İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

EVALUATION OF BUILDING ENERGY CERTIFICATION SYSTEMS IN ITALY AND TURKEY

M.Sc. Thesis by
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Department : **Architecture**

Programme : **Environmental Control and Building Technologies**

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FOREWORD

This work is the consequence of my personal concerns about energy efficient architectural design and I would like to express my deep appreciation and thanks to my advisor Prof. Dr. Zerrin Yılmaz for the precious guidance and the opportunity to work with the Energy Department of Politecnico di Torino by the exchange program of ERASMUS that she provided for me. I, also, want to thank to the Ass. Prof. Stefano Corgniati for his helps on developing this work and directing my researchs during my Erasmus period. Finally, I thank to my mom for all of her patience and helps during the production of this work.

December 2009 Ece Kalaycıoğlu

Architect

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ABBREVIATIONS

EN	**:** European Standard
ENEA	**:** Italian National Agency for New Technologies, Energy and the Environment
EPBD	**:** European Directive on the Energy Performance of Buildings
HVAC	**:** Heating, Ventilation, Air Conditioning
IAQ	**:** Indoor Air Quality
ISO	**:** International Organization for Standardization
ITC-CNR	**:** Construction Technologies Institute – Italian National Research Council
PMV	**:** Predicted Mean Vote
PPD	**:** Predicted Percentage of Dissatisfied
TEP	**:** Ton of Equivalent Petroleum
TS	**:** Turkish Standard
UN	**:** United Nations
UNI/TS	**:** Italian Organization for Standardization
UNFCCC	**:** United Nations Framework Convention on Climate Change
5R1C	**:** Five Resistances, One Capacitance Model

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BUILDING ENERGY CERTIFICATION SYSTEMS WITH THE EXAMPLES OF ITALY AND TURKEY

SUMMARY

Beginning from the 1970s, energy has become a subject of conflict in the world politics. As the western countries has developed their industry, they needed more energy source to carry on producing. On the other side, eastern countries has become richer by selling oil to the western countries. However, the oil prices, exhausting sources and search of new and renewable energy sources are the most disscussed subjects.

While the researchers are trying to find solutions to the problem of “energy”, several countries has started to take actions to decrease the energy consumption, and to achieve a sustainable energy policy. As the building sector is one of the most energy consuming sectors in the world, European Union, has published a directive about energy performance of the buildings in 2002 which obligates to limit the energy that is consumed by buildings and to certificate the energy performances.

Today, all European Union countries has developed their own energy certification system depending on the EPDB. As a candidate to European Union, also Turkey has started to constitute a certification system. In 2007, Energy Efficiency Law has published and in 2010 the energy performance certification of buildings system will be in use.

In this thesis, the current studies of Turkey and Italy on the energy certification systems (by year 2009) are analysed and confronted. DOCET, a certification tool from Italy, was used for the example buildings. By this study it is aimed to obtain experiences for the certification system of Turkey, and also to display the need of harmonization of different systems of different countries.

As a result, even the countries are developing the energy performance certification systems deriving from one directive, they are achiving in different solutions. Hence the results of certification cannot be compared. To obtain comparable results and to find more realistic solutions for Europe, one of the most energy consuming areas of the world, optimization and harmonization of the energy performance certification systems.

İTALYA VE TÜRKİYE ÖRNEKLERİYLE BİNALARDA ENERJİ SERTİFİKASYON SİSTEMLERİ

ÖZET

1970'lerden beri enerji, dünya politikalarında hep bir anlaşmazlık nedeni olagelmiştir. Batı ülkeleri sanayilerini geliştirirken, üretimlerine devam edebilmek için, zaman içinde, daha çok enerji kaynağına ihtiyaç duydular. Diğer taraftan, doğu ülkeleri, batıya, ihtiyacı olan petrolü satarak gittikçe zenginleştiler. Bugüne baktığımızda, petrol fiyatları, tükenen enerji kaynakları ve yeni ve yenilenebilir enerji kaynakları araştırmaları en çok tartışılan konular arasındadır.

Bir yandan araştırmacılar "enerji" sorununa çözümler ararken, öte yandan ülkeler enerji tüketimlerini düşürebilmek ve sürdürülebilir bir enerji politikasına erişebilmek için bir takım önlemler almaya başladılar. Bu aşamada, 2002 yılında Avrupa Birliği de, en çok enerji tüketen sektörlerden olan bina sektörü için, kullanılan enerji miktarını kısıtlayan ve enerji performansını sertifikasını zorunlu kılan bir direktif yayınladı.

Bugün, tüm Avrupa Birliği ülkeleri kendi enerji performansı sertifikasyon sistemlerini, Avrupa Birliği direktifine göre, oluşturmuş durumdadırlar. Avrupa Birliği'ne aday olan Türkiye de sertifikasyon çalışmalarına başlamış, 2007 yılında Enerji Verimliliği Kanunu'nu çıkarmıştır ve 2010 yılında, enerji performansı sertifikasyon sistemi yürürlülüğe girecektir.

Bu tez çalışmasında, Türkiye ve İtalya'nın şimdiye kadar (2009 yılı sonu) enerji sertifikasyonu üzerine yapıtıkları çalışmalar incelenmiş ve bir karşılaştırma çalışması yapılmıştır. İtalya'da kullanılan bir enerji setifikasyonu yazılımı olan DOCET, örnek binalar için uygulanmıştır. Bu çalışmayla amaçlanan, Türkiye'de yürütülen çalışmalara yardımcı olabilecek bir takım tecrübeler elde edebilmek ve farklı ülkelerin geliştirdiği farklı sistemlerin birbirlerine uyum sağlaması gerekliliğini gösterebilmektir.

Tüm ülkeler tek bir direktife bağlı kalarak kendi sistemlereni oluştursalar da, sonuçta birbirinden farklı şekilde işleyen sistemler elde edilmiş durumdadır. Bu durumda, bu farklı sistemlerden elde edilen sonuçlar karşılaştırılabilir değildir. Karşılaştırılabilir sonuçlar elde edebilmek ve dünyada en çok enerji tüketen bölgelerin başında gelen Avrupa için daha gerçekçi çözümler üretebilmek için, henüz çok yeni yürürlüğe girmiş enerji performansı sertifikasyon sistemlerinin optimizasyonu ve birbirlerine uyumlu hale getirilmesi gerekmektedir.

1. INTRODUCTION

In the last decades, rapid decrease of energy sources and global warming issues led the politicians, the energy sector and individuals to search about new energy sources but also efficient usage methods of current energy. Generally under the obligation of protocols, directives or laws, lots of nations, today, specify the limitations for energy usage, carbon dioxide emissions, etc. In this paper, it is aimed to compare the national energy objectives of Turkey and Italy, to gain some experience from the current energy certification practices of Italy while the methodology of energy certification is being studied to set in Turkey and also to find out the factors affecting the energy classes in certification.

1.1 Definitions about Energy

Before discussing the energy aspects, it may be helpful to define some basic terms of energy world, like renewable energy sources, global warming and sustainability, to draw a general picture.

As the energy is the main source to carry out all the actions to live, an energy source is always needed to use, and so to consume, for good production, transportation, to provide comfortable conditions in the buildings and so on. In this point, as our primary energy sources are fossil fuels, it is important to see that consuming energy sources means depleting earth's energy reserves. However consideration about the sustainability of our energy dependent life styles can lead the increase of renewable energy sources.

A renewable energy source is renewed at the same time or faster than it is consumed. Renewable energy sources are generally natural energy sources like sun, wind, or water. What's more these natural energy sources can be also considered as clean sources, because during the energy processing they don't emit the gasses causing global warming.

Using fossils as an energy source causes another problem that during the burning process to extract the energy; they emit some gases causing greenhouse effect. Global warming can be defined as the increase of the average temperature of earth caused by the increase of these greenhouse gas concentrations in the atmosphere. It can be said that such gasses, like carbon dioxide (CO_2), methane (CH_4), CFCs, ozone (O_3), nitrous oxide (NO_x) and water vapor, are being emitted from the ecologically unconscious activities. The term “ecological” contains the processes from acquisition of crude substance to the disposal. Thus the production systems should be reconsidered and precautions should be taken to give the minimum harm to the environment by the new sustainable systems.

Sustainability is the ability to keep the current conditions of a system continuously, as all the systems tend to worsen in time. It can be applied to all kind of systems like social, economical, environmental, production, etc. Differently from renewability, sustainability refers to a system that can be restored as much as they consumed. In this way it requires consciousness and human activity to be restored as renewable energy sources generally restore themselves. Thus renewable energy sources would be critical elements of sustainable energy systems. However to achieve a sustainable energy system within a country, ecological awareness, economical stability and social balance should be provided, also.

Development of technology, increase of population and fossil fuel dependent industry (Figure 1.1 and Figure 1.2) causes more and more energy consumption, and so exhausting energy sources. Thus, sustainable systems in energy sector became one of the most discussed subjects recently. However new technologies which are being developed by renewable energy sources are expensive and not sufficiently efficient, yet. Anyway, beginning with energy efficiency, consuming less fossil fuels and more renewable energies and also ecological approaches in every sector are primary steps to achieve a sustainable environment, as it is the final objective.

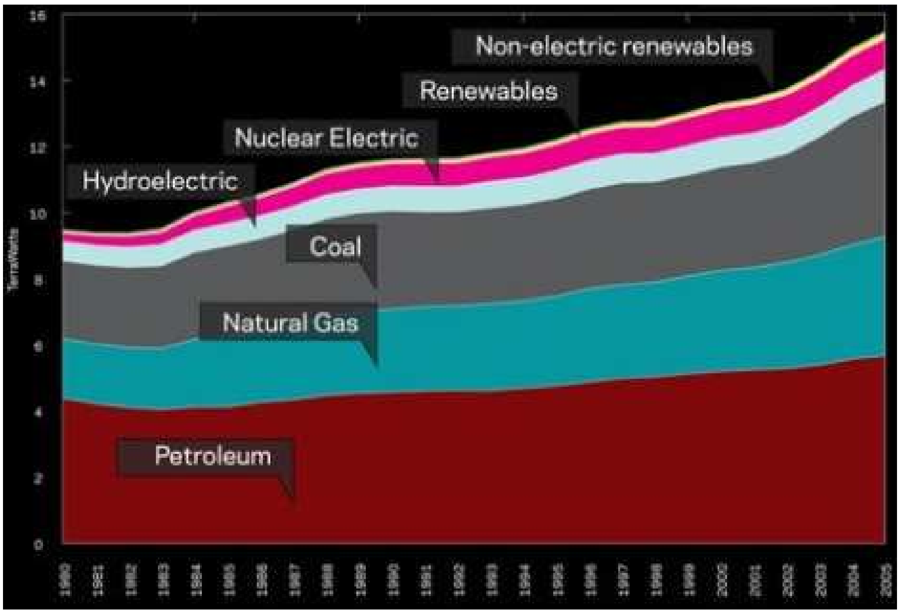


Figure 1.1: Global Energy Consumption between 1980 - 2005 (TeraWatts) [1]

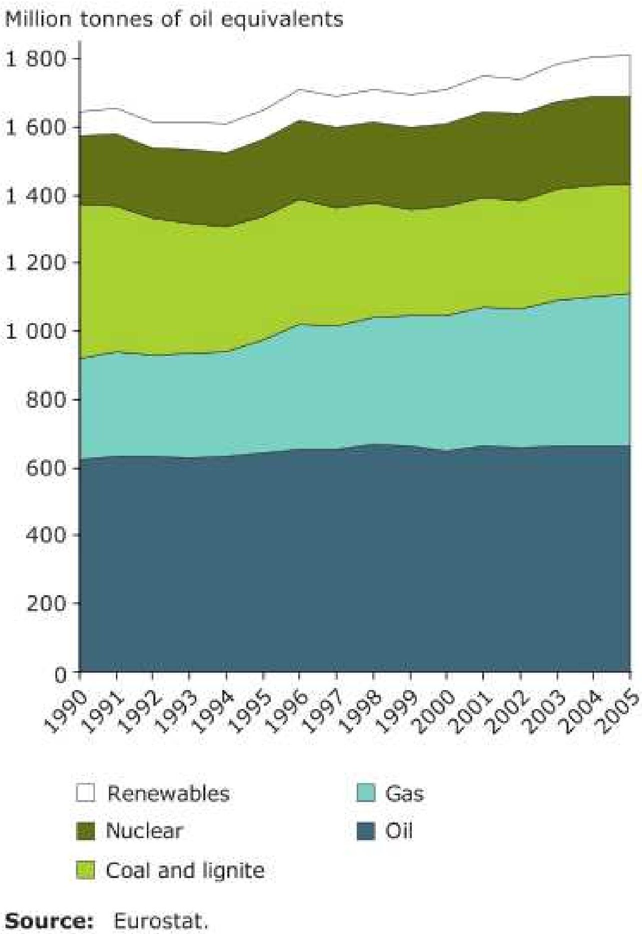


Figure 1.2: Total Primary Energy Consumption by Fuel in Europe (TEP) [2]

1.2 Brief History of Energy in the World

Beginning from the 1970s, energy has started to be related closely with the political issues while the politicians trying to provide sufficient energy sources for the citizens as the demand for energy has been increasing. It has been making the agreements to bring the primary energy sources such as petroleum, natural gas, or electricity from the producer countries to the consumer ones and that trade has been always a subject of a conflict, also. Furthermore the energy politics and national objectives are playing the most important role in the economics. The population of the countries is increasing while the energy sources are being exhausted and the cost of energy is increasing day by day.

The first energy crisis is occurred in 1973, with the embargo that declared by Arab countries of OPEC for United States and other countries, like Holland, and Japan supporting Israel in the Yom Kippur war[1]. In response to the price increases, United States, which has already left the Bretton Wood system[2], has released the American dollar float and so by the increasing inflation the value of the currency is decreased. At the end, even they succeed to block the supporters of Israel, The Arab countries faced also a decrease in income by the oil exports as they were planning to profit the oil embargo. Another oil crisis has occurred in 1979 during the Iranian Revolution and the war between Iran and Iraq. The severe decrease of oil production in these two countries caused price increases and oil shortage in United Stated, another time.

These two close dated oil crisis has affected severely the countries that economically dependent to oil and oil based products. OPEC has lost its unity and power and Russia (Soviet Union) has become the most important oil producer (Figure 1.3). Apart from economic and political effects, these energy crises has led the countries to search for new oil reserves and new energy resources and energy conservation. In the US the Department of Energy was created and the people were forced to conserve energy. The northern oil sources were started to exploit. Natural gas was introduced for heating systems in Australia as coal and nuclear energy usages have risen in Europe. In Brazil, a mixture based on ethanol was started to be use for the

[1] Yom Kippur War, 1973 Arab – Israeli war
[2] Monetary management system that obligates each country to maintain the exchange rate of its currency within a fixed value in terms of gold

vehicles. Interests and researches in renewable energies like solar and wind power has increased.

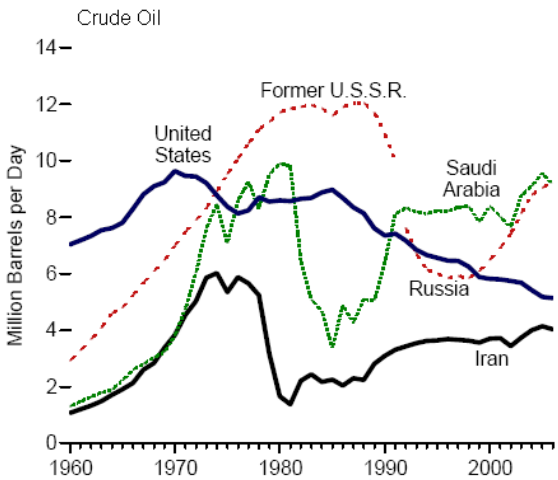


Figure 1.3: Top Oil Producing Countries, 1960-2006 [3]

Another considerable problem of energy is the increase of the global air and ocean temperatures as a result of the high concentrations of gases like CO_2 which are being emitted by combustion of fossil fuels and the climate change which is the result of this increase (Figure 1.5). However this global warming shouldn't be considered just an environmental issue but also social, economical and political as the possible solutions to eliminate these negative changes require reorganization of the entire energy habits.

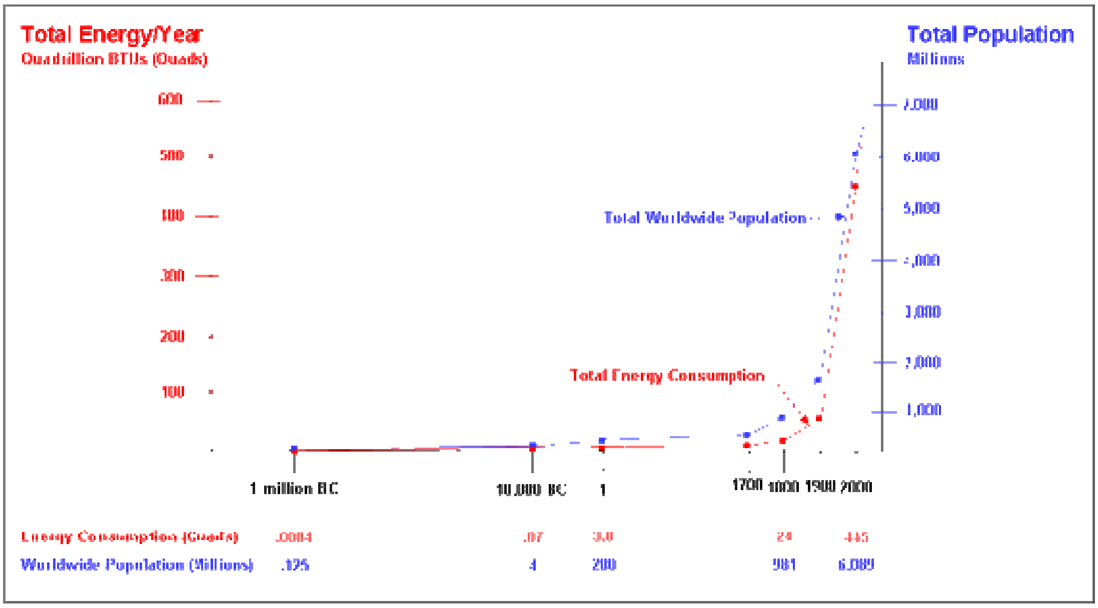


Figure 1.4: Increase of energy consumption and worldwide population [1]

First of all it should be accepted that the global warming is a result of human actions so it is called "Anthropological Global Warming". All production and consumption patterns cause high environmental pollution, environmental erosion and greenhouse gas emissions. Figure 1.4 displays the relation with population and energy consumption. Furthermore the public consciousness is low about this subject that most of the people aren't aware even of the problem. Thus changing regular habits requires an education policy, environmental friendly solutions require strong economies and stable political objectives.

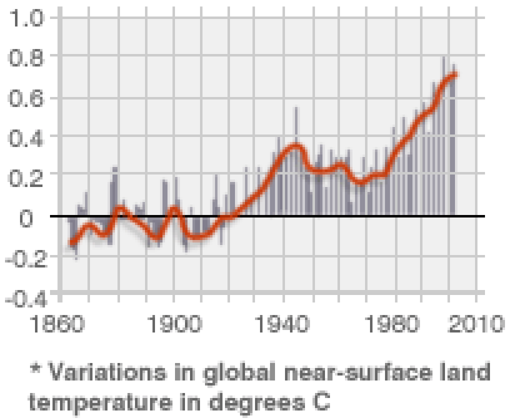


Figure 1.5: Temperature variations by years [4]

In the late 1980s, first actual studies had begun to solve the anthropological global warming problems and to achieve a sustainable environment. United Nations has taken some actions like "Agenda 21" and "Kyoto Protocol". Although nearly all nations accept and promise to effectuate the terms that are decided in assemblies, implementation phase has always been a problematic because of the non renewable energy dependent technology that has been developed until today and high priced, labor intensive and expertise required new technology and methodology for a sustainable environment.

Agenda 21[5], is a program proposing global, national and local actions to be carried out by organizations of the UN, governments, and major groups all over the world where people impact on the environment. The full text of Agenda 21 that is released in 1992 in Rio de Janeiro includes the main titles of "Social and Economic Dimensions" to fight with poverty, to change the consumption patterns and to develop a sustainable social environment, "Conservation and Management of Resources for Development" to protect natural environment, "Strengthening the Role of Majors Groups” to involve the social groups for sustainability, “Means of Implementation” to raise the general consciousness by science and technology. In 1997, five years after the first summit, to evaluate the progress of Agenda 21 UN had a special session however the progress was found “uneven” and finally in 2002 in Johannesburg UN has committed full implementation of Agenda 21.

Kyoto Protocol is an international agreement is affirmed by the United Nations Framework Convention on Climate Change in 1997 and it is entered into force in 2005. The objective of the protocol is set as “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”. The mechanism to achieve that goal is basically called “emission trading” (carbon trading or cap and trade) that not only introduces maximum limits for greenhouse gas emissions but also allows the countries trade in them. Thus the countries buy or sell credits for each equal to one ton of CO_2 if they will exceed the limits or if they won’t use them. Today 183 country, as a ratified member of Kyoto Protocol, are trying to reduce the greenhouse gas emissions averagely by %5.2 by 2012 compared to values of 1990. [6]

1.3 Current Situation in Europe and Turkey

Europe is one of the most energy consuming areas of the world and so one of the most greenhouse gas producers. Besides European Union Countries are mostly energy dependent (Figure 1.6) to other countries. So that European Union sets energy policies to decrease the energy exports and produce projects for sustainable, secure and efficient energy uses [7]. European Commission aims to achieve a 20% reduction by 2020 on primary energy consumptions. However European Union should reduce 330 million tons of carbon dioxide emissions, instead of 45 million (20%), until the end of 2010 to reach the objectives of Kyoto Protocol [8].

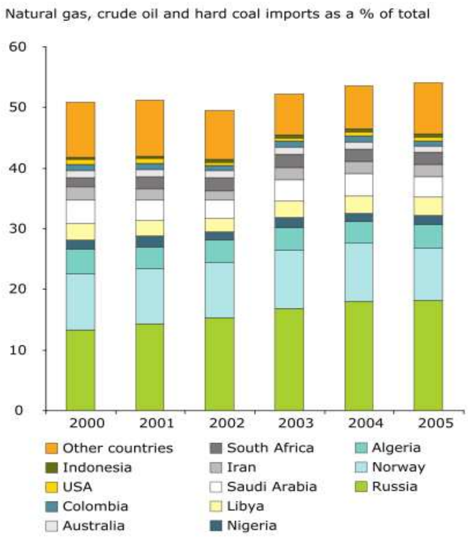
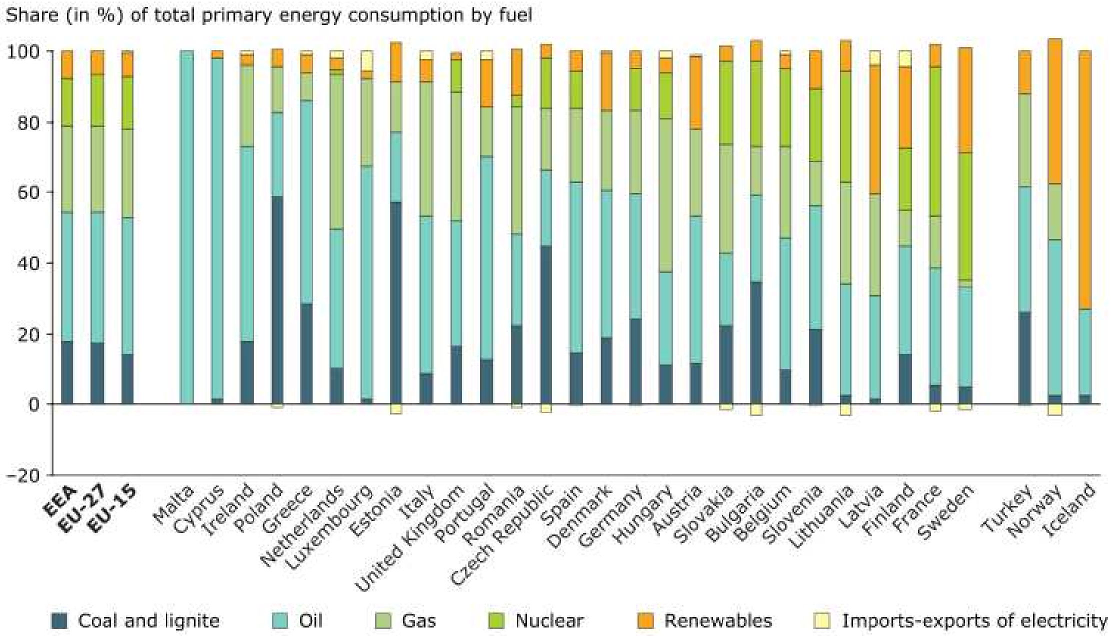


Figure 1.6: Imports of primary energy by country [2]

Turkey has an energy policy depend on 84% fossil fuels (Figure 1.7) and even more coal thermic plant are planned to construct. Today, beyond the measurements to guide the public to conservation of energy and domestic water, an energy policy depending on sustainable management or ecological terms is not defined. However recently, new studies about energy efficiency and certification have started by Energy Efficiency Law and regulations. The studies are, under the obligation of the European directive, basically to found a methodology of assessment and certification system of energy performance of the buildings. On the other hand, for the industry sector, the recent intentions are about to construct nuclear energy plants, which one is more economically efficient, instead of increasing the usage of renewable energy sources, which have a longer payback period, like hydropower and wind power which are widely available in the country.

Figure 1.6 shows that, in comparison to European Union countries, Turkey is one of the most coal and lignite using countries.



Note: Negative shares of electricity indicate exports and the reverse is true for imports.

Source: Eurostat; IEA.

Figure 1.7: Share of total primary energy consumption by fuel, 2005 [2]

2. ENERGY AND BUILDINGS

Comparing the inclination of the overall primary energy consumptions by sector of Europe, Italy and Turkey, the ratios are similar that building sector is always one of the most energy consuming sector (Figure 2.1 and Figure 2.2). For all the European Union countries the building sector is responsible of the approximately 40% of the energy consumption and so emissions of carbon dioxide [8].

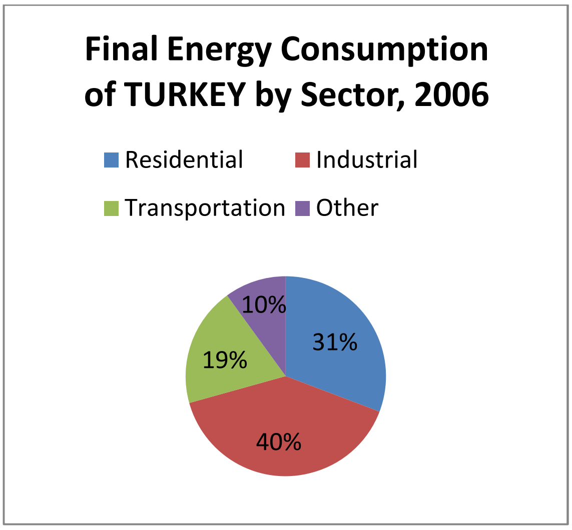


Figure 2.1: Final energy consumption of Turkey by sector, 2006 [9]

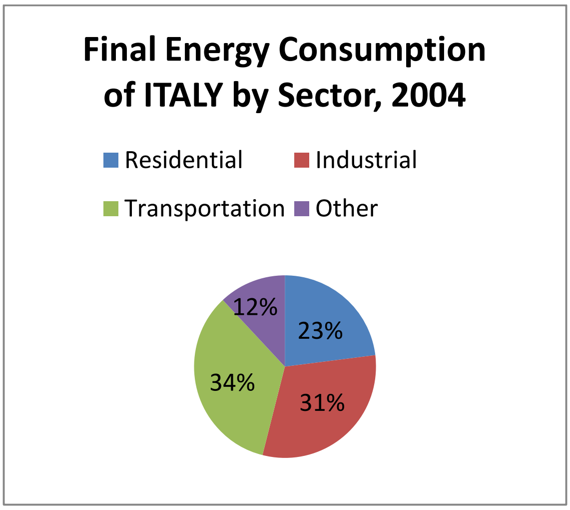


Figure 2.2: Final energy consumption of Italy by sector, 2004

Additionally in Europe, the consumption of energy for heating constitutes the most significant part of the overall consumption by the 57% for the residential buildings and 52% for the non residential buildings [8]. The directive of European Union Commission for energy performance of buildings is basically aiming to increase the energy efficiency in buildings by energy certification system and regular inspections of heating plants.

