İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

EVALUATION OF EU BUILDING ENERGY PERFORMANCE STANDARDS RELATED TO COMMERCIAL BUILDINGS

Master Thesis by
Ayşegül TERECİ, Architect
502031703

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Supervisor (Chairman): Prof. Dr. Gül KOÇLAR ORAL

Members of the Examining Committee Prof. Dr. Zerrin YILMAZ

Prof. Dr. H.Yaşa ERSOY

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AB BİNALARDA ENERJİ PERFORMANS STANDARDLARININ TİCARİ BİNALARLA İLİŞKİLİ DEĞERLENDİRİLMESİ

YÜKSEK LİSANS TEZİ

Ayşegül TERECİ, Mimar
502031703

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Tez Danışmanı :	**Prof. Dr. Gül KOÇLAR ORAL**
Diğer Jüri Üyeleri	**Prof. Dr. Zerrin YILMAZ**
	Prof. Dr. H.Yaşa ERSOY

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SYMBOL LIST

A	: Area of exposed building component
b	: Radiation transmission coefficient of the window and sun protection devices
c	: Specific heat capacity
d	: Effective thickness of one side of an element
F_c	: Permanent curtain factor
F_F	: Ratio of transparent surface to total surface
g	: Total solar transmittance of the surface
$g_{i,month}$	: Solar transmission factor of glazing areas having orientation "I"
H_{iu}	:Total specific heat flow (ventilation plus conduction) between the heated and unheated space
H_{ue}	: Total specific heat flow between the unheated space and the exterior
H_T	: Specific heat loss by transmission
H_V	: Specific heat loss by ventilation
$I_{\max}$	: Maximum value of total radiation for the design month
$I_{diff,\max}$	: Maximum value of diffuse radiation for the design month
$I_{i,month}$	: Monthly average solar radiation on vertical surfaces having orientation "I"
k	: Heat transmission coefficient
k_F	: Heat transmission coefficient of the window
KKO_{month}	: Gains/loss ratio and it is calculated as follows
l	: Simultaneity factor
m_f	: Mass per unit area
$\dot{m}$	: Mass of the material brought into the room or removed from it in the unit of time
n	: Number of persons
n_h	: Air change rate
η	: Motor efficiency
η_x	: Control efficiency
η_e	: Emission efficiency
η_δ	: Distribution efficiency
η_γ	: Conversion efficiency of the system
η_h	: Seasonal heating efficiency of the system
ρ	: Air density
P	: Total installed power of the lights, for discharge lamps including the power loss due to the chokes
$r_{i,month}$	: monthly average shading factor for transparent surfaces having orientation "I"
P_j	: Rated power (shaft power) of the machine j
q_p	: Heat emission from the human body
Q_{year}	: Heat requirement of building for a year
Q_{month}	: Heat requirement of building for a month

Q_l : Heat losses
Q_G : Ground heat losses
Q_T : Transmission loss from the fabric
Q_g : Heat gains
Q_s : Solar gains
Q_h : Internal heat gains
$\dot{Q}_A$: External cooling load
$\dot{Q}_B$: Cooling load due to lighting
$\dot{Q}_C$: Other heat supply and heat removal
$\dot{Q}_G$: Cooling load due to material throughput
$\dot{Q}_I$: Internal cooling load
$\dot{Q}_{KG}$: Cooling load due to material throughput
$\dot{Q}_{KR}$: Room cooling load
$\dot{Q}_M$: Cooling load due to machines and equipment
$\dot{Q}_P$: Cooling load due to persons
$\dot{Q}_R$: Cooling load due to different temperatures in adjacent rooms
$\dot{Q}_S$: Cooling load due to radiation through windows
$\dot{Q}_T$: Cooling load due to transmission through windows
$\dot{Q}_W$: Cooling load through external walls and roofs
$\mathbf{S_a}$: Cooling load factor for external radiation load
S_i : Cooling load factor for internal loads
$\mathbf{T_{i,avg}}$: Average internal temperature
$\mathbf{T_{i,month}}$: Monthly average inside temperature
$\mathbf{T_{d,month}}$: Monthly average outside temperature
$\mathbf{V'}$: Volume flow rate
$\mathbf{V_h}$: Ventilated volume
ϑ_A : Outlet temperature
ϑ_E : Inlet temperature
ϑ_{La} : Instantaneous external air temperature
ϑ_{LR} : Room air temperature
$\Delta\vartheta$: Temperature difference
Δz : Time adjustment of each design
μ_{aj} : Load factor of the machine j at the time
μ_B : Room load factor due to lighting
$\mathbf{\phi_{i,month}}$: Monthly internal heat gains
$\mathbf{\phi_{g,month}}$: Monthly average solar heat gains

EVALUATION OF EU BUILDING ENERGY PERFORMANCE STANDARDS RELATED TO COMMERCIAL BUILDINGS

SUMMARY

The aim of this study is to understand the building energy performance standards of the European Union and to evaluate existing Turkish building energy standards TS825 related to commercial sector buildings. This study has been establishing the impacts on energy consumption of commercial sector buildings and shows the role of building standards on this subject.

In this study commercial building general properties, classification according to principal using types and major features related with energy character are investigated. Modern commercial buildings properties are evaluated from existing low energy buildings and impacts of these trends on the energy consumption are examined. The relation between building properties and energy consumption are evaluated from yearly commercial sector energy consumption charts.

General properties of energy building energy standards constituted at the frame of European Union Building Energy Performance Directive and the method of building energy performance assessment are given in this thesis. European Union member state national regulations and execution techniques are evaluated. However, when building energy standardization is evaluated, a heating energy demand standard ‘TS825’ is only exist in Turkey so in this thesis this standard, its calculation method and deficiencies are examined.

At the final part of the study, recommendation for the content of new commercial building standards of Modern Turkey trying for membership in the EU is made. Furthermore, execution techniques for designing energy efficient building and existing building certification are recommended at this part.

AB BİNALARDA ENERJİ PERFORMANS STANDARDLARININ TİCARİ BİNALARLA İLİŞKİLİ DEĞERLENDİRİLMESİ

ÖZET

Bu tez çalışması kapsamında ticari binalarla ilgili Avrupa Birliği bina enerji performans standartları incelenmiş ve Türkiye'de kullanılmakta olan TS825 standardı değerlendirilmiştir. Çalışma ticari binaların enerji tüketimini etkileyen sebepleri ortaya koyup, enerji standartlarının bu konudaki önemini vurgulamayı hedeflemektedir.

Ticari binaların genel özellikleri, kullanım şekillerine göre sınıflandırılması ve enerji karakterini etkileyen başlıca özellikler tez kapsamında değerlendirilmiştir. Bu veriler doğrultusunda sektöre ait günümüz ticari binalarının özellikleri varolan örneklerden araştırılıp, bu özelliklerin enerji tüketimini nasıl etkilediği sorgulanmıştır. Ticari binalarda enerji tüketimi verilerinin yıllara ve örneklere göre değişimleri irdelenerek, enerji tüketimiyle bina özellikleri arasındaki ilişki değerlendirilmiştir.

Avrupa Birliği Bina Enerji Performans Direktifi çerçevesinde oluşturulan enerji performans standartlarının genel özellikleri, enerji performans değerlendirme yöntemleriyle ortaya koyulmuştur. Bu standartların ülkelere göre uygulanma şekli ticari binalar kapsamında incelenip, uygulama şekilleri değerlendirilmiştir. Türkiye' de binalarda enerji konusunda standartlaşmalara bakıldığında binaların ısıtma enerjisi ihtiyacını hesaplayan TS825 irdelenip, temel hesaplama metodu ve eksiklikleri ortaya konmuştur.

Son bölümde Avrupa Birliğine girme yolunda olan ülkemizin ticari binalarla ilgili enerji performans standartlarını oluştururken standartların içermesi gereken nitelikler çalışma sonuçları doğrultusunda önerilmiştir. Ayrıca yeni binalar için tasarım sürecinde binaların enerji performansını artırmak için izlenmesi gereken yol ortaya konmuştur. Enerji Performans Direktifi çerçevesinde sertifikasyonun önemi ile yeni ve varolan binalarda uygulanma yolu önerilmiştir.

1. INTRODUCTION

Human life is based on energy. The energy is required to support our lifestyles and provides enormous convenience and benefits. But it also exacts big impacts on ecosystems. Human energy consumption causes the depletion of energy resource, global warming and air pollution.

Energy consumption is rising fastest in the developing world. “In the past 35-40 years, worldwide energy consumption has nearly doubled, driven by population growth, rising living standards, invention of energy-dependent technologies, and consumerism" (Shirley Ann Jackson, 2005). A projected increase in fossil fuel consumption, particularly in developing countries, is largely responsible for half of the green house effect.

In 2002, Turkey produced 24.3 Mtoe of energy domestically from primary sources. Annual consumption, however, was nearly three times higher. In other words, according to 2002 figures, only 31 per cent of primary energy demand can be met by domestic production. It is expected that by the year 2010, domestic energy consumption will reach 153.9 Mtoe and in 2020, domestic energy consumption will reach 282.2 Mtoe, while domestic production will be at 62 Mtoe, or 22 per cent of national demand according to projection (General Directorate of Electrical Power, 2004).

Worldwide, people use about a third of all energy for heating, cooling, cooking, lighting and appliances in buildings. Building-related energy demand is rising rapidly. In Turkey, the buildings consume approximately 37% of the final energy used. So reducing the energy consumption on the building sector is really important for Turkey’s future and ecosystem.

In the building sector, commercial buildings take an important place in the energy consumption worldwide. Especially modern commercial buildings consume big amounts of energy. Knowing the reasons for this big amount is an important basis for choosing the strategies to reduce the energy consumption. To determine, which strategy gives what kind of impact is one of the goals of this thesis.

International energy standards are useful tools for reducing the energy consumption. In Turkey for all type of buildings a heating energy demand standard is defined. Modern Turkey is trying for membership in the EU. EU energy performance standards will be in force in 2006. Taking this into regard Turkish building standards should be conformed to the European standards. Focussing on commercial building standards, the evaluation of EU building performance standards is the main goal of this thesis.

For evaluation of commercial building main energy end –use, which is for heating, cooling and lighting, the task is divided four subtasks:

- Profile of Commercial Buildings
- Commercial Building Energy Consumption
- Analysis of Commercial Building Energy Efficiency Standard for Heating, Cooling and Lighting
- Conclusion and recomendation

In the first subtask the commercial building properties are analysed. Their using types and energy related properties are evaluated. Energy consumption data were collected and the possibilities to reach low consumption values are evaluated in the second part. In the third part of the thesis energy performance standards of commercial buildings are researched and a comparison to the Turkish TS825 standard is made. Furthermore to demonstrate the impact of this study's results, on sample model buildings simulation calculations are carried out in the last part of this thesis. In the simulation part the computer building energy analysis program 'TRNSYSlite' is used.

In the simulations the model buildings are defined as energetic systems and the buildings' overall energy performances are calculated. The energy consumption are shown as delivered energy, primary energy and CO_2 emissions like in the EU energy performance standards. The results of the calculations as well as future considerations are discussed in the conclusion part.

2. PROFILE OF COMMERCIAL BUILDINGS

2.1. General Properties of Commercial Buildings

Buildings have a number of features that affect their typology. The buildings are classified according to principal using types as residential, commercial or industrial structures.

"A commercial building is a type of building that is used for commercial use. These can include office buildings, warehouses, etc." (en. wikipedia.org).

"Commercial building" is a building with more than 50% of its floor space used for commercial activities. The commercial sector consists of business establishments and other organizations that provide services (EIA, 2002). The sector includes service businesses, such as retail and wholesale stores, hotels, restaurants and hospitals, as well as a wide range of facilities that would not be considered commercial in a traditional economic sense, such as public schools and religious organizations (See Figure 2.1).

Their shapes, construction types, their envelopes and their energy requirement differ by the type of the commercial activities.

2.2. Commercial Buildings Activities of Different Types

The analysis of the activities in different types of buildings is one of the most important measures to evaluate commercial sector energy use.

Commercial buildings include a variety of building types such as hospitals, schools, police stations, warehouses, offices, shopping malls, libraries, hotels, prisons, churches etc. There are main types of commercial buildings and their activities:

• Retail and Service Buildings: Buildings used for sales and displays of services and goods (except food) ; shopping malls, wholesale shopping clubs, automobile showrooms, car washes, gas stations, service centres, department stores, drugstores, dry cleaners, post offices.

• Office Buildings: Buildings used for general office space, professional offices, and administrative offices; banks, real estate offices, professional office buildings.

• Education Buildings: Buildings used for academic or technical classroom instruction; preschool, elementary and high school buildings, college and university classrooms and laboratories.

• Health Care Buildings: Buildings used as diagnostic and treatment facilities for both inpatient and outpatient care. (Long-term nursing care is included in Lodging); hospitals, rehabilitation facilities, dental clinics, medical clinics, kennels, veterinary clinics.

• Warehouse and Storage Buildings: Buildings used for storage of goods, manufactured products, merchandise or raw materials. Buildings may be refrigerated or non- refrigerated.

• Lodging Buildings: Buildings used to offer multiple accommodations for short-term or long-term residents; hotels, motels, inns, boarding houses, convents and monasteries, orphanages, dormitories.

• Food Service Buildings: Buildings used for preparation and sale of prepared food and beverages for consumption; cafeterias, caterers, fast-food establishments, coffee shops, bars, full-menu restaurants.

Figure 2.1: Examples of Commercial Buildings

• Religious Worship Buildings: Buildings in which people gather for religious activities; mosques, chapels, churches, synagogues, temples.

• Public Order and Safety Buildings: Buildings used for the preservation of law and order or safety; court houses, fire stations, police stations, jails and prisons.

• Public Assembly Buildings: Buildings in which people gather, in private or public meeting halls, for social or recreational activities; entertainment buildings (movie theatres, art galleries, concert halls, television stations and studios), recreational facilities (arcades, bowling alleys, gymnasiums, indoor pools, skating rings), social or public or civic buildings (auditoriums, convention halls, student unions, town halls), other assembly buildings (passenger terminals, stadiums).

• Food Sales Buildings: Buildings used for wholesale and retail sales of food; convenience stores, vegetable markets, seafood and meat stores, retail bakeries, supermarkets and grocery stores.

• Other Buildings: Buildings used for activities that do not fit into the specifically named categories; hangars, crematoriums, public restrooms (EIA, 2002).

The different types have type related activities. Offices have the highest energy consumption, followed by retail and service buildings which use almost as much energy as office buildings. Education buildings use 10% of the total commercial building energy, which is more than health care buildings and warehouses. Lodging and food service buildings each use 7% of the total energy. Public assembly

Figure 2.2: Energy use of commercial sector according to building types(EIA, 2002)

buildings use 6%; food sales buildings (like grocery stores and convenience stores) use 4%. All other types of buildings, like churches, fire stations, police stations etc. account for the remaining 7% (See Figure 2.2).

When people are performing activities in the buildings, comfort conditions are required and nearly all energy use in the commercial sector is associated with these requirements.

2.3. Energy Related Characteristic of Commercial Buildings

Buildings, especially commercial buildings, take an important place in the energy consumption worldwide. Economic growth also determines the degree to which additional commercial sector activities are offered and utilized. Economic and population growth trends drive commercial sector activity and the resulting energy use. As a consequence the energy consumption of the commercial sector in developing countries is lower than in industrial nations (UN Millennium Project, 2005).

The energy performance of a commercial building is influenced by three factors: first the building design, second the service type and system efficiency and third the user behaviour. The final performance of the building would be a product of these three factors. Furthermore these factors are not completely independent and affect each other. An example for building and occupant interaction is a sealed air-conditioned space where users have a chance to manually control windows resulting in wider ranges of thermal conditions and changed energy use (Nick Baker and Koen Steemers, 2000).

Commercial buildings which have different principle activities require different building structures, efficiency of the equipment, work schedules and number of workers. The energy use in this building sector also is affected by the location, the thermophysical and optical characteristics of the buildings. All these factors influence building energy consumption and distribution.

The location of the building is one of the main factors in determining its energy consumption. Different climatic regions have different weather characteristics and the building's energy-related behaviour is influenced by these different conditions. Differences found in temperature, humidity, solar radiation and wind speed show that topography, location and urban occupation may define conditions that change original standard microclimatic data and energy consumption in buildings.

Furthermore solar gains and the indoor temperature are determined by the building orientation, building form and optical and thermo-physical properties of the building envelope. Building facade material and their proportions on the façade also influence the energy distribution. Designing the building envelope, based on climatic data, has a great potential to reduce a building's energy consumption and designers of commercial buildings should focus on the optimization of thermophysical properties and optical characteristics of their facade construction.

Especially in the commercial building sector one of the main energy indicators is the work schedule. Buildings, which have long working hours like hotels or hospitals, have lower energy intensity than the buildings which are used for a shorter working period. The same type of building shows a direct relation between working time and energy consumption. The working schedules especially affect lighting and the space conditioning consumption.

The energy use in office buildings further on has risen because of the growth of information technology energy demand. As the use of computers as well as the use of other office equipment has increased over the last ten to fifteen years, the electricity energy consumed by this equipment has increased as well. The Annual Energy Outlook 2002 forecasts that commercial energy demand will grow at an average annual rate of 1.7 percent, with the most rapid increases in demand projected for computers, office equipment, and telecommunications and other equipment. (www.eia.doe.gov). Looking for strategies to reduce the rising energy consumption of commercial buildings, the demand for equipment is one of the major targets. Therefore as first measures labelling and regulations on the energy consumption of this equipment are introduced by the authorities.

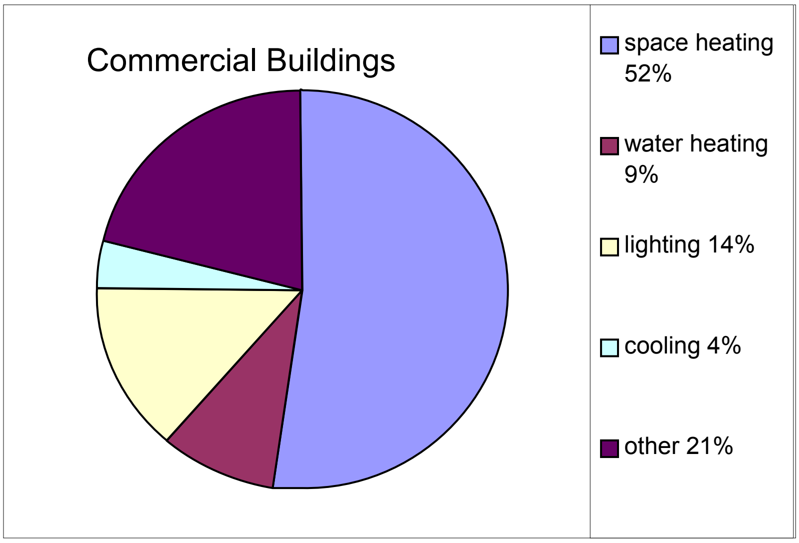


Figure 2.3: Energy consumption by end use in the EU commercial building sector (EC 2001)

Daylighting and natural ventilation have the potential to significantly reduce the energy consumption of commercial buildings. Passive solutions are also preferred by the user, who can play an active role in the environment control of the building which leads to a higher tolerance of variations of conditions inside of the building.

Energy is used in the commercial building sector to provide services such as thermal conditioning, lighting, ventilation, water heating, powering office equipment, and other uses. Generally in commercial buildings higher internal gains are observed due to the people and equipment density. Commercial buildings utilize their energy mostly for lighting and thermal comfort (See Figure 2.3). The energy use for thermal comfort in commercial buildings has risen by reason of the growth of air conditioning market in hot countries more energy is used for space cooling but also in cold or warm countries a strong increase of cooling systems can be recognized. Lighting accounts for 23% of all electricity consumed in the United States from which commercial lighting is estimated to contribute with about 60%. In the European Union, electricity is used for lighting accounts for more than 160 TWh/year in the tertiary and industrial sector. In many buildings, lighting is a substantial energy consumer and a major component of service costs (Paolo Bertoldi, Calin Ciugudeanu, 2003).

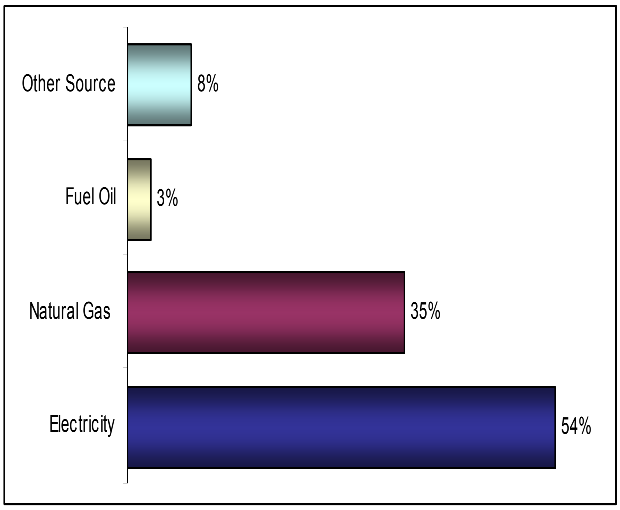


Figure 2.4: Distribution in percent of energy by the source in commercial buildings (EIA, 1999).

The energy used in commercial buildings ranges from electricity, natural gas, fuel oil, to propane, coal and renewable energy sources (See Figure 2.4). Energy consumption in commercial buildings is dominated by electricity with 54%. The second common energy source used is natural gas with 35% and the fuel oil counts for 3% in these building types. Taking into regard rising energy costs, renewable energy sources could be an important energy savings strategy for commercial buildings but up to now is not common practice.

2.4. Conclusion

Commercial buildings include a variety of building types such as offices, hospitals, schools, shopping malls, hotels, prisons, churches etc. Commercial buildings which have different principle activities require different building structures, efficiency of the equipment, work schedules and number of workers and also need different energy requirements. The energy consumption of office and retail building are very high in this sector. The energy performance of a commercial building is influenced by three factors: first the building design, second the service type and system efficiency and third the user behaviour. All these factors influence building energy consumption and distribution. Energy is used in the commercial building sector to provide services such as thermal conditioning, lighting, ventilation, water heating, powering office equipment, and other uses. The electricity consumption is very high in nowadays commercial buildings.

3. ENERGY CONSUMPTION IN COMMERCIAL BUILDINGS

This part evaluates the impact of specific energy consumption on commercial buildings and the development of strategies to improve their energy efficiency.

3.1. General Properties of Commercial Building Energy Consumption

In physical science terminology, "energy" is defined as the capacity for doing work. For human working capacity a major factor for efficiency are comfortable working conditions. These comfortable conditions have to be provided by a well designed commercial building. Comfort conditions of buildings involve the inside temperature, air speed, humidity, air quality and lighting. The range of environment comfort conditions determines the building energy consumption. This range is affected by natural and structural environment parameters (Philip Haves, 1992).

The main factors for energy consumption are:

- the type of the building
- the special features of building
- the special condition for building
- the occupants and their preferences, comfort conditions
- accepted building codes

Two methodologies exist to describe building energy consumption — site energy and source energy:

Site energy includes only energy consumption at the building location. Source energy includes the site energy plus the energy used to produce the site energy, such as the energy required to generate, transmit, and distribute the site energy to the building (http://www.energystar.gov). Site energy is a familiar and common convention used for discussing building energy consumption when multiple fuels are used in a building. When making comparisons between groups of buildings that have varying fuel mixes the source energy convention, not the site energy convention, is a far more equitable means for assessing building performance.

The energy use of commercial building is a complex combination of numerous factors. One of the most important problems of modern commercial buildings is the high heating, cooling and lighting energy consumption. The main objective of this part is the investigation of heating, cooling and lighting consumption under consideration of state of the art trends and standards.

The relation between the surface area of the building envelope and the building volume has a significant impact on the heat loads and gains. Furthermore the transparency of the chosen form is another important parameter. Compact forms with low transparency provide the highest energy conservation opportunities for a building. The facade and shape of commercial buildings clue in the identity of that building's type and owners. That means sometimes a building is used as a symbol and the indoor climatic conditions are ignored. For example large symbolic and representative glazing areas on the facade of an office building can cause unwanted solar gains and the cooling load increases. But if this glazing area is controlled by daylighting controls the cooling demand can be reduced and the lighting energy situation improved with remarkable impacts on the energy efficiency (www.eere.energy.gov).

After the agricultural and industrial revolution, at present we observe a digital revolution, which means a radical reshaping and restructuring of the society caused by digital technology. The using style of the space is shaped by the digital technology's requirements as well as people's activities. By this development the commercial sector is affected much more than the residential sector. The virtual world and digital tools reduce the need for synchronous, face to face communication and communicative space structure begins to gain popularity. Multifunctional one person areas without any hard separation unit designs are commonly used in modern commercial areas (J. Worthington, 1998).

In commercial buildings total energy demand, including thermal and electricity demand has risen year by year due to user requirements. Nowadays the energy consumption of commercial buildings is dominated by the electricity demand. Main factors are lighting, ventilation, cooling and appliances. Naturally available energy, like daylighting or natural ventilation in commercial buildings can be harnessed with artificial systems and could reduce the energy demand. Using electrical power equipment causes rising electricity demand and internal loads. The minimum amount can be achieved by a combination of design measures and the use of more efficient equipment and technologies (www.eere.energy.gov).

Furthermore indoor human comfort levels have to be investigated. Especially temperature and air change rate set points still are very high in most of the buildings. To bring down the limit temperature for mechanical systems would help to reduce the consumption values as high air change rates for example cause the high ventilation losses.

There is a big potential for energy savings in new and existing commercial buildings. Nowadays the expectation for commercial buildings and consumption values could be met by optimizing the controlling system, technologies and energy management.

There are two ways in which the energy performance of buildings can be improved:

- Improved design

▪ Better envelope-reducing the heating and cooling load

▪ Better internal planning-minimize heating and cooling loads in different zones

▪ Better heating, ventilation, air-condition and artificial lighting system-more efficient equipment

- Improved operation

▪ Better control system-operate the building as efficient as possible

▪ Better commissioning –ensure equipment and set up correctly

▪ Better maintenance-routine inspection and servicing

▪ Better energy management-continuously checking that the performance is as expected (Philip Haves , 1992).

For optimizing or choosing the energy conservation strategy we have to know the main factors and the efficiency and costs of their impact. For reducing the energy consumption, the differences in use and construction of buildings have to be determined. This means, that modern commercial building features and occupant requirements have to be examined thoroughly.

3.2. Historical Change of Commercial Building Energy Consumption

The main drivers affecting commercial sector energy consumption over the last thirty years have been changes in technological innovation. As a result of the energy crisis in the 1970's the building industry as well as national authorities set up programs to reduce the energy demand in buildings.

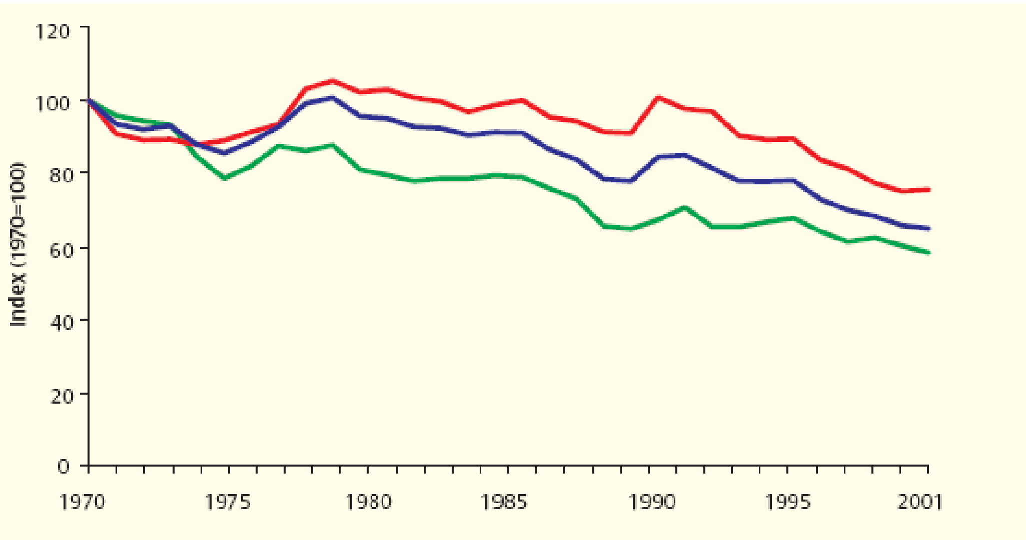


Figure 3.1: Energy intensities for the whole service sector, private commercial and public sectors, 1970 to 2001 (Department of Trade and Industry,2002).

