to the energy usage are conveyed.

In fifth chapter; the data that are explained in theoretical chapters have been numerically searched by modeling an existing energy efficient designed settlement unit in Stuttgart –Germany, with the method of energy simulation in computer. These simulations are repeated both under Stuttgart and İstanbul climatic data. In this way, the local and unique effects of parameters are observed.

In sixth chapter; simulation results are evaluated and how to consider energy efficient building design related to settlement is defined.

YERLEŞMEYE İLİŞKİN TASARIM PARAMETRELERİNİN YEREL İKLİM VERİLERİNE GÖRE DEĞERLENDİRİLMESİ

ÖZET

Mimarlar olarak en önemli sorumluluklarımızdan biri, insanlar için yaşanabilir çevreler yaratırken, dünyamızı ve doğal kaynaklarımızı etkilediğimizin bilincinde olmak ve yapım işini bu anlamda, en doğru biçimde yönetmektir. Dolayısıyla yeryüzüne en az zarar verdiğimiz tasarım felsefesi üzerinde düşünmeli ve üretmeliyiz.

Bu bağlamda, bu çalışmada enerji etkin yapım üzerine yoğunlaşılmış, enerji etkinlik prensipleri saptanarak, yerleşmeye yönelik kriterlerin enerji kullanımına etkileri araştırılmıştır.

Çalışma 5 ana bölümden oluşmaktadır. Giriş bölümünde; çalışmanın amacı ve bu doğrultuda yapılan araştırma ve simülasyon çalışması açıklanmıştır.

İkinci bölümde; enerji etkin bina tasarımı başlığı altında enerji etkin bina tasarım yöntemleri irdelenmiştir.

Üçüncü bölümde; konutlarda enerji yükleri araştırılmıştır. Enerji kullanımı gerektiren konfor koşulları anlatılarak, enerji etkin tasarıma yönelme zorunluluğunun nedenleri sıralanmıştır.

Dördüncü bölümde enerji etkin tasarım prensipleri detaylı olarak değerlendirilerek, bu prensiplerin enerji kullanımına etkileri aktarılmıştır.

Beşinci bölümde; teorik kısımda anlatılan bulgular, Stuttgart-Almanya da bulunan, enerji etkin tasarlanmış mevcut bir yapılaşma bilgisayar ortamında modellenerek, enerji simülasyonları yapılması yöntemiyle, sayısal olarak araştırılmıştır. Bu araştırmalar Stuttgart ve İstanbul iklim verileri altında tekrarlanmış, böylelikle parametrelerin yerel ve tekil etkileri de gözlemlenmiştir.

Altıncı bölümde; simülasyon sonuçları değerlendirilmiş ve yerleşme ölçeğinde enerji etkin bina tasarımına nasıl yaklaşılması gerektiği ifade edilmiştir.

1. INTRODUCTION

Architecture responds the question of sheltering, which is the one of the basic need of humankind, since the beginning of the history.

In the contemporary world, increasing population, decreasing natural sources, energy deficit that is getting a dangerous amount day by day and waste production cause us to search the answer for the question, how we have to build the architecture, which has an important role of these consumptions.

In this context, sustainability concept and energy efficiency approach, which has an aim to affect nature minimum and use sources optimum, answers the problem of waste and energy need, which caused by structuring.

Buildings work as heating, cooling and lighting systems. It affects its environment and also affected by the environment. Ecologically optimized design of these systems that consume less energy and produce less waste, and develop energy efficient systems, are the capability of architects.

In this study, energy efficiency criteria related to settlement are discussed. Impacts of orientation and distances between buildings of buildings have been searched and energy simulations have been made to determine numeric values via computer simulation programs.

Subject simulations have been repeated in two different geographical areas with different climatic data to observe the effects of climatic data variations to the settlement parameters.

As known, whether the buildings themselves have been designed energy efficient, if the effects of one to another and the settlement design on earth are not taken into consideration, optimum energy efficiency will not be provided.

The aim of this study is to emphasize the importance of energy efficient urban approaches for the design.

2. ENERGY EFFICIENT SETTLEMENT DESIGN

2.1 What Is Energy Efficient Design?

In the world and our country, with increasing consumption and produced industrial waste, especially, depending on migration from village to city and industrialization natural sources are reducted gradually and pollution is caused, which in turn begins to destroy ecological balance. Since beginning of the 20. century, industrialization, urbanization and growth of population cause damaging effect on the basic physical components of nature; air, water and ground. Moreover, this affected all living creatures, first of all, human beings [1]. Rapid growth of population, increasing comfort expectations, and effects of industrial production created settlement problems. Unbalanced and insensitive structuring caused destruction of natural resources and permanent damage on ecosystem. In this way, existing situation requires a new design approach, implementation and life concept.

Nowadays, against the environmental problems, when designing comfortable built environment to leave a livable earth to next generation, building structures that save limited energy resources by stopping pollution, are the most important aims of architecture.

The decisions that are made during that act of building, that is, choosing configuration of spaces and putting them together, affect environments that reach far beyond the physical side of construction into the future. Because of rapidly increasing and ecological effect of the act of the building. The building and the built environment represent complex human created systems that are interconnected with other human and non human systems.

As ecology is the study of relationships between organisms and the environment, building ecology is the study of relationships between the act of the building, the buildings and the built forms that are produced, and the natural environment. Building ecology is the study of how our built environment affects our natural environment. It is about discovering the interconnections between buildings and nature and effects of these interactions.

Building ecology is the study of interdependencies and influences of building and natural environments on each other. It seeks to understand how natural systems both affect and are affected by buildings and construction by uncovering the relationship between them. The objective of building ecology, is to discover ways of creating harmony between building and nature. So that, mutually beneficial and life supporting can be designed and constructed [2].

In this content, sustainable design is the most eligible approach. In the framework of the sustainable design, especially, considering the environmental effects, the usage of crude material and energy must be optimized. Consideration of environment at design process is only possible, when health of human being and all other living creatures, ecosystems and natural sources are taken into consideration. Sustainable design products and processes consider relationship between surrounding environmental, economical and social systems and consider to create measurement systems that try to prevent no sustaining effects to these systems [3]**.** One of the most important conditions to realize sustainable design process is to provide way to use energy effectively.

Necessity for effective usage of energy was presented in *Brundtland* report by the thesis that defines; effective energy usage will provide time to earth to find renewable sources that will create bases of 21. century energy structure and ways requiring low energy [4]**.**

Effective usage of energy reaches Norway and Sweden of 1920s. These cold climate countries have already developed insulation standards in those years which used in the England of 1990s. Hopes for cheap fuel production and nuclear plants in 1950s caused to go far from the idea of using energy effectively till 1970. However, with oil crises effective energy usage approach came up again [4]**.**

Against the dwindling fossil fuel supplies, there are still no optimistic prospects of future alternative energy sources and as long as there is no change for the better in respect, drastic economy measures on energy consumption are very desirable [5]**.**

Nowadays, climate changes caused by global warming and predicted finish off of fuel caused growing interest in renewable energy all over the world. Rapid growth of population, decline of natural sources, international competition and increment of energy cost, pollution and enhancement of comfort conditions change the design approach.

In this content, the aim of sustainable construction design is to decrease cost of maintenance, corruption, waste and pollution that is related to construction, alongside these, to increase the efficiency of construction products, strength and flexibility of construction and its components.

Sustainable structure can be defined as the construction that has the minimum harmful effect on built and natural environment.

In the content of architecture, sustainability can be provided with three principals. These principals foresee economical usage of sources, life cycle and humanistic design [6]. Saving sources; reduce, reuse and recycling, life cycle; analyzing the existence period of construction and effects on environment, and humanistic design principle covers the strategies examine relationship between human beings and natural environment [7].

In the construction of sustainable residential settlement unit planning and designing approach should be to save energy, to decrease cost, providing comfort inside, for human health. To protect legislative power and sustainable activity of nature;

- Providing less waste of construction material and labour
- Optimum usage of local solar, earth, air, and water energy sources and climate sensitive design
- Optimum usage of seasonal energies caused by microclimate [8].

Energy efficient design methodologies are important parts of sustainable design. Energy efficient design is a design approach that aims to minimize energy consumption in a wide area, like production of material and components of construction, not only the design of construction but also selection, maintenance, operation and management of sub systems. In another expression, this approach aims both benefit from renewable energy sources and get precautions, to protect energy; while meeting all performance standards for health safety and use. When traditional construction design aims to provide utmost service with least cost, realizes every function at optimal level, uses local crude material, energy and natural potential in best appropriate way economically, energy efficient construction design aims to provide comfort conditions and living standards by providing best harmony between natural data and land using, providing self proficiency by giving priority to use existing sources and opportunities for natural energy and local material usage [4].

2.2 Energy Efficient Settlement Design Methods

Harmful usage of energy, as it is an indispensable component of development, increases the importance of rational usage and using advanced technologies to produce clean energy increase gradually. Necessity for developing new technologies to use renewable energy sources that damaging environment less; like sun, wind and geothermal, is needed, while we depend on energy this much. It is possible to decrease general energy demand about 20-30% in case of developing renewable energy sources and by taking serious precautions to save energy. It is required to head towards alternative sources to provide energy saving [9].

Practically, every design decision affects energy consumption. Energy efficiency needs to be kept in mind throughout the design process; from the broad issues, such as site layout and building form through to the details such as the positioning of the light switches or thermostats [10].

It is possible to provide energy saving and efficiency for existing energy usage by taking simple but, very important decisions at the design phase of constructions. A constructions could be turned into units, which save and store energy by using several architectural components. Architectural components should be configured in a way to provide desired comfort conditions within the existing climate conditions.

- Positioning according to the prevailing wind direction and supplying natural ventilation by achieving proper building form

- Using the sun as heat source considering the fact that heated air rises and obtaining natural ventilation by using temperature differences

- Obtaining natural lighting related to sun position

- Obtaining heat and electricity from solar energy can be considered as appropriate approaches from the energy efficient point of view

2.2.1 Energy efficient settlement design

In energy efficient building design, two different methods are mentioned, which are classified as “passive” and “active”. Generally, passive and active usages are consist of external energy transfer and the measurements about the temperature distribution.

The first energy source that comes into mind is, sun power, as it has not any production cost. It is possible to benefit from the sun in two ways. The first one is collecting sun power and using active heating systems consisting of several elements for collecting and distributing. The second one is making up the building system with the values, which defined to obtain optimum benefit from sun power of design parameters such as direction position, building form, optical and physical properties of building envelope; doing this by excluding the active systems which use energy. Buildings designed like this, function as passive systems. A building, which does not have an active system, is called passive system. It is possible to design buildings as passive systems which will optimize the effects of the climate elements such heating agents as solar radiation and exterior temperature for saving energy by minimizing the functions of the active system in buildings [11].

2.2.1.1 Active systems

These systems are created for turning the sun radiation into heat and electricity.

- Thermal sun technologies; firstly, the heat is obtained from sun power. This heat may be used for either electricity production or direct usage as well.

- Photovoltaic batteries are the systems, which convert the solar energy to electric energy, however, they can not store the energy. The consistency of the electricity is provided by being integrated to network or with the help of a generator.

2.2.1.2 Passive systems

The energy required for heating and cooling of building is approximately 6.7% of total world energy consumption. By proper environmental design, at least 2.35% of the world energy output can be saved. In hot climate countries, energy needs for cooling can amount to two or three times those for heating, on an annual basis. Utilization of the basic principles of heat transfer, coupled to the local climate, and exploitation of the physical properties of the construction materials, could make possible to the control of the comfort conditions in interior buildings [12].

- **Passive heating**

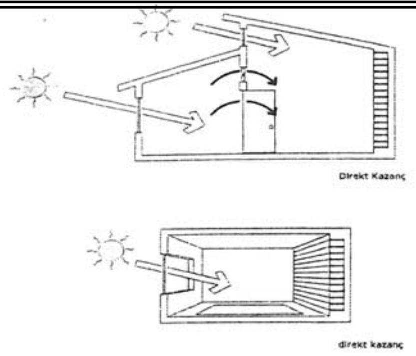
There are three types of energy gain.

- Direct gain; the building is designed as collector of the solar radiation and directly transfer to indoor. The sun power is taken by transparent elements to indoor. The energy is absorbed and collected by the surfaces of the thermal mass. The thermal mass is isolated from outside air by the isolation tools. The indoor is heated by convection, radiation and conduction. The thermal mass, which will be exposed to radiation, has to be placed to meet the solar radiation directly in most of a typical winter day. The thermal mass could be positioned on the floor, on the walls or randomly.

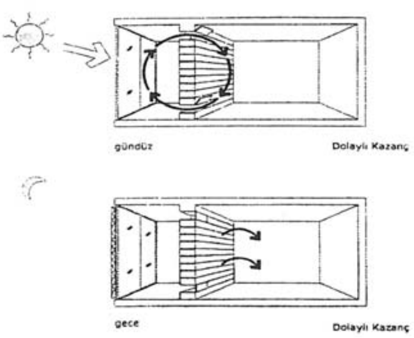
- Indirect gain; energy is saved in somewhere of the building and then transferred to other parts with natural convection (forced convection, if needed). In another words, thermal gain is obtained with the help of a buffer zone. The solar radiation do not enter into directly; but the energy is stored by the elements, which absorb and store the sun power in indoor and outside

- Gain by isolation; it is generally obtained by using the thermal storage elements isolated from living space.

In Figure 2.1, passive heating systems that are defined by graphics may seen.

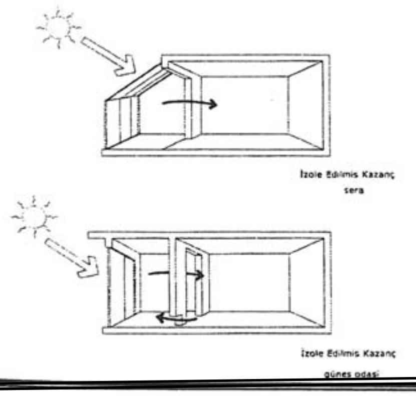


Direct Gain systems
In these systems, for north sphere solar energy collected by the south windows. Double glass opaque surfaces, at the south facade, increase the efficiency of the system. Solar energy, that pass through opaque surface, is collected by massive building elements like concrete floor, walls. And this energy is stored to use at night.



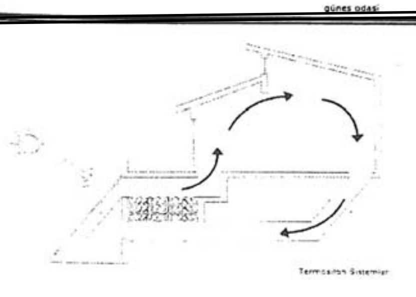
Indirect Gain systems
In indirect gain systems, thermal store mass congregate and store the heat hat is gained directly from sun to transfer it to the living spaces later. There are various types of indirect gain systems.

- Trombe wall
- Roof pool



Isolated Gain systems
In isolated gain systems the collective and storage spaces are isolated from the main spaces of the buildings. Thus, this system can collect and store heat separately from the building. Isolated gain systems have two types;

- green houses
- sun rooms



Termosiphon systems
In this system there is a collective area that connect living area and direct solar gain, separately from the building facade

Figure 2.1 : Examples of passive heating systems [9]

- **Passive ventilation**

The effective comfort ventilation consists of arranging the architectural elements to create movement for cooling the air. There are two main systems: cooling by evaporation on the floor and cooling by spreading. Figure 2.2 defines the passive cooling methods to ventilate a building.

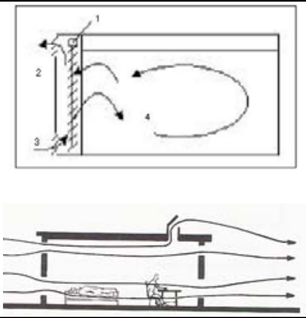
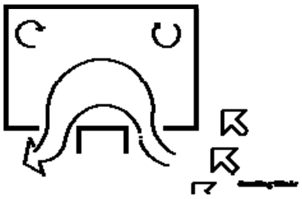
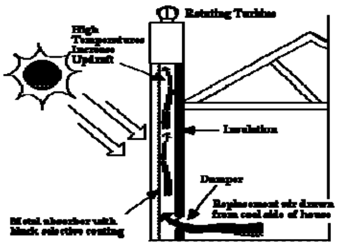
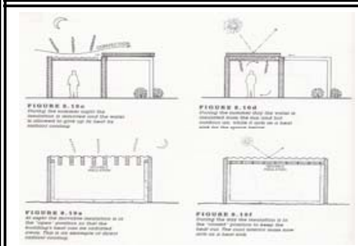
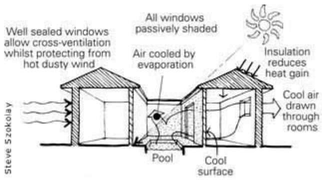
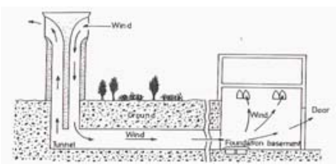
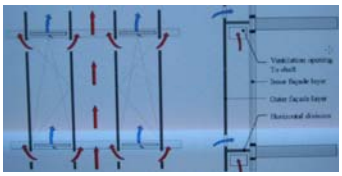
	**Comfort Ventilation** Daily ventilation may increase the comfort sence. It is a useful solution for specially humudity climates. It increases persprition evoporation when the air speed is high. If it is prefered to vantilate the building naturally with open windows, inner air temperature value gets closer to the outer air temperature value.
	**Cross Ventilation** At least one of the walls should face to the prevailing wind direction but the wall shouldnt be perpendicular to the prevailing wind. There must be 30º-60º angle between wall and wind. Wing walls helps to across vantilate.
	**Solar Chimney** This is a system to provide convective air flow from inner to outer. Two exhoust chimney, one is cold the other is hot, which are open to air facilitate air flow inside the building.
	**Radiant Cooling** This method uses whole roof as a convector. Roof opening losses its heat at night. With this formation, cold mass keeps inside cooler. The insulation has to be implement to the roof every day and removed every night.
	**Evaporative Cooling** Outer air contacts with water mass before it is taken into the building and this air gets cooler by the evaporation of the water. Air flow is achived naturally by the differance of the pressure and temperature
	**Surface Cooling** Method is implementing pipes to the ground as a heat converter. Air that circulates in thebuilding goes through these pipes and get cooler.
	**Double Skin Facades** A buffer area out of building skin and seconder skin that covers the buffer area is the double skin facade.

Figure 2.2 : Passive ventilation systems

- **Natural lighting**

Natural lighting systems are the systems which are created for taking the light inside in optimum level and provide minimum need for the artificial lighting.

Daylighting systems are searched in three categories;

- Daylight apertures; windows, roof lights.

- Day light transfer elements; they are the elements such as light shelves, reflector ceilings and light tubes which transfer the light inside.

- Control elements; shading equipments, selective coverings.

Graphics of building elements that are used for natural lighting may seen in

Figure 2.3

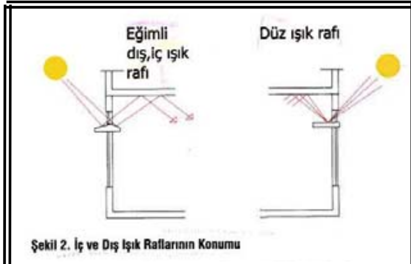
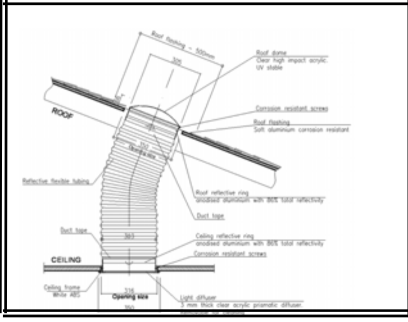
	**Light shelves** They are the horizontal elements used for directing the day light to the ceiling. It also supplies sun protection and shading. The positions of the light shelves depend on their volumes, as they are aimed for preventing the glare and providing appearance
	**Light Pipes** They are used for transferring light to the deep parts of the volumes. The collected sun beam is intensified by using mirror or objective. Highly reflective metal is used for transferring light without any light loss inside the pipe.

Figure 2.3 : Examples of natural lighting

2.2.1.3 Hybrid systems

Hybrid systems generally mean a combination of two or more energy production application (for example; diesel generator and/or PV system) consistently or on critical times.

Hybrid systems are generally designed for providing safety in case of a energy source cut (for example, obtaining PV from sun, wind and so on.), in other words the source's being unusable.

2.3 Energy Efficient Settlement Life Circle

According to traditional approach, life process of a building has four basic phases; design, construction, re-use, demolition, as given in Figure 2.4. This approach does not take into the consideration of the relation of the building with the environment but discuss the process in a limited framework. Traditional approach does not mention environmental problems of procuring and producing of the building materials and do not take interest of recycling and renovation on architectural sources, management of waste.

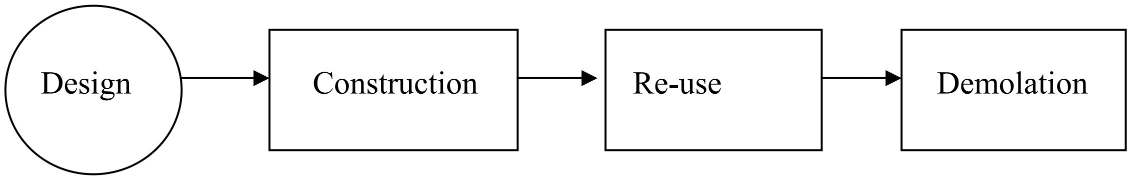


Figure 2.4 : Traditional settlement life circle [3]

There is not a beginning point to evaluate the life circle. Life circle is a cyclic process to produce row material, preparation, marketing, transferring, usage in building construction, reparation of material to treat again for new usage in building and recycle the product or material when it end its life and thus, to be row material again. Energy consumption of a building is examined at four main groups; starting with the phase; before construction, construction phase, usage & operation phase, ending with the phase; recycling. Energy efficiency of a settlement unit is not only a matter of operation during usage but also has to be considered for service, reparation cost and all phases before construction to the demolition.

For low energy consumption, the strategy that concentrated on the energy, which used in the production and use of buildings has to be effective. Consideration must be given to the energy cost-in-use implications of materials and component selection and design stage. The future energy implications of design decisions need to be considered in early stages, to informed judgment can be made. It is conceivable that a particular building assembly costing less in energy terms than a proposed alternative could turn into an inferior thermal performance in operation [10].

Building does not only consume during usage but also from preparing for construction to the demolition. Ecological architecture is a recycling concept. The process beginning with construction has to be considered with whole life circle from start to demolition.

‘Cradle to grave’ concept by *K. Yeang* determines the environmental impact of the lifecycling; produce from natural source to recycling to the nature. A material should be transferred from an efficient material to another after it completes its usage life [3].

Later, the idea of ‘cradle to the grave’ developed the idea of ‘cradle to cradle’. The aim is to create structures and systems like ecosystem. Cradle to cradle is about ensuring that nutrients are continuously cycled as valuable resources, rather than being used and then disposed. This theme includes several aspects of the cyclic idea; the recycling of materials, the development of new “intelligent” materials, reusing materials that are gradually made sustainable, and the lifetime of new projects [13].

Figure 2.5 defines energy efficient settlement life circle.

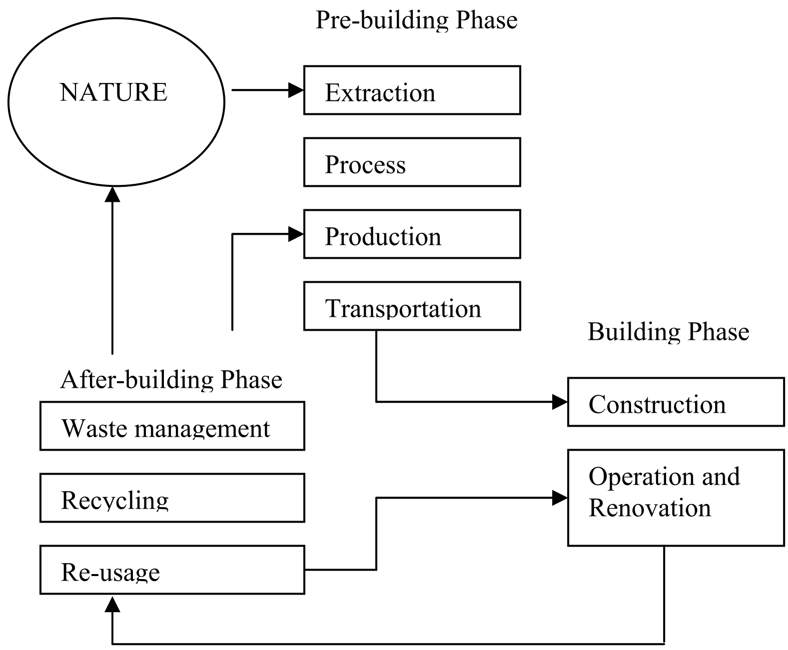


Figure 2.5 : Energy efficient settlement life circle [3]

3. SETTLEMENT ENERGY LOADS

3.1 Contemporary Settlement Energy Wastage And Costs

Energy is a part and parcel of our lives in contemporary world, in which technology develops faster. Consuming of energy consistently and uncontrolled, is the reason for loss of natural energy sources rapidly, decomposition of ecological balance due to environmental pollution, and high costs for energy production.

The accumulation of the effects of the patterns of development pursued by humanity, largely, after the industrial revolution of 18. and 19. centuries. In 1992 it is reported that the source bases of the planet reached critical stage of degradation in three area;

- erosion of global soil base, reducing the worlds capacity for food production as pollutions rise,
- loss of forests and wild lands leading to loss of biodiversity, that to indigenous cultures, and degradation of slopes and watersheds,
- accumulation of pollutants and greenhouse gases in the atmosphere, leading to local hazards to soils, vegetation and human health, and threat of global climate change.

Industrial and economic systems established to meet increasing demand for material goods, neither do not account the pollution and waste produced through out a product life circle, nor do they adequately consider the loss of ecological systems caused by resource extraction. Increased globalization of trade has opened up new markets and financial opportunities, while exposing more of the earth to resource depletion and pollution [14]**.**

In 2005, primary energy consumption of world (measurable and commercial) is 10,5 billion ton gasoline energy (PEE). The portion of the renewable energy (except hydroelectric like; geothermal, solar, wind) in total energy consumption is presumed as approximately 10%, when it is considered with all energy sources that are commercial or uncommercial. Gas oil and natural gas meet the 60%, fossil sources like gas oil, natural gas, coal, meet 85% of world consumption [7]. Worldwide energy consumption due to energy sources may be seen in Figure 3.1.

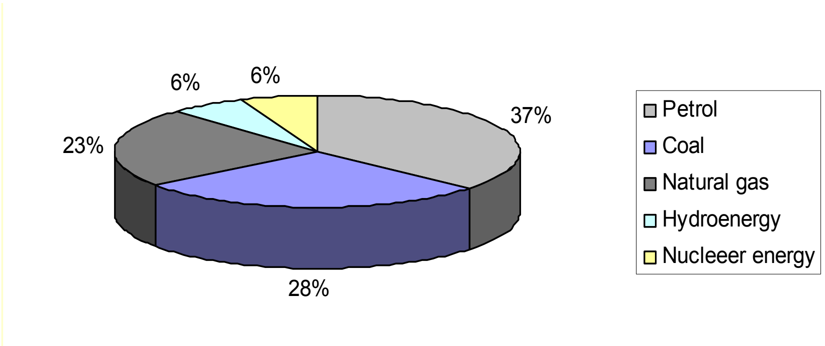


Figure 3.1 : Worldwide energy consumption due to energy sources [7]

As seen in the Figure 3.2, as countries develop, the fraction of their total energy devoted to the buildings may increase. Since total energy use will increase, the significance of buildings in the rising production of CO2 is doubly important in less developed nations [10].

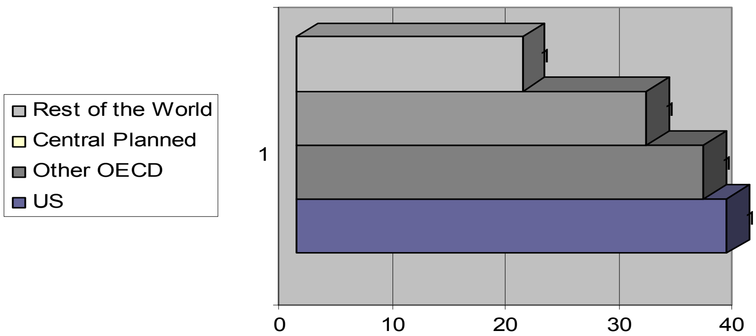


Figure 3.2 : Energy consumption of the countries [10]

The impact of the buildings to the environmental pollution;

- 50% of energy consumption
- 40% of row material
- 50% of chemicals that harm the ozone
- 80% of the land loss that is proper for the agriculture
- 50% of water

is used in buildings.

Impact of constructions to the emission distribution may be seen in Table 3.1

Table 3.1 : Sector-specific distribution of emission, 2000 (Thousand ton) [54]

Sectors	SO2	NOX	CO2
Electrical Energy	1,323	204	72,320
Manufacturing	619	207	68,103
Transportation	62	309	36,562
Others (Construction, Agriculture etc.)	238	192	33,478
Total	2,242	912	210,463

The energy consumed in the building materials industry, in providing materials input to the one year's supply of new buildings, is more than five times greater than the energy consumed by these buildings in the first year of use. Energy savings in the material industry in any year will, therefore, have significantly greater initial impact than equivalent savings in the buildings built in that year [10].

Impact ratio of countries to the world energy consumption may be seen in Figure 3.3.

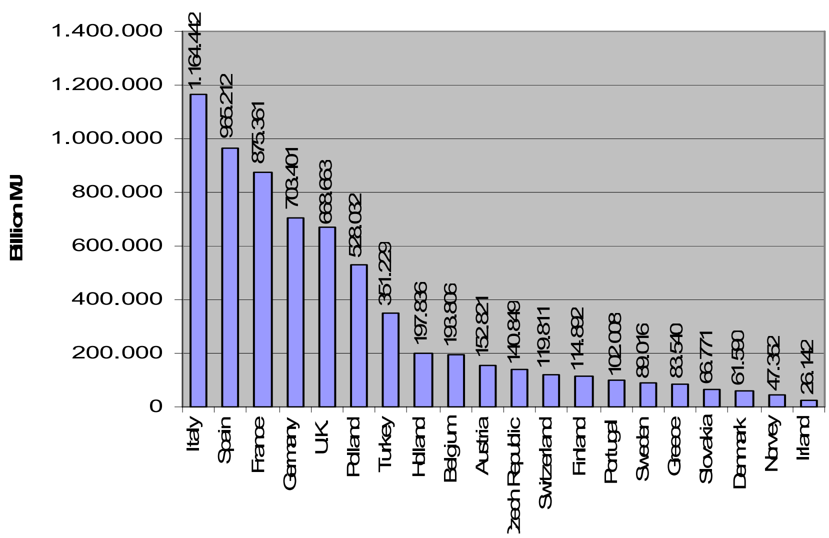


Figure 3.3 : Annually energy consumption of the dwellings [55]

Buildings are using 41% of total world consumption while 42.2% of this energy is used for heating. The great majority of the worldwide energy consumption is used in the heating, cooling and lighting systems of the buildings to arrange desired comfort conditions. In Figure 3.4, the energy usage ratio of buildings of total consumption is seen.

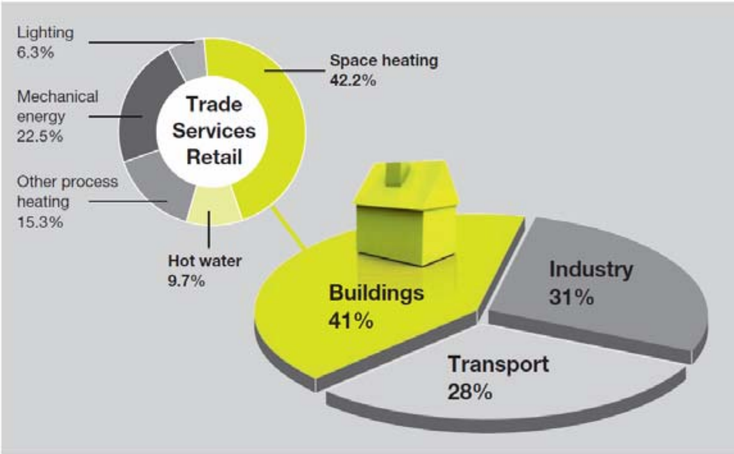


Figure 3.4 : Energy usage ratio of the buildings in total energy consumption

In most buildings, electricity is used for refrigeration, although gas fire refrigeration is also available. Some uses, such as clothes drying, cooking and water heating, may be accomplished with either electricity or some form of combustible fuel, such as natural gas propone, or heating oil. The price per Btu for electricity is several times higher than that for natural gas, and free solar energy can be used for to heat hot water [15].

Figure 3.5 defines the energy usage percentage in dwellings according to equipment.

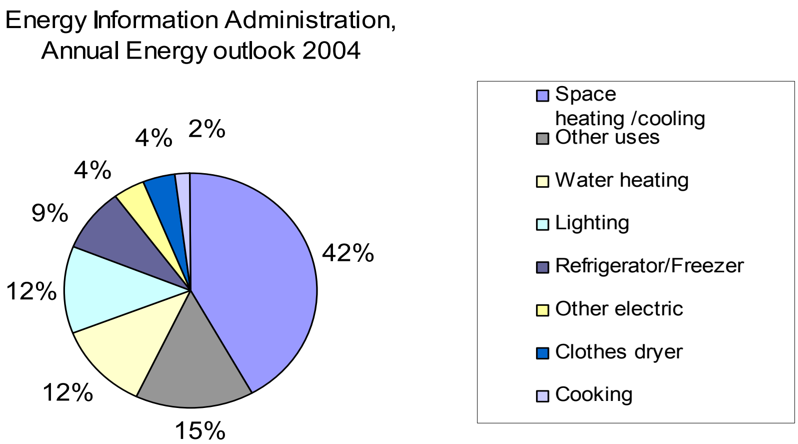
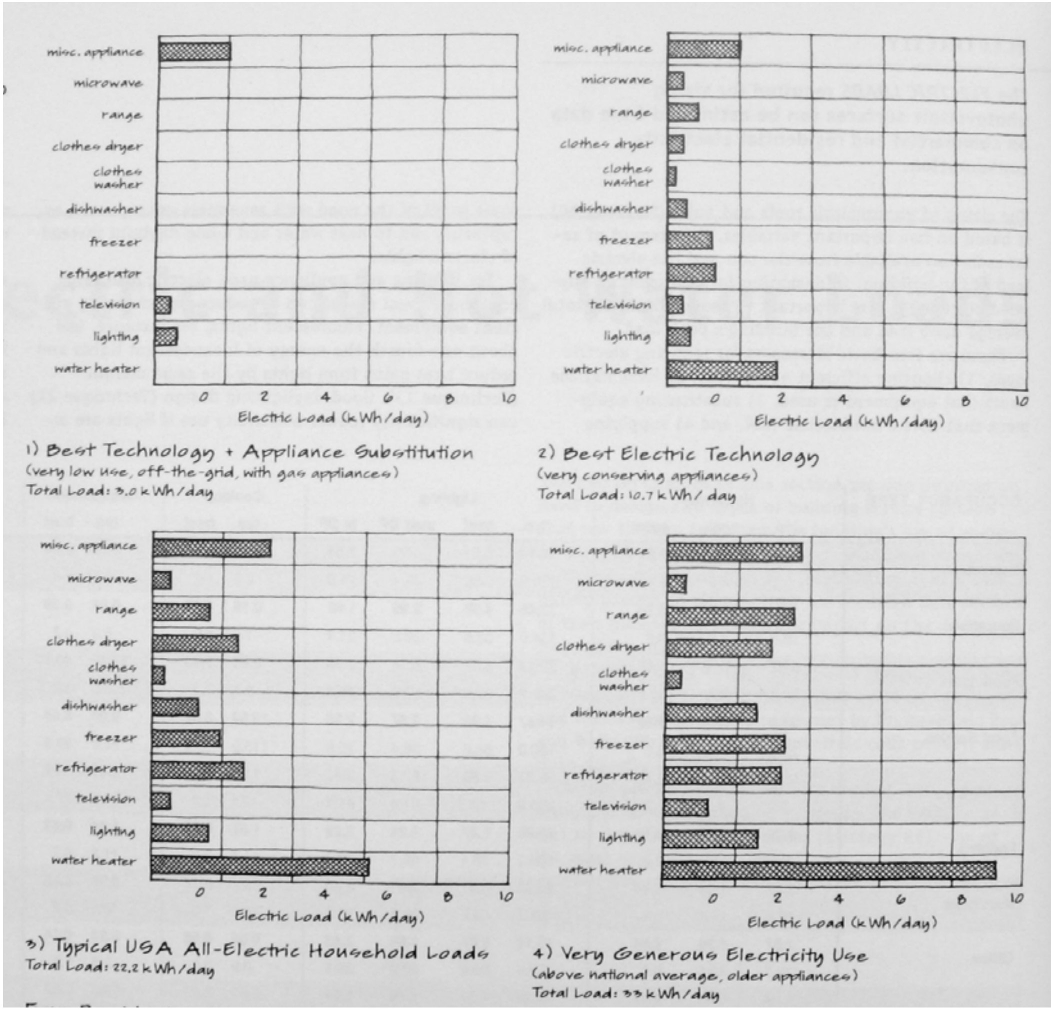


Figure 3.5 : Energy usage percentage in dwellings according to equipment [56]

Electricity consumption of buildings is directly related to the occupant behavior and the quality of the equipments. In Table 3.2; due to the profile of 4 group occupant, electricity consumption is seen. With using best technological equipment, energy usage is 3wh/day while total load is 33wh/ day when older version of equipment is used.

Table 3.2 : Residential electricity usage profiles due to occupant behaviour [15]



The construction of a new building is almost entirely a process of assembly of already manufactured or processed materials. The construction industry is characterized by labour intensive process and energy requirements in the process of construction are relatively small. Of greater significance, is the energy used to win the raw materials, to process and/or manufacture these materials into finished products and transport them to the job site.

3.2 The Factors That Oblige Energy Usage In Residential Units

Comfort status is the total of the conditions which human being can adapt to the environment by using less energy and the conditions that human being is satisfied psychologically. Human's physical, intellectual and physiological performance reach to the maximum level under the comfort conditions in buildings.