2.1 Building Design Parameters Which Affect Energy Usage

Design of the buildings is the primary factor that affecting the energy usage of the building during its whole life. For that reason, it can be said that the decisions which the designers take in the phase of design specifies the energy performance of the building. Thinking nationally, a design which is optimized according to these parameters helps to increase the nations’ energy consumptions by improving the energy efficiency.

2.1.1 Location and Climate

Location of the buildings generally cannot be decided by the designers, however being aware of the potentials of the location can help improving the energy efficiency of the building. Politics and culture, traditional know-how about the construction, local materials and technology and available labor and skills [10] should be searched in the design phase of the buildings, as the traditional architecture examples can be accepted as environmentally good designs.

Climate is also a very important parameter of the location. Air temperature, solar radiation, humidity, wind, cloud and precipitation data of the local area should be obtained, while they affecting the design of form, orientation, the building envelope, and HVAC systems.

2.1.2 Site

Site refers to natural and artificial surroundings of the building. Solar radiation and natural light levels should be modified by design to allow or prevent the heat and light for the passive heating, cooling and illumination modes. Wind increases the heat losses by infiltration, convection and conduction, so the orientation, the relationship with the other buildings and greenery of the site should be organized according to the wind. Trees and other vegetation help also reducing pollution, noise, external air temperature while increasing humidity [10]. Furthermore the slope of the site affects the insolation of the building.

Artificial surroundings, other buildings, especially in the dense urban sites, cause lower solar radiation and natural light levels, reduced wind speeds, slightly higher temperatures and higher humidity by their positions, external surface colors and altitudes.

2.1.3 Orientation and Obstacles

Defining the obstacles on the site and the orientation for the maximum benefit of potential solar radiation for heat gains and losses, natural light for natural lighting, wind for natural ventilation is one of the most important design parameters [10]. It affects also further decisions of facades as the insulation, glazing, shading and ratio of opaque and transparent areas differ according to the north, south or east-west directions.

2.1.4 Plan, Form and Compactness

Organization of the volumes of the building can help improving the energy efficiency. Arranging and zoning the rooms with similar thermal conditions, allowing or preventing the cross-ventilation by placements of doors and windows, using unconditioned spaces as buffer zones [10] are some of the possible planning decisions.

Form of the building affects its heat gains and losses. More compact forms are more energy efficient due to less heat losses [11]. Increasing the external surface areas with the same floor area causes more heat losses. Thus the form should be optimized for the building size and type.

2.1.5 Building Elements and Materials

The building envelope comprises the most important building elements, such as external walls, doors and windows, affecting the energy efficiency of a building [11]. As these elements compose the layer between exterior and interior environment, the features like absorption, reflection and permeability for the solar radiance, heat transmission and transparency ratio should be designed by optimizing the heat gains, losses and natural lighting.

Furthermore, the material of the structure can affect the energy efficiency as a thermal mass. Heavy structures such as stone have high capacity to store the heat, so causes less heat losses. On the other hand, light structures like timber or steel don’t store any heat, so their response is quick to the temperature changes.

2.1.6 Operation and Automation

Usage patterns may differ from how the designer intended [10]. Thus the building should provide a comfortable indoor environment and simple operation tools of the technical systems for the users.

Furthermore, the automation systems are an important element of the operation system of the building and they can be designed as consuming electricity that is produced by renewable sources [11].

3. ENERGY CERTIFICATION

Energy certification is basically a document (Figure 3.1) that informs the users about energy performance of the buildings and provides them some reference values to compare the energy performance of their building with other similar buildings. Energy Certification is an *indicator* for the building energy performance which is calculated (estimated) by standard data (outdoor/indoor climate, heat gains, etc.) of a standard usage pattern of space heating-cooling, domestic hot water, ventilation and lighting [12]. Every country in Europe sets the methodology for certification nationally and locally by the force of the directive of the European Parliament and of the Council on the energy performance of the buildings (2002/91/EC).

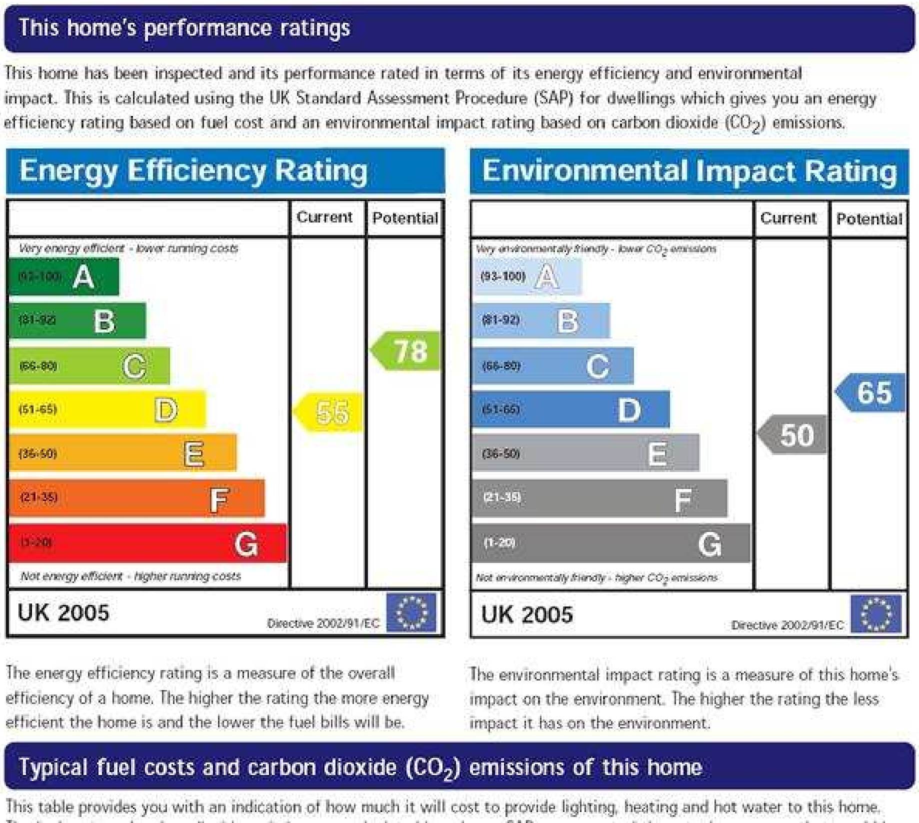


Figure 3.1: Example energy performance certification document

Energy certification should be based on a basic energy diagnosis of the building that includes energy efficiency values. Thus the certification document should conclude also possible interventions and improvements energetically and economically [13]. Besides presenting the energy performance of the building, it should also include a compulsion to restrict the use of energy and advices for energy efficiency by the laws and standards that it is based on.

Another important objective of the energy certification is to create and to develop a consciousness of the final user about energy subjects. As asserted in the directive, the public buildings or the buildings that are visited regularly by a certain number of people can be the examples for the application and development of the energy efficiency projects and certification procedure [8]. Furthermore, organizing the energy certification document as an indicator easy to understand, not only for experts, but for everyone, will contribute to increase the consciousness about energy and will increase the value of more energy efficient buildings in the market [12].

Actually the idea of certificating the buildings energetically is quite new and the nations are getting experienced by the implementation difficulties. So the process of energy certification is not completed in any country and so the certification is not still being applied completely. Generally the application process begins with heating period certification for existing residential buildings and continues by new and non-residential buildings and includes also cooling periods.

3.1 Directives, Laws, Standards

The certification system for energy performance of buildings may be studied by legislative parties, politicians and experts to define the basic concepts, methodology and sanctions. In the case of Europe the basic outline is defined by the EU directive 2002/91/EC – Energy Performance of Buildings Directive. However the energy needs and usage of the buildings are very much related to the climatic conditions, local laws, and so local tradition of usage of materials, thus certification systems should be detailed by national laws, standards or regulations. According to the directive every country is responsible to develop its own energy politics, targets, legal basis and energy certification system.

3.2 Organization

Application of energy certification system requires a collaborative work, as it requires a legal basis, an organization for inspection, experts for the energy diagnosis and certification of the buildings. The government, universities, private organizations and individual experts are all needed for a complete certification system. It is also important for the entirety of the system that the designers and the clients are also conscious about energy efficiency subjects to take places in the system.

In fact, as the users are responsible to get energetically certificated the buildings; they become the most important part of the system. So an easier system, apart from the energy diagnosis, to see and to compare quickly the energy performance of the building, may also be developed.

3.3 Data Collection

Data collection part is one of the most significant processes of energy certification as it affects the calculation results. For a detailed energy diagnosis, every detail about the design, building elements, materials and details of the building should be reached, and then all the data should be organized according to the required calculation such as heating, cooling, ventilation, etc. However some pre-defined data that is specified by legislative documents may be used in energy certification. In this point, experts and politicians should decide together about the pre-defined data for the easiness of the system and the compatibility to national energy policies.

In the action of data collection, the local laws, standards or producers' catalogues would be helpful to find the materials' features such as thermal conductivity, specific heat, etc. Thus it is also important for the material producers to be transparent about the information.

3.4 Methodology of the Assessment of the Energy Performance

Every nation that wants to have an energy certification system has to define a methodology and calculation procedure for the assessment of the energy performance of the buildings. Calculation procedure for the Energy Certification should be clear and may be supported by a calculation tool also. The important point is that the procedure should be national but also international in the means of that a building that is certificated by different energy certification systems should have similar results and energy classes [12].

Energy performance includes active and passive thermal and electrical characteristics of the building and should be determined according to the minimum and maximum limit values. Additionally it differs depending on the type of the building and the phase of project. In the directive the buildings are classified like:

- Single-family houses of different types
- Apartment blocks
- Offices
- Education buildings
- Hospitals
- Hotels and Restaurants
- Sport facilities
- Whole sale and retail trade services buildings
- Other types of energy-consuming buildings

Energy certification is basically applied to constructed buildings, however energy diagnosis should be performed in different phases of construction to achieve a more energy efficient building system. There are basically three phases of construction which an energy examination can be profited:

1. If the project is on the phase of design or construction, energy needs of the building should be calculated and checked compatibility to the required values. In this phase simulation programs would be helpful to visualize more or less the real situation of the building. Afterwards, by the help of the outputs of the simulation, the design should be optimized according to the energy requirements.
2. If the calculation is being made on the existing buildings or after the construction (measurements made just after the construction cannot be reliable as it takes couple of years for the building to reach the energy balance), energy consumption of the building should be measured and classified according to the certification system. In this phase, the computer

programs that are developed for the current certification system would be helpful to display the performance of the building. There are several programs published on the internet that they are very useful for everyone can find out if their building is compatible with the laws.

3. However in the case of restoration, first the current situation should be checked. The details should be examined, and all the necessary data should be gathered. Programs developed for the certification system can be used in this phase. Furthermore the restoration project should be prepared according to the data and the outputs of the program. Simulation programs can be used to develop the new construction to be compatible with the current laws.

3.5 Giving Advices

Energy certification system aims to develop energy efficiency of buildings and decrease the greenhouse gas emissions, especially CO_2. In another point of view, the certification gives an extra value to the building as the directive sets the terms that the certification documents should be presented in case of selling and it should be displayed to people in the public buildings. So energy certification shouldn't be a static document that demonstrates the situation of a moment. Contrarily it should help the users to advance the buildings' energetic characteristics for further examinations. For these reasons in the certification document, there should be placed advices and possible interventions to develop the current situation and reference values to compare the energy performance of the building. Additionally the renewable energy sources should be mentioned.

4. ENERGY CERTIFICATIONS IN EUROPE

Energy Certification studies have started in European Union Countries by the directive on energy performance of the buildings in 2002, and so on every nation has built up the legislative basis and certification system nationally and regionally. As the two comparison cases of this essay are the certification system of Italy and Turkey, we shall analyze the national laws and regulations of these countries in accordance with the European directive and standards. In Italy first law about the energy performance of the buildings has come into force in 1991, however by the laws D. Lgsl. n. 192/2005 and D. Lgsl. n.311/2006 the certification system has started and today for the existing residential buildings, the energy certification system is in use. Turkey, as a candidate to European Union, is also responsible to fulfill the requirements of the Union. For that reason Turkey has started the studies about energy certification in 2007 by the Energy Efficiency Law (5584). However for the certification system, studies are in progress (December, 2009).

4.1 Legislative Basis in Europe for Energy Performance Assessment

The European Directive 2002/91/EC draws a basic frame for the certification of the energy performance of buildings. Furthermore European Committee for Standardization has regulated the standards to make available the necessary data and to provide an infrastructure for the nations to build up their own certification systems. Here in this chapter the summaries of the directive and the some of the most important standards which the countries are following during the energy performance calculations are given to display the basic criteria of the energy certification system of Europe.

4.1.1 EPBD European Directive on the Energy Performance of Buildings, 2002/91/EC

The objective of the European Directive on the Energy Performance of Buildings 2002/91/EC is stated to define a common procedure for the calculation of total energy performance of buildings, to set minimum energy performance requirements for new buildings and existing large scaled buildings which are renovated. Additionally it defines the general conditions of energy certification of buildings. Finally it establishes the systematical examination of boilers and air conditioning systems. [14] Thus, the directive determines the general points to develop energy performance in the buildings by taking into account the local climates, internal heat gains and losses, and energy and cost efficiency of the heating systems. This concept contributes the need of obtaining the criteria to compare different buildings, especially non residential ones, in different countries basically in terms of energy costs [8].

The directive defines only a comprehensive structure of the calculation methodology for all the member states; however they can develop their own detailed method for the calculation of energy performance of buildings and certification system on national or regional base. As refers Cellura, Lo Brano and Orioli, the directive, to evaluate the energy consumptions of the buildings, requires simply introducing the common criteria to determine the energy efficiencies, performing regular inspections and updating energy analysis, requiring the advanced standards in the presence of the large scaled restorations and developing new standards for new buildings [8]. Followings are the aspects which are necessary to be considered in the methodology that every nation will define:

- Thermal characteristics of the building envelope and internal partitions, including air-tightness features,
- Heating and hot water supply system, including their insulation characteristics,
- Air-conditioning and ventilation system,
- Illumination system, mainly for non-residential buildings,
- Position and orientation of the building, including outdoor climate,
- Passive solar systems and solar protection,
- Natural ventilation,
- Indoor climatic conditions, including the designed indoor climate.

Furthermore it is stated that heating and air conditioning systems should be designed and examined for optimum consumption of energy to obtain the physical comfort of the occupants [15].

In addition, it is important to take into account the positive contributions of the technical systems, such as active solar systems and electricity generation systems based on renewable energy sources, district or block heating and cooling systems and natural illumination systems.

Every member state should decide the minimum energy performance requirements for buildings according to the general structure which is set by the directive. Besides it is specified that to decide upon the requirements, it is necessary to analyze the construction years and types, environmental situation and surroundings of the building. Once the minimum requirements are set, they should be revised continuously in a period that shouldn't be longer than five years. Finally the directive allows the member states to decide to have some exceptions for the appliance of the requirements in some cases which are defined particularly in the directive.

In the phase of determining the minimum energy performance requirements, it shouldn't be forgotten neither the indoor climate conditions which may have some positive effects if it was recuperated the old and insufficient ventilation systems. Actually a special attention paid to the air conditioning systems may create a development of energy efficiency of the building during the summer period and finally it is aimed also an improvement of the passive cooling systems [8].

In the directive, two articles are set for the implementation of the minimum requirements for the new and existing buildings. For the new buildings, the directive gives the responsibility to the member states to take the essential actions to guarantee the new buildings meet the minimum energy performance requirements. Moreover, before the construction of the buildings with a net floor area more than $1000m^2$, the technical, environmental and economic feasibility studies for alternative systems should be completed. For the existing buildings with a net floor area more than $1000m^2$, in the case of major renovations, it is necessary to update the energy performance according to the minimum energy performance requirements.

Another significant article in the directive that an energy performance certificate should be prepared for buildings and in the case of selling or renting it should be presented. According to the directive, the energy performance certificate is valid for maximum 10 years. The certification document should also provide the reference values and recommendations for the consumers to compare the building's energy performance and to improve it. Besides in the certification document, recommended and current indoor temperatures should be displayed. Furthermore the certification documents for the public buildings or buildings which are being visited by a large number of people frequently should be displayed in a place easily-seen by public. Finally it is asserted that the expression of the energy performance of the building should be easily understandable, comparable and also CO_2 emissions of the building may be contained.

Another subject that the directive refers is the "inspection of the boilers" to reduce the energy consumption and carbon dioxide emissions. Every nation should set up rules to achieve an inspection system for the boilers which are using non-renewable combustibles and with a output of 20kW to 100kW. However for the boilers which have an effected rated output more than 100kW inspection should be performed every two years and for the ones older than 15 years, an inspection, including the assessment of the efficiency of the boiler and the evaluation of the comparison of the size of the boiler and heating requirements of the building, should be made for the whole heating plant. Likewise the similar inspections should be applied to the air conditioning systems that have an affected rated output more than 12kW.

To conclude, to perform the energy certification and the inspection of the boilers and air conditions should be performed by independent experts.

4.1.2 EN 15251 Indoor Environment Input Parameters for Design and Assessment of Energy Performance of Buildings – Addressing Indoor Air Quality, Thermal Environment, Lighting and Acoustics

The European Standard named as "EN 15251 Indoor Environment Input Parameters for Design and Assessment of Energy Performance of Buildings – Addressing Indoor Air Quality, Thermal Environment, Lighting and Acoustics" asserts that design and usage pattern of indoor environment systems have a significant effect on energy consumption the buildings, as indoor environment is directly related with the physical comfort of the users [16]. It is also defined in Directive of Energy

Performance of Building [14] that indoor environment conditions should be optimized by satisfying the minimum energy performance requirements.

The standard designates how to determine the parameters to design indoor climate and to calculate the energy performance of the building. It specifies the indicators for long term evaluation of the indoor environment. It also describes the necessary criteria to measure in case of inspection, and to find out the indoor environment conditions. However it is important to note that in the standard it is asserted that it can be used mainly for the non-industrial buildings.

In this standard there are several ways for each calculation, but it is up to member states to decide which one is proper for their national conditions.

<u>Design Input Criteria for Dimensioning of Buildings, Heating, Cooling, Mechanical and Natural Ventilation Systems</u>

To reach a comfortable environment, the input data for dimensioning different systems contains these aspects:

- <u>Thermal Environment:</u> The standard proposes for an optimum thermal environment that the PMV-PPD (predicted mean vote – predicted percentage of dissatisfied) indices should be used. These indices allow achieving an indoor temperature value by assuming the level of action and thermal insulation for clothing. Also, when dimensioning the heating or cooling systems, using PMV-PPD indices, instead of temperature, allows to take into account the effect of increased air velocity. Another advantage of these indices is they can be used for the buildings without mechanical cooling as well as mechanically ventilated, cooled and heated buildings. However it should be considered also that the adaptations of the occupants in the buildings without mechanical cooling can be high for warmer conditions.

- <u>Indoor Air Quality and Ventilation Rates:</u> The ventilation rates for indoor air quality are independent from season. They depend on occupancy, indoor activities, processes and emissions from building materials and furniture. In the residential buildings, the humidity should be considered also for the indoor air quality as it causes condensation and mould problems that affect the health. The methods and the tables to obtain the ventilation rates for residential and non-residential buildings are explained in the annexes of the standard. Filtration of the supply air can be helping to improve the IAQ in very polluted areas and limiting the pollens, odors and gaseous contaminants.

- Humidity: Humidification of indoor air is usually not required except the very humid climates or for some special buildings like museums, historical buildings, etc. Humidity not only affects the thermal comfort (microbial growth or dryness, irritation of eyes and air ways) and indoor air quality, but also the physical requirements (condensation) of the building.

- Lighting: Lighting conditions should be considered especially for the non-residential buildings as the volumes and depths are larger than residential spaces and the tasks performed requires different illuminance levels which are given in the annexes of the standard. The design luminance levels can be obtained by daylighting, artificial lighting or both. However daylighting has more advantages over artificial lighting as it is healthier, more comfortable and less energy consuming. The combination of light sources should depend on occupancy hours, location of the building, amount of day light hours during the year.

- Noise: Noise here indicates the noise from the HVAC systems, not the noise from outside. The noise from HVAC systems can disturb the occupants and prevent the intended use of the space or the building (e.g. theaters, halls, etc.) The noise levels for different building types and functions are explained in the annexes of the standard. Furthermore, in the standard it is asserted that the ventilation should not rely on openings of windows in the areas with high outdoor noise levels.

Indoor Environment Parameters for Energy Calculation

To perform a yearly energy calculation as it explained in EN ISO 13790, standardized input data is required and for different types of calculation methods (monthly, seasonal, hourly, etc.) the input data may differ also.

- Thermal Environment: For the seasonal and monthly calculation methods of energy consumptions, the same indoor air temperature values that are used to design the heating and cooling systems can be used. However for hourly calculation methods, the temperature ranges are given in the annexes of the standard.

- Indoor Air Quality and Ventilation: In non-residential buildings same values of ventilation rates that are used for the design of the ventilation system can be used. The special consideration is required to ensure the good indoor air quality in the beginning of the occupancy hours. The ventilation can be started before the occupancy or a minimum level of ventilation should be provided for the unoccupied hours. In the residential buildings, however, if the mechanical ventilation system is used, a lower ventilation rate should be fixed during unoccupied hours. In case of natural ventilation in the residential buildings, calculations should be made depending on building layout, location and weather conditions and for the same ventilation rate values that are used to design the ventilation systems can be used.
- Humidity: Indoor air humidity should not exceed a minimum and maximum level of relative humidity. However, unoccupied buildings may be dehumidified to prevent long term moisture damages.
- Lighting: The same criteria for designing the system may be used for the energy calculations. Luminance level is independent from the seasons, but energy calculations should be made only for occupation hours.

Evaluation of the Indoor Environment and Long Term Indicators

An evaluation study should be performed after the whole system designed for internal environment to ensure the minimum energy performance requirements. The evaluation is made for representative rooms for every zone and for representative time periods. The evaluation studies can be based on design, calculations, measurements or questionnaires.

In the design phase the evaluation studies should be made under the categories that are described in previous parts: thermal criteria for winter and summer, air quality and ventilation criteria, humidity, lighting and acoustic criteria.

For the studies based on calculations are consists the building simulation tools. There are some different options as:

- Simply, to evaluate whole performance of the building some representative rooms are simulated,
- Hourly, the total hours which meet the design criteria or not are calculated.

- Degree hours, the upper and lower boundary of the degree hour values of the exterior environment can be used as an indicator.
- The PMV technique can be used as an indicator.

All methods are described in detail in the standard.

To evaluate overall performance of the building, some measurements can be made also. In this case the nation acceptable deviations should be defined.

- For the thermal environment, the temporal measurements should be taken in representative rooms, orientations, with different loads in representative time periods and spatial distribution of the temperatures should be controlled.
- The measurements for the IAQ and ventilation should be made by taking samples from different air supplying units and zones. CO_2 concentrations can be measured when the building is fully occupied. For the ventilation the air flows in the ducts can be measured.
- Measurement of illuminance can allow the evaluation of lighting.
- Evaluation of the noise is the optimization of the exterior noise and noise from the ventilation systems. If adequate ventilation can be obtained by opening the windows and the exterior noise remains under the acceptable levels.

Finally direct reactions of the occupants can be used by questionnaires to evaluate the overall energy performance of the building.

<u>Inspections and Measurement of the Indoor Environment in Existing Buildings</u>

During the inspections of the building systems some measurements are necessary to check and to improve the system's performance (heating and cooling loads, system sizes) and to give advices to users (operation).

Measurements for the thermal environment should be made where the occupants are using the most and for the 3 coldest months of the winter and 3 warmest months of the summer. Measurement period should be minimum 10 days to be representative.

For the indoor air quality measurements there are two approaches. One is based on the measurement of the CO_2 concentrations where the people are the main pollutants. The measurements should be made in a representative place where the occupants are using the most and at the head level in the winter conditions when the fresh air supply is lowest. In some cases the measurement on the certain moments (the worst time) may be enough. The other approach is based on the fresh air supply measurements. At the whole building level the fresh air value per m^2 and at room level fresh air value per m^2 and per person should be checked reference values.

Illuminance measurements should be made to check the light quality and the discomfort conditions like glare. Measurements should be performed without the daylight and during average cloudy conditions on horizontal planes approximately at 0,8m.

Classification and Certification of the Indoor Environment

For the overall evaluation of the energy performance of the building and classification, indoor environment information should be included in the energy certificate document. This can be made in two different manners:

- Detailed classification and certification displays the design criteria, calculations, measurements for each parameter, thermal conditions for winter and summer, air quality and ventilation, lighting and acoustic.
- Recommended (simple) classification and certification includes footprints just for thermal and indoor air quality conditions that are displayed as the percentage of time and separately.

4.1.3 ISO/FDIS 13790 Energy Performance of Buildings – Calculation of Energy Use for Space Heating and Cooling

The European Standard named as "ISO/FDIS 13790 Energy Performance of Buildings – Calculation of Energy Use for Space Heating and Cooling" introduces the assessment methods for the design and evaluation of the energy performance of the buildings, by taking into account the additional affects of recoverable energy losses, the contribution of building products and services to the energy conservation [17]. In the standard, different calculation procedures can be found for different phases of design, and also for the existing buildings. The calculations that the standard defines basically are:

- the heat transfer by transmission and ventilation,
- internal and solar heat gains,

- annual energy needs for heating and cooling,
- annual energy usage for heating and cooling.

It is also defined the necessary inputs, such as information about the thermal transmission and ventilation, external or inner heat gains, climate features, physical description of the building, required optimum comfort conditions and all data for HVAC and lighting systems, for the outputs of annual (or monthly) energy needs and annual (or monthly) energy use for space heating and cooling, and the duration of heating and cooling periods.

The standard assumes that calculations can be made for residential or non-residential buildings. Buildings can be divided in different zones according to the set-point temperatures. The calculation interval can be chosen one season (heating or cooling), one month or one hour by using hourly schedules.

The standard can be helpful to check the compliance of the energy regulations, to compare the different alternative designs in terms of energy performance of a building, to standardize the energy performance levels of the existing buildings, to see the potential energy conservation measurements and to figure out the future energy needs.

<u>The Calculation Procedure</u>

The proposed calculation procedure of the standard is based on the energy balance of the buildings and systems (Figure 4.1). Basically the elements of energy balance at the building level are the transmissions and ventilation heat transfers between the exterior and conditioned zones or between the adjacent zones, internal and solar heat gains, heat storages and losses from the heat mass, recovered energy losses and energy need for heating or cooling. However at the system level the elements are energy need for heating or cooling of the zone, renewable and non renewable energy inputs, system energy losses by generation, storage, distribution, emission and control subsystems, energy need for pre-heating or pre-cooling, recovered energy losses and energy output from the heating or cooling systems. The Image shows the energy balance of an energy system.