For instance, Figure 3.1 shows how energy consumption in the service sector has changed since 1970 in England. After energy crisis, consumption has decreased by approximately 20 per cent until 1990 and by 30 per cent since 2001.

Energy shortage and rising energy costs as well as environmental concerns are major reasons for reducing energy consumption. Therefore in this work the historical change of commercial building is evaluated to form a base for further improvement strategies.

Pre-Energy Crisis Commercial Buildings

Prior to the worldwide energy crisis in the early 1970s, energy conservation in buildings was rarely considered an issue. A typical commercial building of that time would include the following features:

- Combination of operable windows and air conditioning;
- Clear single glazing with internal shades;
- Use of generous amounts of energy to solve comfort problems;
- High artificial lighting levels
- Negligible equipment loads. (Mahadev Raman, 2001).

Post-Energy Crisis Commercial Buildings

The energy crisis precipitated many innovations in building systems, materials and design, many of which were eventually mandated in building energy codes. The features of a typical building of this time are as follows:

- Reduced fresh air supply to occupants;
- Extensive use of dark and reflective glass;
- Increasing use of double glazing;
- Use of 'economizer' free cooling;
- Advent of variable air volume systems
- Increase in equipment loads with the advent of personal computers.

Despite the increase in equipment loads, the various energy saving measures above had a dramatic impact on energy consumption (Mahadev Raman, 2001).

Contemporary High-Performance Buildings

Many of the energy saving systems and measures introduced after the energy crisis had the unforeseen side effect of degrading the working environment. Reduced fresh air levels and variable volume systems in combination with the increased use of artificial materials in the workplace led to poor indoor air quality and problems such as sick building syndrome. The use of low transmission glazing reduced the sense of connection with the outdoor environment. Modern building designs, particularly since the early 1990s, have begun to address these issues while maintaining good energy efficiency. Common attributes include the following:

- Increased fresh air supply to occupants;
- Clearer glass with smart coatings and/or physical shading to control heat gain;
- More efficient artificial light sources with better colour rendering;
- Better control systems with greater personal control of the immediate environment;
- Further increases in equipment loads;
- Displacement type air-conditioning systems.

The need to improve environmental conditions in that place, along with the increase in equipment loads, has slowed down improvements in energy conservation. Nevertheless, analysis shows that contemporary high-performance office buildings use 40% less energy than their pre-energy crisis counterparts (Mahadev Raman, 2001).

3.3. Energy Consumption Values in Low Energy Commercial Building

The analysis of consumption values from sample buildings is one of the most important measures to evaluate the commercial sector energy use. Therefore in this work building data from previous research efforts were collected (See Table 3.1).

Table 3.1: Building energy consumption data from previous research

Building Name	Country	Building Type	Total Area	Number of Occupants	Heating Con. kWh/m²	Cooling Con.. kWh/m²	Lighting Con kWh/m²	SOURCE
Is bank tower Istanbul	Turkey	OFFICE	224.357 m^2	1772	45,7	60,7	-	Michael Sohmer Master thesis 2005
Baigneux-les-Juifs	France	School	505m²	100	50,0	-	-	SARL F. Barcon et associes
Egebjerg School after refurbishment	Denmark	School	-	-	87,3	-	-	MEDUCA project,1998
Chemical Engineering Building	Greece	School	30.000m²	12000	85,5	49,0	-	IEA case studies
Retrofitting of Chemical Engineering Building	Greece	School	30.000m²	12000	54,4	13,3	-	IEA case studies
Egebjerg School	Denmark	School	-	-	181,0	-	-	MEDUCA project
Berlaymont Building	Germany	OFFICE	170.721m²	-	47,0	12,7	18,7	Energy cert. paper, Dipl.Ing.Hans Erhorn, Dipl.Ing.Heike Erhorn
BRE Environmental Building	UK	OFFICE	2100m²	100	65,3	-	9,0	European Green Building Forum
Tax Office	Netherlands	OFFICE	4300m²	-	76,0	-	2,0	European Green Building Forum
Irish Energy Centre	Ireland	OFFICE	410m²	-	121,5	-	6,7	European Green Building Forum
Metliki Ltd.	Greece	OFFICE	1100m²	37	22,4	44,1	-	Mid-Career Education:
Royal Life Insurance Company	UK	OFFICE	20500 m²	1000	80,7	33,0	-	Mid-Career Education: Solar Energy in European Office Building
Office Vienna cur. energy standard (WBO)	Austria	OFFICE	-	-	-	23,9	28,2	TU Graz Report Klimanet Project 2004
Office Zagreb Low energy standard	Croatia	OFFICE	-	-	-	24,7	28,4	TU Graz Report Klimanet Project 2004
Office Bar Italy	Italy	OFFICE	-	-	-	48,3	28,6	TU Graz Report Klimanet Project 2004
Swiss Statistics Main Office	Switzerland	OFFICE	26415 m²	-	28,0	-	-	Green Grand Tour Project
Elizabeth Fry Building	Norwich	OFFICE	-	-	25,0	-	-	Green Grand Tour Project
Gasser Building Materials Sales Office	Switzerland	OFFICE	755 m²	-	22,7	-	-	Green Grand Tour Project
Mader School	Switzerland	OFFICE	3775 m²	180-250	17,0	-	-	Green Grand Tour Project

Table 3.1: Building energy consumption data from previous research (CONT')

Building Name	Country	Building Type	Total Area	Number of Occupants	Heating Con. kWh/m²	Cooling Con.. kWh/m²	Lighting Con kWh/m²	SOURCE
Columbia Bank	Missouri	Bank	609 m²	-	207,0	59,0	73,0	Energy-10 PROGRAM case study
Columbia Bank after energy eff.str.	Missouri	Bank	609 m²	-	13,0	24,0	31,0	Energy-10 PROGRAM case study
Helvetia Building	Frankfurt	OFFICE	-	-	25,0		200,0	Dr.Werner Neuman "Advanced office building with efficient technologies in Frankfurt"
Primary Health Care Center	Spain	OFFICE	3000m²	150	67,0	71,0	58,0	SARA project
Southampton educational office building	UK	OFFICE	2600m²	-	226,8	18,0	38,0	SARA project
CONCERTO offices Stuttgart	Germany	OFFICE	178.000m² total project area	10.000 total project	50,0	50,0	30,0	Polycity CONCERTO project
CONCERTO offices Barcelona	Spain	OFFICE	2.00.000 m² total project area	-	40,5	40,5	54,0	Polycity CONCERTO project
CONCERTO offices Turin	Italy	OFFICE	87.500m² tot. project area	-	50,0	50,0	30,0	Polycity CONCERTO project
Rome current practise	Italy	OFFICE	-	-	53,5	-	-	Susanne Truschel Diplomarbeit 2002
Rome passive	Italy	OFFICE	-	-	14,5	-	-	Susanne Truschel Diplomarbeit 2002
Helsinki current practice	Helsinki	OFFICE	-	-	92,6	-	-	Susanne Truschel Diplomarbeit 2002
Helsinki passive	Helsinki	OFFICE	-	-	20,0	-	-	Susanne Truschel Diplomarbeit 2002
Stockholm current practice	Stockholm	OFFICE	-	-	54,9	-	-	Susanne Truschel Diplomarbeit 2002
Stockholm passive	Stockholm	OFFICE	-	-	17,8	-	-	Susanne Truschel Diplomarbeit 2002
standard air conditioned UK good practise	UK	OFFICE	-	-	97,0	42,0	27,0	ECON 19
standard air conditioned UK normal	UK	OFFICE	-	-	178,0	93,0	54,0	ECON 19
HSS Kassel	Germany	OFFICE	-	-	25,0	-	-	(SolarBauMonitor 2000)
ESS	Switzerland	OFFICE	-	-	33,0	-	-	Dr. Prof. Ursula Eicker

Table 3.1: Building energy consumption data from previous research (CONT')

Building Name	Country	Building Type	Total Area	Number of Occupants	Heating Con. kWh/m²	Cooling Con.. kWh/m²	Lighting Con kWh/m²	SOURCE
LEO	Köln, Germany	OFFICE	2800m²	-	50,0	-	-	Dr. Prof. Ursula Eicker
DBU Osnabrück	Germany	OFFICE	-	-	60,0	-	-	Dr. Prof. Ursula Eicker
VDI 3807, V1 einfache technische Ausstattung	Germany	OFFICE	-	-	127,0	-	-	VDI 3807
VDI 3807, V2 hohe technische Ausstattung	Germany	OFFICE	-	-	128,0	-	-	VDI 3807
Schweiz Statistic	Switzerland	OFFICE	-	-	122,0	-	-	Dr. Prof. Ursula Eicker
Landys&Gyr Schweiz	Switzerland	OFFICE	-	-	50,0	-	-	Dr. Prof. Ursula Eicker
Baden Württemberg	Germany	OFFICE	-	-	217,0	-	-	Dr. Prof. Ursula Eicker
Lamparter	Stuttgart, Germany	OFFICE	1488m²	2000	17,1	0	6,1	(SolarBauMonitor 2000)
Solarfabrik	Germany	OFFICE	-	-	95,0	-	-	Dr. Prof. Ursula Eicker
Züblin	Germany	OFFICE	-	-	55,0	-	-	Dr. Prof. Ursula Eicker
DB	Hamm, Germany	OFFICE	5974m²	-	120,0	-	-	Dr. Prof. Ursula Eicker
EOS headquarters	Switzerland	OFFICE	5900m²	40	270,3	-	9,7	Stephane Cıtherlet (PHD Thesis)
Lighthouse Building	Glasgow	OFFICE	-	-	118,3	-	100,1	(PHD Thesis)
Germany LaSalle 2004*	Germany	OFFICE	-	-	-	57,6	-	office service analysis report www.Joneslangsalle.de
Frankfurt office buildings	Germany	OFFICE	avg. 40.000m²	-	133,0	-	-	IEA case studies
Madrid office with low internal loads	Madrid, Italy	OFFICE	450m²	-	-	43,0	-	Dr. Prof. Ursula Eicker
Madrid office with high internal loads	Madrid, Italy	OFFICE	450m²	-	-	154,0	-	Dr. Prof. Ursula Eicker
Madrid hotel low internal loads	Madrid, Italy	HOTEL	3000 m^2	-	-	22,0	-	Dr. Prof. Ursula Eicker
Madrid hotel high internal loads	Madrid, Italy	HOTEL	3000 m^2	-	-	79,0	-	Dr. Prof. Ursula Eicker

Due to the fact that energy consumption of office buildings is very high a lot of research efforts have been made. The values of the buildings in Figure 3.2 from low energy buildings change related to the location, building area, internal loads and working hours. The envelope design and inside zone planning is also of importance to reach the results of Figure 3.2. Figure 3.3 is showing the heating consumption values and Figure 3.4 the lighting consumption values.

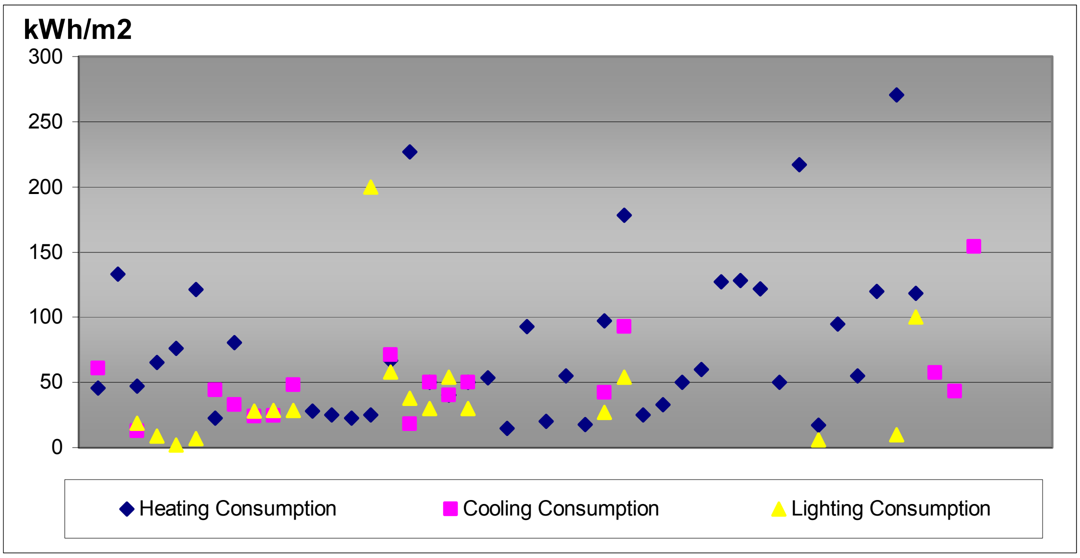


Figure 3.2: Heating, cooling and lighting consumption values from low energy commercial buildings (from Table3.1).

In the samples the total consumption values differ between 25 kWh/m^2 and 250 kWh/m^2. Some samples special for the specific consumption like some research on only heating consumption.

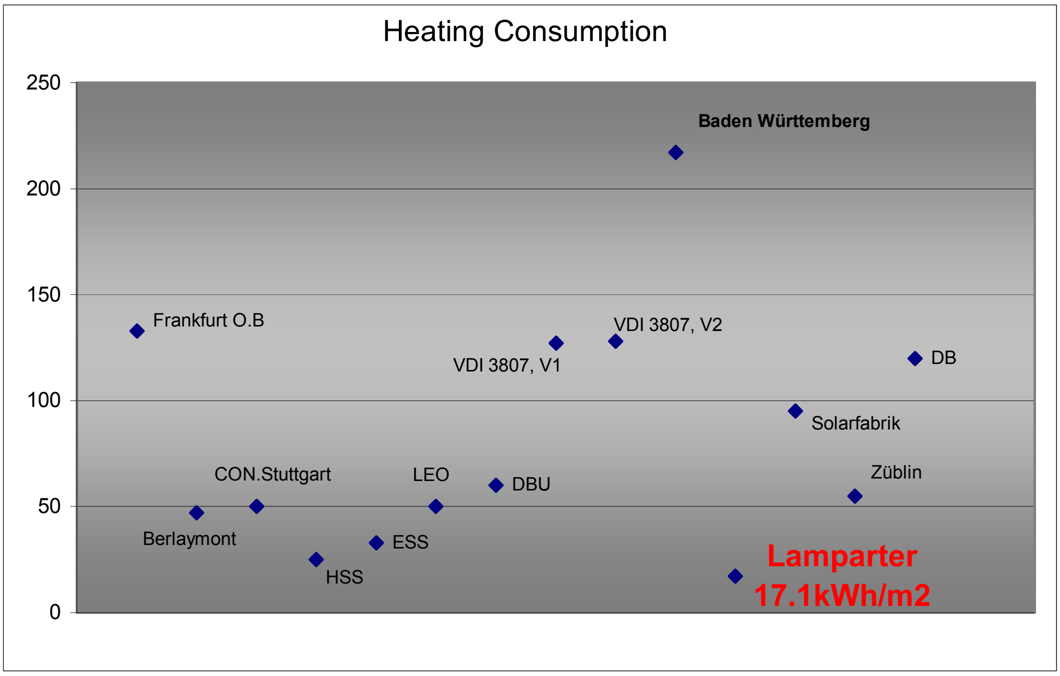


Figure 3.3: Heating consumption values in Germany for different low office buildings.

Looking at the results, the main question will be how those values could be reached. To find answers to that question, in this work the Lamparter building in Germany, which has the lowest total consumption value, was evaluated more detailed.

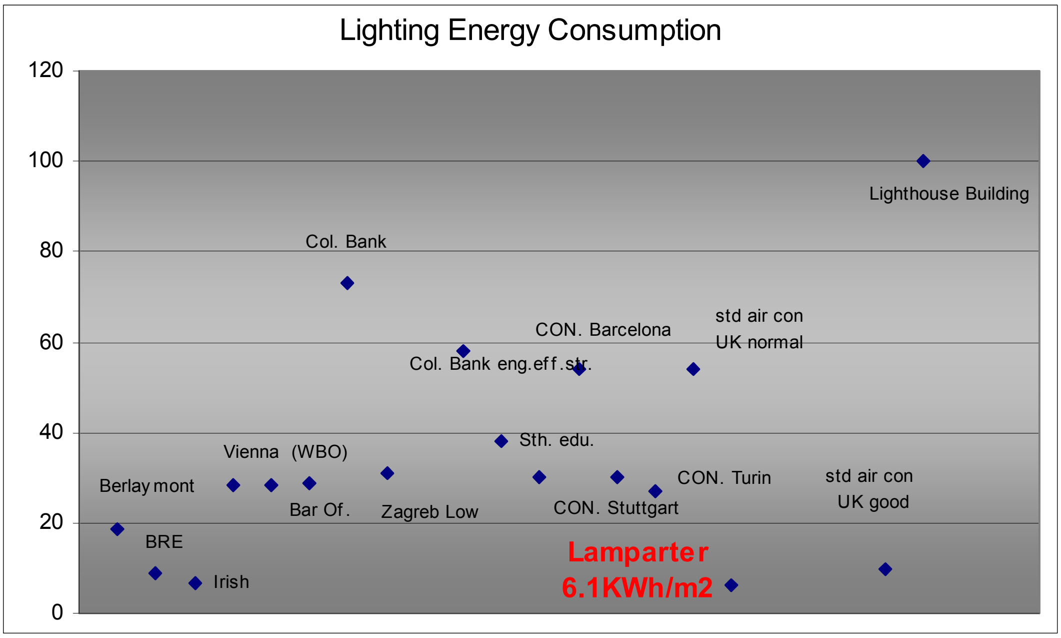


Figure 3.4: Lighting consumption values in low energy commercial buildings.

The Lamparter office building values are 17.1 kWh/m^2 for heating, 6.1 kWh/m^2 for lighting and 0 kWh/m^2 for cooling consumption. Total building energy consumption is 23.2 kWh/m^2 and year. This value is getting better during the operation time of the building by optimizing the energy management (See Figure 3.5).

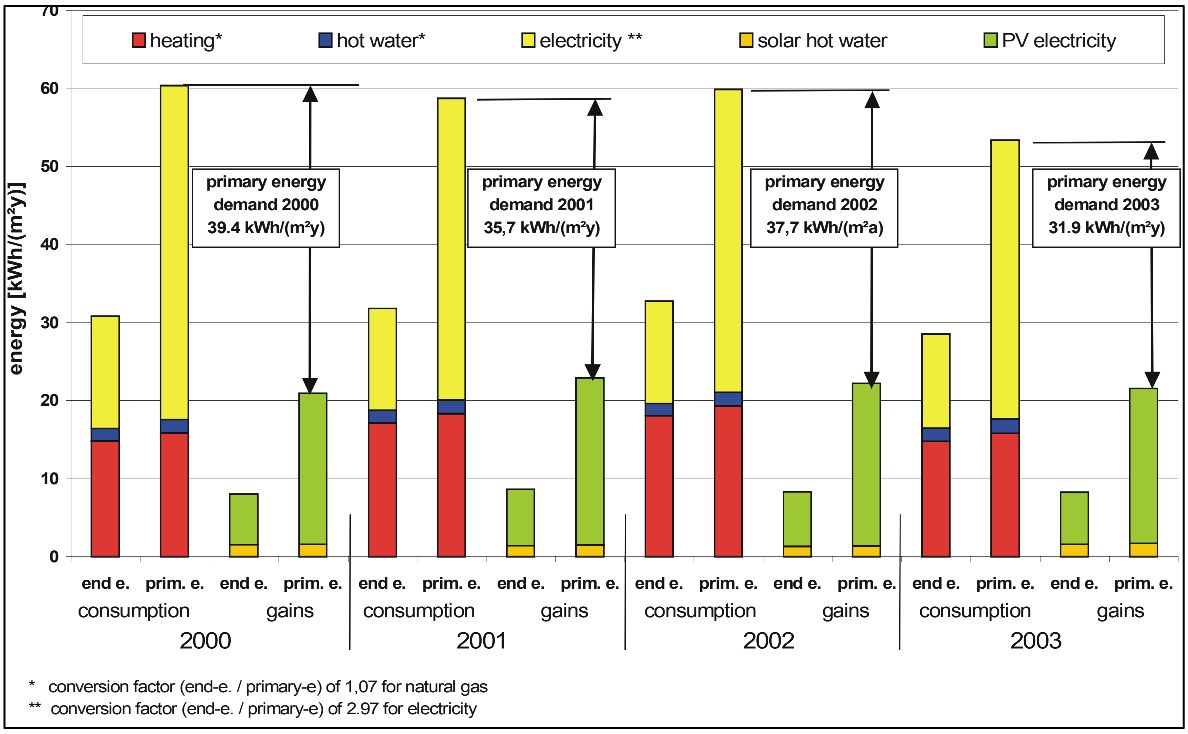
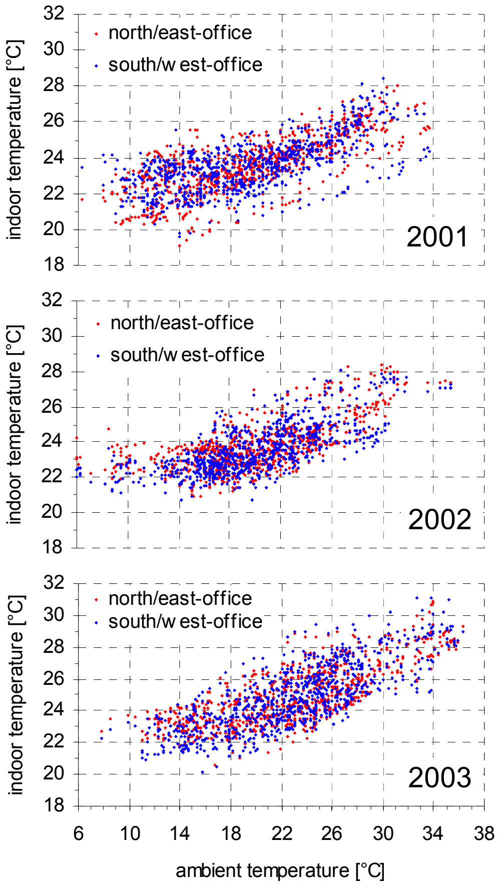


Figure 3.5: Yearly end,primary energy consumption of the office building Lamparter

The administration building of the Hans Lamparter GbR, a firm of consulting engineers and surveyors, was rigorously planned from the very beginning as a passive building (See Figure 3.6). The building is located in a central, prominent position on the site of the former railway station in the town of Weilheim surrounded by two-storey residential buildings.

Figure 3.6: Lamparter building picture

Figure 3.7: Indoor and outdoor temperatures of the office building Lamparter



The outer appearance of the compact structure is divided into a two storey structure with wood panelling and a recessed attic storey separated by fibre-cement slabs. Due to its extremely good thermal insulation standard, its compact structure, passive use of solar energy and ventilation system with highly efficient heat recovery and use of ground heat energy consumption data, user behaviour is recorded and analyzed and then the findings and data is used for optimizing system (See Figure 3.7). Incoming solar gains in the cooling period as well as the artificial lighting are also being controlled and managed carefully **(SolarBauMonitor, 2000)**

The excellent performance values of the Lamparter Building could only be achieved by using all the basic principles of energy performance optimization and strictly following passive design criteria. The strict design combined with a computer based Facility Management System (FMS) lead to the outstanding energy performance values of this building.

3.4. Conclusion

Most of the development in commercial buildings took place in the last 10 to 20 years. Both, the building structure and occupant requirements changed dramatically in this period.

Energy consumption in the commercial buildings is extremely high and is affected by the basic building concept such as site, orientation, form, building envelope, shading control system, space schedule programming and the performance of system. Commercial buildings have a high potential for energy conservation, which can be achieved by building optimizing and system controlling. Advanced construction methods, materials and improved building envelopes are basic parameters for energy saving concepts. The most critical decisions have to be made in the design phase of the building.

Passive solutions should be favoured as a cost effective way of energy conservation. Furthermore energy efficient standard supply technologies should be employed because of their high potential to significantly reduce the energy consumption of commercial buildings.

The trend toward increased automation and control of a building's mechanical and electrical systems will develop into fully integrated systems that rely on information technologies for their operation. A variety of information technologies affect the design, construction, operation, and financing of commercial buildings. If properly deployed throughout the building life-cycle, an integrated set of such computer tools could significantly enhance performance of all types of commercial buildings. In addition to providing increased comfort, health and safety to the building's occupants, enhanced use of information technologies could contribute substantially to reducing energy consumption and maintenance costs. As especially the energy management is a challenge in commercial buildings, adopted and standardised IT (Informatics Technology)-technology would be helpful.

To obtain energy economy and sustainable energy, designers and owners of the building can provide energy efficient buildings. But taking into regard the global dimension of the problem, it is very obvious that governments and the world community have to react with standardized strict building codes, which are rigorously controlled by the authorities.

4. ANALYSIS OF COMMERCIAL BUILDINGS RELATED TO ENERGY EFFICIENCY STANDARDS FOR HEATING,COOLING AND LIGHTING

4.1. General Properties of Energy Standards

One of the absolutely essential needs of human existing is to provide comfort condition and control of climatic conditions. Buildings are there to support quality of working and living conditions, even under different climatic zones. The building components and mechanical systems are used as energy sources in order to adjust indoor conditions to human comfort levels to a state which ensures satisfaction with the indoor environment. **Energy standards** are concerned with human comfort levels and the calculation of energy needed to balance the interactions between the indoor and the outdoor climatic conditions.

4.2. Greenhouse Gases and Kyoto Protocol

While the fossil energy carriers like coal, petrol and diesel are used in the industry, buildings and transport they induce Greenhouse gases (like carbon dioxide) as a result. The use of fossil energy carriers has caused a regular growth in levels of carbon rich gases and other pollutants. Earth's atmosphere causes the climatic conditions that are necessary for the variety of life on the Earth. In the atmosphere CO_2 is highly transparent to the short-wave energy of the high temperature sun, but opaque to the long-wave radiation emitted by earth surface temperatures. If levels of carbon rich gases and other pollutants increase, this results in the trapping of infra-red radiation and increased temperatures at the surface of the earth. Researchers predict that higher levels of greenhouse gases will cause a significant warming of the earth by about one to five degrees Celsius in the next 10-50 years. This could cause potentially disastrous changes in the environment like violent storms, expanding deserts and melting ice caps, causing sea levels to rise and engulf coastal regions. When the international society observed and understood the result of green house gases, that subject aroused international society‘s interest. The international community decided to cooperate for reducing greenhouse gas emissions and improving the global environment. (http://www.koeri.boun.edu.tr)

International negotiations have lead to first steps in combating climate change with the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The Kyoto Protocol signed by about 180 countries at Kyoto, Japan, in December 1997 for the reducing the green gas emission. The protocol commits 38 industrialized countries to cut their emissions of greenhouse gases between 2008 and 2012 to levels that are 5.2 per cent below 1990 levels. Two main strategies can be considered for the reducing the green gas emission: reduction of energy consumption, increase use of renewable energy sources. (Sebastian Oberthür, Hermann E. Ott, 1999)

The energy consumed in buildings has an important proportion of total greenhouse gas emissions. Although buildings also produce Carbon Dioxide (CO_2) emissions, this sector draws less attention compared to other pollution contributors such as the transportation and industry sectors. The proportional use of energy in the building sector rose in the countries total energy consumption, meanwhile the total energy demand is also increasing year by year. Space heating and cooling of buildings in both Western Europe and North America are major contributors to CO_2 emissions. Similarly for Turkey, households account for a quarter of the CO_2 emissions; with space heating accounting for around 69 million t of these emissions (The Lisbon Declaration on CO_2 Reductions, 1997). In the EU, the building sector accounts for more than 40% of total energy consumption, which shows the importance of this sector regarding energy saving potential.

4.3. International Trends of Building Energy Efficiency Codes and Standards

A minimum amount of energy for heating, cooling and lighting is required to sustain space comfort conditions in buildings. This minimum amount can be achieved by the use of efficient components and technologies, which should be defined in building energy efficiency standards to assist to reduce energy consumption. In the residential and commercial building sector, the use of an appropriate energy efficiency technology and insulation obtain the most effective energy saving. The energy generated from renewable sources is favoured for heating, cooling, ventilating or lighting. Renewable energy will as well reduce the carbon dioxide emissions in addition to energy conservation and energy efficient conventional technology.

Building energy standards and codes have been developed and used in many countries to provide a degree of control over building design and to encourage awareness and innovation of energy conscious design in buildings (Janda and Busch, 1994; UN-ESCAP, 1999). Nowadays, on the whole, the focus of energy standards is put on the determination of the criteria for space **comfort** conditions, the **quality** level of these conditions and in this way providing the human **safety**. Most countries have set up energy efficiency standards on the building sector (Table 4.1). Some of those standards for commercial buildings are mandatory (Hong Kong, Taiwan) and in some parts are voluntary (Canada). In less developed countries regulations for commercial buildings are more stiff than for residential buildings, for example the mandatory standards for large commercial buildings in Chile, Hong Kong, the Philippines and Taiwan.

