The Contribution of Mineral Wool and other Thermal Insulation Materials to Energy Saving and Climate Protection in Europe

Report established by ECOFYS

for EURIMA - European Insulation Manufacturers Association

This report was prepared by

Carsten Petersdorff - Thomas Boermans - Jochen Harnisch

Suzanne Joosen - Frank Wouters

ECOFYS GmbH - Eupener Straße 59 - D-50933 Cologne - Germany

Phone: +49 221 510907-0 - E-mail: info@ecofys.de

In February 2002 EURIMA, the European Association of Insulation Material Manufacturers assigned Ecofys to find answers to a number of questions regarding the energy, climate and economic effects of insulation use (see annex). This catalogue of questions formed the basis to this report. For the sake of better legibility the order and exact division of questions have been dissolved.

In the framework of several climate studies, Ecofys has analysed the potential for a reduction of CO_2-emissions through an improved thermal insulation of buildings. However, the environmental and economic impact of thermal insulation has never before been comprehensively quantified for the European building stock. Generally, insulation measures are perceived as utmost important to mitigate climate change, however their influence is mostly incorporated into the overall energy balance of buildings. On the one hand this is due to the structure of national and international accounting and reporting methods but on the other hand also due to the dependence of insulation measures on the building type and the interaction with other technical and structural energy saving measures. These interactions and their effects on the reduction of CO_2-emissions play an important role in the evaluation of innovative building projects using energy efficient and renewable technologies and materials, which is an important part of Ecofys' portfolio. A multidisciplinary team of Ecofys' experts answered EURIMA's questions in the framework of this study.

The quantitative results regarding the relevance of insulation materials to mitigate climate change and the reduction of energy consumption and costs are based on an analysis of the building structure (age, usage, type of building and type of energy supply) in EU-15, Switzerland, Norway and Turkey cast into a model, developed by Ecofys for this study.

The results of this study permit a differentiated view on the building sector as a corner stone for greenhouse gas emission reductions in Europe. Moreover, the results impressively illustrate the relevance of insulation products in the framework of energy conservation, climate change and heating costs.

1. EXECUTIVE SUMMARY

Among other industrialised countries the European Union and Switzerland have committed themselves in the Kyoto Agreement to reduce their CO_2-emissions relative to the base year 1990 by 8 per cent till 2010. As the building sector is responsible for about 40% of Europe's total ultimate energy consumption, its reduction potential is highly relevant to reach these targets. Thermal insulation combined with the application of energy saving windows holds a key position to lower the CO_2-emissions of the European building stock.

To investigate the special contribution of thermal insulation to the reduction of energy consumption and the related CO_2-emissions in the building sector Ecofys developed a model of the European building stock. This model specifies 36 standard houses divided into 3 building types, 3 climatic zones and 4 building age groups. For all the standard houses and its corresponding U-values the energy consumption and CO_2-emissions were calculated and weighted according to the demography of the European building stock. The results provide a robust indication of the magnitude of the respective energy saving potentials. Moreover, the results impressively illustrate the relevance of insulation products in the framework of energy conservation, climate change and heating costs. A few highlights from the study:

- In the European countries considered, adding thermal insulation to existing buildings could potentially reduce the CO_2-emissions and the respective energy costs for heating by 42%. This corresponds to an annual avoidance of 353 million tons of additional CO_2 emissions. The lion's share of this reduction potential is located in the moderate climatic zone.
- Assuming that additional insulation measures for the building stock are applied as part of the conventional retrofit cycles, in the year 2010 thereof 94 million tons of CO_2-emissions could already be avoided.
- Additionally, in 2010 the CO_2 emissions could be reduced by 10 million tons per year, if all new buildings would be built following the recommended energy standards (compared to current average new buildings).
- This results in a total annual potential for savings of CO_2 emission of 363 million tons, if the recommended energy standards in the case of retrofit and new buildings were to be implemented.
- All of this is taking place in the context of rising emissions from the building sector: from their level of 710 million tons of CO_2 in 1990, emissions are estimated to have risen to 839 million tons in 2002. Emissions are projected to continue to rise to a level of 865 million tons in 2010 if no additional actions are taken.
- Assuming equal contributions of all sectors to meet the target of the Kyoto Agreement, the maximum CO_2-emissions of the building sector would be limited to 653 million tons in 2010. Including thermal insulation added within retrofit cycle the building stock would be responsible for 760 million tons of CO_2 in 2010, whereas the emissions could be reduced to about 500 million tons, if the whole potential of thermal insulation would be realized.
- Hence, a proportional contribution to climate protection can only be achieved in the building sector, if additional political initiatives promote energy saving both in new buildings and in the existing building stock. Considering that emissions from a number of rapidly growing sectors like e.g. the transport sector are difficult to control, the contribution of the building sector is of high relevance.
- On a relative basis the building sector in Eastern European exhibits even larger reduction potentials due to its extensive and partly neglected stock of fairly old buildings.