Comfort conditions are the bases of the design criteria for;

- To determine comfort standards for internal environment
- To determine design criteria for the buildings that are planned to be climatic and visually comfortable and energy efficient
- To evaluate the criteria for climatic and visually comfortable and energy efficient buildings and sites

Therefore, comfort conditions define optimum inner climate and visual conditions of the buildings and built environment.

The purpose is to create comfortable inner environment whose heating, cooling and lighting energy consumption is at minimum level. Therefore, determining climatic and visual comfort conditions are the first step to create buildings and settlement units with comfortable inner environment [16]**.**

For climatic building design, climatic characteristic and human comfort conditions must be taken into consideration. Climatic comfort is defined as that condition of mind, which expresses satisfaction with the thermal environment for human during his physical or logical activity, in a natural or built environment. Climatic comfort should be achieved by minimum energy from the energy conservation point of view. Climatic comfort conditions are related to person's gender, age, metabolism, activity level, cloths.

Part of the task of designing a building is deciding which properties of the indoor environment need to be controlled, how they are going to be controlled, and the values at which they will be maintained under different circumstances. The first problem is to determine what range of environmental conditions will meet the occupant's need for a productive environment.

The variables involved include;

- Temperature
- Air movement
- Humidity
- Indoor air quality
- Surface temperature
- Internal illumination
- Luminance
- Colours

3.2.1 Climatic comfort

With the present worry about the use of energy, not only because of cost or scarcity, but also because of implications for the emission of the carbon dioxide and global warming, a grasp of dynamics of thermal comfort has become of increased importance [10].

Air temperature, surface heat, humidity, air movement are the components of the internal climate condition. Limited values of these components are acceptable for comfort conditions. Combination of climatic comfort conditions defines optimum climatic condition. Thermal comfort is related to the thermal balance between heat gains due to the metabolism of the body to the environment.

Figure 3.6, indicates the breakdown of the heat loss mechanism; 20% by evaporation, 45% by radiation and 35% by convection. The environmental parameters controlling these components are, respectively, humidity and air movement and mean radiant temperature. These individual components can vary, in proportion up to certain limits provided the medium term heat loss balances the metabolic rate. For example, people may be comfortable on a sunlit snow slope because the high radiant temperature compensates for the low air temperature and consequent high convective losses.

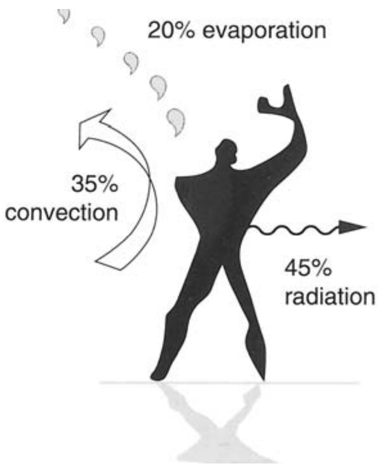


Figure 3.6 : Heat loss from the body in typical conditions [7]

Most of the causes of discomfort can be explained by long-term imbalance of losses and metabolic gains or extreme values of one of the environmental parameters.

It is also helpful to understand the influence on comfort of a person's activity and their clothing level. This is indicated in Figure 3.7, which shows the thermal comfort zone as a function of metabolic rate and clothing level. It underlines the wastefulness of, for example, heating a department store in winter to generous indoor temperatures when the majority of people will be in outdoor clothing. Similarly, stairways and circulation areas should be at lower temperatures to allow for higher activity levels [17].

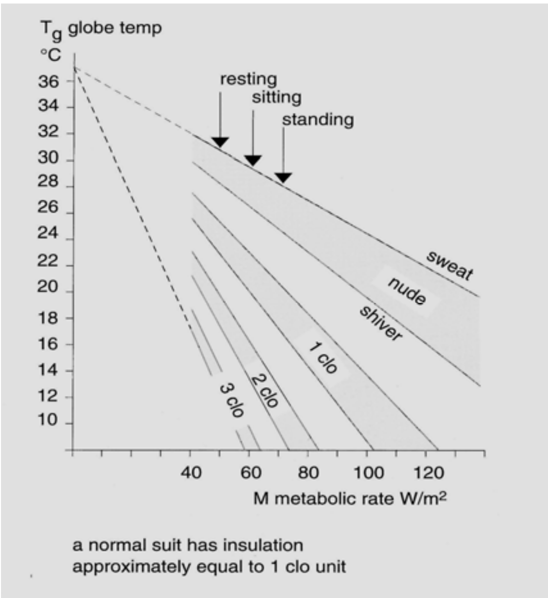


Figure 3.7 : The influence of activity and clothing on thermal comfort zones [15]

Comfort conditions are provided by only the values in specific limits of the components, like air temperature, surface temperature, humidity, air movement. The combinations of the climatic comfort conditions define optimal climate situation.

Corresponding of these needs, with active climate systems at minimum level, provide energy efficiency.

As human produce energy by his metabolism, he can be expected as a heat source for the building, not only by himself but also by activity behavior and usage habits of equipments in the building. This provides internal heat gain that has to be considered to provide and reduce hasting consumption. When large amount of the solar gain coincide with high values of the internal heat gain, uncomfortable indoor temperatures can result. Internal heat gains are by product of occupant activity and use of household appliances, all of which discharge heat, as do electric lights. Much of this heat coincides with occupancy periods and is potentially useful for space heating. In well insulated houses, especially small terrace houses and flats, internal heat gains can be the main source of heating [18].

Figure 3.8 indicates an example chart for average hourly profile of internal heat gains in dwelling with daytime occupancy.

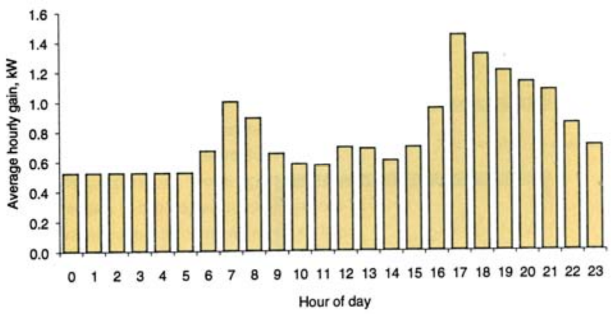


Figure 3.8 : Example chart for average hourly profile of internal heat gains in dwelling with daytime occupancy [22]

3.2.2 Visual comfort

Visual comfort of the human is possible with increasing visual performance and efficiency while protecting eye health and sustain comfort situation that responds physical and physiological needs [19].

It is a common experience that visual performance is in some way dependent upon the lighting level. Both too little and too much result in the eyestrain and discomfort.

When specifying artificial lighting, luminance standards can be met quite precisely. However, due to variability of the sky as a light source, ensuring adequate luminance under daylighting conditions is more complex, as are all aspects of visual comfort.

The other parameters that affect visual comfort are; glare problem, veiling reflections, and color rendering. Furthermore, both daylighting and artificial lighting have an important role in expressing the architectural intentions of the buildings, and hence may affect the pleasure and well-being of the occupants.

To provide visual comfort;

- The design should ensure that all permanent work places are daylighted for the majority of the hours of the daylight
- Sufficient illumination must be provided to enable the occupants to carry out their particular tasks in comfort
- Large areas of the vertical glazing for daylight penetration will need careful detailed design, possibly including redirecting elements such as light shelves, to avoid glare from direct sunlight and bright diffuse sky.
- Consider the positioning and reflectance of the surfaces both inside and outside the building to minimize the risk of glare
- Artificial illumination should be low in glare and of good color rendering, especially in areas where occupants spend long periods. This consideration should influence choice of both lamp and luminary.
- Where automatic light switching, controls are used, ensure that they do not create irritation and interference to occupants [17].

Providing visual comfort with minimum energy usage is possible to design building as a natural lighting system; a system that provides optimal performance. Physiological and psychological needs can be corresponded by providing quality and quantity of the light, which is at the acceptable level or between specific limits.

3.2.3 Air quality

The provision of an adequate amount of fresh air is essential for occupant health, for the removal of moisture and pollutants, and as a source of heat dissipation and cooling when indoor temperatures are high. In winter, the design objective is to ensure adequate air quality with unnecessary increase in heat loss.

A minimum fresh air supply of 20-35 m^3 per hour per person is recommended. Translated to an average whole-house value of air changes per hour, this may range between 0.5-1.0 ac/ h depending on dwelling volume and occupancy. The required ac/h in individual rooms can vary considerably according to the number of occupants and the activity. Care should be taken to avoid draughts, which are a cause of considerable discomfort [18].

For well designed houses, even with low mass, hard finishes and normal number of occupancy but where the moisture problems have been removed from the interior of the house to a wet one, most problems of air-quality will disappear when the air change rate is 0.2 ac h^{-1}. That means that one-fifth of the air of a room is changed every hour. Humidity control can be achieved with a rate of 0.3 ac h^{-1} or more. Actually, this level of air change can be achieved almost door opening air intake only. Air change rate of around 0.45 ac h^{-1} is recommended by researchers [20].

The impact of the humidity on human comfort is complex. Humidity does not directly affect physical responses to the environment. The role of humidity is in its effect on the environmental potential for the evaporation and the way by which the body adapts to the changes in the evaporative potential. The evaporative capacity of the air is a function of the air humidity and air speed.

Low humidity may cause the irritation; the skin becomes too dry and cracks may appear. At higher humidity level, its effect on human comfort and physiology is indirect. It reduces evaporative cooling potential from a given surface area of the skin [21].

There are two ways, in which ventilation can improve air comfort. One is by a direct effect, providing a higher indoor airspeed by opening the windows to let air in, the other way is indirectly, to ventilate the building only at night and thus to cool the interior mass of the building. When a building is cross-ventilated during daytime hours the temperature of the indoor air and surfaces follow closely the ambient temperature. As seen in Figure 3.9, there is a point in applying daytime ventilation only when indoor comfort can be experienced at outdoor temperature, with acceptable indoor airspeed.

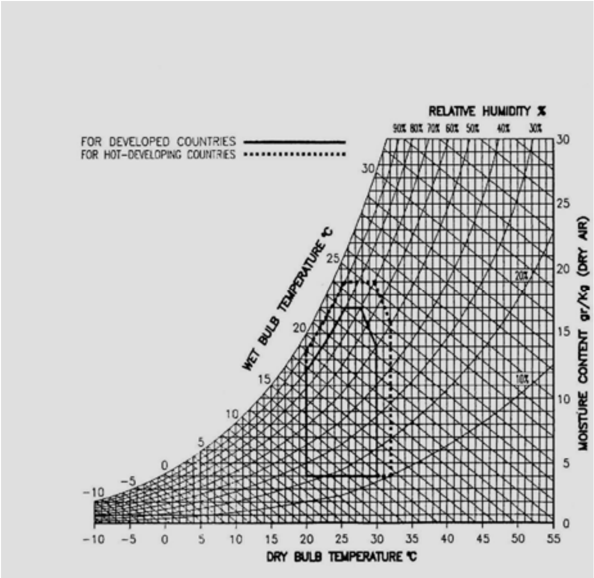


Figure 3.9 : Boundaries of outdoor temperature and humidity within which indoor comfort can be provided by natural ventilation of the day, airspeed 2m/s [15]

3.3 The Obligatory Of Using Energy Efficient Settlement Design

Energy efficiency is no longer an optional extra design, it has become a basic requirement for the designing professions.

The need to design buildings that consume less energy arises from a variety of external pressures; developments in legislation on performance, increasing demands of professional institutions in the field of energy performance; the importance when working with developing technology, of limiting liability risk. Many designers believe, it is imperative to built green buildings because they appreciate the importance to all of us of stabilizing emissions of greenhouse and ozone depleting gases, and minimizing our pollution of this planet.

Decreasing of energy sources, increasing of costs and air pollution that affects human health necessitate energy consumptions of the artificial heating, cooling and lighting to minimum. It is clear that as more and more people become city dwellers, the demand for building must increase, yet an increase in construction activity without the integration of lessons learnt about the environmental impacts of the common practice will make things worse. If we want to survive, our urban future there is no option but to build in ways that not only reduce environmental damage, but which improve the health of ecosystems and protect natural sources [14].

4. FACTORS WHICH AFFECT THE ENERGY EFFICIENT SETTLEMENT DESIGN AND ITS ENERGY COSTS

The factors that affect on energy efficiency process are discussed in three main groups. In first group; parameters related to occupancy, in second group external climate properties and in third group, design parameters related to the built environment take place.

Effective factors for energy efficient building design are seen in Table 4.1.

Table 4.1 : Effective factors for energy efficient building design [9]

OCCUPANCY RELATED PARAMETERS	CLIMATE RELATED PARAMATERS	BUILDING RELATED PARAMETERS
Parameters of occupancy attribute and character - Race, age, gender, activity level, type of clothes Physiological parameters - Body temperature, skin temperature.	External climate parameters - Solar radiation - Ext. weather temp. - External weather humidity - Wind Internal climate parameters -Air temperature -Surface temp. -Air movement -Humudity	-Location -Spaces between buildings -Orientation -Form - Optical and thermo physical properties of building -Natural ventilation avalibility

4.1 Parameters Related to Occupancy

Occupancy parameters can be considered into two parts; occupancy attribute and character and occupancy physiological parameters.

4.1.1 Parameters of occupancy attribute and character

Occupancy attribute and character parameters are classified as race, age, gender, activity level, type of clothes.

Activity level is an important parameter. It affects energy value, which is defined as "metabolism level". Metabolism level is the energy, gained from nutrition, that human body produces in a unit of time. Metabolism level is directly related to the activity type, in other words activity level, of the human. It is, generally, defined with MET unit [9].

Metabolism level is related to the age and gender of the person and it is variable from person to person. Table 4.2 indicates metabolism level for certain activities.

Table 4.2 : Metabolism level for the certain activities (ASHRAE, 55-8,1981)

Activity Type	Metabolism level (MET)
Resting	0.8
Sitting	1.0
Working while sitting (at school, office..)	1.2
Standing	1.2
Light works while standing (etc. Shopping)	1.6
Average heavy works while standing	2.0
Heavy works while standing	3.0

Type of the clothes (insulation level) is one of the most important personal parameter that has to be known to define climatic comfort conditions. Because, type of the clothes defines the thermal insulation resistance, thus, type of the clothes affect heat transfer value between human and his environment [9]. Resistance level for the certain cloth types may be seen in Table 4.3.

Table 4.3 : Resistance level for the certain cloth types (ASHRAE, 55-8,1981)

Cloth Type	Thermal resistance of clothing (Clo)
Winter cloths	0.8-1.2 (0.90)
Summer cloths	0.35-0.60 (0.50)
Spring cloths	0.60- 0.80 (0.70)

4.1.2 Physiological parameters

Physiological parameters are considered in two groups named objective and subjective parameters. The objective parameters are the measurable body responses, such as body heat, skin heat, the amount of sweat and pulse. On the other hand, the subjective parameters (like body form, fatt amount of the body) are responses due to human sensation such as thermal emotion and obvious sweating.

4.2 Parameters of Natural Environment

Ambient parameters are the local and natural properties that belong to related building's location.

4.2.1 Climatic factors

Climate can be described as the resultant value of atmospheric events such as temperature, wind, humidity and solar radiation data in minimum 30 years period, of proper location. Hence, the climate properties are the characteristic results of atmospheric events in a proper zone depends on time.

The continual ambient climate condition is a resultant value of climate parameters such as air temperature, solar radiation, air humidity and wind. Therefore, ambient climate condition can be expressed via these parameters. Buildings should be designed as passive heating and climatization (air conditioning) systems where a proper climatic condition exists in that zone. Since the ambient climatic conditions vary among zones, optimal passive heating and climatization design parameters should differ due to zones [16].

4.2.1.1 Solar radiation

The solar radiation out of atmosphere, on a unit surface that perpendicular to direction of rays is described as a constant value, 1353 W/m^2 by numerous researchers. However, this value can differ depending on orbital distance and time function [23].

The solar radiation intensity on the earth could be changed depending on some effects such as atmospheric conditions, solar constant, height above sea level, sun rising angle, solar rays incoming angle. Solar radiation heats the air, earth and other objects, which causes temperature increasement [24].

The total solar radiation that reaches to building surface from surrounding surfaces, is the sum of the direct solar radiation, the diffuse solar radiation and the reflected solar radiation.

The sun has an important role for both natural lighting and heating energy. The proper usage of solar radiation is advantageous in cold terms, on the contrary in the hot terms, effective sun shading and solar control should be necessary in order not to increase solar heat gain. The insulation amount and duration varies depending on location of the zone.

Turkey's average annual total solar duration is recorded as 2640 hours. (daily total is 7.2hr) and average total heating intensity is 1311 kWh/m2 / year (daily total is 3,6 kWh/m2) [7]. Solar radiation potential of the world may be seen in Figure 4.1.

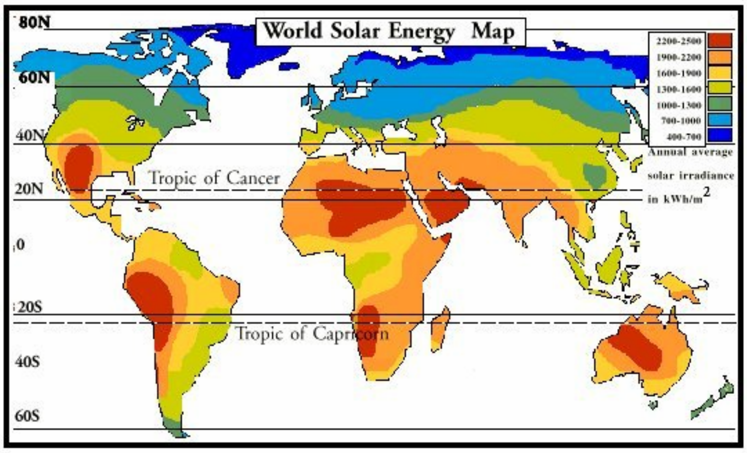


Figure 4.1: Solar radiation potential of the world [57]

4.2.1.2 External weather temperature

Temperature is the most important climate component. Because, weather issues like rain or wind is under the effect of temperature. Kinetic energy, which is the diffusion of heat energy to the environment, is temperature. Diffusion of this energy to the earth is related to the geographical factors, as;

- Solar incidence on the earth

- Distance that the solar radiation pass through atmosphere

- Solar radiation period

- Elevation

- Configuration of sea and land [25].

Temperature value is calculated by a dry thermometer whose body is settled at a certain height from earth, in a shaded area. Daily air temperature difference is related to the atmospheric conditions. At clear atmospheric conditions, daily temperature difference is higher because solar radiation value is higher and concurrently, transmission of solar radiation through the atmosphere is higher. At overcost atmospheric conditions, clouds avoid escaping of radiation, thus, temperature change is fractionally [24].

Figure 4.2 indicates world wide average temperature values due to latitude. Average temperature decreases while the lattitude increases.

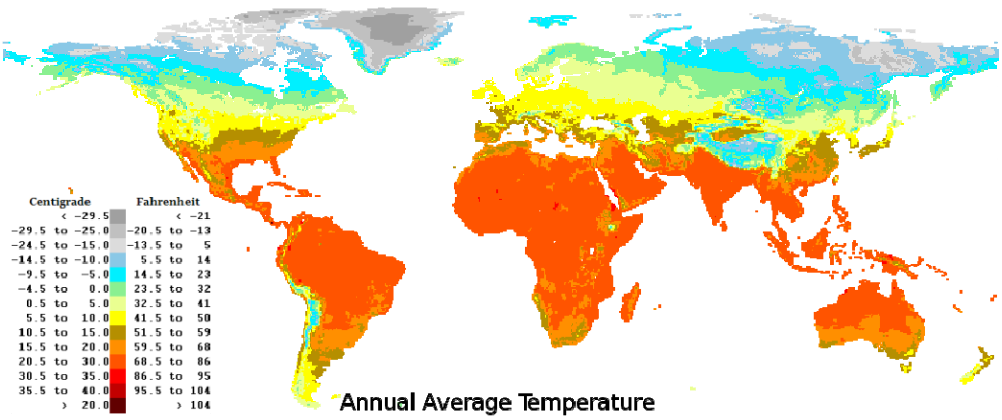


Figure 4.2: World wide average temperature values due to latitude [58]

4.2.1.3 External weather humidity

Water vapor or moisture amount at the atmosphere is called humidity. This rate change by the impact of the factors like; wind, temperature and pressure. The change of the humidity rate affects precipitation. Outer air humidity affects the bioclimatic comfort situation of the inner space. As a result of natural ventilation, outer air that is taken into the building causes changes of the humidity of the air.

Humidity of the air influences precipitation. Rising warm air carries water vapor high into the sky where it cools, forming water droplets around tiny bits of dust in the air. Some vapor freezes into tiny ice crystals which attract cooled water drops. The drops freeze to the ice crystals, forming larger crystals are called snowflakes. When the snowflakes become heavy, they fall. When the snowflakes meet warmer air on the way down, they melt into raindrops. Worldwide rain character is seen in Figure 4.3.

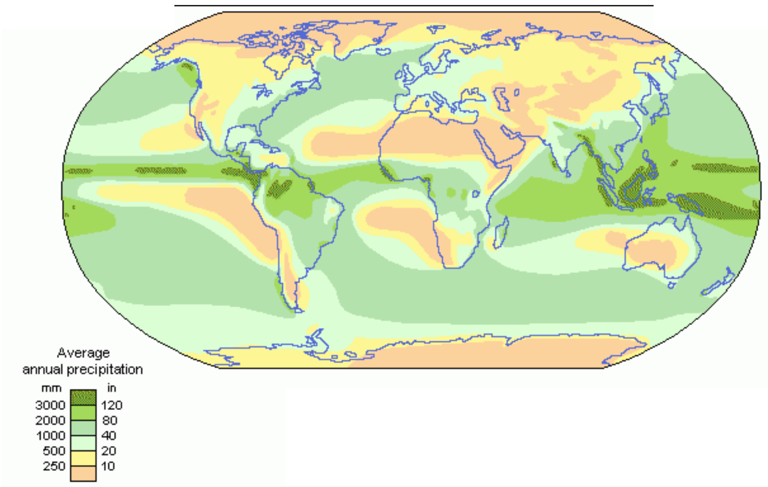


Figure 4.3: Worldwide average precipitation values [59]

4.2.1.4 Wind

Air flows from hot air temperature and high-pressure areas to cold air temperature and low-pressure areas. This airflow is the base of the wind. For the energy efficiency, wind should be used truly. Wind might cause avoiding energy protection by infiltrating through building envelope in cold climates, although it may cause cooler air and comfort effect by avoiding evaporation in hot climates.

In the high-speed wind regions, infiltration impact may occur through buildings. When the amount of the infiltration increases, it is not only insalubrious for the health but also a reason to loose heat. Heat loss of the infiltration is 30% of the total heat consumption. For this reason, buildings shouldn't be directly settled toward prevailing wind direction and undesirable effects of the wind should be blocked by the wind breakers [26].

The effect of infiltration to the energy consumption in different type of buildings is seen in Table 4.4.

Wind is an important factor that affects energy efficient design decisions both at location and at building scale. This impact is totally related to the form and the height of the building. When the impact of a cubical building to the wind is considered, increased wind speed is seen upper side of the roof of the building. At the side that is not affected by the wind turbulence occurs. This kind of formation, normally, as of the bottom level, disperses pollution and diffuses it by the cooperation of the side wind [27]. Figure 4.4 indicates air movement around buildings.

Table 4.4 : Heat gain/loss ratio due to ventilation [15]

Building Type / Room	Ventilation Heat Gain/Loss Btu/hr, F, ft²		Ventilation Heat Gain/Loss W/K, m²	
	Average	Maximum	Average	Maximum
Retail Bldgs.	**0.08**	**0.32**	**0.43**	**1.84**
Mall		0.22		1.23
Office Bldgs.	0.09	0.15	0.49	0.86
Assembly Bldgs.	**0.32**		**1.84**	
Auditorium spaces	2.03	2.27	11.49	12.87
Conference rooms		1.08		6.13
Warehouse	**0.01**	**0.05**	**0.06**	**0.31**
Restaurant Bldgs.	**0.15**		**0.86**	**0.00**
Dining rooms		1.51		8.58
Fast food, bars		3.24		18.38
Kitchens		0.32		1.84
Education Bldgs.	**0.16**	**0.49**	**0.92**	**2.76**
Classroom		0.81		4.60
Laboratory		0.65		3.68
Libraries		0.32		1.84
Grocery Stores	**0.13**	**0.32**	**0.74**	**1.84**
Lodging Bldgs.	**0.06**	**0.08**	**0.37**	**0.46**
Hospital patient rms.		0.27		1.53
Residential, multifamily	**0.05**	**0.05**	**0.28**	**0.28**
Dormitory sleeping rms.		0.32		1.84
Auto Repair Shop		**1.62**		**9.19**
Recreation Facilities				
Spectator areas		2.43		13.79
Gymnasium		0.65		3.68
Ball room		2.70		15.32

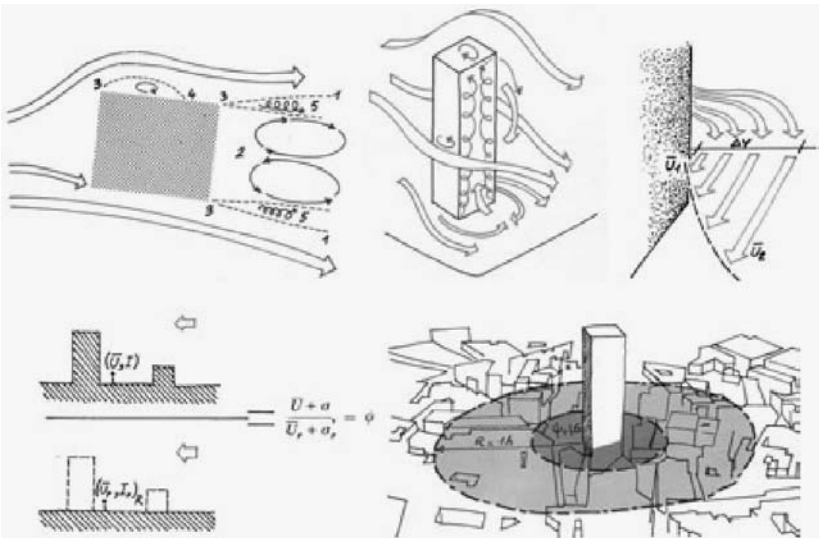


Figure 4.4: Air movement schemas that occurs around buildings [8]

Table 4.5 indicates the characteristic properties of the climate types.

Table 4.5 : Evaluation of the climate types due to climatic parameters [25]

	Sun	**Wind**	**Humidity**
Hot climates	For annual temperature; equator and tropical climate are similliar to each other, temperature difference is not more than 4º -5º.	Continual winds are trade winds. At the north sphere, wind direction is NE to SW, at the south sphere, wind direction is SE to NW	Humidity comes into being because of high rain amount. This levels day time temperature.
Hot and humid	Although seasonal average temperature difference is 25º, daily average temperature difference is 40º-50º	It is hard to define this climate for wind, because it is seen all over the world. It is affected by the trade winds and wet winds.	There are exiguous rain. Daily temperature difference is high because of the few humidity.
Moderate climates	For temperature behaviour; Mediterranean and oceanal climate are similiar (avarage temperature difference is 15º)and , climate are similliar to each other. (avarage temperature difference is 40º)	In general affected by west wind. At the north sphere, wind direction is SW to NE, at the south sphere, wind direction is NW to SE	Rain chart of oceanal, continental and step climate are similliar; rainy in summer. Mediterranean climate is; dry in summer, rainy in winter.
Cold climates	In some regions, annual temperature difference is about 65º	Pole winds are dominant. At the north sphere, wind direction is NE to SW, at the south sphere, wind direction is SE to NW	There are exiguous rain..

4.2.2 Natural Lighting

Buildings function as a natural lighting system, under the daylight conditions due to outer environment. Therefore, while designing the buildings as a natural lighting system, local outer daylight conditions have to be predicted.

For building up city form, access of sun light and solar radiation to the buildings is an important factor, and this certain situation inspires many architects for their architectural concept.

For sustainable and energy efficient architectural design, values related to the parameters as from location scale, slope of the site, direction, position, environmental barriers have to be considered and evaluated. These parameters are important for reflective properties and impacts of the buildings one to another. The affect of direct sun light and solar radiation varies due to the latitude of the site. To provide, both visual and thermal comfort, the location of the sun has to be researched in detail that varies during the course of the year.

Sunlight is a determinant factor that changes continuously, due to variable fact, it is benefited by lighting design process, related to architectural design principles. By using this factor properly, the occupants in the built environment are in comfort [28].

4.2.3 Geographical factors

Geographical factors are the physical environment factors that affect energy demands;

- Longitude of the site
- Latitude of the site
- Elevation of the site

Latitude angle (Φ) : On earth, the distance of the location of the point, to the equator in north-south direction

Longitude angle (L) : On earth, the distance of the location of the point, to the prime meridian in east-west direction [29].

4.3 Design Parameters of Built Environment

Built environment is the volume that comes into being by directing the natural formation of earth or shaping the material for the specific purpose, by human hand artificially executed. Built environment is settled by the needs and local conditions, in traditional process. But at the present day, designed platforms are needed which are arranged according to the contemporary needs, opportunities and give answer to how to affect the earth less.

4.3.1 Design parameters on the settlement unit scale

Location based parameters has a range of variable factors. These factors have to be considered from building level to the urban scale. Each factor has not only direct influences to the demands but also influences to the other factors. The parameters defiened for settlement unit scale have to be taken into consideration for the impact of one to another. For some examples, increasing distances between buildings solves overshading problem but may causes undesired wind effect, so that, each parameter has to be evaluated for its impact to the other parameters.

At this scale, design parameters that affect the climatic performance of the settlement, in other words, the conservation of energy efficiency are geometrical and thermo physical properties related to the factors like settlement area, the location of the buildings that occurs site texture spaces between buildings, forms, sizes, physical properties of open spaces, ground properties and landscape

Design parameters related to the location area defines building environment and microclimatic properties. Design parameters related to the buildings affect city microclimate while it is affecting inner space climate [30].

4.3.1.1 Site and topography

In design process, selection of building location affects many other design parameters and causes dense energy savings and losses. For settlement zones selection of a right location that optimizes climatic effect causes positive results below;

- To minimize heating and cooling needs, which cause energy losses and air pollution

- To avoid the effect of industrial zones over residential zones
- To maximize the building density without compromising human health and using the site rationally
- To design healthy and comfortable open spaces [16].

In a region, depending on the changes of conditions like altitude, topography, earth specialties, built environment dense, flora, lake, sea or river, it is likely to appear a local climate or smaller scale climate that is separated from the region climate. This local climate is called microclimate [31]. While researching energy efficiency on building, in urban scale built environment, the detailed knowledge on that microclimate is required [32]. The energy performance of buildings and thermal comfort needs of the mankind is related to microclimate that natural and built environment defines [33].

The site of the building determines many parameters that effect on the design decisions. Geological and geomorphologic situation of the site and local characteristics have to be determined and it is a must to define design strategies accordingly.

Topographical situation of the building is very important to take the advantage of solar radiation and natural ventilation.

Effects of climatic elements change according to the topographical properties of the site. This change increases the solar radiation value because of the altitude in the atmosphere and permeability of atmosphere. The local area gains heat at various amounts and at various times by solar radiation or loses heat by windy air movements and cold air stream due to the topographical regulation of the site [30].

South hillside of the mountains are warmer than the north side, because it gains more solar radiation and is effected less from cold north wind and as a result of high level solar radiation of the noon time.

The settlements beside lake or sea are warmer in winter and colder in summer because of air movement, depends on rule; land gets heated faster than water. During daytime wind movement from water to land comes into being, and at night time it is inversion [7].

Figure 4.5 indicates possibilities of topography usage for energy efficiency. As seen, topographical parameters have high impact on the climate properties. Each difference of topography in a region may cause its own microclimate.

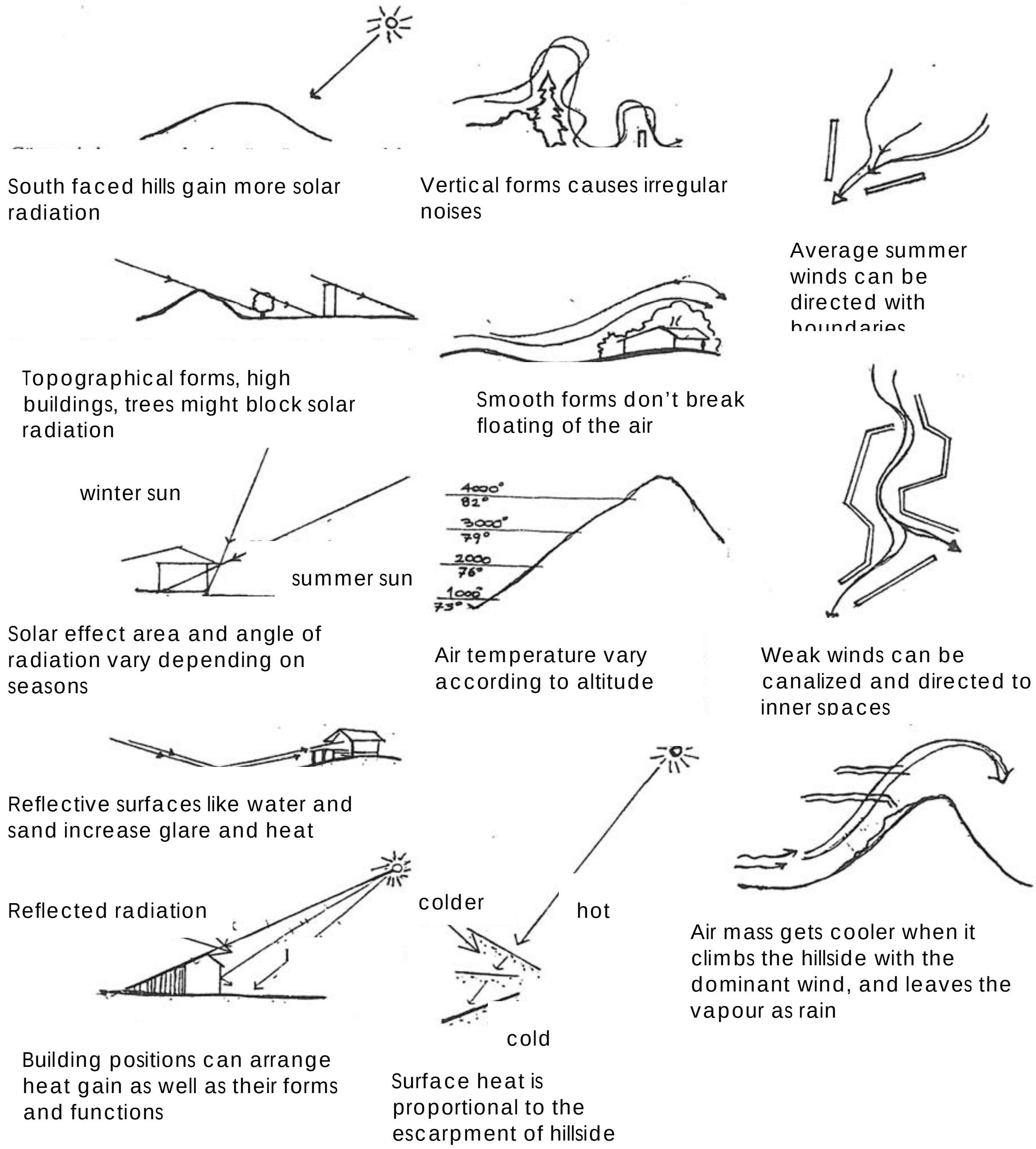


Figure 4.5: Usage of the topography to optimize the climatic effects [8]

- **Slope and orientation of the site**

The slope, and the orientation of the site effect available solar radiation. Solar radiation values increase when the altitude increases. The reasons for this increase are atmospheric conditions, cleanness of the air and the distance that solar radiation passes.

The solar radiation value that affects any land differs due to inclination and direction of surface, as they are exact components. Inclination is an effective parameter that is important to take the advantages of sun [7].

Wind speed at the top of the slope may be 20 percent greater than the wind speed on the flat side, given the same conditions. This acceleration is due to shape of the land and makes this area along the ridge a "cold site". Increased wind velocities accelerate convective heat loss and infiltration from the building envelope.

Another important aspect of site inclination is its orientation with respect to the sun. The amount of solar radiation received by a sloping site is determined by its pitch and orientation. A south facing slope receives more solar radiation than a level site. In winter, when the sun is low in the sky of southern sphere, solar radiation strikes the earth at a low angle. Sites sloped to the south are actually pitched towards the winter sun and receive more of its energy. A 10 % slope to the south, will receive as much radiation as a site 6° in latitude to the south [34].

In the situation of locating a building to a pitched site or hillside, the finest direction and angle that site have solar radiation at most; have to be determined according to latitude. For example in Turkey, highest solar radiation can be gained by orienting to south bounded with 22° for the settlement areas.

Orientation at location scale, should be optimized before orientation of the building itself. A building that is located to a hill, which is faced to sun at the lowest level, might gain less solar radiation although it is oriented truly.

Figure 4.6 indicates combined effects of slope and orientation on annual radiation due to lattitude. As seen for the western hemisphere, to gain higher solar radiaton more vertical slope has to be preferred when the lattitude is higher.