Table 4.1: Worldwide Status of Energy Codes (The table compiled from data gathered in 2003 and 2005. http://www.deringergroup.com).

COUNTRY	DEVELOPMENT STATUS OF CODES	OFFICIAL POLICY ON ENFORCEMENT AND IMPLEMENTATION
Australia	Energy efficiency provisions for commercial and public building codes were incorporated into the Building Code of Australia in May 2005.	
Austria	The Energy Efficiency Agreement in 1995 includes specific regulations regarding building structures and heating systems.	
Belgium	Codes in place.	Mandatory - Residential and non-commercial tertiary buildings
Canada	Codes in place.	Mixed enforcement
Chile	Codes in place.	Mandatory - Residential and commercial
China	Codes in place.	Mandatory - Residential and commercial
Colombia	National energy policy approved by the Columbian government in January 2000.	
Denmark	The 1996 code enforced large buildings, while the 1998 code enforced small buildings.	Mandatory - Residential and commercial
Egypt	ECBC in process (2005).	

Table 4.1: Worldwide Status of Energy Codes (CONT')

Finland	The National Building Code of Finland was revised in 1985 to apply to all new building projects.	Mixed enforcement - Residential and non-residential
France	Codes in place.	Mandatory - Residential and commercial
Germany	Codes in place.	Mandatory - Residential and commercial
Greece	Codes in place. Thermal insulation and minimum energy efficiency building standards are in process.	
Hong Kong	Proposed for non-residential buildings only.	
Hungary	Codes in place.	Voluntary - Non-residential buildings only
India	ECBC in process (2005).	
Indonesia	Proposed for non-residential buildings only.	
Ireland	Codes in place.	
Israel	Codes in place.	Mandatory - Residential
Italy	Regulations on mandatory efficiency codes for all new buildings and renovation of old buildings were introduced in 1993. Additional non-mandatory building codes are in process.	Mandatory - Residential and commercial
Ivory Coast	Codes in place.	
Jamaica	Codes in place for non-residential buildings only	Mixed enforcement
Japan	Codes in place.	Mandatory - Residential and commercial
Korea	Codes in place.	Mandatory - Residential and commercial
Kuwait	Codes in place.	Mandatory - Residential and commercial
Luxembourg	The Energy Efficiency Law was established in 1993. Mandatory insulation standards for new buildings came in to force in 1996.	
Malaysia	Codes in place.	Voluntary - Non-residential buildings only
Mexico	Codes possibly in place (approved in 2004).	
Netherlands	Energy Performance Standards for new buildings and non-residential buildings came into effect in 1995.	Mandatory - Residential and commercial
New Zealand	The National Energy Efficiency and Conservation Strategy was prepared and released in 2001. Regulations covering mandatory energy performance standards and labelling came into force in 2002.	Mandatory - Residential and commercial
Norway	ECBC was established in 1997.	Mandatory - Residential and commercial
Pakistan	ECBC was established in 1990.	Voluntary

Table 4.1: Worldwide Status of Energy Codes (CONT')

Philippines	Codes in place.	Voluntary - Non-residential buildings only
Portugal	Codes in place.	
Russia	A national ECBC has been in effect since 1979 and a fully developed energy code was adopted in 1999.	Mandatory - Federal and Regional
Saudi Arabia	Codes in place.	Voluntary
Singapore	Codes in place for non-residential only.	Mandatory - All air-conditioned buildings only
South Africa	Codes in place for non-residential buildings only.	Voluntary - Non-residential buildings only
Spain	Energy savings standards were established in 1979.	Mandatory - Residential and commercial
Sri Lanka	Codes in place.	
Sweden	Thermal insulation requirements were included in ECBC in 1960. The revised building regulations of 1988 introduced a building performance standard instead of requiring insulation for certain building components. The last revision of these codes was in 1998.	Mandatory - Residential and commercial
Switzerland	Codes in place.	Mandatory - Residential and commercial
Thailand	Codes in place.	Mandatory - Residential and commercial
Turkey	Mandatory standards for heat insulation in new buildings were adopted in 1985.	Mandatory - Residential and commercial
United Kingdom	The current building regulations that came into force in 2002 will be replaced in 2006 by the EU's Energy Performance of Buildings Directive in 2006.	Mandatory - Residential, commercial, and public buildings
United States	Nearly all state and local governments established energy efficiency standards for new residential buildings in the 1970s.	Mixed enforcement
Yugoslavia	Codes in place.	Mandatory - Residential and commercial

When we look at present commercial building stock, existing buildings participate with approximately 95%. To implement energy efficient standards into new buildings is easier. Consequently the reducing of the existing building energy consumption is the major problem. The existing commercial sector provides the greater occasion for implementation of energy efficiency measures as well as the greater opportunity for overall energy efficiency gains. There is also still legal problems which prevent building owners from imposing retroactively energy saving measures on existing buildings. A solution for this problem is the delivery of building energy performance certificates which give an idea about energy efficiency of both, existing and new buildings. According to EU's energy performance of buildings directive, new buildings should be designed with the minimum energy performance standards based on an integrated methodology. Also existing buildings, which have a floor surface of more than 1000 m^2, should be designed under these standards in the case the building undergoes larger renovations. This solution could be a practical way to solve existing buildings' energy problems (N.Dicke, C. Weber, E. Kjelisson, H. Despretz, 2003).

4.4. Measurement Based Approaches to Standards

Most countries have implemented energy efficiency policies and measures for several years out of different reasons such as energy or oil crisis or environmental worries.

The building energy standards have to define an agreed level of indoor climate conditions and a certain methodology for determining building energy consumption. All standards base on geographical data which include weather or location specific data. Due to the fact that energy standards are defined nationally a number of different standards are in practice. These standards generally can be classified in "Unit approach Standards", "Overall Envelope Standards", "Energy Limitation Standards", "Energy Performance Standards" and for future options "Life Cycle Standards" (WEC, www.worldenergy.org.).

4.4.1. Unit approach Standards

The standards based on unit approach are characterized by the efficiency improvement of the individual components of the building, such as heat transfer of the roof, the windows, etc. The thermal component approach is a method, which divides the shell into its individual components and considers the maximum heat transmission value for each of the components. This heat transmission value (U-value) can be defined as the amount of heat that flows through a square meter of building component with temperature difference of 1 K. Especially most early thermal building codes were of this type and nowadays this method is used to certify building materials with specified thickness **(WEC, www.worldenergy.org.).**

4.4.2. Overall Envelope Standards

Another type is the overall envelope approach for thermal building energy standards. Overall envelope approach considers a limit of the overall heat transfer through the building envelope. To give the average transmission value for the building shell, instead of the standardising each building component, the designers have a chance to limit the heat transfer. It gives higher flexibility for designers as a higher transmission from one component can be balanced with the better values from other components. The limit value specified is typically the mean k-value (U-value or thermal resistance) of the building envelope. This kind of standard for example is used in the province of Victoria, Australia. (WEC, www.worldenergy.org.).

4.4.3. Energy Limitation Standards

When we looked at the lighting part there is limitation on the illumination level for the building types due to human comfort conditions. The Illumination Engineering Society publishes lighting guidelines by detailed space function. The guideline for each function consists of a low, medium, and high value, ranging from low to high by a factor of two or two and one-half. Actual levels in place may be outside this range. Nevertheless, the guidelines serve as an indicator of relative lighting requirements for different types of buildings (WEC, www.worldenergy.org.).

Furthermore limitation of heating, cooling, lighting demand is another type of standard. These types of thermal codes which also take into account the contributions from ventilation losses/gains, passive solar gains through building components (in particular through windows) and internal heat sources, are fundamentally more systematic approaches than the previous two. Together with this approach a reduction of the energy demand could be achieved via increasing use of passive design strategies. The standard is specified in terms of heating, cooling demand per cubic meter of volume or per square meter of floor area. An example standard for this approach is the building code WSVO 95 which is used by Germany.

4.4.4. Energy Performance Standards

Energy performance standards for the first consider the whole building as a system. It integrates not only the demand for heating, cooling, lighting; but in addition all of the building equipment such as heating and air conditioning systems, energy for ventilation, hot water preparation, pumps, elevators, etc. Further on, it also includes all active solar energy gains from solar collectors, photovoltaic units, etc. A performance-based building energy code includes the state of the art for technical solutions and also design tools. The standard is specified in terms of annual (primary or final) energy consumption per cubic or square meter. A performance-based building energy code sets a maximum allowable energy consumption level without specification of the methods, materials, processes to be employed to achieve it. The designer is responsible to present a design solution together with appropriate predictive evidence of its energy behaviour. The performance option will need to study and estimate the likely consumption levels based on the integrated performance of the elements concerned, such as building envelope, lighting and HVAC. But the actual number of areas to be included in the evaluation may vary depending on the purpose and scope of the assessment. Performance standards get the flexibility of choosing the optimal mix between passive solutions and active technologies for designers. Examples are the performance standards in California, the present standards of Germany and France and the EU building code.

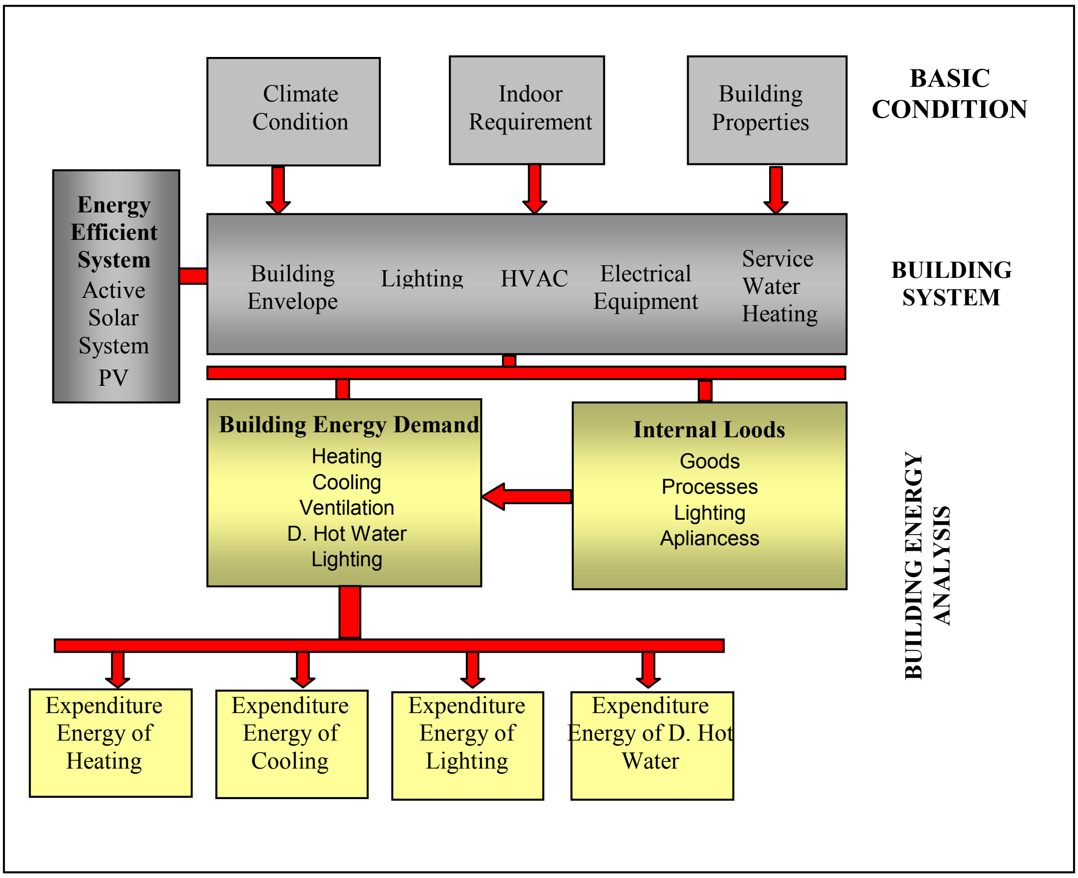


Figure4.1. Building performance standards basic concepts with major elements and compliance paths.

In present years, there has been strong interest in the world to improve or revise building energy codes using a performance-based approach. This approach gives the flexibility, clarity and effectiveness to the codes. While building energy consumption is calculated, also economical analysis of the measures is carried out.

4.4.5. Life Cycle Standards

Life cycle standard is not yet realized in any country, but is under research. In addition to items covered in energy performance standards. It would include the energy incorporated in the buildings. This recognizes that, as energy consumption of buildings becomes lower and lower, so-called "grey energy" (e.g. energy used to produce the insulation materials) becomes more and more important compared to the direct consumption of the buildings. Sometimes the economic methodology was based on marginal analysis by considering an upgraded construction component and then determining the incremental energy-cost savings to the incremental modification costs over a specified life-cycle period. Questions ascend concerning the economic assumptions used in developing the standard. There are recommendations that impact studies should be carried out to evaluate the cost-estimating techniques and the basic economic assumptions. This is certainly a matter of further research, and must be made transparent in future building codes (WEC, www.worldenergy.org.).

Buildings, especially commercial buildings, become more complex with new technologies. PV systems, CHP based internal combustion engines, fuel cells and so on are used in new commercial buildings. Over time requirements change and standards should take into regard research efforts and market penetration of technologies. Consequently building codes also have to be adopted to the technological improvement and therefore have to be continuously changed. Building energy codes need to be flexible to adapt to dynamic conditions such as technological advances. They also should increase incentives for the industry to invest in the development of more energy efficient technology. However, even in the case of the performance-based provisions, the prescription of a minimum required level is necessary.

4.5 EU Building Energy Standards

Energy use in buildings accounts for more than 40 % of the final energy demand in the EU. Heating fuel is the most important component (52% of non-residential building consumption). Water heating accounts for 9% of non-residential use. Lighting accounts for up to 25% of emissions due to commercial buildings (Weber-EU Save II Project, 2002).

The increasing emissions of greenhouse gases are making it difficult to respond to the challenge of the climate change. As a reaction the European Union under the Kyoto protocol committed itself to reduce CO_2-emmissions by 8 % in the period from 2008 to 2012 related to the level in the year 1990. The implementation of the Directive on the Energy Performance of Buildings (2002/91/EC, ANNEX I – II), as from 2006 will permit a decrease estimated at some 40 megatons of oil equivalent between now and 2013 (cf. /EU 1998/). These observations provide strong reasons to economize the use of energy from buildings.

The European Directive 2002/91/EC on Energy Performance of Buildings came into force on 16 December 2002 and requires implementation in the legislation of the 15 present Member States by 4 January 2006. In addition to the aim of improving the overall energy efficiency of new buildings, large existing buildings (>1000m2) have become a target as soon as they undergo significant renovation. Energy Performance Directive (EPD), which was adopted in 2002 and published in the Official Journal of the European Communities on January 4 2003, lays down requirements as regards:

a. the general framework for a methodology of calculation of the integrated energy performance of buildings (Articles 3 and 4);

b. the application of minimum requirements on the energy performance of new buildings (article 5);

c. the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation (article 6);

d. energy certification of buildings (article 7); and

e. regular inspection of boilers and of air-conditioning systems in buildings and in addition assessment of the heating installation in which the boilers are more than 15 years old (articles 8 and 9).

The main content of the Energy Performance of Buildings Directive is:

· Application and regular updating of minimum standards for energy performance of buildings based on a common methodology for all new buildings and for existing buildings of more than 1000 square meters that are being renovated. The performance will include energy use for heating, ventilation, lighting, as well as the opportunity of heat recovery and local renewable energy supply used in cost-effective ways.

· Common methodology for the preparation of minimum integrated energy performance standards, which Member States will have to adopt for each type of building. This methodology will have to take account of differences in climate and include factors relating to insulation, heating, ventilation, lighting, building orientation, heat recovery, and use of renewable energy sources.

· Certification systems for new and existing buildings: energy performance certificates for buildings not older ten years, containing advice on how to improve energy performance, will have to be available for all buildings when built, sold or leased. These energy performance certificates, together with information on recommended and actual indoor temperatures, will also be displayed in public buildings and in other types of building frequented by the public.

· Specific checks and assessment of heating and cooling equipment by experts. Member States will have to make arrangements for regular inspection of boilers of a rated output between 20 and 100 kW. Boilers above this threshold must be inspected every two years (gas boilers every four years).

4.5.1. EU Building Energy Performance CEN Standards

Directive 2002/91/EC on the energy performance of buildings (the EPBD) requires several different measures to achieve prudent and rational use of energy resources and to reduce the environmental impact of the energy use for buildings. The application of the Directive is monitored by Commission. The energy performance of buildings is calculated using a methodology based on the common framework and is sometimes differentiated at a regional level. Out of this reason around 30 European Standardisation Organisation (CEN) standards have been developed. Standards are being written in CEN that shall support the Directive. Looking at the CEN standards and documents hierarchy; the law and technical regulations are obligatory; EN and HD standards are strong pressure to apply the document; CWA, TS, ES documents are only recommendation and TR documents are informative.

The European Standards (ENs) support the EPBD by providing the calculation methods and associated material to obtain the overall energy performance of a building. While many of these standards have already been published, there are several others which currently are at various stages of the drafting process(Table4.2).

Table 4.2. List of EN and ISO standards related to building energy performance. *The italics have not been published yet* (http://europa.eu.int/comm).

Aspect / **Sub-aspect**	**Commities ofCEN**	**Standard No**	**Building category**	**Comments in brief**
a. Thermal characteristics	89			
building components	89	EN ISO 7345 EN ISO 6946 EN ISO 13789 *prEN 13947* EN ISO 13370 EN ISO 10077-1 EN ISO 10077-2 ISO 10292	a. Single-family houses b. Apartment blocks c. Offices d. Education buildings e. Hospitals f. Hotels and restaurants g. Sport facilities h. Wholesale and retail trade services buildings i. Other (warehouses, museums, cold stores...)	Definitions. Thermal resistance and thermal transmittance. Transmission heat loss coefficient. Curtain walls, simplified method. Heat transfer to ground. Windows, doors and shutters, U simple and numerical. U for multiple glazing.
thermal bridges	89	EN ISO 10211-1 EN ISO 10211-2 EN ISO 14683	a-i	General methods Linear thermal bridges. Linear thermal bridges and default.
air leakage	89	EN ISO 13790	a-i	Annex G (informative).
thermal storage of envelope, interior partitions and floors	89	EN ISO 13786	a-i	Dynamic thermal characteristics.
b. Heating installation				
emission losses, distribution losses (e.g. pipe and boiler insulation levels), control losses DHW losses	228	*prEN 12831* *prEN 14335* EN 14336		Method for calculation of the design heat load. Method for calculation of system energy requirements and system efficiencies. Commissioning of heating systems.

c. Air-conditioning instal.				
cooling load, efficiency	156 89	*WI 156057* *WI 156058* *TC 89 N 602* *TC 89 N 742*		Energy requirements for AC-buildings Cooling load (JWG). Part 1: Cooling load calculation. Part 2: Calculation of energy needs for building with air conditioning.
d. Ventilation				
air flow	156	EN 13465 *WI 156077* *WI 156078* *WI 156079* EN 13779 *(N433)* *WI 156064 (N300)*	a,b c,f,h a,b a,b	Air flow in dwellings. Air flow rates in commercial buildings. Energy losses due to ventilation and infiltration in commercial buildings. Energy losses due to ventilation and infiltration in dwellings. System performance including energy. Design and dimensioning for residential buildings.
air leakage		EN ISO 13790	a-i	Annex G (informative)
airing				
e. Built-in lighting Install.	169			
f. Position and orientation of buildings, outdoor climate	89	EN ISO 13790 *prEN ISO 15927-5* *prEN ISO 15927-4* *prEN ISO 15927-2* *prEN ISO 15927-6* *prEN ISO 15927-1* *prEN ISO 15927-3*	a-i	Calculation and presentation of climatic data: Winter external design air temperatures and related data. Data for assessing the annual energy demand for cooling and heating systems. Data for design cooling loads Accumulated temperature differences (degree days) Monthly and annual means of single meteorological elements Calculation of a driving rain index for vertical surfaces from hourly wind and rain data
g. Passive solar systems and solar protection	89	ISO 9050 EN 13363-1 *prEN 13363-2* EN ISO 13790	a-i	Light and solar transmittance Solar protection and glazing. Simplified and reference methods. Annexes E and F.
h. Natural ventilation	89	EN ISO 13790	a,b	a,b Annex G (informative)
i. Indoor climatic conditions, including the design indoor climate.	 89	*prEN ISO 13791* *prEN ISO 13792*	a,b,c	Internal temp. of a room without cooling. Criteria and validation procedures, Simplified calculation method.
	156	CR1752:1998	c,d,f,h	Design criteria and the indoor environment. Criteria to achieve good indoor air quality in offices, schools, meeting rooms, restaurants, stores etc. Classification scheme based on perceived indoor climate

The energy performance standards will specify what should be included in the energy use of a building in order to express energy performance or an energy label (e.g. heating, cooling, hot water, lighting) and set out how energy from different sources (e.g. electricity, gas, oil, biomass) can be combined to one or more numeric indicators (e.g. primary energy, CO_2 emissions).

Overall energy performance criteria can be based on asset rating obtained from delivered energy, primary energy, CO_2 emissions, energy costs but regulation based on delivered energy, primary energy and CO_2 emissions. This standard is on revision till spring 2006 and it will be published in mid 2007.

This standard will provide:

- A definition of system boundaries (e.g. building, installations, energy supply) and calculation periods;

- The definition of the overall energy uses (which uses are taken into account within the system boundaries);

- A method to be used to calculate the overall energy use of buildings (net energy, delivered energy, etc) provided by references to other standards for heating, cooling, ventilation, hot water and lighting;

- The procedures for taking building decentralised energy production based on renewable energy and CHP (combined heat and power production) into consideration;

- The rules for assessing primary energy consumption and CO_2 emission of buildings;

- The rules for taking into account the interactions between the different energy uses (e.g. calculation of recovered gains and losses).

CEN Definitions:

The following passages describe the energy performance definitions of buildings according to CEN and some definition related energy performance indicators (CEN/TC WG4 N 310 rev1 E):

Energy performance of buildings

"Amount of energy actually consumed or estimated to meet the different needs associated with a standardised used of the building." (Figure 4.2)

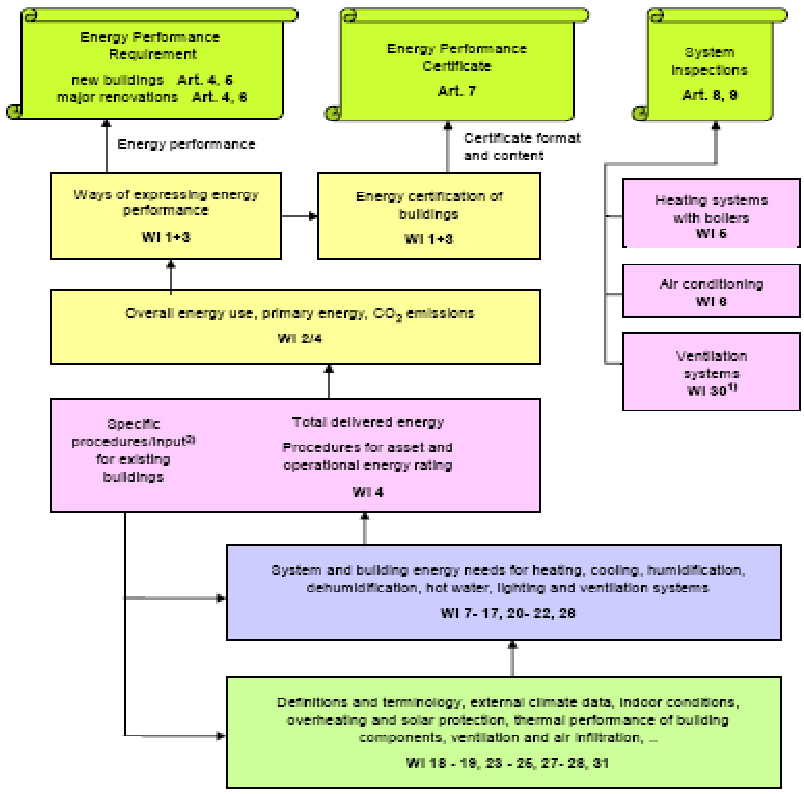


Figure 4.2: Methodology scheme for calculating energy performance

Energy demand

"Energy to be delivered to provide the required service with an ideal system (no system losses taken into account) to the end user (e.g. to maintain the internal set-point temperature of the heated space)

Delivered energy

"Energy supplied to the building from the last market agent. The boundaries of the building are those defined for calculating its energy balance. The energy produced by the building itself ,for example using solar water heater, photovoltaic systems or co-generation and delivered back to the market is subtracted. It is the sum of energy ware."

Auxiliary energy

"Energy used by heating, cooling, domestic water, lighting and ventilation systems to transform the delivered energy into the useful energy. This includes energy for fans, pumps, pilot flames, electronics, etc., but not the energy that is transformed."

Net energy

"The energy to be supplied by the energy systems to provide the required services, such as maintaining the building at the specified internal temperature, lighting and ventilating a space, etc., taking account of useful gains."

The building net energy can be calculated for each energy use separately or merged (e.g. subgroups: heating and ventilation). This is specified in a national annex.

The building net energy $Q_{building}$ net is calculated as follows **(4.1):**

$$Q_{net} = Q_{losses} - Q_{recovered\ thermal\ gains} \quad \text{(4.1)}$$

Where:

Q_{losses} losses or needs determined in specific standards (calculation, operational rating, etc) $Q_{recovered\ thermal\ gains}$ recovered thermal gains determined in specific standards (calculation, operational rating)

$$Q_{building\ net,\ thermal} = Q_{net,heating} + Q_{net,ventilation} + Q_{net,cooling} + Q_{net,hot\ water} \quad \text{(4.1a)}$$

$$Q_{building\ net,\ electrical} = Q_{net,lighting} \quad \text{(4.1b)}$$

$$Q_{building\ net} = Q_{building\ net,\ thermal} + Q_{building\ net,\ electrical} \quad \text{(4.1c)}$$

Total energy use of building

"Total energy delivered to the energy systems for heating, cooling, ventilation, hot water preparation, lighting, appliances, etc. The total energy use is the sum of the delivered energy produced and used on the site, including passive gains, collected per energy ware. Energy delivered back to the market is not included."

In the building, energy is not only consumed but also produced (e.g. boilers, combined heat and power). If the decentralised energy supply system is based on renewable energy (e.g. active thermal solar) or on combined heat and power, then the positive influence of the building decentralised energy production is taken into account separately for thermal energy and electrical energy. If the building's decentralised electricity production is higher than the specific energy consumption then energy credit is allocated to the building.

It seems worth to point out the positive influence of the decentralised building energy production, and not to reduce directly the delivered energy

The building systems could be divided in the following subsystems:

- Emission,
- Storage,
- Distribution,
- Generation

For each use i (heating, ventilation, etc.) and each subsystem j (emission, distribution, storage) the net system thermal losses, without building generation devices, can be calculated as follows **(4.2)**:

$$Q_{net,thermal,\ system\ loss,\ i,j} = Q_{thermal,\ system\ loss,\ i,j} - Q_{system,\ recovered\ thermal\ loss,\ i,j} \quad \text{.....(4.2)}$$

$Q_{thermal\ system\ losses\ i,j}$ losses determined in specific standards (calculation, operational rating, etc) $Q_{system,\ recovered\ thermal\ loss\ i,i}$ recovered thermal gains determined in specific standards (calculation, etc)

The net thermal system losses (without building generation devices) are calculated by:

$$Q_{net,\ therm.\ sys\ loss\ without\ generation} = \Sigma(Q_{therm.\ sys\ loss,\ i,j} - Q_{sys\ recovered\ thermal\ loss,\ i,j}) \quad \textbf{(4.2a)}$$

The electricity system loss (without lighting needs) is calculated by:

$$Q_{\text{electricity system loss without generation}} = \Sigma\ (Q_{\text{electricity system loss i, j}}) \quad \textbf{(4.2b)}$$

The building net energy and the net thermal system loss (without generation) are added together in order to determine the thermal energy requirements of the buildings distribution systems. The electricity consumption is also determined. Theses requirements have to be satisfied by the building energy generation systems and / or by energy supplied from outside the building (district heating, grid). The energy requirements of the buildings distribution systems are calculated with **(4.3)**:

$$Q_{\text{therm.requirements,distribution}} = Q_{\text{build. net, therm}} + Q_{\text{net, therm system loss without generation}} \quad \textbf{(4.3a)}$$

$$Q_{\text{elec. equirements,distribution}} = Q_{\text{build, net, electricity}} + Q_{\text{electrical system loss without generation}} \quad \textbf{(4.3b)}$$

Primary energy

"Energy which has not been subjected to any conversion or transformation process. For a building, it is the energy used to produce the energy delivered to the building. It is delivered energy divided by the conversion or transformation factor of each form of energy. "

The primary energy approach makes the simple addition of different types of energies (e.g. thermal and electrical) possible, because this approach integrate the losses of the whole energy chain. Therefore the primary energy consumption may be used for comparison of different types of energy systems. The energy production losses located outside the building system boundary (e.g. district heating) are taken into account by the primary energy approach. Theses losses, and the gains in case of building decentralised energy production, are also calculated with the primary energy factor. The energy used for different purposes and by different fuels is recorded separately.