As a result, this approach leads us to different types of calculation methods, as they are defined in the standard:

- Calculating the heat balance over a long time period (month or season) and taking into account the dynamic conditions by a utilization factor is called “quasi-steady-state methods”,
- Calculating the heat balance by short time lags (hours) and taking into account the heat storage capacity of the building mass is called “dynamic methods”.

However ISO 13790 includes three different types of calculation methods which can all be parts of the whole calculation procedure.

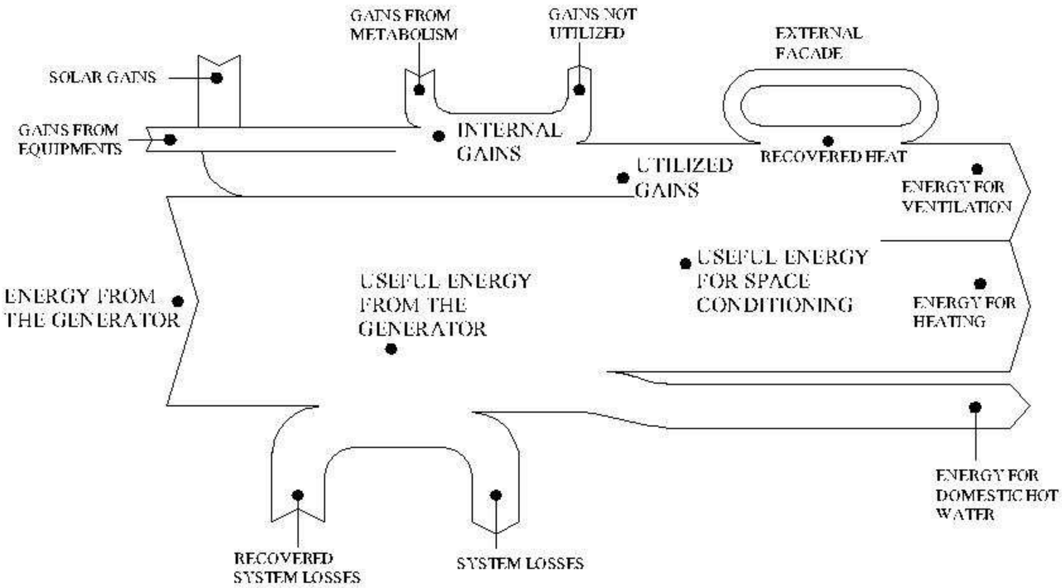


Figure 4.1: Energy Balance [6]

The proposed general outline for the calculation procedure is given below:

1. Decide the calculation method, quasi-steady-state or dynamic methods.
2. Define the boundaries and thermal zones of the building.
3. Define the input data for calculations: internal conditions, set-point temperatures, the external climate and environmental data.
4. Calculate the cooling and heating energy need for every time step and zone.
5. Calculate the operational length of heating or cooling season.
6. Combine the results.

1. Deciding the Calculation Method:

At national level it can be decided which method or methods can be used or will be mandatory.

- Monthly Quasi-Steady-State Calculation Method: Calculation of energy needs by months gives correct results for the whole year. However the results for the months which are close to the beginning or the end of the heating or cooling season may have some errors. In this method the dynamic effects like gains, losses or storages of heat should be taking into account by the correlation factors.
- Simple Hourly Dynamic Calculation Method: This method allows to use hourly schedules of users and systems. However the results for individual hours may have some errors.
- Detailed Dynamic Calculation Method: Dynamic methods give the most reliable results as they model the whole heat characteristics like flows by transmissions or ventilations, storages of the building. However they can be very complex that requires a laborious work. Thus in this standard only the standardized data of boundaries, inputs and outputs are given to be used in different dynamic methods.

2. Defining the Boundaries and Thermal Zones of the Building:

First of all the boundaries of the building of which the energy performance will be calculated should be defined. Conditioned areas should be separated from the external environment and adjacent buildings for the energy need calculations for heating or cooling. After defining the boundaries, the whole building can be modeled as a one zone or it can be divided into several zones according to the different thermal conditions of each room. The principles of the zoning of a building are as followings:

- If the difference between the set-point temperatures of the different spaces of the building is not higher than 4°K, they can be considered as a one zone.
- If different spaces are serviced by the same heating, cooling or ventilation systems, they can be considered as a one zone.

- Even if the different spaces are serviced by the same system, if they have different requirement of usage and set-point difference more than 4°K, they can be considered different zones.

3. Defining the Input Data for Calculations:

After defining the zones, the set point temperatures for the zones are calculated depending on the chosen calculation method. If a whole building is defined as a one zone, the set-point temperature is calculated basically as:

$$\theta_{\text{int,set}} = \frac{\sum_s A_{f,s}\theta_{int,s,set}}{\sum_s A_{f,s}} \quad \textbf{(4.1)}$$

$\theta_{\text{int},s,\text{set}}$ is set point temperature of the space, may be for heating or cooling.

$A_{\text{f},s}$ is conditioned floor area of the space.

If there is more than one zone, it should be decided if the calculations will be made as assuming that there is or there is not heat transfer between the adjacent zones. Furthermore in this phase the data for the energy need calculations such as external mean air temperatures, data about the sun, wind and humidity, should be gathered.

4. Calculating the Cooling and Heating Energy Needs:

Calculation procedure may differ depending on the chosen calculation method (first step), however generally all methods follow these steps:

a. Calculation of the internal, environmental and other relevant data inputs,
b. Calculation of heat transfer by transmission,
c. Calculation of heat transmission by ventilation,
d. Calculation of the internal heat gains,
e. Calculation of the solar heat gains,
f. Calculation of the dynamic parameters.

However, before explaining the steps, it can be summarized different calculation methods to see the differences of approaches. For monthly and seasonal methods the energy need for heating is calculated for each zone and each time step as:

$$Q_{\text{H,nd}} = Q_{\text{H,ht}} - \eta_{\text{H,gn}} Q_{\text{H,gn}} \quad \textbf{(4.2)}$$

Where $Q_{H,ht}$ is total heat transfer for heating mode, $Q_{H,gn}$ is total heat gains for heating mode and $\eta_{H,gn}$ is dimensionless gain utilization factor.

And energy need for cooling is calculated for each zone and each time step as:

$$Q_{C,nd} = Q_{C,gn} - \eta_{C,ls} Q_{C,ht} \qquad \textbf{(4.3)}$$

Where $Q_{C,ht}$ is total heat transfer for cooling mode, $Q_{C,gn}$ is total heat gains for cooling mode and $\eta_{C,ls}$ is dimensionless utilization factors for heat losses.

Total heat transfers indicate the sum of the heat transfers by transmission and by ventilation and total heat gains indicate the sum of the internal and solar heat gains.

Secondly, simple hourly method is a simplified dynamic method with the some advantages of monthly methods, like limited set of equations, reduction of input data, and traceability of calculation process. Furthermore simple hourly method takes into account the hourly schedules that cannot be used in monthly method. Also in the calculation internal air temperatures and mean radiant temperatures are specified differently, so this enables to check the thermal comfort conditions. The model is based on equivalent resistance-capacitance model.

In the Figure 4.2, it is illustrated the basic calculation logic, input data and the relations in between. The energy need for heating and cooling ($\Phi_{HC,nd}$) is found by the calculations for each hour. This energy is given to internal air (θ_{air}) to ensure a set-point temperature (θ_{s}) which is weighted mean of air (θ_{air}) and mean radiant temperature ($\theta_{r,mn}$). Heat transfer by ventilation (H_{ve}) and transmission (H_{tr}) are both connected to set-point temperature (θ_{air}). However heat transfer by transmission is split into heat transfer by windows – zero thermal mass ($H_{tr,w}$) and by thermal mass ($H_{tr,op}$). Furthermore the internal and solar heat gains are affecting all three nodes.

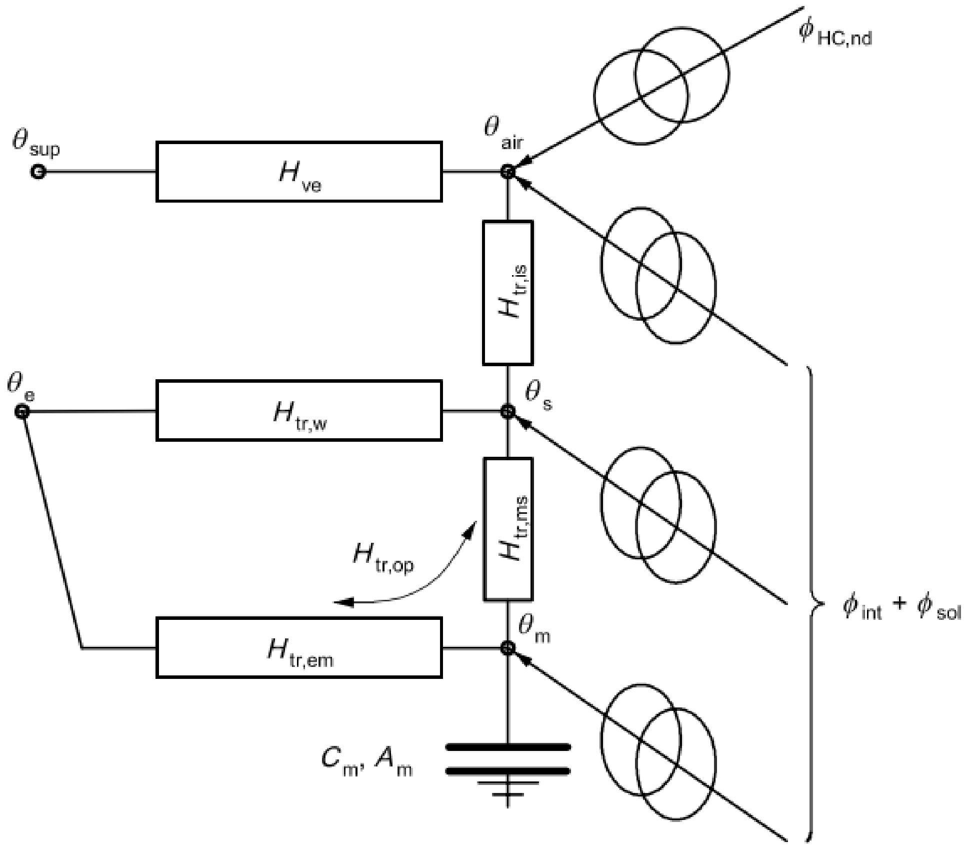


Figure 4.2: Five resistances, one capacitance (5R1C) model

Finally for the detailed dynamic calculations there numerous methods and programs that can be used, so for these methods the compliance with the related standards are important.

Apart from the calculation procedures for energy needs of heating and cooling systems, in the same part of the standard, the steps of iterations to integrate or isolate the interactions between the systems and building, between the zones, etc. and the calculation of the season lengths are explained.

4b. Calculation of Heat Transfer by Transmission

For the monthly or seasonal method heat transfer by transmission (Q_{tr}) is calculated for each zone and time step as follows:

$$Q_{tr} = H_{tr,adj}(\theta_{int,set,H/C} - \theta_e)t \qquad \textbf{(4.4)}$$

$H_{tr,adj}$ is overall heat transfer coefficient by transmission of the zone, adjusted for the indoor-outdoor temperature difference.

$\theta_{int,set,H/C}$ is set-point temperature of the zone for heating or cooling.

θ_e is temperature of external environment.

t is duration of the calculation step.

$$H_{tr,adj} = H_D + H_g + H_U + H_A \qquad \textbf{(4.4a)}$$

H_D is direct heat transfer coefficient by transmission to the external environment.

H_g is steady-state heat transfer coefficient to the ground.

H_U is heat transfer coefficient by transmission through unconditioned spaces.

H_A is heat transfer coefficient to adjacent buildings.

In general H_x, representing the H_D, H_g, H_U, or H_A is obtained as,

$$\mathrm{H}_x = b_{tr,x}\,[\Sigma_i A_i U_i + \Sigma_k l_k \psi_k + \Sigma_j x_j] \qquad \textbf{(4.4b)}$$

Where $b_{tr,x}$ is adjustment factor, it is not equal to 1 if the temperature at the other side of the construction is not equal to the external air temperature, such as the adjacent unconditioned spaces.

A_i is area of the building element I of the building envelope.

U_i is thermal transmittance of the element.

l_k is length of the linear thermal bridge k.

ψ_k is linear thermal transmittance of the thermal bridge.

x_j is point thermal transmittance of the point thermal bridge j.

Heat transfer coefficients are used in the simple hourly method; however a distinction is necessary between lightweight (glazed envelope) and heavyweight building elements (5R1C model).

The detailed calculation scheme, the special elements and procedure are explained in the standard for every calculation method.

4c. Calculation of Heat Transmission by Ventilation

For the monthly or seasonal method the calculation of total heat transfer by ventilation (Q_{ve}) for each zone is:

$$Q_{ve} = H_{ve,adj}(\theta_{int,set,H/C} - \theta_e)t \qquad \textbf{(4.5)}$$

$H_{ve,adj}$ is overall heat transfer coefficient by ventilation, adjusted for the indoor-outdoor temperature difference.

$\theta_{\text{int,set,H/C}}$ is set-point temperature of the zone for heating or cooling.

θ_e is temperature of external environment.

t is duration of the calculation step.

The overall ventilation heat transfer coefficient is:

$$H_{\text{ve,adj}} = \rho_a c_a \left(\Sigma_k b_{\text{ve,k}} q_{\text{ve,k,mn}}\right) \qquad \textbf{(4.5a)}$$

$\rho_a c_a$ is heat capacity of air per volume = 1200 J/m^{3}K.

$q_{\text{ve,k,mn}}$ is time-average air flow rate of air flow element k.

$b_{\text{ve,k}}$ is temperature adjustment factor for air flow element k, it is not equal to 1 if the supply air temperature is not equal to the external air temperature, in case of pre-heating, pre-cooling or heat-recovery.

The same method can be used for simple hourly method by calculating $H_{\text{ve,adj}} = H_{\text{ve}}$ for each hour and for every different system.

The detailed calculation scheme, the special elements and procedure are explained in the standard for every calculation method.

4d. Calculation of the internal heat gains

Internal heat gains consists any heat gains (or losses as negative gains) in the conditioned space:

- Metabolic heat from occupants,
- Heat from lighting devices,
- Heat dissipated from or absorbed by hot and mains water and sewage system,
- Heat dissipated from or absorbed by heating, cooling or ventilation systems,
- Recoverable system thermal losses.

For the monthly and seasonal method the internal heat gains are calculated for each zone and time step as:

$$Q_{\text{int}} = \left(\sum_k \Phi_{\text{int,mn},k}\right)t + \left[\sum_l (1 - b_{\text{tr},l} \Phi_{\text{int,mn},u,l}\right]t \qquad \textbf{(4.6)}$$

$b_{\text{tr},l}$ is the reduction factor for the adjacent unconditioned space with internal heat source l.

$\Phi_{\text{int,mn},k}$ is time average heat flow rate from internal heat source k.

$\Phi_{\text{int,mn,u},l}$ is time average heat flow rate from internal heat source l in the adjacent unconditioned space.

t is length of the considered month or season.

For the simple hourly method, the hourly values of heat flow rates of internal heat sources can be summed or can be used again the average values for a decided time period.

The detailed calculation scheme, the special elements and procedure are explained in the standard for every calculation method.

4e. Calculation of the Solar Heat Gains

The orientation of the building and transparent parts of the building, shading devices, other obstacles, solar transmittance and absorption values, thermal heat transfer characteristics of the envelope element of the building are all affecting the total solar heat gains of the building.

The collecting areas are,

- The glazing, including any solar shading
- The external opaque elements
- The internal walls and floors of sunspaces
- The walls behind a transparent cover or transparent insulation

The characteristics of the heat flow from solar gains depend on climate, time and location. It can be said that the characteristics vary over time, so for the calculations the adequate mean or conservative values can be used.

The overall solar heat gains are calculated for monthly and seasonal method for each zone and each time step as:

$$Q_{\text{sol}} = \left(\sum_k \Phi_{\text{sol,mn},k}\right)t + \left[\sum_l \left(1 - b_{\text{tr},l}\right)\Phi_{\text{sol,mn,u},l}\right]t \qquad \textbf{(4.7)}$$

$b_{\text{tr},l}$ is adjustment factor for the adjacent unconditioned space with internal heat source l.

$\Phi_{\text{sol,mn},k}$ is time-average heat flow rate from solar heat source k.

$\Phi_{sol,mn,u,l}$ is time-average heat flow rate from the heat source l in the adjacent unconditioned space.

t is length of the considered month or season.

For the simple hourly method, the hourly values of heat flow rates of solar heat sources can be summed or can be used again the average values for a decided time period.

$$\Phi_{sol,k} = F_{sh,ob,k} A_{sol,k} I_{sol,k} - F_{r,k}\Phi_{r,k} \quad \textbf{(4.7a)}$$

$F_{sh,ob,k}$ is shading reduction factor for external obstacles for the solar effective collective areaof surface k.

$A_{sol,k}$ is effective collecting area of surface k with a given orientation and tilt angle.

$I_{sol,k}$ is solar irradiance, the mean energy of the solar irradiation over the time step of the calculation, per square meter of collecting area surface k with a given orientation and tilt angle.

$F_{r,k}$ is form factor between the building element and the sky.

$\Phi_{r,k}$ is extra heat flow due to the thermal radiation to the sky from building element k.

Effective collecting area for the glazed elements is calculated as:

$$A_{sol} = F_{sh,gl}\, g_{gl}\, (1-F_F)\, A_{w,p} \quad \textbf{(4.7b)}$$

$F_{sh,gl}$ is shading reduction factor for movable shading provisions.

g_{gl} is total solar energy transmittance of the transparent part of the element.

F_F is frame area fraction, ratio of the projected frame area to the overall projected area of the glazed element.

$A_{w,p}$ is overall projected area of the glazed element.

Effective collecting area for the opaque elements is calculated as:

$$A_{sol} = \alpha_{S,c} \text{ x } R_{se} \text{ x } U_c \text{ x } A_c \quad \textbf{(4.7c)}$$

$\alpha_{S,c}$ is dimensionless absorption coefficient for solar radiation of the opaque part.

R_{se} is external surface heat resistance of the opaque part.

U_c is thermal transmittance of the opaque part.

A_c is projected area of the opaque part.

Solar heat gains from opaque elements can be only a small portion of total solar gains and can be ignored. However for the dark colored and poorly isolated large faces the solar heat gains can be important.

The detailed calculation scheme, the special elements and procedure are explained in the standard for every calculation method.

4f. Calculation of the Dynamic Parameters

In the monthly and seasonal method the dynamic effects are taking into account by gain utilization factor for heating system and loss utilization factors for cooling systems. The simple hourly method, however, combines the thermal capacity of the building zone in to a single resistance-capacitance pair.

In the standard the detailed calculation methods can be found for dimensionless gain and loss utilization factors. Also the calculations and equations for the application of the 5R1C model can be found. Finally the internal heat capacity of the building is explained for both monthly and seasonal method and simple hourly method.

5. Calculating the Operational Length of Heating or Cooling Season:

The calculation method for the length of the season (L) can be decided nationally, however the standard proposes the following methods.

For the monthly calculations:

$L_{\mathrm{H}} = \sum_{m=1}^{m=12} f_{\mathrm{H},m}$ and **(4.8)**

$L_{\mathrm{C}} = \sum_{m=1}^{m=12} f_{\mathrm{C},m}$ **(4.9)**

L_{H} is length of the heating season

L_{C} is length of the heating season

$f_{\mathrm{H},m}$ is fraction of the month that is part of the heating season

$f_{\mathrm{C},m}$ is fraction of the month that is part of the heating season

The fraction of the month can be decided according to two different options:

Option1 is a simplified method that bases on the ratio of heating and cooling energy need to overall energy need of the building.

Option2 bases on the monthly values for the heat balance ratio for the heating mode.

The two options are explained in detail in the standard.

For the seasonal calculations, length of the heating and cooling season depends on the heat-balance ratio and thermal inertia.

For the simple hourly calculations, the length of the heating or cooling period is determined by averaging the heating or cooling need over the previous four weeks. The start and end of the seasons are determined with a threshold value of 1 W/m^2 floor area.

6. Combining the Results:

After calculating the overall energy needs for heating and cooling for each zone and for each time step, to find the annual energy needs for heating and cooling all results should be summed:

$Q_{\mathrm{H,nd,an}} = \sum_i Q_{\mathrm{H,nd},i}$ and **(4.10)**

$Q_{\mathrm{C,nd,an}} = \sum_j Q_{\mathrm{C,nd},j}$ **(4.11)**

In the case of multi-zone calculation, each sum for each zone also should be summed to reach the final total energy need for heating and cooling.

After finding the energy needs separately for each system, to combine the results the standard offers 3 options:

- Option1: Overall annual energy need (Q_{H}) is obtained by summation of energy use of each system ($Q_{\mathrm{H,sys}}$ and $Q_{\mathrm{C,sys}}$) plus auxiliary energy use. The thermal loses are found by taking the difference between the energy needs for heating and cooling.
- Option2: Overall annual energy need (Q_{H}) is obtained by summation of total energy needs for each system, total system loss and auxiliary energy use. The thermal losses and auxiliary energy comprise generation, transport, control, distribution, storage and emission.
- Option3: The heat losses are indicated by an efficiency factor and total system energy needs are:

$Q_{\mathrm{H,sys}} = \frac{Q_{\mathrm{H,nd}}}{\eta_{\mathrm{H,sys}}}$ and **(4.12)**

$Q_{\mathrm{C,sys}} = \frac{Q_{\mathrm{C,nd}}}{\eta_{\mathrm{C,sys}}}$ **(4.13)**

The table that is shown in Figure 4.3 is given by the standard to propose a way to present the inputs and outputs that are necessary for energy certification. The table can be prepared for different zones and systems and summated for the whole building.

Use of energy	Energy carrier								
	Heat	Oil [b]	Gas	Coal	District heating	District cooling	Wood	Electricity	Carrier *n*
Energy needs for heating									
Energy need for central pre-heating of ventilation air									
Heating system thermal losses									
Heating system energy use									
Auxiliary energy use for heating									
Energy needs for cooling									
Energy need for central pre-cooling of ventilation air									
Cooling system thermal losses									
Cooling system energy use									
Auxiliary energy use for cooling									
Energy use for ventilation (fans and controls)									
Ventilation system thermal losses for central pre-heating									
Ventilation system thermal losses for central pre-cooling									
Energy use for central pre-heating of ventilation air									
Energy use for central pre-cooling of ventilation air									
Sub-total									
Total									

This table contains the result for:
(fill in: zones Z or Y with same combination of systems, or sum for whole building)

Explanation:

Blank cells: Input possible or required

Grey cells: Not applicable

[a] If applicable, this table shall be completed per cluster of zones that are serviced by the same combination of systems as distinguished in 14.2.

A similar table shall be completed for the whole building, summating the results of the clusters of zones.

[b] Examples of energy carriers; to be adapted to the specific situation.

Figure 4.3: Example table given in the standard to present the calculation results for energy certification

4.1.4 EN 15603 Energy Performance of Buildings – Overall Energy Use and Definition of Energy Rating

The European Standard named as EN 15603 Energy Performance of Buildings – Overall Energy Use and Definition of Energy Rating defines a general methodology for evaluation of total energy usage [18]. This evaluation can be used to decide the energy performance of the building and the result can be displayed on the energy certification.

The standard proposes two kinds of energy assessments for buildings:

- "Calculated energy rating" which can be used for new buildings as the calculation is based on the energy requirements of the building. After the calculation of energy needs for electrical and thermal services, the necessary amount of primary energy is determined.
- "Measured energy rating" is based on measuring the total amount of energy carrier to the building in a defined period.

Accumulation of each calculation for different energy carriers is also essential to achieve a more precise overall used energy in a building. The standard also defines different methods to aggregate all calculations.

Each member state may decide nationally to use which of these rating method for which type of building.

Assessment of Energy Performance of Buildings

Annual energy use of a building shall comprise all systems such as heating, cooling, ventilation, domestic hot water, lighting, etc., all system losses and auxiliary energy uses. However before the assessment, the system boundaries should be defined clearly (Figure 4.4). More than one building can be considered as a group if they are served by the same systems and the assessments can be made for the group. These kinds of details and principles for the definition of the boundaries should be defined at national level.

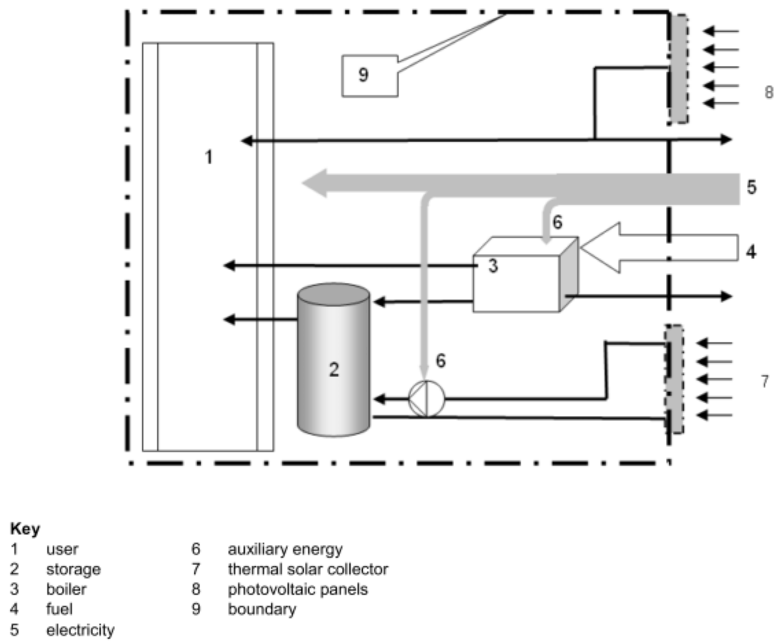


Figure 4.4: Example of energy flows across the system boundary

<u>Calculated Energy Rating</u>

The objective of the calculation is to obtain the annual primary energy use and CO_2 emissions. For the calculation, annual average values can be used or the year can be divided in to time steps and the calculations are performed for each step. However, in both ways, the direction of the calculations goes from the building energy needs to primary energy.

This rating can be tailored, standardized and is called “design rating” if it is performed for a planned building.

For the calculations, it should be defined at national level if the heat gains and recoverable system losses will be included or not. There are two approaches to take into account the effects of heat gains and recovered system losses:

- Calculation procedure for the Holistic Approach:

- Calculating the sub-system energy needs and determination of the recoverable system losses.
- Summation of all recoverable system losses and heat gains with the total energy need of the building.
- Recalculation of the total energy needs for heating and cooling.

- Following the same iterations until the difference of the energy needs between two iterations is less than a defined value.
- Obtaining the recovered system loses by subtracting the final energy need value from the first value.

- Calculation procedure for the Simplified Approach:

- Calculating the sub-system energy needs and determination of the recoverable system losses.
- Obtaining the recovered system loses by multiplying the recoverable system losses by a conventional recovery factor that is defined nationally.

<u>Measured Energy Rating</u>

This rating is based on measuring all the energy carriers delivered to the building and exported by the building and it is called also “operational rating”.

Assessment period for the measurements is an important element that for reliable results the period shall:

- Be integer number of years, preferable recent years,
- Be longer than 3 years, if not a correction for weather data should be performed,
- Begin one or two years later after erection.
- During the assessment period, new modifications which change the energy performance should not be made to the building.

In the standard, several methods are explained to assess the used amount of energy carriers during the assessment period. Consumption of the metered energy carriers can be read from energy bills or directly from the meters. The accurate amount can be obtained by the difference between the values on the beginning and end of the assessment period. For the liquid fuels bought, the levels in the tank can be read in the beginning and end of the assessment period. What else, for solid fuels weighing the fuel in the beginning and end of the assessment period gives the most accurate result.