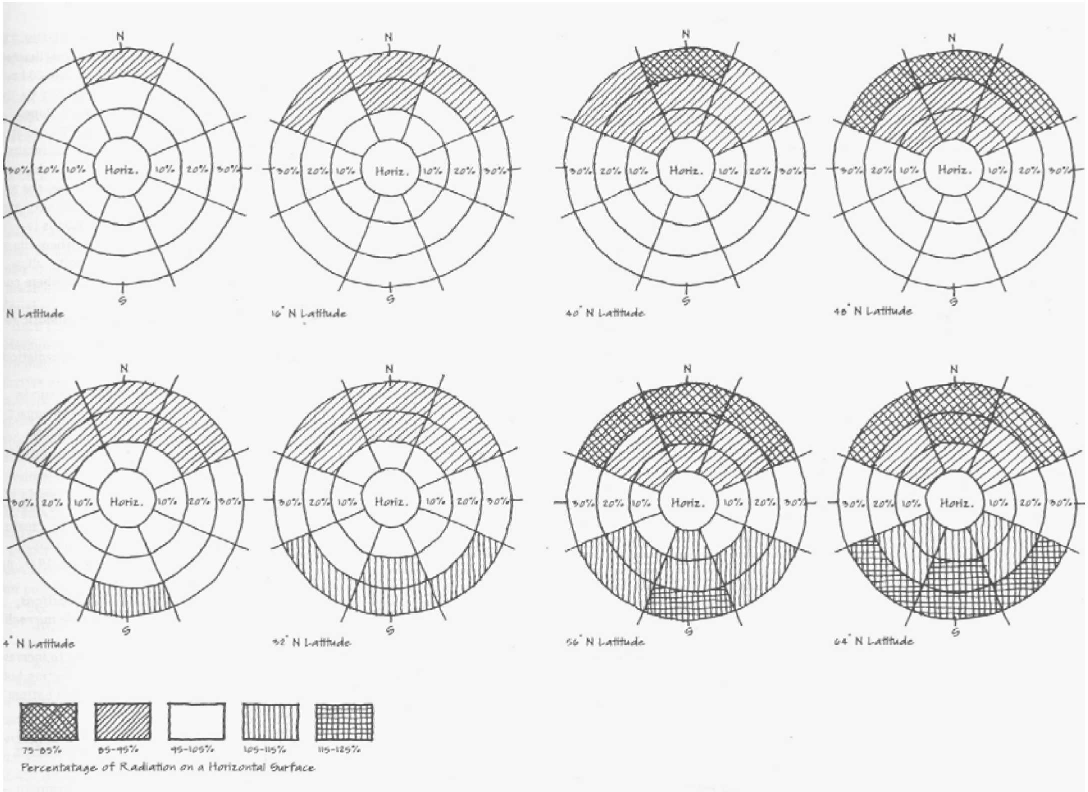


Figure 4.6: Combined effects of slope and orientation on annual radiation due to latitude [15]

4.3.1.2 Landscape

Landscape is an important parameter to control energy loses at residential buildings. By conscious usage of flora it is possible to provide to control the wind, decrement of air pollution and filtering of the air and cleaning the dust pieces. Landscape has positive effects not only on human psychology but also increasing of ecological diversity.

Planting can be used as third skin that optimizes the wind's positive and negative effects. In cold days the trees that have leaf yearly, can be used as wind blocker which might decreases the heat loss of the buildings. For this aim, the height of the trees and the distances from buildings should be set truly. The trees that patch off don't block the advantages of sun in winter and are also shading devices in summer.

Especially, at south, southeast, southwest facades, shading effects can be used. But it is found out in researches that even in winter, the trees without leaf might have shading effect with the rate of 20-40% which can not be underestimated [35]**.** At cold climate regions, in the effective wind direction boundary walls can be built with plants. This kind of protection decreases the heat difference at building surfaces by convection. The height and the distance of these walls toward building are important to ensure taking the wind inside of the building.

In urban scale main ways to improve climatic comfort by planting are;

- shading
- evaporation
- controlling air movement

Especially at hot climate regions, planting has effects on cooling and thermal arranging. In this point, plants help to decrease the effect of heat island [32].

Shading of the plants change the thermal solar radiation interaction between buildings and built environment. During daytime, trees block solar radiation and do not let to reach to the buildings, streets, surfaces like walls and roofs. However, at nighttime trees cover the space of visible sky and underestimate cooling that occurs by heat transfer. At this situation tree leafs become envelope for the earth level. At night air temperature under tree level is higher than sky, as seen in Figure 4.7 [35]. Because of this reason at night air temperature falls are lower according to day time. It is possible more effective results with landscape based passive cooling strategies and design parameters of site location [32].

In winter thin and thick branches of the trees without leaf block the %35-45 of solar heat and let pass %55-65

In summer trees with leafs absorb % 70-85 of sun heat and let pass % 15-30

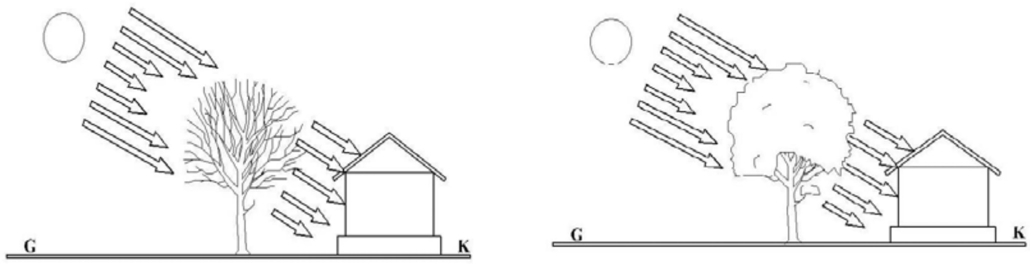


Figure 4.7: Solar heating control with trees [32]

4.3.1.3 Settlement texture

To design distances between buildings and open spaces around building groups design criteria like solar radiation and air stream should be considered.

To benefit from these criteria for passive climate, the distances between buildings and optimal location related to the building size have to be determined.

- **Settlement form**

Settlement form is determined as the buildings themselves and the pattern of the open spaces between them. Settlement form creates microclimatic environment by the geometric and thermo physical properties of buildings and open spaces between them.

To create expected effects for the buildings in the neighborhood;

- The way of location configuration has not to block or ensure protection of gains of solar radiation and wind of each building to one another.
- Homogeneous configurations with homogeneous distances toward prevailing wind direction have to be created to avoid wind turbulence at the level that pedestrian walks at the open spaces
- Buildings heights have to be designed according to expected effect of prevailing wind and wind stream that effects form [30].

Figure 4.8 indicates the effect of site texture on solar access.

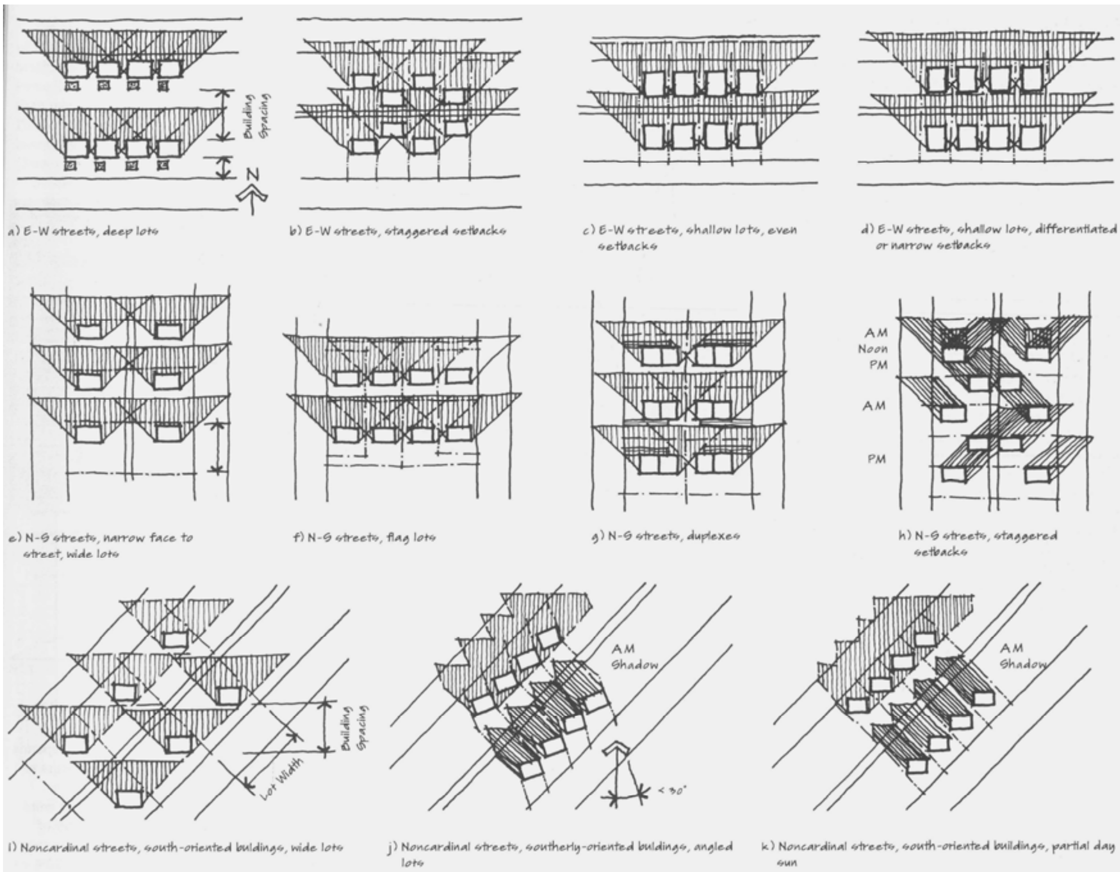


Figure 4.8: Site configuration proposals for solar access [15]

- **Site configuration design**

By the choice of site, the question of designing site configuration comes through. Urban designers use many methodologies to define site texture, which affect thermal and visual opportunities of the site. The form of the site is a parameter that has impacts of shading properties of buildings one to another, local wind property, solar radiation potential of given case.

- **Settlement texture density**

Settlement texture density is an important factor for design criteria. In the cities with dense locations, the wind movement acts different when compared to country locations because of the factors like shading on, keeping heat, reflecting sun. In the dense location regions, air movement speed is lower, air temperature is higher, and as a result of defecting of landscape, humidity is lower.

In general, the higher density of buildings in a given area, the poorer its ventilation conditions. On the other hand, a high density is beneficial for reducing the solar exposure of buildings during summer period. The influence of the urban density on the ventilation conditions depends on the wind direction and the spatial arrangement of the buildings and their height. A bigger separation between buildings in north and south directions than east and west ia proposed, in order to ensure high solar collection during winter and solar protection of the west and the east sides, which are not easily shaded, during summer [37]**.**

The geometrical character of built environment effects heat interaction between buildings and environment. Heat degree of outer space that the building locates is determined not only by the wind speed, solar radiation or regional climatic properties but also determined by the local microclimate that is changed by the cities urban

In some regions, climatic differentiations might occur in only few kilometers. Energy balance of building is total of interaction of building and built environment that the building is located. The situation differs according to locating in the city, in the country or near the city. Heat island effect might be seen according to the microclimatic properties of location.

- **Heat island effect**

Heat island effect is increment of the heat that ensures thermal discomfort at the built environment at night and day. In summer days, the value of strength of high heat island effect can be defined with observing the heat difference between country and city. Heat island is a phenomenon related to built environment geometry, thermo physical properties of surface materials, landscape and water factors [38].

Main reasons of heat island formation;

- Presence of high density of buildings on ground of varying levels sunlight is repeatedly reflected of many surfaces. This means that buildings and ground surfaces absorb more solar radiation during the day, while the dense built environment disturbs the heat radiation towards the cold sky at night.
- Except in spots with the strong winds, decreased wind and velocity in densely built environments, compared with that in the sky above.
- Decrease in permeable ground surfaces, such as bare earth and greenery. This result is an increasing amount of heat radiation from the ground, as the capacity to retain water is reduced and thus the cooling effect of evaporation is lost.
- Ground plane in cities is covered with materials of high thermal capacity; solar heat absorbed during the day is emitted at night, producing uncomfortably hot temperature even after dark.
- In city centers for example, the heat generated by consumption of energy by air conditioning equipment, lighting systems, automobiles, and factories, is released into the atmosphere.
- Ambient pollution produces smog, which traps heat. This can rise temperatures by transforming an entire city into a “glasshouse” enclosed in a layer of polluted air [13].

Avoiding the heat island effects is possible with applying the design parameters at location scale truly. Locations that are correctly oriented, sized to let ventilation, and configured are less effected like locations that have enough green area and green roofs.

The graphic of heat island effect in the cities may be seen in Figure 4.9. The temperature difference is seen about 4ºC between suburban residentials and downtown.

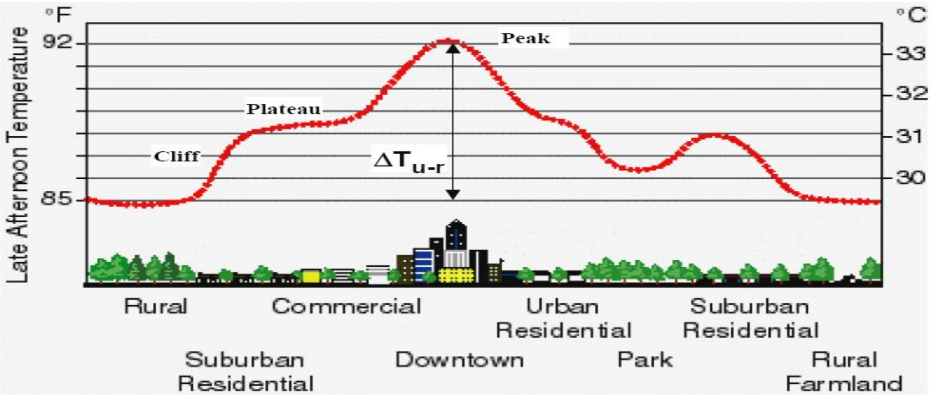


Figure 4.9: Heat island effect in cities [32]

- **Open spaces of settlement texture density**

Climatic performances of open spaces and the buildings around them are affected with the microclimatic facts that are related to the material of the surface coverings. Surface heat might rise to the high levels according to the ground cover material variation.

For landscape design of open spaces between buildings and open spaces around building groups, solar radiation and wind effect, have to be considered.

- **Orientation of open spaces between buildings**

By the orientation of spaces between buildings, wind can be directed to increase its cooler effect. Distances between buildings can be optimized for its solar radiation and shading effects and wind can reach to all buildings of the site as it is expected. Building height and configuration of location is important for the direction of wind.

An optimum street layout, which provides good ventilation conditions to the pedestrians in the streets and to the buildings along the street, is one with wide main avenues oriented at an oblique angle (20º-30º) to the prevailing winds. In this way, wind can blow through the city.

Built spaces in the cities, decrease the speed of wind. On the other hand, different building groups ensure local differences of the wind speed. Around high buildings, at ground level, local increase of the wind is seen because of the turbulence. To avoid the negative wind effects of the high-rise buildings in urban spaces, some prevention has to be added to the design of the form and façade.

For energy efficiency, due to climate conditions open spaces could be designed as indicated Figure 4.10.

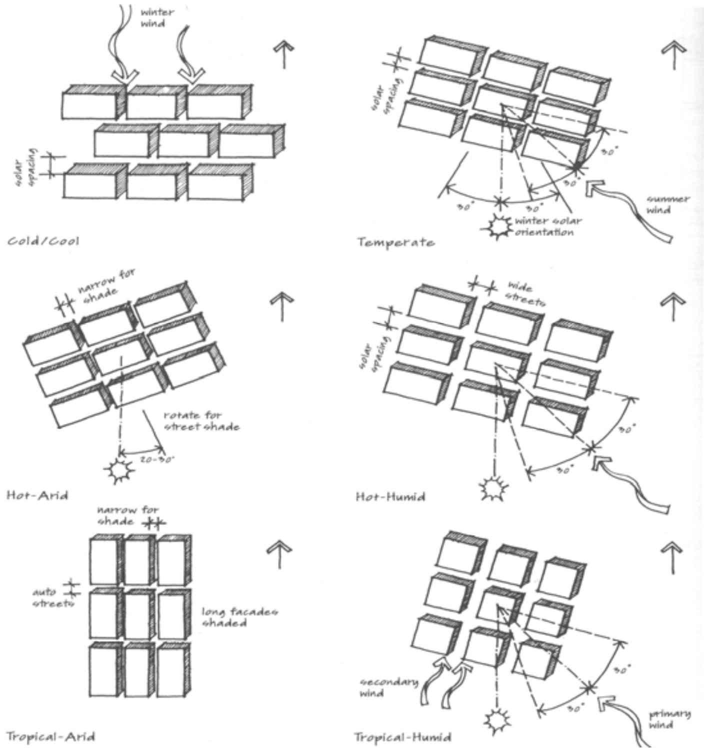


Figure 4.10: Urban pattern recommendations due to the climate [15]

4.3.1.4 Distances between buildings

Buildings might be solar and wind barriers for one another related to the distances between, heights and relative location.

Therefore, to take the advantages or avoidance of heating effects of solar radiation for climate is a function of sizes of open spaces between buildings. When solar radiation hits to a barrier, there are dimensional changes of shading area, for whole day, related to the angular solar situation. When the facades are expected to be affected at the high level; distances between buildings have to be equal to the depth of shading area of neighbor building or more then it is [16].

On the other hand, in hot climate regions or in local areas gaining solar radiation directly might not be preferred at the dates of cooling.

Distances between buildings have to be optimized according to the local climatic data and the distances that provide minimum heating, cooling gains and undesirable shading effects. Distances between buildings have to be determined to not to avoid the positive wind effects.

Buildings react as solar and wind barrier for on another. Outer wind speed that provides inner wind effect differs related to the spaces between buildings. According to increasing of distances between buildings, the outer wind speed decreases [16]**.**

The positive effect of buildings one to another for decreasing climate energy to minimum;

- The distances between buildings have to be determined according to the building sizes, to take the advantages of the solar and the wind when it is needed.
- Shading lengths have to be considered according to the site slope, orientation and location dense to determine the distances between buildings.
- For passive cooling, it is needed to benefit from wind effects. The spaces between buildings toward prevailing wind have to be defined at the level that affects the performance as expected.

The required distance between buildings should be adjusted according to latitude of the place and height of the buildings. In order to benefit from direct radiation on the sunlight hours without blocking each other, the required distance between buildings according to climate are specified in Table 4.6. As seen according to wind achievement in humit climates larger distances are needed while for solar gain temperate climatesdesire larger distances between buildings.

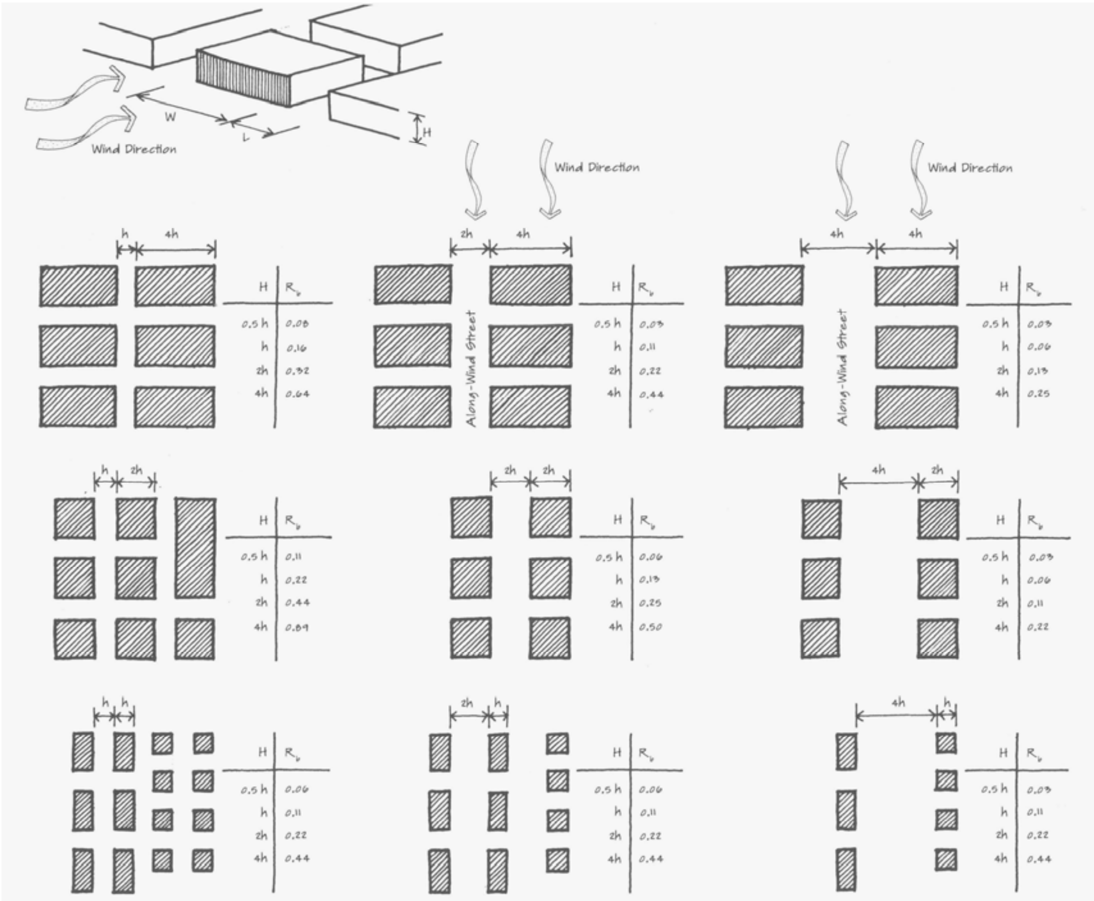
Table 4.6 : The required distances between buildings [60]

Humid	Hot dry	Temperate dry	Temperate humid	Cool
Depending on the wind (In the direction of prevailing wind)				
5-7H<DX	1,5H-2H	H-5H	H-5H	H-5H
Depending on the sun (In the N-S direction)				
1,5H-2,5H	1,5H-2,5H	2-3H	2-3H	1,5H-2,5H

Air movement in streets can be either an asset or liability, depending on season and climate. Wind is desirable in streets of hot climate to cool people and remove excess heat from the streets; it is also potential resource to cool buildings [15].

Table 4.7 indicates the wind effect depending on the distances between buildings

Table 4.7 : Wind effect depending on the distances between buildings [15]



Daylight access is a precondition to the use of daylighting in buildings. In dense context, limitations on building massing are necessary to insure daylight access to every building. A daylight envelope is the maximum volume that can be built on a given site while still protecting daylight access to neighboring buildings or sites. Daylight envelopes; offer a prescriptive development control. As a development tool, the daylight envelope will tend to produce street-oriented buildings of high site coverage and a site is fully developed stepped building forms. While solar envelopes are concerned with access to direct beam sunlight, and thus are determined by sun angles, daylight envelopes protect access to light, which comes from entire sky [15].

- **Determination of distances between buildings**

Due to energy efficiency, aim to define proper distances between buildings is to maximize the heating impact of solar radiation when heating is needed. Thus, for optimum solar gain without solar shading limit values of the distances between buildings has to be known and implement to the design.

- **Determination of characteristic design day of the winter**

Design day of the winter for northern sphere is 21 January that characterize the meteorological heating term.

- **Determination of profile angle**

Profile angle for given design day has to be defined for each direction of the facade due to altitude and orientation. As seen in Figure 4.11, it is calculated with the formula ;

$\tan \Omega = \dfrac{\tan \beta}{\cos \gamma}$ in this correlation; Ω: profile angle

β: solar rising angle

γ: solar azimuth angle

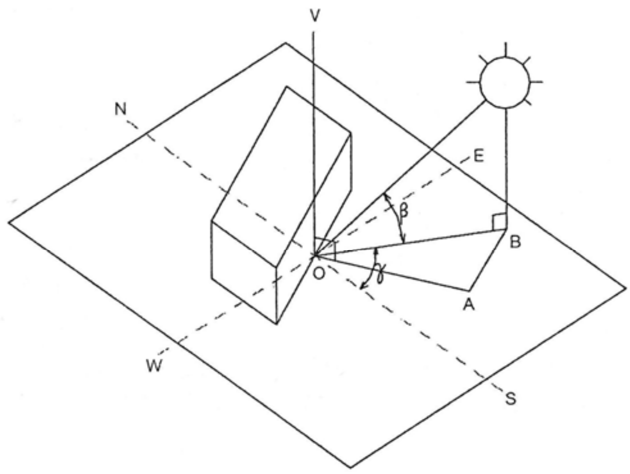


Figure 4.11: Definition of solar rising and azimuth angles [16]

- **Determination of shaded area by the building**

Shaded areas made by buildings in a site are related to the topography. As seen in Figure 4.12, shaded area dimensions are due to the slope of the site.

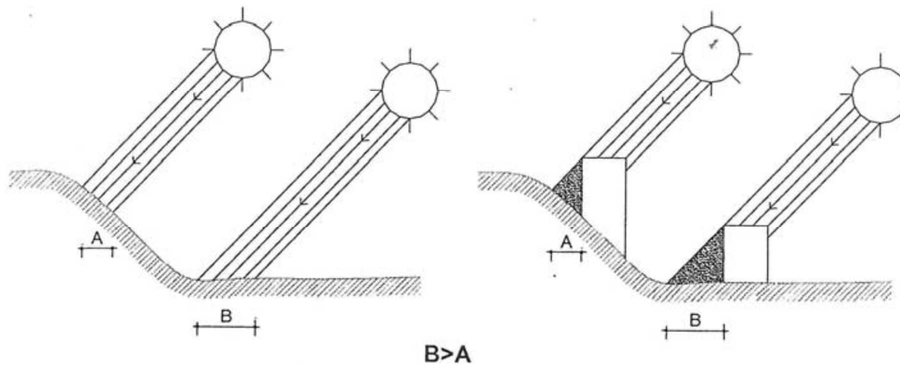


Figure 4.12: Shading dimensions and solar radiation of slope surfaces [16]

- **Shaded area depth of building on a horizontal plane**

Shaded area depth of any building, at any hour of the day, which is oriented to any direction is calculated as seen in Figure 4.14.

- **Shaded area depth o f building on a slope plane**

At slope plane, shading depth is calculated due to the direction of facade, hour, profile angle and height of building, which may seen the impact of the direction in Figure 4.13.

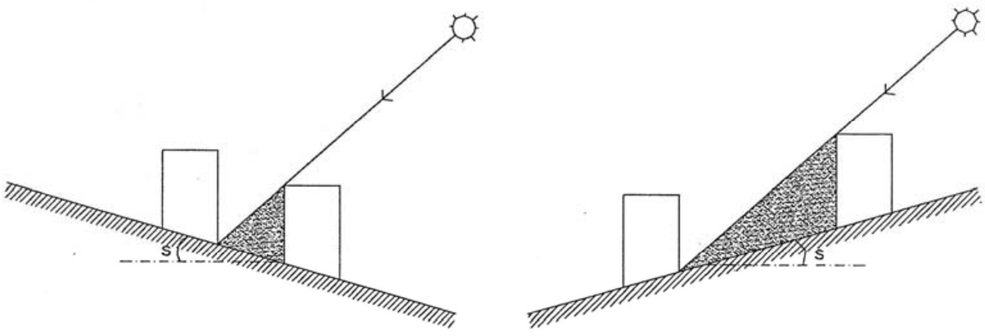


Figure 4.13: Variation of shaded are depth of slope plane due to direction [16]

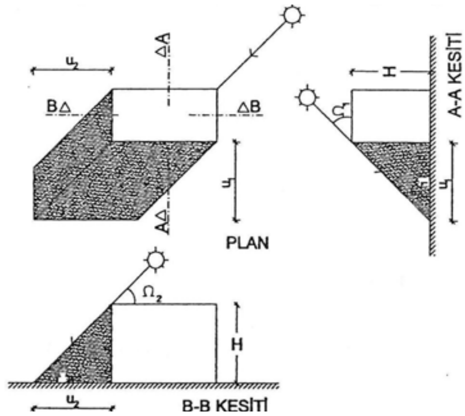
Shading depth of slope plane varies due to the front and back façade height of the building. Front façade is the façade that face the hillside and its height shown as

(Hö) . Back façade height is shown as (Ha)

- **Calculation of shaded area depth due to front and back façade height**

Calculation of shaded area depth due to front and back façade height is determined in Figure 4.14.

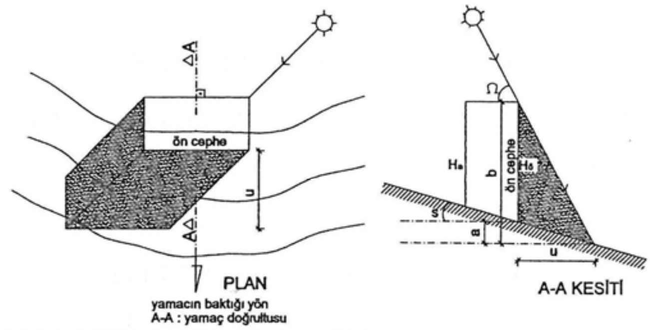
Calculation of the shaded area depth of building on horizontal plane



$$u = \cot\Omega . H$$

Ω: profile angle due to the direction of the facade at given hour
u: shaded area depth around the surrounding of the building
s: altitude angle of the site
H: height of the building

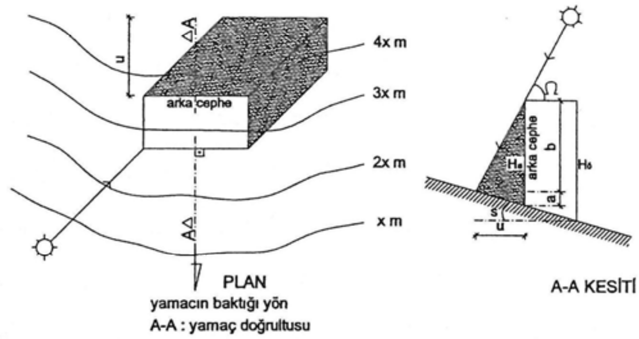
Calculation of the shaded area depth of building on slope plane



Related to front façade (Hö):

$$u = \frac{1}{(\tan\Omega - \tan s)} \cdot H_{\ddot{o}}$$

Ω: profile angle
Ho: front façade height
Ha: back façade height
s: slope angle of the site
u: shaded area depth in front of the façade

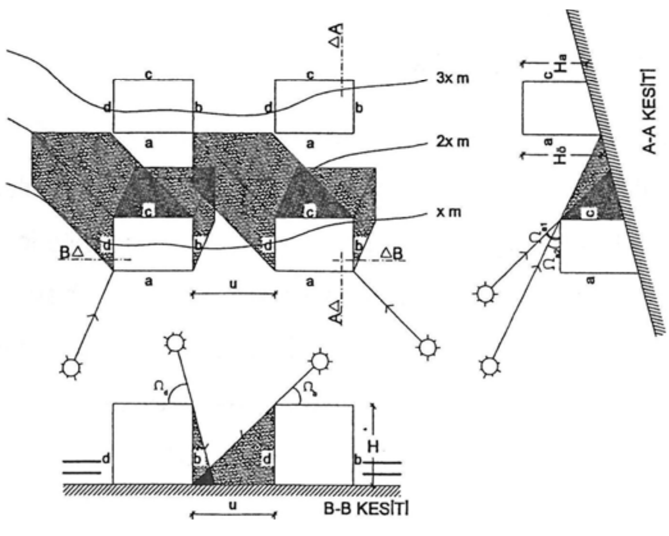


Related to back façade (Ha):

$$u = \frac{1}{(\tan\Omega + \tan s)} \cdot H_a$$

Ω: profile angle
Ho: front façade height
Ha: back façade height
s: slope angle of the site
u: shaded area depth in front of the façade

Depth of the shaded area that is vertical to the hill direction



$$H = \frac{H_{\ddot{o}} + H_a}{2}$$

B-B: vertical direction to the hill direction
Ho: front façade height
Ha: back façade height
s: slope angle of the site
u: Depth of the shaded area that is vertical to the hill direction

Figure 4.14: Calculation of shaded areas around buildings [16]

4.3.1.5 Location of settlement unit according to the other settlement units

Outer climatic factors, as if solar radiation and wind movement speed are differ related to the distance between buildings, surrounding buildings or barriers, height, configuration of buildings according to one to another. It is not possible to gain direct solar radiation at the shaded areas of the building façade that is affected by the other buildings. This part of the building is heated by only diffuse solar radiation. Accordingly, the heat that is gained from solar radiation and inner climate factors, like average radiation heat that affect the climate comfort, decreases when compared with the unshaded buildings [39].

The exact boundary of the shaded part of buildings changes continuously from sunrise to sunset. Some methods have been searched to describe shading affects. A photographic technique for shading analysis of very complex forms is used. A scale model of the building constructed, rotated, and photographed in such a way that the camera sees the model as the sun would see it. Another method is to use a computer graphic display. Computer produces image of building, as seen by sun, after suitable rotations along two axes. A technique that involves use of microcomputer without graphics is used by researchers, which consists rotating mathematical images of the building [40].

To optimize the effects of the buildings one another it must be provided at the dates of heating expected, to minimize the shading. It must be considered at the dates of cooling expected that shading has positive effects on cooling. To ensure energy efficiency in buildings, optimum localization that gains maximum solar radiation in winter and controlled solar radiation in summer must be searched.

Solar envelope is the one of the methods to minimize the negative effects of the buildings one to another.

- **Solar envelope**

Solar envelope is defined as the three dimensional boundary of a building that does not shade on the surrounding buildings. Another definition is that solar envelope is maximum volume of built object that does not shade on the other buildings. A building that is designed in the boundary of solar envelope does not block the other buildings solar radiation opportunity. In other words, solar envelope is the space that considers the benefits of solar radiation and shading situations. It is a space that all design solutions are possible inside [32].

All built mass has light reflective character that results from physical properties of the façade and roof materials. This is not only a reason to gain more heat but also more reflective heating on the other buildings. This is a factor that increases the glare effects at the dates and latitudes, which solar control is expected. The negative effects to the natural lightening have to be considered when the configuration of the buildings one to another is determined.

- **Height of the building**

The height of the buildings is the most important factor that is determining the wind pattern over a built up urban area and this, in association with the distance separating the buildings, characterizes urban ventilation conditions. These parameters also affect solar exposure of the buildings.

Long rows of high, long buildings of the same height, which are perpendicular to the prevailing wind direction, block the wind in the first row and divert it upwards, creating poor ventilation conditions both along the streets and inside the buildings in the rows behind.

Individual tall buildings, rising higher than neighboring ones, disturb the wind pattern of the area and create strong wind currents, especially at pedestrian level [37].

4.3.2 Design parameters of building scale

When building scale built environment is the point of issue, which aims at energy efficient sustainable environment, leading design parameters that affect energy consumptions; are building form, building envelope and thermo physical of the mass.

4.3.2.1 Building form

Due to the form of building envelope, which covers any living area and distinguishes the living area from the environment, the rate between total outer surface area of the building, façade and roof surface areas that are oriented to the variable directions and with variable slope are vary. Building form may defined by the parameters like; ratio of length of the building to the depth of the building on plan, building height, roof type, roof slope, façade slope [16].

Optimal building form according to heating and cooling energy efficiency is the form that minimizes heat loss to the environment during heating term, and minimizes heat gain to the environment during cooling term by the building environment. In the other words, heat gain or heat loss through building envelope is the most important indicator to define a building form that has optimal performance as a passive heating and cooling system. Heat amount that is gained or loosed through building envelope is not only related to the thermo physical properties of the envelope or optical properties toward the solar radiation but also related to the surface area of the envelope and orientation of the building. Surface area of the building envelope is the function of building base surface area and form. Thus, to determine the building that has optimal performance due to heating and cooling energy, proper combinations of orientation and form related to the thermo physical properties of building envelope have to be defined [16].

The region of the building and the climate properties of the region have direct impact on energy efficiency of the building. Table 4.8 indicates the requirements of building form for different climate types.

Table 4.8 : Requirements of building form for different climate types [15]

Climate	Element and requirements	Purpose
Warm humid	Minimize building depth	For ventilation
	Minimize west facing wall	To reduce heat gain
	Maximize south and north walls	To reduce heat gain
	Maximize surface area	For night cooling
	Maximize window wall	For ventilation
Composite	Controlled building depth	For thermal capacity
	Minimize west wall	To reduce heat gain
	Limited south wall	For ventilation and some winter heating
	Medium area of window wall	For controlled ventilation
Hot dry	Minimize south and west walls	To reduce heat gain
	Minimize surface area	To reduce heat gain and loss
	Maximize building depth	To increase thermal capacity
	Minimize window wall	To control ventilation heat gain and light
Mediterranean	Minimize west wall	To reduce heat gain (summer)
	Moderate area of south wall	To allow (winter) heat gain
	Moderate surface area	To control heat gain
	Small to moderate window	To reduce heat gain but allow winter light
Cool temperate	Minimize surface area	To reduce heat loss
	Moderate area of north and west walls	To receive heat gain
	Minimize roof area	To reduce heat loss
	Large window wall	For heat gain and light
Equatorial upland	Maximize north and south walls	To reduce heat gain
	Maximize west-facing walls	To reduce heat gain
	Medium building depth	To increase thermal capacity
	Minimize surface area	To reduce heat loss and gain

At the first studies to define ideal building form, minimizing of building envelope surface, to settle the loss energy that is loosed through the envelope is suggested. This idea has it its train that surface area and the volume covered by the envelope have a direct relation. Consequently, most efficient building form is considered as the form, which minimizes ratio between surface area and volume [41].

Same volume of geometric form variations is defined.

As seen in Figure 4.15, cube surface area is accepted as %100 and it is combined with the other surface areas of the geometric forms. Half sphere has the minimum surface area (%96). The volume that as defined by dividing the cube into 8 equal cubes have double surface area (%200).

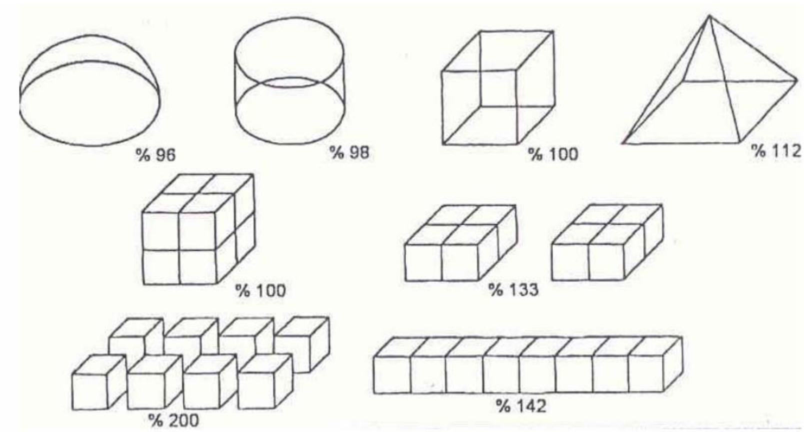


Figure 4.15: The building form – surface relationship [7]

However, it is a complex relationship between the forms and heat loss, thereby, energy efficiency, which cannot be resolved by only surface reduction at the level of simple forms. In this context, computer simulation tools with various algorithms are produced. One of the first study is the multi-criteria optimization by *Radford and Gero,* that aimed for heat loads, daylight and form optimization. On the other hand, *Petzold and Zum* tried to make an optimization between the thermal transmittance end wall dimensions, *Adamski and Marks* worked on the building plan – volume optimization. *Caldas and Norford* were able to calculate the energy loads of the more amorphous forms by the GA Control and Computational Fluid Dynamics (CFD) method. The researches are going on to produce the intelligent simulation systems [36].