The integrated energy performance of buildings, expressed in primary energy, is calculated by **(4.4)**:

$$Q_{primary,\ building} = \Sigma\ (Q_{delivered,i} \times f_{primary,i}) \quad \textbf{(4.4)}$$

The electricity production of the building is taken into account with a negative value in the calculation of the delivered energy.

CO_2 emission calculation

The CO_2 emission of the building is calculated by **(4.5)**:

$$E_{CO_2,building} = \Sigma(Q_{delivered,i} \times f_{CO_2,i}) \quad \textbf{(4.5)}$$

4.5.2 Calculation of Heating Load for EU Building

The **thermal performance of buildings** calculations are based on CEN standard EN ISO 13790 (formerly EN832). The approach for determining heating load is simplified. Conditions are assumed steady-state (do not change with time) – constant external conditions, constant internal temperature. The heating of a building is essentially an energy balance. To maintain the internal space at a constant temperature the heat inputs into the building must balance heat losses.

Heat inputs include:

- Input from the heating system
- Solar gains
- Occupant and equipment gains
- Losses include
- Fabric losses
- Ventilation losses

The following Sankey diagram illustrates this (Figure 4.3):

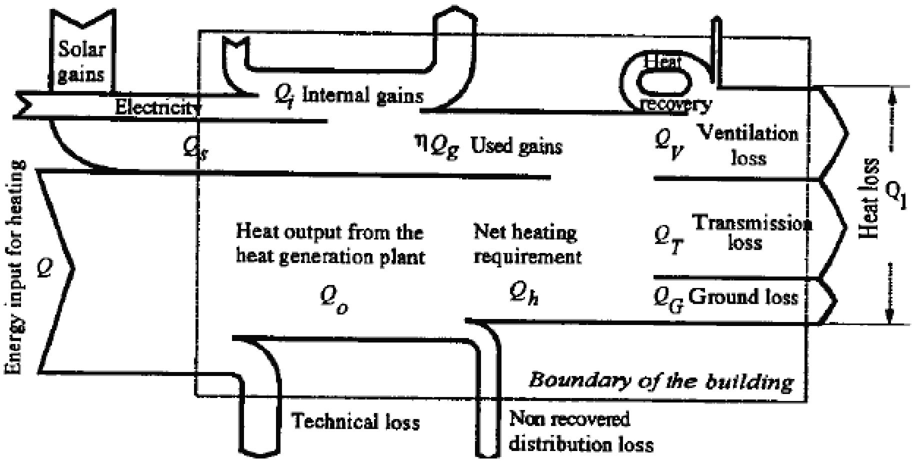


***Figure* 4.3.** Sankey diagram

For this energy balance all the losses and gains must equate to zero**(4.6)**.

$$\Sigma Q = 0 \quad \text{(4.6)}$$

By working out the other loads and gains associated with the building, the heating load can be specified. Once the heating load has been determined the heating energy consumption is found from**(4.7)**:

$$Q_h = Q_l - \eta Q_g \quad \text{(4.7)}$$

t is the length of time of the analysis period, e.g. monthly or for the course of an entire heating season.) Q_l are the total losses and Q_g are the gains. η is added to account for the non steady state nature of the gains over time (t) of the analysis period, e.g. monthly or for the course of an entire heating season and is an "utilisation factor" (which partly takes into account the thermal capacity of the building). One or more analysis periods may be used – e.g. heating load for each winter month.

The procedure for calculating the heating energy consumption of the building is as follows:

- Define the boundaries of the heated space and, if needed, of different zones and unheated spaces.
- Calculate specific heat loss (loss per K) for single or multi zone building.
- Define the set-point temperatures and, if necessary, the intermittency patterns.
- For seasonal calculations, define or calculate length and climatic data of the heating season.
- For each period:

a) Calculate heat loss based on assumption of constant internal temperature

b) Calculate internal and solar gains

c) Calculate the utilization factor for the gains

d) Calculate the net heat requirements

e) Calculate the effect of intermittency

f) With monthly calculation, calculate the annual space heating requirements from the sum of individual months

g) Calculate the energy requirement taking account of the seasonal efficiency of the heating system

Zoning defines areas of a building with the same thermal characteristics – so a building heated to the same temperature could be treated as a single zone. However if there are significant differences between the north and south solar gains (due to a large glazing area) then two zones would be required. Alternatively multiple zones would be required if different areas of the building are heated to different temperatures.

Calculating Heat Losses

The total heat loss from the building is the sum of fabric, ventilation and ground heat losses (Q_G) **(4.8):**

$$Q_l = (H_T + H_V)(\theta_i - \theta_e)t + Q_G \quad \textbf{(4.8)}$$

Ground losses are calculated according to prEN ISO 13370 (an equivalent thermal transmittance).

The Transmission Loss from the Fabric

The transmission losses are a combination of fabric and ventilation heat losses, where the fabric heat loss is given by the following equation **(4.8)**:

$$Q_T = H_T(\theta_i - \theta_e)t \quad \textbf{(4.8)}$$

The specific fabric heat loss is **(4.9):**

$$H_T = \sum_{j=1}^{n}(UA)_j + \sum_{k=1}^{m}(\psi)_k + \sum_{l=1}^{p}(x)_l \quad \textbf{(4.9)}$$

UA should be familiar from classes. The two other terms account for thermal bridging, the first being linear thermal bridges, the second being point thermal bridges.

Ventilation Loss

The specific ventilation loss is calculated from **(4.10):**

$$H_V = \dot{V}p_a c_a \quad \textbf{(4.10)}$$

where V_C is the volume flow rate through the space. This can be calculated from the air change rate (n) by **(4.11):**

$$\dot{V} = \frac{V_n}{3600} \quad \textbf{(4.11)}$$

For natural ventilation n is 0.5 ac/h, V is the building volume.

Intervening Unheated Spaces

Specific heat losses can be directly to outside or to outside via an unheated space. In the latter case, the following applies **(4.12)**:

$$H_{ie} = H_{iu}(1-b) \quad \textbf{(4.12)}$$

where : $$b = \frac{H_{iu}}{H_{iu} + H_{ue}} \quad \textbf{(4.12a)}$$

H_{iu} is the total specific heat flow (ventilation plus conduction) between the heated and unheated space, H_{ue} is the total specific heat flow between the unheated space and the exterior.

The heat flow from the heated space to the exterior is therefore **(4.13):**

$$Q_{lie} = H_{iu}(1-b)(\theta_i - \theta_e) \quad \textbf{(4.13)}$$

Ground Heat Loss

Heat loss to the ground is often calculated by an equivalent U-value for the floor (heat flows are not linear!).

Q_G is the ground heat loss often calculated with a specific heat loss H_G that simplifies complex 3-D heat flow through ground connecting elements **(4.14)**.

$$Q_G = H_G(\theta_i - \theta_G)t \quad \textbf{(4.14)}$$

The total heat loss is therefore **(4.15):**

$$Q_l = H(\theta_i - \theta_e)t + Q_G \quad \textbf{(4.15)}$$

H is the sum of the total specific fabric and ventilation heat losses for the building.

Intermittent Heating

Intermittent heating is dealt with by replacing the internal set point by an equivalent internal temperature which is the constant internal temperature leading to the same heat loss as the one with intermittent heating. National procedures or the Annex in the CEN standard can be used to calculate this according to heating type.

Calculating Heat Gains

The total heat gains from the building are the sum of internal and solar heat gains.

$$Q_g = Q_h + Q_s \quad \textbf{(4.16)}$$

Heat Gains

These come from three sources:

- Gains from occupants
- Gains from appliances
- Solar gains

Gains from occupants and equipment would commonly be given in terms of W/m^2 of floor area. Calculation of solar gains depends on site, glazing areas, orientation, etc. The basic equation for the gain is **(4.17):**

$$Q_s = \sum_{j=1}^{n} q_{sj} \left(\sum_{k=1}^{m} A_{skj} \right) \quad \textbf{(4.17)}$$

The first sum is over all the building orientations (e.g. vertical N, S, E and W and horizontal), and the second is over all the surfaces on that orientation. The effective collecting area of each element of glazing is

$$A_{sm} = A_m (1 - s_m) F_{c_m} F_{F_m} g_n \quad \textbf{(4.18)}$$

Where A is an area, s_m is the permanent shading factor of the surface, F_c is the permanent curtain factor, F_F is the ratio of transparent surface to total surface (reduction due to frame) and g is the total solar transmittance of the surface, which is the time averaged transmittance of the non-shaded area of the glass. The shading factor s is in the range 0 to 1. It includes shading from adjacent buildings, and shading devices, shown in the appendices of the CEN standard. The curtain factor and framing factor also vary between 0 and 1.

Internal Heat Gains

The equation for the space heating requirement is **(4.19):**

$$Q_h = Q_l - \eta Q_g \quad \text{(4.19)}$$

where η is the utilisation factor. The utilisation factor for internal and passive solar heat gains represents the effect of heat storage in building fabric. This is calculated as follows.

Calculate the gain/loss ratio of the space, where Q_g and Q_l are calculated for each calculation period**(4.20):**

$$\gamma = \frac{Q_g}{Q_l} \quad \text{(4.20)}$$

The utilisation factor is then calculated from **(4.21)**:

$$\eta = \frac{1-\gamma^a}{1-\gamma^{a+1}} \quad \gamma \neq 1 \quad \text{or} \quad \eta = \frac{a}{1+a} \quad \gamma = 1 \quad \text{(4.21)}$$

where $a = a_0 \dfrac{\tau}{\tau_0}$

a=2.5 is the constant value for non residential buildings (day time use)

τ is the time constant of the building (hours or seconds) and is a function of the internal thermal capacity of the heated space (i.e. light or heavyweight) and the losses typically ranging from a few hours for a lightweight structure to a few days for a heavyweight structure **(4.22)**.

$$\tau = \frac{C}{H} \quad \textbf{(4.22)}$$

Calculation of Thermal Capacity

The effective thermal capacity C of the heated volume is essentially the heat stored when the internal temperature varies sinusoidally by 1K within a given period of time (24 hours). This is calculated by summing the effective thermal capacities of all the internal building elements in direct contact with the internal air**(4.23-24)**:

$$C = \sum_{k=1}^{n} X_k A_k \quad \textbf{(4.23)}$$

where k is the number of thermal capacity elements.

$$\mathrm{X} = \sum_{j=1}^{n} p_j d_j c_j \quad \textbf{(4.24)}$$

d is an effective thickness of one side of an element .

Monthly Calculation Method

The total heating energy requirement is the sum of the monthly energy requirements where average external temperatures are lower than the internal temperature **(4.25):**

$$Q_h = \sum_{j=1_{J=jan,feb......,dec}}^{12} Q_{hj} \quad \textbf{(4.25)}$$

Seasonal Calculation Method

The limits of the heating season can be defined nationally, or can be determined as those days for which the gross heat gains balance the heat losses, i.e when **(4.26):**

$$\theta_e = \theta_i - \frac{Q_g}{H_t} \qquad \textbf{(4.26)}$$

The space heating requirement for the season is therefore **(4.27):**

$$Q_h = H(\theta_i - \theta_e)t + Q_G - \eta(\theta_i + \theta_s) \qquad \textbf{(4.27)}$$

where t is the duration of the heating season. (θi – θe) t is directly related to degree days.

Heating System Efficiency

The energy delivered to a space to maintain environmental conditions must be delivered to the space by a heating system. There are inefficiencies associated with the system and so the delivered energy does not equal the energy consumption. Over a period of time the energy delivered to a heating system is given by **(4.28):**

$$\theta = \frac{Q_h}{\eta_h} \qquad \textbf{(4.28)}$$

where η_h. is the seasonal heating efficiency of the system.

This is the product of several efficiencies **(4.29)**:

$$\eta_h = \eta_\chi \eta_\in \eta_\delta \eta_\gamma \qquad \textbf{(4.29)}$$

η_x. is the control efficiency, expressing the effect of dynamics and the control of the heating system. Also a system that does not respond quickly and efficiently to changes in load may cause overheating – increasing the energy consumption of the system. $\eta_{e.}$ is the emission efficiency, expressing the effect of the extra heat losses due to emission devices – for example consider radiators in a room. η_{δ} is the distribution efficiency, expressing the effect of heat losses from the distribution network. η_{χ} is the conversion efficiency of the system and is the ratio of heat output to energy input of the heat source – e.g. a boiler.

4.5.3 Calculation of Cooling Load for EU Building

The cooling load calculation procedure is applicable to rooms for which temperature requirements must be complied with in the case of thermal loads, and humidity requirements in the case of humidity loads. The aim of this abridged process is to determine the cooling load of a room or building for fixed boundary conditions.

The most important boundary conditions are:

- Constant room air temperature.
- Periodic internal and external loads - quasi steady state
- 24 hour plant operation
- Constant sun protection factor of the whole window (no wandering shadows) (VDI 2078, 1996)

Room cooling load $\dot{Q}_{KR}$

The room cooling load is the sum of the internal and external cooling load components **(4.30)**:

$$\dot{Q}_{KR} = \dot{Q}_I + \dot{Q}_A \quad \textbf{(4.30)}$$

Building cooling load $\dot{Q}_{KG}$

The building cooling load at time t is obtained from the sum of all room cooling loads at time t **(4.31)**:

$$\dot{Q}_{KG} = \sum_{j=1}^{n} \dot{Q}_{KRj}(t) \qquad \textbf{(4.31)}$$

The building maximum cooling load can be stated as maximum of the corresponding time function once the temporal progression over the relevant hours has been determined.

Internal cooling load $\dot{Q}_I$ (4.32),

$$\dot{Q}_I = \dot{Q}_P + \dot{Q}_B + \dot{Q}_M + \dot{Q}_G + \dot{Q}_C + \dot{Q}_R \qquad \textbf{(4.32)}$$

Cooling load due to persons $\dot{Q}_P$ (4.33),

$$\dot{Q}_P = n \cdot q_p \cdot S_i \qquad \textbf{(4.33)}$$

n number of persons

q_p heat emission from the human body

S_i cooling load factor for internal loads

Cooling load due to lighting $\dot{Q}_B$ (4.34),

$$\dot{Q}_B = P \cdot l \cdot \mu_B \cdot S_i \qquad \textbf{(4.34)}$$

P total installed power of the lights, for discharge lamps including the power loss due to the chokes

l simultaneity factor of the lighting at the time concerned

μ_B room load factor due to lighting

Cooling load due to machines and equipment $\dot{Q}_M$ (4.35),

$$\dot{Q}_M = l \cdot S_i \sum_{j=1}^{n} \frac{P_j}{\eta} \mu_{aj} \quad \textbf{(4.35)}$$

P_j rated power (shaft power) of the machine j

η mean motor efficiency

μ_{aj} load factor of the machine j at the time in question

l simultaneity factor

Cooling load due to material throughput $\dot{Q}_G$ (4.36),

$$\dot{Q}_G = \dot{m} \cdot c \cdot (\vartheta E - \vartheta A) \cdot S_i \quad \textbf{(4.36)}$$

$\dot{m}$ mass of the material brought into the room or removed from it in the unit of time

c mean specific heat capacity

ϑ_A outlet temperature

ϑ_E inlet temperature

Cooling load due to different temperatures in adjacent rooms $\dot{Q}_R$ (4.37),

$$\dot{Q}_R = k \cdot A \cdot \Delta\vartheta \quad \textbf{(4.37)}$$

k heat transmission coefficient

A area

$\Delta\vartheta$ temperature difference

Only the steady-state component of the heat flow is taken info consideration.

Other heat supply and heat removal

The effect of all other heat supply and removal $\dot{Q}_C$ on the room climate should be estimated and taken into consideration - if necessary divided into sensible and latent heat. Where the radiation component of the source is known, the cooling load may be calculated by means of a storage function.

External cooling load $\dot{Q}_A$ (4.38),

$$\dot{Q}_A = \dot{Q}_W + \dot{Q}_T + \dot{Q}_S + \dot{Q}_{FL} \quad \textbf{(4.38)}$$

Cooling load through external walls and roofs $\dot{Q}_W$

The instantaneous heat flow $\dot{Q}_W$ through external walls AW and roofs DA into the room arises from the following **(4.39)**:

$$\dot{Q}_W = k \cdot A \cdot \Delta\vartheta_{eq} \quad \textbf{(4.39)}$$

m_f the mass per un it area

Δz the so-called time adjustment of each design.

The time adjustment takes into consideration the delay behaviour of structural designs if it deviates from the behaviour of the corresponding class. If the time adjustment takes on a value which deviates from zero, then the time at which the equivalent temperature difference is to be determined should be modified by the stated time adjustment, and read off at this point. With a time adjustment of zero; the value of the equivalent temperature difference at the time of determination should be used. In general, the following applies **(4.40)**:

$$\Delta\vartheta_{eq}(z) = \Delta\vartheta_{eq,table}(z + \Delta z) \quad \text{(4.40)}$$

if the external walls and roofs have surfaces whose absorption factors and emissivities deviate from the values used as basis (pale-tinted walls, dark roof), $\dot{Q}_W$ is also formed using a corrected value $\Delta\vartheta_{eq2}$

Dark-tinted wall (ϵ = 0.9, a_S = 0.9):

$$\Delta\vartheta_{eq2} = \Delta\vartheta_{eq} + \Delta\vartheta_{eq,a_S}$$

White wall (ϵ = 0.9, a_S = O..)"):

$$\Delta\vartheta_{eq2} = \Delta\vartheta_{eq} - \Delta\vartheta_{eq,a_S}$$

Meta/tic bright watt (ϵ == 0.5, a_S = 0.5):

$$\Delta\vartheta_{eq2} = \Delta\vartheta_{eq} - \Delta\vartheta_{eq,a_S} + 2.0$$

Light-tinted roof (ϵ = 0.9, a_S = 0.7):

$$\Delta\vartheta_{eq2} = \Delta\vartheta_{eq} - \Delta\vartheta_{eq,a_S}$$

White roof(ϵ = 0.9, a_S = 0.5):

$$\Delta\vartheta_{eq2} = \Delta\vartheta_{eq} - 2\Delta\vartheta_{eq,a_S}$$

Whereby $\Delta\vartheta_{eq,a_S}$ is the correction value when modifying the absorption factor by

Δa_S = = 0.2.

Cooling load due to transmission through windows $\dot{Q}_T$ (4.41),

$$\dot{Q}_T = k_F \cdot A_M \cdot (\vartheta_{La} - \vartheta_{LR}) \quad \text{(4.41)}$$

k_F heat transmission coefficient of the window

A_M total window area (wall opening dimension)

ϑ_{La} instantaneous external air temperature

ϑ_{LR} room air temperature

Cooling load due to radiation through windows $\dot{Q}_S$ (4.42),

$$\dot{Q}_S = \left[A_1 \cdot I_{\max} + \left(A - A_1\right) \cdot I_{diff,\max}\right] \cdot b \cdot S_a \quad \text{(4.42)}$$

A_1 sun-exposed glass area

$A \approx g_v \cdot A_M$ total glass area (in special cases, with, for example, folded roofs, the projection area on the direction of calculation should be used in each case.)

g_v glass surface component of window area;

$A_M - A$ is the frame area

$I_{\max}$ maximum value of total radiation for the design month

$I_{diff,\max}$ maximum value of diffuse radiation for the design month

S_a cooling load factor for external radiation load

b radiation transmission coefficient of the window and sun protection devices

With moveable sun protection, the calculation process assumes that the sun protection is drawn for the whole day; if this is hat the case, i.e. if the sun protection is not drawn during periods without direct sun radiation, the following preliminary calculation should be carried out to decide which radiation values and cooling load factors should be used **(4.43)**:

$$\dot{Q}_{S,\mathrm{Im}ax} = b_1 \cdot b_2 \cdot I_{tot\,\max} \cdot S_{a\,\max} \quad \textbf{(4.43a)}$$

$$\dot{Q}_{S,I\,\mathrm{Im}ax} = b_1 \cdot I_{N\,\max} \cdot S_{aN\,\max} \quad \textbf{(4.43b)}$$

The radiation values, cooling load factors and transmission coefficients should then be used for the greater cooling load value.

Cooling load due to infiltration $\dot{Q}_{FL}$

This cooling load component is only taken into consideration in special cases.

4.5.4 Calculation of Lighting Energy Performance for EU Buildings

Light is an essential part of the interior environment of any building. The lighting should accommodate the visual needs as a function of the task performed in the space. (Egan, 1983) There are two sources for light: natural light coming from the sun, and artificially generated light. Artificial light is a major source of energy consumption in buildings. Limitation on the lighting consumption should be important part of the energy performance standard in commercial buildings. The measurement of light traditionally means measuring the illuminance in lux.

The **lighting performance of buildings** calculations haven't been specified in CEN, yet. As an example we can look at the approach of the Dutch energy performance of non-residential building standard to determine lighting consumption.

The primary energy consumption for lighting can be calculated with the following simplified formulas **(4.44)**:

$$Q_{primary;lighting} = 10.9 \cdot (E_{lighting;daylight\ sector} + E_{lighting;artificial\ lighting\ sector}) \quad \textbf{(4.44)}$$

$Q_{primary;lighting}$ is the primary energy consumption for lighting

$E_{lighting}$ is the electrical energy consumption for lighting in the daylight or artificial light sector

10.9 is conversion factor from kWhel to MJ primary energy

The electrical energy consumption for the daylight sector during the day period can be calculated as follows **(4.45)**:

$$E_{lighting;daylight\ sector} = P_{lighting} \bullet f_{control;daylight} \bullet (A_{daylight\ sector} / A_{surface\ area\ in\ use}) \bullet t_{day} \quad \textbf{(4.45)}$$

$P_{lighting}$ total installed load for lighting, including ballast

$f_{control;daylight}$ factor for the control/switching system

$A_{daylight}$ sector surface area of the daylight sector

$A_{surface\ area\ in\ use}$ surface area in use in the building

t_{day} number of burning hours per year in the day

The electrical energy consumption for the artificial light sector during the day period can be calculated as follows **(4.46)**:

$$E_{light;\ artificial\ sector} = P_{ligh.} \bullet f_{control;artificial\ light} \bullet (A_{artificial\ light\ sector} / A_{surface\ area\ in\ use}) \bullet t_{day} \quad \textbf{(4.46)}$$

$f_{control;artificial}$ light factor for the control/switching system

$A_{artificial}$ light sector surface area of the artificial light sector

The electrical energy consumption during the evening period can be calculated as follows **(4.47)**:

$$E_{lighting;evening} = P_{lighting} \bullet f_{lighting\ evening} \bullet t_{evening} \quad \textbf{(4.47)}$$

$P_{lighting}$ total installed load for lighting, including ballast

$f_{control;evening}$ fraction of the maximum energy consumption for lighting in the evening/night period (0.5 to 0.8)

$t_{evening}$ number of burning hours per year in the evening period

4.5.5. EU Countries National Regulations

Comparing the standards, there aren't any consumption limits defined for commercial buildings. They are defined in national building regulations according to building type. These limits should be related with building using type.

The member state countries are regulating their consumption limits on the national level of their building energy standards. Investigation of the different countries recent energy standards in the EU is a way to understand the basic methodology for integrated energy performance standards for commercial buildings.

4.5.5.1. GERMANY

The simplest energy standards for buildings are referring to the specific heating energy demand. Typical values for the specific heating energy demand for the building stock are in the range 100 to 300 kWh/m²·a. By appropriate technical effort the heating energy demand can be strongly reduced. The following standards or technologies, respectively, have been introduced in the German-speaking area:

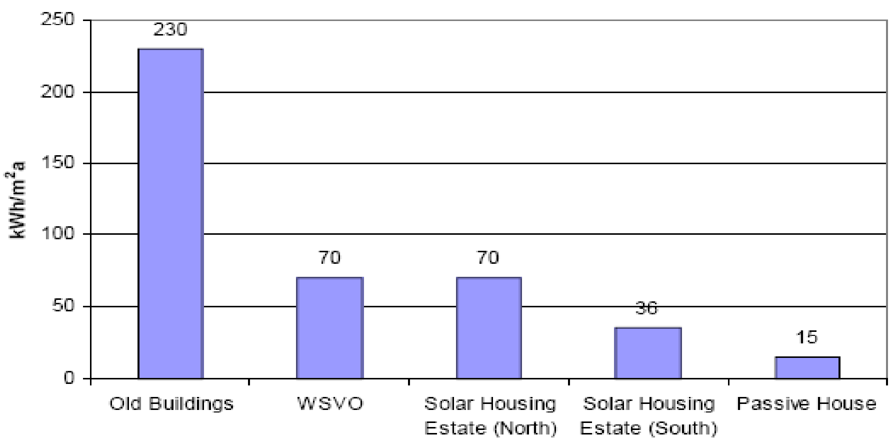


Figure 4.4: Heating energy demand in German building related to standards

Low energy houses (Niedrigenergiehäuser) have values for the heating energy demand of about 50 to 70 kWh/m²·a. In Germany, this appellation is used for buildings, which have an about 30% lower heating energy demand than allowed by the building code for new buildings (WSVO'95), which was in force between 1995 and February 2002. So called "3 litre houses" have a specific heating energy demand of (somewhat less than) 30 kWh/m²·a. This corresponds to an oil demand for heating of about 3 litre/m²·a. This classification does only make sense, if the heating energy demand is actually covered by fossil fuels. If a heating based on electric energy is used, the specific primary energy demand is increased by a factor of 3, because of the losses caused by the electricity generation. In such a case, a heating energy demand of 30 kWh/m²·a would correspond to a primary energy demand of 9 litre/m²·a. Passive houses (Passivhäuser) have an extreme high insulation level, use ventilation systems with very efficient heat recovery, and utilise solar energy by energy efficient glazing or windows, respectively. They exhibit a typical heating energy demand in the region 15 to 25 kWh/m²·a (Figure 4.4) (K. Voss, 1998).

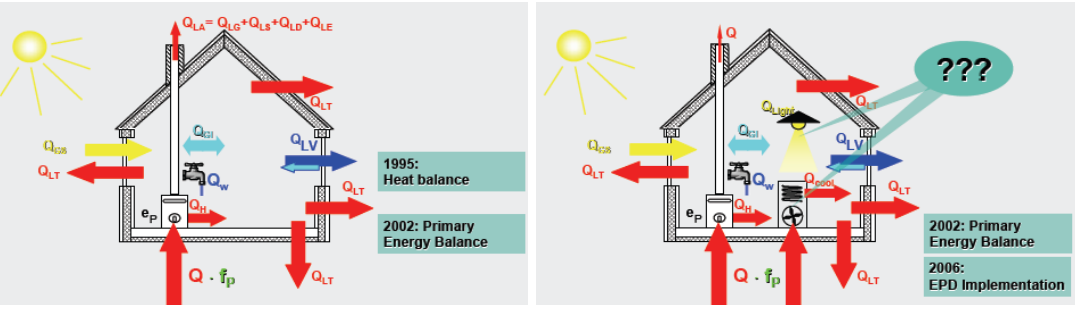


Figure 4.5: German building energy calculation schemes

Present German Calculation Scheme (Figure 4.5):

EN 832 + + DIN V 4701-10

DIN V 4701-10: Calculation scheme for heating, mechanical ventilation and hot water appliances (end energy and primary energy; ~ EN 14335)

Calculation scheme for energy performance is based on simplifications not valid for air-conditioned buildings. Air conditioned buildings can only be handled properly with major changes of the calculation system.

Non-residential buildings are very different in terms of use, size, shape and typical construction. They are characterized by strong differences in the energy demand for lighting, for ventilation, for cooling, the intended use of the building and its parts, the shape of the building and the size of the building. Even the heating energy demand may be different because of different internal temperatures and different intended periods of use. The present calculation and requirement scheme is sufficient for residential buildings. The scheme is in force since 2002. The new aspects new "lighting" and "air-conditioning" have no impact on the design of residential buildings. Germany plans to keep the present scheme for residential buildings and to establish a new scheme for non-residential buildings only (P. Schettler-Köhler, 2004).