Table 4.1: Types of ratings

	Name	Input Data			Utility or purpose
		Use	Climate	Building	
calculated	design	standard	standard	design	Building permit, certificate under conditions
calculated	standard	standard	standard	actual	Energy performance certificate, regulation
calculated	tailored	Depending on purpose		actual	Optimization, validation, retrofit planning
measured	operational	actual	actual	actual	Energy performance certificate, regulation

Table 4.1 summarizes the types of ratings that are defined in the standard. Depending on the purpose, the type of the rating should be chosen.

<u>Weighted Energy Ratings</u>

In the buildings, generally more than one energy carriers are used, thus a common expression is needed to express the total primary energy consumption, total CO_2 emission, etc. The standard defines several aggregation methods and different types of factors and coefficients.

- Average factor or coefficient is based on annual average impact of all plants delivering energy to the building.
- Marginal factor or coefficient takes into account only production units that are affected by changes in energy demand.
- End use factor or coefficient is used when the demand patterns differs severely for each system.

Total primary energy used in the building is obtained by total delivered energy and total exported energy. To be able to sum these different types of energies, primary energy factors are needed. Total primary energy factor comprises all phases of delivery: production out of the boundary, transport and extraction. Another factor, non-renewable primary energy factor, however excludes renewable energy component.

Total CO_2 emission is obtained by total delivered energy and total exported energy. To be able to make calculation CO_2 emission coefficients are needed. In national standards it should be defined if the CO_2 emission coefficients include other green house gas emissions or not.

Validated Building Calculation Model

The standard proposes a method to compare the calculated results with the measured results (actual usage) for existing buildings. The procedure of the method is:

- Obtaining the measured energy rating of the building,
- Collecting the data that cannot be assessed like actual climatic data, air permeability of the envelope, ventilation rate, heating system efficiencies, actual internal conditions,
- Calculating a tailored rating using the data collected (the amount of energy carriers used other than heating, cooling, ventilation, hot water or lighting should also be included),
- Comparing the measured results and tailored results for each energy carrier,
- If the difference between the results is larger than the confidence intervals, further investigations should be made.

The method and data collection is explained in detailed in the standard.

Planning of Retrofit Measures for Existing Buildings

In the existing some measures can be taken in the net delivered energy carriers. These measures can be assessed by the rating methods which are defined in this standard, however ‘the validated calculation model’ is recommended. The data obtained by these calculations should be used in case of sales, change of usage or occupancy.

For the energy saving measurement more than one scenarios should be prepared and for each the calculations should be made to be available to see the optimum solution and the amount of saved energy use.

Report

After assessment of energy use of a building, a report should be prepared apart from the certification (Figure 4.5). The report should comprise:

- Reference to the standard EN 15603,
- Purpose of energy rating,

- Description of the building and its location, its activities, equipments and occupancy,
- Type of rating,
- Rating itself with its confidence intervals

For calculated rating only			
Building thermal needs (without technical building systems)	**Technical building system performance** (thermal system losses-recovered losses)	**Energy delivered** (content of energy carriers)	**Energy rating** (Weighted Energy carriers)
Heating: $Q_{H,nd}$ $Q_{H,hum,nd}$ Hot water: $Q_{W,nd}$ Cooling: $Q_{C,nd}$ $Q_{C,dhum,nd}$	Heat (H+W): $Q_{HW,ls,nrvd}$ Cooling: $Q_{C,ls,nrvd}$ Electricity *): Heat auxiliary W_{HW} Cooling auxiliary W_C Lighting E_L Ventilation E_V	Gas $E_{gas,del}$ Oil $E_{oil,del}$ Electricity $E_{el,del}$ District heating $E_{dh,del}$ Wood $E_{Wd,del}$ Energy carrier (i) $E_{i,del}$	$\Sigma E_{P,del,i}$ or $\Sigma E_{pol,del,i}$ or $\Sigma m_{CO2,del,\,i}$
		Energy exported (Unweighted energycarriers)	$\Sigma E_{P,exp,i}$ or $\Sigma E_{pol,exp,i}$ or $\Sigma m_{CO2,exp,\,i}$
		Thermal: $Q_{T,\,exp}$	
		Electrical $E_{el,\,exp}$	
			E_P; m_{CO2}, or E_{pol}
		Renewable energy produced on site	
		Thermal $Q_{H,gen,out}$	
		Electrical $E_{el,gen,out}$	
*) Includes electricity for ventilation, lighting and the auxiliary energy for the thermal technical systems; it does not include electricity for heating, cooling, DHW, humidification and dehumidification.			

Figure 4.5: Example table given in the standard for reporting of the overall energy use or CO_2 emission for the calculated and measured energy rating

Further information to be displayed on the report should be decided by national documents. These can be:

- Climatic data (average external temperature, solar irradiance, etc.) that is used for the calculations,
- For the calculated ratings, relevant standards, assumptions, energy use,
- For the measured ratings, assessment time period, methodology of assessment, methodology for extrapolation and weather correction, the delivered and exported energy,

- For the validated ratings, report for the measured energy rating, assumptions used to fit the tailored rating to the measured rating, calculated rating results,
- For the measures for improvement, list of measures, effect of each measure on the energy performance, cost effectiveness of the measures.

5. ITALIAN AND TURKISH BUILDING ENERGY CERTIFICATION SYSTEMS

In this study, the energy performance certification systems which were in force during the researches for the thesis in Turkey and during the exchange program of Erasmus in Italy (between October 2008 and July 2009) are discussed. Furthermore in both countries, in Italy and in Turkey, the studies to develop and to improve the current systems are still in progress. While Turkey is about to initiate a new energy certification system, Italy continues to develop the current system.

5.1 Italian Energy Certification System

5.1.1 Brief Historical Process of Legislative Base of Energy Certification

In Italy the annual consummation of energy is equal to 190 million TEP (ton of equivalent petroleum) and 28 million of this consumption is belongs to the residential usage. For the heating, which is the 50% of the operation costs, it is consumed annually 14 billion m^3 gas, 4,2 billion kilos of gas oil, and 2,4 million tons of solid combustible (wood and coal). That corresponds the 380.000 tons of pollutant substances and makes the heating the second important factor, after traffic, for environmental pollution. Furthermore, in compliance with Kyoto Protocol, Italy commits to reduce the production of carbon dioxide emissions 6,5% until 2012, with respect to the values of 1990. Today any reductions are recorded, but the trend is rising.

Italian energy certification system is basically based on the European Directive on the Energy Performance of Buildings 2002/91/EC and the European standards that are defined above. Italy has chosen to implement the "Monthly Quasi-Steady-State Calculation Method" for the existing residential buildings.

Under the obligation of the directive, in Italy the council of ministries (the Ministry of Economy, the Ministry of Environment and the Ministry of Infrastructures) has published the laws D. Lgsl. n. 192/2005 and D. Lgsl. n.311/2006. Before these laws the energy certification was present also in the law n.10/91, however it never had been applied, maybe because of the imperfection of sensibility on the energy subjects of the construction sector and the people. [19] Today these laws and the national standards draws a general frame for the calculation methodology and gives the responsibility to each regions to develop and to implement their own certification systems.

Here in this thesis, the standards of UNI - UNI/TS 11300 Energy Performance of Buildings-part 1 and 2 are specified, as a calculation methodology of Italy.

5.1.2 National Laws and Calculation Methodology

Italy accepts the "monthly calculation method" (EN13790) as a national calculation method for the certification of energy performance of the buildings. By the laws D. Lgsl. n. 192/2005 and D. Lgsl. n.311/2006 the procedure is defined and it is obligated for all the regions building up the certification system separately. The application of the certification system is now for the heating period and for the existing building.

The legislative decree n.192, 2005 has the objective of improving energy performance of the buildings, in the point of view of saving energy, introduction and contribution of renewable energy sources, and, in the building sector, achievement to the national objectives of reducing the sera gasses that estimated in the Kyoto Protocol. [19]

According to the law n.192/05, the followings should be defined to calculate the energy performance of the buildings:

- Internal and external climate
- Thermal characteristics of the building,
- Heating and hot water production systems,
- Air condition and ventilation systems,
- Illumination systems,
- Position and orientation of the building,
- Passive solar and solar protection systems,

- Natural ventilation systems,
- Renewable energy systems,
- Internal air quality systems.

By taking into account of these systems and the function of the building, the law also gives the obligation of defining the methodology of calculation, and minimum energy consumption requirements in 120 days after the law came into force.[19] What's more, the requirements of energy performance of the buildings that are defined in the law related to the primary energy needs should be expressed in degree-day concept and s/v ratio, the minimum values of transmittance (U values) of the elements of the envelope of the building should be set, and the total seasonal mean energy performance of the heating system should be calculated. [19,20]

The legislative decree n.311, 2006, however, contains some modifications for the law n.192/05. It corrects some problems that were highlighted in the application of the previous law and it introduces currently lots of verifications and obligations to obtain an energy saving in new and existing buildings [21]. In the law n.311/06 the application of the certification system includes all building with a gradual method as the law n.192/05 only involved the new construction:

- from 01.09.2007, all the buildings that larger than $1000m^2$,
- from 01.09.2008, the buildings smaller than $1000m^2$, in case of selling,
- from 01.09.2009, the single houses,

should have energy certification. [19] Another modification in the law n.311/06 is the definition of the certifications: the one that is related with the qualitative terms of energy performance of the building is defined as "Energy Qualification" and it refers to a document that reports the compliance of the works carried out according to the project. The other one that is related with directly the energy performance is called "Energy Certification" and it should include the data of the energy efficiency of the building, the values of the norms and the reference values to allow the users compare the energy performance of the building, and the possible interventions to develop the energy performance of the building. [19] In fact the word *certification* is modified from *qualification* as the fundamental difference between the terms is a third party is needed to verify and control the works carried out for certification as for the qualification can be implemented by the designer, too. [21]

According to the definitions that are set in the law, the energy consumption contains:

- space heating for winter conditions
- space cooling for summer conditions
- domestic hot water production
- ventilation
- illumination

However the law gives limitations only for space heating and prescriptions about space cooling. [21]

Finally for the application of the law 311/06 includes a three stepped method (scheduled as: from 01.01.2006, from 01.01.2008, and from 01.01.2010) for primary energy need values and thermal transmittance values of the building elements, as the law 192/02 had values from 2006 and 2009. Furthermore the primary energy need values are divided into two as for residential buildings and other buildings.

In the laws the definition of the certification doesn't contain the methodology for the energy certification and neither who is going to give the certification. [21] Thus the laws give the responsibility to the national standards and every region to constitute its own certification system for the energy performance of the buildings. According to the laws, Italy, the 21 regions, is divided into 6 climatic zones by degree-day concept, and the energy certifications are valid for 10 years, however the minimum requirements should be revised every 5 years.

Today some regions have developed programs, easily reachable on the internet, to assess the energy performance of buildings, such as DoCEt and CasaClima.

5.1.2.1 UNI/TS 11300 Energy Performance of Buildings, 2008

UNI – Italian Organization for Standardization has published the national standard UNI/TS 11300 to define the national energy performance calculation methodology by recognizing the standard EN ISO 13790 as a base and under the obligation of European Directive 2002/91/CE Energy Performance of Buildings. The proposed calculation methodology is based on the energy balance in static regime [Figure 4.1], but it considers also the dynamic affects of the temperature differences between outside and inside and solar gains by a utilization factor.

According to the standard, to evaluate the energy performance of the buildings following assessments should be made:

1. Energy need for space heating and cooling,
2. Energy need for domestic hot water,
3. The performance and primary energy need for the heating systems,
4. The performance and primary energy need for the domestic hot water production systems,
5. Possible primary energy savings for space heating and domestic hot water production by renewable energy usage and other types of generation methods,
6. The performance and primary energy need for the cooling systems.

These assessments can be used in different types of ratings (Table 5.1) which are chosen depending on the purpose.

Thus the UNI/TS 11300 has four parts to cover these calculations: Part 1 is for evaluation of the thermal energy need for space heating and cooling of the buildings. Part 2 defines the evaluation of the primary energy need and of the system efficiencies for space heating and domestic hot water production. Part 3, in elaboration, states the evaluation of primary energy need and the performance of space cooling. Part 4, also in elaboration, explains the use of renewable energies and the other energy generation methods for heating and sanitary hot water.

In general meaning UNI/TS 11300 defines a method for the application of UNI EN ISO 13790:2008 and it uses the monthly calculation procedure for the heating and cooling energy needs.

Table 5.1: Types of rating proposed by the standard

Type of rating	Input Data			Purpose of rating
	Use	**Climate**	**Building**	
Design rating	standard	standard	design	Building permit, energy performance certification or qualification of the project
Asset rating (Standard)	standard	standard	actual	Energy performance certification or qualification
Tailored rating	Depending on purpose		actual	Optimization, validation, retrofit planning

5.1.2.2 UNI/TS 11300 Energy Performance of Buildings - Part 1 - Evaluation of the Thermal Energy Need for Space Heating and Cooling of the Buildings - 2008

In the part 1 of the standard [22], before the detailed definition of the calculation procedure for the thermal energy need of the building, the necessary data for the calculation is stated under the headlines like 'the characteristic data of the building typology', 'the data of the thermal features of the building construction', 'climatic data', the data of the occupation and utilization of the building'.

In the standard, the calculation procedure is defined briefly as:

1. Defining the borders of conditioned and non-conditioned volumes of the building,
2. Defining the different thermal zones of the building,
3. Defining the desired internal conditions and the data of the external climate,
4. Calculating the heating and cooling energy needs of the building for every zone and every month,
5. Summing the results of every zone and month.

The rules for determining the thermal zones are specified basically like every different volume that has a different set-point temperature should be defined as a different thermal zone. So if the volumes that are not adjacent, but they have similar thermal condition, they can be counted as a same thermal zone. Also if the difference between the heating or cooling temperature of the different volumes is less than 4°K and for the volumes that are served by the same system, zone division is not required.

Finally it is stated that for the heating and cooling conditions the thermal zones may differ in a building.

For determination of the internal temperature, the type of the building and the utilization profile are primarily important parameters. However the standard proposes some values like:

- General values for all type of buildings are for winter 20°C and for summer 26°C,
- For the buildings like swimming pool and sauna the value is, for summer and winter, 28°C ,
- For the gyms the values are, for winter, 18°C and, for summer, 24°C,

Besides the standards UNI EN 12831 and UNI EN ISO 13789:2008 are referred for other types of buildings or other situations.

For all kinds of climatic data necessary for the calculation for Italy, UNI 10340 can be utilized.

Before the calculation, it is also essential to define the length of the heating and cooling seasons. Thus the standard introduces a table of heating season periods for all the climatic zones of Italy. However, if it possible to estimate the real duration of the period that is needed heating energy supply precisely, the real length of the heating season can be defined separately. Besides, the standard gives a formula to find the first and the last days of the heating or cooling periods:

$$\theta_{\mathrm{e,day}} < \theta_{\mathrm{i,set,H}} - \frac{Q_{\mathrm{gn,day}}}{H x t_{\mathrm{day}}} \quad \textbf{(5.1)}$$

$\theta_{\mathrm{e,day}}$ is mean daily external temperature.
$\theta_{\mathrm{i,set,H}}$ is heating set point temperature.
$Q_{\mathrm{gn,day}}$ is mean daily internal and solar gains.
H is global heat change coefficient of the building, W/K.
t_d is duration of the day.

In the part 1 of the standard, it is pointed out that to calculate the thermal transmission of the building zones, the methodology explained in the standards UNI EN ISO 13789:2008 and UNI EN ISO 13370 should be used. However the parameters that are necessary for the calculation can be found in the standard:

thermal features, thermal resistance and coefficients of the *opaque elements*; thermal transmittance values for *transparent elements,* window frames and shutters. Besides the weighting values for *thermal bridges* that are given on a table in the standard, the heat exchange of the thermal bridges should be calculated according to UNI EN ISO 14683. It is also explained the calculation of global coefficient values and correction factors for *heat exchange between the air-conditioned volumes and non conditioned volumes,* for *heat exchange by earth*; and it is also given the parameters for the calculation of *extra heat flow by radiation* to the open air.

To perform the calculations for ventilation, the necessary parameters are given in the standard. In the case of natural ventilation the air change rate values can be obtained from the standard UNI 10339 or for the residential buildings it can be received 0,3 vol/h. For the mechanical ventilation, however, the formula for the calculation of air change rate is given in the standard for the cases of simple flow or double flow. It is also mentioned that the capacity of the ventilation depends on the usage of the building, and, for example, in the case of natural ventilation it is impossible to predict the real rates of air change, because it depends the exterior climate, permeability the envelope, and the usage pattern. Additionally it is explained that in the case of mechanical ventilation, free cooling (night time ventilation) can be considered for the cooling season, too. Thus the values of air change rate for the free cooling are also present in the standard.

Furthermore in the standard the global mean values of the heat gains of the buildings are given in a table according to the building type, time schedules, density of the occupants (Figure 5.1). Additionally the standard explains how to integrate the solar heat gains to the calculation of thermal energy needs. Absorption factors for the opaque part of the building envelope and the values of total solar energy transmittance of the some types of glasses for the transparent parts of the building. It is also clarified, by formulas and tables, how to take into account the window frames, movable and permanent shadow elements.

Categoria di edificio	Destinazione d'uso	Apporti medi globali
		W/m^2
E.1 (3)	Edifici adibiti ad albergo, pensione ed attività similari	6
E.2	Edifici adibiti a uffici e assimilabili	6
E.3	Edifici adibiti a ospedali, cliniche o case di cura e assimilabili	8
E.4 (1)	Cinema e teatri, sale di riunione per congressi	8
E.4 (2)	Mostre, musei e biblioteche, luoghi di culto	8
E.4 (3)	Bar, ristoranti, sale da ballo	10
E.5	Edifici adibiti ad attività commerciali e assimilabili	8
E.6 (1)	Piscine, saune e assimilabili	10
E.6 (2)	Palestre e assimilabili	5
E.6 (3)	Servizi di supporto alle attività sportive	4
E.7	Edifici adibiti ad attività scolastiche a tutti i livelli e assimilabili	4
E.8	Edifici adibiti ad attività industriali ed artigianali e assimilabili	6

Figure 5.1: Example table from the standard for global mean values of the heat gains

In the standard, to transform the calculations in a dynamic model, the utilization factors for heating and cooling are also provided. However to use and calculate the utilization factors, the thermal capacity of the building should be determined first. The capacity of the building should be determined precisely according to the standard UNI EN ISO 13786, but there is also a table given in the standard UNI/TS 11300 to get a more general value. Finally for the cases of intermittent heating and cooling, it is given two basic cases that should be considered.

5.1.2.3 UNI/TS 11300 Energy Performance of Buildings - Part 2 - Evaluation of the Primary Energy Need and of the System Efficiencies for Space Heating and Domestic Hot Water Production - 2008

The second part of the standard UNI/TS 11300 starts defining the "useful energy need". The calculations of useful energy need for heating, ventilation and domestic hot water are necessary for the calculations of primary energy usage. Furthermore it is asserted that primary energy usage, different from heating, ventilation or hot water production, should be also taken into account [23].

Useful energy need for space heating is considered in three phases:

1. <u>Ideal energy need:</u> It is fundamentally the primary energy need that is calculated according to the standards UNI EN ISO 13790 and UNI/TS 11300-1

2. Net ideal energy need (Q'_{h}): It is the energy need that obtained by subtracting the recovered energy ($Q_{W,lrh}$) from ideal energy need (Q_{h}),

$Q'_{h} = Q_{h} - Q_{W,lrh}$ [Wh] **(5.2)**

3. Effective energy need (useful energy need) (Q_{hr}): The energy need that includes the losses of emissions ($Q_{l,e}$) and adjustments ($Q_{l,rg}$) and the final energy amount that should be introduced into the conditioned space by the distribution system.

$Q_{hr} = Q'_{h} + Q_{l,e} + Q_{l,rg} – Q_{aux,e,lrh}$ [Wh] **(5.3)**

Where, $Q_{aux,e,lrh}$ is recovered electrical energy from the emissions.

It is also given a formula to find the energy need for domestic hot water production. However it is explained that for the given formula all the parameters (besides the density and specific heat of the water, the difference between the temperatures of requested hot water (40°C) and cold water (15°C) that enters to the system are accepted constant and equal to 25K), are constant but the volume of the requested hot water. Thus by following the tables given in the standard, the energy need for domestic hot water ($Q_{h,w}$) can be calculated easily.

$Q_{h,w} = \sum_i \rho x c x V_w \ x \ (\theta_{er} - \theta_o) x G$ **(5.4)**

Additionally it is given a table for the energy need for other actions such as cooking, beside the heating and hot water production.

In this second standard it is explained widely the methodology of the primary energy calculation for heating and the evaluation of the system performance of the heating plant. It is basically asserted that to make the calculation for the whole system, it is necessary to make the following calculations for every subsystem:

- Requested input energy need, Q_{in},
- Total auxiliary energy need, Q_{aux},
- The energy losses, Q_{l},
- The recovered energy losses, Q_{lrh},

and in the sense of output of the useful energy supply (Q_{out}), the formula is:

$Q_{in} = Q_{out} + (Q_{l} - Q_{lrh}) - Q_{aux,lrh}$ [Wh] **(5.5)**

According to the standard, for the heating and the hot water system, the following subsystems should be considered:

For the heating system,

- Subsystem of emissions,
- Subsystem of regulation of heat emissions into the space,
- Subsystem of distribution,
- Subsystem of accumulation,
- Subsystem of generation.

For the domestic hot water production system,

- Subsystem of supply,
- Subsystem of distribution,
- Subsystem of accumulation,
- Subsystem of generation.

In addition in case of the calculation for the different parts of a building, the losses of the subsystems of distribution and generation belong to the whole building.

General expression of the "Primary Energy Need" is:

$$Q_{p,H,W} = \Sigma Q_{H,c,i} x f_{p,i} + \Sigma\ Q_{W,c,j} x f_{p,j} + (Q_{H,aux} + Q_{W,aux} + Q_{INT,aux} - Q_{el,exp}) x f_{p,el} \quad \textbf{(5.6)}$$

$Q_{H,c}$ is energy need for heating.

$Q_{W,c}$ is energy need for domestic hot water production.

$Q_{H,aux}$ is auxiliary electric energy need for heating plant.

$Q_{W,aux}$ is auxiliary electric energy need for domestic hot water production plant.

$Q_{INT,aux}$ is auxiliary electric energy need for renewable energy or cogeneration systems.

$Q_{el,exp}$ is electrical energy exported from the system (pv, cogeneration).

f_p is the primary energy conversion factor .

The value f_p, for the fossil combustibles, is 1. For the other types of energy, the value should be gathered from other legislative sources.

Auxiliary energy is the energy that used for the operation of the energy plant and it generally electrical energy.

Recoverable Losses and Non-Recoverable Losses

Recoverable losses, Q_{lrr}, indicate the energy losses that can be recovered, Q_{lrh}, and in the standard the following equation is given:

$$Q_{lrh} = 0{,}8Q_{lrr} \qquad \textbf{(5.7)}$$

In the calculations, recovered energy losses can be considered in two ways: reducing the system losses or reducing the useful energy need.

The Seasonal Mean Efficiencies of the Systems

The efficiencies can be studied separately or together for the heating and hot water system.

Just for the heating system it is equal to:

$$\eta_{g,H} = Q_h / Q_{p,H} \qquad \textbf{(5.8)}$$

$Q_{p,H}$ is calculated primary energy need for heating.

Q_h is useful energy need for heating.

The efficiency of the domestic hot water production system is equal to:

$$\eta_{g,W} = Q_{h,W} / Q_{p,W} \qquad \textbf{(5.9)}$$

$Q_{p,W}$ is calculated primary energy need for domestic hot water.

$Q_{h,W}$ is useful energy need for domestic hot water.

The global efficiency of both heating system and hot water production system is equal to:

$$\eta_{g,H,W} = (Q_h + Q_{h,W})/ Q_{p,H,W} \qquad \textbf{(5.10)}$$

$Q_{p,H,W}$ is calculated primary energy need for heating and domestic hot water.

Q_h is useful energy need for heating.

$Q_{h,W}$ is useful energy need for domestic hot water.

Additionally, the efficiencies of the subsystems should be considered separately. In the standard the points that should be taken into account are clarified. For the subsystem of emissions, for example, the most important factor affecting the efficiency of the system is altitude of the space which is heated. Thus for the cases of altitude less that 4m and between 4m and 14m, there is given tables where can be found the efficiency values of different kinds of emission subsystems for heating. Furthermore, for all the other types of subsystem like regulation, distribution, accumulation and generation the tables, the equations and calculation methods are given.

Auxiliary Energy Need of Subsystems

In general, the total auxiliary energy need of a heating system is equal to sum of the all auxiliary energy needs of subsystems. The auxiliary (electrical) energy need of the systems can be determined in three phases: in the phase of projection of the system, by making measurements of the system, or by making calculations. Thus, in the standard, the tables, the formulas and the calculation methods are given to determine the auxiliary energy need of subsystems.

Simplified Calculation Method for Primary Energy Need

Basically, the simplified method is the sum of the seasonal energy need for heating and annual energy need for domestic hot water. In the standard, it is explained the calculation method step by step, and to be simplified it is based on reading the necessary values from tables given in the standard. However, to have more precise results, more detailed data should be obtained about the systems and should be making the calculations.

Methods to Measure the Effective Combustible Consumption

The data of effective combustible consumption can be used to compare the results of primary energy need calculations. The measurements can be performed by the assistance of a counter or, if there is a tank, the levels of the combustible can be read. The problem is the energy generator system for heating, hot water and other usages can be the same, thus the consumption of combustible is equal to:

In the heating period,

$$Co_{obtained} = Co_{h} + Co_{W} + Co_{cooking} + Co_{others} \text{ [kWh]} \quad \textbf{(5.11)}$$

Out of the heating period,

$$Co_{obtained} = Co_{W} + Co_{cooking} + Co_{others} \text{ [kWh]} \quad \textbf{(5.12)}$$

The attribution of consumption of the combustible in a determined period can be performed directly by measuring or the data of consumption can be obtained from bills. In the case of using bills, the beginning and ending period of the bill may not be the same as the period of heating. On the other hand, in a determined period, the measurement can be made also by reading the values of combustible from a counter. Instead, the levels of the liquid combustible can be read in a tank in the beginning and end of the period. In this case the consumption is equal to:

$$CQ = (CQ_I - CQ_F) + CQ_A \quad [kWh] \tag{5.13}$$

$CQ_I - CQ_F$ is the difference between the beginning and the end of the period in quantity.

CQ_A is the quantity of combustible that added during the period.

5.2 Turkish Energy Certification System

In Turkey the national policy and objectives for energy usage is determined and applied by Ministry of Energy and Natural Sources and General Directorate of Electrical Power Resources Survey and Development Administration. According to the Ministry, Turkey is importing the 75% of the total energy that is being used. Another important point asserted by the Ministry is that there is the potential of conserving energy 30% in building sector, 20% in industry sector and 15% in transportation sector. Thus the aim of the Ministry is asserted as decreasing the dependence on foreign energy sources, maximum energy efficiency and conservation, mitigate the energy costs in economy and protection of the environment [9]. General Directorate of Electrical Power Resources Survey and Development Administration is working for energy efficiency, increasing the consciousness about energy, conservation and renewable sources and gives courses about energy administration.

Turkey has signed the United Nations Framework Convention on Climate Change (UNFCCC) in 2003 and the Kyoto Protocol in 2009. So it can be said that Turkey was relatively late to take action about climate change and sera gases as well as the current policies are not efficient enough to satisfy the obligations like reduction on 20% of sera gas emissions that Kyoto protocol sets. For the future plans energy sources non-renewable and harmful to environment like nuclear energy plant and new coal based thermic plants are taking places but not any renewable sources.