Various design methods have been proposed about the impact of solar radiation on the form. *M. R. Sharma* searched on the variation of the orientation depending on the latitude, according to a fixed shape parameter. For different latitudes, he determined the solar radiation load on a flat roof building with ½ length / depth ratio when the facade height is kept constant. *P.Valko* studied on the changes of total solar radiation loads on all external surfaces of buildings according to their direction and forms. He claimed the direction that gets maximum solar radiation for the heating period on January 15 and minimum solar radiation for the cooling period on July 15, which are determined as characteristic is to be optimal. *V.Olgyay;* optimal direction status is the orientation of the all building to the direction that maximizes for heating period and minimizes for cooling period, gets maximum solar radiation on January 21 and minimum solar radiation on July 21, which are determined as characteristic and also determined according to the facade on which the most used spaces of building are and the slope of roof surfaces [29]. The effect of form and orientation on the heat gains and losses may be seen in Figure 4.16.

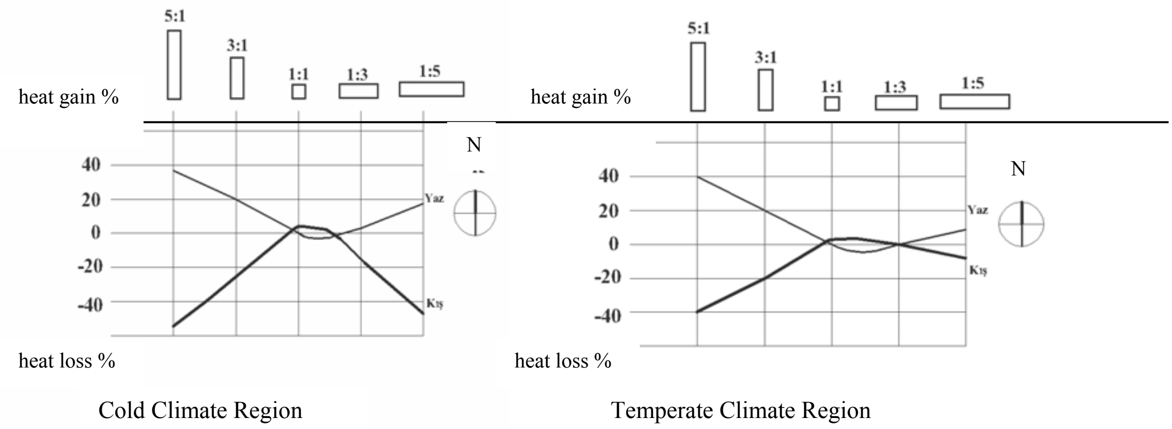
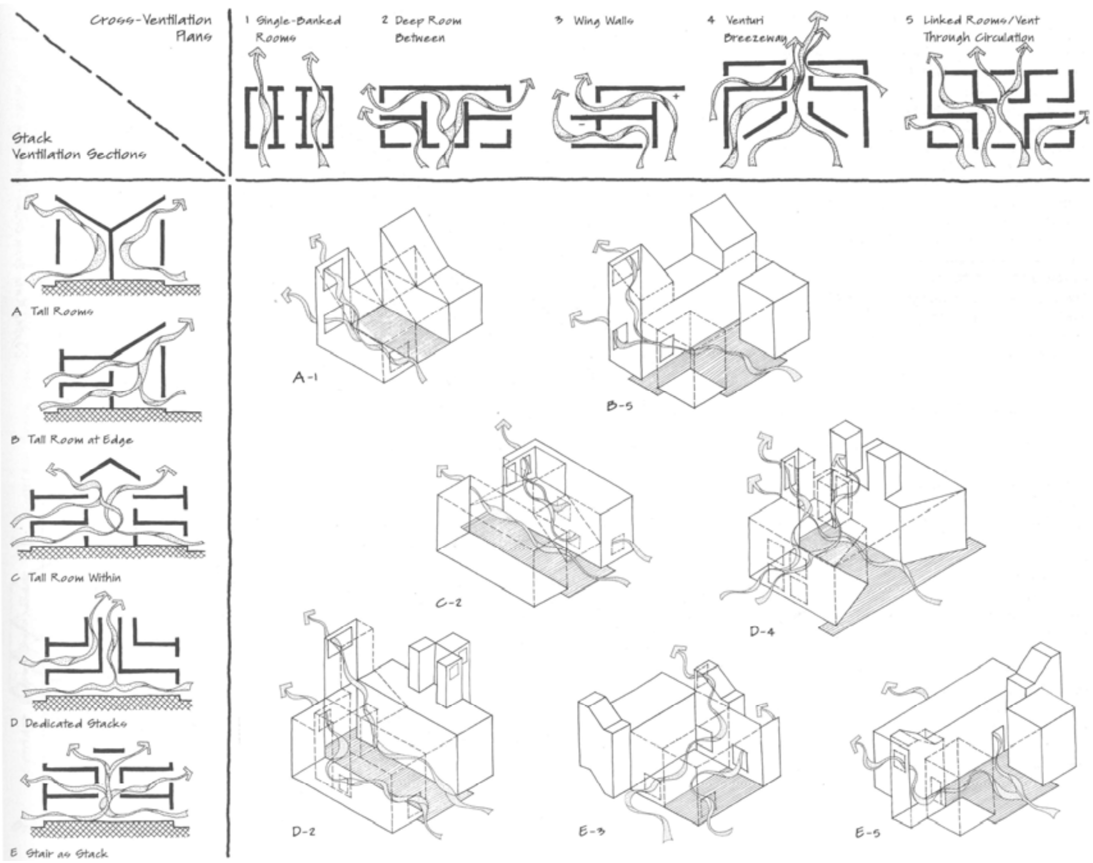


Figure 4.16: The effect of form and orientation on the heat gains and losses [32]

The configuration of the zones in a building, due to energy saving, may define the form of the building. In different climates, as comfort conditions vary, the form of the building varies according to the need of heat gain and natural ventilation. Therefore, cross-ventilation has valuable means of cooling during warm periods because it not only removes heat from the space but also increases the sensation of cooling by increasing people's rate of evaporation. However, in hot climate and in temperate climates at night, air movement is frequently slow, in which case stack ventilation becomes an important supplementary parameter.

In this context, Table 4.9 indicates room organization strategies due to natural ventilation**.**

Table 4.9 : Room organization strategies due to natural ventilation [15]



4.3.2.2 Orientation of the buildings

The orientation of the building is important for inner climatic comfort. Orientation problem has to be solved as a combination of many factors like adaptation to the topographic circumstances, confidence, abstain from noise, orienting toward the view, ensuring and protecting from solar radiation and wind, as it is needed [7].

Outer climate elements like solar radiation and wind differ according to the direction. The heating effect of the solar radiation and cooling effect of the wind change according to the direction and building orientation. Therefore, these parameters can be optimized related to the climatic comfort needs. Besides, related to the orientation of the buildings the amount of the solar radiation of the skin of the building changes. The heat amount that passes through the module area of the skin changes accordingly [16].

Buildings affect each others solar radiation level mutually.

The effect of solar radiation to the building mass differs due to the height, distance and location of the surrounding buildings. The configuration has to be defined with the consideration of the solar radiation in winter. Solar radiation must reach to the building façade, not be blocked by a barrier and be receiving energy accordingly in a definite period. In different climate regions, it is possible to define the main façade of the building related to the orientation. In cold climates, because the benefits of the sun are important, south and southeast are appropriate orientation directions [32]. Figure 4.17 indicates proper directions for climates.

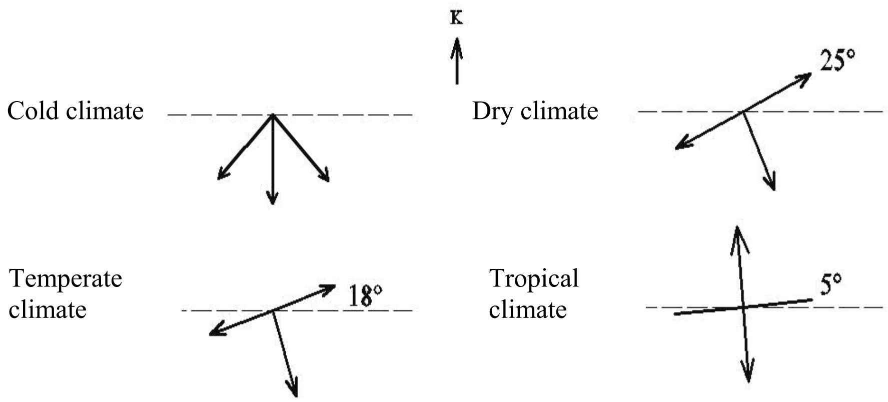


Figure 4.17: Convenient directions for the climatic types [32]

- **Orientation according to wind**

Orientation according to the wind, affects proper ventilation of inner volume, potential of natural ventilation in hot season, heat loss in cold season. Building area that is affected by wind and the direction of absorption are determined by the orientation. The wind blowing toward building provides positive pressure against the elements that is affected by the wind and meanwhile negative pressure occurs at the opposite side. This pressure formation is called absorption. The pressure of the wind that hits the surface of the building depends on the speed and direction angle. Distribution of the pressure on the surface depends on form and rate of the area. Buildings those are perpendicularly oriented to the wind gains total effects of the wind but 45° of direction change decrease %50 of the effect [41].

In Figure 4.18, impact of the wind due to orientation and form of the building may be seen in plan and section scale.

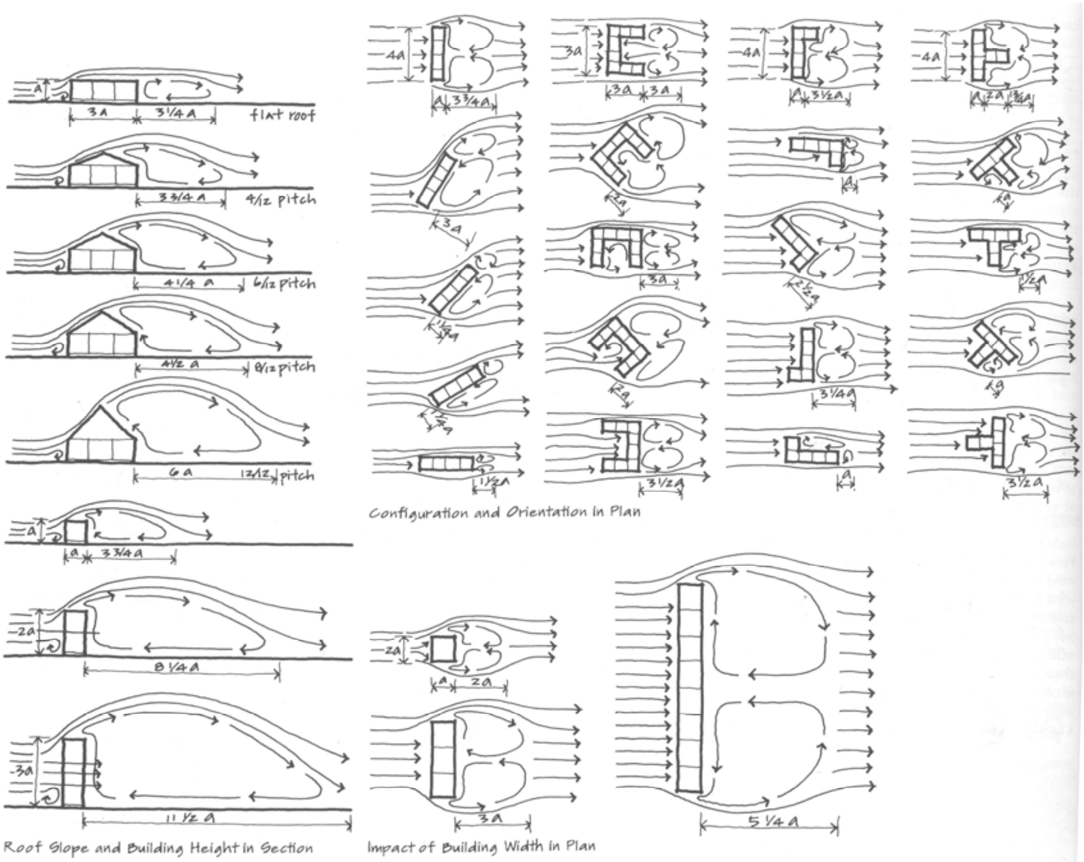


Figure 4.18: Orientation according to wind effects [15]

- **Sun light effect**

Orientation is important for natural lighting or accessing to the sunlight. The chosen optimal direction for heat gains and cooling has to be evaluated for the natural lighting.

Especially in summer seasons, uncontrolled solar radiation may cause glare effects and lighting level more than needed. This brings into account solar control demands. The effect of solar control on heating and cooling has to be revised to reach optimum orientation.

The properties like value of solar radiation, speed of regional wind, quality and continuance of wind, potential of natural lighting vary according to the direction. Buildings have various lighting and solar gain opportunity due to climate of the location that provides various solar radiation from various directions, at various times.

At the different locations of the earth, different values of solar radiation are gained from different directions, at different time periods. This is a reason for lighting variations and different amount of heat gains related to the orientation of the building. Thence, the angle of optimum orientation, related to the location, according to south must be calculated.

Optimization of the solar radiation, lightening, and wind effects can be provided by the orientation of the building.

4.3.2.3 Optical and thermo physical properties of building envelope

In energy efficient settlement design, after the control of environmental factors and microclimate, another important issue is the control of thermal performance of the building envelope. The building envelope that is important in terms of climatic comfort, must provide protection against wind, heat and cold primarily. Thermal transmission properties of the layers forming the envelope, level of air tightness of the envelope, positioning of windows, frames, colors and reflectivity of the glass used are the important inputs for energy control in dwelling. The building envelope is defined as the building element consists of all horizontal, vertical and inclined building components, which separates the internal and external environment. In terms of passive heating function, the optical and thermo physical properties of building envelope get important.

Optical and thermo physical properties of the building envelope determine the heat transfer through the unit area of the envelope in terms of the inner-outer air temperature difference and effects of solar radiation. Depending on this amount, climatic conditions of the internal environment, artificial heating and air conditioning loads vary [16].

Depending on this amount, the inner environmental climatic condition, artificial heating and air conditioning loads vary.

When the external climatic conditions, local data and climatic comfort conditions are considered as the human internal environment data, the variables under the architect’s control is just the optical and thermo physical properties of building envelope during the process of the realization of internal climate comfort conditions.

As it is seen, the building envelope generates different climatic condition in internal environment from the external environment’s depending on its optical and thermo physical properties. It is desired that the climatic comfort conditions in internal environment is carried out continuously.

However, depending on the severity of local climatic conditions, indoor climatic comfort conditions can be achieved with passive heating and air conditioning only in specific periods of the year. In the other periods of the year, artificial heating and air conditioning is required due to the fact that the internal environment's climatic condition differs from the climatic comfort condition.

Because of the fact that the aim is to create a comfortable environment based on minimum energy consumption of artificial heating and air conditioning, the function of the building envelope must be provided to fulfill as an optimized passive system element that let us to need minimum artificial heating and air conditioning supplements [16].

- **Thermo physical properties of the building envelope**
  - **Total heat conduction coefficient (U):** Decrease of the average heat transmittance coefficient of the envelope formed by the opaque and transparent surfaces or increase of the heat conduction resistance reduces heat transfer through the envelope. Thus, saving is provided for heating and cooling energy by keeping the inner air temperature constant.
  - **Transparency rate:** It is the ratio of the glazed area to the total envelope area. While solar gain is provided for lighting and heating by proper use of glazed area, it can cause high heat loss due to its low resistance to heat transmission compared to opaque components of the envelope. The balance of the cold/hot period heat gain/loss and the transparency of the envelope in terms of natural lighting must be carefully determined.
  - **Expansion reduction factor:** The change of the outdoor temperature slows down the heat flow proportional to heat storage capability of the building envelope components and reduces the amplitude of temperature swings or the average temperature deviation value. It is called the expansion reduction factor of the envelope. It is determined as the ratio of the deviation value of internal environment temperature from the average to the deviation value of external environment temperature from the average.

- **Time lag:** It is defined as the time for the highest temperature on the external surface of the envelope during the day to create the highest surface temperature on the inner surface of the component. It varies depending on the thermal mass of the envelope.

- **Decrement factor:** It is defined as the ratio of the highest (Ti,max) and lowest (Ti,min) temperature difference on the inner surface to the highest (Te,max) and lowest (Te,min) temperature difference on the external surface on one day [7].

Figure 4.19 defines time lag and decrement factor of the building envelope.

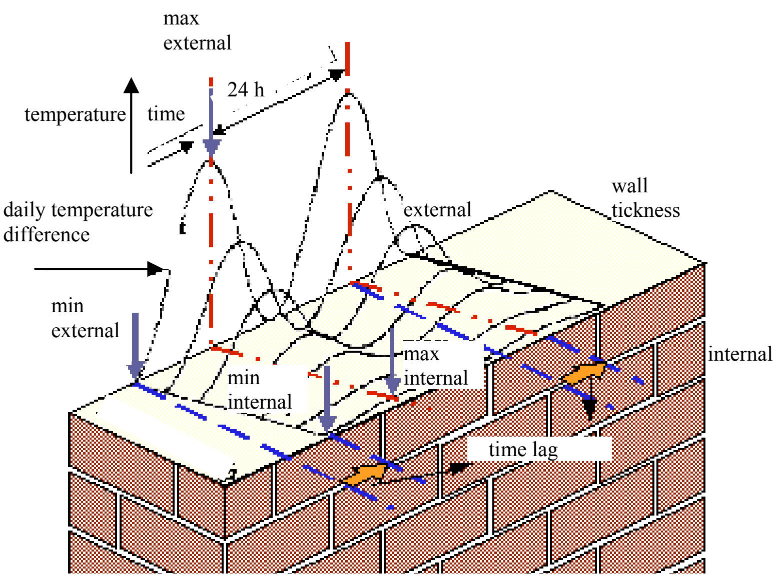


Figure 4.19: Time lag and decrement factor [7]

The amounts of the loss and the gains from the unit area of the envelope element, so is the internal climatic elements, interior surfaces and interior air temperatures are changes depending on thermo physical properties.

In determining the appropriate value of thermo physical properties; since the solar radiation varies according to the direction, it is clear that the question of fair values will also vary depending on the direction.

- **The optical properties of the building envelope**
  - The absorbance of the inner and outer planes of the building envelope.
  - The transmittance of the inner and outer planes of the building envelope.
  - The reflectance of the inner and outer planes of the building envelope

The optical properties of the building envelope can be defined as a relationship between components such as glass walls and roof surfaces' solar radiance. Absorbance, transmittance and reflectance vary according to the opaque and transparent components of the building envelope materials. While the transparent surfaces transmit the short-wavelength light, the long-wavelength's radiance shows opaque features, which gain heat in inner spaces by creating greenhouse effect. Opaque materials do not transmit the rays. They reflect some according to the angle of incidence and turn the rest to heat energy depending on color, texture, surface heat of the opaque material and wavelength of the rays. This feature enables the use of the energy at night, which was gathered during the day in the buildings using passive solar energy. Regarding the daily cycle of the solar energy, the material, which will be used as a thermal mass, should be sufficiently limited in thickness. The thermal capacity, the specific heat and the mass, therefore, the density of the material is proportional to its total volume [42].

The definition of the building envelope from the aspect of passive heating and air conditioning, the envelope's optical features such as solar radiation absorbance (a) , transmittance (τ), reflectance (r), coefficient of total heat conduction (k), transparency (x) is defined with the thermo physical features such as mentioned above.

Relations between the optical features such as solar absorbance (a), transmittance (τ), and reflectance (r) of envelope are;

- For opaque building surfaces $a_o + r_o = 1$
- For transparent building surfaces $a_c + r_c + \tau_c = 1$

The coefficients values of absorbance, transmittance and reflection are the ratios of the incoming solar radiation to the outer surface to the absorbed, transmitted and reflected amounts. The solar radiation on the outer surface of building components, depending on the optical properties of the component is turning to solar heat gain [16].

4.3.3 Design parameters on the room scale

Buildings can block sun and wind; they create series of different microclimates around them. Thus, combinations of wind and sun directions have implications for where to locate rooms. Orientation configuration of the rooms according to their function has to be considered for energy efficiency.

4.3.3.1 Orientation of the room

In any climate where the sun and its heat play a dominant role in human comfort, the direction that a residential settlement is orientated is the most effective parameter. The north and south exposures are the easiest to deal with in the northern hemisphere. The north side can be considered the cool side as the sun spends very little time in the northern sky. The south side can be considered the sunny side, since during the course of a day the sun spends more time in the southern sky. However, in the northern hemisphere, the sun is almost straight up in the sky, at noon, in summer because of latitude, which means that a southern wall can be very well shaded from the sun with a very slight overhang. The advantage is that in winter, when the sun is lower in the sky, these slight overhangs allow sunlight penetration deep into a house to provide some passive solar heating.

The east side of a residential settlement will take a lot of the sun's morning heat, while the west side of the residential settlement will bear the brunt of the sun's afternoon heat. In the northern hemisphere, the overheated period (the time when air conditioner will run the most, and the time to avoid going outside and doing strenuous activities) occurs between 2pm and 5pm. Since ambient heat of a day has built up, the sun's added heat will compound. For this reason, it is better to avoid purchasing residential settlement with a lot of western exposure, even if the air conditioning system is sized specifically for it, because residential settlement will consume more energy to keep cool than the one with less western exposure.

4.3.3.2 Dimension of the room

Space sizes are, before all else, important for natural lighting. Light radiation must be determined in room rate, to have an effective natural lighting. The aims of room daylighting are to adequately illuminate visual tasks, to create an attractive visual environment and save electrical energy. [45].

The amount of the light that reaches to the interior of the room lit from one side is a function of the distance from the window, the height of the window from the floor, the size of the window, and the reflectivity of the room surfaces. As one moves from the window wall, the proportion of the exterior daylight available inside decreases. Therefore, depth of the room is an important design consideration for the daylight [15].

In Figure 4.20, impact of the room width and depth to the daylighting may be seen.

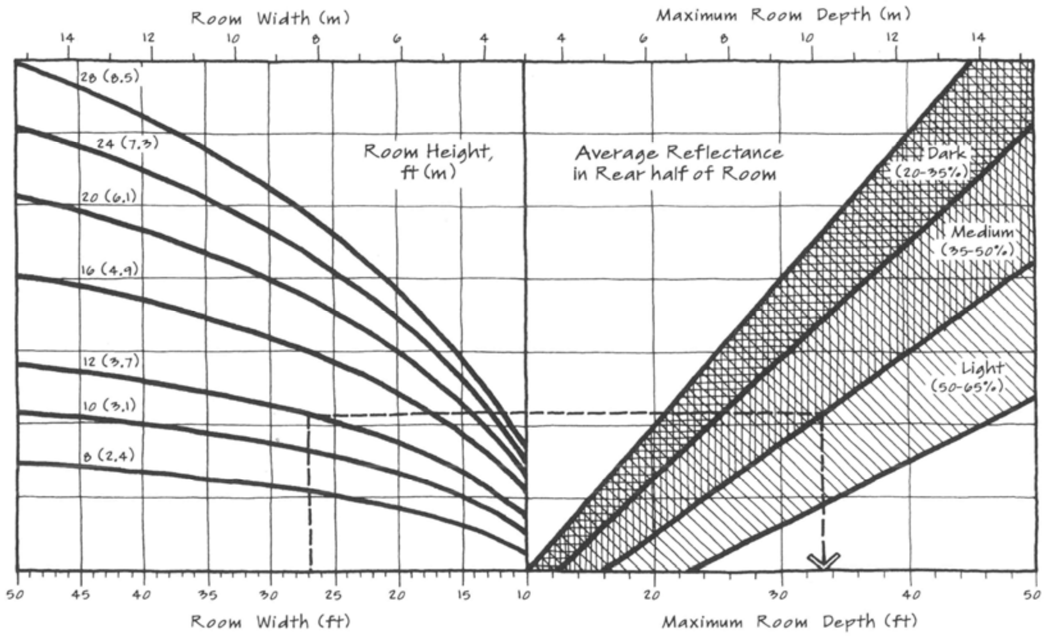


Figure 4.20: Maximum room depth for natural daylighting [15]

4.3.3.3 Room form

The amount of exposed skin relative to the volume enclosed increases as comfort forms like cubes elongate to forms like rectangles or more articulated envelopes. Therefore, the heat loss or gain through the skin by conduction and convection is greater for elongated forms than for compact forms of the same volume. Similarly, large buildings have less area of the exposed skin as a ratio of a floor area, than do small buildings of the same massing proportions. Buildings with a higher skin/ volume ratio also have more radiation falling on their walls, windows and roofs. When controlling heat loss or gain through the skin is a primary concern, rooms can be contracted into a compact form.

Figure 4.21 indicates the impact of space organization to the solar radiation gain.

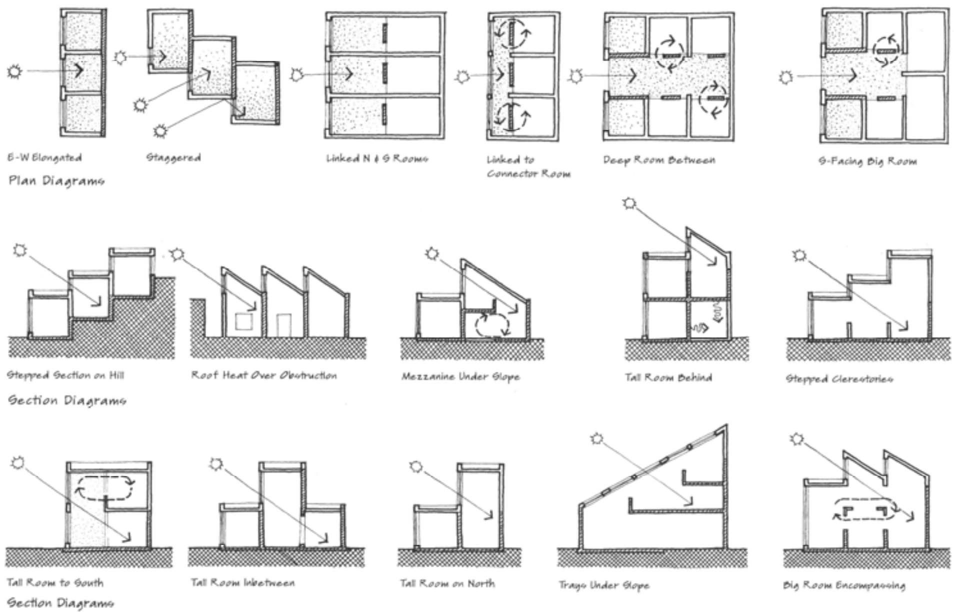


Figure 4.21: Plan and section organization for solar heating [15]

While solar access to each room makes solar heating each space simple for thin, elongated organizations facing the sun, thicker buildings of two or more rooms thick provide a challenge when solar heat is desired [15].

As seen in Figure 4.22, the ratio of skin area/ floor area of the room has an effect on the heat gain and loss.

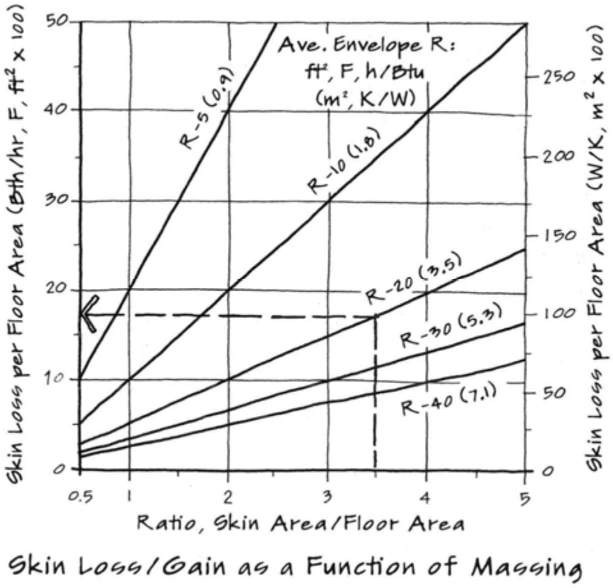


Figure 4.22: Skin loss/gain as a function of room form [15]

4.3.3.4 Location of the room in the building

Heat desire of a person in each dwelling unit, depending on the usage activity, varies. Therefore, living rooms are preferred to orient south east to south west for gaining direct solar. Bathrooms and kitchens are tend to be oriented to north, as comfort heat gain of equipments in kitchen increases the temperature and bathrooms are preferred with small ratio of glazing for the privacy reasons. Bedrooms may orient to eastern, to take the advantages of the morning sun.

4.3.3.5 Light reflection coefficients of the surfaces inside the room

Primarily, criteria of light quality design of inner surfaces are; lighting level, gleam distribution, avoiding glare, directing light, shading and light colors. Each time, all criteria have to be implemented and adapted to the design, to answer to the special needs.

The distribution of sunlight in inner spaces is affected by reflection and refraction properties of the light, hits to the surface, and also color properties of light and surface. Surface color varies due to light formation and reflective property of different wavelengths. The relation between reflective property of light and lighting level is an important research issue. Each color has own reflective property. Color property of light source affects visual comfort in inner space. Substances can be seen with the color of light source color [43].

With the lighting system planning, the spaces, in which high reflective materials and colors are used, are lighted more effective. In addition, they look larger than the low reflective spaces. Thus, reflective property of the materials of a space has to be known before lighting. To not to make lighting according to the pattern properties and reflective quality of the material may cause misunderstanding of the function of the space and uncomfortable environment. For example, reflective of a luminous material surface is very different from non- luminous material surface. Thus, material reflective properties have to be considered when lighting is designed. Reflective attribute of all materials, which are used in inner spaces, vary. Reflective factor is the range of reflectance of the light that hits on surface. Therefore, reflective factor vary due to color and pattern of the materials that are used inner spaces [12].

4.3.4 Design parameters on the building element scale

Consciousness of energy in building design, from the perspective of solar heat gain, the glass substrates are the basic components to provide the heat gain. What matter designing the transparent surfaces of the building envelope is not just providing natural light and heating for the cold periods but also it is important to avoid the unneeded effects of the sun in hot periods.

The optimization of window size and orientation during the design process in relation to energy consumption gives an unrealistic picture if only the thermal properties of window assemblies are taken into account. The thermal properties of a window for transmission and solar radiation are after all not more than a side-effect of it's main property, the possibility to admit an amount of daylight into the room. The amount depends on window size and shape, room depth, sky luminance and internal and external reflection factors [5].

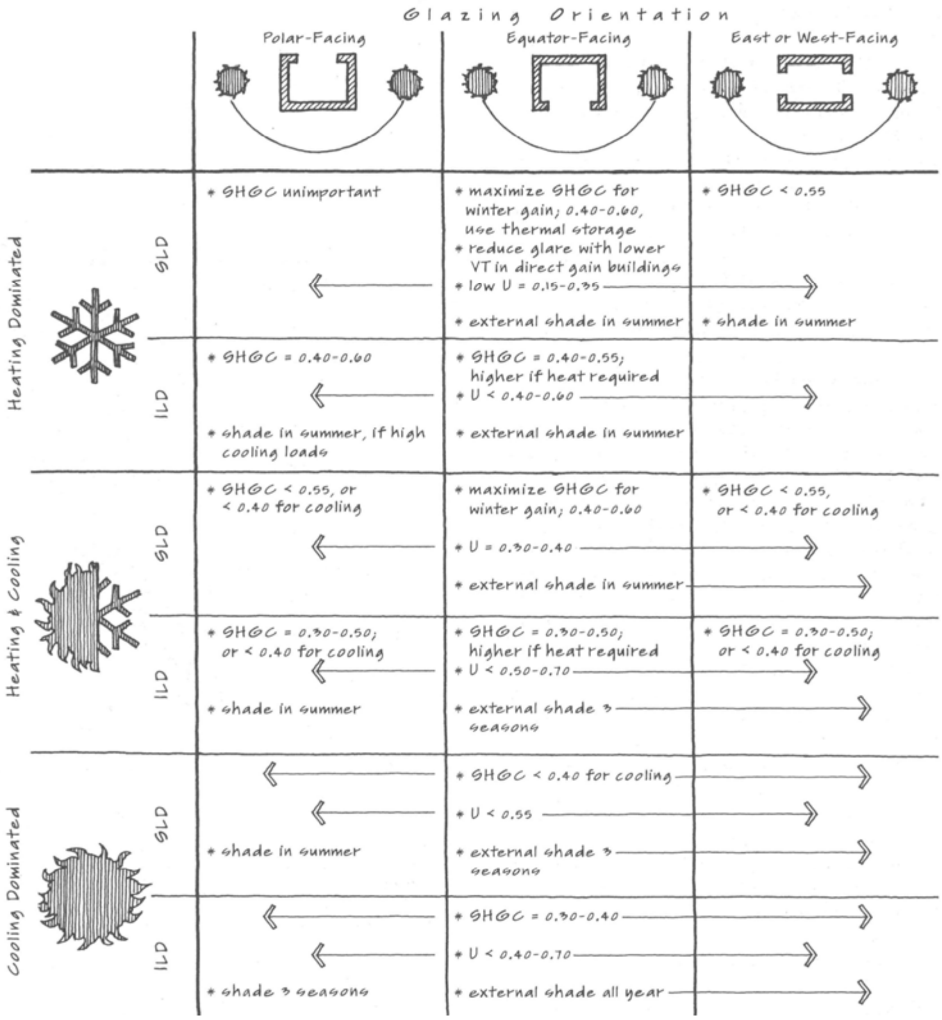
4.3.4.1 Orientation of the elements

The appropriate direction of the building at the design stage and the organization of the spaces depending on the direction effect the building performance in terms of solar control and shading performance.

For each orientation, different design strategies should be developed. For North hemisphere, the glazed surfaces in the south wall of buildings, at wintertime, must allow the use of solar heat when desired. The north wall openings should be applied when the winter sun is not desired. Against overheating and the intense glare problems in summer, the east and west facing openings exposed to direct sunlight during the half of the day should be avoided [43].

In Table 4.10, proper glazing orientations due to the climatic properties and comfort need may be seen.

Table 4.10 : Glazing orientation recommendations [15]



4.3.4.2 Texture, size and form of elements

Window opening connects the internal environment and external environment; windows can be in the wall plane may also be designed as roof openings tab. If horizontally designed windows are located in the wall's part that is near the ceiling the sunlight reaches the most distant point. Thus, problems such as glare are resolved and also the contrast between surfaces and windows would be reduced in internal spaces.

Shape and size of the window openings vary depending on the building's features, usage purpose, and climate conditions, material types of window's frames and joineries and window's form. Generally, windows used for natural lighting in indoor sections, the ratio of window area to room floor area goes between 1/3 and 1/10. Study rooms and offices between 1/3 and 1/5, in living rooms and bedrooms may be between1/5 and 1/10 [44].

However, sunlight can make uncomfortable because of their heat and light. The sun's rays coming perpendicular to window are 90% effective. Until 45° the light intensity does not change.

4.3.4.3 Optical and thermophysical properties of the opaque and transparent elements

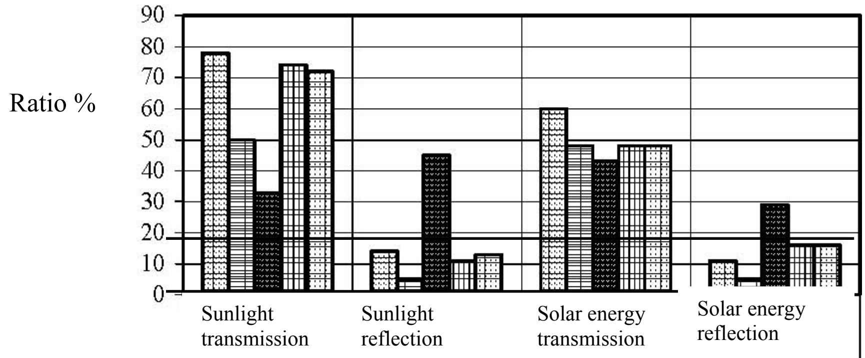
Providing adequate lighting levels, at the same time preventing glare and also providing adequate visual relationship with the outdoor are the most basic features expected from a building's windows. Transparent surfaces transmit a certain percentage of light falling on.

Ratio of the transmitted light to the total incoming light gives the coefficient value of the glass' transmittance. The coefficient value of the glass used in the window, window's dimensions and locations can affect the level of sunlight brightness inside. Beside the coefficient value of glass, the heat and sound transmittance values must be taken into consideration as well. Type used in window joinery and the frequency of window cleaning is one of the variables that effects received amount of sunlight in.

The main types of glass are; air-layered glasses, solar control glasses (reflective) and climate control glasses (Low-e coated glasses). Air-layered glass units are obtained by the use of two or more glasses together. Thermal properties of this type of glasses vary due to the gap between the glass and the type of the frame. Solar control glasses (reflective glasses) control excessive brightness and heat radiation of the sun's rays.

Glasses preventing the visuality from the side where the light is strong, providing unity at the facade by hiding the underlying structural elements and glasses giving color to the buildings are identified as environmental control glasses. Although the optical properties of glass do not change much, reflecting the long-wavelength radiation energy, the coating type that brings improvement on heat permeability coefficients is named as Low-e Coated (Low Emmisivity), as indicated in Table 4.11. Those kinds of glasses are also named as climate control glasses; just opposite to the solar control glasses, reduce earnings from passive solar radiation reflecting the sunrays outside. When are used together, surplus values to the effectiveness of solar control coatings [45].