In Germany there are some guidelines for new commercial buildings and they give thermal service consumption values. In the town of Essen in Germany the target values for commercial sector buildings are set in the HUMEB (Energie in Hochbau, Leitfaden energiebewusste Gebäudeplanung1996) guideline. An other guideline for Germany is VDI 3807 (1994: VDI- Richtlinie 3807: Energieverbrauchskennwerte für Gebäude; Heizenergie und Stromverbrauchskennwerte, Blatt 2, Düsseldorf)

Table 4.3: Thermal services energy consumption values from VDI3807 and HUMEB (*Units in kWh/m^2/a)

BUILDING TYPE	VDI 3807 Good Practice	HUMEB Required	Target
Schools	**55**	**75**	**50**
Sports facilities	**65**	**60**	**40**
Kinder gardens	**65**		
Office buildings	**65**	**75**	**50**
Shops		**75**	**50**
Warehouses		**60**	**40**

Following some results of research carried out on current energy consumption of existing buildings are shown. Some typical values of delivered energy consumption for space heating demand according to ISI (1998), VDI 3807, Ages (2000) are some of samples.

Table 4.4: Delivered energy consumption for space heating demand from Ages(2000), VDI 3807 and ISI (1998) (*Units in kWh/m^2/a)

BUILDING TYPE	Ages(2000)	VDI 3807 Avg.	ISI(1998)
Schools	Primary schools 158 Gymnasiums 1000-2000 187 9 year elementary school 150	90	
Sports facilities		140	
Kinder gardens		120	
Office buildings	Federal and state ministries 130	110	164
	Administrative buildings 143		
	Administrative buil. normal 120		
Meeting halls	Youth meeting centres 218		

4.5.5.2 Netherlands

Until December 1995, the energy sections of the Building Decree contained provisions for the minimum heat resistance of the building envelope, the glazing and the air density. The Building Decree imposed no requirements on systems for climate control, lighting and transport. On the one hand, this decision has the advantage of simple implementation and control, whereas on the other, this limited approach provides no stimulation to optimise the energy management of a building with all its installations as a whole. Furthermore, the limits for building more economically in terms of energy consumption are quickly attained if legislation restricts itself to only a few aspects of a building. This is why the Dutch government preferred to impose performance requirements on the energy efficiency of buildings as a whole, including the installations these buildings comprise. This not only includes climate control, ventilation and the hot tap water supply, but also the lighting systems.

New energy performance requirements laid down in Dutch building legislation took effect in December 1995. A new method, the energy performance standard, has been developed to determine the energy efficiency of a building. This method can be used to express the energy efficiency of a building in a single figure; the energy performance coefficient (EPC). The Building Decree lays down threshold values for the maximum permissible EPC. The introduction of this new standard means that the various aspects of a building are no longer assessed individually when applying for a building permit. This gives architects and consultants ample leeway when designing a new building. They are free to opt for design solutions, provided the overall design meets the energy performance requirements (IEA, 2003).

The Dutch standard defines energy performance as the measure of the energetic properties of a building. In other words, it indicates how energy-efficient a building is. To determine the energy performance, the characteristic energy consumption and the permissible characteristic energy consumption of a building are calculated. The EPC is the quotient of the characteristic and permissible characteristic energy consumption. The required energy performance depends on the building's function (office building, health care building, building for the hotel and catering industry, sports building, shop building, etc.). The requirements for each building are determined by means of cost-effect studies based on a package of measures that is more or less cost-neutral in relation to the operating costs. This establishes the required EPC at such a level that the measures imposed by the legislation are still viable (J.T.H.Straatman, 1997).

NEN 2916 "Energy performance of non-residential buildings; Determination method", NPR 29 17 "Energy performance of non-residential buildings" (practical guidelines) are current Dutch commercial building standards.

The determination method is limited to the items on the energy balance sheet that are building-related. The energy consumption for office equipment, catering, etc. is not included. User behaviour is standardised. The following items are included:

• Heating: transmission, ventilation, heat gain (sun, inside heat), efficiency

• Cooling: cooling requirements, heat gain (sun, inside heat), heat loss, efficiency

• Ventilators

• Lighting

• Pumps

• Hot water supply

The energy performance coefficient can be calculated with the following formula:

$$EPC = (Q_{performance;\,total} / Q_{performance;permissible}) \cdot EPC_{requirement} \quad \text{(4.48)}$$

$Q_{performance;total}$ numerical value of the characteristic energy performance in MJ primary energy. $Q_{performance;total}$ can be calculated as the sum of fossil fuel consumption for heating, ventilators, lighting, pumps, cooling, humidification and hot water supply.

$Q_{performance;permissible}$ numerical value of the permissible characteristic energy performance in MJ. $Q_{performance;\,permissible}$ can be calculated on the basis of an empirical formula. For a building with only one building function, $Qp_{erformance;\,permissible}$ is equal to 330 • Ag, where Ag is the surface area in use.

4.5.5.3 UNITED KINGDOM

Minimum legitimate requirements for the energy performance of new buildings have been used since 1965 and the standards got strictly regularly every few years. The current building regulations, which came into force in July 1995, elevated the minimum standard in order that new buildings should have been 25-35% more energy-efficient than before. Proposals for revisions to the regulations, which included the practical possibilities of regulating the existing stock of buildings, as well as further improving standards for new construction, were published in June 2000 for further consultation. These changes came into effect on 1 April 2002. For buildings other than dwellings, similar improvements are required for insulation and there are new requirements for heating, lighting and air-conditioning, including the provision of energy meters, and testing and commissioning (IEA, 2003).

A Carbon Performance Rating Method is included in the documents as a way of showing compliance for office buildings and there are other ways of carbon

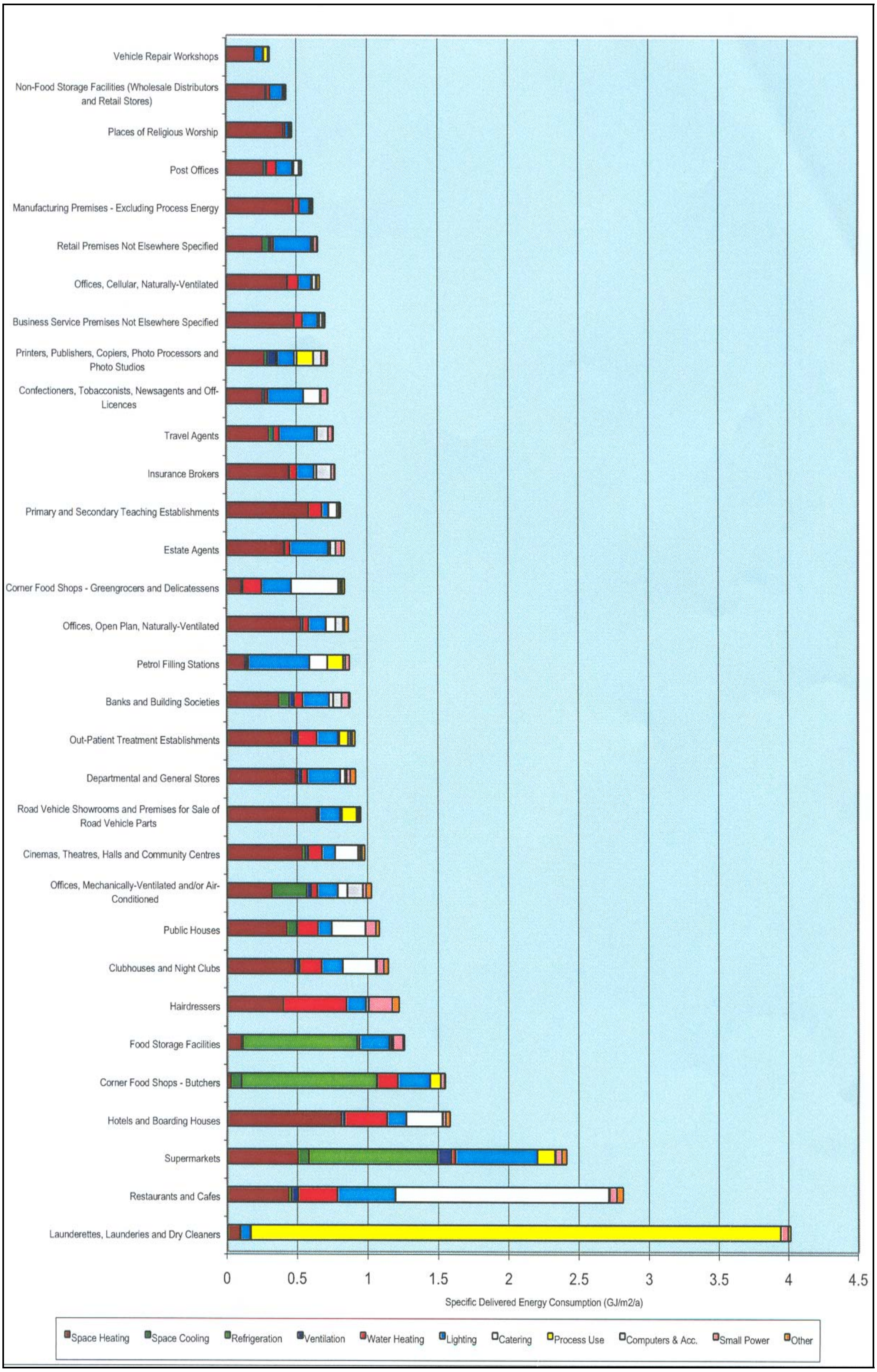


Figure 4.6. Average Specific Delivered Energy Consumption of All Applications by Activity Classification in UK commercial building sector (M.A. Elsayed, J.F. Grant, N.D. Mortimer, 2002)

accounting for other types of buildings. In the UK a National Calculation Tool (NCT), which is calculation methodology for performance of non dwelling buildings, is being developed based on the energy performance standards. The National Calculation Methodology for non-residential buildings in England & Wales has been released as an updated beta test version. The methodology, called the Simplified Building Energy Model (SBEM), calculates monthly energy use and carbon dioxide emissions of a building given its geometry, construction detailing, use, HVAC and lighting services. Originally based on the Dutch methodology NEN 2916:1998, it has since been modified to comply with emerging CEN standards (http://www.esta.org.uk).

	1		2		3		4	
	Good practice	*Typical*	*Good practice*	*Typical*	*Good practice*	*Typical*	*Good practice*	*Typic*
Heating and hot water – gas or oil	79	151	79	151	97	178	107	201
Cooling	0	0	1	2	14	31	21	41
Fans, pumps, controls	2	6	4	8	30	60	36	67
Humidification (where fitted)	0	0	0	0	8	18	12	23
Lighting	14	23	22	38	27	54	29	60
Office equipment	12	18	20	27	23	31	23	32
Catering, gas	0	0	0	0	0	0	7	9
Catering, electricity	2	3	3	5	5	6	13	15
Other electricity	3	4	4	5	7	8	13	15
Computer room (where appropriate)	0	0	0	0	14	18	87	105
Total gas or oil	79	151	79	151	97	178	114	210
Total electricity	33	54	54	85	128	226	234	358

■ OFFICE TYPE 1
Naturally ventilated cellular
■ OFFICE TYPE 2
Naturally ventilated open-plan
■ OFFICE TYPE 3
Air-conditioned standard
■ OFFICE TYPE 4
Air-conditioned prestige

Figure 4.7. Office buildings energy consumption values according to United Kingdom's office building energy consumption guide.

4.5.5.4 FRANCE

Former thermal regulations in force in the new commercial sector were less stringent than those applying to new housing units since 1 January 1989. These regulations, as mentioned above, have been revised according to RT2000 with the aim of gaining 40% energy efficiency. To incite professionals to design more energy-efficient buildings than the current regulations require, sectored guides have been produced by ADEME and the Association of Air-Conditioning, Ventilation and Cold Engineers. Eight guides (hotel, office, health, educational, retail, leisure, industry and agricultural sectors) were published between 1992 and 1997. On the assumption that new building projects continue at the present rate, a gain in unit consumption of 25% with respect to the current regulations will produce an energy saving of 90 000 toe a year for the buildings put into service each year as from 1998. (Helen O'Neill, Andrew Warren, 2001)

There are 28.9 million houses in the residential sector, including 23.9 million principal residences occupied on a permanent basis, and 753 million square metres of heated commercial premises. Most of this property, about 66% for residential buildings and around 65% in the commercial sector, was built before 1975, date at which the first thermal building regulations came into force in France. Policy aimed at this category of housing has been in place since 1975, based on three types of action: 1- Decision-making assistance aimed at encouraging owners to carry out energy saving improvements, in particular through a thermal diagnostic tool. 2- Regulation and standardisation of components with, in particular, the regulation of boiler performance as from 1975. 3- Investment assistance, subject to various terms and conditions such as direct subsidies or tax incentives.

Current energy consumption for new buildings is much higher than other European countries. SAVE II ENPER-TEBUC (Weber 2002) study shows thermal energy performance standard of new buildings in European Union members and in that study France values are really high.

Denmark	**48 Kwh/m^2/a**
Sweden	**75 Kwh/m^2/a**
Netherlands	**91 Kwh/m^2/a**
Germany	**102 Kwh/m^2/a**
France	**105 Kwh/m^2/a**

Table 4.5: Energy consumption values for new buildings in EU countries (Weber, 2002)

4.5.5.5 BELGIUM

The main insulation standards for new buildings and retrofitting in the residential and tertiary sector currently being implemented in the three regions are as follows:

Wallonia: For new lodgement buildings (residential, but also hospitals, hotels, boarding schools, barracks, prisons) either the *K55*(The K ratio concerns the total level of thermal insulation calculated on the basis of a technical standard established by the Belgian Institute for Standardisation (IBN). It takes into account mainly the insulation of the various shells but neither solar heat, nor occupant behaviour nor the efficiency of heating.) standard or the *Be 450* (The Be ratio concerns the calculation of the net needs for energy for heating, which means taking into account the free inputs of solar heat) standard is enforced. In both cases, k values (A "k value" designates a heat loss coefficient of a wall system of a building. It allows the calculation of the specific heat loss of a wall while the K65 or K55 (note the capital K) is the heat loss value of a whole building. The current regulation in Belgium refers to a “k maximum value” for every type of wall used in a building. Consequently, it is easier to use a “k value” for a wall in the case of a renovation project as the regulation would apply only to the walls that were renovated) max for various building shells and a ventilation rate are enforced. For new non-commercial tertiary buildings (offices, schools) K65 standard, k_{max} values and a ventilation rate are enforced. In the case of retrofitting of lodgement and non-commercial tertiary buildings with change of allotment, theK65 and K70 standards respectively are enforced, together with k max values and a ventilation rate. When retrofitting the above type of buildings with no change of allotment, only k max values for the retrofitted elements are enforced. For rooms with retrofitted windows, a ventilation rate is enforced.

Flanders: For new buildings in the tertiary sector, i.e. hospitals, hotels, boarding schools, barracks and prisons, the Flemish Region enforces the K55 standard and k max values. For buildings the use of which is changed the Flemish Region enforces k max values.

Brussels-Capital: Since 1 January 2000, in the Region Brussels-Capital, the thermal insulation standards of buildings are similar to those in force in Wallonia.

Before a building permit can be issued, the calculation of the K ratio is checked by the regional administration of town planning. It is considering the introduction of an energy performance standard following the Dutch experience for new buildings (dwellings and office buildings) and efficient control and motivation activities to enforce the existing legislation concerning insulation of buildings. For industry and the service sector, the objective is to increase energy efficiency by 2004 compared to 1998.

Interregional collaboration

Interregional collaboration on inspection of the insulation and ventilation regulations takes place in the framework of the Belgian Building Research Institute. The goal is to produce a manual for a uniform inspection procedure throughout the country and standardization and legislation to elaborate an Energy Performance Standard (cf. the Netherlands).In the framework of this collaboration, a website with information on ventilation and insulation legislation in the three regions has been created. This initiative was co-funded through the CONCERE/ENOVER group. In the Belgian National Programme for Reducing CO_2 Emissions, it is planned to strengthen the thermal insulation of new buildings through the mandatory adoption of the K55 insulation standard in the residential and tertiary sector of the three regions. In the public sector, the specific minimum performance standards for new buildings defined a significant improvement over existing building regulations. (Helen O'Neill, Andrew Warren, 2001)

Table 4.6: Recommended minimum energy performance standard (max. delivered energy) for space heating, hot water and space ventilation in new and destructed office space in Belgium

Existing buildings	**70 Kwh/m^2/a**
New buildings	**40 Kwh/m^2/a**

4.5.5.6 SWITZERLAND

The model decree on efficient energy use in buildings contains certain requirements concerning building shells and installation technologies used in the construction sector. With respect to the shell, there are two options to choose from: observing either a specific heating energy requirement or individual U-values. With respect to household technology, the decree contains certain requirements such as condensation gas boilers, maximum distribution temperatures, adjustment controls in each room, requirements for air-conditioning systems, etc. These sections are supplemented by the Clean Air Act, which calls for homologation for heating boilers. Here, certain strict requirements have to be observed with respect to exhaust and standby losses, and the Clean Air Act also stipulates that periodic inspections must be carried out, in which exhaust losses and air pollution levels have to be measured (carbon monoxide, soot, non-burned oil particles, nitrogen dioxide). Most of the cantons have already adopted and introduced this model decree based on the standards of SIA 380/1, and the aim now is to work together with the cantons to adapt it to the latest status of technology. The focus here is to be on lowering the U-values and tightening up threshold parameters for heating energy requirements, as well as on the promotion of renewable energies. For example, one proposal that has been put forward is to demand that 20% of heating energy requirements should be covered by the use of renewable energies. If a developer does not want this, then he should be required to save this amount by using more effective insulation (IEA, 2003).

Another proposal involves drawing up electricity consumption specifications for buildings in the services sector. With the Programme of the Cantons for the 2nd Half of Energy 2000, adopted in April 1996 by the Conference of Cantonal Energy Directors, cantons agreed on strengthening their efforts in eight areas, including retrofitting in existing buildings (already implemented in four cantons) and introduction of the Recommendation SIA 380/4(produced by the Swiss Association of Architects and Engineers) related to the efficient use of electricity in public buildings (already implemented in 14 cantons). According to that standard, the electricity consumption for lighting is 13.8 kWh/m^2a in office spaces. (http://www.minergie.com)

At present, around 450 000 dwellings in Switzerland (out of a total of 1.2 million that could be converted) use consumption-based heating cost allocation. It is possible to achieve savings in heating energy of around 14% on average, even in times of low energy prices. In its Energy Law, the federal government has only stipulated an obligation of consumption-based heating cost allocation for new buildings. Cantons are required to draw up corresponding provisions.

Table 4.7: Minergie standards of commercial buildings type

BUILDING TYPE	**MINERGIE(heating, hot water and ventilation) Required (kWh / m^2a)**	
	New	**Old**
Schools	**40**	**70**
Sports facilities	**25**	**50**
Office buildings	**35**	**65**
Shops	**35**	**60**
Restaurants	**45**	**85**
Meeting halls	**40**	**80**
Hospitals	**75**	**110**
Industry	**20**	**50**
Warehouses	**20**	**45**

The cantons launched an initiative for the promotion of MINERGIE standards and labels. Swiss Minergie Standards define methodologies and comfort levels for new and refurbished buildings. Minergie is based on building specific energy consumption, building comfort and cost. Specific energy consumption is used as the main indicator to quantify the required building quality. In this way, a reliable assessment can be assured. Only the final energy consumed is relevant. According to this concept, heat consumption would not be higher than 160 MJ/m^2 per year without jeopardising comfort and competitiveness. For commercial sector Minergie also defines limits for energy use of lighting systems. The limit based on the SIA 380/4 building code (PROST – APPENDIX 4).

Energho is an association of large energy-consuming public institutions. It includes hospitals, cantonal and federal buildings. Its aim is to save 10% of energy in ten years and to increase energy efficiency in public buildings through Energy Performance Management, a voluntary commitment to save energy with an action programme and targets, training and exchange of experience (Thomas Jud, 2005).

4.5.5.7 SPAIN

Standards for energy savings in buildings were established by Royal Decree 2429 of 1979, which sets mandatory minimum requirements (NBE-CT- 79) for thermal insulation. New more strict mandatory standards, in compliance with the "SAVE Directive" has been introduced in 2002. The autonomous regions are responsible for the enforcement of these standards. They are based on an evaluation of the building project at the planning phase and on random check-ups of new buildings. Currently, IDAE is working on the development of instruments permitting Spain's adaptation to the so-called "Save Directive" of the EU (93/76/EEC) regarding the Certification and Labelling of Buildings. Once the details of the certificate are set by IDAE and a new law to make the certificate mandatory is passed, the Directive will be enforced by the autonomous regions. The certificate is issued for the use of passive solar energy, the correct use of thermal insulation materials, the use of low consumption electric lamps, the evaluation of CO_2 emissions and the assessment of building materials according to regions. IDAE has developed two computer tools to support the energy certification process, namely Energy Rating of Homes (Calificación Energética de Viviendas, CEV) and Energy Rating of Buildings (Calificación Energética de

Edificios, CALENER) (http://www.codigotecnico.org/espa/programas.htm).The use of this new feature-based regulation entails the configuration of a more flexible environment which can readily be updated as technologies develop and society's demands evolve. This is based on accrued experience of technical developments. The code includes 6 basic documents establishing the energy efficiency and renewable energy requirements that new and refurbished buildings must meet according to the following basic documents:

HE.1: Limiting energy demands

HE.2: Performance of heating/cooling systems.

HE.3: Energy efficiency of lighting systems

HE.4: Minimum solar contribution to water heating.

HE.5: Minimum photovoltaic contribution to electrical power

These requirements have been established pursuant to Article 4 of Directive 2002/91/EC, 16 December 2002, on the energy efficiency of buildings (http://www.idae.es/revision-rite/index.html).

4.6 Considerations in Turkey

4.6.1. The Building Energy Standards in Turkey

The first building regulation and standards in Turkey were established in 1970. This standard contained provisions for the maximum heat transmission resistance value for opaque components. It didn't take into calculation any building form features, transparency rate, the orientation of the opaque components and the type of glass.

After 1970, the Ministry of Energy established the regulation about heating and steam facilities due to economy and reducing the air pollution. This standard considered the maximum heat transmission value for the overall envelope. It depends on the rate between building total heat losses area and building volume. The building orientation and solar gains were neglected.

The Ministry of Public Works established the heat conservation regulation in 1985. It considered the minimum heat transmission resistance value of building component and the maximum heat transmission value of building outer wall and glass area according to climatic zones. It was a mandatory regulation for all buildings. But also the building orientation and solar gains were not taken into account again.

Former thermal regulations for new buildings have been in force in 1998.In TS 825-1998, the yearly total heating energy demand of new buildings is limited by the building shape (A_{tot} / V_{brut}) and the building degree-day zone. In that standard the internal gains and the solar gains through the windows are taken to the calculation. Before 1998 only the transmission losses were calculated for heat losses and the ventilation heat losses were added to the calculation within that standard. This building regulation based on ‘Thermal Performance of buildings prEN832 European Standard, ‘Thermal Insulation-Calculation of Space Heating Requirements of Residential buildings.’9164 ISO standard and Germany Building heat conservation regulation. Since 14 June 2000 this standard is mandatory for new buildings (Z.Yılmaz, G. Koçlar Oral, G. Manioğlu, 2000).

4.6.2 TS825 Calculation Approach

Heat requirement of building Q_{year} for a year is calculated by the sum of requirement per month ($Q_{year} = \sum Q_{month}$).Heat requirement per month for one zone is calculated by using monthly average values **(4.49)**:

$$Q_{month} = [\ H(T_i - T_o) - \eta_m(\phi_i + \phi_{sg})\ ] \cdot t \quad \textbf{(4.49)}$$

If there is a more than 4 K difference between zones, the average value should be taken to calculation as an inner temperature.

Average internal temperature is calculated by **(4.50)**:

$$T_{i,avg} = \frac{\sum_n H_n \cdot T_{i,n}}{\sum_n H_n} = \frac{H_1 \cdot T_{i1} + H_2 \cdot T_{i2} + \cdots + H_n \cdot T_{in}}{H_1 + H_2 + \cdots + H_n} \quad \textbf{(4.50)}$$

Specific heat loss H is calculated by the following formulas **(4.51)**:

$H = H_T + H_V$ .... **(4.51)**

H_T (specific heat loss by transmission) **(4.52)**

$H_T = \Sigma AU + l\, U_l$ .... **(4.52)**

$\Sigma AU = U_{ow}A_{ow} + U_w.A_w + U_d.A_d + 0.8\, U_c.A_c + 0.5\, U_fA_f + U_{of}A_{of} + 0.5U_{lh}A_{lh}$

H_V(specific heat loss by ventilation)

$H_{V=}\ \rho.c.V^{I} = \rho.c.n_h\, V_h$ .... **(4.53)**

ρ : Air density

c : Air specific heat

V^1: volume flow rate

n_h: air change rate

V_h: ventilated volume $(Vh = 0,8 \times V_{brüt})$

The variation of p and c according to pressure can be negligible. And formulates can be written with 20˚C and 100kPa;

$H_{V=}\ 0.33\, n_h.V_h$ .... **(4.54)**

The internal heat gains include following data:

- Metabolic heat gains from occupants
- Heat gains from water heating system
- Heat gains from cooking
- Heat gains from lighting system
- Heat gains from appliances

In houses, schools and the building with normal appliances: $\phi_{i,month} \leq 5 \times A_n$

Monthly average solar heat gains ($\phi_{g,month}$) are calculated by the following formulates

$$\phi_{g,month} = \Sigma\, r_{i,month}\ x\ g_{i,month}\ x\ I_{i,month}\ x\ A_i \quad \textbf{(4.55)}$$

$r_{i,month}$: monthly average shading factor for transparent surfaces having orientation "i"

$g_{i,month}$: solar transmission factor of glazing areas having orientation "i"

$I_{i,month}$: monthly average solar radiation on vertical surfaces having orientation "i"

A_i : total glazing area having orientation "i"

Monthly average utilization factor for gains is calculated by the following formulates

$$\eta_{month} = 1 - e^{(-1/KKO\ ay)} \quad \textbf{(4.56)}$$

KKO_{ay} : gains/loss ratio and it is calculated as follows:

$$KKO_{month} = (\phi_{i,month} + \phi_{gmonth}) / H(T_{i,month} - T_{d,month}) \quad \textbf{(4.57)}$$

$T_{i,month}$: monthly average inside temperature

$T_{d,month}$: monthly average outside temperature

$\phi_{i,month}$: monthly internal heat gains

$\phi_{g,month}$: monthly average solar heat

In those calculations according to the building climatic zones climatic factors are taken into regard. There are four climatic zones in Turkey which are determined by degree days.

Climatic Zones According to Degree Days:

1. **Climatic Zone Cities:** Adana, Aydın, Mersin, Osmaniye, Antalya, Hatay, İzmir

2. **Climatic Zone Cities:** Sakarya, Çanakkale, Kahramanmaraş, Rize, Trabzon, Adıyaman, Denizli, Kilis, Samsun, Yalova, Amasya, Diyarbakır, Kocaeli, Siirt,

Zonguldak, Balıkesir, Bartın, Gaziantep, Mardin, Şanlıurfa, Edirne, Manisa, Sinop, Düzce, Batman, Bursa, İstanbul, Ordu, Tekirdağ, Giresun, Muğla, Şırnak

3. Climatic Zone Cities: Afyon, Burdur, Karabük, Malatya, Aksaray, Çankırı, Karaman, Nevşehir, Ankara, Çorum, Kırıkkale, Niğde, Artvin, Elazığ, Kırklareli, Tokat, Bilecik, Eskişehir, Kırşehir, Tunceli, Bingöl, Iğdır, Konya, Uşak, Bolu, Isparta, Kütahya

4. Climatic Zone Cities: Ağrı, Erzurum, Kayseri, Ardahan, Gümüşhane, Muş, Bayburt, Hakkari, Sivas, Bitlis, Kars, Van, Erzincan, Kastamonu, Yozgat

The building heating demand is limited by TS 825 for four zones. This difference is coming from A/V rate.

Table 4.8: Building heating demand according to A/V rate in TS825.