Although a new evolution and reorganization about environment and ecology is rising among government, business sector, designers and clients.

The relationships between Turkey and European Union have started first in 1959 by the application of Turkey to join. In 1963 the parties has signed the Agreement Creating An Association Between the Republic of Turkey and the European Economic Community and that started the official relations. Turkey has applied for the full membership in 1987 and the application is confirmed in 1990. After signing the Customs Union Agreement in 1995, Turkey was officially recognized as a candidate for full membership in 1999. Finally in 2005, negotiations were started for the full membership. Today Turkey has twinning projects in the adaptation program of European Union. Following the program, in 2007, Turkey has published a new law about energy efficiency and under the obligation of this law the studies about energy certification have begun.

5.2.1 Brief Historical Process of Legislative Base of Energy Certification

Considering that the energy for heating of the buildings constitutes the greatest part of the energy consumption in Turkey, The Institute of Turkish Standards has published the first standard about energy conservation in 1970: TS 825 "The Regulations for Preservations from the Heat Effects on Buildings (Binalarda Isı Etkilerinden Korunma Kuralları)". Then the first revision has been made in 1979 and the title has been changed to TS 825 The Regulation for Thermal Insulation of the Buildings (Binalarda Isı Yalıtım Kuralları). After another revision in 1985, to ensure a better energy conservation, the standard is revised comprehensively and reorganized in 1998. The changes on that revision were:

- Turkey is divided four degree-day regions instead of three like in the previous version.
- In addition to the limits for thermal transmittance values of the building elements, new limits for annual heat losses for buildings are introduced according to the S/V values and degree-day regions.
- The internal and solar heat gains were taken into account.
- In addition to the calculation of the heat losses by transmission, heat losses by ventilation were introduced in the calculation procedure.

- Besides the limits of about energy, the transition of vapor is analyzed and the mass of the condensing water is limited.

By these revisions, The Institute of Turkish Standards has proposed to the Ministry of Public Works and Settlement that the TS 825 to become a compulsory standard. So after the Ministry has decided that the proposal was appropriate, since the year of 1999 the standard is being applied to all buildings.

Last revision of the Standard was made in 2008 according to the Energy Efficiency Law, 2007.

5.2.2 National Laws and Calculation Methodology

5.2.2.1 TS 825 – National Standard – Thermal Insulation Requirements for Buildings, May 2008

TS 825 is a national standard aiming to limit the quantity of energy that is using for the heating of buildings, so increasing the energy efficiency. It sets the calculating methodology for the energy needs for heating of buildings, limit values for heat transmission of the envelope and total heating energy performance limits [24].

The subject of the standard is defined as regulations of calculations for net heating energy need and maximum permissible heating energy values in buildings. After the terms, definitions and symbols part, the scope of the standard is divided in two parts: new and existing buildings. The standard comprise the heating energy calculation method and maximum heat loss limit values for the new constructions and thermal transmittance values for the large scaled renovations, restorations or additions for the existing buildings.

The objections of the standard are set like:

- to limit the heating energy usage, and so to increase the energy conservation,

- to specify the standard calculation method and values for heating energy need,

- to find out the choice with the best energy performance for a new construction by applying the calculation methodology that is specified in this standard to different design alternatives for a building,

- to specify the net heating energy consumptions of the existing buildings,

- to find out the potential energy conservation amounts before the application of a renovation project,

- to predict the future national energy needs.

The building types that this standard will be applied to are:

- Residences,

- Offices and service buildings,

- Hotels and restaurants,

- Buildings for education,

- Theaters and concert halls,

- Quarters,

- Prisons,

- Museums and galleries,

- Airports,

- Hospitals,

- Swimming pools,

- Factories and ateliers,

- Industry buildings with the internal temperature of 15°C.

The general explanations part provides information for the designers and engineers about the importance of the energy conservation, preventions for bad energy performances of the buildings and suggestions for the design of the buildings to decrease the energy consumption. Some of the information is given below:

- Indoor thermal conditions of a building are primarily related with the users' comfort and health.

- The heating energy needs depend on the thermal insulation and thermal mass of the envelope of the buildings.

- Protection of the building from the thermal effects prevent the building envelope from the condensation of water vapor and so prevent the potential damages caused by condensation and decrease the maintenance costs.

- The measures which have been taken in the project phase, such as orientation, the ratio of S/V and the surroundings, can affect the energy need of the building.

- The relation of the building with other buildings and obstructions (shadows, wind, etc.) and the organization of the internal spaces (heated or non heated spaces) of the building affect the energy need.

Furthermore the factors which are affecting the heating energy need of the buildings and which are taken into account for the calculation method in the standard are stated as:

- Characteristics of the building,

- Characteristics of the heating system,

- Internal climatic conditions,

- External climatic conditions,

- Internal heat gain sources,

- Solar heat gains.

Finally, in this part, the exceptions and special situations for some settlements and some types of building are explained about U (thermal transmittance) values and limit values for annual heating energy need.

<u>Calculation Method:</u>

Before explaining the calculation method, the standard provides the basic information to utilize in the calculation steps. The calculation of the resistance of thermal transmittance (R) and thermal transmittance (U) values for one and more than one layered building elements and the calculation of heat loss of the building element are given for primary steps.

Annual heating energy need is defined as the amount of energy that should be provided by the heating system to ensure a pre-defined internal temperature in addition to the internal and solar heat gains and heat losses in a well isolated building. Annual energy need for heating is the sum of the heating energy needs for every month in the heating season. To divide the building into thermal zones, it should be specified the internal temperatures according to the functions of the spaces and if the difference between the temperatures are less than 4K the whole building can be assumed as a one unique zone. The formula for the annual heating energy need is:

$Q_{year} = \Sigma Q_{month}$ **(5.14)**

$Q_{month} = [\ H(\theta_i - \theta_e) - \eta_{month}(\phi_{i,month} + \phi_{s,month})\ ] \ .\ t$ **(5.14a)**

Q_{year} is annual heating energy need (joule)

Q_{month} is monthly heating energy need (joule)

H is specific heat loss of the building (W/K)

θ_i is monthly mean internal temperature (°C)

θ_e is monthly mean external temperature (°C)

η_{month} is monthly mean utilization factor for the gains

$\phi_{i,month}$ is monthly mean internal gains (W)

$\phi_{s,month}$ is monthly mean solar gain (W)

t is time (s)

Afterwards the calculation of the specific heat loss of the building (H) by ventilation and by transmission and internal and solar heat gains are explained in detail.

For the buildings which have more than one zone the standard suggests two different calculation ways. On the first the heating energy needs for every zone should be calculated and then all the results should be summed for total heating energy need. The other suggestion is, however, after specifying the internal temperatures for every zone, the average temperature for the whole building can be use in the calculation of the heating energy needs.

<u>Calculation Report:</u>

For the new buildings or large scaled renovations or restorations of the existing buildings there should be presented ‘the thermal insulation project’ by using the limit values for thermal transmittance and heating energy needs values. In the projects, the material choices, dimensioning the building elements, and building details should be demonstrated. Furthermore in the standard it is asserted that for the calculations and for the report of the project, SI unit system (International System of Units) should be used. In the standard it can be found the detailed list of the information that should be placed in the thermal insulation project. At the end of this part two calculation examples are given to display how to organize the thermal insulation projects and how to use the tables given in the project.

In the annexes of the standard the tables of the limit values of heating energy needs and the thermal transmittance values of the building envelope elements, the internal temperature values for the spaces according to the functions, the mean external temperatures by month and by climatic zones, the climatic zones of Turkey, thermal conductivity values for different materials for the calculation of the thermal transmittance values are given.

Furthermore the calculation method for verification and delimitation of the vapor transition can be found in the annex F. The vapor transition and condensation is defined in the standard as the water vapor in the air moves in the same direction with the heat as a result of pressure differences of the internal and external surfaces of the building envelope, however during this movement if the vapor touches a colder surface, it condenses to water. This colder surface can be the outer surfaces or can be inside of the building element. In every case the water causes to formations of organisms like the mildews or fungous and black stains that threat the human health and comfort and damage the construction system of the buildings and increase the heat losses.

To prevent from the negative effects of the water transition and to evaluation of the water condensation risks the standard propose a calculation method. However in this method the followings are not taking into account:

- Dependence of thermal conductivity on the amount of humidity,
- Hidden heat that is absorbed and released,
- Changing of the characteristics of the materials depending on the amount of humidity,
- Capillary absorption and water transition through materials,
- Air movements in cracks and air sections,
- Hygroscopic moisture capacity of the materials.

Diameters of the building materials, their resistance for heat transfer and water vapor diffusion, material arrangements, heat distribution among the materials, the function of the building and the climatic conditions affects the condensation. Beside these factors, the input data for the calculation are given below:

- The characteristics of the materials: thermal conductivity, resistance factor of water vapor diffusion,
- Internal and external conditions: external air temperatures, temperature of the soil that adjoined to building elements, internal air temperatures, internal and external relative humidity.

Before the calculation, the temperatures of the internal surfaces should be determined. To prevent the mildew and to ensure the comfort conditions, surface temperatures should be maximum 3°C lower than the internal temperatures. By the method that standard suggests (Glaser Method) it should be controlled if there is a condensation in the building envelope elements. If it is discovered that there is a condensation risk on the building element, it should be redesigned and the calculation should be repeated. Additionally the graphics of diffusion flux should be reported and should be added to the thermal insulation project, even if there is no condensation at least for the months of December and January. In the standard an example is given to demonstrate how to arrange the drawings, graphics and tables.

Additionally in the standard it can be found the tables for monthly mean relative humidity values for the cities.

5.2.2.2 Energy Efficiency Law, April 2007

The energy efficiency law has come in to force on 18.04.2007, as a part of the 2003 twinning projects of Turkey for European Union.

The scope of the law is set as to improve the energy efficiency, to prevent the waste of energy, to decrease the energy costs and to increase the efficiency in usage of energy and energy sources to protect the environment. The law comprises the procedures and methods about [25]:

- Production, transmission, distribution and consumption of energy,
- Increasing and supporting the energy efficiency in industrial operations, buildings, electrical energy production facilities, energy transmission and distribution network and transportation,

- Improving the level of consciousness about energy throughout the country,
- Utilization of renewable energy sources.

Under the estimations of this scope, the law stipulates some regulations about,

- Energy directors of the industrial organizations and their education,
- General education and raising the consciousness about the energy effectiveness,
- Energy certification procedure and documentation,
- Economical support to the energy efficiency application and research projects, and employ some ministries to put into practice.

The articles under this chapter declare that a ‘Coordination Commission of Energy Efficiency’ should be constituted to ensure that the labor about energy efficiency is being prosecuted effectively and then to monitor and to coordinate the results. After explaining the participant ministries, foundations and chambers, the law sets the missions, authorities and responsibilities of the commission. Basically the commission will work for projection and coordination of strategies, plans and programs for energy efficiency and evaluation of the effectiveness of the projects in national level.

According to the Law, authorizing the universities, chambers and companies are arranged by these principles:

- General Directorate of Electrical Power Resources Survey and Development Administration, by the ratification of the Coordination Commission of Energy Efficiency, gives authorization to universities and chambers to make education about energy management and energy certification and to give authorizations to the private companies. This authorization is to be renewed every five years.
- General Directorate of Electrical Power Resources Survey and Development Administration or authorized universities and chambers can give authorization to the private companies to perform educations, etudes, counseling and applications of energy manager certification. This authorization is to be renewed every three years.

- The authorized companies, by the etude studies, should prepare and apply the projects for energy efficiency and conservation. In the final measurements of the applied projects, if it can be realized the declared energy efficiency or conservation for three times, the authorization is cancelled for one year.

Educations and consciousness raising actions should be taken to increase the fertility of the energy efficiency projects. According to the law, the education program for the private companies, in government, private and military schools and in military for soldiers should include the theoretic and practical information about the definitions of the terms about energy and energy efficiency, the current general energetic situation of Turkey, energy sources, energy production systems, efficient usage techniques of energy in daily life and climate change. Additionally for the comprehension of the public here are some of the most important services that the law declares:

- General Directorate of Electrical Power Resources Survey and Development Administration is responsible to prepare films and programs for television to increase the consciousness about energy.
- In the user manuals of the energy consuming goods, the energy efficient usage methods should be explained.

Under the "Applications" part it is explained the conditions in which it is compulsory to have an energy manager and energy management department for the industrial organizations. Besides, the law asserts that the main principals about architectural design, insulations, the heating and cooling systems, electricity installations, illumination design and hot water systems of the buildings should be set by another regulation which will be published by the Ministry of Public Works and Settlement. According to the same regulation, an "Energy Identity Document" should also be presented for the buildings to display the energy performance, insulation characteristics, the efficiencies of heating and cooling systems and the energy classification of the building.

Additionally the law declares the other regulations to arrange the principles about the energy efficient applications in electric energy production and distribution plants, transportation and domestic energy consuming products.

The law clarifies also the circumstances for the financial supports which will be make for the energy efficiency application projects, energy density decreasing research and development projects under the part of supports. Additionally, for the energy efficiency application projects, the law employs the Ministry of Energy and Natural Sources to publish a regulation to specify the supports in detail.

In the last chapter, the principles and in which situations they will be applied are explained for the administrative sanctions. After this part the exceptions are specified as the Turkish Armed Forces, the Ministry of National Defense and National Intelligence Organization.

5.2.2.3 Energy Performance Regulation of the Buildings, December 2008

The regulation is published by the Ministry of Public Works and Settlement under the obligation of the Energy Efficiency Law, April 2008 (5627) and the Construction Law (3194) and published in the gazette in 5 December 2008 [26].

The objection of the regulation is to determine a calculation method for the evaluation of the all types of energy consumption of a building and the classification of the energy performance according to the primary energy consumptions and carbon dioxide (CO_2) emissions by taking into account climatic conditions, internal space requirements and cost efficiency. Furthermore for the new buildings and existing buildings that will be renewed in a large scale, the regulation specifies the minimum energy performance requirements, evaluates the feasibility of the renewable energy sources, controls the heating and cooling systems, limits the greenhouse gas emissions, sets the principles of energy performance criteria and applications and ensures to protect the environment.

The regulation comprises these subjects:

- The researches, examinations and evaluations of the experiments about energy performance limits of new and existing buildings, calculation methodology of the energy performance, preparation of the energy identity document, authorization of the individual foundations to certificate and control the buildings and determination of the national energy policy.

- Feasibility studies for the application of the cogeneration system and renewable energy sources on the buildings with the utilization space larger than 1000m^2.
- Performing the consciousness rising educations for users and educating the employee of the private organizations in the energy sector to ensure the efficient usage of the energy.
- Energy efficiency projects of the buildings which are registrated as cultural heritage and applications of these projects without damaging the special characteristics of the buildings.

In the articles 7 and 8 the architectural design and applications are explained in the manner of better energy performance of the building. The principles which are mentioned in the regulation are:

- The energy needs of the heating, cooling and illumination should be kept in a minimum level and natural heating, cooling, ventilation and illumination chances should be profited in a maximum level by taking into account the local settlement, humidity and wind factors.
- The undesirable losses and gains should be minimized by the orientation of the buildings and the spaces according to the meteorological data like solar, wind, humidity and rain of the climate zone. Besides the living areas in the building should be oriented to take optimum sun light and to be ventilated naturally.
- Thermal insulation should be continuous and heat bridges should be prevented.
- The alternatives for architectural design should be developed according to the reports about the potential renewable energy sources of the settlement.

In the fourth chapter the principles for thermal insulation, minimum air circulation and air tightness are explained. The principles for thermal insulation are followings:

- The annual energy need for heating of a building should not exceed the values declared in the standard TS 825 and also the thermal insulation of the envelope of the building should be applied according to the TS 825. The heat bridges should be prevented.

- In the calculation of the energy need for heating for the attached houses the walls in between should be assumed as outside walls. Additionally the thermal transmittance values of the common walls which separate the different user spaces should be lower than 0.80 W/m^2K.
- In the thermal insulation projects heat loss and gains and the ratio of the loss and gains, annual heating energy need, different zones in the building (if there are), the thermal transmittance values of the building envelope elements with materials, details and surface areas, characteristics of the ventilation, calculation of the condensation should be placed.
- Furthermore the pipes, collectors, joints, valves and ducts of the heating, cooling, and ventilation systems and all other mechanical equipment of the domestic hot water production systems must be insulated by thermal and/or sound insulation materials. The details of the insulation principles are explained in the regulation.

In the regulation it is clarified the usage of specific materials to ensure the air tightness at the places where are possible heat losses such as the surfaces like expansion joints, sections or shafts. However to prevent the bad indoor air quality, a minimum air circulation should be provided. The air leakages from the windows and door frames should be calculated taking into account the minimum air circulation needed for user health.

In the chapter five the design and application principles of heating and cooling systems are discussed. Basically, the related standards and norms are stated, the thermal transmittance values and design characteristics of the central and individual heating systems in the buildings are specified. Finally for the application of the heating systems the most important points that expressed are:

- The fresh air supply and ejection of exhaust air,
- The regular inspections of the system performance, efficiency of the system and analysis of the chimney gases.

For the cooling systems also, the requirements, the principles and the necessary inspections are explained.

The principles about ventilation and air conditioning are taking part in this chapter. Besides the related standards and norm about the subject, the fundamental points are humidification of the places, mechanical ventilation systems for non residential buildings. Furthermore the heat recuperation systems and minimum efficiency requirements for the new constructions are explained. Finally the conditions for the inspections, tests and maintenance services are stated.

The chapter sets the crucial points about the sanitary hot water production systems. These points can be summed as:

- The related standards and norms,
- Optimum economic and hygienic resolutions,
- The design principles for non residential but vacation buildings,
- Individual and central systems.

Automatic control systems are enforced to assist the systems, to increase the efficiency and to facilitate the inspections basically in these situations:

- With the gas or liquid fueled boilers,
- In non residential buildings, to control and to set the different temperatures for different spaces, to control the illumination levels according to the daylight,
- In residential buildings to ensure the minimum outgoing water and outdoor air compensation for the boilers ,
- To ensure the automatic run of the circulation pumps of the sanitary hot water systems,
- For the new constructions, to provide the energy consumptions of each system separately.

In the ninth chapter the basic principles for the energy efficiency of electrical installations and illumination systems are explained as:

- Manual control panels should be used to allow the users to achieve an optimum illuminance level,

- The systems with the movement, heat and light sensors should be used to shut down the illumination systems when there is nobody in a space and to prevent the unnecessary usages,
- Time-regulated or daylight dependent keys should be used to maximize the daylight usage,
- The illumination armatures should be placed to achieve a homogenous illumination levels and should be chosen energy efficient to ensure the minimum energy consumption,
- The light colors of furniture and walls should be preferred to help increasing illuminance levels with fewer armatures.

In this chapter the usage of renewable energy sources are reported. According to the standard,

- For every new construction with more than $1000m^2$ usage area, the designers should prepare a report about the potential renewable energy sources.
- If the first investment costs (opportunity costs) can be re-purchased in 10 years for the buildings less than $2000m^2$ or in 15 years for the buildings more than $2000m^2$, it is obligatory to construct these renewable systems.
- The obligatory conditions about heat pumps and sun collectors are set.
- The ventilation systems in the non-residential buildings should be assisted by natural ventilation systems to increase the efficiency.
- In case of the usage of the geothermal energy, the return water of the heating system should be send back to the geothermal source.

In this chapter it is stated that for all the mechanical systems for heating, cooling, ventilation, electricity, illumination and hot water a report that defines the periodic maintenances should be prepared by the body which is responsible for the energy identity document.

These principles are determined for the energy identity document:

- The energy identity documents are prepared according to the EN15217 standard and they will be valid for 10 years.

- The energy identity document is prepared for the existing building which has at least 1000m^2 of usage area and for the new buildings and the document should be used together with the permission of building usage document.
- One copy of the energy identity document should be placed in the entrance of the building to be seen easily by public and in the cases of sell or rent it should be given to the new user or energy manager.
- In a case of an application that changes the annual energy need of the building, the energy identity document should be renewed.
- Energy identity document can be prepared for the whole building or for separate parts of different usage areas.
- The methods for the surface area calculation, energy transformation coefficients, transformations of final energies to primary energies, final energy consumptions, coefficients of sera gas emission transformations and carbon dioxide emissions should be placed as annexes of the energy identity document.

The data that should be placed in the energy identity document are (Figure 5.2):

- General information about the building,
- Usage area of the building (m^2),
- Function of the building,
- Energy amount for heating, cooling, conditioning, ventilation and sanitary hot water (kWh/year),
- Annual primary energy amounts depending on every different energy type (kWh/year),
- Classification of annual primary energy consumption of the building between the reference values from A to G (Figure 5.3),
- Annual sera gas emissions (kg CO_2/m^2-year) and classification between the reference values from A to G (Figure 5.4),
- Energy consumption amount for illumination.

ENERJİ KİMLİK BELGESİ

Belge No :
Bina tipi :
İnşaat yılı :
Kapalı Kullanma alanı:
Ada, Parsel :
Adres :

Tarih :
Belgeyi Düzenleyen :
Oda Sicil No :
Belgenin Son Geçerlilik Tarihi :
İmza :

Mülk sahibi:
İsim:
Adres:

Müşterek tesisatların sahibi (gerekliyse):
İsim:
Adres:

Enerji tipine göre yıllık tüketimler

	Nihai Enerji tüketimleri	Birincil Enerji tüketimleri
Enerji Kullanım Alanı	kW saat	kW saat
Isıtma :		
Sıhhi sıcak su :		
Soğutma :		
Aydınlatma :		
TOPLAM :		

Isıtma, sıhhi sıcak su üretimi, soğutma ve aydınlatma için enerji tüketimleri (birincil enerji olarak)	Isıtma, sıhhi sıcak su üretimi, soğutma ve aydınlatma için sera etkisi gazı (SEG) emisyonları
Nihai tüketim: …………kWsaat/ m².yıl	Emisyon salımı: ……………..kg $_{eşd.}$ CO_2 / m².yıl

Figure 5.2: Energy identification document

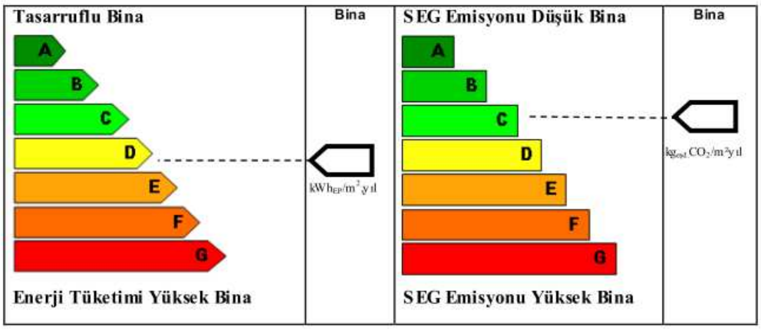


Figure 5.3: Energy certification document

In the calculations of the annual energy need of the building, the energy consumptions for heating, cooling, sanitary hot water and illumination should be taken into account. Furthermore the relative standards about the calculations of heating, cooling, illumination and sanitary hot water systems are stated here.

Finally in the annexes minimum insulation thicknesses for the heating and sanitary hot water installations, illumination sources for the general illumination, example of energy identity document, references of primary energy and sera gases according to the climatic zones, the values of energy classes for primary energy consumption and sera gases emissions by final energy consumptions, sera gases transformation coefficients according to the primary energy types, thermal insulation application examples can be found.

6. EVALUATION OF TURKISH AND ITALIAN ENERGY CERTIFICATION SYSTEM THROUGH A CASE STUDY

6.1 Energy Performance Certification Process for Buildings

The calculations that are defined by standards and regulations are to find out the energy performance of the building. Afterwards to comprehend and to compare the energetic situation of the buildings, the certification of the energy performance of the buildings shall be used. At this point it is important to make a difference between determining the energy performance and labeling the energy performance. As the energy diagnosis is a part of the certification, it is defined as a qualification of the potential abnormalities and possible optimizations of the "building system" by comparing the obtained or calculated primary energy efficiency characteristics of the building and its plants with an energy efficient building [11]. The energy certification is a final document to highlight the results of diagnosis and reference values.

Energy performance certification is a complicated and effortful process as it bases on numerous calculations. However one of the scopes of the energy certification is to be easily accessible to inform the users about the energetic situation of the building. Hence it may be needed to develop some tools that use some basic data from the building and pre-determined values to evaluate the energy certification. While expertization is needed for energy diagnosis, the energy certification shall be performed easily also by the users.

Furthermore, certificating energetically existing buildings and new buildings differs depending on some aspects. First of all, the valid laws and regulations in the date of design and construction affect the energy performance through material usage, construction details, thermal transmittance values, HVAC systems, and their efficiencies. Secondly, obtaining the actual data of the envelope, HVAC systems, etc. of an existing building may be rather difficult. For these reasons, it should be differentiated the certification of new and existing buildings.

It is also important to be differentiated the certification procedure for different types of buildings. The function of the building affects the expected comfort conditions and user habits and so the characteristics of lighting, ventilation, heating, cooling, etc.

Finally it has a significant value to certificate existing buildings to see the current situation of the buildings energetically all over the country. What's more, the certification document involves some suggestions for improvement of the energy efficiency and possible interventions, so it may be obtained the total potential profit of individual energy efficiency development operations through a country. Thus energy certification of existing building stock may affect also the energy politics and objectives of the country.

DOCET is one of the tools developed for energy certification in Italy. As Turkey continues to develop its own national program for the energy certification in the meantime of the research of this thesis, for the case studies DOCET is used.

6.2 DOCET

DOCET is a software program that is used to analyze and perform the energy certification for the existing buildings in Italy. It was developed by ITC-CNR (Istituto per le Tecnologie della Costruzione – Consiglio Nazionale delle Ricerche / Construction Technologies Institute – Italian National Research Council) and ENEA (Ente per le Nuove Tecnologie, l'Energia e l'Ambiente / Italian National Agency for New Technologies, Energy and the Environment). DOCET is a simple program which is based on Italian national calculation methodology (UNI/TS 11300) for energy certification of the buildings. It only makes calculations for existing residential buildings and has two options for family houses or apartments (Figure 6.1).

Figure 6.1: First page of DOCET

DOCET makes the calculations according to the steady-state conditions and it has basically five parts that are divided in sub-parts like:

1. Net Energy

- Data of Context: Data about location of the building. By choosing the province and the city, program determines the climatic zone and degree-day of the site.
- Data of the Building: the year of construction, color of the outer surface, bearing construction typology, important renovations or restorations and the data about the geometry and orientation of the building.
- Non-heated volumes: data about the volumes that are not heated, if there is.
- Opaque Envelope: the transmittance values of the opaque parts of the envelope.
- Transparent Envelope: the transmittance values and areal ratio of the transparent parts of the envelope.

Entering these data gives the results about net energy needs for heating, cooling, domestic hot water and electricity.

2. Supplied Energy

- Heating: data about heating system of the building.

- Sanitary Hot Water: data about sanitary hot water production system.
- Electricity Usage: data about usage of electricity

Entering these data gives the results about supplied energy for heating, domestic hot water and electricity.

3. Primary Energy

- Heating Plant: data about the combustible that is used in the heating system.
- Domestic Hot Water Plant: data about the combustible that is used in the hot water system.
- Final Useful Energy

Entering these data gives the results about total primary energy usage, non-renewable primary energy usage and carbon dioxide emissions.