Table 4.11 : Comparison of performance of glass units due to solar control [43]



	Sunlight transmission	Sunlight reflection	Solar energy transmission	Solar energy reflection
Colorless double glazing	78	14	60	11
Colorful bronze double glazing	50	5	48	5
Solar control glazing	33	45	43	29
Colorless Low-e double glazing	74	11	48	16
Blue Low-e double glazing	72	13	48	16

When solar radiation strikes a surface, a portion of the energy is absorbed and rest is reflected. If too little is absorbed by massive surfaces, the room air can become hot. Absorbance of a material depends on the color, finish and the type of the material. Massive floors in direct gain spaces should generally be dark to absorb solar radiation. As the mass surface area in the room increases beyond three times the area o solar glazing, absorbance is less important.

Table 4.12 defines the solar absorbance and reflectance properties of the surfaces**.**

Table 4.12 : Solar absorbance/reflectance of the finishes [15]

Color/Material	Absorptance	Reflectance
optical flat black paint	**0.98**	0.02
flat black paint	**0.95**	0.05
black lacquer	**0.92**	0.08
dark grey paint	**0.91**	0.09
black concrete	**0.91**	0.09
dark blue lacquer	**0.91**	0.09
black oil paint	**0.90**	0.10
stafford blue bricks	**0.89**	0.11
dark olive drab paint	**0.89**	0.11
dark brown paint	**0.88**	0.12
dark blue-gray paint	**0.88**	0.12
azure blue / dark green lacquer	**0.88**	0.12
brown concrete	**0.85**	0.15
medium brown paint	**0.84**	0.16
medium light brown paint	**0.80**	0.20
brown or green lacquer	**0.79**	0.21
medium rust paint	**0.78**	0.22
light grey oil paint	**0.75**	0.25
red oil paint	**0.74**	0.26
red bricks	**0.70**	0.30
uncolored concrete	**0.65**	0.35
moderately light buff bricks	**0.60**	0.40
medium dull green paint	**0.59**	0.41
medium orange paint	**0.58**	0.42
medium yellow paint	**0.57**	0.43
medium blue paint	**0.51**	0.49
medium kelly green paint	**0.51**	0.49
light green paint	0.47	0.53
white semi-gloss paint	0.30	0.70
white gloss paint	0.25	0.75
silver paint	0.25	0.75
white lacquer	0.21	0.79
polished aluminum reflector	0.12	0.88
aluminized mylar film	0.10	0.90
lab vapor-deposited coatings	0.02	0.98

5. EVALUATION OF THE DESIGN PARAMETERS OF AN EXISTING ENERGY EFFICIENT SETTLEMENT UNIT UNDER THE CLIMATE DATA OF STUTTGART AND ISTANBUL

5.1 Aim of the Study

The aim of the study is to research the effect of the design parameters on energy consumption in the settlement unit scale. To be able to calculate the impact of settlement unit scale parameters, occupancy and building envelope properties are settled constant and variations of rather properties are checked. For this purpose, demands of chosen settlement are searched under different climatic conditions, in the variations of orientation and spaces between buildings, by computer energy simulation. Therefore, an existing settlement is chosen and energy consumptions of different climatic data are compared.

5.2 Method of the Study

As a sample settlement, Scharnhauser Park is chosen nearby Stuttgart-Germany. The settlement, at this issue is designed as an energy efficient complex. By choosing energy efficient settlement, it is intended to examine the importance of the energy efficient settlement unit in detail. As it is more manageable to control of energy loses of an energy efficient design compared to a design that is not energy efficient, it is considered that energy efficient design is more effective example. Firstly, chosen settlement is modeled with the simulation program according to the building envelope data, which is declared by the designer. In given example, the number of the occupancy is known, in this way, energy usage behavior of the occupancy is defined according to the researches, which explain typical German citizen domestic habits. Due to these habits internal equipment gains are simulated. Annual heating, cooling and lighting consumptions of the model is compared with the monthly measurements of electricity and heating energy usage of Scharnhauser Park and simulation results are validated according to measured consumption. Afterwards, design parameters examined based on chosen building, which is located in the center of site. Therefore, to take into consideration the effect of the other buildings become possible. Energy consumption is calculated for 24 directions with 15°degree intervals from 0 to 360, are calculated and optimum orientation direction is found out according to consumption results.

In the next part, optimum distances between buildings has been calculated by basing on the previous research studies (Ref. No. 2) and collated to the variations that the distances between buildings are increased. Distances between buildings are changed 1/2h meters for each variation, while the heights of the buildings are constant (h) and the effect of the distances between buildings on the energy demands is searched.

These simulations have been done under both Stuttgart and Istanbul Climatic data. In this way, the impact of the climatic data to the location scale parameters is searched and optimized results are compared.

5.3 Simulation Tools

Various building energy simulation programs developed around the world are reaching maturity. Many use simulation methods (and even code) that originated in the 1960s. Without substantial redesign and restructuring of the programs, continuing to expand their capabilities has become difficult, time-consuming, and prohibitively expensive. However, phenomenal advances in analysis methods and computational power have increased the opportunity for significant improvements in the flexibility and comprehensiveness of these tools.

In this study, for energy simulations EnergyPlus and for modeling Google SketchUp-Open Studio, DesignBuilder are used.

EnergyPlus is a new building performance simulation program that combines the best capabilities and features from BLAST and DOE-2 along with new capabilities. EnergyPlus comprises completely new code written in Fortran 90. It is primarily a simulation engine—there is no formal user interface. Both BLAST and DOE-2 have many user interfaces developed by independent third-party developers. Beta testing of EnergyPlus began in late 1999 and the first release is scheduled for early 2001 [46].

5.4 Properties of Chosen Settlement

The Town of Ostfildern, with 35,000 inhabitants, is located in the adjoining southeast of Stuttgart, the capital of Baden-Württemberg, Germany, indicated in Figure 5.1. The project Scharnhauser Park is currently the largest development project of the Stuttgart Region and has been developed after the American military forces had left the area in 1992, indicated in Figure 5.2. The new district will provide space for about 10,000 inhabitants. 2500 new jobs and green parkways will be constructed during the development period. In the new district life and transport concepts will be integrated on a high level of comfort and low energy consumption [47].

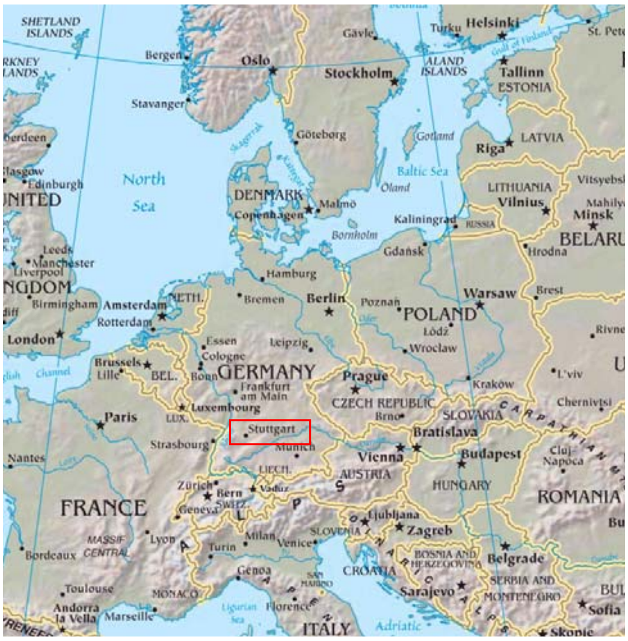


Figure 5.1 : Stuttgart location [61]

The development, which consists of 3500 dwellings (out of which 80% are owner-occupied and 20% rented), started in 1996 and is due to be completed in 2012. Scharnhauser Park covers 140 hectares, out of which 48 hectares are land for sale, 25 hectares are infrastructure including streets and light rail tracks, 25 hectares are public spaces including parks and squares and 42 hectares are open landscape. The overall density is of 150 inhabitants per hectare.

The services include a kindergarten, a primary and a secondary schools, a sport centre, a commercial centre with several small shops and a new town hall that offers different services (municipal library, music school and art gallery). The basis for the site development is the urban plan from the town planning competition, which defines the residential, commercial and industrial sections of the site. Detailed zoning plans are developed gradually for each block in a very innovative co-operative procedure with only a few invited investors and architects [48].

Figure 5.2 : Scharnhauser Park [48]

The whole project is designed as an exemplary ecological community development, where low energy building standards are prescribed for all plots and a wood-fired ORC co-generation plant will deliver electricity and heating energy. Combining work places, residential areas and green park sections leads to an integrated living and transportation concept with high comfort and low energy consumption.

5.4.1 Residential houses in Scharnhauser Park

Based on the plan suggested by the office Jansen and Wolfrum in 1992, the Scharnhauser Park in its current form emanates from a comprehensive urban development competition. The park can be divided into three different areas: in the northern district, the generally renovated American residential houses have been re-consolidated by the addition of tower houses. In the district located at the eastern part of the road, one can find a compact area with individual houses as row house development, while in the bigger Western part, four-storey multi-family houses with extensive green areas have been established along the character-giving landscaped stairs. Photo of the residential units may be seen in Figure 5.3.

Figure 5.3 : Photo of residential units

From an energy point of view, the heat supply, based mainly on biomass for all residential houses, is particularly exemplary. For this, all buildings were required to connect to the partially already existing long-distance heating network, which leads to extremely low CO_2 emissions as a result. Further, as prescribed in the development plan, the high-tech insulation coverings for all buildings had to be built according to a low-energy standard (WSVO, German energy saving regulations). In 1995, with a level of 25 % less than the maximum values allowed then by from the heat insulation ordinance, an unusually good standard for the middle of the 90s was created for all buildings, from which the building users of the Scharnhauser Park still benefit. In order to achieve good overall neighborhood energy efficiency figures, proprietary apartments and houses have also been built according to the low-energy building method, so that the consumption levels specified in the current energy saving regulation (EnEV 2002, German insulation regulations) are undercut by around 20 %. This was reached through additional measures such as reinforced exterior wall insulation, windows with improved environmental values, low temperature heaters in the form of floor heating, living space ventilation and quality controls using Blower-Door-Tests [49].

- Transport; Scharnhauser Park benefits from excellent transport links to the city centre of Stuttgart by light rail (20 minutes journey). An existing tram line was extended through the site to Nellingen, one of the four original villages of Ostfildern at a very early stage of the development. In order to achieve the relatively high densities and to make public transport viable, private parking has been restricted to one parking space per unit, to be accommodated on-plot.

- With respect to the superficial rainwater-management via channels it is not allowed to drain rainwater through the sewage system if it is not used in the household before. All lightly polluted rainwater from roofs, terraces, paths, car-parks and driveways must be led into the rainwater-drainage. All waste waters from toilets, kitchens, bathrooms, laundries or other water polluted by other use must be led into the sewer system.

- The administration of the city of Ostfildern instructed the low energy level to all new buildings in Scharnhauser Park from the begin on. This means all the investors had to insulate the buildings on a level of -25 % related to WSVO 1995.

- Basis of the energy supply is the district heating plant, mainly run on woodchips. It supplies all the buildings in the Scharnhauser Park with district heating.

- Big part of "Scharnhauser Park" are oriented to the south and thus for the buildings they are suitable to reach a good energy balance. Besides that, they are calculated in height so they hardly shadow each other.

5.4.2 Physical properties

In this study, 10 family houses, between Gabrialle-Münter Strasse and Bettina von Arnim Strasse are simulated. First of all, single house, which is in the center, is chosen to validate measured consumptions. Single house is occupying in the center of the site; that may cause negative shading effects and increase the heating demands. Single house is chosen to be able to search over shading impacts.

3D model of the site that is made for simulations is seen in Figure 5.4.

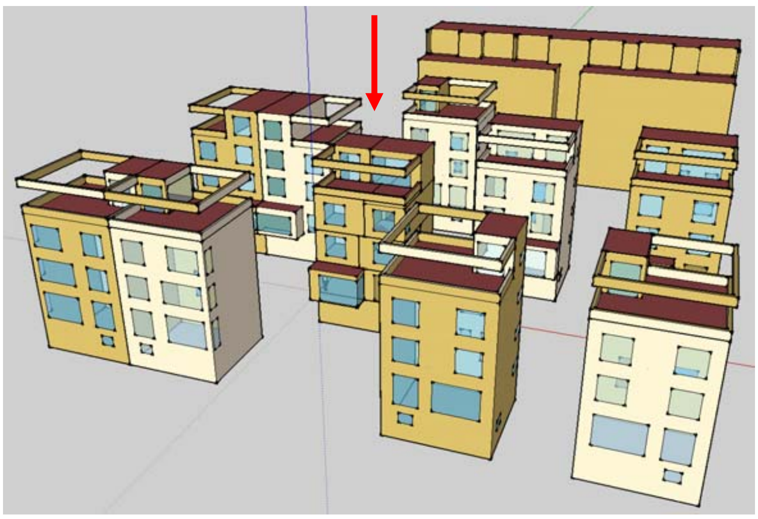


Figure 5.4 : Model of the site

5.4.2.1 Project data

Site is oriented to the north with -13°. Main facade is faces south, southeast. Figure 5.5 indicates site plan of the chosen residential units.

See Appendices B for the plan, section and elevation drawings of the given example for the simulations.

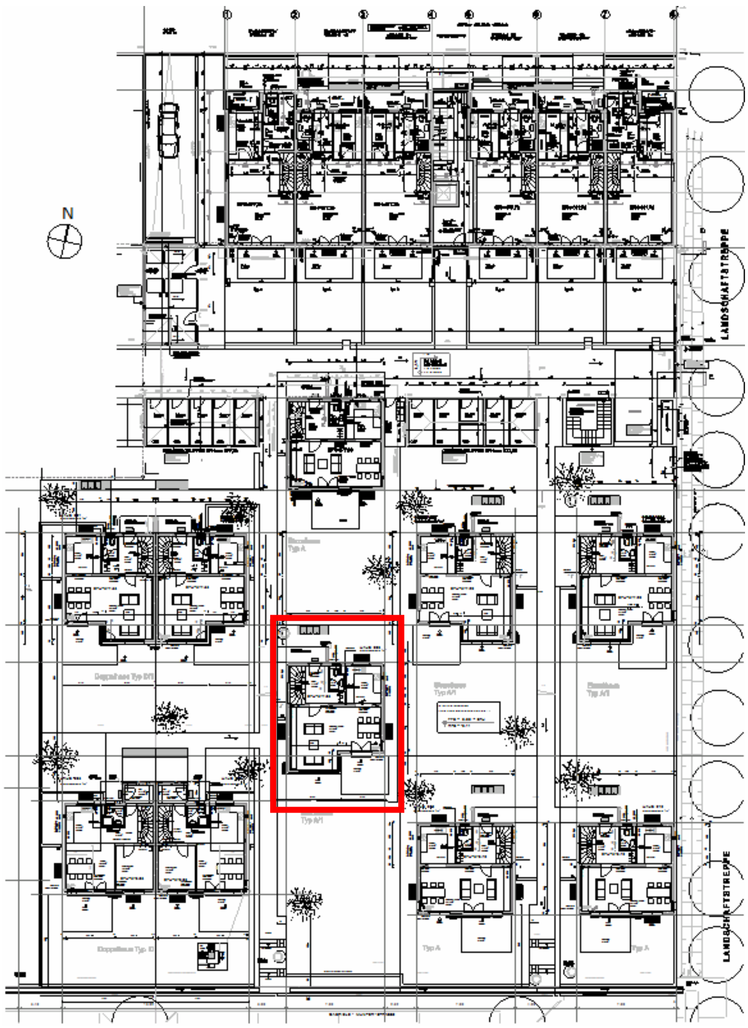


Figure 5.5 : Site layout of the residential units

5.4.2.2 Building envelope properties

Scharnhauser Park residential houses have been designed as low energy buildings. Therefore, it is assumed that each building has to have minimum on a level of 25 % related to WSVO 1995. The U values of the building envelope determined below are the values submitted by the designer architects, which are constructed at the site accordingly.

The details and U values of the building envelope may be seen Table 5.1.

Table 5.1 : U values for the single house [62]

EXTERNAL WALL		
material	width mm	λ w/mk
internal plaster	15	0,7
masonry	175	1,1
heat insulation	140	0,035
render	10	
		U: 0,230 W/m²K

WALL UNDER THE GROUND		
material	width mm	λ w/mk
internal plaster	10	0,7
concrete	240	2,5
water proof		
insulation	100	0,04
		U: 0,360 W/m²K

ROOF		
material	width mm	λ w/mk
internal plaster	10	0,7
reinforced concrete	200	2,5
vapor barrier		
heat insulation	140	0,035
water proof		
		U: 0,233 W/m²K

TERRACE		
material	width mm	λ w/mk
internal plaster	10	0,7
reinforced concrete	200	2,5
vapor barrier		
heat insulation	140	0,035
water proof		
		U: 0,233 W/m²K

FLOOR UNDER THE GROUND		
material	width mm	λ w/mk
screed	35	1,4
water proof		
concrete	180	2,5
insulation	100	0,04
		U: 0,352W/m²K

double glass window type
U: 1,23 W/m²K

door type
U: 1,98 W/m²K

5.4.3 Energy consumptions and validation of the model

To be able to make further simulations, to validate model according to the exact consumption, has to be done. For the validation, model has been simulated due to the each variation of parameters and checked according to the measured consumptions and optimum combination is selected.

First of all, weather data has been provided for year 2008. For the weather data of computational simulation, 5 parameters have been considered. They were internal and external surface temperature, ambient temperatures, relative humidity and mean radiant temperature.

The use pattern varies depending on the different factors, such as climate, household composition, family income, culture background, and human factor, etc. In order to produce domestic load profile with taking into account various factors, a cluster analysis method has been applied. The energy demand can be categorized into two types of determinants:

- **Behavioral determinants**

This type of energy-consumed has non-related or little-related to climate but strongly related to households human factor. It has a high correlation to people's habits and may slightly influenced by season, for example, cooker, microwave oven, washing machine, fridge-freezer, kettle, television, dishwasher, etc. The relationship between electricity used in households and the behavior of end uses has been discussed widely. Behavioral determinants, such as the frequency of use per appliance, involve relatively 'flexible' decisions, which are made on an hourly/daily/weekly time scale.

- **Physical determinants**

This type of energy-consumed, for example, heating/cooling and lighting energy, has high co-relation to climate and building design, however has low co-relation to people's habits. The physical determinants of energy use, such as dwelling's size, building design, and its space-heating system are the results of relatively 'fixed' decisions. The use of heating/ cooling energy for thermal comfort also related to the occupancy pattern and household income level. For example, most people will set internal comfort temperature low when the house is in unoccupied period and during the night. People preferring warm environment may set higher comfort temperature while the others may set lower. From the description of above two types of energy load, we can see that both behavioral determinants and physical determinants related energy-consumption are more or less influenced by people's occupancy pattern [50].

Then internal gain, lighting and occupancy schedules are prepared according to the electricity usage schedules. Total demands are validated additional of the heating and cooling demands. Heating cooling and air change rate set points are the parameters that directly affect the demands of the model.

As a result, 5 people family with 2 parents and 2 children and 1 elder person have been accepted as occupancy profile and comfort thermal set points settled as;

Air change rate: 0,4

Set point heating temperature: 21°C

Set point cooling temperature: 26°C

5.4.3.1 Measured dataset

Scharnhaıser Park is a research project of POLYCITY. Policity is a project of the CONCERTO initiative, co-funded by the European Commission. In the course of the Policity Project, three large urban areas in Germany, Spain and Italy will be developed, particularly in the field of energy optimization and the use of renewable energies. In order to search energy efficiency each building's consumptions are measured hourly, reported, and published, as seen in Figure 5.6. Annual heating cooling and electricity consumptions are validated due to these measurements.

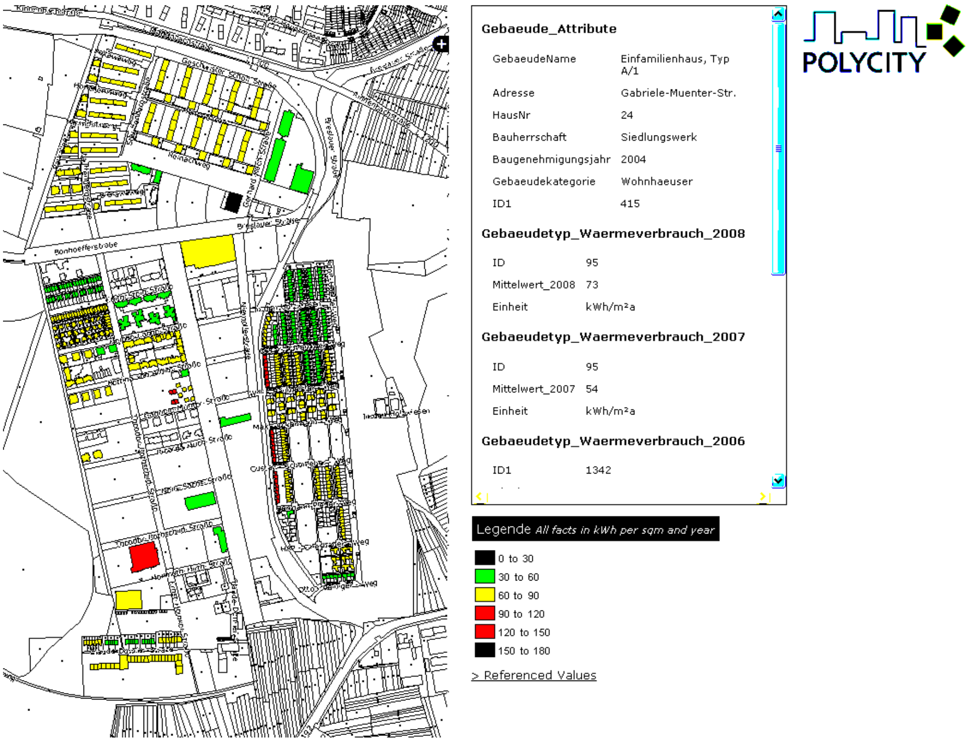


Figure 5.6 : Measured heating load for single house for 2008 (http://www.polycity.net/GIS/) [47]

In Figure 5.7, the graphic of the site may be seen. Each house is given a number to define the consumptions, which is indicated in the Figure 5.8. Chosen example settlement unit of this study is 'single house 6'. Single house 6,7,8 are designed as same building with the plan configuration and construction properties, which defined as Type A1. Other single houses 5,9,10 are the diversity of type A1 that defined as Type A. Double houses are the designed as the detached form of single houses. Type D is the detached form of Type A and Type D1 is the detached form of Type A1.

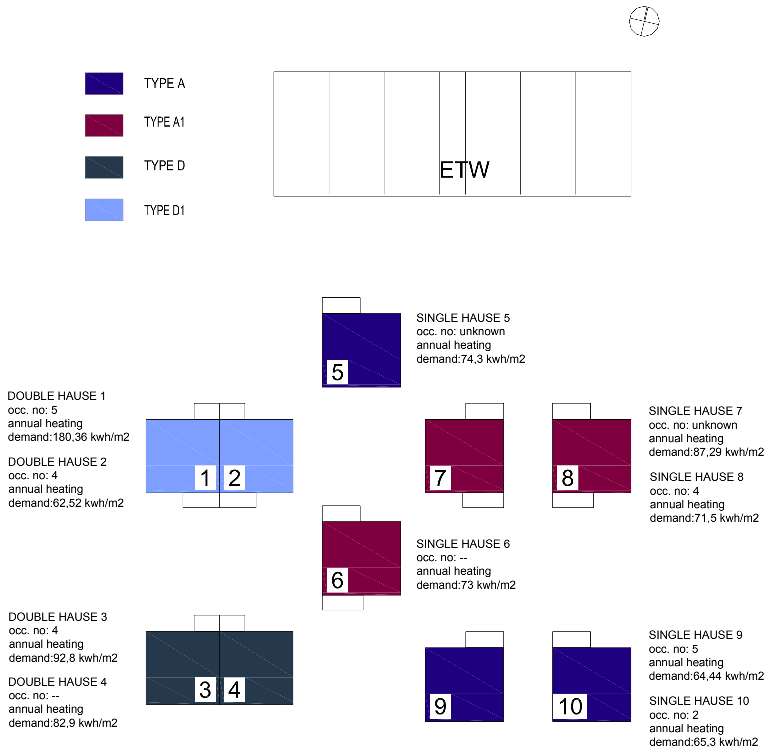


Figure 5.7 : Type graphics of houses

The diversity of heating demands of constuction with the same physical properties may be explained with the impact of occupancy number and the behaviour of the occupancy due to this number. Solar radiation capacity and shading situation are also important parameters.

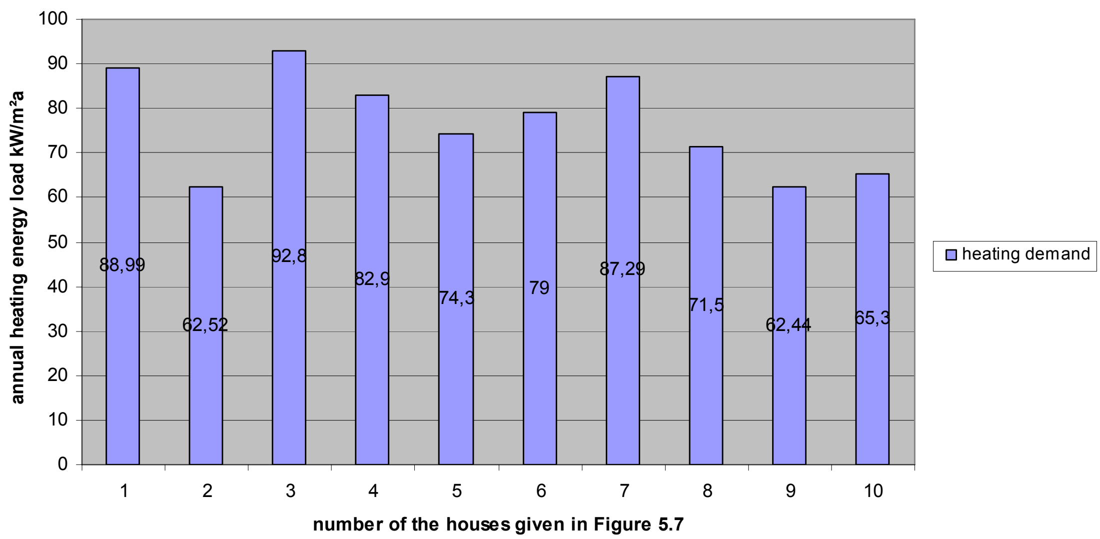


Figure 5.8 : Measured annual heating demands for the site for 2008

5.4.3.2 Considerations in simulation

- **Electricity consumption**

It is crucial to perform energy simulations during the building process in order to design a building that meets demands regarding low energy use. In a low energy building, internal heat gains, such as excess heat from household electricity are a large part of the heat balance of the building. The internal heat gains are depending on the occupants and not constant. Result from energy simulations with household electricity that varied during the day and the year according to a model based on measured data are presented. To make accurate energy calculations of low energy buildings, the daily and annual variations in use of household electricity should be taken into account [51].

Electricity data is validated due to measurements of intelligence counters in Schanhauser Park. Energy for 3 months, for 3 houses is considered and average annual average consumption is defined.

It is calculated as = 4162,98 kWh/a, simulation result is 3933 kWh/a which is accepted as validated, as the result is close to measured load in an acceptable range.

By this result, it is assumed that lighting controls and inner equipment usage of the simulation is proper.

- **Occupant behavior research and internal gain control tables**

As a part of decreasing the energy use, and thus carbon dioxide emissions within the European Union, focus has increased on both low energy buildings and the ability to simulate the energy use of buildings properly. To design a building that fulfils demands on low energy use, it is crucial to perform energy simulations of the building in question during the building process and the simulations must represent the building during operation. Researchers stress the importance of accurate input data for energy simulations. The building users' behavior is very important in low energy buildings and also the hardest to model. When optimizing the design of a low energy building, it is of great importance to know what amount of household electricity is likely to be used and how it varies over the year and during the day in order to understand the internal load pattern, since excess heat from household electricity is a major heating source [51].

Control tables are built up according to the existing number of occupancy and behavior. It is determined according to the researches, which are explaining German citizens' general house usage behavior, and internal equipment gains are simulated accordingly.

In this study, for simulation of single house, 5 occupants are accepted. 5 people are said as a family with 2 parents and 2 children and 1 elder person. Children are at the age of primary or high school education. Therefore heating, cooling, lighting and equipment usage schedule is settled accordingly.

At Appendices A, control tables are seen, which are settled after checking several variations of occupant energy usage profile.

5.5 Site Texture Variations and Effects of Site Texture on Energy Demands

The texture elements of the site are, either as blocks, as groups or as individual elements, has an effect on key environmental concerns. The design in this respect should take account of the surrounding to the site, in particular existing buildings, and assessment of the impact on the sunlight, daylight, shading, airflow and other factors should be determined. The main problem of site configuration design is avoiding overshading impacts.

5.5.1 Calculation of shading effects of external obstacles

In this group of simulation, to check the impact of the external obstacles, buildings are simulated to find heating, cooling and lighting loads. External obstacles are the neighbor buildings, which may be seen in site plan, Figure 5.5. In this version of the simulation landscape objects like trees are not occupying.

Simulation results are found out both for Stuttgart and İstanbul. Firstly, due to existing configuration, which is shaded by neighbor buildings, is simulated. In Figure 5.9, model of the simulation in winter design day, 21 January at 11:00 am is seen, to define the shading impact. As known, winter design day is the typical day that heating is needed and negative shading effect is not expected. Subsequently, unshaded version of building by any external obstacle is simulated. The results are compared to search for the effects of shading.

Figure 5.9 : Shading effect of other buildings on single house, in winter design day, 21 January at 11:00 am

Table 5.2 defines the effects of external shading elements to the energy loads of given building. As seen, both for İstanbul and Stuttgart, cooling loads are decreasing when external obstacles shade the building. Ratio difference of cooling load of İstanbul and Stuttgart may be explained as; İstanbul has climate with a higher average temperature, which is the reason to have less ratio of shading impact.

Heating loads decrease and solar radiation access potential to the building increases if the building is not shaded.

When the total loads are concerned, for Stuttgart %2 reduce of energy load is seen, while İstanbul total loads for each variation are very close, which can be explained with cooling impact characteristic of shading objects.

Table 5.2 : Energy loads comparison due to external shading obstacles

STUTTGART	Unshaded by external obstacles	Base case shaded by external obstacles kW/m²	Load reduction %
Lighting	6,61	6,66	**0,7 %**
Cooling	13,58	11,34	**- 16 %**
Heating	74,80	78,62	**5 %**
Total	94,99	96,62	**2 %**
İSTANBUL	unshaded by external obstacles	Base case shaded by external obstacles kW/m²	Load reduction %
Lighting	6,55	6,59	**0,6 %**
Cooling	32,84	29,61	**- 10 %**
Heating	45,05	48,25	**7 %**
Total	84,44	84,45	**0,1 %**

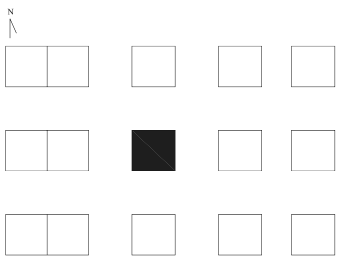
5.5.2 Energy Demands of site texture variations

In this part of the study, the effects of site texture are searched. Variations of site configurations simulated and compared with the energy loads of unshaded unique building, of the given example. Texture of the site is defined by the configuration of the streets. All physical and occupant properties, which are defined before, are accepted as the same, except the orientation of the streets and configuration of the buildings.

For the given example, main façade oriented to south. First variation describes a site texture, which streets are oriented south-north and east-west and regularly configured.

In the Table 5.3, the results of simulation for the variation 1 and unshaded single building are seen. For İstanbul, total energy load decreases when unshaded building's total load is compared to variation 1. But for Stuttgart total load increases. For both data, cooling loads decrease obviously. This result may explained as; the decrease of cooling load of Stuttgart is comparatively higher than İstanbul because of the temperature differance of two cities. As solar radiation is higher in İstanbul climate, thus, shading effect of external buildings do not affect as much as Stuttgart.

Table 5.3 : Load effect of site configuration variation 1

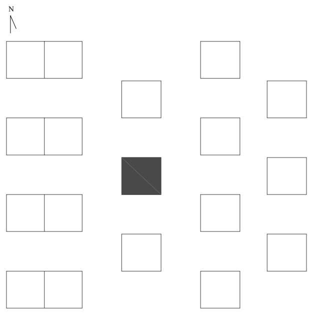


STUTTGART	Unshaded by external obstacles	Site variation 1	Load reduction %
Lighting load	6,61	6,95	**5 %**
Cooling load	13,58	10,76	**- 21 %**
Heating load	74,80	78,19	**4 %**
Total load	94,99	95,90	**0,9 %**
İSTANBUL	Unshaded by external obstacles	Site variation 1	Load reduction %
Lighting load	6,55	6,85	**5 %**
Cooling load	32,84	28,61	**- 12 %**
Heating load	45,05	47,95	**6 %**
Total load	84,44	83,41	**- 1 %**

In Table 5.4, comparison of variation 2 and energy loads of unshaded building may be seen. The results, similarly to variation 1, which define that cooling loads decrease when buildings are shaded by external buildings.

However, in variation 2, buildings are configured irregularly, while streets are oriented south to west. This is the reason that causes shading effect from all direction. Therefore, cooling energy loads decrease more relatively to the variation 1.

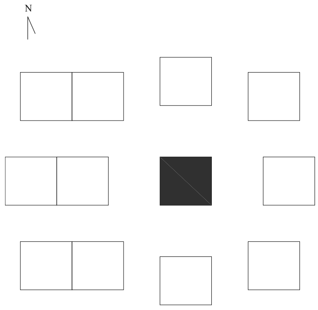
Table 5.4 : Load effect of site configuration variation 2



STUTTGART	Unshaded by external obstacles	Site variation 2	Load reduction %
Lighting load	6,61	6,96	**5 %**
Cooling load	13,58	10,51	**- 23 %**
Heating load	74,80	78,52	**5 %**
Total load	94,99	95,99	**1 %**
İSTANBUL	Unshaded by external obstacles	Site variation 2	Load reduction %
Lighting load	6,55	6,85	**5 %**
Cooling load	32,84	28,32	**- 13 %**
Heating load	45,05	48,11	**7 %**
Total load	84,44	83,28	**- 1 %**

In variation 3, which is indicated Table 5.5, the buildings are configured circular. A main street direction is not defined. When the simulation results are compared, it is seen that cooling loads decrease, as they are expected but the decreasement relatively less than variation 2 and closely to variation 1. Nevertheless, total loads increase for both cities.

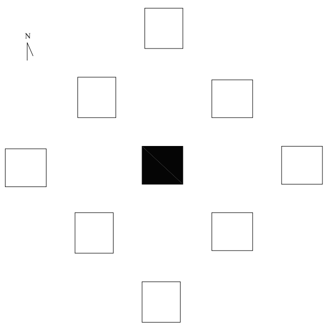
Table 5.5 : Load effect of site configuration variation 3



STUTTGART	Unshaded by external obstacles	Site variation 3	Load reduction %
Lighting load	6,61	6,96	**5 %**
Cooling load	13,58	10,71	**- 21 %**
Heating load	74,80	79,47	**6 %**
Total load	94,99	97,14	**2 %**
İSTANBUL	Unshaded by external obstacles	Site variation 3	Load reduction %
Lighting load	6,55	6,84	**4 %**
Cooling load	32,84	28,52	**- 13 %**
Heating load	45,05	48,92	**8 %**
Total load	84,44	84,28	**- 0,2 %**

Table 5.6 describes the simulation results of variation 4 for İstanbul and Stuttgart. In this variation, streets are oriented 45° to the main directions. Street width is kept same with the other variations, thus, buildings come near to each other from the corner, which cause less shading effect one to another. As seen in the table, cooling energy demand decrease relatively less than the other variations but heating energy demand increase relatively less, which is explained by total load ratio change that is relatively less than the other variations.

Table 5.6 : Load effect of site configuration variation 4



STUTTGART	Unshaded by external obstacles	Site variation 3	Load reduction %
Lighting load	6,61	6,65	**0,6 %**
Cooling load	13,58	12,03	**- 11 %**
Heating load	74,80	77,00	**3 %**
Total load	94,99	95,68	**0,7 %**
İSTANBUL	Unshaded by external obstacles	Site variation 3	Load reduction %
Lighting load	6,55	6,58	**0,5 %**
Cooling load	32,84	30,57	**- 7 %**
Heating load	45,05	46,81	**4 %**
Total load	84,44	83,96	**- 0,5 %**

5.6 Stuttgart Climatic Dataset and Calculation of Energy Loads

A city's climate is determined by its latitude, altitude, type of subsoil it is built on, the topography as well as man-made changes in the landscape.

Stuttgart's climate is classified as warm moderate. With an average annual temperature of about 10 °C in the basin of the city and about 8.4 °C in the more elevated outskirts situated about 400 m. The average temperature of the coldest month lies between +18 und -3°C. All Months are humid. Average temperature of the warmest month lies under +22° C, at least four moths with average temperatures of at least +10° C.

As Stuttgart lies on the lee side of the Black Forest and the Swabian Alb, north latitude 48°46', and east longitude 9°10'.

The average hours of sunshine it sees per year are relatively considerable (1,720 hours). While the sun shines only less than 60 hours in December, it shines more than 230 hours in July.

Region's climate largely depends on precipitation. The region of Stuttgart has very little precipitation compared to other regions in Germany. The average annual amount of precipitation in the centre is 679 mm.

The highest position of the sun is only about 18 degrees above the horizon on this winter day [52]. Climatic data of Stuttgart is given in Appendix C.1.

5.6.1 Effects of orientation related parameters to heating, cooling and lighting loads

In this part of the study, verified simulation model of Sharhauser Park single house 6 has been oriented and simulated to each 15° to research the impacts of the orientation to the energy demands. Other buildings dimensions, physical properties, occupant characteristic and distances between buildings are kept as it is. Shading effect of the other buildings is unique for this site and for this group of simulation.

For energy simulation variations for orientation, main façade is defined as south face façade as 60% of glazing occurs in this façade. As seen Figure 5.10, the position of main façade face to south accepted as 0º and model of building is oriented with 15º intervals, in each simulation.