1. ZONE	Related to A_n $Q'_{1.DG}$ =	44,1 x	A/V	+	10,4	[kWh/m²,yıl]
	Related to $V_{brüt}$ $Q'_{1.DG}$ =	14,1 x	A/V	+	3,4	[kWh/m³,yıl]
2. ZONE	Related to A_n $Q'_{2.DG}$ =	70 x	A/V	+	24,4	[kWh/m²,yıl]
	Related to $V_{brüt}$ $Q'_{2.DG}$ =	22,4 x	A/V	+	7,8	[kWh/m³,yıl]
3. ZONE	Related to A_n $Q'_{3.DG}$ =	76,3 x	A/V	+	36,4	[kWh/m²,yıl]
	Related to $V_{brüt}$ $Q'_{3.DG}$ =	24,4 x	A/V	+	11,7	[kWh/m³,yıl]
4. ZONE	Related to A_n $Q'_{4.DG}$ =	82,8 x	A/V	+	50,7	[kWh/m²,yıl]
	Related to $V_{brüt}$ $Q'_{4.DG}$ =	26,5 x	A/V	+	16,3	[kWh/m³,yıl]

Calculation method in this standard is limited to the heating demand and doesn't take into regard all climatic data. In climatic zones, there are cities which have different climatic characteristic. For example; Diyarbakır has dry and hot climate and Istanbul has temperate and humid climate and both of them are in the same zone. Those zones weren't defined with all climatic data. And also the heat requirement of buildings isn't classified according to building type. Only the inside temperature differs according to the building type.

As it is known, comfort conditions in buildings can not be defined by only heating requirement. There aren't any cooling or lighting calculation standards in Turkey. Standards must be covered all energy calculations and buildings should be thought about as a complete system where the energy consumption should be limited for the whole building.

4.7 Conclusion

Many non-domestic buildings are major energy-wasters (Bordass, 2001). New buildings can be designed by basing on the regulations but energy consumptions in existing buildings account a considerable portion of total energy consumption.

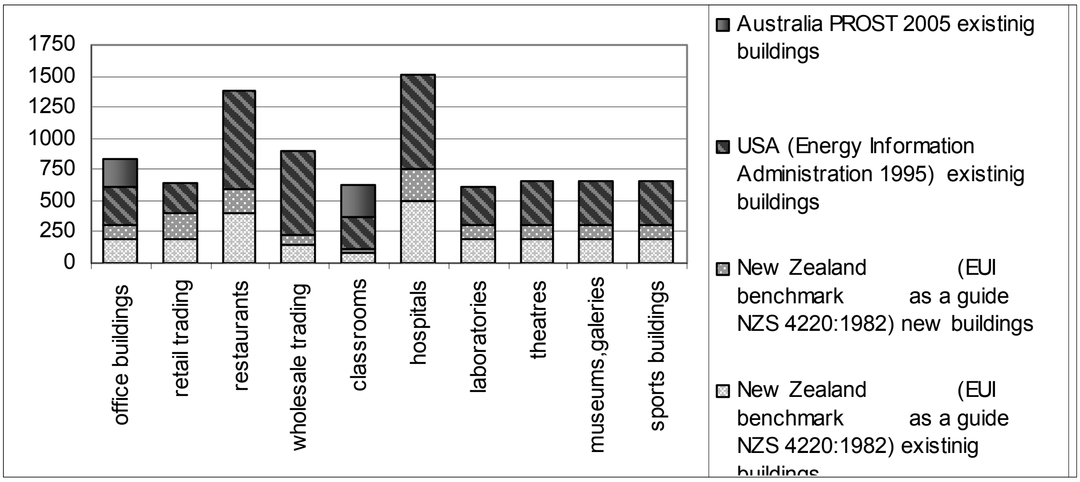


Figure 4.8: Commercial building consumption values from PROST 2005, EIA 1995, NZS 4220 (kWh/m^2a)

The building codes and standards have different calculation approaches all over the world and also their limit value is changing according to climatic conditions.(See in Figure 4.8) Especially in the USA the commercial sector energy consumption is enormous. Their standard values are too high and also their comfort condition limit value is very high. Nevertheless as the standard values are getting stricter consequently the energy savings are getting higher.

Figure 4.9 summarizes the U-values applicable to insulated building elements, and the corresponding percentage of insulated tertiary sector buildings in the EU countries, if data is available. Depending on data availability, for each EU member state the following information is presented: The first row presents the U-values (W/m2.K) for insulated building elements: Walls / Load bearing / Roof. The second row identifies the percentage, expressed as an average for all tertiary sector buildings, which may be considered to have insulated building elements (external walls / load bearing / roof / double glazing)

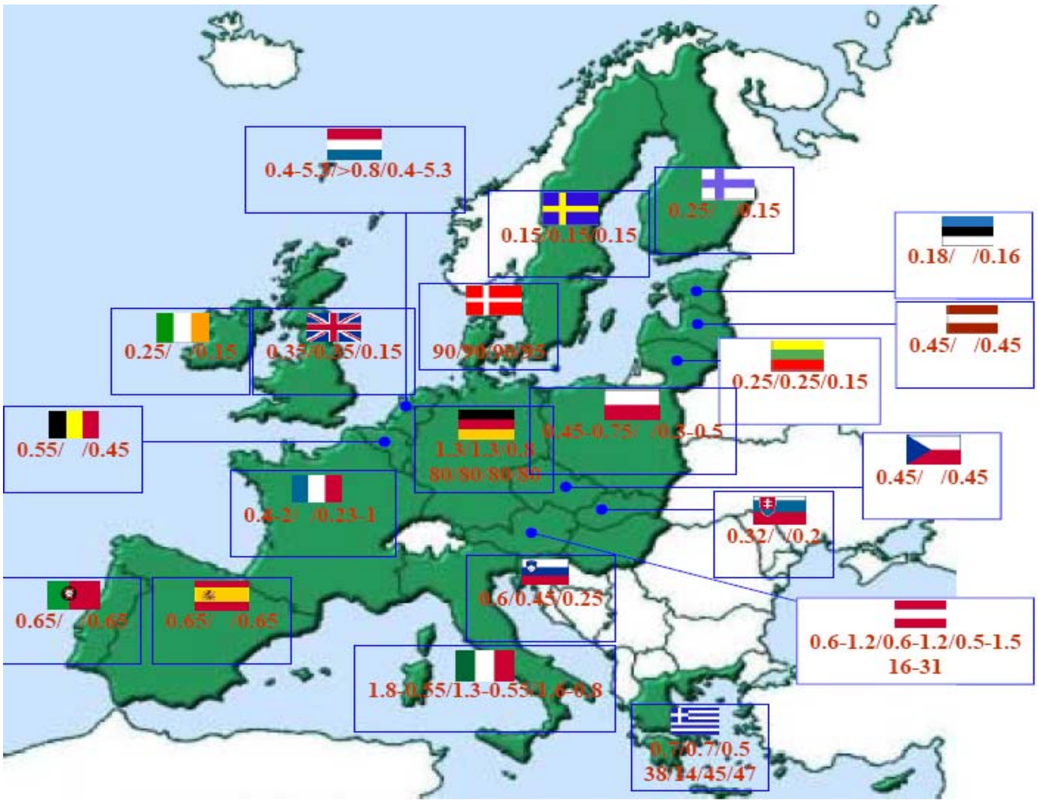


Figure 4.9: Typical Construction U-value (W/m^{2}K) in EU Countries (EPA-NR Survey: National context and need for instruments ,2005)

When we look at the commercial building consumption values in the EU countries, EU authorities are setting up the framework for the national governments, which define their own limits and values. Given that every country has to develop its own mechanism, it might be sensible to pool resources from the EU and there might come up a single energy performance comparison mechanism for all commercial buildings throughout Europe. In the EU, the calculation approach is taking the building as a system and calculating the overall building performance.

Table 4.9: Maximum U-value (kWh/m^2) in EU Countries (IZODER, 2005)

COUNTRİES	WALL	WİNDOW	DOOR	ROOF	FLOOR
AUSTRİA	0,35	1.7	1.7	0.2	0.4
BELGİUM	0.4-0.6	2.5-3.5	3.5	0.4-0.6	0.6-1.2
DENMARK	0.3	1.8	1.8	0.15	0.2
FRANCE	0.28	2.45	1.3	0.2	0.37
GERMANY	0.5	1.65	2	0.22	0.35
ITALY	0.58	2.75	3.6	0.75	0.74
PORTEQUİSE	0.95	4.2	3.5	0.75	0.75
UK	0.35	2.2	2.2	0.16-0.25	0.25
TÜRKİYE I.zone	0.8	2.8	-	0.5	0.8
TÜRKİYE II.zone	0.6	2.6	-	0.4	0.6
TÜRKİYE III.zone	0.5	2.6	-	0.3	0.45
TÜRKİYE IV.zone	0.4	2.4	-	0.25	0.4

Comparing the standard values from Table 4.9 it can be observed, that the energy consumption values of countries in cold zones are lower than those of countries in warm zones and the standards are stricter. In countries of cold climatic zones more passive and efficient technologies are used. Especially Denmark set up very energy efficient designs ranging from country development scale down to the individual building. As stated in ENERGY 2000 project, Denmark plans to improve the energy efficiency of commercial buildings by 50% in the next 50 years (Energy Policies of IEA Countries,2001). This program includes not only special isolation, solar and geothermal energy methods, but also a broad scale education program for all citizens.

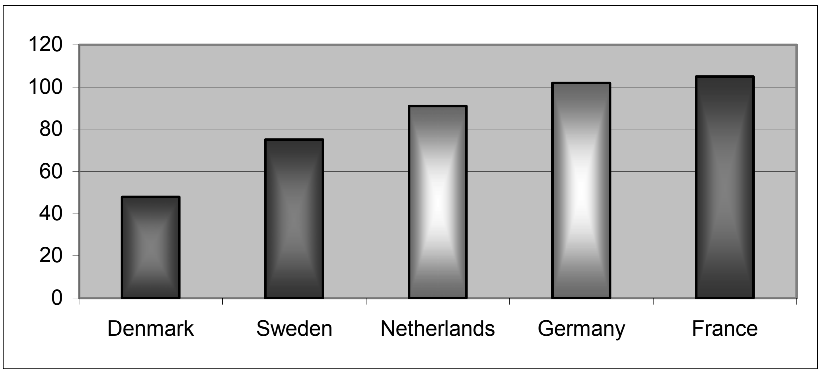


Figure 4.10: Energy consumption values for new buildings in EU countries(kWh/m^2)

When the heating and cooling consumption values are evaluated, heating building code regulations are made by nearly all the countries. For low energy consumption buildings not only the perfect thermal insulation of the building envelope is important, but also the design and control of the heating systems, which are distributors of energy in the building and main producers of the operational pollution.

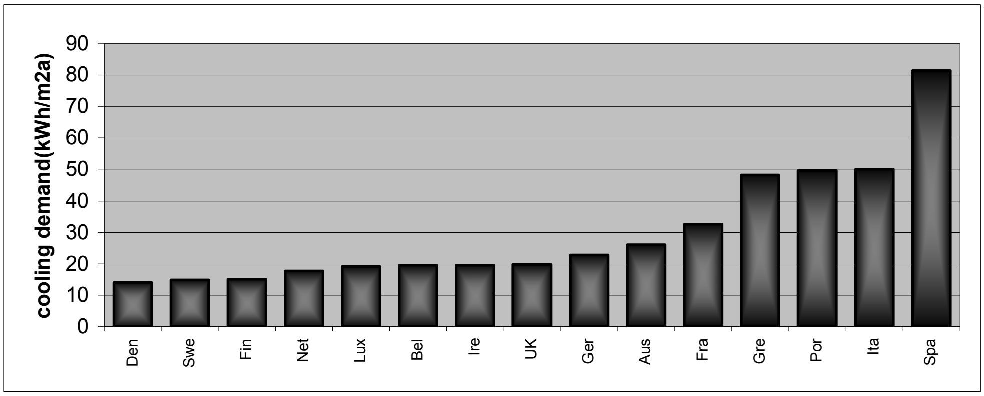
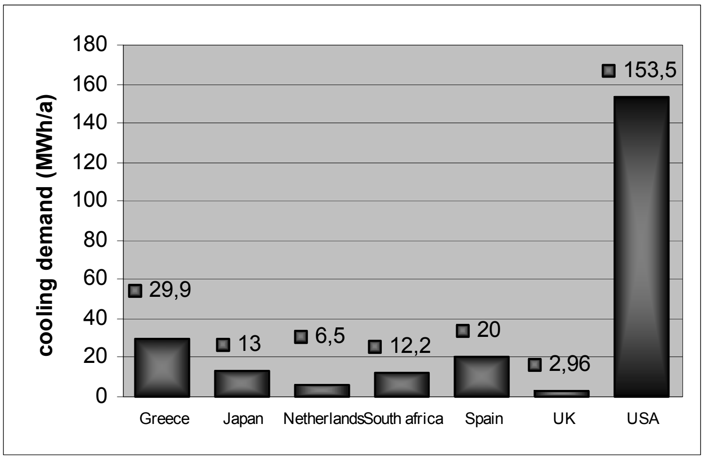


Figure 4.11: Average cooling energy demand EU countries (Adnot)

Countries in hot climatic zones more energy is used for space cooling but also countries in cold climatic or warm countries a significant increase of cooling systems can be recognized. In comparison with EU countries of the same climatic conditions Spain's annual cooling demand is exceptionally high (Table 13). Related to global warming and the increase of human comfort demand the building cooling demand of cold climate countries is also rising.



Generally the cooling energy load of commercial buildings world wide is increasing. In the USA, the cooling energy demand is more than five times higher than in comparable industrialised countries (Table 4.14).

Figure 4.12: Cooling energy demand for new commercial buildings (Breembroek and Lazaro, 1999)

Lighting energy demand standard values are difficult to define. Most of the standards give the nominal illumination values for certain activities. Without loss in lighting comfort, the lighting energy consumption can be reduced. Especially the use of day lighting to supplement artificial lighting in non-residential buildings such as offices, schools, and showrooms has a high energy saving potential. In the EU countries for example the Swiss standard SIA 380/4 marks an approach for the future.

When we look at Turkey, we can only find a heating energy standard, which is based on the performance of the building envelope. Compared to other standards it seems to be insufficient just to calculate the heating performance of a building, especially for the commercial building sector. There isn't any calculation standard for cooling and lighting demand. There should be a calculation standard, which takes all kinds of building

5. CONCLUSION AND RECOMMENDATIONS

The aim of this study is to evaluate EU building energy performance standards and to give suggestions for the implementation of EU conform standards in Turkey. In the study the impacts of different standards on energy consumption of commercial buildings are discussed and the specific effects of national and international standards have been worked out.

As a first step, in this thesis, international energy performance standards of commercial buildings are evaluated. EU energy performance national standards will be in force in 2006 in Member State Countries and, in accordance to the main principles of the EU energy performance standard, the member state countries at present make revisions of their national standards. These standards will include the overall energy use of the building and calculation methods containing lighting and appliances energy consumption. Especially for commercial buildings, consumption values of appliances play a significant role in the building energy consumption balance. England and the Netherlands already use Energy Performance Standards and Germany plans to introduce these standards for non-residential buildings.

In Turkey building energy performance standards have not been developed yet. The Turkish standard TS825, which came into force in Turkey in 2000, includes only heating energy calculations. This regulation covers upper limit values of annual heat demand in buildings, but heat requirements are not classified according to the building type. Annual heat demands are limited in relation to climatic zones. The TS825 depends on obviously insufficient meteorological data and neglects renewable energy sources, such as the important solar energy potential of Turkey. Although Turkey has very different climatic zones, this standard neglects cooling load calculation. The Turkish energy regulations also do not cover lighting loads.

Modern Turkey is trying for membership in the EU and therefore is not in a position to disregard revision studies on energy regulations. Taking this into regard, Turkish building standards should be conformed to the European standards. As a result of comparing Turkish energy regulations with EU standards, the following main important points, which should be duly considered in Turkey, were elaborated:

- The building code-regulations should be considered as a system for the energy consumption of the whole building.

- The calculation method of standards should consider the definition of the overall energy use.

- In the building standards a method has to be used to calculate the overall energy use of buildings supported by specific calculations from other standards for heating, cooling, ventilation, hot water and lighting based on the regional meteorological data. The heating, cooling, ventilation, hot water and lighting standards have to take into account the interactions between the different energy uses.

- The calculation method of these standards should determine the performance level according to energy indicators and comfort conditions. This method should be developed related to the state of the art energy technologies, present requirements and new materials.

- Building overall energy performance standards criteria should be based on asset rating obtained from delivered energy, primary energy and CO_2 emissions.

- The standards have to support the design quality and should give opportunities for choosing architectural decisions on form, facade and inside planning. All design parameters should be considered as a whole.

- In the standards energy efficiency and renewable energies should be regarded and the promotion of renewable energy resources should be included.

- A fundamental methodological basis and primary codes, which comply with the advanced international level, should be defined

- Especially for commercial buildings, the operation of the building should be done according to building codes.

Further on this thesis deals with the approaches to analyze the properties of commercial buildings. It was found that the design, construction and operation of commercial buildings have impacts on natural resources, environmental quality, working productivity and community well-being. Most of the major energy-consuming systems in a building are intended to create an effective and comfortable working environment.

Energy consumption data are collected and the possibilities to reach low consumption values were evaluated in the study. Today's commercial buildings are changing rapidly and we are observing the major change in commercial building energy consumption related to the introduction of new technologies. On the other hand, low energy building strategies are also improving with technology development. Optimisation and integration of building control strategies could save huge amounts of energy, while preserving or improving on present standards of comfort. Being the result of recent developments in computer science these techniques, already adopted in other industrial processes, is widely recognised to open new possibilities for the solution of integrated complex and adaptive control problems, as encountered in the building energy sector. They enable to carry out multi-functional actions directed to integrate energy plants with envelope components and human presence by means of reliable and low-cost control components.

Investigation of energy consumption under consideration of state of the art trends and standards is made in the last part of the thesis. Firstly modern commercial buildings' properties are explained and the impacts of these trends on the energy consumption are analyzed. After this analysis, indicators of energy consumption in the commercial building sector are defined. As a result of modern design trends, technical equipment and comfort requirements, heating, cooling and lighting demand is increasing. Further on the analysis of the set points of temperature and air change rates carried out in this work show, that the yearly thermal demand can be decreased significantly with the set values chosen.

Consequently the design of new buildings, which is considering improved building energy standards, should include the following steps (Figure 6.1):

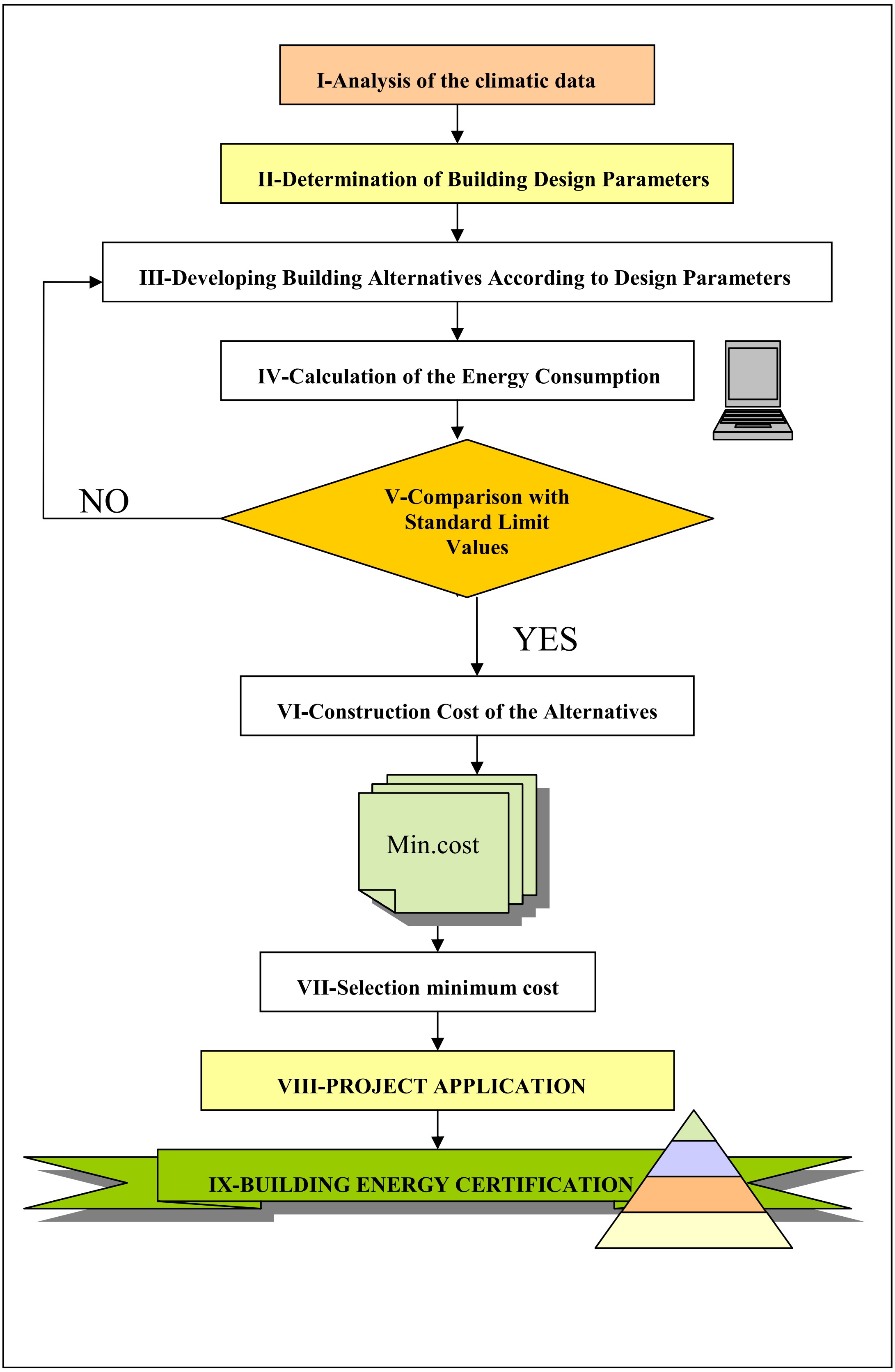


Figure 6.1: Design steps for new energy efficient building design

- Analysis of the Environmental Impact

At first meteorological data should be analyzed. This analysis should contain ambient temperature, relative humidity, wind speed, wind direction and solar radiation intensity and then according to climatic data, heating or cooling level and schedule should be determined.

A base-case building analysis should be completed for understanding design strategies that will have the greatest impact on the building design for the particular building function. For minimizing the environmental impact on energy consumption a site analysis considering natural or artificial obstacles is also important. In this site analysis adjacencies should be also evaluated for building functions and the way the building interacts with the site.

- Search for Alternatives According to Design Parameters

At the end of the analysis of the environmental impact, alternatives should be designed. In this stage, the architectural design has to include building energy calculations for defining the building energy demand (1-3) and the resulting energy flow (4-9) as described in Figure 6.2. Building orientation, building form, optical and thermo-physical properties of the building envelope influence the building's energy performance. All these parameters should be related to each other. Optimum values of these parameters also define building as an optimum passive system from the energy conservation point of view. Building mechanical and electrical system sizes can be minimized. Active systems should be integrated with passive system parameters. For the selection optimum system of the design stage and to achieve the above describe strategy computers can be used to guide design decisions.

- Calculation of the Energy Consumption and Comparison with Standard Limit Values

In the calculation of the values of the parameters effective on heating and cooling energy consumption can be based on the steps of calculation method of European Union Energy Performance Standards. These steps are explained by Figure 6.2. The European calculation method gives a detailed idea of the overall system performance of a building.

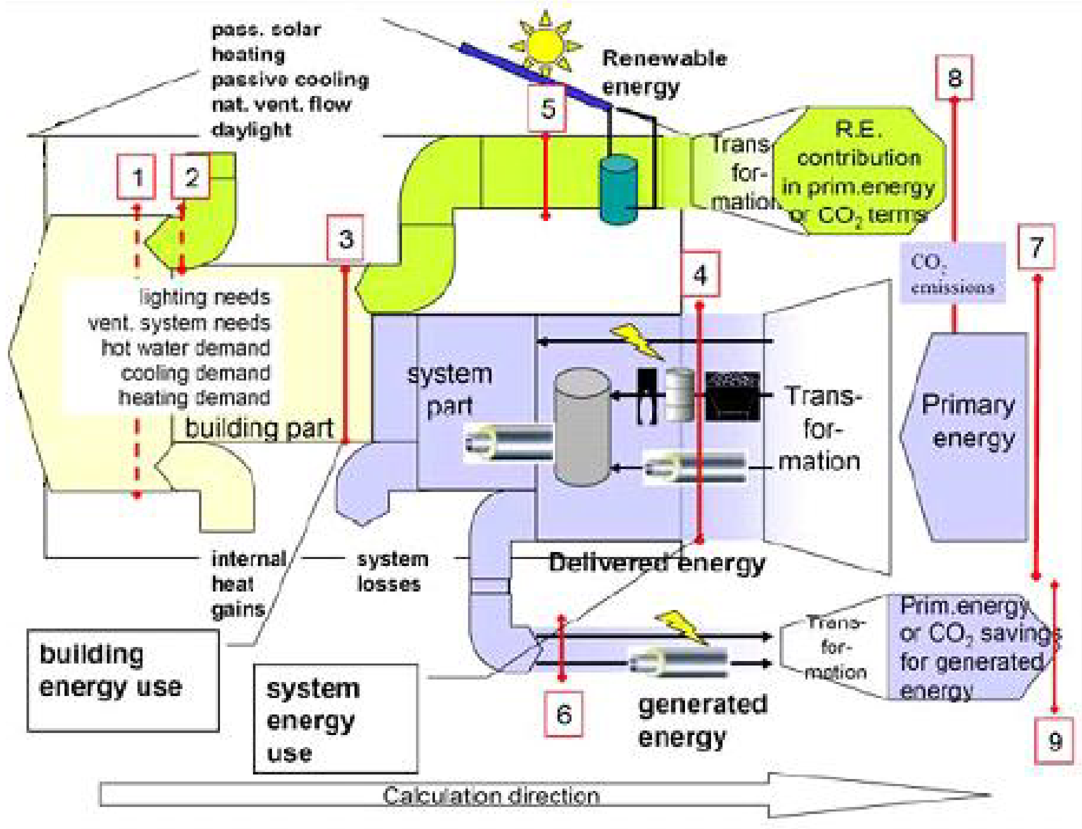


Figure 6.2: Energy Calculation Steps 1 to 9 for Building Energy Flows

Figure 6.3 shows calculation steps for heating energy consumption and with minor adoptions can be transferred to other energy demand calculations (cooling etc.). Computer simulation can be used for the necessary calculations. The calculated values should be compared with the limit values of the standards and alternatives, which result in a higher energy consumption than the limit values should be eliminated by redesigning. All suggested design changes can be re-evaluated by computer simulations before implementation, to ensure that the changes will not detract from meeting the overall building design goals.

- Construction Cost of the Alternatives

In order to choose the appropriate alternative, different alternatives are compared with each other. The alternative which provides minimum cost qualifies to be the most appropriate one (among the different alternatives).