DOCET performs the certification for existing buildings for heating conditions according to the national calculation methodology. However it gives results for energy needs of heating, cooling, hot water, and electricity; supplied energy for heating, hot water, and electricity; total and non-renewable primary energy uses and carbon dioxide emissions by using pre-defined data in respect of the data entered. The data it requires are basically for the physical definition of the building to specify the heated volume. Defining the location of the building allows the program to use the climatic data and thermal transmittance values and the ratio of the opaque and transparent parts of the envelope are necessary for the basic calculations. For the calculations of primary energy need for heating and domestic hot water production systems, the type of the system and also the distribution sub-system should be defined.

Finally, DOCET forms out the energy certification according to the non-renewable primary energy need and CO_2 emissions.

In the following figure (Figure 6.2), the Italian Energy Performance Methodology and DOCET's calculation methodology can be seen as steps. Obviously DOCET's calculation steps are less as it is a simplified tool. As the colors indicate the similar data and calculation steps between two approaches, it can be seen also that DOCET does not provide a complete energy diagnosis.

UNI 11300		DOCET
1. Collecting data about the building	4. Calculation of primary energy need	1. Net Energy
2. Definition of borders of the spaces air conditioned and non-conditioned.	4.1. Calculation of primary energy need for heating	Data of Context: Data about location of the building. By choosing the province and the city, program determines the climatic zone and degree-day of the site.
3. Definition of the zones in the building	4.1.1. Calculation of primary energy need of every subsystem of the heating system	Data of the Building: the year of construction, color of the outer surface, bearing construction typology, important renovations or restorations and the data about the geometry and orientation of the building.
4. Definition of internal temperatures	4.1.2. Calculation of electrical energy need of every subsystem of the heating system	Non-heated volumes: data about the volumes that are not heated, if there is.
5. Definition of the time intervals / durations of the heating and cooling periods	4.1.3. Calculation of the energy losses of every subsystem of the heating system / system efficiency	Opaque Envelope: the transmittance values of the opaque parts of the envelope.
6. Calculation of thermal transmittance of opaque and transparent elements of the envelope	4.1.4. Calculation of the recoverable and recovered energy losses of every subsystem of the heating system	Transparent Envelope: the transmittance values and areal ratio of the transparent parts of the envelope.
7. Calculation of energy need for heating for every zone and for every month	4.1.5. Calculation of the useful energy need	2. Supplied Energy
8. Calculation of thermal bridges	4.1.6.	Heating: data about heating system of the building.
9. Calculating the utilization factors of heat exchange to obtain dynamic results	4.2. Calculation of primary energy need for cooling	Sanitary Hot Water: data about sanitary hot water production system.
10. Calculation of thermal capacity of the building	4.3. Calculation of primary energy need for domestic hot water	Electricity Usage: data about usage of electricity
	4.4.	3. Primary Energy
7. Calculation for heating energy need	• Calculation for cooling energy need	Heating Plant: data about the combustible that is used in the heating system.
		Sanitary Hot Water Plant: data about the combustible that is used in the hot water system.
1. Calculation of heat exchange for heating		Griglia Energetica
1.1. Calculation of global coefficients of heat exchange, H		
1.2. Calculation of the form factor between the building and open air, F		
1.3. Calculation of the extra thermal flow by infrared radiation towards open air, Φ		
2. Calculation of heat exchange by ventilation		
3. Calculation of heat losses and gains		
3.1. Calculation of heat gains		
3.1.1. Calculation of internal and solar heat gains		
• Calculation of reduction factors for the spaces con conditioned, b		
• Calculation of thermal flow from the internal heat source and sun, Φ		
• Calculation of reduction factor for shading, effective solar capturing area and monthly mean solar radiation		
• Solar energy transmittance value of the transparent element, ratio of the areas of the glass and frames, total window area		
• Solar absorption factor of the opaque element, thermal resistance and thermal transmittance values of the opaque element, and total area		
3.2. Calculation of heat losses		
3.2.1. Calculation of utilization factors for heat losses		

Figure 6.2 : Calculation steps proposed by the standard UNI/TS 11300 and the steps of DOCET

6.3 A Case-Study by DOCET

6.3.1 Introduction

A comparison study had been performed with the example buildings for Italy and Turkey to understand the working principles of DOCET. It has a significant value to see the opportunities of such a software for the certification studies in Turkey. As DOCET is developed for Italy, it can be obtained a background for the similar certification tools by running it for Turkish conditions.

For the study a single family house and an apartment building example, that are projected and constructed recently in Turkey in the degree-day zone 2, were chosen, so both of them are proper to the current laws and standard of Turkey. However in the study, these buildings are assumed to be placed in different cities in Italy and Turkey. In each country two different climatic zones from two different cities, Istanbul and Ankara from Turkey and Bari and L'Aquila from Italy, were chosen and the comparisons are made between the cities with similar climatic data, between Istanbul and Bari, and between Ankara and L'Aquila.

6.3.2 Selection of the Cities

The cities are chosen from Turkey and Italy according to their similar degree-day values and daily mean temperature values.

Below it is given the zones, degree days, and thermal transmittance values for Italy (Figure 6.3 and Table 6.1, Table6.2, Table 6.3, Table 6.4, Table6.8) and Turkey (Figure 6.4 and Table 6.5, Table 6.6).

Figure 6.3: Degree day zones of Italy

Table 6.1: Energy performance limits for residential buildings (kWh/m²) in Italy

Building form factor S/V	Climatic Zones A		B		C		D		E	F
	Up to 600 DD	from 601 DD	to 900 DD	from 901 DD	to 1400 DD	from 1401 DD	to 2100 DD	from 2101 DD	to 3000 DD	beyond 3000 DD
≤0,2	10	10	15	15	25	25	40	40	55	55
≥0,9	45	45	60	60	85	85	110	110	145	145

Table 6.2: Thermal transmittance limit values of **opaque vertical surfaces** for Italy

CLIMATIC ZONES	from 1st January 2006 U (W/m²K)	from 1st January 2008 U (W/m²K)	from 1st January 2010 U (W/m²K)
A	0,85	0,72	0,62
B	0,64	0,54	0,48
C	0,57	0,46	0,40
D	0,50	0,40	0,36
E	0,46	0,37	0,34
F	0,44	0,35	0,33

Table 6.3: Thermal transmittance limit values of roofs for Italy

CLIMATIC ZONES	from 1st January 2006 U (W/m²K)	from 1st January 2008 U (W/m²K)	from 1st January 2010 U (W/m²K)
A	0,80	0,42	0,38
B	0,60	0,42	0,38
C	0,55	0,42	0,38
D	0,46	0,35	0,32
E	0,43	0,32	0,30
F	0,41	0,31	0,29

Table 6.4: Thermal transmittance limit values of basements for Italy

CLIMATIC ZONES	from 1st January 2006 U (W/m²K)	from 1st January 2008 U (W/m²K)	from 1st January 2010 U (W/m²K)
A	0,80	0,74	0,65
B	0,60	0,55	0,49
C	0,55	0,49	0,42
D	0,46	0,41	0,36
E	0,43	0,38	0,33
F	0,41	0,36	0,32

Table 6.5: Thermal transmittance limit values of vertical windows for Italy

CLIMATIC ZONES	from 1st January 2006 U (W/m²K)	from 1st January 2008 U (W/m²K)	from 1st January 2010 U (W/m²K)
A	5,5	5,0	4,6
B	4,0	3,6	3,0
C	3,3	3,0	2,6
D	3,1	2,8	2,4
E	2,8	2,4	2,2
F	2,4	2,2	2,0

The chosen cities in Italy for the case study are Bari and L'Aquila. Bari is located in climatic zone C (degree days between 900 and 1400) and L'Aquila is located in climatic zone E (degree days between 2000 and 2500).

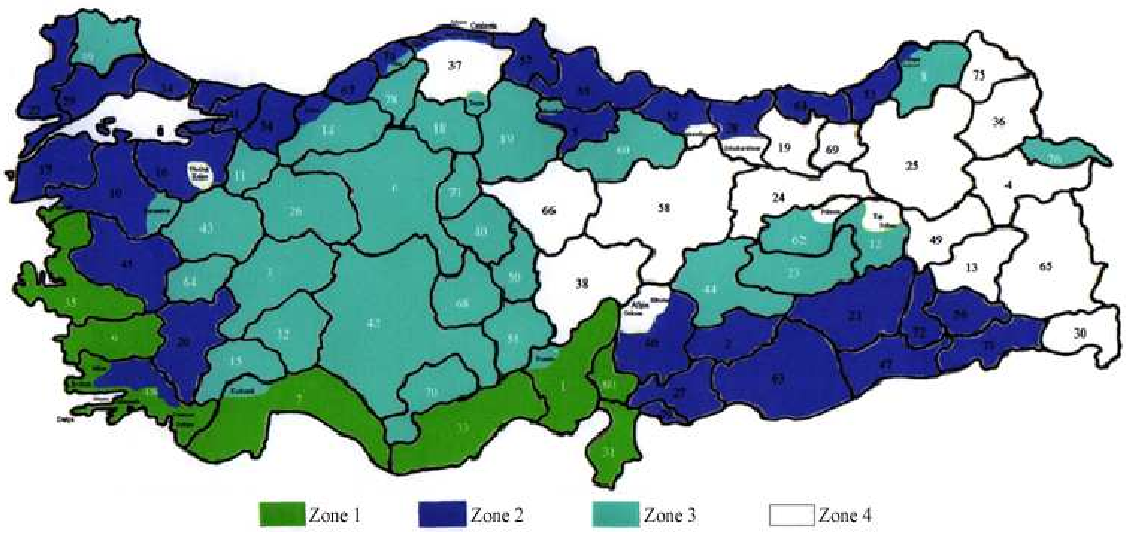


Figure 6.4: Degree day zones of Turkey

Table 6.6: Energy Performance limits (kWh/m^2) for year in force since 22 May 2008 in Turkey

Building Form Factor (S/V)	CLIMATIC ZONES 1 Up to 1500 DD	2 From 1500DD to 2250DD	3 From 2250DD to 3000DD	4 Beyond 3000DD
S/V < 0,2	19,2	38,4	51,7	67,3
S/V < 1,05	56,7	97,9	116,5	137,6

Table 6.7: Limit values of the thermal transmittance for Turkey

	U_{wall} (W/m²K)	U_{roof} (W/m²K)	$U_{basement}$ (W/m²K)	U_{window} (W/m²K)
ZONE 1	0,70	0,45	0,70	2,4
ZONE 2	0,60	0,40	0,60	2,4
ZONE 3	0,50	0,30	0,45	2,4
ZONE 4	0,40	0,25	0,40	2,4

The chosen cities in Turkey for the case study are Istanbul and Ankara. Istanbul is located in climatic zone 2 (degree days between 1500 and 2250) and Ankara is located in climatic zone 3 (degree days between 2250 and 3000).

According to the energy performance limit values depending on S/V values for Italy (Table 6.1) and Turkey (6.6), the values of Turkey are more restrict. For example, as for the Zone E in Italy the limit values are changing from 110kWh/m^2 to 145kWh/m^2, the third zone of Turkey, with the similar degree-day values to the Zone E, has a lower limit value of 116,5kWh/m^2.

Comparison of the daily mean temperatures of the chosen cities: Mean temperature values of Bari (Table 6.8) are changing between 8°C and 24,5°C and the values for Istanbul (Table 6.9) are very similar to Bari. Then if we compare the mean temperature values of L'Aquila (Table 6.8) which are changing from 2°C to 22°C, the values for Ankara (Table 6.10) are very similar changing from -3°C to 23°C.

Table 6.8: Monthly average values of daily mean external air temperatures for the cities in Italy

N°	Sigla Provincia	Località	Altitudine m	GEN. °C	FEB. °C	MAR. °C	APR. °C	MAG. °C	GIU. °C	LUG. °C	AGO. °C	SET. °C	OTT. °C	NOV. °C	DIC. °C
1	AG	Agrigento	230	10,4	10,8	12,7	15,6	19,4	24,1	26,9	26,5	24,0	19,9	15,9	12,2
2	AL	Alessandria	95	0,0	2,8	8,1	13,1	17,3	22,0	24,7	23,6	19,9	13,1	6,9	1,9
3	AN	Ancona	16	6,3	7,1	9,9	13,4	17,0	21,8	24,4	24,1	21,3	16,5	12,1	7,8
4	AO	Aosta	583	−0,3	2,6	6,7	11,0	14,7	18,7	20,5	19,4	15,9	10,3	4,8	0,8
5	AP	Ascoli Piceno	154	5,5	6,6	9,5	13,3	17,2	21,7	24,4	24,3	21,1	15,8	10,9	7,0
6	AQ	L'Aquila	714	2,0	3,0	7,1	11,4	15,0	19,1	22,0	21,8	18,6	13,1	8,2	3,8
7	AR	Arezzo	246	5,1	5,9	9,2	12,6	16,4	20,9	24,0	23,4	20,3	15,0	10,2	6,1
8	AT	Asti	123	−0,4	2,7	7,9	13,0	17,0	21,6	24,2	22,9	18,9	12,7	6,1	1,3
9	AV	Avellino	348	5,5	6,5	8,8	12,4	16,0	20,3	23,1	22,6	19,6	14,8	10,4	6,8
10	BA	Bari	5	6,6	9,2	11,1	14,2	18,0	22,3	24,7	24,5	22,0	17,9	14,0	10,2
11	BG	Bergamo	249	3,1	4,9	8,9	13,3	17,0	21,3	23,7	23,2	19,9	14,2	8,6	4,5
12	BL	Belluno	383	0,1	2,3	6,8	11,2	14,9	18,9	21,2	20,8	17,7	12,4	6,5	1,7
13	BN	Benevento	135	6,8	7,7	10,3	13,7	17,5	22,1	24,8	24,3	21,4	16,5	12,1	8,0
14	BO	Bologna	54	2,1	4,6	9,4	14,2	18,2	22,9	25,4	24,9	21,2	14,9	8,7	4,0
15	BR	Brindisi	15	9,3	9,6	11,4	14,2	18,0	22,0	24,5	24,5	22,1	18,3	14,4	10,9
16	BS	Brescia	149	1,5	4,2	9,3	13,5	17,7	22,0	24,4	23,7	19,9	14,0	7,8	3,5
17	BZ	Bolzano	262	1,2	4,2	9,0	13,4	16,9	21,0	22,7	22,0	18,8	12,9	6,7	2,2
18	CA	Cagliari	4	10,3	10,8	12,8	15,1	18,4	22,9	25,5	25,5	23,3	19,4	15,5	11,7
19	CB	Campobasso	701	3,7	4,8	7,3	11,1	14,8	19,6	22,5	22,2	18,9	13,5	9,0	5,0
20	CE	Caserta	68	8,7	9,4	12,0	15,3	19,1	23,5	26,2	26,1	23,0	18,2	13,9	10,3

Table 6.9 : Monthly mean temperatures of Istanbul

ISTASYON ADI : GOZTEPE/ISTANBU
ISTASYON NO : 17062

AYLIK ORTALAMA SICAKLIK (øC)

YIL	OCAK	SUBA	MART	NISA	MAYI	HAZI	TEMM	AGUS	EYLU	EKIM	KASI	ARAL
1996	4.9	5.7	5.3	10.0	19.1	21.5	23.8	23.9	19.2	14.2	12.3	10.1
1997	6.9	5.4	6.1	9.2	16.7	21.4	23.8	21.6	17.5	14.2	11.9	8.8
1998	6.9	6.9	6.2	14.2	16.6	22.5	24.4	25.1	20.4	16.9	11.8	6.7
1999	7.2	6.8	9.1	14.4	17.5	21.9	25.4	24.5	20.7	16.2	11.5	10.8
2000	3.5	6.5	7.7	14.3	16.7	21.1	25.1	24.1	20.7	15.3	13.6	9.6
2001	8.6	8.0	12.7	13.6	16.8	21.8	26.1	25.1	21.5	16.6	10.9	5.0
2002	4.9	8.9	9.4	11.1	16.9	22.7	26.6	24.6	20.4	16.2	12.7	6.2
2003	7.8	2.7	4.9	9.8	18.1	23.1	25.1	25.5	19.5	16.3	10.8	7.8
2004	5.3	5.9	8.4	12.2	16.4	21.4	23.7	23.6	20.9	17.3	12.1	8.5
2005	7.1	6.1	7.5	12.4	16.4	20.6	24.3	25.2	21.1	14.7	10.5	8.8
2006	4.4	5.8	8.6	12.8								

Table 6.10 : Monthly mean temperatures of Ankara

ISTASYON ADI : ANKARA
ISTASYON NO : 17130

AYLIK ORTALAMA SICAKLIK (øC)

YIL	OCAK	SUBA	MART	NISA	MAYI	HAZI	TEMM	AGUS	EYLU	EKIM	KASI	ARAL
1995	3.3	5.2	6.7	9.9	17.6	21.8	20.8	23.4	19.0	11.6	3.4	2.9
1996	1.8	4.8	3.8	9.3	17.9	20.2	25.2	23.4	17.3	11.5	8.0	6.5
1997	2.3	0.7	3.4	7.5	17.4	20.2	22.7	20.8	15.9	12.9	7.2	3.6
1998	2.1	3.2	3.9	13.5	16.0	20.2	24.6	25.2	19.3	14.5	8.5	4.5
1999	3.3	3.3	6.6	12.1	16.9	20.0	24.4	23.8	18.8	13.9	6.7	5.0
2000	−3.4	−1.1	4.5	13.0	15.5	19.8	26.5	22.8	18.9	12.2	8.7	2.2
2001	3.0	4.1	11.5	12.6	14.8	21.9	26.3	24.7	20.8	13.2	6.9	2.5
2002	−3.8	5.0	8.6	10.4	16.7	20.8	24.8	22.5	18.3	13.3	8.0	−0.8
2003	5.4	−0.3	3.2	10.3	19.0	22.6	23.5	24.3	18.0	14.4	8.0	1.9
2004	0.2	2.4	7.2	11.5	15.8	20.0	23.6	22.9	19.3	14.2	7.2	2.3
2005	3.5	2.5	6.1	11.6	16.6	19.5	25.0	25.4	18.7	10.8	6.1	3.0
2006	−1.7	0.4	7.5	13.1								

6.3.3 Example Projects

There are two example projects that are used in DOCET. One is a single family house and the other is an apartment. Followings are the details about the project which were required by DOCET.

- Family House (Figure 6.5, Figure 6.6 and Figure 6.7)

It is a three storey house assumed to be located in countryside. The building's southern façade is the most transparent one and the outer color of the building is light. The heating system and domestic hot water production system are the same plant which uses natural gas (methane). The basement and the stare hole are not conditioned.

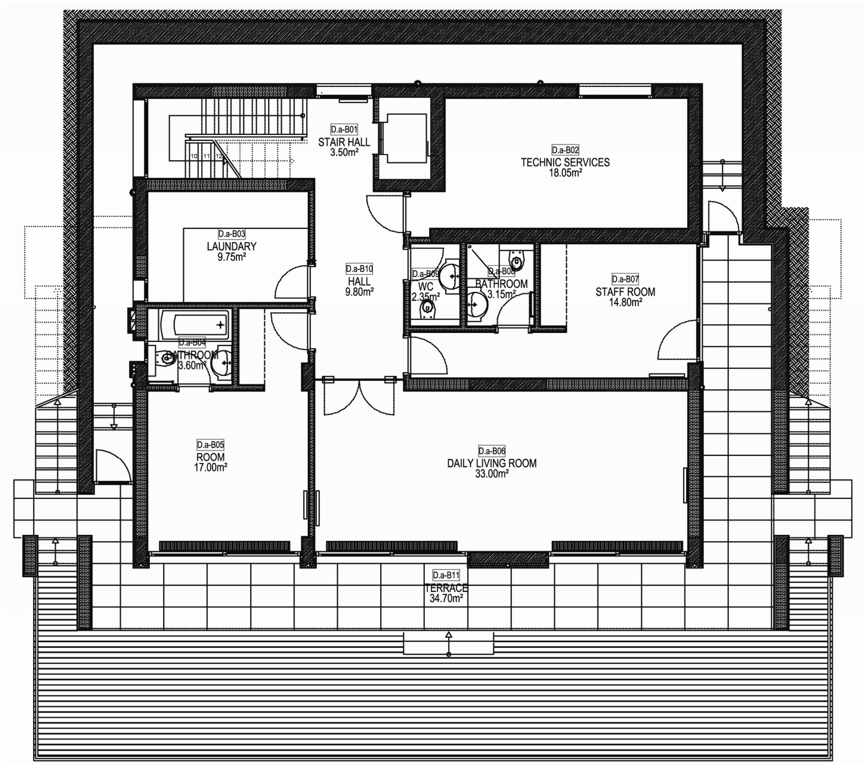


Figure 6.5: Basement floor plan of single family house

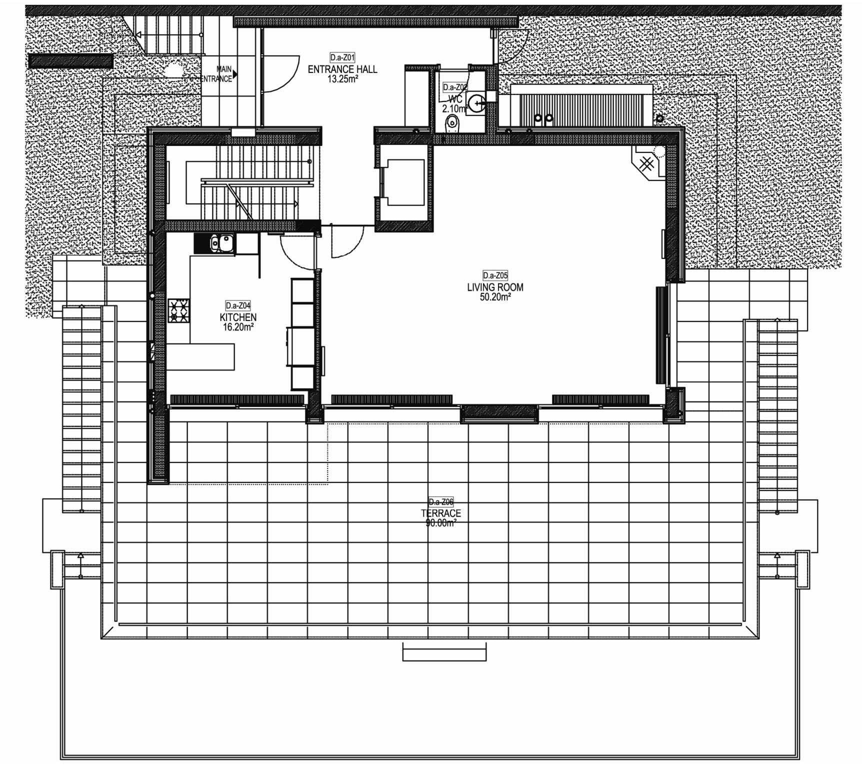


Figure 6.6: Ground floor plan of single family house

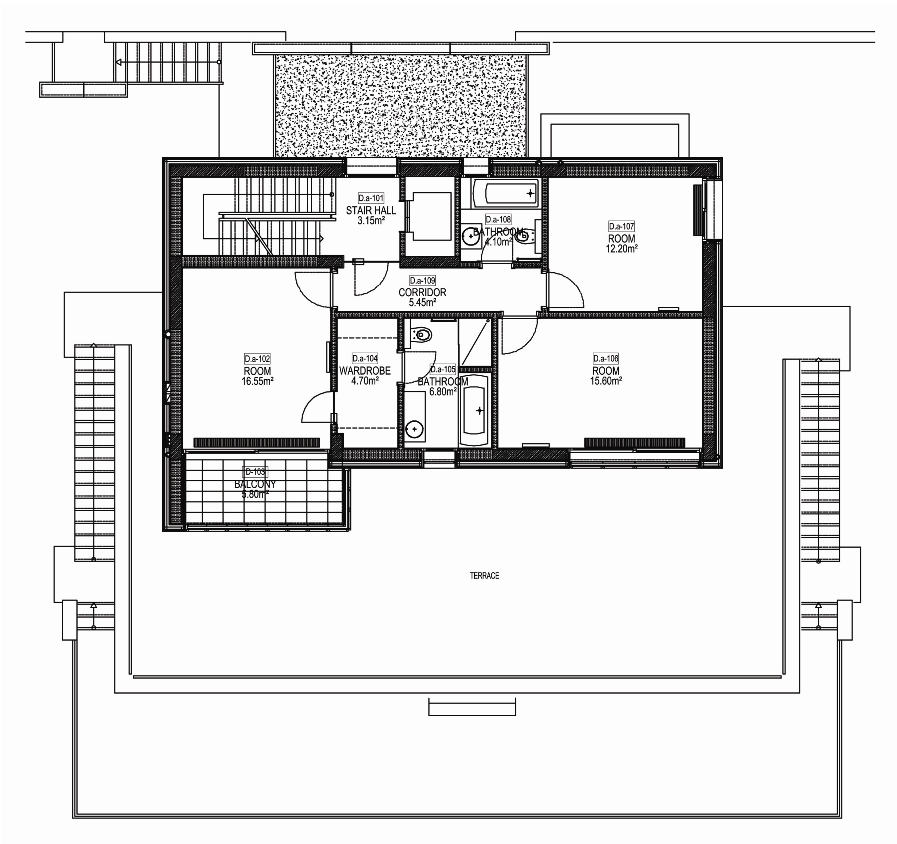


Figure 6.7: First floor plan of single family house

- Apartment Block (Figure 6.8)

It is a multi-storey building which has two individual apartments on every storey. These two individual parts are oriented West and East. For the DOCET application the apartment that is oriented to East on the 4th floor is chosen. The heating system and domestic hot water production system are the same plant which uses natural gas (methane) and it is unique for the whole building.

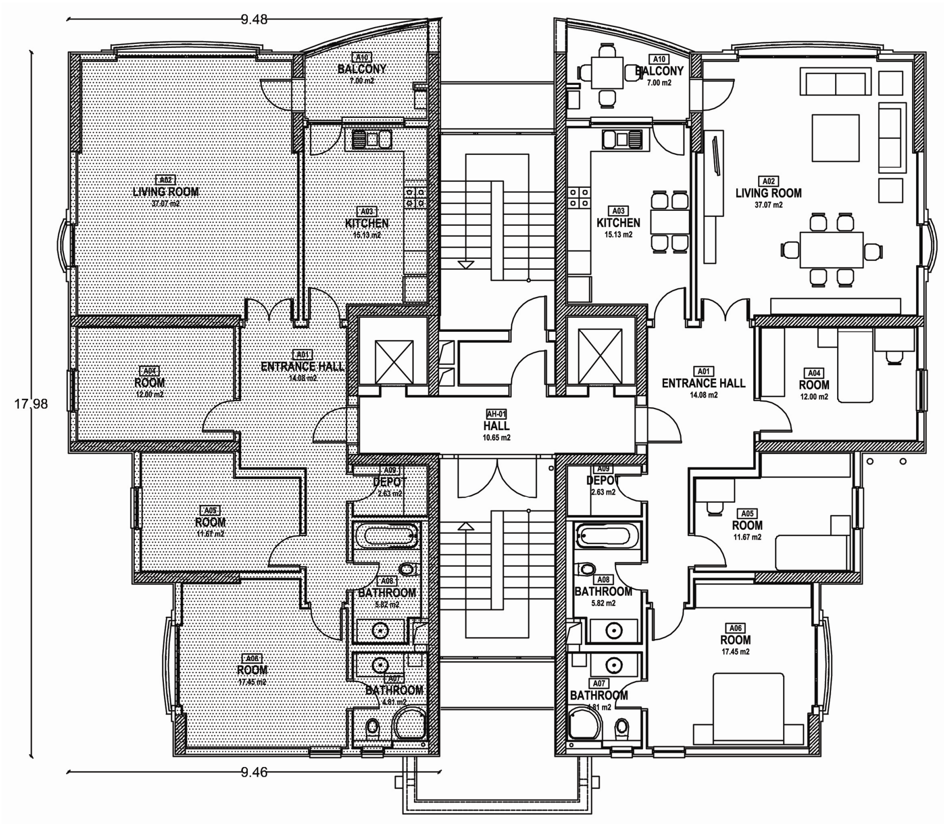


Figure 6.8: Floor plan of the apartment

6.3.4 Application of DOCET

The DOCET is performed for 16 cases: for two projects, four cities and two different types of heating system. After determination of the cities and matching (Bari with Istanbul and L'Aquila with Ankara), the thermal transmittance values of the envelope elements are assumed to be proper to the national laws for both countries and degree-day zones, so the values on the laws are used in the program. For the heating system, boiler and heat pump were chosen as they are the most common heating plants in Italy and Turkey. The domestic hot water production is assumed that it is being provided from the same plant as heating system in every case.