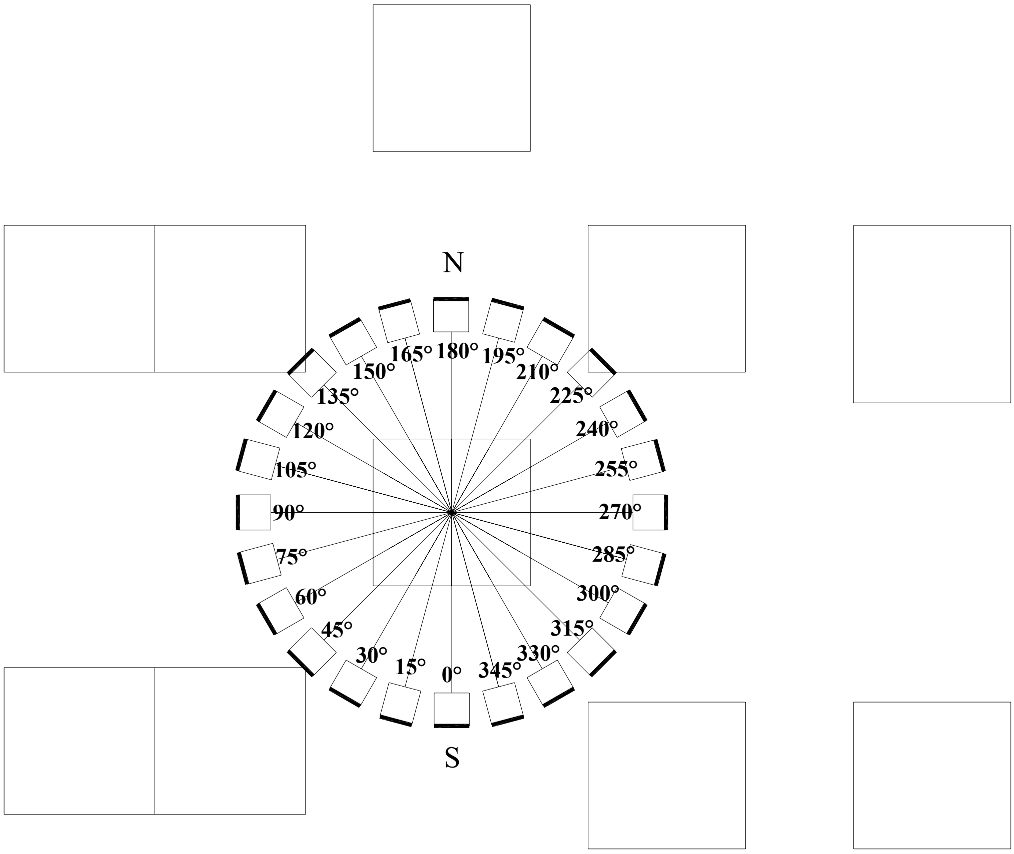


Figure 5.10 : Orientation angle diagram that are specified in the simulations

In the Figure 5.11, 5.12, 5.13, 5.14 lighting heating, cooling and total energy loads of simulation variations of orientation of single house 6 may be seen.

Glazing density of single house is mostly at south and north façades. 60% of glazing at south façade, 17% is at north façade, 15% at east, 8% is at west façade related to original position that means 0 degree at the chart. Thus, building gains daylighting mostly from south façade but relatively less from north and west façades.

For daylighting control of the simulation, two points in the building zone are accepted as control point and 5 lux/m² is settled for setpoint of artificial lighting.

Another important parameter is shading effect of surrounding buildings. As seen in Figure 5.5, site plan, building texture is configured to give spaces through main directions east-west and south-north. In these directions, less shading impact is seen. Therefore, at the orientation angles 0º, 90 º and 270 º; lighting loads are minimum related to more density of glazing and less shading object around. Lighting results are indicated in Figure 5.11.

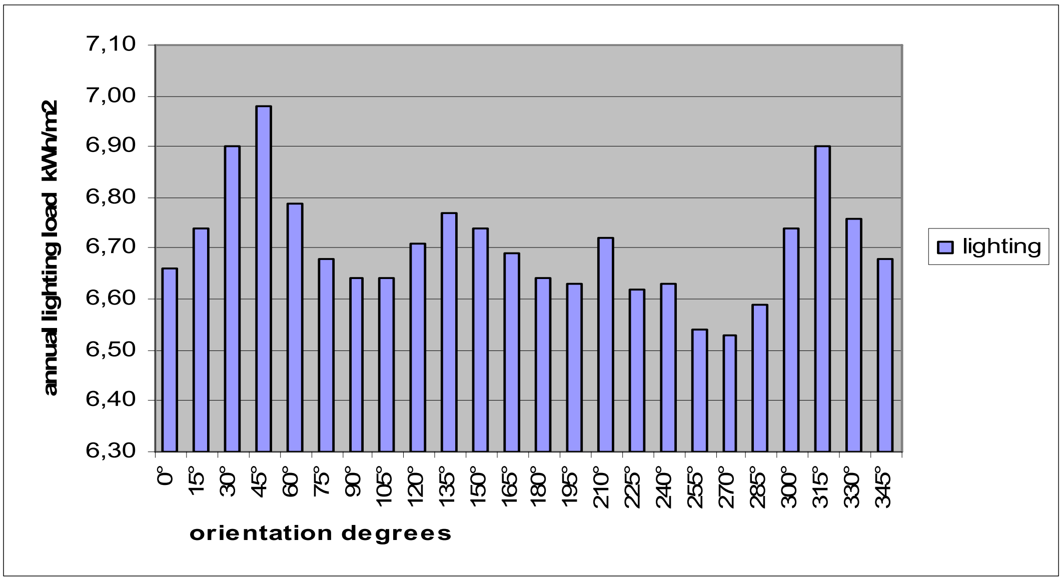


Figure 5.11 : Lighting load chart for chosen building under Stuttgart climate data

As seen in the Figure 5.12; cooling load is minimum at 180º, in which main glazed façade face to north. North is the direction that a building gains minimum direct solar radiation at the north sphere. This is the reason for the minimum cooling loads for the north facing variation.

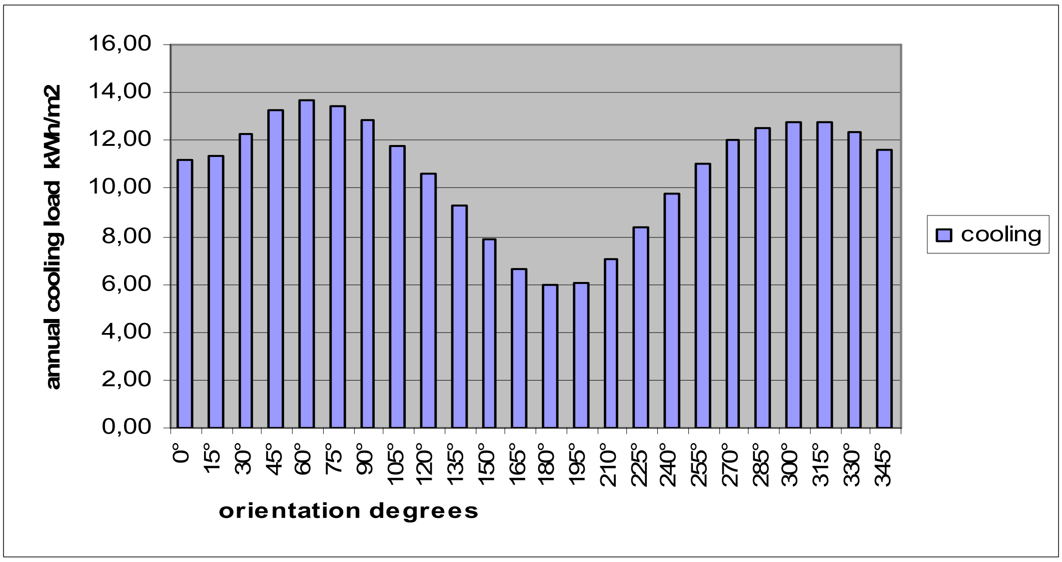


Figure 5.12 : Cooling load chart for chosen building under Stuttgart climate data

Figure 5.13 defines that, heating loads are minimum between -15 º, 0 º,+15 º to the south when main glazed façade face to the south and heating loads are at maximum at 180 º to 210 º, when main façade face to north, less solar radiation causes more heating demand.

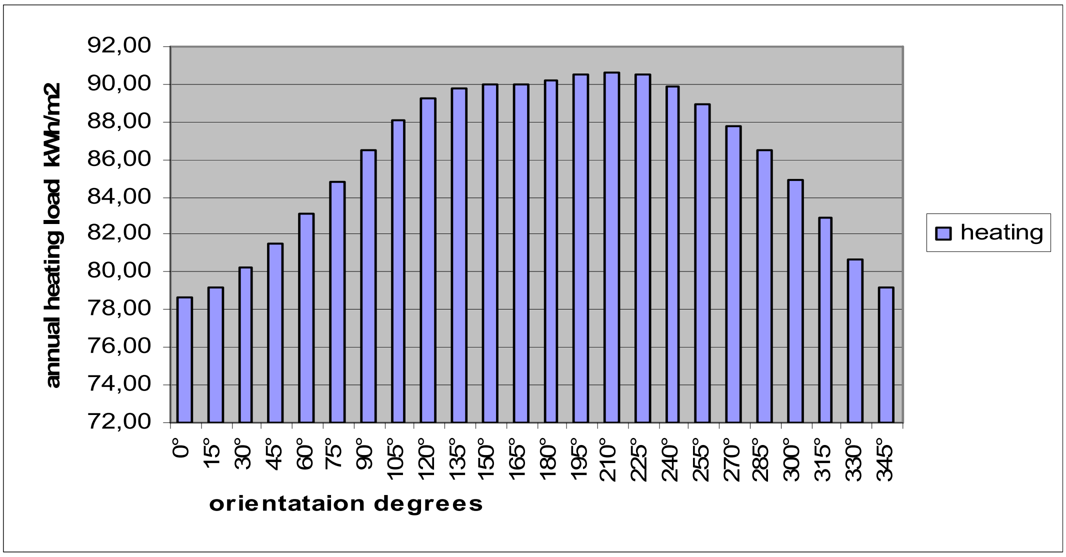


Figure 5.13 : Heating load chart for chosen building under Stuttgart climate data

Conclusion;

As seen in the Figure 5.14, lowest annual sum of lighting, cooling and heating load is determined at the orientation between -15 º, 0 º,+15 º to the south as the main glazed façade face to the south for Stuttgart climatic dataset.

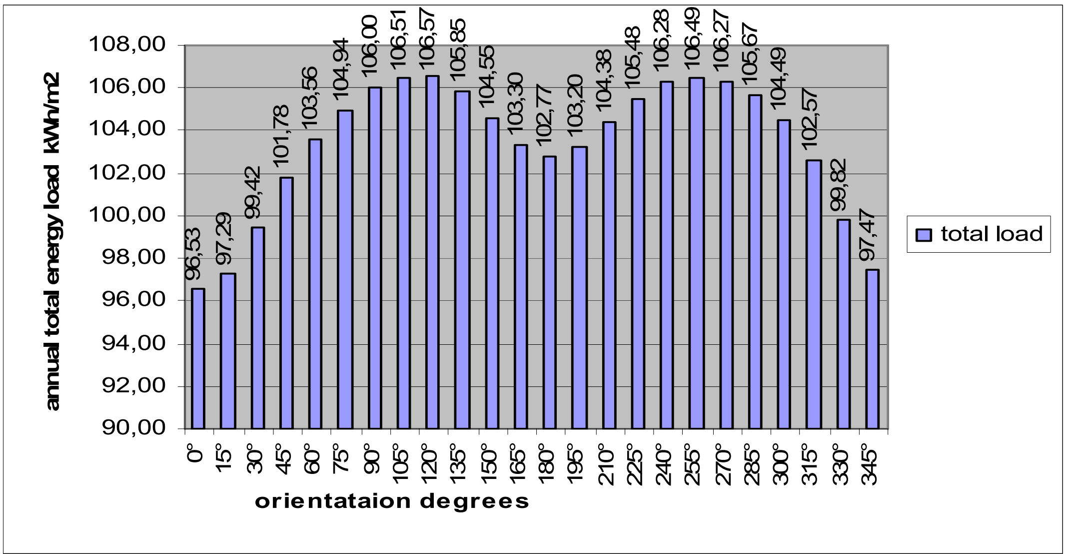


Figure 5.14 : Total load chart for chosen building under Stuttgart climate data

5.6.2 Effects of distances between buildings related parameters to heating, cooling and lighting loads

This part of the study includes the researches to find optimum spaces between buildings. Simulation parameters are set according to the research report **"**Enerji Etkin Konut Ve Yerleşme Tasarımı", Tübitak-İntag 201, prepared by Berköz, E., Küçükdoğu, M.,Yılmaz, Z., Kocaaslan, G., in 1995, in Istanbul Technical University.

Obstruction angle for winter design day, January 21, in Stuttgart has assumed as 18°. Accordingly, minimum spaces that has to be left to not to be shaded by the neighbor building has been calculated as seen Figure 5.15.

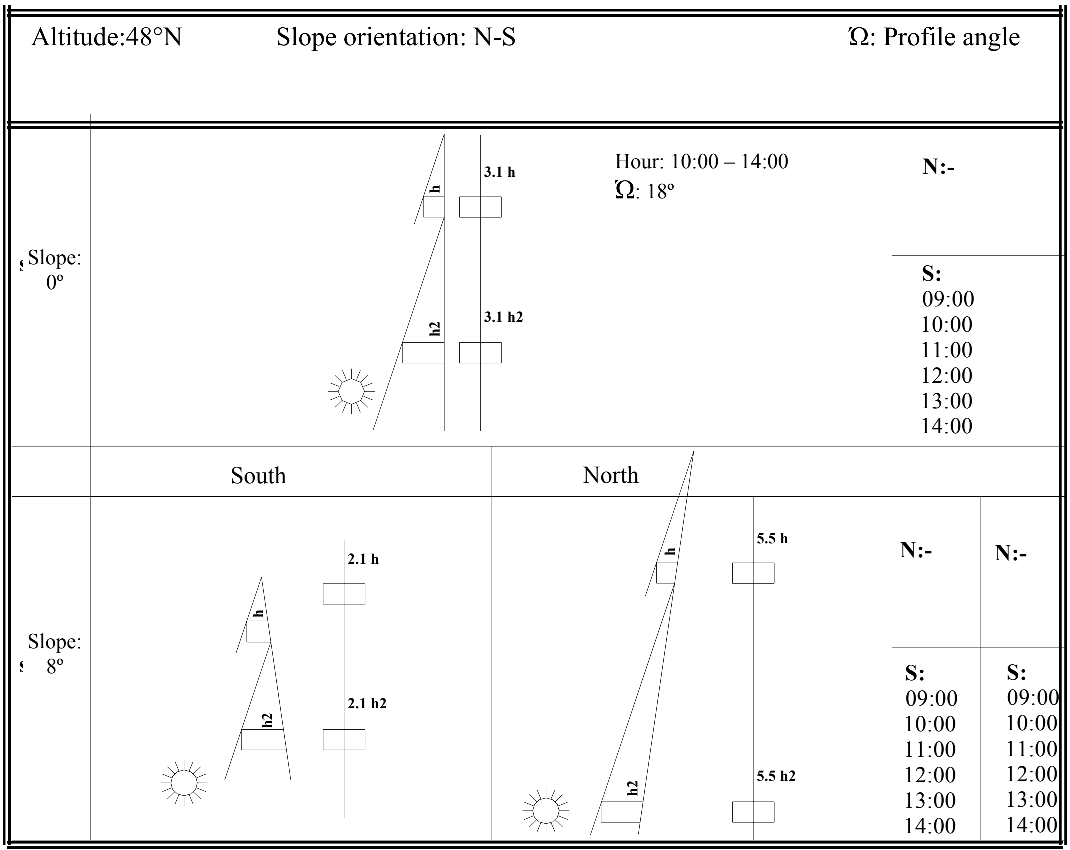


Figure 5.15 : Calculation of optimum distance between buildings for Stuttgart

For Sharnhauser Park, as the site has a slope of 0°, optimum distance between buildings is calculated 3.1h, when the building height is h. To compare the energy impacts of the distances between buildings, simulations varied for the distance between buildings as 0,5h and intervals of it. Figure 5.16 explains the configuration of the variations.

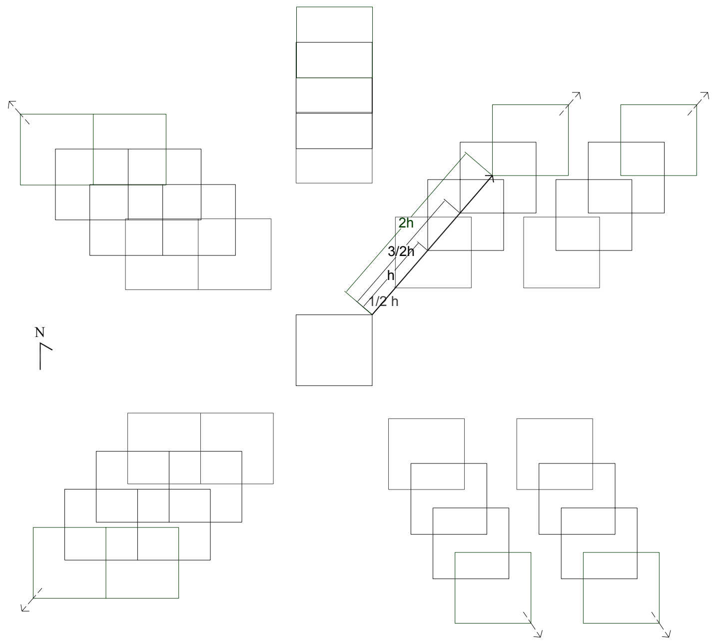


Figure 5.16 : Simulations variations for to find optimum distances between buildings

In the Figure 5.17, 5.18, 5.19, 5.20 lighting, heating, cooling and total loads of simulation variations to find optimum distances between single house 6 and neighbor buildings may be seen.

Figure 5.17 describes the lighting loads according to the variations of distances between buildings. The distances value up to 3,1h enables the same value of lighting load.

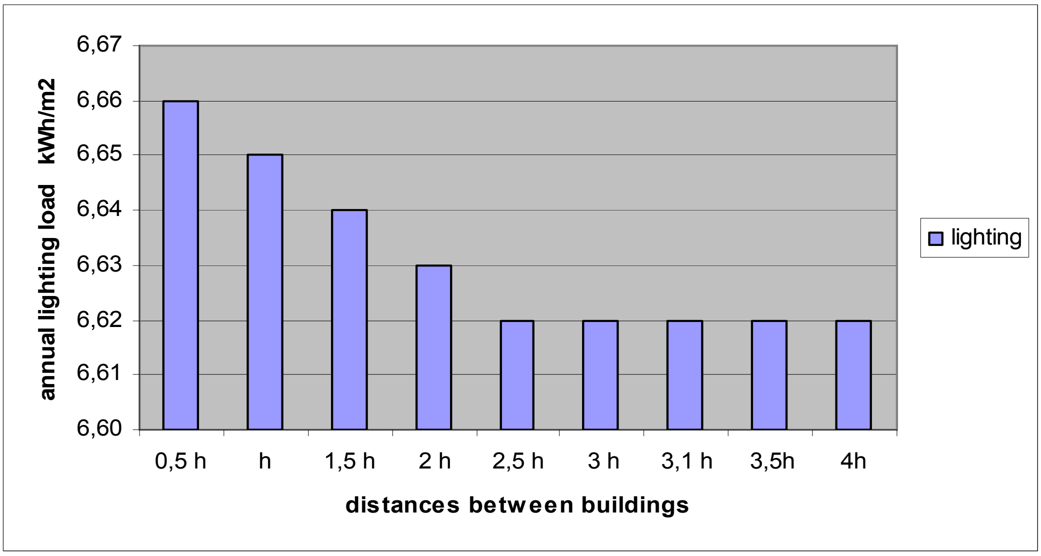


Figure 5.17 : Lighting load chart for chosen building under Stuttgart climate data

Figure 5.18 indicates that cooling loads are increasing at the distance values from 0,5h to 1,5h while cooling loads are equal at the distances values from 3h to 4 h.

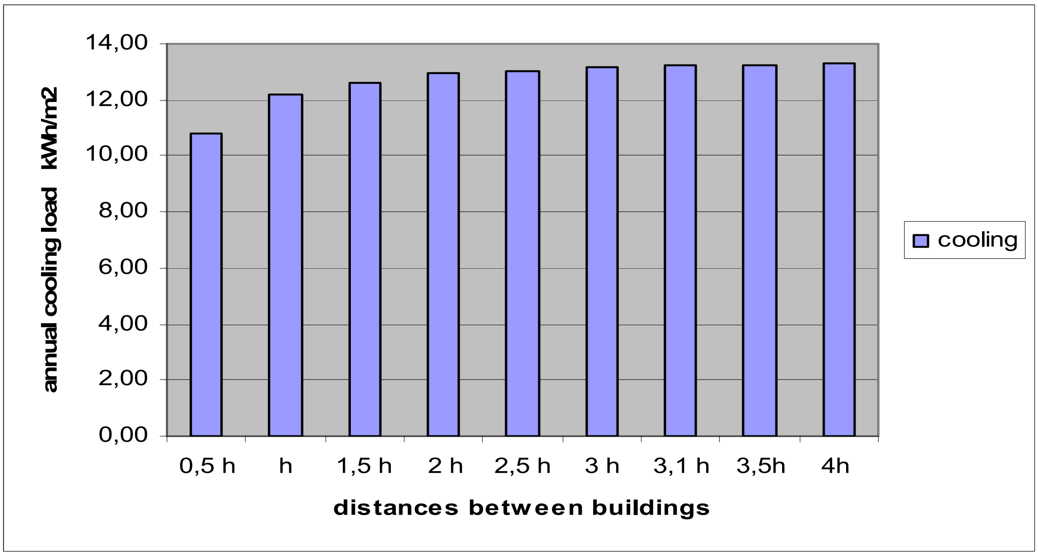


Figure 5.18 : Cooling load chart for chosen building under Stuttgart climate data

The heating load presents a reduction for the different distance values; this reduction is quite low at the distance values from 3h to 4h. The effect of the distance on the chosen building is about the same for the values upper than 3 h, as indicated in Figure 5.19.

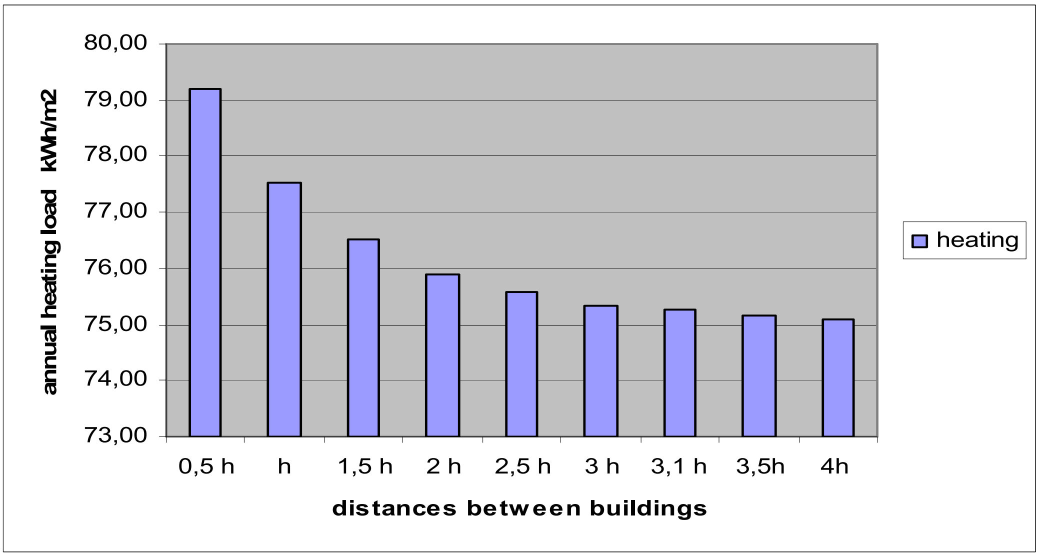


Figure 5.19 : Heating load chart for chosen building under Stuttgart climate data

Conclusion;

As seen in the Figure 5.20, optimum annual sum of lighting, cooling and heating load are found at the 3h distance level. This is the validation of the calculations that are seen in Figure 5.15. Over increasing, the distance may cause unneeded wind impact and ineffective usage of the site. The simulations show when the distance between building 6 and neighbour building is at 3h value; heating load presents a significant decrease but cooling load presents not a significant increase. Therefore, 3h distance value could be qualified as the most appropriate one.

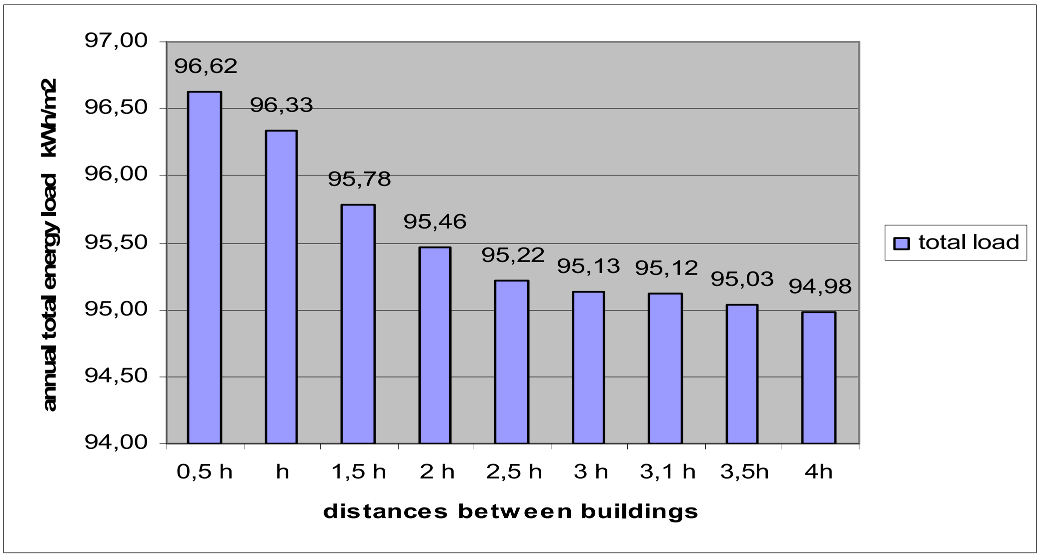


Figure 5.20 : Total load chart for chosen building under Stuttgart climate data

5.7 Istanbul Climatic Dataset and Calculation of Energy Loads

There is no definite climate type for the whole Istanbul Province. Because of its geographic location and physical geographic features, it carries different climate features than the ones in the same latitudes.

Being in the low-pressure and high-pressure zones which repeats twice in order, starting from equator on the earth, 41° north latitude and 29°east longitude, Istanbul is in the borders of subtropical high pressure zone and cold-warm part of low-pressure zone; or terrestrial (dry) alize winds and west winds (humid and rainy) of sea. With the movement of earth, various climate conditions are experienced in winter and summer.

Throughout the year, three types of weather are dominant in Istanbul. One is coming from north and south and the other is more calm weather type. Weather types of east-west direction bound are insignificant. Among these three types of weather, highest frequency (most frequent blowing), one comes along when the northern winds are prevailing. There are four phases according to the seasons; two transition phases of one short and one long with hot and cold periods [53].

Annual precipitation is 720-788 mm. and mostly seen in winter and spring. Annual average temperature is 13.5°C. Temperature varies between -14°C and +41,5°C in a year. Climatic data of İstanbul is given in Appendix C.2.

5.7.1 Effects of orientation related parameters to heating, cooling and lighting demands

In the Figure 5.21, 5.22, 5.23, 5.24 lighting, heating, cooling and total loads of simulation variations of orientation of single house 6 under İstanbul climatic data may be seen. The chart to describe the configuration of orientation simulations is Figure 5.10.

Main glazed façade of the given building is south. Thus, building gains daylighting mostly from south façade but less from north and west façades. Another important parameter is shading effect of surrounding buildings. Spaces of the site oriented east-west and south-north. In these directions, less shading impact is seen. Therefore, at the orientation angles 0º, 90 º and 270 º; lighting loads are minimum related to more density of glazing and less shading object around. The curve of the graphic of demand chart of simulations of Istanbul climate is almost same with the chart of Stuttgart but with lower values, as indicated in Figure 5.21.

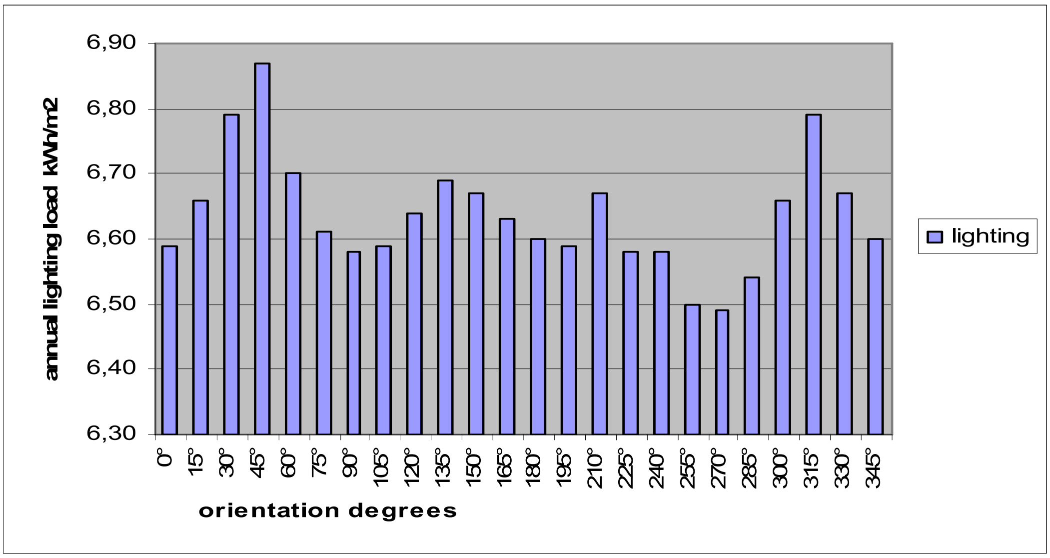


Figure 5.21 : Lighting load chart for chosen building under İstanbul climate data

As seen, in the Figure 5.22; cooling load is minimum at 180º, which main glazed façade face to north. East-west orientation provides more direct solar gain; as sun rises from east and till noon east façade gets direct sun, specially, when there is not an external shading object, like in given example site, direct solar radiation causes overheating. Thus, when the main glazed façades oriented east-west direction cooling energy increases. The cooling charts of Stuttgart and İstanbul are also similar but cooling load values of İstanbul is higher, because of its climate conditions.

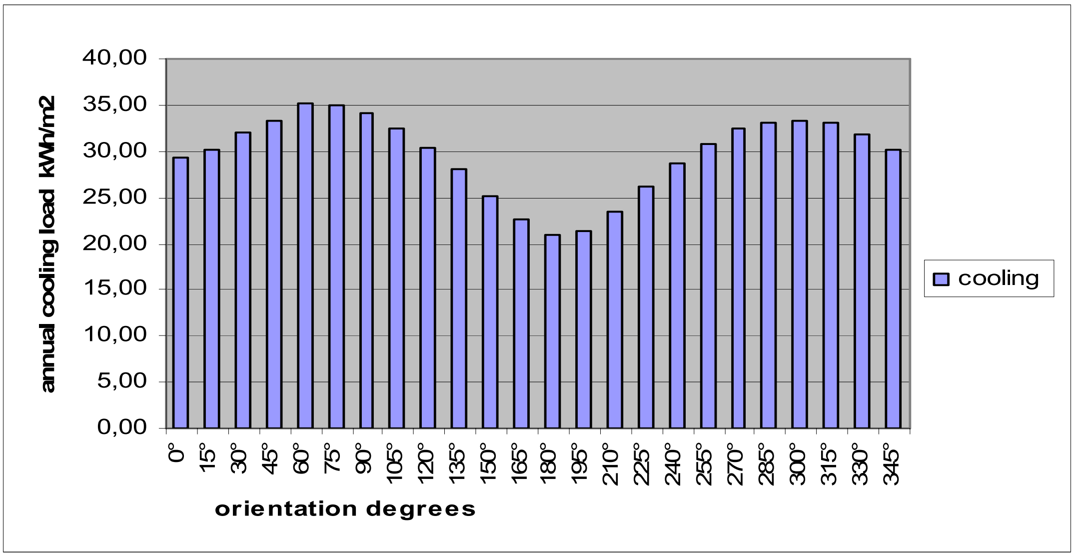


Figure 5.22 : Cooling load chart for chosen building under İstanbul climate data

Heating chart, Figure 5.23, express that -15 º, 0 º, +15 º orientations are proper directions. The heating charts of Stuttgart and İstanbul are also similar but heating load values of İstanbul relatively lower because of its temperate climate conditions.

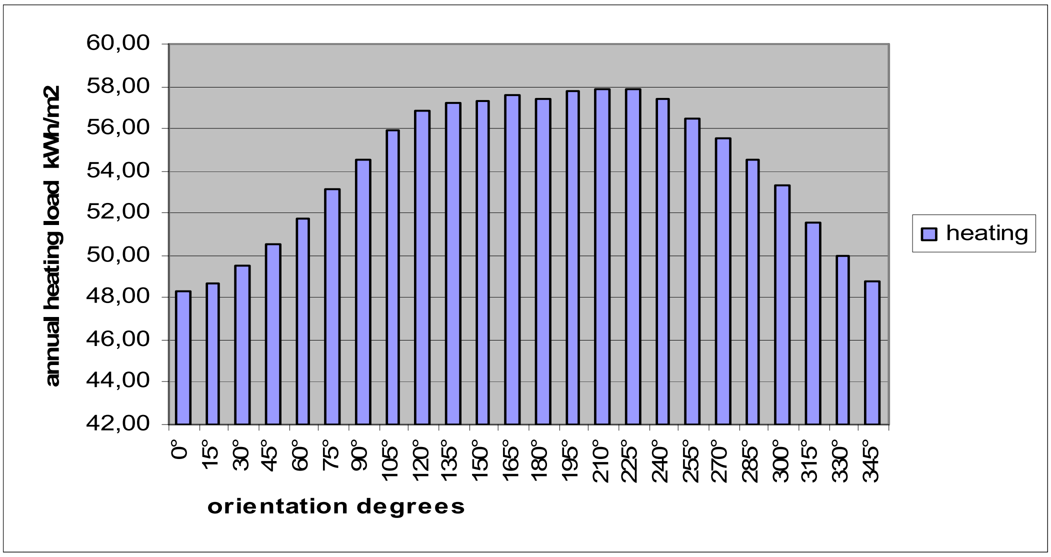


Figure 5.23 : Heating load chart for chosen building under İstanbul climate data

Conclusion;

As seen in the Figure 5.24, lowest annual sum of lighting, cooling and heating load is determined at the orientation between -15 º, 0 º,+15 º to the south as the main glazed façade face to the south for İstanbul climatic dataset.

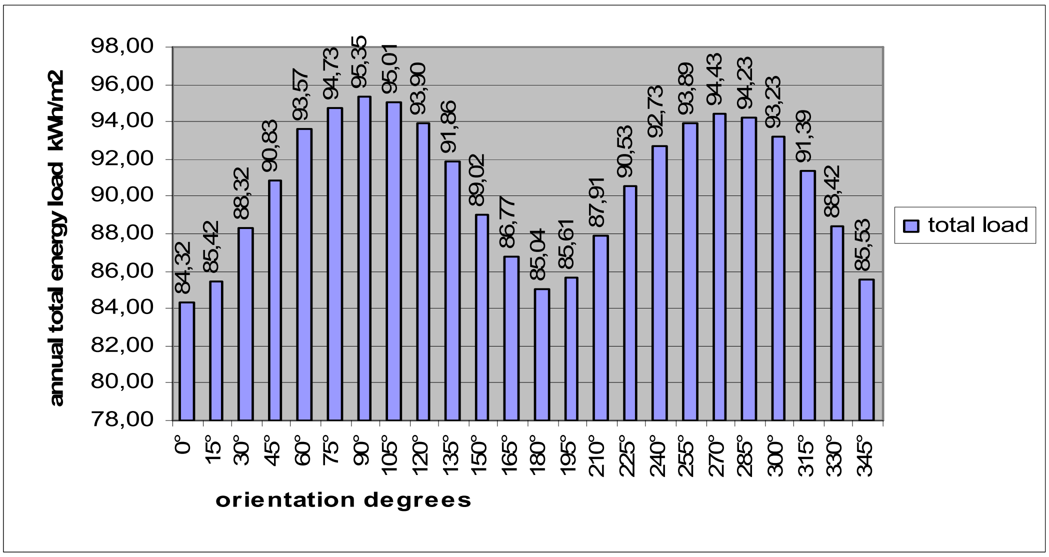


Figure 5.24 : Total load chart for chosen building under İstanbul climate data

5.7.2 Effects of distances between buildings related parameters to heating, cooling and lighting loads

In this part of the study, optimum distances between buildings are searched under İstanbul climate data. The research report "Enerji Etkin Konut Ve Yerleşme Tasarımı", Tübitak-İntag 201, made by Berköz, E., Küçükdoğu, M.,Yılmaz, Z., Kocaaslan, G., in Istanbul Technical University is the base of the calculation Figure 5.25.

Obstruction angle for January 21 in İstanbul is assumed as 24°. Minimum desired distance between buildings is calculated 2.1h, when the building height h. To compare the energy impacts of the distances between buildings, simulation varied for the distance between buildings as 0,5h and multiples of it. In the Figure 5.16, the definition of the simulations may be seen, which distances between buildings in the simulation are defined accordingly.