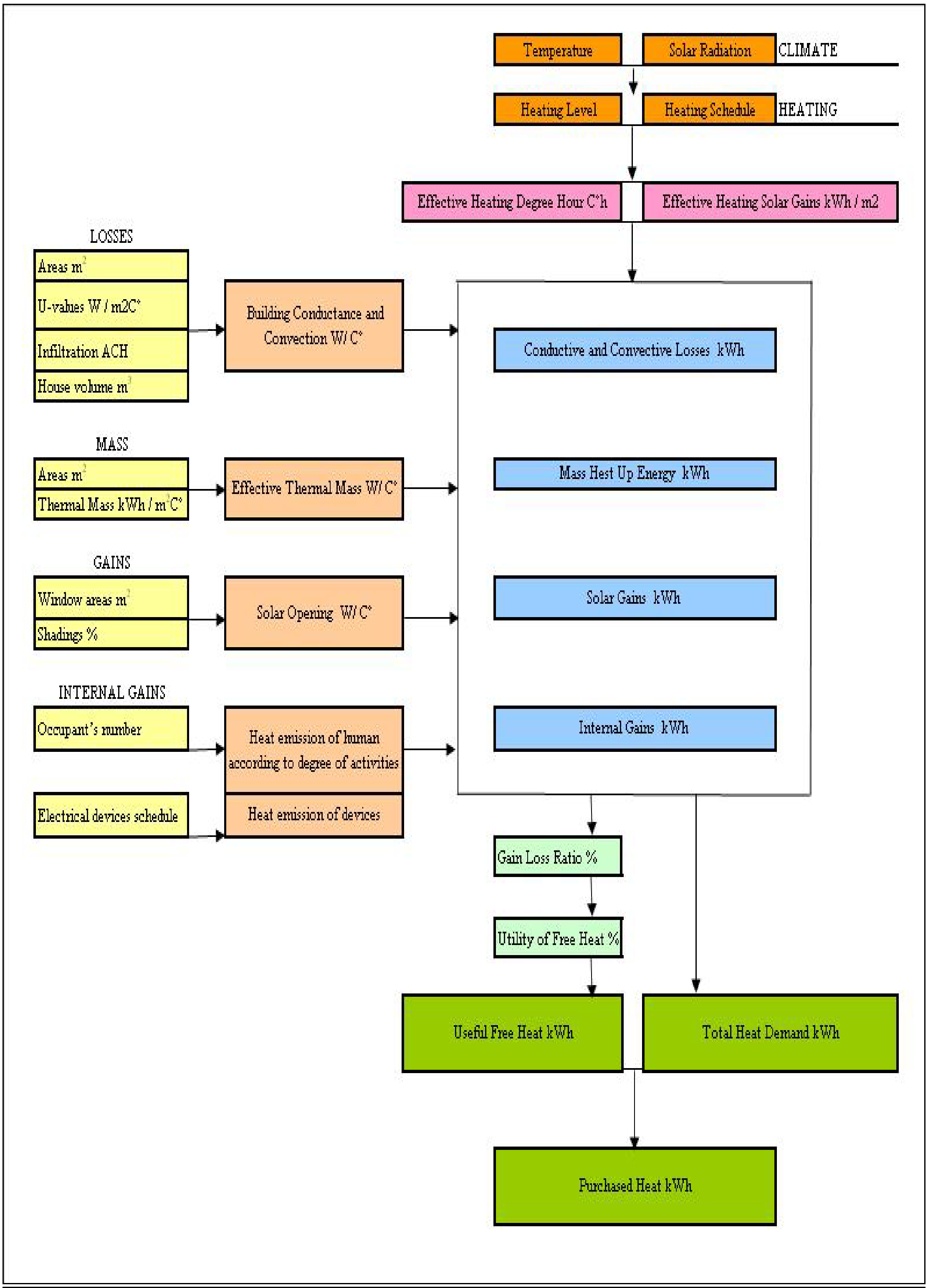


Figure 6.3: Calculation steps of the Heating Energy Consumption

- <u>Application</u>

In the application stage, the construction side of the project is also important for reducing energy consumption. "Constructability" striving for minimal environmental disruption, resource consumption and material waste as well as identifying opportunities for reuse/recycling of construction debris should be considered. When the material is on the application in the site, especially isolation material should be handled carefully not to give any harm and applied in accordance to technical rules in order to achieve the design energy properties of the building.

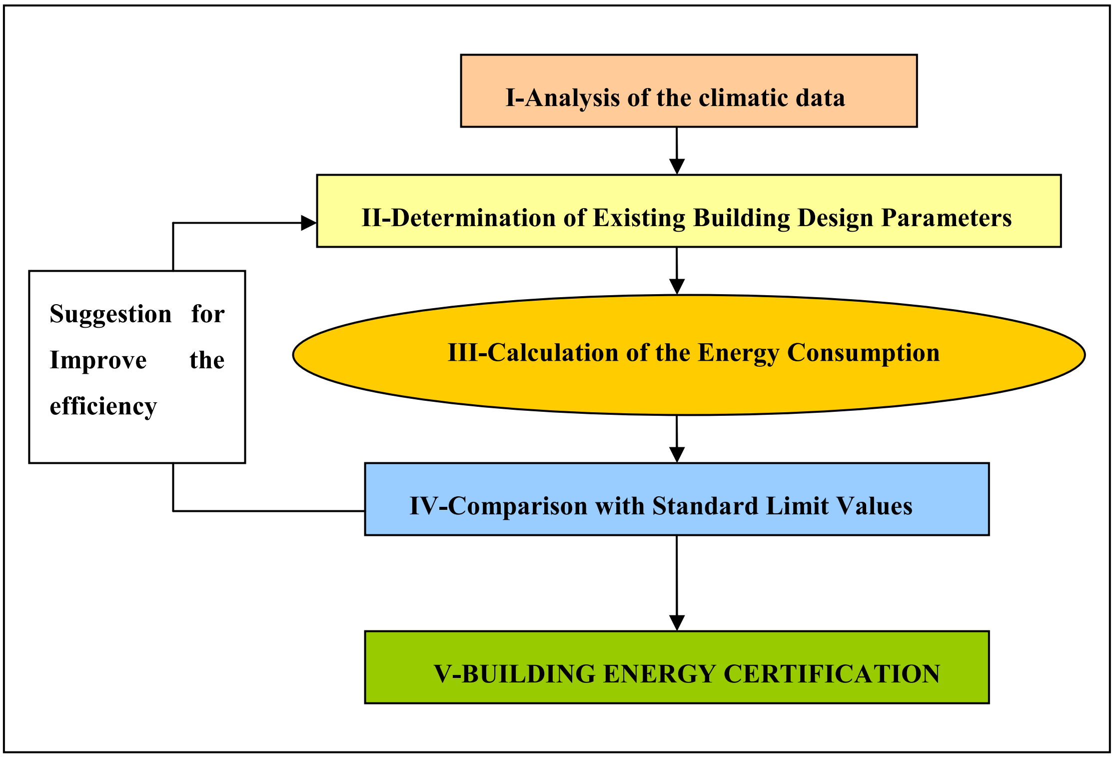


Figure 6.4: Evaluation steps concerning energy efficiency of existing building

- <u>Building Energy Certification</u>

Furthermore energy efficient buildings should be certificated. A certificate should provide the description of the building characteristics and information for prospective users concerning building energy efficiency and expected building operation costs. About energy certification application, there have been several sample countries in EU. For example in Denmark, a certification program has been in operation since 1981. In the newest version of this mandatory program which went into effect on January 1997, there are two sets of regulations: one for buildings with an area of less than 1,500 square meters, and one for larger buildings. A report includes a ranking of the building's heating-energy performance on a scale from A to C, similar displays for electricity and water consumption, CO_2 emission level and savings in heating, electricity and water use, which can be achieved by implementing conservation measures. Using similar certification systems will contribute to achieve energy efficient building design and construction in Turkey.

On the other hand existing buildings must be taken into consideration to achieve energy conservation in Turkey. Therefore in Figure 6.4's steps for the evaluation of existing buildings are given. First, environmental impact should be analyzed and existing design parameters should be defined. Secondly, energy consumption of building should be calculated and the calculated value should be compared with the required value given in the standard. If the calculated value can not meet the required value cost effective renovation measures should be carried out for achieving energy efficiency.

As a result, for Turkey regulations are required to provide right decision in the design stage from the energy conservation point of view. Due to the fact that appropriate calculation methods of heating, cooling and lighting are not considered correctly, the construction and operation costs of buildings in Turkey in many cases are unnecessarily high. Therefore, designers, manufactures and decision-taking organs have to regard investigation, identification and application of measures designed to save energy in buildings as one of their main tasks.

The knowledge and technical information which have been complied in this study will contribute to achieve one of the main objectives of modern commercial buildings design: the use of minimum energy and improved building economy in order to spare national and global recourses.

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ANNEX

ANNEX-I: DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

ANNEX-II: BİNALARIN ENERJİ PERFORMANSI HAKKINDA AVRUPA PARLEMENTOSU VE KONSEYİ 2002/91/EC SAYILI DİREKTİFİ (Turkish version)

ANNEX-I

DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE
EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission (1),

Having regard to the opinion of the Economic and SocialCommittee (2),

Having regard to the opinion of the Committee of the Regions (3),

Acting in accordance with the procedure laid down in Article251 of the Treaty (4),

Whereas:

(1) Article 6 of the Treaty requires environmental protection requirements to be integrated into the definition and implementation of Community policies and actions.

(2) The natural resources, to the prudent and rational utilisation of which Article 174 of the Treaty refers, include oil products, natural gas and solid fuels, which are essential sources of energy but also the leading sources of carbon dioxide emissions.

(3) Increased energy efficiency constitutes an important part of the package of policies and measures needed to comply with the Kyoto Protocol and should appear in any policy package to meet further commitments.

(4) Demand management of energy is an important tool enabling the Community to influence the global energy market and hence the security of energy supply in the medium and long term.

(5) In its conclusions of 30 May 2000 and of 5 December 2000, the Council endorsed the Commission's action plan on energy efficiency and requested specific measures in the building sector.

(6) The residential and tertiary sector, the major part of which is buildings, accounts for more than 40 % of final energy consumption in the Community and is expanding, a trend which is bound to increase its energy consumption and hence also its carbon dioxide emissions.

(7) Council Directive 93/76/EEC of 13 September 1993 to limit carbon dioxide emissions by improving energy efficiency
(SAVE) (5), which require Member States to develop, implement and report on programmes in the field of energy efficiency in the building sector, is now starting to show some important benefits. However, a complementary legal instrument is needed to lay down more concrete actions with a view to achieving the great unrealised potential for energy savings and reducing the large differences between Member States' results in this sector.

(8) Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (6) requires construction works and their heating, cooling and ventilation installations to be designed and built in such a way that the amount of energy required in use will be low, having regard to the climatic conditions of the location and the occupants.

(9) The measures further to improve the energy performance of buildings should take into account climatic and local conditions as well as indoor climate environment and cost-effectiveness. They should not contravene other essential requirements concerning buildings such as accessibility, prudence and the intended use of the building.

(10) The energy performance of buildings should be calculated on the basis of a methodology, which may be differentiated at regional level, that includes, in addition to thermal insulation other factors that play an increasingly important role such as heating and air-conditioning installations, application of renewable energy sources and design of the building. A common approach to this process, carried out by qualified and/or accredited experts, whose independence is to be guaranteed on the basis of objective criteria, will contribute to a level playing field as regards efforts made in Member States to energy saving in the buildings sector and will introduce transparency for prospective owners or users with regard to the energy performance in the Community property market.

(11) The Commission intends further to develop standards such as EN 832 and prEN 13790, also including consideration of air-conditioning systems and lighting.

4.1.2003 EN Official Journal of the European Communities L 1/65

(1) OJ C 213 E, 31.7.2001, p. 266 and OJ C 203 E, 27.8.2002, p. 69.

(2) OJ C 36, 8.2.2002, p. 20.

(3) OJ C 107, 3.5.2002, p. 76.

(4) Opinion of the European Parliament of 6 February 2002 (not yet published in the Official Journal), Council Common Position of 7 June 2002 (OJ C 197, 20.8.2002, p. 6) and decision of the European Parliament of 10 October 2002 (not yet published in the Official Journal).

(5) OJ L 237, 22.9.1993, p. 28.

(6) OJ L 40, 11.2.1989, p. 12. Directive as amended by Directive 93/ 68/EEC (OJ L 220, 30.8.1993, p.1).

(12) Buildings will have an impact on long-term energy consumption and new buildings should therefore meet minimum energy performance requirements tailored to the local climate. Best practice should in this respect be geared to the optimum use of factors relevant to enhancing energy performance. As the application of alternative energy supply systems is generally not explored to its full potential, the technical, environmental and economic feasibility of alternative energy supply systems should be considered; this can be carried out once, by the Member State, through a study which produces a list of energy conservation measures, for average local market conditions, meeting cost-effectiveness criteria.

Before construction starts, specific studies may be requested if the measure, or measures, are deemed feasible.

(13) Major renovations of existing buildings above a certain size should be regarded as an opportunity to take costeffective measures to enhance energy performance.

Major renovations are cases such as those where the total cost of the renovation related to the building shell and/or energy installations such as heating, hot water supply, air-conditioning, ventilation and lighting is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated, or those where more than 25 % of the building shell undergoes renovation.

(14) However, the improvement of the overall energy performance of an existing building does not necessarily mean a total renovation of the building but could be confined to those parts that are most relevant for the energy performance of the building and are cost-effective.

(15) Renovation requirements for existing buildings should not be incompatible with the intended function, quality or character of the building. It should be possible to recover additional costs involved in such renovation within a reasonable period of time in relation to the expected technical lifetime of the investment by accrued energy savings.

(16) The certification process may be supported by programmes to facilitate equal access to improved energy performance; based upon agreements between organisations of stakeholders and a body appointed by the Member States; carried out by energy service companies which agree to commit themselves to undertake the identified investments. The schemes adopted should be supervised and followed up by Member States, which should also facilitate the use of incentive systems. To the extent possible, the certificate should describe the actual energy-performance situation of the building and may be revised accordingly. Public authority buildings and buildings frequently visited by the public should set an example by taking environmental and energy considerations into account and therefore should be subject to energy certification on a regular basis. The dissemination to the public of this information on energy performance should be enhanced by clearly displaying these energy certificates. Moreover, the displaying of officially recommended indoor temperatures, together with the actual measured temperature, should discourage the misuse of heating, air-conditioning and ventilation systems. This should contribute to avoiding unnecessary use of energy and to safeguarding comfortable indoor climatic conditions (thermal comfort) in relation to the outside temperature.

(17) Member States may also employ other means/measures, not provided for in this Directive, to encourage enhanced energy performance. Member States should encourage good energy management, taking into account the intensity of use of buildings.

(18) Recent years have seen a rise in the number of air-conditioning systems in southern European countries. This creates considerable problems at peak load times, increasing the cost of electricity and disrupting the energy balance in those countries. Priority should be given to strategies which enhance the thermal performance of buildings during the summer period. To this end there should be further development of passive cooling techniques, primarily those that improve indoor climatic conditions and the microclimate around buildings.

(19) Regular maintenance of boilers and of air-conditioning systems by qualified personnel contributes to maintaining their correct adjustment in accordance with the product specification and in that way will ensure optimal performance from an environmental, safety and energy point of view. An independent assessment of the total heating installation is appropriate whenever replacement could be considered on the basis of cost-effectiveness.

(20) The billing, to occupants of buildings, of the costs of heating, air-conditioning and hot water, calculated in proportion to actual consumption, could contribute towards energy saving in the residential sector. Occupants should be enabled to regulate their own consumption of heat and hot water, in so far as such measures are cost effective.

(21) In accordance with the principles of subsidiarity and proportionality as set out in Article 5 of the Treaty, general principles providing for a system of energy performance requirements and its objectives should be established at Community level, but the detailed implementation should be left to Member States, thus allowing each Member State to choose the regime which corresponds best to its particular situation. This Directive confines itself to the minimum required in order to achieve those objectives and does not go beyond what is necessary for that purpose. L 1/66 EN Official Journal of the European Communities 4.1.2003

(22) Provision should be made for the possibility of rapidly adapting the methodology of calculation and of Member States regularly reviewing minimum requirements in the field of energy performance of buildings with regard to technical progress, *inter alia*, as concerns the insulation properties (or quality) of the construction material, and to future developments in standardisation.

(23) The measures necessary for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission (1),

HAVE ADOPTED THIS DIRECTIVE:

Article 1

Objective

The objective of this Directive is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

This Directive lays down requirements as regards:

(a) the general framework for a methodology of calculation of the integrated energy performance of buildings;

(b) the application of minimum requirements on the energy performance of new buildings;

(c) the application of minimum requirements on the energy performance of large existing buildings that are subject to
major renovation;

(d) energy certification of buildings; and

(e) regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old.

Article 2

Definitions

For the purpose of this Directive, the following definitions shall apply:

1. 'building': a roofed construction having walls, for which energy is used to condition the indoor climate; a building may refer to the building as a whole or parts thereof that have been designed or altered to be used separately;

2. 'energy performance of a building': the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use of the building, which may include, *inter alia*, heating, hot water heating, cooling, ventilation and lighting. This amount shall be reflected in one or more numeric indicators which have been calculated, taking into account insulation, technical and installation characteristics, design and positioning in relation to climatic aspects, solar exposure and influence of neighbouring structures, own-energy generation and other factors, including indoor climate, that influence the energy demand;

3. 'energy performance certificate of a building': a certificate recognised by the Member State or a legal person designated by it, which includes the energy performance of a building calculated according to a methodology based on the general framework set out in the Annex;

4. 'CHP' (combined heat and power): the simultaneous conversion of primary fuels into mechanical or electrical and thermal energy, meeting certain quality criteria of energy efficiency;

5. 'air-conditioning system': a combination of all components required to provide a form of air treatment in which temperature is controlled or can be lowered, possibly in combination with the control of ventilation, humidity and air cleanliness;

6. 'boiler': the combined boiler body and burner-unit designed to transmit to water the heat released from combustion;

7. 'effective rated output (expressed in kW)': the maximum calorific output specified and guaranteed by the manufacturer as being deliverable during continuous operation while complying with the useful efficiency indicated by the manufacturer;

8. 'heat pump': a device or installation that extracts heat at low temperature from air, water or earth and supplies the heat to the building.

Article 3

Adoption of a methodology

Member States shall apply a methodology, at national or regional level, of calculation of the energy performance of buildings on the basis of the general framework set out in the
Annex. Parts 1 and 2 of this framework shall be adapted to technical progress in accordance with the procedure referred to in Article 14(2), taking into account standards or norms applied in Member State legislation. This methodology shall be set at national or regional level. The energy performance of a building shall be expressed in a transparent manner and may include a CO2 emission indicator.

Article 4

Setting of energy performance requirements

1. Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings are set, based on the methodology referred to in Article 3. When setting requirements, Member States may differentiate between new and existing buildings and different categories of buildings. These requirements shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation, as well as local conditions and the designated function and the age of the building. These requirements shall be reviewed at regular intervals which should not be longer than five years and, if necessary, updated in order to reflect technical progress in the building sector.

4.1.2003 EN Official Journal of the European Communities L 1/67

(1) OJ L 184, 17.7.1999, p. 23.

2. The energy performance requirements shall be applied in accordance with Articles 5 and 6.

3. Member States may decide not to set or apply the requirements referred to in paragraph 1 for the following categories of buildings:

— buildings and monuments officially protected as part of a designated environment or because of their special architectural or historic merit, where

compliance with the requirements would unacceptably alter their character or appearance,
— buildings used as places of worship and for religious activities,
— temporary buildings with a planned time of use of two years or less, industrial sites, workshops and non-residential agricultural buildings with low energy demand and non-residential agricultural buildings which are in use by a sector covered by a national sectoral agreement on energy performance,
— residential buildings which are intended to be used less than four months of the year,
— stand-alone buildings with a total useful floor area of less than 50 m2.

Article 5
New buildings
Member States shall take the necessary measures to ensure that new buildings meet the minimum energy performance requirements referred to in Article 4. For new buildings with a total useful floor area over 1 000 m2, Member States shall ensure that the technical, environmental and economic feasibility of alternative systems such as:
— decentralised energy supply systems based on renewable energy,
— CHP,
— district or block heating or cooling, if available,
— heat pumps, under certain conditions, is considered and is taken into account before construction starts.

Article 6
Existing buildings
Member States shall take the necessary measures to ensure that when buildings with a total useful floor area over 1 000 m2 undergo major renovation, their energy performance is upgraded in order to meet minimum requirements in so far as this is technically, functionally and economically feasible.
Member States shall derive these minimum energy performance requirements on the basis of the energy performance requirements set for buildings in accordance with Article 4. The requirements may be set either for the renovated building as a whole or for the renovated systems or components when these are part of a renovation to be carried out within a limited time period, with the abovementioned objective of improving the overall energy performance of the building.

Article 7
Energy performance certificate
1. Member States shall ensure that, when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant, as the case might be. The validity of the certificate shall not exceed 10 years. Certification for apartments or units designed for separate use in blocks may be based:
— on a common certification of the whole building for blocks with a common heating system, or
— on the assessment of another representative apartment in the same block. Member States may exclude the categories referred to in Article
4(3) from the application of this paragraph. 2. The energy performance certificate for buildings shall include reference values such as current legal standards and benchmarks in order to make it possible for consumers to compare and assess the energy performance of the building. The certificate shall be accompanied by recommendations for the cost-effective improvement of the energy performance. The objective of the certificates shall be limited to the provision of information and any effects of these certificates in terms of legal proceedings or otherwise shall be decided in accordance with national rules.
3. Member States shall take measures to ensure that for buildings with a total useful floor area over 1 000 m2 occupied by public authorities and by institutions providing public services to a large number of persons and therefore frequently visited by these persons an energy certificate, not older than 10 years, is placed in a prominent place clearly visible to the public.
The range of recommended and current indoor temperatures and, when appropriate, other relevant climatic factors may also be clearly displayed.

Article 8
Inspection of boilers
With regard to reducing energy consumption and limiting carbon dioxide emissions, Member States shall either:
(a) lay down the necessary measures to establish a regular inspection of boilers fired by non-renewable liquid or solid fuel of an effective rated output of 20 kW to 100 kW. Such inspection may also be applied to boilers using other fuels. Boilers of an effective rated output of more than 100 Kw shall be inspected at least every two years. For gas boilers, this period may be extended to four years. L 1/68 EN Official Journal of the European Communities 4.1.2003
For heating installations with boilers of an effective rated output of more than 20 kW which are older than 15 years, Member States shall lay down the necessary measures to establish a one-off inspection of the whole heating installation.
On the basis of this inspection, which shall include an assessment of the boiler efficiency and the boiler sizing compared to the heating requirements of the building, the experts shall provide advice to the users on the replacement of the boilers, other modifications to the heating system and on alternative solutions; or
(b) take steps to ensure the provision of advice to the users on the replacement of boilers, other modifications to the heating system and on alternative solutions which may include inspections to assess the efficiency and appropriate size of the boiler. The overall impact of this approach should be broadly equivalent to that arising from the provisions set out in (a). Member States that choose this option shall submit a report on the equivalence of their approach to the Commission every two years.

Article 9
Inspection of air-conditioning systems
With regard to reducing energy consumption and limiting carbon dioxide emissions, Member States shall lay down the necessary measures to establish a regular inspection of airconditioning systems of an effective rated output of more than 12 kW. This inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building. Appropriate advice shall be provided to the users on possible improvement or replacement of the air-conditioning system and on alternative solutions.

Article 10
Independent experts
Member States shall ensure that the certification of buildings, the drafting of the accompanying recommendations and the inspection of boilers and air-conditioning systems are carried out in an independent manner by qualified and/or accredited experts, whether operating as sole traders or employed by public or private enterprise bodies.

Article 11
Review
The Commission, assisted by the Committee established by Article 14, shall evaluate this Directive in the light of experience gained during its application, and, if necessary, make proposals with respect to, *inter alia*:
(a) possible complementary measures referring to the renovations in buildings with a total useful floor area less than 1 000 m2;
(b) general incentives for further energy efficiency measures in buildings.

Article 12
Information
Member States may take the necessary measures to inform the users of buildings as to the different methods and practices that serve to enhance energy performance. Upon Member States' request, the Commission shall assist Member States in staging the information campaigns concerned, which may be dealt with in Community programmes.

Article 13
Adaptation of the framework
Points 1 and 2 of the Annex shall be reviewed at regular intervals, which shall not be shorter than two years. Any amendments necessary in order to adapt points 1 and 2 of the Annex to technical progress shall be adopted in accordance with the procedure referred to in Article 14(2).

Article 14

Committee
1. The Commission shall be assisted by a Committee.
2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof. The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.
3. The Committee shall adopt its Rules of Procedure.

Article 15
Transposition
1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive at the latest on 4 January 2006. They shall forthwith inform the Commission thereof. When Member States adopt these measures, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. Member States shall determine how such reference is to be made. 4.1.2003 EN Official Journal of the European Communities L 1/69
2. Member States may, because of lack of qualified and/or accredited experts, have an additional period of three years to apply fully the provisions of Articles 7, 8 and 9. When making use of this option, Member States shall notify the Commission, providing the appropriate justification together with a time schedule with respect to the further implementation of this Directive.

Article 16
Entry into force
This Directive shall enter into force on the day of its publication in the *Official Journal of the European C.*

General framework for the calculation of energy performance of buildings (Article 3)

1. The methodology of calculation of energy performances of buildings shall include at least the following aspects:

(a) thermal characteristics of the building (shell and internal partitions, etc.). These characteristics may also include air-tightness;

(b) heating installation and hot water supply, including their insulation characteristics;

(c) air-conditioning installation;

(d) ventilation;

(e) built-in lighting installation (mainly the non-residential sector);

(f) position and orientation of buildings, including outdoor climate;

(g) passive solar systems and solar protection;

(h) natural ventilation;

(i) indoor climatic conditions, including the designed indoor climate.

2. The positive influence of the following aspects shall, where relevant in this calculation, be taken into account:

(a) active solar systems and other heating and electricity systems based on renewable energy sources;

(b) electricity produced by CHP;

(c) district or block heating and cooling systems;

(d) natural lighting.

3. For the purpose of this calculation buildings should be adequately classified into categories such as:

(a) single-family houses of different types;

(b) apartment blocks;

(c) offices;

(d) education buildings;

(e) hospitals;

(f) hotels and restaurants;

(g) sports facilities;

(h) wholesale and retail trade services buildings;

(i) other types of energy-consuming buildings.

4.1.2003 EN Official Journal of the European Communities L 1/71

ANNEX-II

Binaların enerji performansı hakkında

AVRUPA PARLEMENTOSU VE KONSEYİ 2002/91/EC SAYILI DİREKTİFİ

16 Aralık 2002

AVRUPA PARLAMENTOSU VE AVRUPA BİRLİĞİ KONSEYİ,

Avrupa Topluluğu'nun kuran Anlaşma ve özellikle de bu Anlaşma'nın 175(1). Maddesi'ni,

Komisyon'un[1] önerisini,

Ekonomik ve Sosyal Komite'nin[2] görüşünü,

Bölgeler Komitesi'nin[3] görüşünü dikkate alarak veAnlaşma'nın[4] 251. Maddesi'nde belirlenen prosedüre uygun olarak aşağıdaki direktifi çıkarmıştır.

Aşağıdaki şartlara dayanarak;

(1) Anlaşma'nın 6. Maddesi, çevre koruma gereklerinin, Topluluğun politika ve eylemlerinin tanım ve uygulamasına entegre edilmesini gerektirmektedir.

(2) Anlaşma'nın 174. Maddesi'nde; önemli enerji kaynakları olmalarının yanısıra başlıca karbon dioksit emisyonu kaynağı olan petrol ürünleri, doğal gaz ve katı yakıtları içeren doğal kaynakların dikkatli ve rasyonel bir şekilde kullanılmalarına işaret edilmektedir.

(3) Kyoto Protokolü'ne uymak üzere enerji verimliliğinin arttırılması politika ve önlemler paketinin ciddi bir bölümünü oluşturmakta olup, gelecekte ortaya çıkacak taahhütlerin de yerine geitirilebilmesi için, bu konu her tür politikada yerini almalıdır.

(4) Enerji taleplerinin yönetilmesi, Topluluğun dünya enerji pazarı üzerindeki etkisini ve dolayısıyla da, orta ve uzun vadede enerji arzının güvenliğini sağlayan önemli bir araçtır.

(5) 30 Mayıs 2000 ve 5 Aralık 2000 tarihli Kararlarında, Konsey, Komisyon'un Enerji Verimliliğine İlişkin Eylem Planını onaylamış, inşaat sektörü için belli tedbirler alınmasını talep etmiştir.

(6) Topluluk'ın enerji tüketiminin %40'ından fazlası, çoğunluğu bina olan konutlar ile üçüncü tip sektöründen oluşmaktadır ve bu sektör genişlemektedir. Bu eğilim, topluluktaki enerji tüketimini, dolayısıyla da karbon diyoksit emisyonunu arttırıcı bir etki yapacaktır.

(7) Enerji verimliliğinin arttırılması (SAVE)[5] suretiyle karbon dioksit emisyonlarının sınırlanmasını sağlayan ve Üye Ülkelerin inşaat sektöründe enerji verimliliği alanında çeşitli programlar geliştirmesini, uygulamasını ve bu konuda rapor vermesini ön gören 13 Eylül 1993 tarih ve 93/76/EEC sayılı Konsey Yönergesi'nin önemli yararları görülmeye başlanmıştır. Ancak, enerji tasarrufu konusunda gerçekleştirilememiş olan büyük potansiyelden yararlanmak ve Üye Ülkeler'in bu sektörle ilgili olarak elde ettiği sonuçlar arasındaki büyük farkı azaltmak açısından daha somut adımlar atılması için, tamamlayıcı bir yasal belgeye gerek duyulmaktadır.

(8) Üye Ülkelerin inşaat ürünleri[6] ile ilgili kanun, yönetmelik ve idari hükümlerinin birbirine uyumlu hale getirilmesine ilişkin 21 Aralık 1988 tarih ve 89/106/EEC sayılı Konsey Direktifi, inşaat işlerinin ve bu işlerdeki ısıtma, soğutma ve havalandırma tesisatlarının, mekanın iklim koşulları ile orada yaşayan kişilere bağlı olarak, az miktarda enerji gerektirecek şekilde tasarlanıp inşa edilmesini ön görmektedir.