6.3.5 Results

DOCET gives results for energy needs of heating, cooling, hot water, and electricity; supplied energy for heating, hot water, and electricity; total and non-renewable primary energy uses and carbon dioxide emissions. After all, it gives the certification results with all the values that are mentioned before.

The results of calculation are shown in the tables below:

Table 6.11: Delivered Energy Needs for Single Family House

	Building Type	Heating Plant Type	Delivered Energy Need for Heating kWh/m^2	Delivered Energy Need for Hot Water kWh/m^2	CO_2 emissions kg/m^2	Energy Class
Istanbul	single family	boiler	55,4	15,9	11,2	**E**
Bari	single family	boiler	48,7	15,9	9,8	**E**
Istanbul	single family	heat pump	25,1	6,7	5,1	**B**
Bari	single family	heat pump	20,6	6,7	4,2	**B**
Ankara	single family	boiler	112,6	15,9	22,7	**E**
L'Aquila	single family	boiler	101	15,9	20,4	**E**
Ankara	single family	heat pump	47,5	6,7	9,6	**B**
L'Aquila	single family	heat pump	42,6	6,7	8,6	**B**

Table 6.12: Delivered Energy Needs for Apartment

	Building Type	Heating Plant Type	Delivered Energy Need for Heating kWh/m^2	Delivered Energy Need for Hot Water kWh/m^2	CO_2 emissions kg/m^2	Energy Class
Istanbul	apartment	boiler	45,9	18,6	9,3	**E**
Bari	apartment	boiler	38,4	18,6	7,8	**D**
Istanbul	apartment	heat pump	19	7,7	3,8	**B**
Bari	apartment	heat pump	15,9	7,7	3,2	**A**
Ankara	apartment	boiler	90,2	18,6	18,2	**E**
L'Aquila	apartment	boiler	74,7	18,6	15,1	**D**
Ankara	apartment	heat pump	37,3	7,7	7,5	**B**
L'Aquila	apartment	heat pump	30,8	7,7	6,2	**A**

In both tables, for single family house and apartment unit, nearly similar results can be observed: the thermal transmittances of the building envelope affect the energy consumption and so this may change the energy class. This effect can be seen in the Table 6.11 and Table 6.12 between the results of the cases with the same heating system. Because of the higher thermal transmittance values for Turkish cities, the energy needs and CO_2 emissions are higher. On the other hand, Italy has lower thermal transmittance values, and beginning from 2010, the limit values will be even lower. So this causes lower energy consumption and better energy classes compared to Turkey cases.

However the software, at this stage of implementation, does not use any conversion factor from delivered energy to primary energy, as it is developed for the whole country, since each region should fix its own conversion factors.

In Italy, the typical conversion factors are,

For methane f_{CH4} = 1.1 kWh_{pe} /kWh_{CH4} (Boiler)

For electricity $f_e \cong 2$ kWh_{pe}/kWh_e (Heat Pump)

For Turkey cases, the conversion factors are,

For methane f_{CH4} = 1 kWh_{pe} /kWh_{CH4} (Boiler)

For electricity f_e = 2.9 kWh_{pe}/kWh_e (Heat Pump)

By using these conversion factors the tables for Primary Energy Need for Heating and Energy Classes should be like below:

Table 6.13: Primary Energy Needs for Single Family House

	Building Type	Heating Plant Type	Primary Energy Need for Heating kWh/m^2	Primary Energy Need for Hot Water kWh/m^2	CO_2 emissions kg/m^2	Energy Class
Istanbul	single family	boiler	**55,4**	15,9	11,2	**E**
Bari	single family	boiler	**53,6**	15,9	9,8	**E**
Istanbul	single family	heat pump	**73,1**	6,7	5,1	**F**
Bari	single family	heat pump	**41,2**	6,7	4,2	**D**
Ankara	single family	boiler	**112,6**	15,9	22,7	**E**
L'Aquila	single family	boiler	**111,1**	15,9	20,4	**E**
Ankara	single family	heat pump	**137,8**	6,7	9,6	**F**
L'Aquila	single family	heat pump	**85,2**	6,7	8,6	**E**

Table 6.14: Primary Energy Needs for Apartment

	Building Type	Heating Plant Type	Primary Energy Need for Heating kWh/m^2	Primary Energy Need for Hot Water kWh/m^2	CO_2 emissions kg/m^2	Energy Class
Istanbul	apartment	boiler	**45,9**	18,6	9,3	**D**
Bari	apartment	boiler	**42,2**	18,6	7,8	**D**
Istanbul	apartment	heat pump	**55,1**	7,7	3,8	**E**
Bari	apartment	heat pump	**31,8**	7,7	3,2	**C**
Ankara	apartment	boiler	**90,2**	18,6	18,2	**E**
L'Aquila	apartment	boiler	**82,2**	18,6	15,1	**D**
Ankara	apartment	heat pump	**108,2**	7,7	7,5	**E**
L'Aquila	apartment	heat pump	**61,6**	7,7	6,2	**C**

As the Table 6.13 and Table 6.14 display more realistic results for primary energy needs which are obtained by multiplying the delivered energy results with the conversion factors, it can be observed that the heating system and fuel type have more drastic effects on the energy consumptions and so, on energy classes.

Another aspect that should be discussed according to these results is the efficiency of the heating plant. However, the results provided from the program, as previously highlighted, does not refer exactly to the converted primary energy needs, but to delivered energy needs for heating (since the conversion factor is assumed always $1kWh_{pe}/kWh_i$ in the software). When the heating plant is chosen as boiler, the primary (delivered) energy needs for heating are higher compared to heating pump in both countries. The heating systems are affecting the energy class even more than thermal transmittance values as the changes are from E class to B and from D class to A (Table 6.11 and Table 6.12). For that reason it is very important to make regular interventions of all HVAC systems as it is mentioned in the EPBD.

It is assumed that the necessary energy for the domestic hot water production system is being supplied also from the heating plant. So the results for primary (delivered) energy needs for hot water have changed only for different heating plant examples.

CO_2 emissions are affecting both from the thermal transmittance values and heating system. Thus the lower values are achieved for the cases with the lowest thermal transmittance value and the heating system of heat pump. However, again the results of CO_2 emissions depend on the conversion factor (kg_{CO2}/kWh) which is pre-defined in DOCET. Also in this case, each region should fix its own conversion factor.

As DOCET uses pre-defined data, real values of energy consumptions and CO_2 emissions cannot be achieved, so it shouldn't be perceived that DOCET provides a proper energy diagnosis. However, as it is mentioned above, it responds to the expectations for an energy certification tool.

Followings are the last pages of DOCET displaying the results for every case:

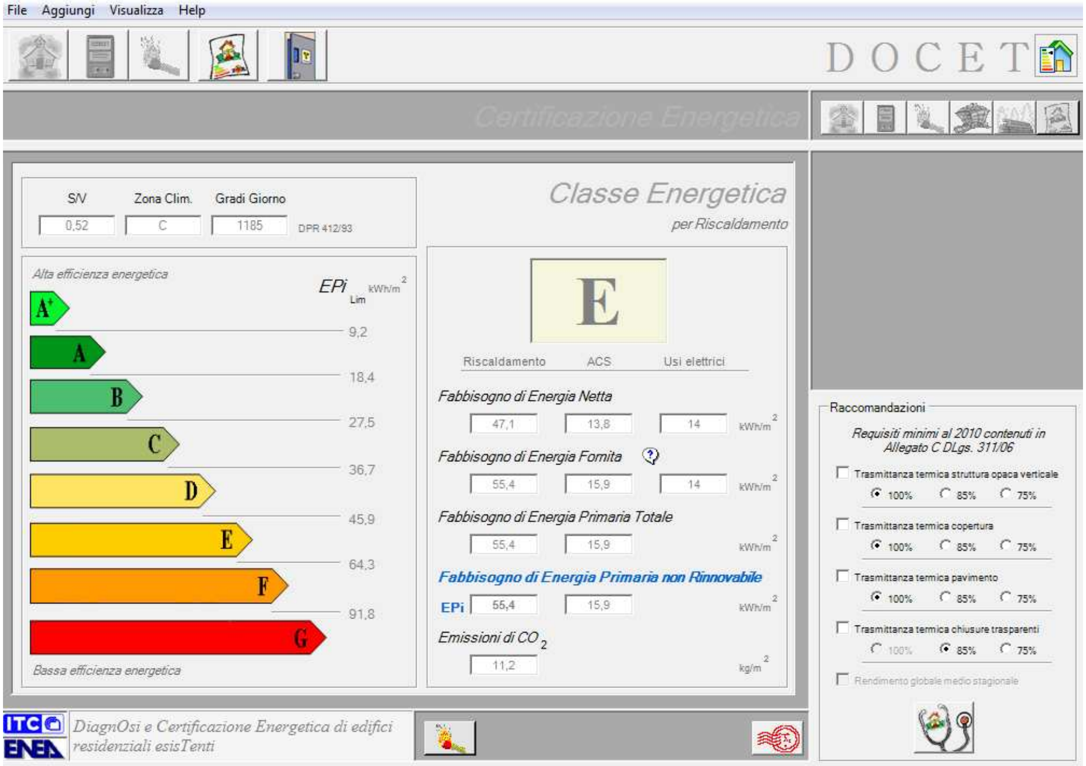


Figure 6.9: Energy Certification Results of Single Family House with boiler in Istanbul (Degree-day zone in Italy is C): Non-renewable primary energy need is 55,4 kWh/m^2

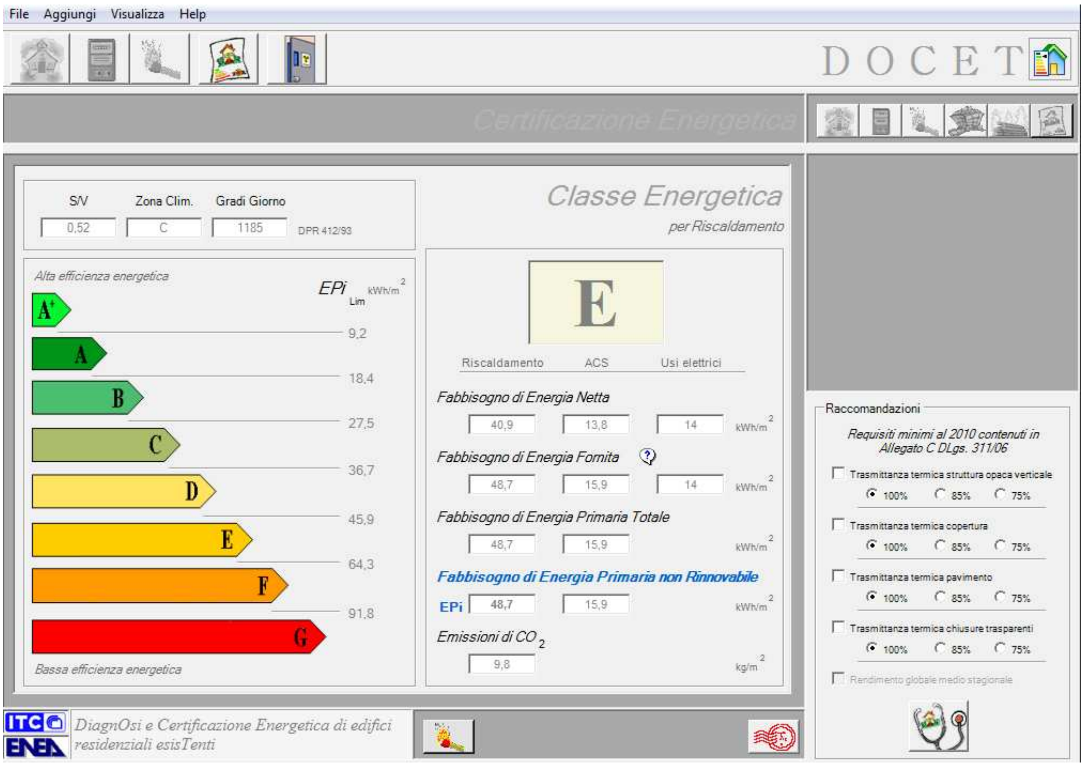


Figure 6.10: Energy Certification Results of Single Family House with boiler in Bari (Degree-day zone in Italy is C): Non-renewable primary energy need is 48,7 kWh/m^2

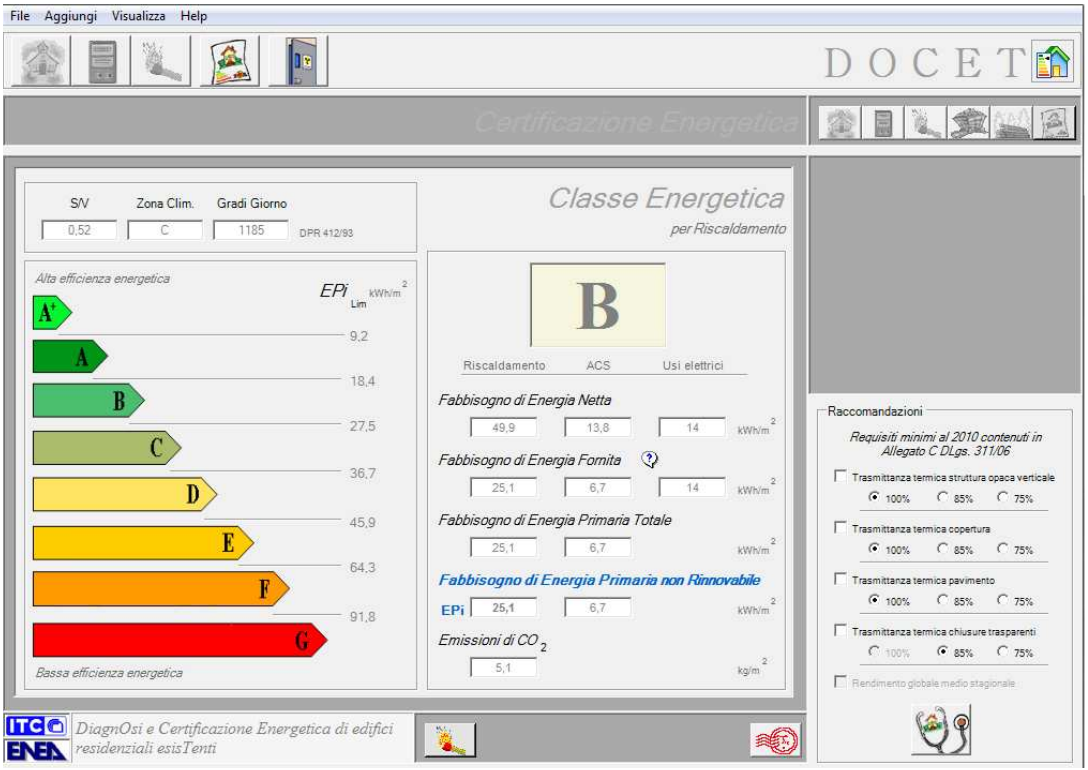


Figure 6.11: Energy Certification Results of Single Family House with heat pump in Istanbul (Degree-day zone in Italy is C): Non-renewable primary energy need is 25,1 kWh/m^2

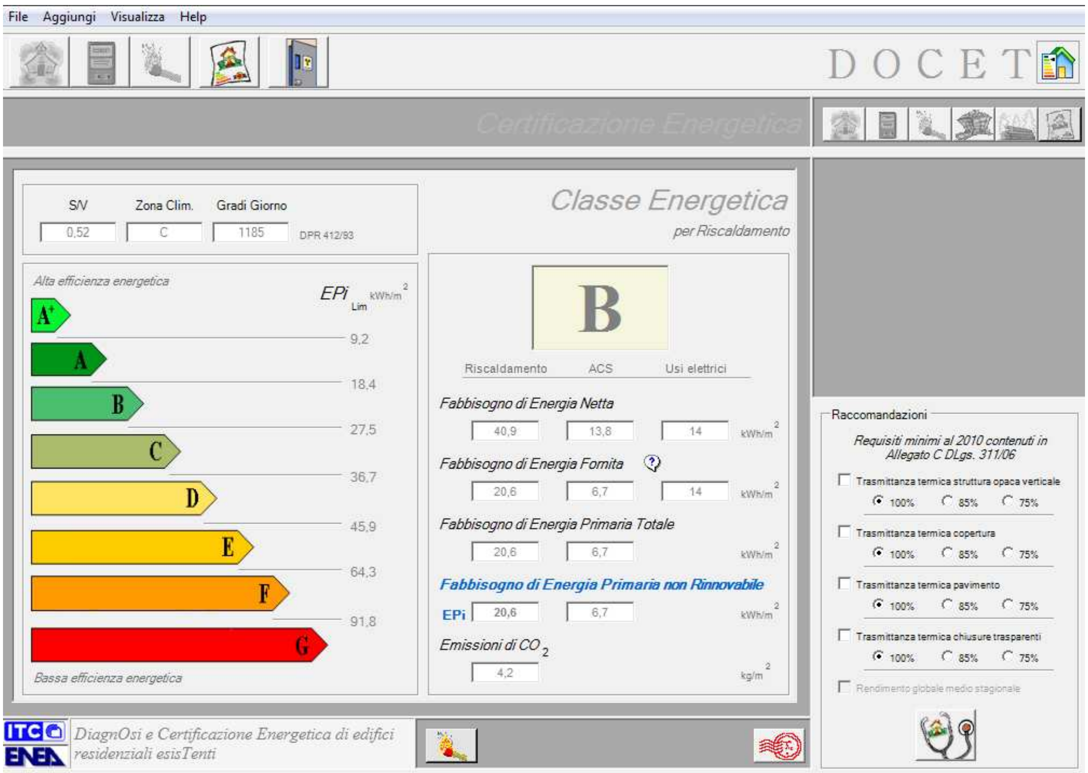


Figure 6.12: Energy Certification Results of Single Family House with heat pump in Bari (Degree-day zone in Italy is C): Non-renewable primary energy need is 20,6 kWh/m^2

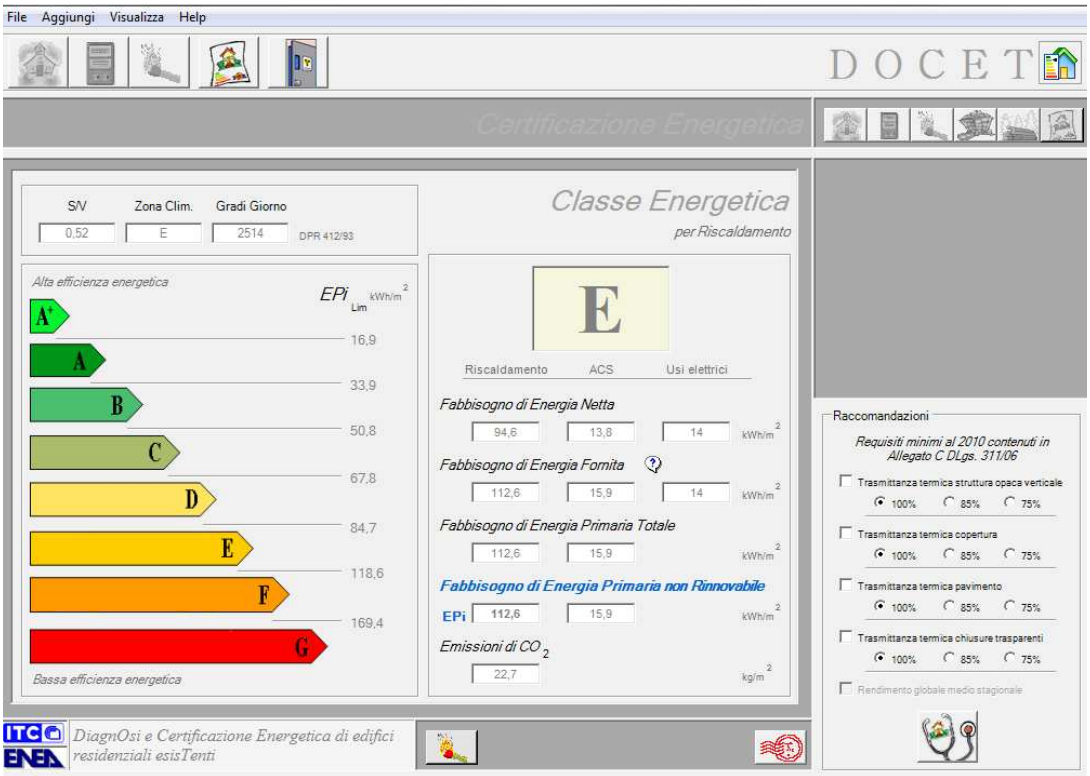


Figure 6.13: Energy Certification Results of Single Family House with boiler in Ankara (Degree-day zone in Italy is E): Non-renewable primary energy need is 112,6 kWh/m^2

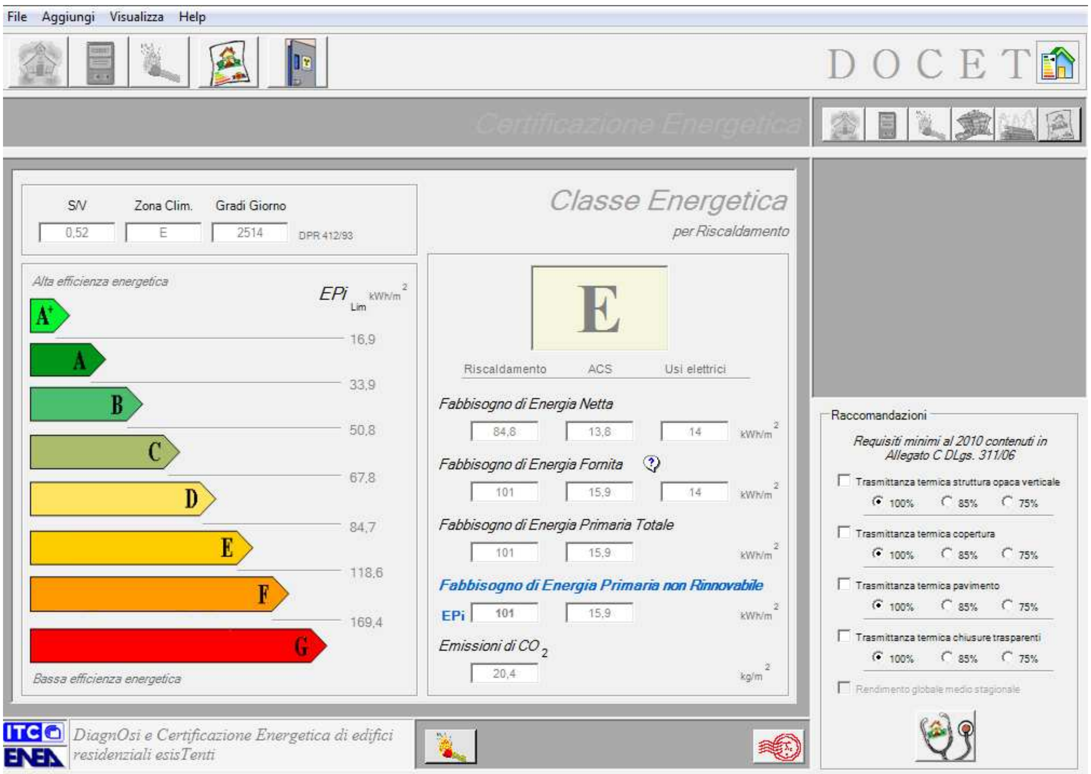


Figure 6.14: Energy Certification Results of Single Family House with boiler in L'Aquilla (Degree-day zone in Italy is E): Non-renewable primary energy need is 101kWh/m^2

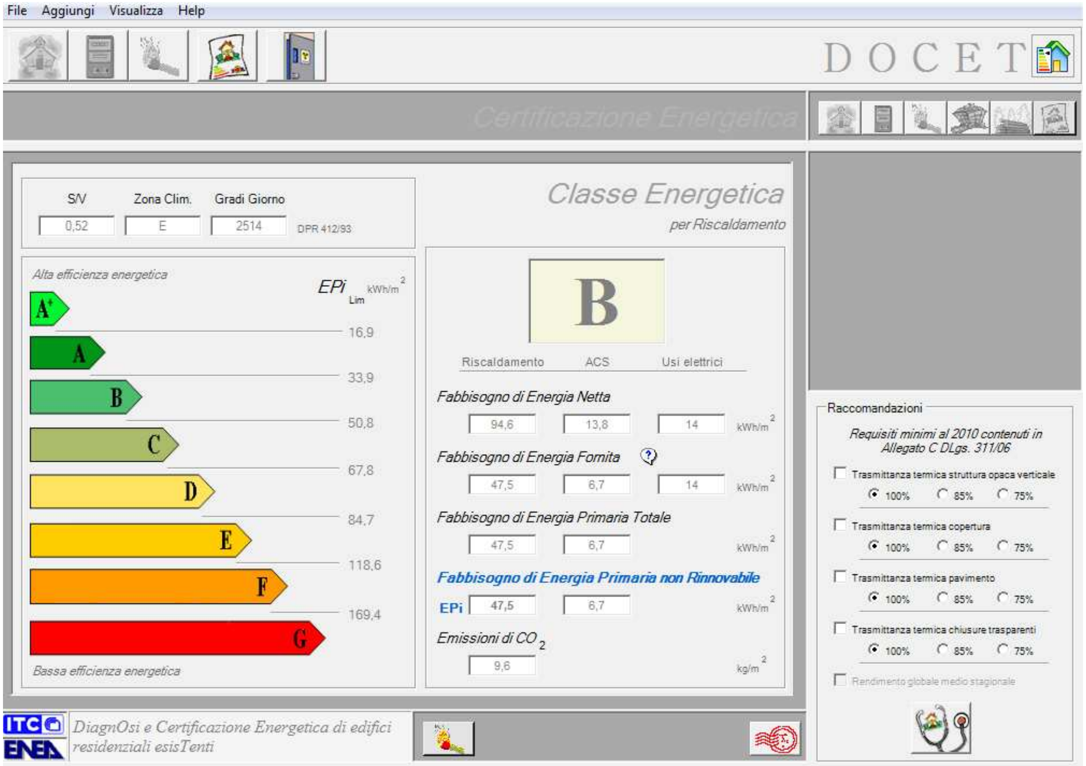


Figure 6.15: Energy Certification Results of Single Family House with heat pump in Ankara (Degree-day zone in Italy is E): Non-renewable primary energy need is 47,5 kWh/m^2