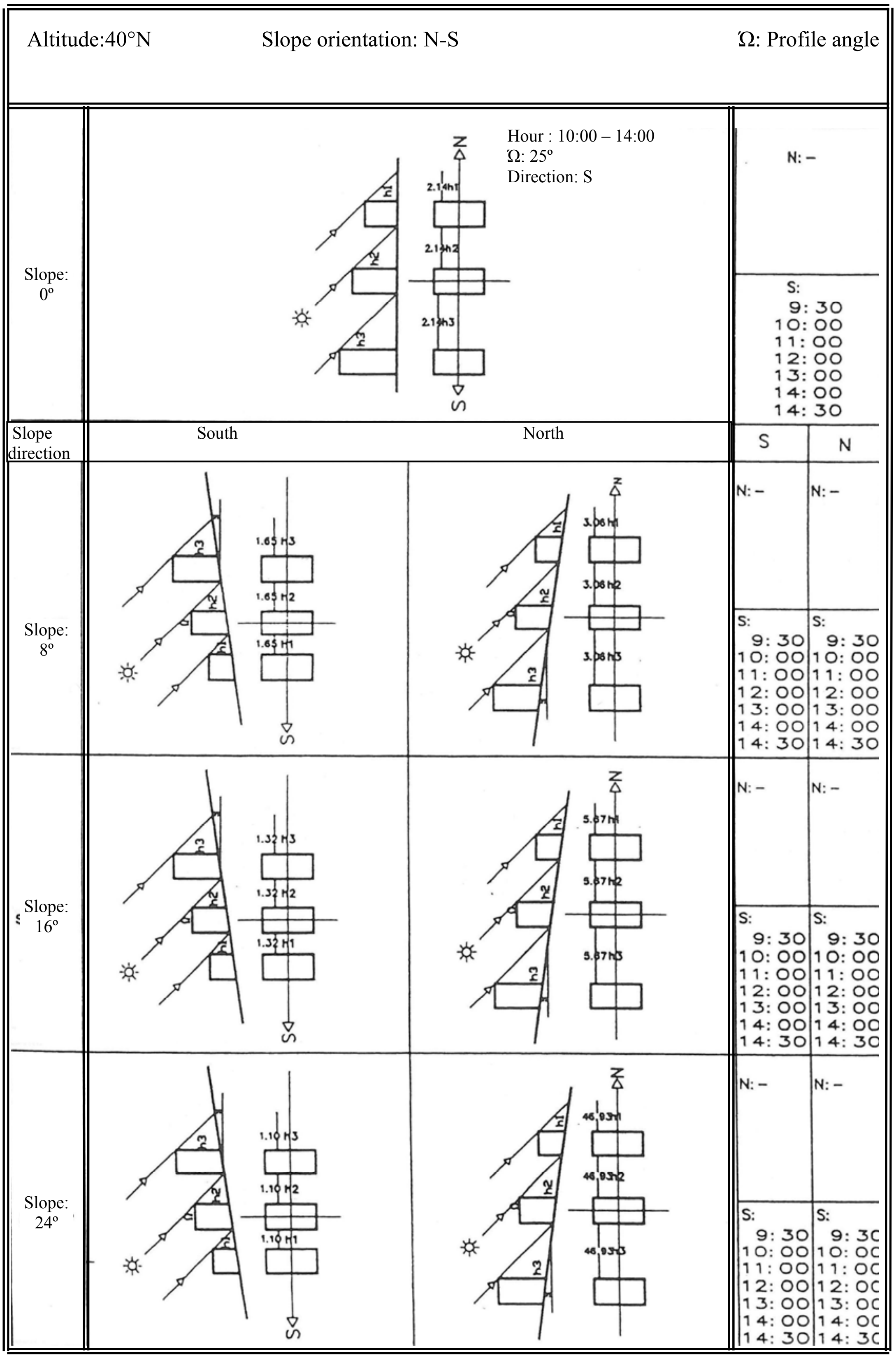


Figure 5.25 : Calculation of optimum distance between buildings for İstanbul [16]

In the Figure 5.26, 5.27, 5.28, 5.29 lighting heating, cooling and total loads of simulation variations, to find optimum distances between buildings of given example under İstanbul climatic data, may be seen.

Figure 5.26 describes the lighting loads according to the variations of optimum distances between buildings. The distances between buildings, value up to 2,1h enables the same value of lighting load.

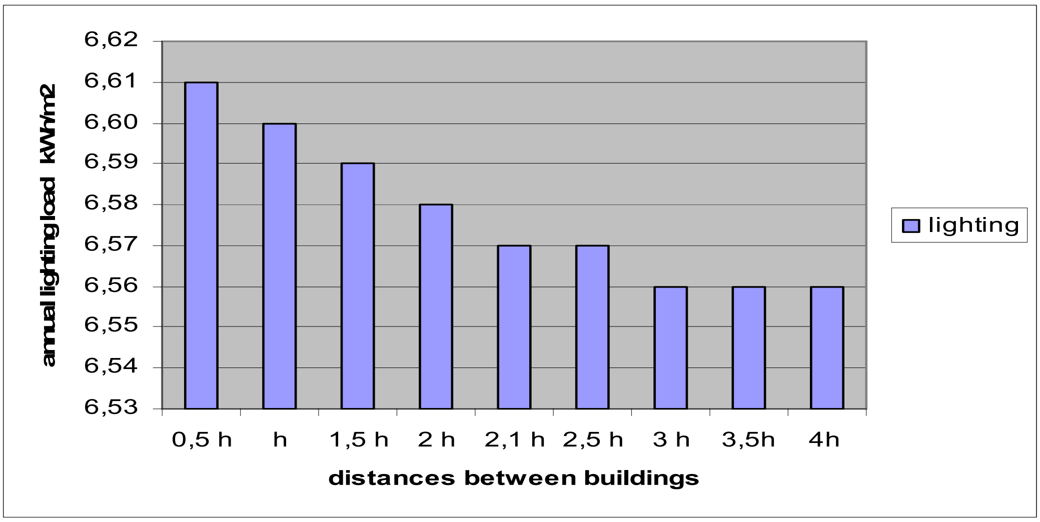


Figure 5.26 : Lighting load chart for chosen building under İstanbul climate data

For the cooling load analyze of distances between buildings, Figure 5.27 indicates that starting with 2h, cooling load values are similar. These distances between buildings values provide large shaded areas on which the neighbouring buildings cast their shadows.

Figure 5.27 : Cooling load chart for chosen building under İstanbul climate data

As seen in the Figure 5.28, acceleration of the curve of demands chart reaches the constant value about 2h distance, it means more than 2h distance heating loads are at acceptable levels.

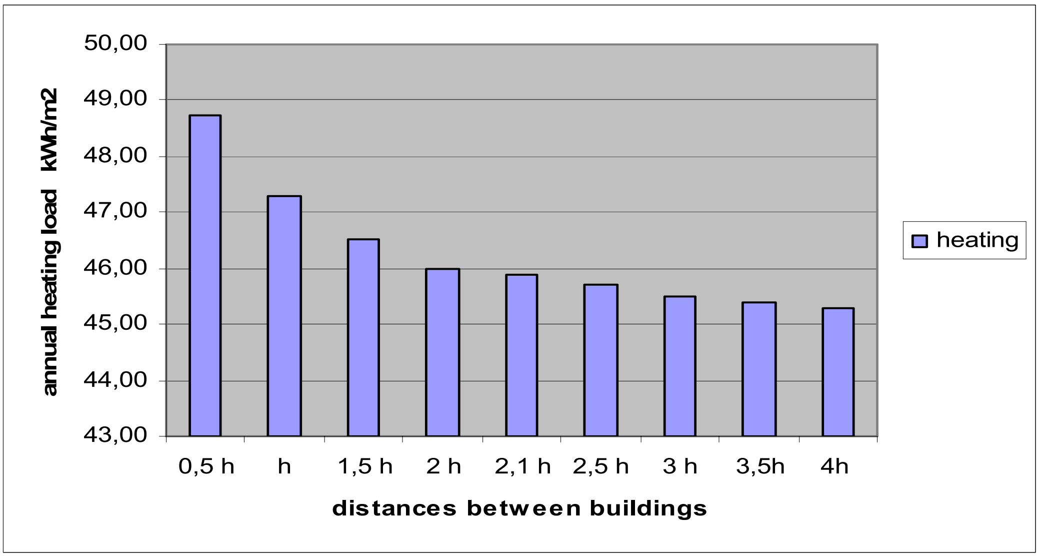


Figure 5.28 : Heating load chart for chosen building under İstanbul climate data

Conclusion;

As seen in the Figure 5.29, optimum annual sum of lighting, cooling and heating load is found at the 3h distance level. This is the validation of the calculations seen in Figure 5.25. Increasing distance more may cause unneeded wind impact and ineffective usage of the site.

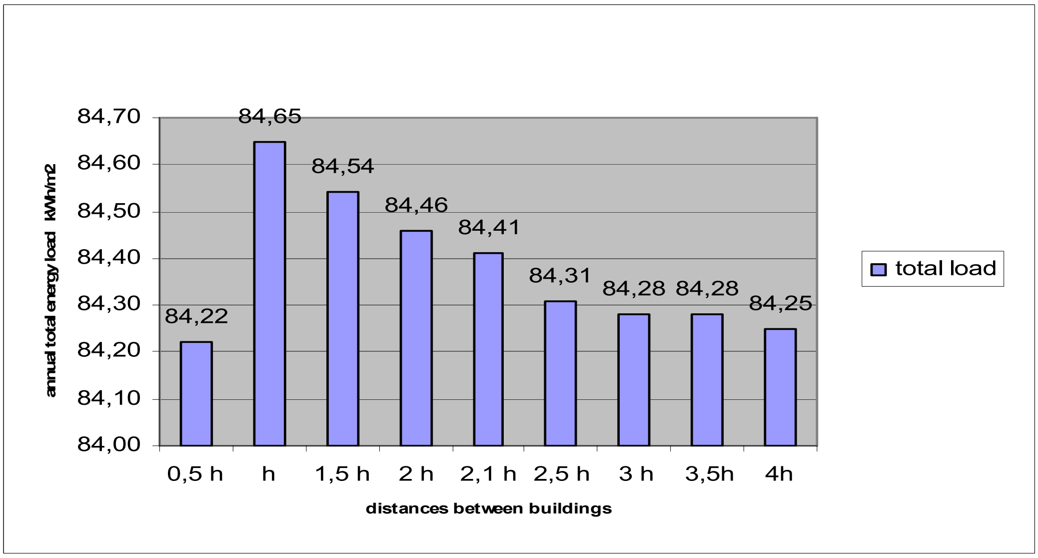


Figure 5.29 : Total load chart for chosen building under İstanbul climate data

5.8 Evaluation of Simulation Results

In this part of the study, the results of simulations are compared to be able to find out the effects of different climate conditions to the location parameters.

5.8.1 Evaluation results of orientation simulations

As seen in Figure 5.30, cooling behaviour of the orientation simulation is similar for both Stuttgart and İstanbul climate. However, obviously, annual cooling consumption of Stuttgart is lower than İstanbul as its average temperature is lower. Moreover, the deviation of the curve of results can be explained by the temperature difference of the climates, as, the difference between maximum and minimum annual cooling consumptions are more in İstanbul than Stuttgart, due to, solar radiation in İstanbul is yearly higher. Therefore, the cooling effect of north orientation does not affect as strong as Stuttgart.

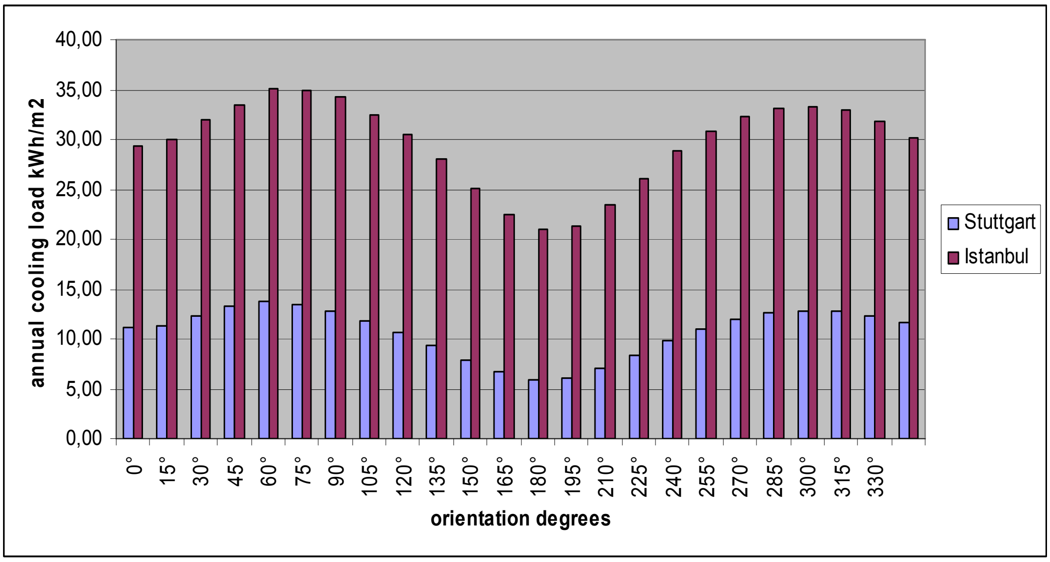


Figure 5.30 : Comparison of cooling load of given house under Stuttgart and İstanbul climate data

The comparison of annual heating loads of Stuttgart and İstanbul, which is indicated in Figure 5.31, defines that heating loads of Stuttgart is higher due to the average temperature of Stuttgart is lower then the İstanbul, but both in cities orientation between -15° to 15° is more energy efficient.

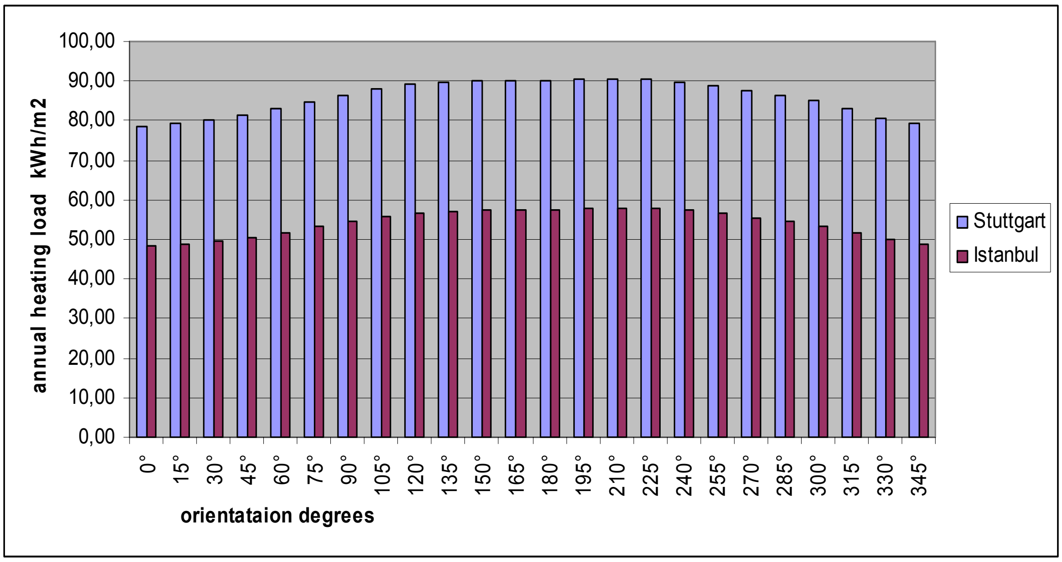


Figure 5.31 : Comparison of heating load of given house under Stuttgart and İstanbul climate data

The comparison of total energy demands of Stuttgart and İstanbul for the orientation variation simulations, Figure 5.32, express that in both climates south west to south east directions are proper directions for energy efficiency. The difference of the table is; in İstanbul, orientation of main façade to north cause lower energy load, which can be explained. as; the climate of İstanbul has higher temperatures that blocks the cooler effect of north facade.

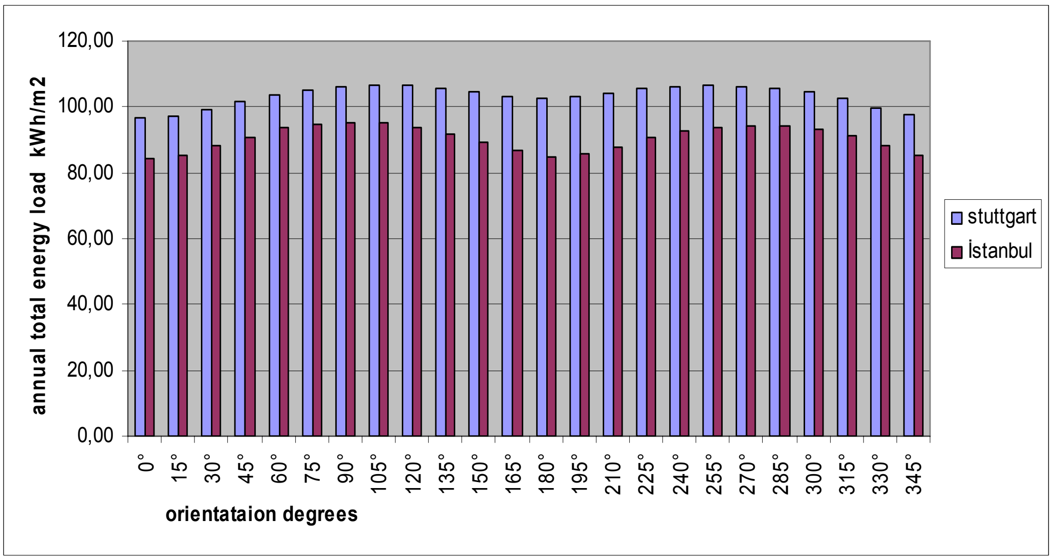


Figure 5.32 : Comparison of total load of given house under Stuttgart and İstanbul climate data

5.8.2 Evaluation results of distances between buildings simulations

Comparison of optimum distances between buildings simulations for Stuttgart and İstanbul to find cooling loads may be seen in Figure 5.33.

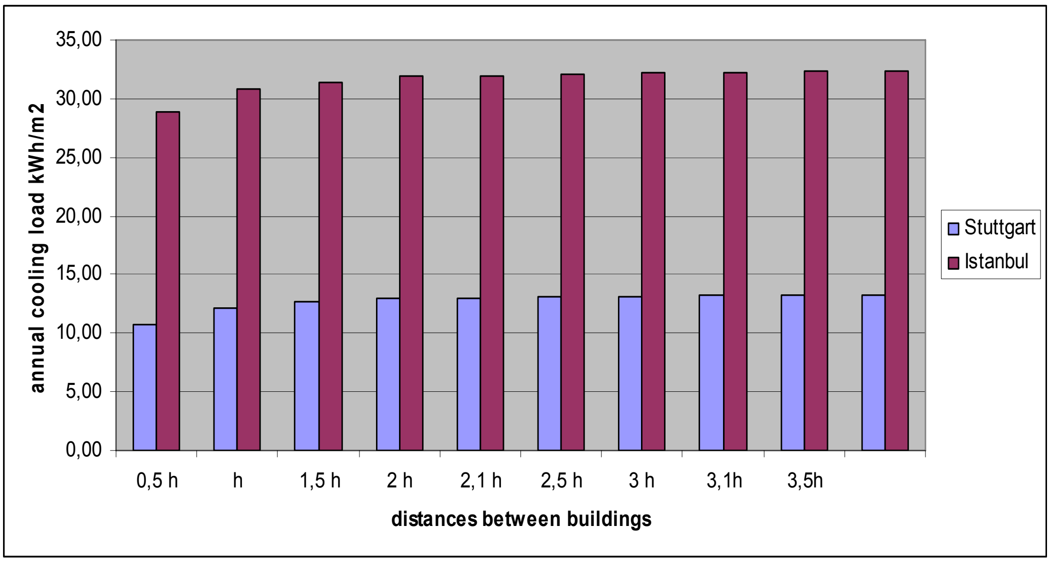


Figure 5.33 : Comparison of cooling load of given house under Stuttgart and İstanbul climate data

Figure 5.34 defines comparison of optimum distances between buildings simulations for Stuttgart and İstanbul to find heating loads.

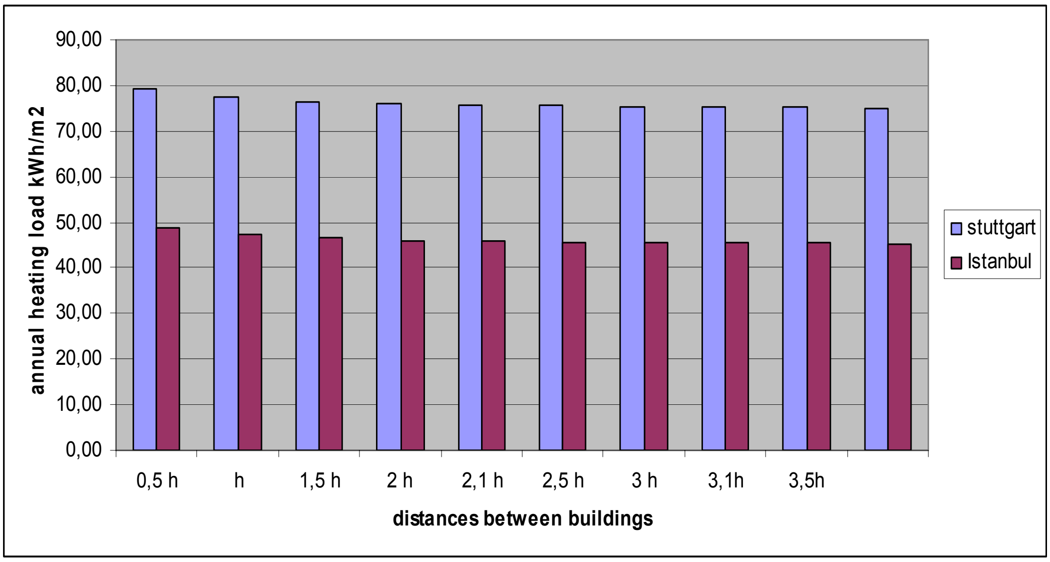


Figure 5.34 : Comparison of heating load of given house under Stuttgart and İstanbul climate data

The comparison of variations, to find optimum distances between buildings of Stuttgart and İstanbul climate data, define that the calculations based on the research are appropriate. Energy simulations, Figure 5.35, define that the distances between buildings values upper than 3 h give the same load value for Stuttgart and for İstanbul this distance value is 2h.

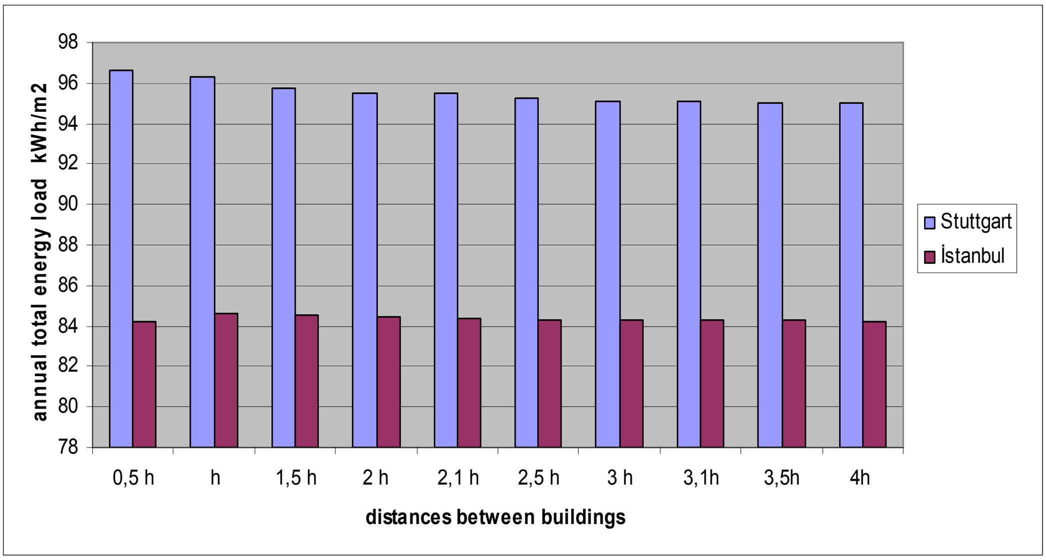


Figure 5.35 : Comparison of total load of given house under Stuttgart and İstanbul climate data

6. CONCLUSIONS

In the contemporary world that the technology develops, construction and population increase fast. The main and the most important problem of the human being is, vital energy sources that are faced to be consumed. Therefore, human have to take into consideration the construction methods, which has a large ratio in energy consumption starting with design to demolition. It is obvious that energy dissipation in the sector would be extremely huge if the correct built methods are not used

At this point, architects may have very important role for protecting natural energy sources of the world by applying energy efficient design approach.

In accordance with this aim, in this study energy efficient design approaches related to the settlement unit have been evaluated by choosing an existing settlement unit.

The study consists of two main parts. Firstly, energy efficient design parameters in the settlement unit are explained in detail and the impacts of these parameters are defined. Subsequently, the calculation methods that are determined in research studies, in Istanbul Technical University, are applied to the energy simulation of chosen example settlement unit, to search the impacts of settlement unit related parameters to the energy consumption. Given example building is a residence building that is accepted as energy efficient design, in Stuttgart, Germany. As given dwelling is built as a part of a research project, existing energy consumptions of the building are measured by the counters. Therefore, the validation has been made by comparing simulation results and measured demands.

For the simulation study, first of all, the effects of site texture are searched. Variations of site configurations simulated and compared with the energy loads of unshaded unique building for the given example. It is seen that, by the comparison of unshaded and given example variations, external obstacles have shading effect, which reduces cooling demands and increases heating demands. But the point is, the reduction ratio of Stuttgart and İstanbul differs due to annual solar radiation and temperature data of these cities. It is seen that shading impact affected cooling demands in Stuttgart relatively more, according to İstanbul. It can be considered that cooling effect of shading of external obstacles are not enough to decrease cooling load in Istanbul as Stuttgart because solar radiation intensity and air temperature values are higher in İstanbul than Stuttgart

As a result, for hot and temperate climates, alternative passive cooling preventions in addition to external shading elements have to be taken into consideration.

The results of texture configuration simulations defined that street orientation of main directions south-north and east-west are affecting cooling demands more efficiently, depending on shading potential of a building to the neighbor buildings.

At the second part of the simulation study, from the energy conservation point of view, the effect of orientation and distances between buildings, which are the most important parameters of settlement scale, on energy loads are evaluated. For this purpose, heating, cooling and lighting energy consumptions are calculated for each orientation with 15 º interval and compared for Stuttgart and İstanbul climatic data. The comparison of total energy demands of Stuttgart and İstanbul for the orientation variation simulations express that annual energy loads of İstanbul are lower than Stuttgart for each direction as Stuttgart has cooler climate but in both climates, from south west to south east directions, between -15 º to 15 º, are proper directions for energy efficiency.

For Istanbul the alternative of orientation of main façade to north provides lower total energy load because north orientation causes lower cooling load.

Distances between buildings simulations are variated in dependence of chosen building; height (h) and the difference of the distance for each variation 0,5h is accepted as the intervals. Results are compared with the calculated results of related research (ref. No 2). Distances between buildings simulations defined that, due to the undesired effects of external buildings, needed distance has to be calculated for the winter design day. It is seen in the variations of simulations that for İstanbul 2,1h and for Stuttgart 3,1h distance are more effective. It is accepted that simulation results are validating the research calculation.

Increase of distance more then the desired length do not have any efficiency on energy loads, besides, area loose of site is not proper, specially, in the cities, which settlement areas are very valuable.

The observation of the effect of local climate to the energy consumption is the reason to repeat all simulations under Stuttgart and İstanbul climate data, which are located in different latitudes and have different characteristic of climate.

To summarize, the simulation results for site texture, orientation and optimum distance between buildings, it is obvious that all parameters of settlement unit scale have to be considered for each unique configuration under local climate data. Microclimate, prevailing wind, over shading problems, topography are the most effective parameters that requires specific search for the optimum energy efficient localization of a building.

The simulation study presented in this thesis is a sample study for a chosen settlement unit to explain the effect of design parameters in the settlement unit scale on building energy loads. In order to obtain minimum energy loads it is necessary to evaluate different settlement texture alternatives for different combination values of design parameters in the design stage by means of regional climatic data. Thus, it is possible to determine optimum values of design parameters, which provide minimum energy loads and costs.

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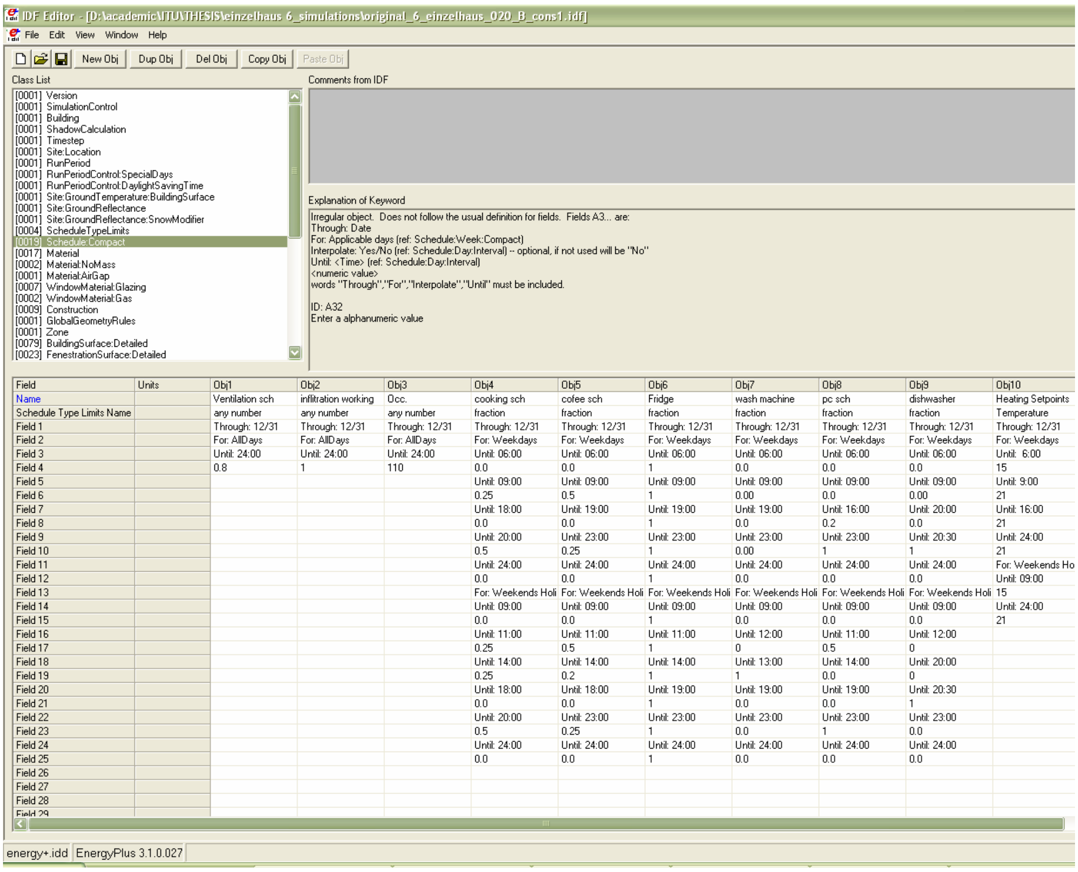
APPENDICES

APPENDIX A.1 : Defination Schedules for Energyplus Simulation

EnergyPlus has its roots in both the BLAST and DOE–2 programs. BLAST (Building Loads Analysis and System Thermodynamics) and DOE–2 were both developed and released in the late 1970s and early 1980s as energy and load simulation tools. Their intended audience is a design engineer or architect that wishes to size appropriate HVAC equipment, develop retrofit studies for life cycling cost analyses, optimize energy performance, etc. Born out of concerns driven by the energy crisis of the early 1970s and recognition that building energy consumption is a major component of the American energy usage statistics, the two programs attempted to solve the same problem from two slightly different perspectives. Both programs had their merits and shortcomings, their supporters and detractors, and solid user bases both nationally and internationally. Like its parent programs, EnergyPlus is an energy analysis and thermal load simulation program. Based on a user's description of a building from the perspective of the building's physical make up, associated mechanical systems, etc., EnergyPlus will calculate the heating and cooling loads necessary to maintain thermal control setpoints, conditions throughout an secondary HVAC system and coil loads, and the energy consumption of primary plant equipment as well as many other simulation details that are necessary to verify that the simulation is performing as the actual building would. Many of the simulation characteristics have been inherited from the legacy programs of BLAST and DOE–2.

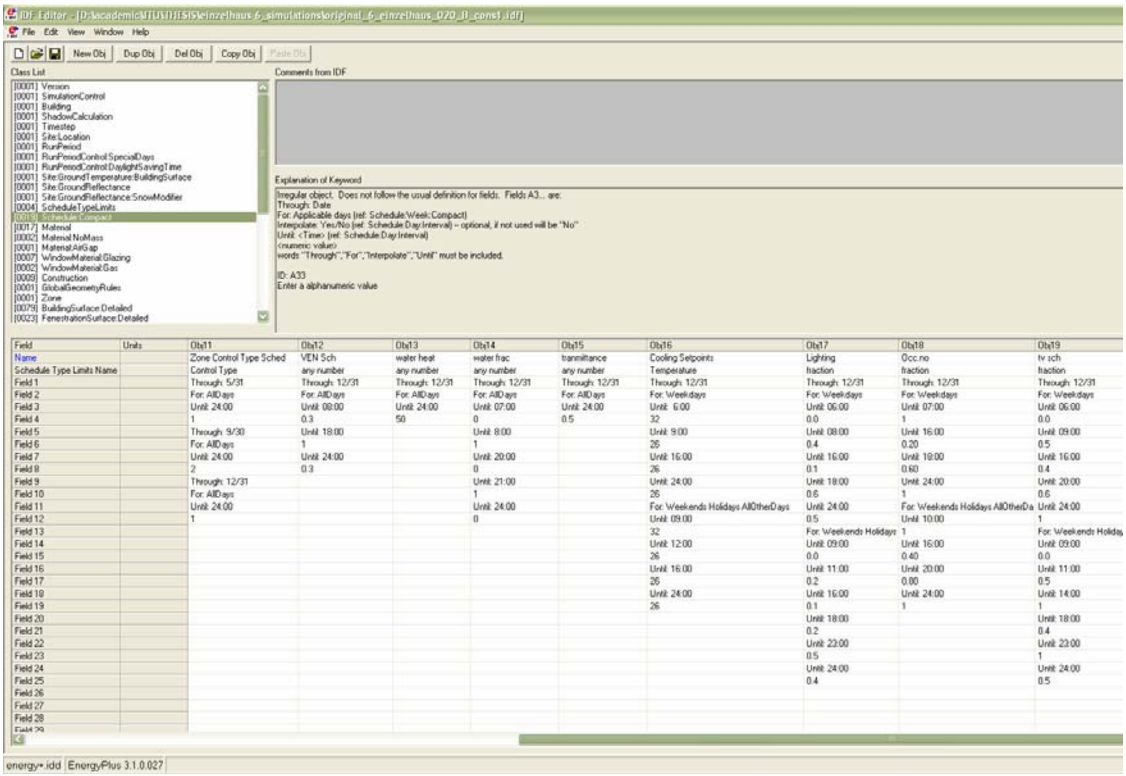
At following schedules that determine the acceptations in Energyplus simulations can be seen. Energyplus is an opensource program that provides to be controlled each data in its class list menu.