(9) Binaların enerji performansını arttırmak üzere alınacak tedbirlerde, iç meken iklim koşulları

[1] OJ C 213 E, 31.7.2001, Sf. 266.
[2] OJ C 36, 8.2.2002, Sf: 20.
[3] Görüş, 15 Kasım 2001 tarihinde verilmiştir. (Henüz Resmi Gazete'de yayınlanmamıştır.)
[4] 6 Şubat 2002 tarihli Avrupa Parlamentosu Görüşü (Henüz Resmi Gazete'de yayınlanmamıştır.), ……….. tarihli Ortak Konsey Görüşü (Henüz Resmi Gazete'de yayınlanmamıştır.), ………….. tarihli Avrupa Parlamentosu Kararı.

[5] OJ L 237, 22.9.1993, Sf: 28.
[6] OJ L 40, 11.2.1989, Sf: 12.

ve uygun maliyetin yanısıra, iklim ve yerel koşullar da hesaba katılmalıdır. Bu tedbirler, erişilebilirlik, ihtiyat ve kullanım amacı gibi bina ile ilgili diğer temel gereklerin tersine bir eyleme dönüşmemelidir.

(10) Binaların enerji performansları, ısı yalıtımının yanısıra, ısıtma ve iklimleme tesisatları, yenilenebilir enerji kaynaklarının uygulanması ve binanın tasarımı gibi gitgide önemi artan diğer faktörleri de içeren ve bölgesel düzeyde farklılaşmaya gidilebilecek olan belli bir metodolojiye göre hesaplanmalıdır. Bağımsızlıkları nesnel kıstaslara dayanarak garantilenen kalifiye ve/veya akredite edilmiş uzmanlar tarafından bu sürece ortak bir yaklaşım geliştirilmesi Üye Ülkelerin, inşaat sektöründe enerji tasarrufu yapılmasına yönelik çabaları açısından bakıldığında son derece yararlı olacaktır ve Topluluğun emlak piyasasındaki enerji tasarrufu bağlamında, gelecekteki mülk sahipleri ya da kullanıcıları açısından konuya saydamlık getirecektir.

(11) Komisyon önümüzdeki dönemlerde, iklimleme sistemleri ve aydınlatma konularını da kapsayacak şekilde, EN 832 ve prEN 13790 gibi standartlar geliştirmek niyetindedir.

(12) Binaların uzun vadede enerji tüketimi üzerinde önemli etkileri olacaktır ve bu nedenle, yeni binaların yerel iklime uygun olarak minimum enerji performans gereklerini karşılamaları gerekmektedir. Bu anlamda, enerji performansını arttırılması ile ilgili faktörlerin en elverişli kullanımına yönelik en iyi uygulamanın hızlandırılması gerekmektedir. Alternatif enerji kaynağı sistemlerinin uygulanması, genel olarak tam anlamıyla araştırılmamış olduğu için, alternatif enerji kaynağı sistemlerinin teknik, çevresel ve ekonomik yapılabilirliği (fizibilite) göz önünde bulundurulmalıdır. Bu, Üye Ülke tarafından, ortalama yerel pazar koşullarına göre ve uygun maliyet kıstaslarını karşılayan enerji koruma tedbirlerini listeleyen bir çalışma vasıtasıyla bir kereliğine gerçekleştirilebilir. Bu tedbir ya da tedbirler uygun görüldüğü takdirde inşaat başlamadan önce bazı çalışmalar talep edilebilir.

(13) Belli bir boyutun üstündeki mevcut binalarda yapılacak büyük çaplı yenilikler, enerji performansını arttırmak üzere uygun maliyetli tedbirlerin alınması ile ilgili bir fırsat olarak değerlendirilmelidir. Bu tür büyük çaplı yenilikler, bina cephesi ve/veya ısıtma, sıcak su tesisatı, havalandırma, iklimleme ve ışıklandırma gibi enerji tesisatları ile ilgili yenilemenin toplam maliyetinin, binanın arazi değeri dışındaki değerinin %25'ini aştığı ya da bina iskeletinin %25'inden fazlasında değişiklik yapıldığı yeniliklerdir.

(14) Bununla beraber, mevcut bir binanın toplam enerji performansının iyileştirilmesi, binanın baştan aşağı yenilenmesi anlamına gelmemekte olup, uygun maliyetli ve binanın enerji performansını en çok etkileyen bölümlerinin yenilenmesi ve ile sınırlandırılabilmelidir.

(15) Mevcut binaların yenilenmesine ilişkin koşullar, binanın hedeflenen işlevi, niteliği ya da karakterine ters düşmemelidir. Enerji tasarrufu ile elde edilecek mali birikim ile, yatırımın tahmin edilen teknik yaşam süresi düşünüldüğünde, bu yenileme çalışmalarında karşılaşılan ek maliyetin makul bir süre içinde geri kazanımı mümkün olacaktır.

(16) Üye Ülkelerce belirlenecek bir kurum ve kurumsal paydaş organizasyonları arasındaki anlaşmalara dayanarak, belirlenmiş olan yatırımları gerçekleştirmeyi taahhüt eden enerji hizmeti şirketleri tarafından geliştirilmiş enerji performansına eşit şekilde erişimi kolaylaştırmak üzere hazırlanan programlar kullanılarak, belgelendirme sürecini desteklemek mümkündür. Teşvik edici sistemlerin kullanımını kolaylaştırmayı da sağlayacak olan seçilmiş sistem, Üye Ülkeler tarafından denetlenmeli ve takip edilmelidir. Mümkün olduğu oranda, bu belge, binanın halihazırdaki enerji performansı durumunu tanımlamalı ve duruma göre tekrar gözden geçirilebilir olmalıdır. Kamu binaları ve halka açık binalarda, çevre ve enerji konularının üzerinde önemle durularak buna bir örnek teşkil edilmelidir ve bu nedenle bu binalar düzenli olarak enerji belgelendirmesi sürecine tabi tutulmalıdır. Enerji performansı ile ilgili bu tür bilgilerin halka duyurulması sırasında, bu enerji belgeleri açık bir şekilde gösterilmelidir. Bunun yanısıra, resmi olarak önerilen binaiçi sıcaklık derecesi ile birlikte ortamda o anda ölçülen sıcaklık derecesinin gösterilmesi sayesinde ısıtma, havalandırma ve iklimleme sistemlerinin yanlış kullanımıının da önüne geçilebilir. Bu durum, enerjinin gereksiz yere kullanımını önlemeye ve dışarıdaki sıcaklık derecesine oranla, binaiçi iklim koşullarının (ısıl konfor) uygun bir düzeyde muhafaza edilmesine katkı sağlayacaktır.

(17) Üye Ülkeler, enerji performansını arttırmaya özendirmek için bu Direktifte söz edilmeyen başka ifade/tedbirler de uygulayabilir. Üye Ülkeler, bina kullanımı yoğunluğunu göz önünde bulundurarak, iyi enerji yönetimini özendirmelidir.

(18) Son yıllarda, güney Avrupa ülkelerinde iklimlendirme sistemleri kullanımında artış görülmektedir. Bu durum, elektrik maliyetini yükselterek ve bu ülkelerdeki enerji dengesini bozarak, enerji tüketiminin en yüksek olduğu saatlerde ciddi sıkıntılara neden olmaktadır. Yaz aylarında binaların ısıl performanslarını arttırmaya yönelik stratejilere öncelik

verilmelidir. Bu amaçla, özellikle binaiçi iklim koşullarını ve binaların çevresindeki mikroiklimleri düzelten, pasif soğutma teknikleri geliştirilmelidir.

(19) Nitelikli elemanlar tarafından kazan ve iklimleme sistemlerinin düzenli olarak bakıma alınması, ürünlerin şartnamelerine uygun doğru ayarların muhafaza edilmesine katkı sağlayacaktır ve bu sayede, çevre, emniyet ve enerji açılarından bakıldığında, optimal performans sağlanacaktır. Uygun maliyetli sistem değiştirilmesi mümkün olduğunda, ısıtma tesisatının tamamının bağımsız bir değerlendirmeye tabi tutulması uygun olacaktır.

(20) Binada yaşayan kişilere, ısıtma, iklimleme ve sıcak su için, gerçekten kullandıkları miktara göre faturalandırmaya gidilmesi, konut sektöründe sonraki dönemlerde enerji tasarrufuna katkı sağlayabilecektir. Bu tür tedbirler uygun maliyetli olduğu sürece, binalarda yaşayan kişiler, kendi ısıtma ve sıcak su tüketimlerini ayarlayabileceklerdir.

(21) Anlaşma'nın 5. Maddesi'nde anılan doğrudan destek ve orantısallık ilkeleri uyarınca, enerji performansı koşulları ve amaçlarına ilişkin genel ilkeler, Topluluk düzeyinde belirlenmelidir, ancak, bunların uygulanmasını sağlayacak ayrıntılar, Üye Ülkelere bırakılmalı ve bu sayede, her bir Üye Ülkenin kendi durumuna en uygun olan uygulamaya gitmesine olanak verilmelidir. Bu Direktif, bu hedefleri sağlamak üzere gerekli minimum şartlarla sınırlıdır ve bu amaca yönelik olarak gerekenlerin ötesine geçmemektedir.

(22) Hesaplama yönteminin hızlı bir şekilde uyarlanması ve Üye Ülkelerin binaların enerji performansları konusunda, yapı malzemelerinin yalıtım özellikleri (ya da niteliği) ve standardizasyon konusunda ileriki dönemlerde oluşacak gelişmeler gibi teknik gelişmeler hakkında minimum gereklerin düzenli olarak yeniden gözden geçirilmesi olasılığına karşılık gerekli hükümler oluşturulmalıdır.

(23) Bu Direktifin uygulanması için gerekli tedbirler, Komisyona verilen yaptırım gücünün uygulanma prosedürü hakkındaki 28 Haziran 1999 tarih ve 1999/468/EC sayılı Konsey Kararı[1] uyarınca yürürlüğe girmelidir.

BU DİREKTİFİ KABUL ETMİŞTİR.

[1] OJ L 184, 17.7.1999, Sf: 23.

Madde 1

Amaç

Bu Direktifin amacı Topluluk içerisindeki binaların, dış mekan iklim şartları, iç mekan ortam gereksinimleri, yerel koşullar ve uygun maliyet de dikkate alınarak, enerji performanslarının arttırılmasını temin etmektir.

Bu Direktif:

(a) Binaların bütüncül enerji performansını hesaplamak için ortak bir yöntemin genel çerçevesi,
(b) Yeni Binaların enerji performansı için minimum şartların uygulanması
(c) Önemli yenileme çalışmalarına konu olacak, mevcut büyük binaların enerji performansı için minimum şartların uygulanması,
(d) Binaların enerji sertifikasyonu
(e) 15 yıldan daha eski kazanların olduğu ısıtma tesisatları için yapılacak değerlendirmeye ek olarak, binaların kazanları ve merkezi air-condition sistemlerinin düzenli denetimi

Hakkında gerekleri ortaya koyar.

Madde 2

Tanımlar

Bu Direktif kapsamında, aşağıdaki tanımlar kullanılacaktır;

1. 'bina' iç mekanın iklimini düzenlemek için enerjinin kullanıldığı, duvarları ve üzerinde çatısı olan yapı; 'bina' tanımı bütün olarak binaya veya binanın ayrı ayrı kullanılabilmesi için tasarlanan veya değiştirilen bölümlerine de karşılık gelebilir.

2. 'binanın enerji performansı' bir binanın ısınma, su ısıtma, soğutma, havalandırma, ve aydınlatma gibi yapının standart kullanımına ilişkin çeşitli ihtiyaçları karşılamak için harcanan gerçek veya tahmin edilen enerji miktarı Bu miktar, yalıtım, teknik ve tesisat özellikleri, iklime göre tasarım ve konumlandırma, güneşe maruz kalma, komşu binaların etkileri, binanın kendi kendine ürettiği enerji ve iç mekanın iklimi gibi binanın enerji gereksinimini etkileyen faktörler dikkate alınarak hesaplanmış bir veya daha fazla sayısal göstergede belirtilecektir.

3. 'binanın enerji performans sertifikası' bir binanın, ekler bölümünde tarif edilen yönteme

göre hesaplanan enerji performansını içeren, Üye Devlet ya da tarafınca atanmış yasal kişi tarafından onaylanan serifika

4. 'bileşik ısı ve güç' belirli enerji verimliliği kalite kriterlerini karşılayacak şekilde, birincil yakıtların eş zamanlı olarak mekanik enerjiye, elektrik enerjisine ve ısıya çevirimi

5. 'iklimlendirme sistemi havalandırma, nem ve hava temizliği kontrolünün de yapılabildiği, ısının kontrol edildiği veya düşürüldüğü bir çeşit hava arıtma sağlama işlemi için gereken tüm bileşenler

6. 'kazan' yanma sonrası açığa çıkan ısıyı, suya iletmek için tasarlanmış bileşik kazan gövdesi ve yakıcı ünite.

7. 'efektif nominal güç (kw cinsinden ifade edilir)' üretici tarafından ve belirtmiş olduğu verime uygun olarak sürekli işletim sırasında oluşacağı belirtilen ve garanti edilen, en yüksek kalori gücü.

8. 'ısı pompası' havadan, sudan veya topraktan düşük derecede ısı alarak binaya ısı temin eden araç veya tesisat

Madde 3

Yöntemin belirlenmesi

Üye Devletler binaların enerji performanslarını hesaplama yöntemini, Eklerde yer alan genel çerçeveyi temel alarak ulusal ya da bölgesel düzeyde uygulayacaklardır. Bu çerçevenin 1 ve 2. bölümleri, Üye Ülke mevzuatındaki standartlar ya da normlar dikkate alınarak, madde 14(2) de bahsedilen prosedüre uygun olarak teknik ilerlemelere göre uyarlanacaktır.

Bu yöntem ulusal ya da bölgesel düzeyde kurulacaktır.

Bir binanın enerji performansı açık bir biçimde belirtilecektir ve CO_2 emisyonlarını içerebilecektir.

Madde 4

Enerji performansı gereklerinin saptanması

1. Üye Ülkeler, Madde 3'te bahsedilen yöntemi temel alarak, binalar için saptanmış minimum enerji performansı gereklerini sağlamak üzere gerekli tedbirleri alacaklardır. Bu gerekler saptanırken, Üye Ülkeler yeni binalar ve mevcut binalar ve de farklı kategorilerdeki binalar için sınıflandırmaya gidebilirler. Bu gereklerde, yapının yaşı, belirlenmiş fonksiyonu ve yerel şartlar kadar, yetersiz havalandırma gibi olası negatif etkilerden kaçınmak için genel iç iklim koşulları da dikkate alınacaktır. Bu enerji performans kuralları, 5 yıldan daha uzun olmamak kaydıyla, belirli zaman dilimlerinde gözden geçirilecek, gerektiğinde de yapı sektöründeki teknik gelişmeyi yansıtabilmek üzere güncellenecektir.

2. Enerji performansı gerekleri Madde 5 ve 6'ya göre uygulanacaktır.

3. Üye devletler, aşağıda belirtilen kategoriler için, 1. paragrafta bahsedilen kuralları koymayabilir veya uygulamayabilir;

– tanımlanmış bir alanda resmi olarak korunan, veya tarihi, mimari bir değer taşıyan ve bu kuralların uygulanmasıyla özelliklerinde veya görünümlerinde kabul edilemez değişikliklerin olabileceği yapı ve anıtlarda,

– ibadet yerleri ve dinsel aktiviteler için kullanılan yapılar,

– 2 yıl veya daha az süre için kullanılması planlanan geçici yapılar, düşük enerji talebinde olan sanayi alanları, atölyeler ve konut dışı tarım yapıları ve enerji performansı konusunda milli bir sektör anlaşması kapsamında kalan bir sektör tarafından kullanılan konut dışı tarım yapıları,

– yılda 4 aydan daha az süre için kullanılan konutlar

– toplam kullanılabilir zemin alanı 50 m2'den küçük müstakil binalar.

Madde 5

Yeni binalar

Üye Ülkeler yeni binalarda Madde 4'te bahsedilen minimum enerji performans gereklerinin yerine getirlimesini sağlamak için gerekli tedbirleri alacaklardır.

Toplam kullanım alanı 1000 m2 den büyük yeni binalar için Üye devletler;

– yenilenebilir enerjiye dayanan merkezi olmayan enerji sağlama sistemleri,

– bileşik ısı ve güç,

– sağlanabilirse bölgesel ya da blok ısıtma ya da soğutma,

– belirli koşullarda ısı pompaları,

gibi alternatif sistemlerin inşaat başlamadan önce teknik, çevresel ve ekonomik olarak yapılabilirliğinin düşünülmesini ve göz önünde tutulmasını sağlayacaklardır

Madde 6

Mevcut binalar

Üye Ülkeler toplam kullanım alanı 1000 m^2'den büyük binalarda kapsamlı bir tadilat yapıldığında, teknik, fonksiyonel ve ekonomik olarak mümkün olduğu oranda , bu binaların enerji performansının minimum gerekleri karşılamak üzere güncellenmesini sağlamak için gerekli tedbirleri alacaklardır. Üye Ülkeler, bu minimum enerji performans gereklerini Madde 4 uyarınca binalar için saptanmış enerji performans gereklerine göre oluşturacaklardır. Yukarıda bahsedildiği gibi binanın enerji performansının arttırılması amacına yönelik olarak, bu gerekler ya yenilenen binanın tümü veya belirli bir dönem içerisinde tamamlanacak bir yenilemenin parçası oldukları zaman, yenilenmiş sistemler ya da bileşenler için oluşturulabilir.

Madde 7

Enerji performansı sertifikası

1. Üye Ülkeler, binalar yapıldığında, satıldığında ya da kiraya verildiğinde, malsahibine ya da malsahibi tarafından duruma göre, alıcı ya da kiracıya bir enerji performansı belgesi verilmesini sağlayacaktır. Sertifikanın geçerliliği 10 yılı aşmayacaktır.

Bloklarda daireler veya bağımsız kullanım için tasarlanmış birimler için sertifikalandırma;

– ortak ısınma sistemi olan yapılarda, tüm yapı için ortak veya,

– aynı blok içinde benzer bir dairenin değerlendirilmesine dayanarak yapılabilir

Üye devletler, Madde 4(3)'te bahsedilen kategorileri, bu paragrafın uygulanmasından muaf tutabilirler.

2. Binalar için enerji performans sertifikası, tüketicilerin binanın enerji performansını karşılaştırabilmeleri ve değerlendirebilmeleri için halihazır yasal standartlar ve sabit değerler gibi referans değer bilgilerini içerecektir. Sertifikada, enerji performansını attıracak uygun maliyetli öneriler verilecektir.

Sertifikaların amacı bilgilendirme ile sınırlı olacaktır ve adli (hukuki) muameleler bağlamında sertifikaların her türlü etkisi ulusal kurallara göre kararlaştırılacaktır.

3. Üye Ülkeler, çok sayıda kişi tarafından ziyaret edilen ve bu kişilere hizmet sağlayan, kamu çalışanları ve kuruluşları tarafından kullanılan toplam kullanım alanı 1000 m^2'den büyük binalar için; 10 yıldan eski olmayan enerji sertifikasını, kolayca görülebilir bir yere yerleştirilmesini sağlamak üzere tedbirleri alacaklardır.

Tavsiye edilen ve mevcut sıcaklık dağılımı ve uygun olduğu takdirde ilgili iklimsel faktörler de açık olarak gösterilebilir.

Madde 8

Kazanların denetimi

Üye Ülkeler, enerji tüketiminin azaltılması ve karbondioksit emisyonlarının sınırlandırılması konusunda ayrıca;

(a) yenilenebilir olmayan sıvı ya da katı yakıtla yanan , efektif nominal gücü 20 kW'dan 100 kW'ya kadar olan kazanların düzenli denetimini sağlamak üzere gerekli tedbirleri belirleyeceklerdir.

efektif nominal gücü 100 kW'dan büyük kazanlar en az iki yılda bir denetlenecektir. Gaz kazanları için bu süre dört yıla çıkarılabilir.

15 yaşından büyük, efektif nominal gücü 20 kW'dan fazla kazanlı ısıtma tesisatları için Üye Ülkeler bir seferlik tüm ısıtma tesisatı denetimi kurmak üzere gerekli tedbirleri belirleyeceklerdir. Binanın ısıtma ihtiyacına karşılık gelen kazan büyüklüğü ve verimliliği değerlendirmesi içerecek olan bu denetimin temelinde uzmanlar kullanıcılara, kazanların yer değiştirmesi, ısıtma sisteminde başka değişiklikler yapılması ve alternatif çözümlere ilişkin gerekli önerileri verecektir. Ya da

b) kullanıcılar için kazanların yer değiştirmesi, , ısıtma sisteminde başka değişiklikler yapılması ve alternatif çözümler üzerine, kazanın uygun boyut ve verimliliğini değerlendiren denetlemeleri içerebilen öneri hükümlerini sağlamak üzere gerekenleri yapacaklardır. Bu yaklaşımın yaratacağı toplam etki (a) bendinde yer alan hükümlerde anılan önlemlerin yaratacağı etkiyle genel anlamda uygun olmalıdır. Bu seçeneği seçen Üye Ülkeler, Komisyona yaklaşımlarının denkliği üzerine iki yılda bir rapor sunacaklardır.

Madde 9

İklimlendirme sistemlerinin denetimi

Enerji tüketiminin azaltılması ve karbondioksit emisyonlarının sınırlandırılması hakkında Üye Ülkeler, efektif nominal gücü 12 kW'dan fazla olan iklimlendirme sistemlerinin düzenli denetimini oluşturmak üzere gerekli tedbirleri belirleyeceklerdir.

Bu denetim, iklimlendirme verimliliği ve binanın soğutulması ihtiyacına karşılık gelen boyutlandırma değerlendirmesini içerecektir. Kullanıcılara, iklimlendirme sisteminin kimi yer değitirme ya da ilerlemeler ve alternatif çözümler üzerine uygun tavsiyelerde bulunulacaktır.

Madde 10

Bağımsız uzmanlar

Üye Ülkeler, binaların sertifikalandırılması, sertifika ile beraber verilen öneri taslaklarının hazırlanması ve kazanların ve iklimlendirme sistemlerinin denetimi işlerinin, münferit çalışan ya da kamu veya özel teşebbüs kurumlarınca görevlendirilmiş kalifiye ve/veya akredite edilmiş uzmanlarca bağımsız şekilde sürdürülmesini sağlayacaklardır.

Madde 11

Gözden geçirme

Madde 14'e göre oluşturulan Komite ile birlikte Komisyon, Direktifi uygulanması sürecinde kazanılan tecrübeler ışığında geliştirecek ve gerekirse;

(a) Toplam kullanım alanı 1000 m^2'den küçük binaların yenilenmesinde uygulanabilecek olası tamamlayıcı tedbirler

(b) Binalarda daha sonraki enerji verimliliği tedbirleri için genel teşvikler arasından birisi ile ilgili öneriler oluşturacaktır.

Madde 12

Bilgi

Üye Ülkeler enerji performansını arttırmaya yarayan farklı yöntem ve çalışmalar hakkında binaların kullanıcılarını bilgilendirmek üzere gerekli tedbirler alabilirler. Üye Ülkelerin isteği üzerine Komisyon, Topluluk programlarında yer alabilen konu ile ilgili bilgilendirme kampanyaları düzenlemede Üye Ülkelere yardımcı olacaktır.

Madde 13

Çerçevenin uyarlanması

Ekin 1 ve 2. noktaları iki yıldan az olmayacak düzenli aralıklarda yeniden gözden geçirilecektir.

Ekin 1 ve 2. noktalarını ilerlemelere uyarlamak için gerekli her tür değişiklik Madde 14(2)'de bahsedilen yöntem uyarınca benimsenecektir

Madde 14

Komite

1. Komisyon Komite tarafından desteklenecektir.

2. Bu paragrafa madde 8'in hükümleri hakkında referans verildiğinde 1999/468/EC sayılı Kararın 5 ve 7. Maddeleri uygulanacaktır.

1999/468/EC sayılı Kararın 5(6). Maddesinde yer alan süre üç ay olarak tayin edilecektir.

3. Yöntem kurallarını Komite uyarlayacaktır

Madde 15

Takdim ve tehir

1. Üye Ülkeler bu Direktife uymak üzere gerekli kanunlar, yönetmelikler ve idari hükümleri en geç 4 Ocak 2006 tarihine kadar yürürlüğe koyacaklardır. Bundan dolayı Komisyonu hemen bilgilendireceklerdir.

Üye Ülkeler bu tedbirleri uyarlarken, bu yönetmeliğe atıfta bulunacak veya resmi yayınları aracılığıyla bu yönetmeliğe atıf yapacaklardır. Üye devletler bunun nasıl yapılacağını belirleyecektir.

2. Üye Ülkeler, ehliyetli ve/veya akredite edilmiş uzmanların yokluğu durumunda Madde 7,8 ve 9'un hükümlerinin tamamını uygulamak üzere üç yıllık bir ek süreye sahip olabilirler. Bu seçenek uygulandığında Üye Ülkeler, bu Direktifin ileriki yürürlüğü ile ilgili zaman çizelgesi ile birlikte uygun gerekçe belirtmek şartıyla Komisyonu bilgilendireceklerdir.

Madde 16

Yürürlük

Bu Direktif Avrupa Toplulukları Resmi Gazetesinde yayımlandığı tarihte yürürlüğe girer.

Madde 17

Muhataplar

Bu yönetmelik üye devletlere yöneliktir.

16 Aralık 2002'de Brüksel'de hazırlanmıştır.

Binalarda enerji performansının hesaplanması için genel çerçeve (madde 3)

1. Binalarda enerji performansının hesaplanmasında kullanılacak yöntemde en az aşağıdaki unsurları içerecektir:

   (a) binanın ısıl özellikleri (kabuk ve dahili bölmeler, vs.). Bu özellikler arasında hava geçirmezlik de olabilir.

   (b) yalıtım özellikleri ile beraber ısıtma tesisatı ve sıcak su temini

   (c) iklimlendirme tesisatı

   (d) havalandırma

   (e) yerleşik aydınlatme tesisatı (özellikle mesken olmayan binalar)

   (f) dış iklim şartları ile beraber binaların konum ve yönlenimi

   (g) pasif güneş sistemleri ve güneşten korunma

   (h) doğal havalandırma

   (i) tasarlanan bina içi iklim dahil bina içi iklim şartları

2. Bu hesaplama ile ilgili olduğu zamanlarda aşağıdaki unsurların olumlu etkileri göz önünde bulundurulacaktır

   (a) yenilenebilir enerji kaynaklarına dayanan ısıtma ve elektrik sistemleri ve aktif güneş sistemleri,

   (b) KIG'ün ürettiği elektrik

   (c) bölgesel ya da blok ısıtma ve soğutma sistemleri

   (d) doğal aydınlatma

3.hesaplama yönteminde binalar gerektiği şekilde aşağıdaki kategorilere ayrılacaklardır:

   (a) çeşitli tiplerdeki çekirdek aile evleri,

   (b) daireler,

   (c) işyerleri,

   (d) eğitim yapıları,

   (e) hastaneler,

   (f) otel ve lokantalar,

   (g) spor tesisleri,

   (h) toptan ve perakende ticaret hizmet yapıları,

   (i) enerji tüketen diğer yapılar.

CURRICULUM VITAE

AYŞEGÜL TERECİ -aysegultereci@gmail.com

Ayşegül Tereci was born on 10.07.1980 in Uşak. She graduated from Department of Architecture at Gazi University, Faculty of Engineering & Architecture in 2003. She has been studied as an Erasmus Student at Stuttgart University of Applied Science, Fachhochschule Für Technik-Stuttgart, Faculty of Architecture, Department of Building Physics for one year. She worked as a researcher in the EU SARA project in 2005. She worked as a researcher at Global Sun-Tech Trade Co. Inc in Germany. She was a participant with announcement report: “Application of Solar Technologies on the Building Cooling System” in the TMMOB-Solar Energy Technologies Symposium and Exhibition 2005(with Dilay KESTEN). She got the MSc degree from Department of Construction Technology and Control of Physical Environment in 2006. She is working as an architect in the Ministry of Public Works and Settlement. She is a participant and representative for Ministry of Public Works and Settlement in the Building Energy Regulation Committee of Turkey. She can use Autocad, Photoshop, TRNSYS, Thermplan, Calkühl, RADIANCE, 3D Studio Max and she knows English and German