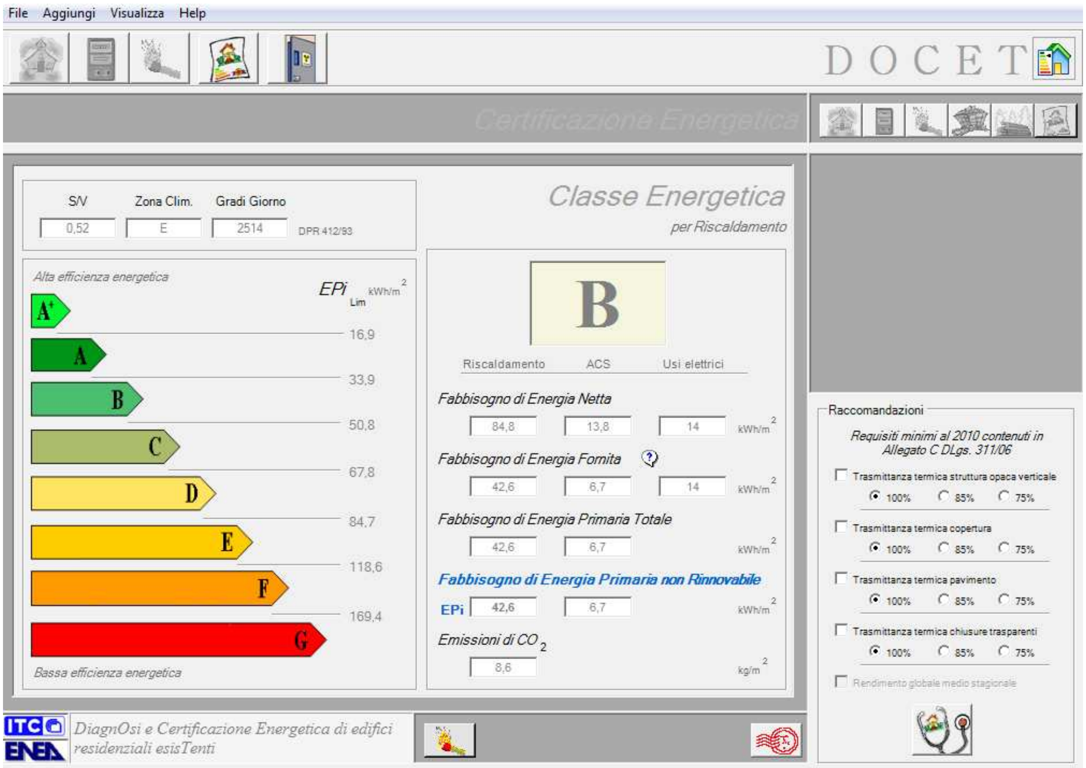


Figure 6.16: Energy Certification Results of Single Family House with heat pump in L'Aquilla (Degree-day zone in Italy is E): Non-renewable primary energy need is 42,6kWh/m^2

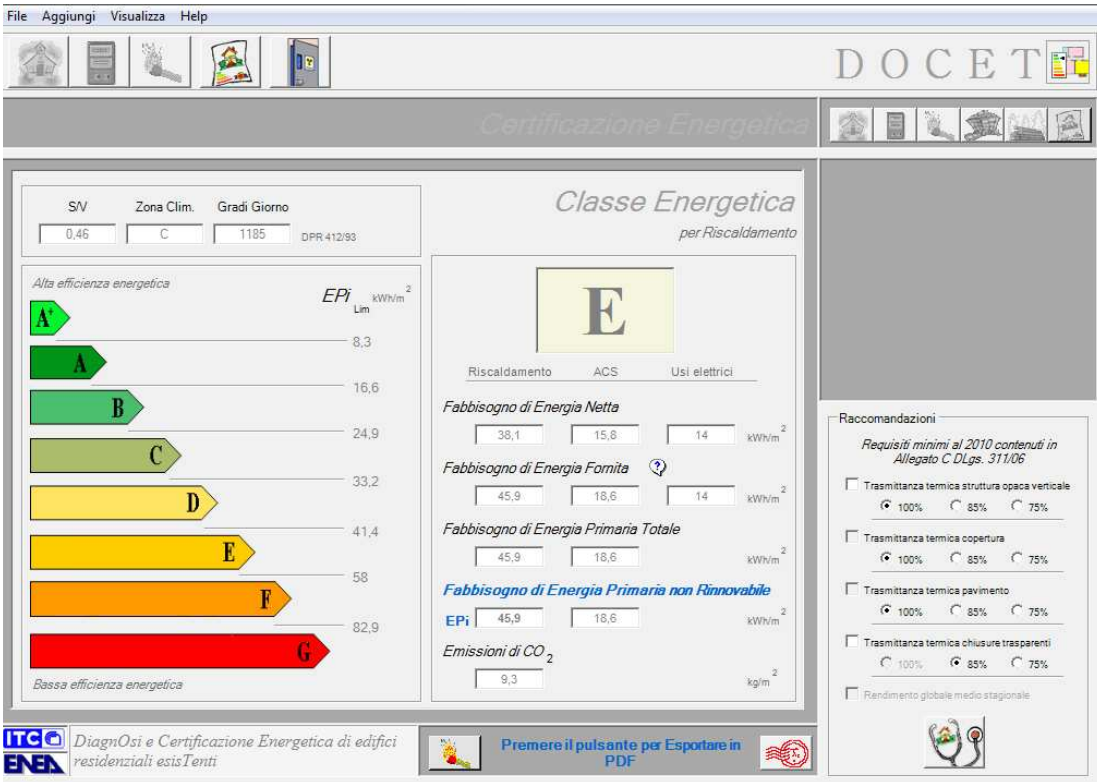


Figure 6.17: Energy Certification Results of Apartment with boiler in Istanbul (Degree-day zone in Italy is C): Non-renewable primary energy need is 45,9 kWh/m^2

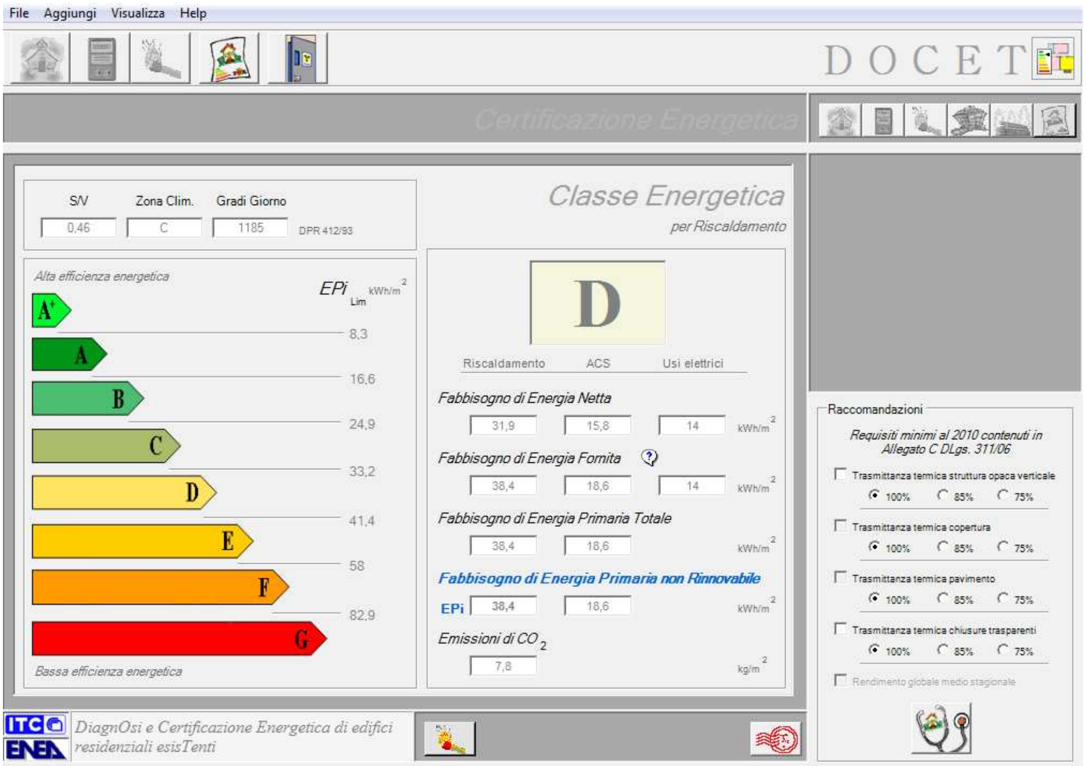


Figure 6.18: Energy Certification Results of Apartment with boiler in Bari (Degree-day zone in Italy is C): Non-renewable primary energy need is 38,4 kWh/m^2

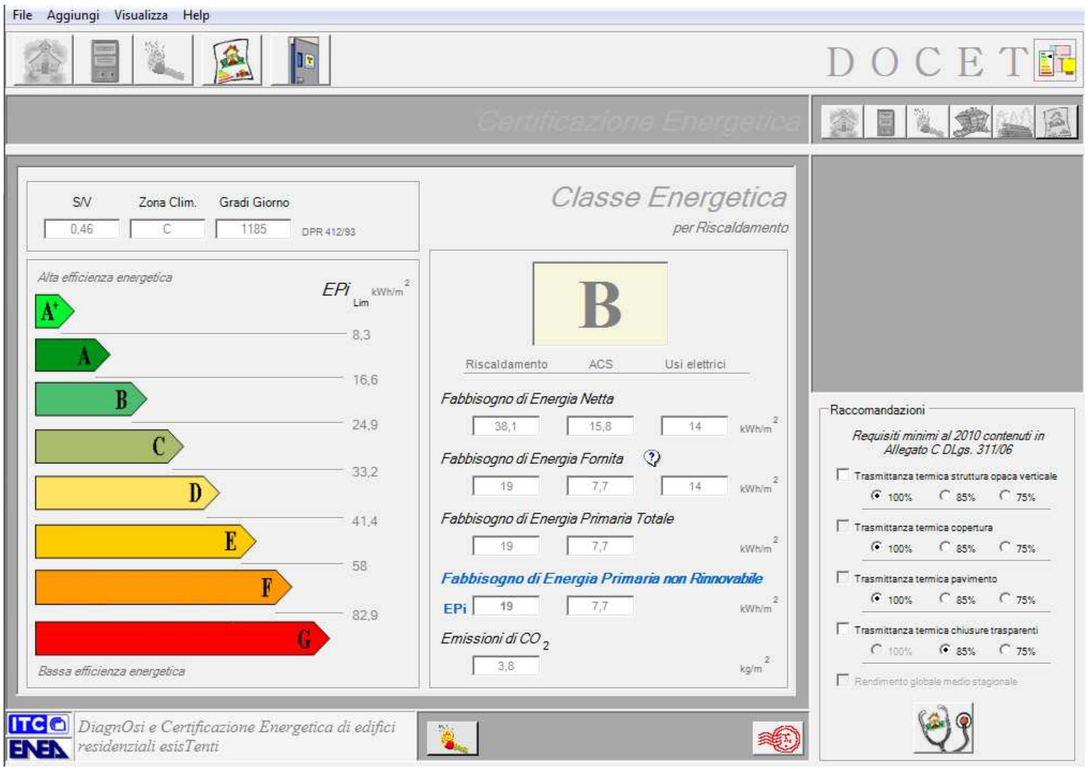


Figure 6.19: Energy Certification Results of Apartment with heat pump in Istanbul (Degree-day zone in Italy is C): Non-renewable primary energy need is 19kWh/m^2

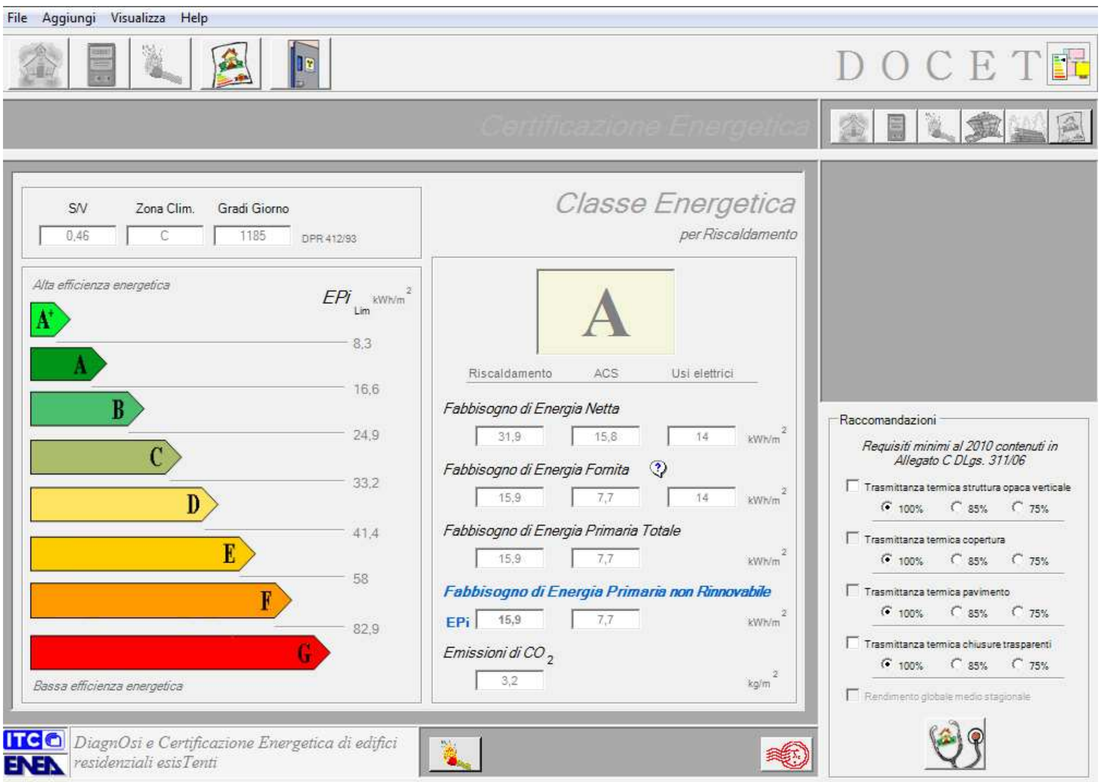


Figure 6.20: Energy Certification Results of Apartment with heat pump in Bari (Degree-day zone in Italy is C): Non-renewable primary energy need is 15,9 kWh/m^2

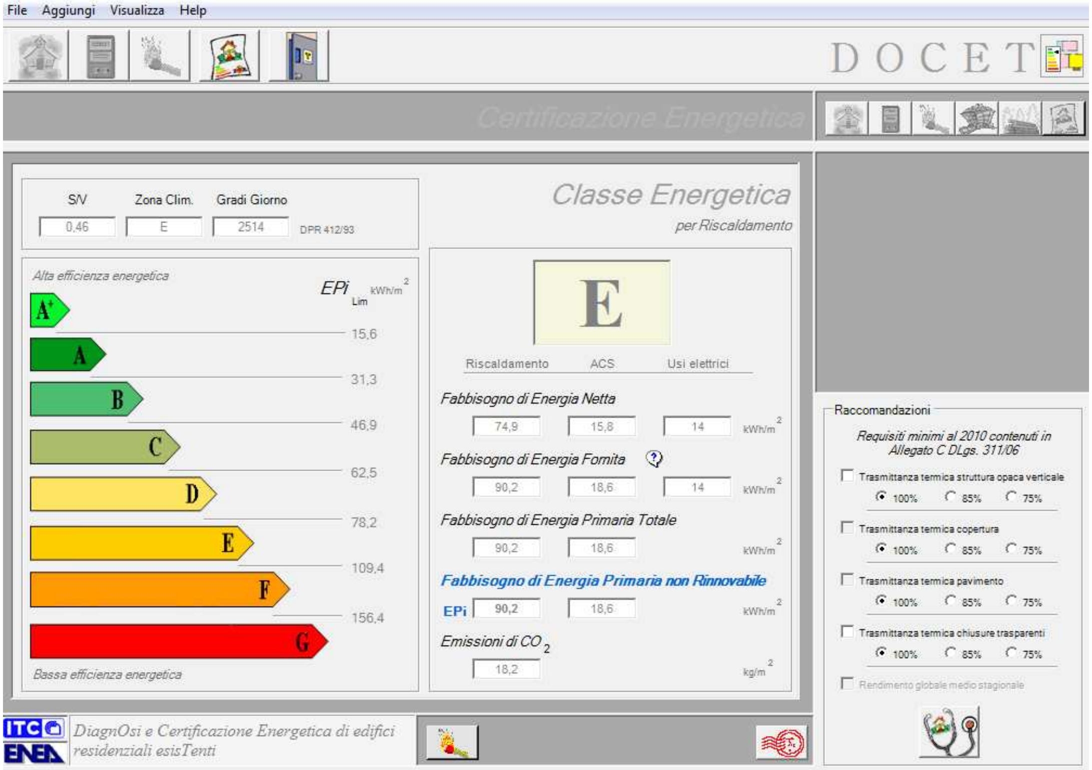


Figure 6.21: Energy Certification Results of Apartment with boiler in Ankara (Degree-day zone in Italy is E): Non-renewable primary energy need is 90,2 kWh/m^2

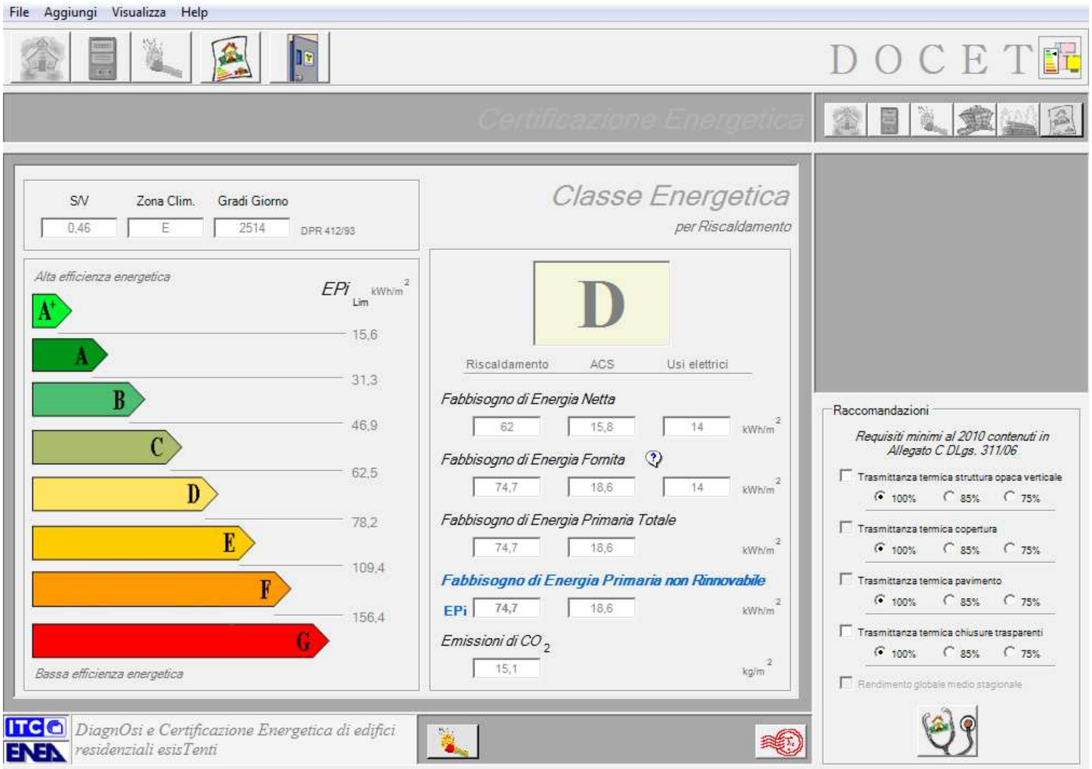


Figure 6.22: Energy Certification Results of Apartment with boiler in L'Aquilla (Degree-day zone in Italy is E): Non-renewable primary energy need is 74,7 kWh/m^2

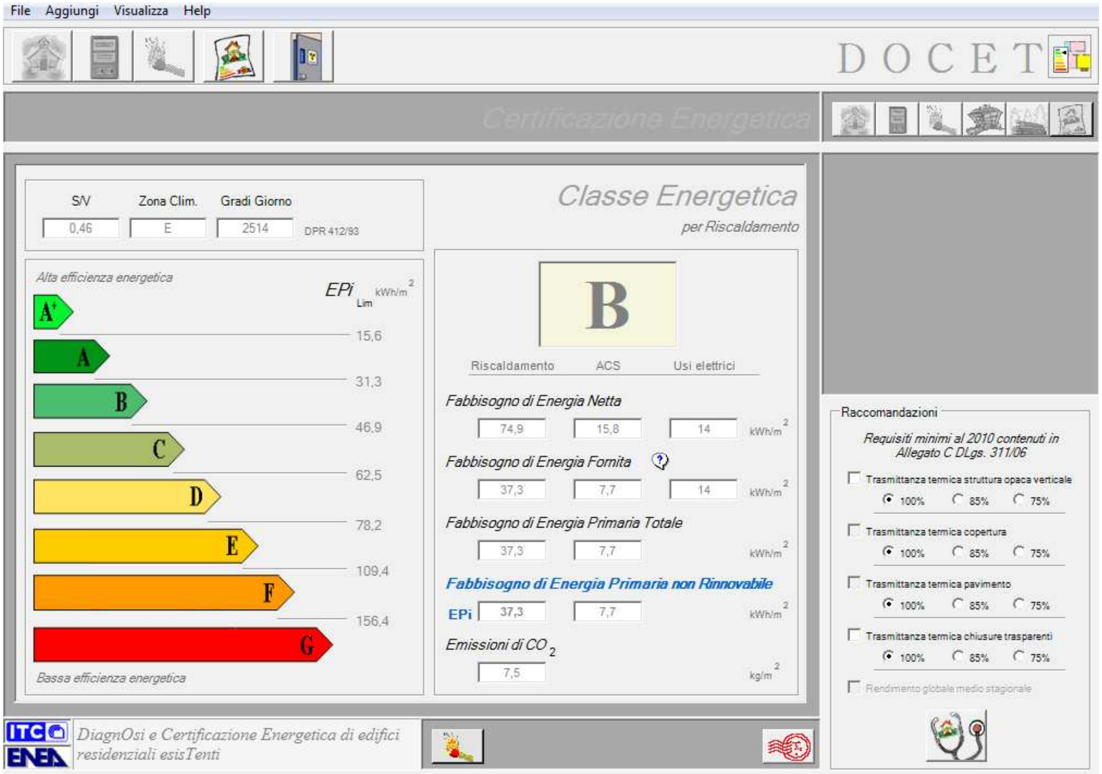


Figure 6.23: Energy Certification Results of Apartment with heat pump in Ankara (Degree-day zone in Italy is E): Non-renewable primary energy need is 37,3 kWh/m^2

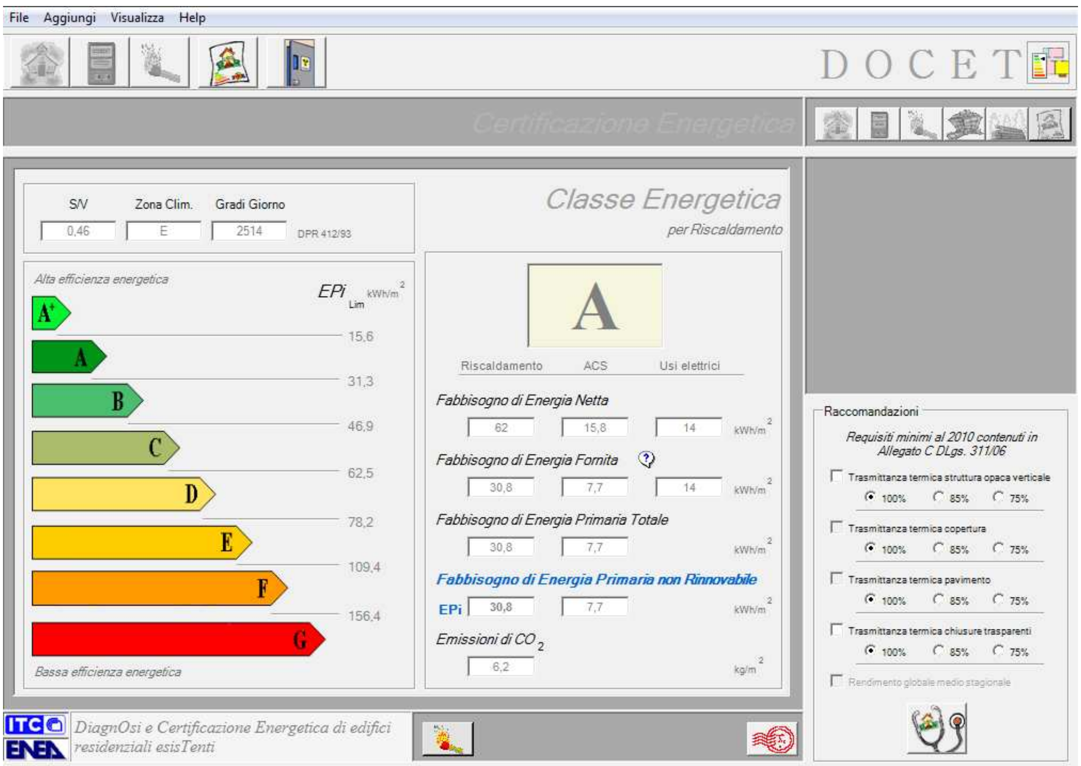


Figure 6.24: Energy Certification Results of Apartment with heat pump in L'Aquilla (Degree-day zone in Italy is E): Non-renewable primary energy need is 30,8kWh/m^2

7. CONCLUSION

Energy certification of buildings is a way to limit the energy demand and to conserve the primary energy in the building sector which is one of the most energy consuming sectors in Europe. Since 2003, when the directive has come into force, all European Union Countries has built up their own certification system and each one has started to apply and to conserve primary energy.

By limitations on energy requirements, the optimum comfort conditions in the buildings may be ensured by less energy and the unhealthy conditions may be prevented as the certification is obligatory. Furthermore the consciousness of the final user about energy conservation will be raised as the certification document shall be presented in the sale and rents of the buildings and apartments. After beginning to apply of the certification system properly, as it decided in the beginning, it may be displayed the energetic situation of the building sector of a country more precisely than before.

This work in particular is focused on the status of Energy Certifications in Europe and it deepens on the Italian Energy Certification System. What's more, the Italian Certification Methodology was applied with reference to the new law and regulation about the Energy Efficiency and Certification in Turkey. The tool DOCET shows potentialities of an easy application, but also some critical aspects about the calculation of primary energy needs.

In Italy the energy certification system of building has started to implement and, by the same time, the studies to develop the system, by the feedback data from the actual system, is on progress. DOCET, for example, is one of the energy certification tools which are being used currently in Italy. It performs the certification for existing residential buildings by the energy performance calculation method that is defined in laws. Italy is developing the system to certificate not only existing residential buildings, but also all types of new buildings. Additionally the third and fourth part of the UNI/TS 11300 Energy Performance of Buildings will be completed.

For Turkey, as a candidate to European Union, the energy certification of building system is an opportunity for energy conservation. Before the directive, Turkey had only a standard for the thermal insulation and the calculation of heat transmissions of the building envelope, TS 825. Today, by the studies of the energy certification, a new law and the regulations have come into force. By 2010 the energy certification system for buildings will be in use.

In this thesis, it is also observed that the national energy politics and decisions affect the certification system and energy classes. By the means of the conversion factors for primary energy that are decided nationally by energy experts and politicians together, it may be obtained different results for the same buildings and consumptions by different conversion factors.

Hence the problem is that the certification systems of each country are very different so the results are not comparable. It is important considering local conditions of a building for energy efficiency; however certification and energy classes should be harmonized for the analogy of different countries. In this thesis only Italian Certification System has been applied to the example building as the Turkish Certification System has not been completely in use. Thus it cannot be observed for the same building how the results of two different systems are changing. But it can be anticipated that the results won't be comparable as the general approaches of the two countries are very discrete.

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