Table A.1 : Energy Plus control schedules for electricity device usage and heating set point timetables



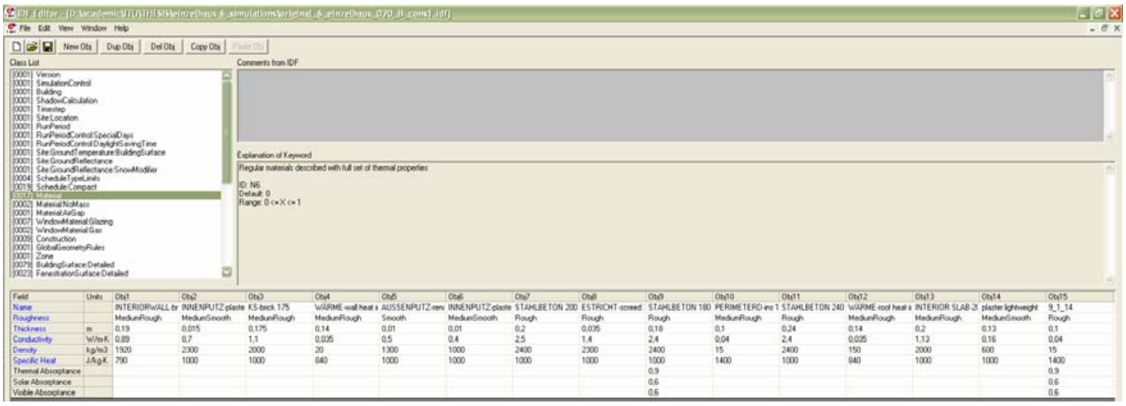
Field	Units	Obj1	Obj2	Obj3	Obj4	Obj5	Obj6	Obj7	Obj8	Obj9	Obj10
Name		Ventilation sch	infiltration working	Occ.	cooking sch	cofee sch	Fridge	wash machine	pc sch	dishwasher	Heating Setpoints
Schedule Type Limits Name		any number	any number	any number	fraction	fraction	fraction	fraction	fraction	fraction	Temperature
Field 1		Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31
Field 2		For: AllDays	For: AllDays	For: AllDays	For: Weekdays	For: Weekdays	For: Weekdays	For: Weekdays	For: Weekdays	For: Weekdays	For: Weekdays
Field 3		Until: 24:00	Until: 24:00	Until: 24:00	Until: 06:00	Until: 06:00	Until: 06:00	Until: 06:00	Until: 06:00	Until: 06:00	Until: 6:00
Field 4		0.8	1	110	0.0	0.0	1	0.0	0.0	0.0	15
Field 5					Until: 09:00	Until: 09:00	Until: 09:00	Until: 09:00	Until: 09:00	Until: 09:00	Until: 9:00
Field 6					0.25	0.5	1	0.00	0.0	0.00	21
Field 7					Until: 18:00	Until: 19:00	Until: 19:00	Until: 19:00	Until: 16:00	Until: 20:00	Until: 16:00
Field 8					0.0	0.0	1	0.0	0.2	0.0	21
Field 9					Until: 20:00	Until: 23:00	Until: 23:00	Until: 23:00	Until: 23:00	Until: 20:30	Until: 24:00
Field 10					0.5	0.25	1	0.00	1	1	21
Field 11					Until: 24:00	Until: 24:00	Until: 24:00	Until: 24:00	Until: 24:00	Until: 24:00	For: Weekends Ho
Field 12					0.0	0.0	1	0.0	0.0	0.0	Until: 09:00
Field 13					For: Weekends Holi	For: Weekends Holi	For: Weekends Holi	For: Weekends Holi	For: Weekends Holi	For: Weekends Holi	15
Field 14					Until: 09:00	Until: 09:00	Until: 09:00	Until: 09:00	Until: 09:00	Until: 09:00	Until: 24:00
Field 15					0.0	0.0	1	0.0	0.0	0.0	21
Field 16					Until: 11:00	Until: 11:00	Until: 11:00	Until: 12:00	Until: 11:00	Until: 12:00	
Field 17					0.25	0.5	1	0	0.5	0	
Field 18					Until: 14:00	Until: 14:00	Until: 14:00	Until: 13:00	Until: 14:00	Until: 20:00	
Field 19					0.25	0.2	1	1	0.0	0	
Field 20					Until: 18:00	Until: 18:00	Until: 19:00	Until: 19:00	Until: 19:00	Until: 20:30	
Field 21					0.0	0.0	1	0.0	0.0	1	
Field 22					Until: 20:00	Until: 23:00	Until: 23:00	Until: 23:00	Until: 23:00	Until: 23:00	
Field 23					0.5	0.25	1	0.0	1	0.0	
Field 24					Until: 24:00	Until: 24:00	Until: 24:00	Until: 24:00	Until: 24:00	Until: 24:00	
Field 25					0.0	0.0	1	0.0	0.0	0.0	
Field 26											
Field 27											
Field 28											

Table A.2 : Energy Plus control schedules for cooling set point timetables



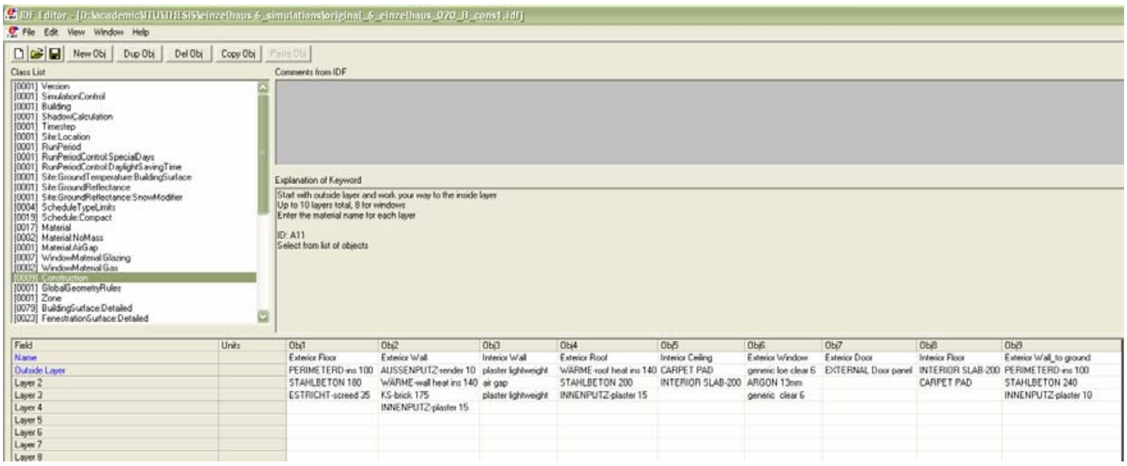
Field	Units	Obj11	Obj12	Obj13	Obj14	Obj15	Obj16	Obj17	Obj18	Obj19
Name		Zone Control Type Sched	VEN Sch	water heat	water frac	tranmittance	Cooling Setpoints	Lighting	Occ.no	tv sch
Schedule Type Limits Name		Control Type	any number	any number	any number	any number	Temperature	fraction	fraction	fraction
Field 1		Through: 5/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31	Through: 12/31
Field 2		For: AllDays	For: AllDays	For: AllDays	For: AllDays	For: AllDays	For: Weekdays	For: Weekdays	For: Weekdays	For: Weekdays
Field 3		Until: 24:00	Until: 08:00	Until: 24:00	Until: 07:00	Until: 24:00	Until: 6:00	Until: 06:00	Until: 07:00	Until: 06:00
Field 4		1	0.3	50	0	0.5	32	0.0	1	0.0
Field 5		Through: 9/30	Until: 18:00		Until: 8:00		Until: 9:00	Until: 08:00	Until: 16:00	Until: 09:00
Field 6		For: AllDays	1		1		26	0.4	0.20	0.5
Field 7		Until: 24:00	Until: 24:00		Until: 20:00		Until: 16:00	Until: 16:00	Until: 18:00	Until: 16:00
Field 8		2	0.3		0		26	0.1	0.60	0.4
Field 9		Through: 12/31			Until: 21:00		Until: 24:00	Until: 18:00	Until: 24:00	Until: 20:00
Field 10		For: AllDays			1		26	0.6	1	0.6
Field 11		Until: 24:00			Until: 24:00		For: Weekends Holidays AllOtherDays	Until: 24:00	For: Weekends Holidays AllOtherDa	Until: 24:00
Field 12		1			0		Until: 09:00	0.5	Until: 10:00	1
Field 13							32	For: Weekends Holidays	1	For: Weekends Holiday
Field 14							Until: 12:00	Until: 09:00	Until: 16:00	Until: 09:00
Field 15							26	0.0	0.40	0.0
Field 16							Until: 16:00	Until: 11:00	Until: 20:00	Until: 11:00
Field 17							26	0.2	0.80	0.5
Field 18							Until: 24:00	Until: 16:00	Until: 24:00	Until: 14:00
Field 19							26	0.1	1	1
Field 20								Until: 18:00		Until: 18:00
Field 21								0.2		0.4
Field 22								Until: 23:00		Until: 23:00
Field 23								0.5		1
Field 24								Until: 24:00		Until: 24:00
Field 25								0.4		0.5
Field 26										
Field 27										
Field 28										

Table A.3 : Energy Plus control schedules for material determination



Field	Units	Obj1	Obj2	Obj3	Obj4	Obj5	Obj6	Obj7	Obj8	Obj9	Obj10	Obj11	Obj12	Obj13	Obj14	Obj15
Name		INTERIORWALL-br	INNENPUTZ-plaste	KS-brick 175	WARME-wall heat i	AUSSENPUTZ-ren	INNENPUTZ-plaste	STAHLBETON 200	ESTRICHT-screed	STAHLBETON 180	PERIMETERD-ins 1	STAHLBETON 240	WARME-roof heat i	INTERIOR SLAB-2	plaster lightweight	9_1_14
Roughness		MediumRough	MediumSmooth	MediumRough	MediumRough	Smooth	MediumSmooth	Rough	Rough	Rough	MediumRough	Rough	MediumRough	MediumRough	MediumSmooth	Rough
Thickness	m	0,19	0,015	0,175	0,14	0,01	0,01	0,2	0,035	0,18	0,1	0,24	0,14	0,2	0,13	0,1
Conductivity	W/m-K	0,89	0,7	1,1	0,035	0,5	0,4	2,5	1,4	2,4	0,04	2,4	0,035	1,13	0,16	0,04
Density	kg/m3	1920	2300	2000	20	1300	1000	2400	2300	2400	15	2400	150	2000	600	15
Specific Heat	J/kg-K	790	1000	1000	840	1000	1000	1000	1000	1000	1400	1000	840	1000	1000	1400
Thermal Absorptance										0,9						0,9
Solar Absorptance										0,6						0,6
Visible Absorptance										0,6						0,6

Table A.4 : Energy Plus control schedules for construction determination



Field	Units	Obj1	Obj2	Obj3	Obj4	Obj5	Obj6	Obj7	Obj8	Obj9
Name		Exterior Floor	Exterior Wall	Interior Wall	Exterior Roof	Interior Ceiling	Exterior Window	Exterior Door	Interior Floor	Exterior Wall_to ground
Outside Layer		PERIMETERD-ins 100	AUSSENPUTZ-render 10	plaster lightweight	WÄRME-roof heat ins 140	CARPET PAD	generic low clear 6	EXTERNAL Door panel	INTERIOR SLAB-200	PERIMETERD-ins 100
Layer 2		STAHLBETON 180	WÄRME-wall heat ins 140	air gap	STAHLBETON 200	INTERIOR SLAB-200	ARGON 13mm		CARPET PAD	STAHLBETON 240
Layer 3		ESTRICHT-screed 35	KS-brick 175	plaster lightweight	INNENPUTZ-plaster 15		generic clear 6			INNENPUTZ-plaster 10
Layer 4			INNENPUTZ-plaster 15							
Layer 5										
Layer 6										
Layer 7										
Layer 8										

APPENDIX B.1: Defination Schedules for Energyplus Simulation

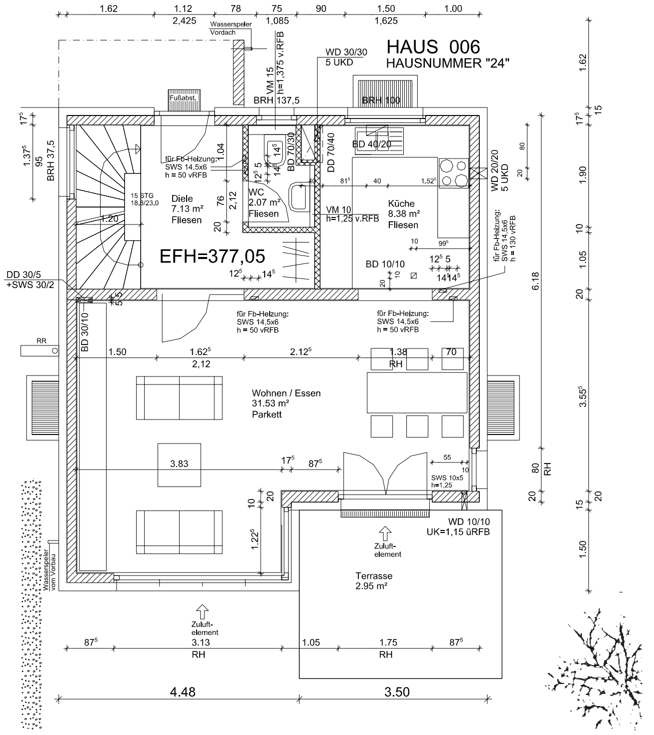


Figure B.1 : Ground floor plan

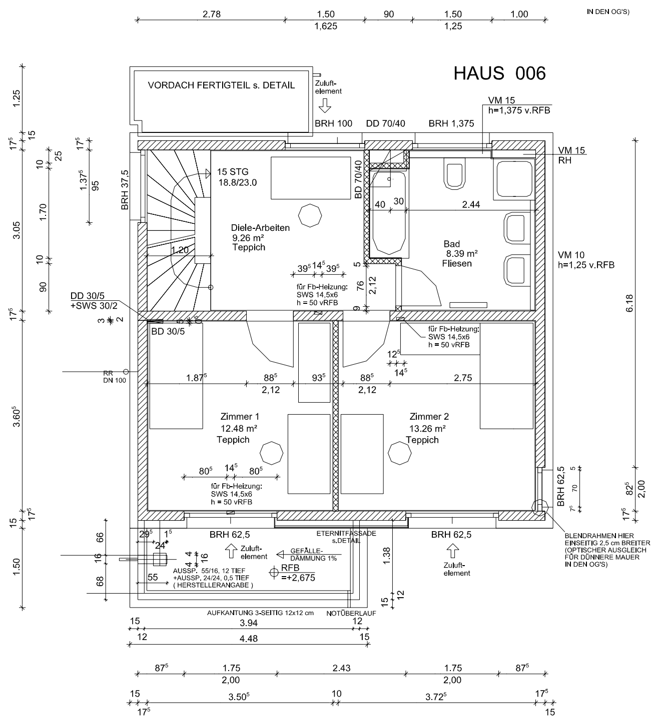


Figure B.2 : First floor plan

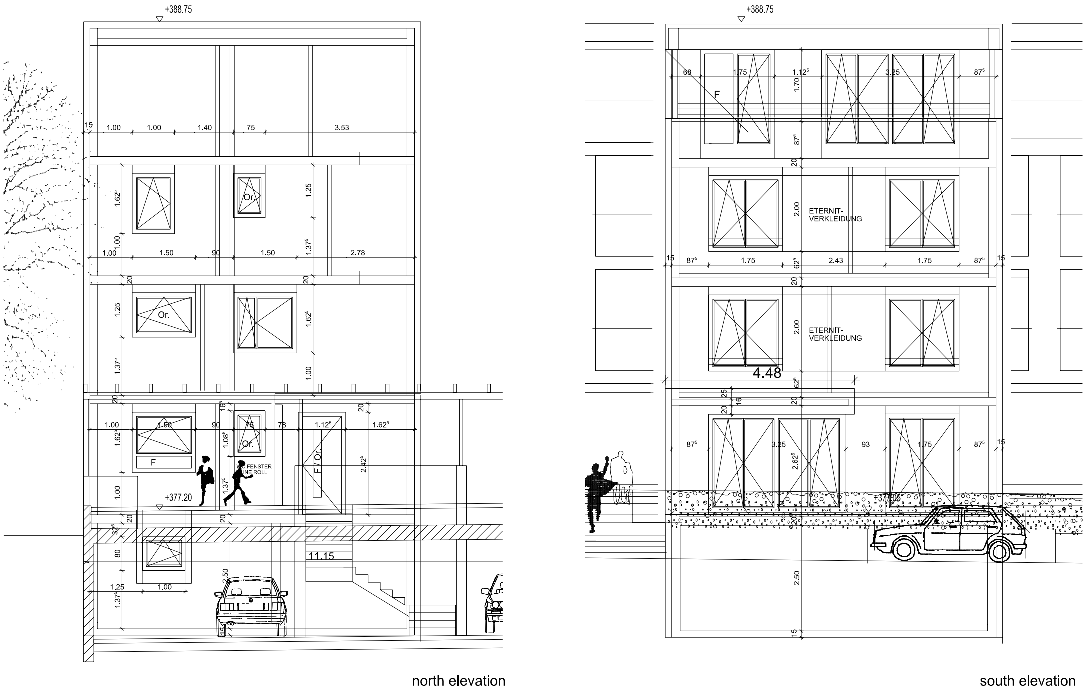


Figure B.3 : North and south elevation

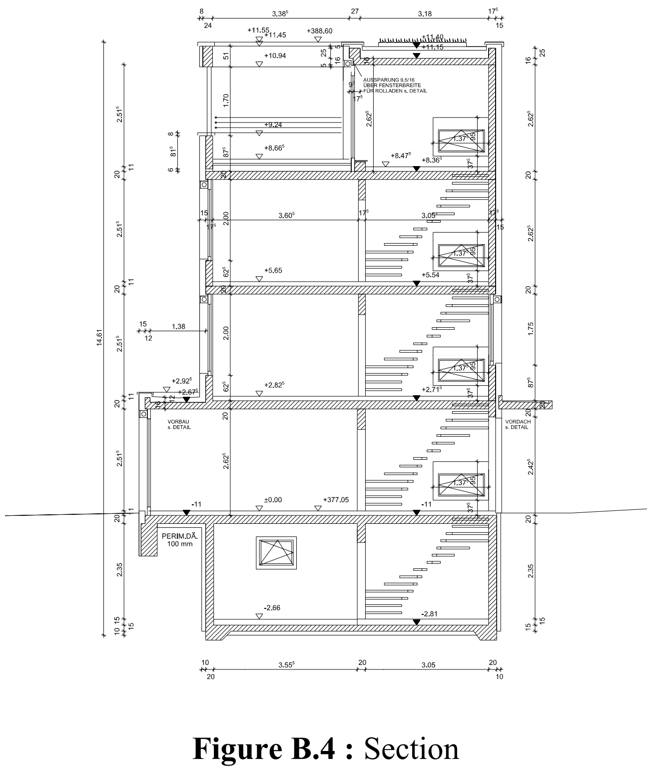


Figure B.4 : Section

APPENDIX C.1: Weather data for Stuttgart

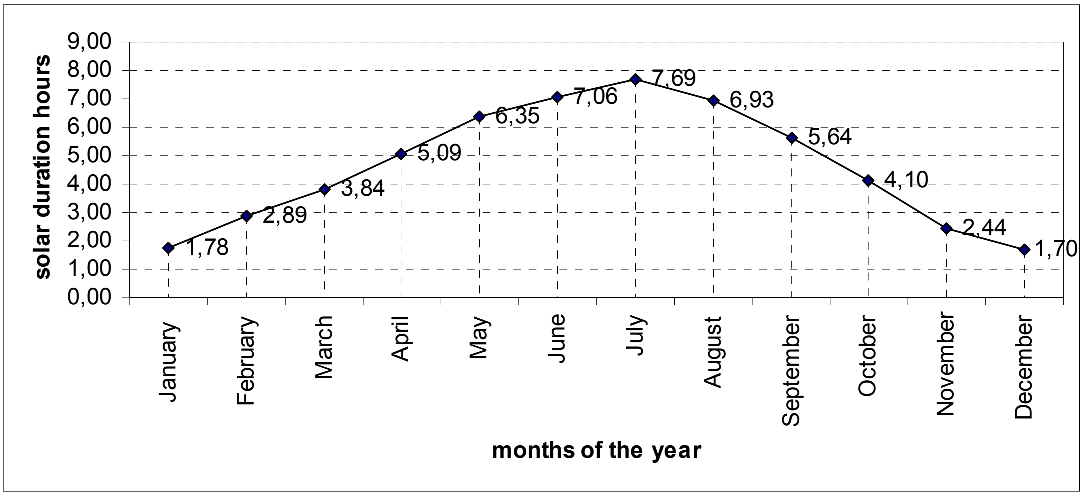


Figure C.1 : Monthly average solar duration values for Stuttgart 1961-1990

Annual average solar duration is total1691,7 hours per year [52]

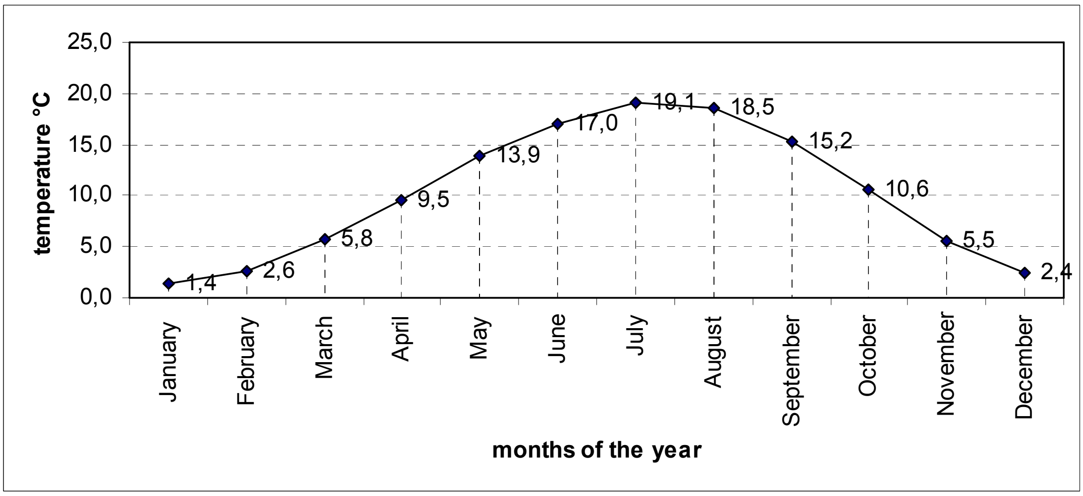


Figure C.2 : Monthly average temperture values for Stuttgart 1961-1990

Annual average temperature is 10,1 °C [52]

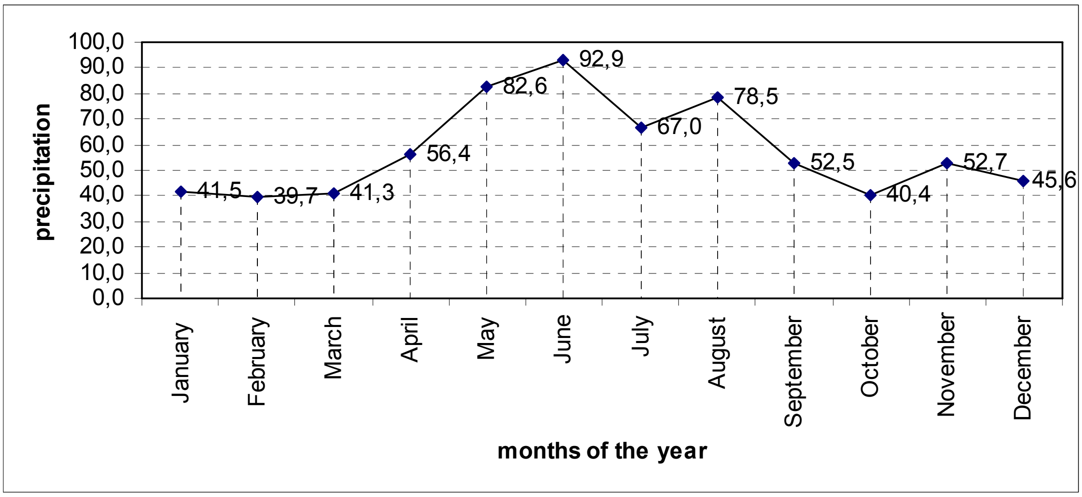
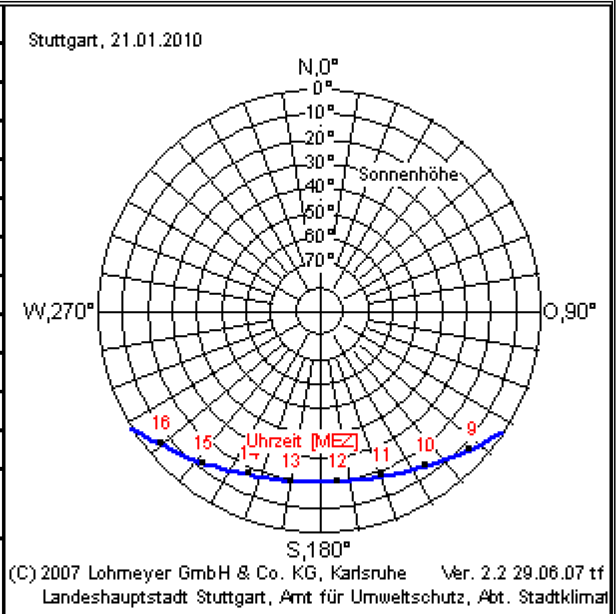


Figure C.3 : Monthly average precipitation values for Stuttgart 1961-1990

Annual average precipitation is 691 mm [52]

Table C.1 : Solar occupation of Stuttgart at winter design day, 21th January [52]

Stuttgart (48°46'39", 9°10'44") am 21.01.2010	
Local time(=GMT+1.0 h)	**21.50**
Begin of astronomic dawn	**6.15**
Begin of nautic dawn	**6.52**
Begin of civil dawn	**7.31**
Sunrise	**8.06**
True noon tide (highest sun's altitude)	**12.35**
Sunset	**17.03**
End of civil twilight	**17.38**
End of nautic twilight	**18.17**
End of astronomic twilight	**18.54**
Duration of sunshine [hh.mm]	**8.57**
Highest sun's altitude (upper culmination point)	**21°21'**
Lowest sun's altitude (lower culmination point)	**-61°06'**
Quarter at sunrise Quarter at sunset	**119°57'** **240°03'**



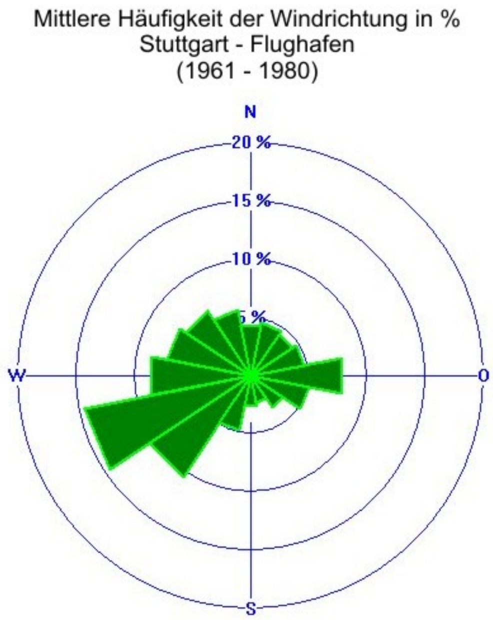


Figure C.4 : Wind rose for Stuttgart 1961-1990 [52]

The most frequent and also strongest winds in the region of northern Württemberg as a long-term average come from West to Southwest (prevailing wind direction). This could be seen in the wind rose Figure C.1

APPENDIX C.2: Weather data for İstanbul

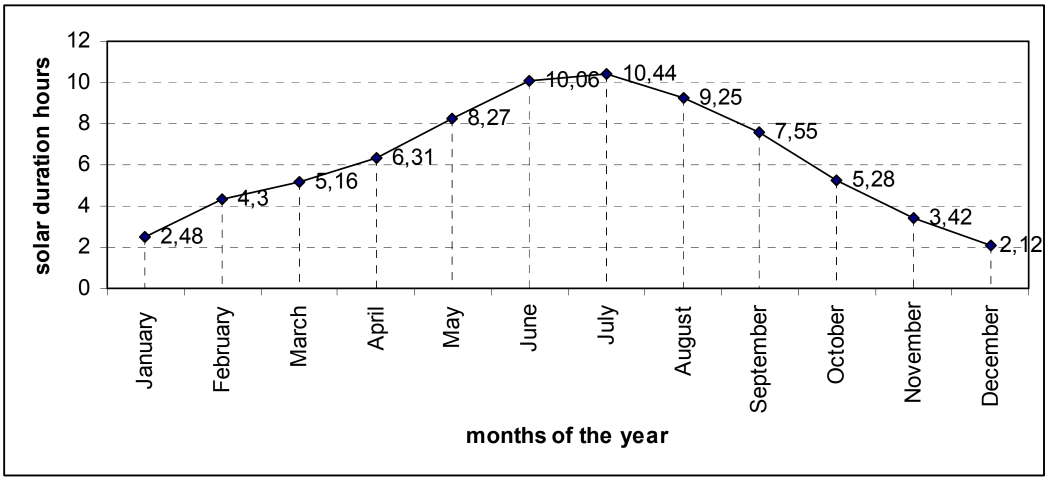


Figure C.5 : Monthly average solar duration values for İstanbul

1993-2002 from Göztepe Meteorology Station

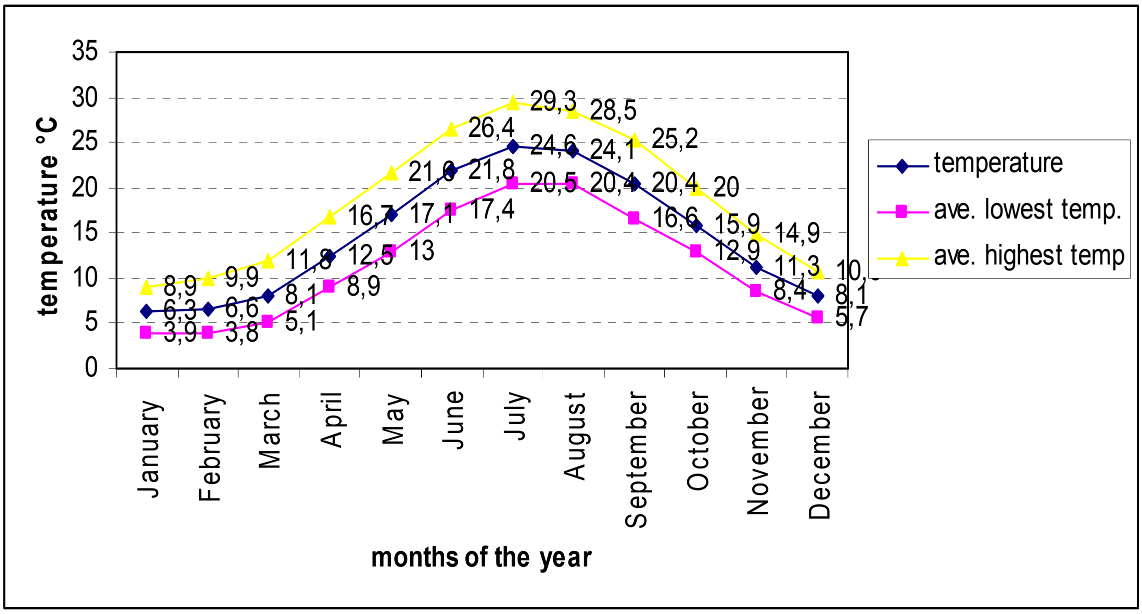


Figure C.6 : Monthly average temperture values for İstanbul

1993-2002 from Göztepe Meteorology Station

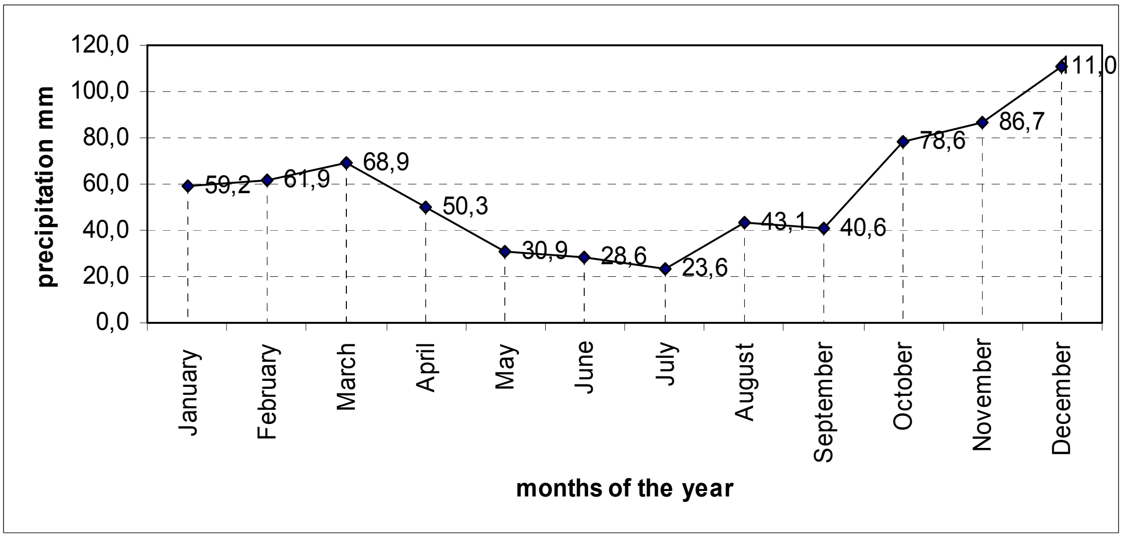


Figure C.7 : Monthly average precipitation values for İstanbul

1993-2002 from Göztepe Meteorology Station

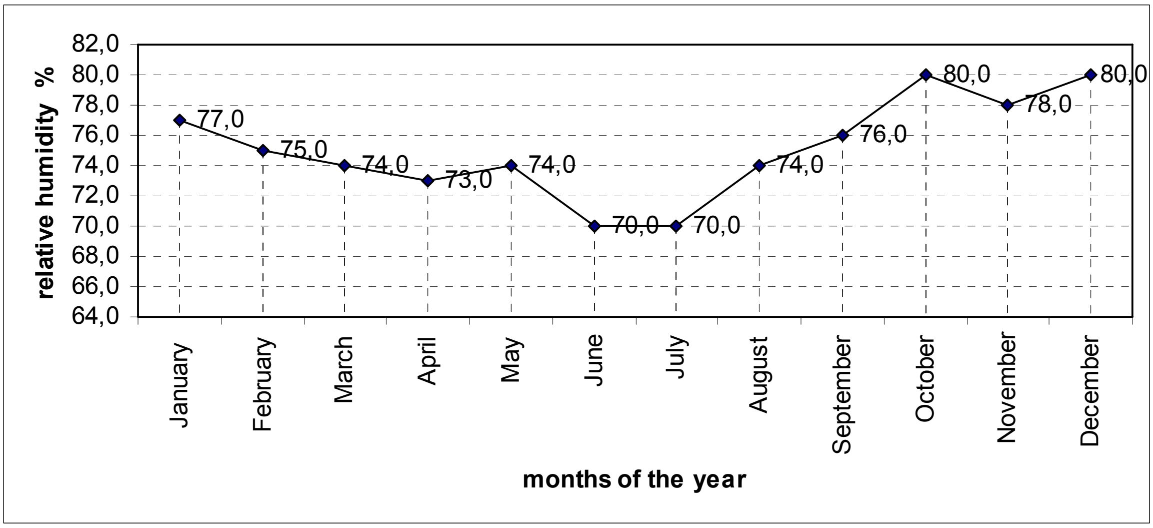
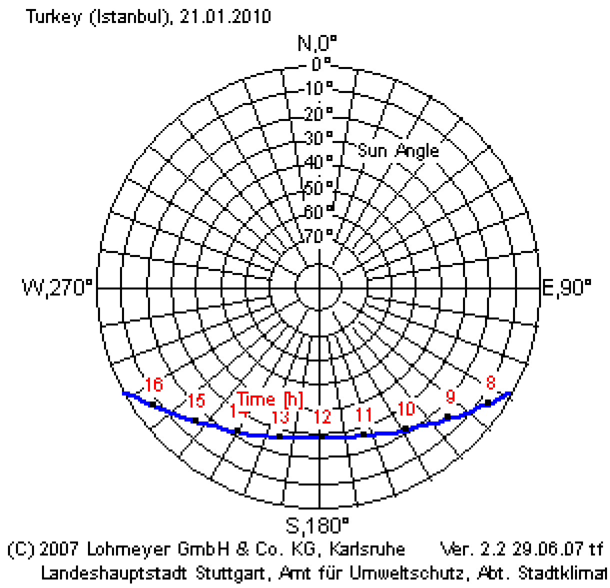


Figure C.8 : Monthly average relative humidity values for İstanbul 1993-2002 from Göztepe Meteorology Station

Table C.2: Solar occupation of İstanbul at winter design day, 21th January [52]

Istanbul (E/O 28° 58', N 41° 1') at 21.01.2010	
Local time(=GMT+2.0 h)	**22.43**
Begin of astronomic dawn	**5.48**
Begin of nautic dawn	**6.20**
Begin of civil dawn	**6.54**
Sunrise	**7.24**
True noon tide (highest sun's altitude)	**12.15**
Sunset	**17.07**
End of civil twilight	**17.37**
End of nautic twilight	**18.10**
End of astronomic twilight	**18.43**
Duration of sunshine [hh.mm]	**9.43**
Highest sun's altitude (upper culmination point)	**29°06'**
Lowest sun's altitude (lower culmination point)	**-68°51'**
Quarter at sunrise Quarter at sunset	**115°59'** **244°01'**



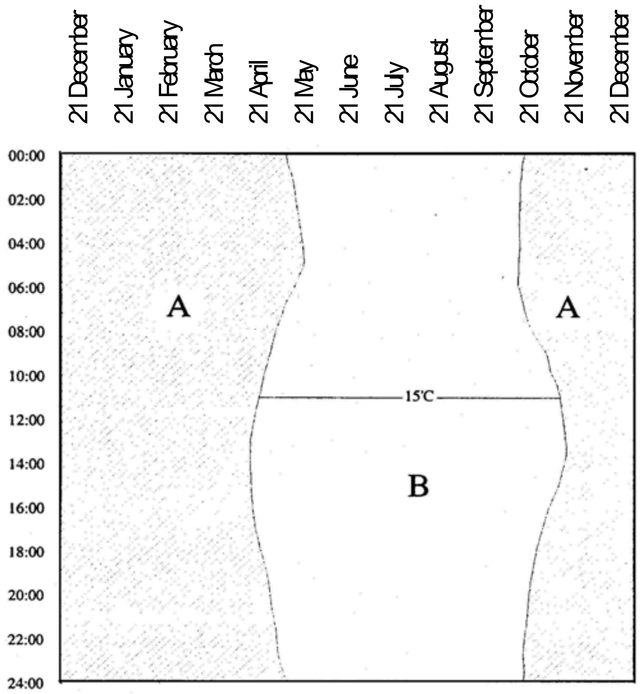


Figure C.9 : Heating seasons for İstanbul

A Heating is required ; 198 days

B Heating is not required; 276 days

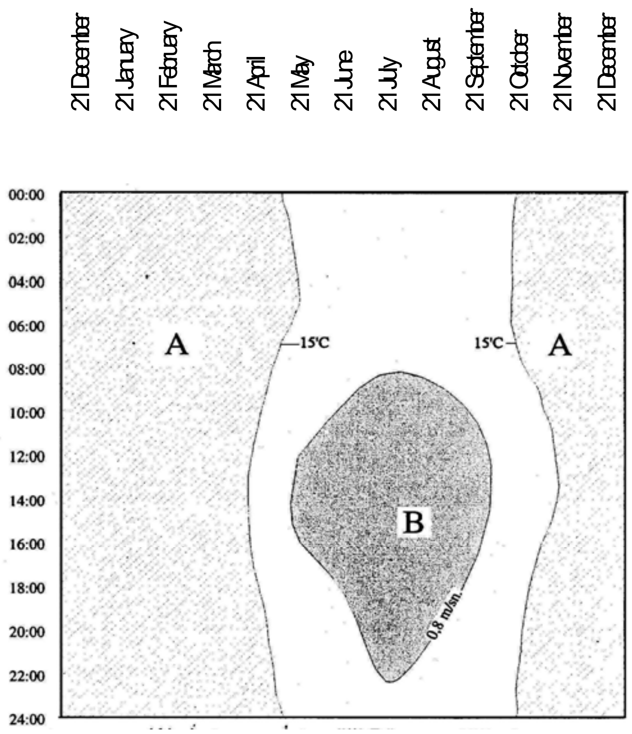


Figure C.10: Heating and cooling seasons duration for İstanbul

A Heating is required ; 198 days

B Cooling is required; 50 days

CURRICULUM VITA

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