2. INTRODUCTION

In the 1970's, the first buildings with modern thermal insulation were built in Northern and Central Europe. The thickness (1) of the insulation layers has increased continually ever since, as impressively illustrated by the EURIMA market survey (see Figure 1). However, due to the warmer climate, energy saving in Southern European buildings is not advancing significantly.

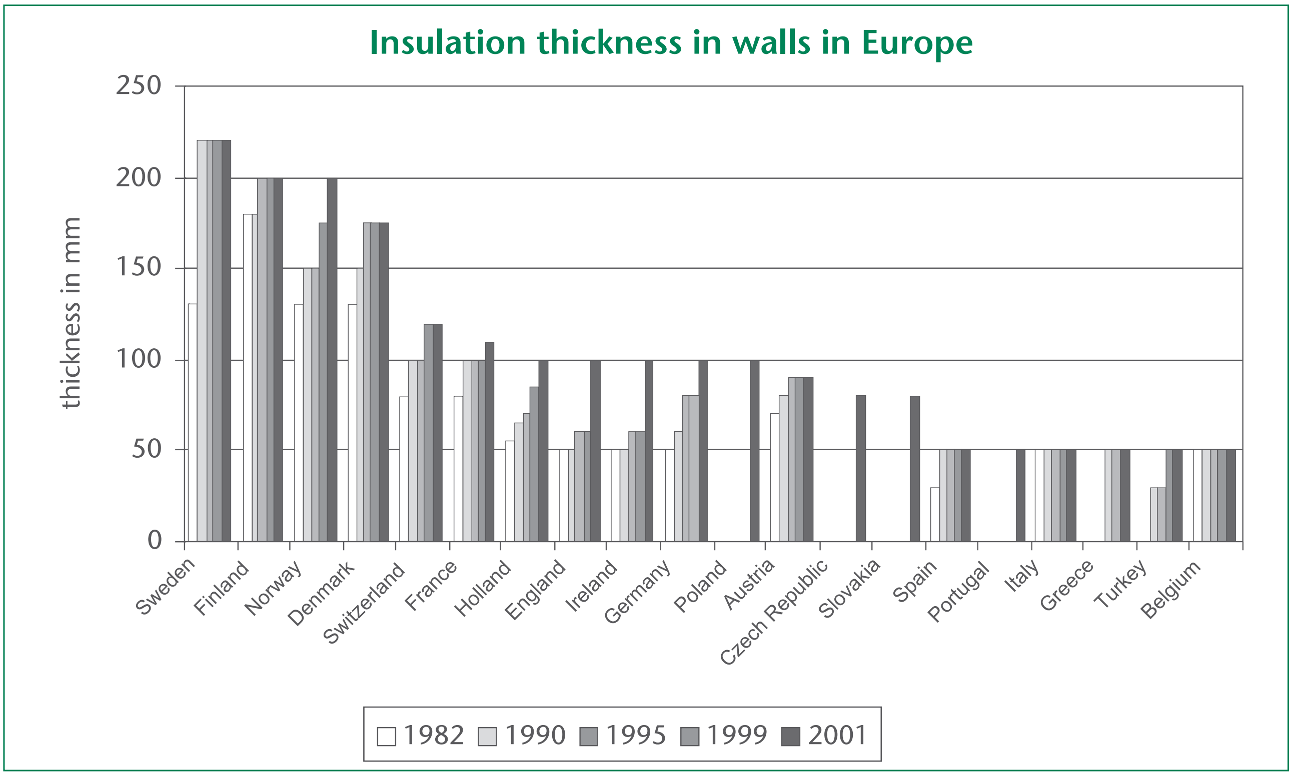

Figure 1: Increase in insulation material thicknesses (standards and / or use) [Eurima 2002]

Initially, the chief motive for using thermal insulation was the wish of the European countries to become more independent of oil imports. Many of the thermal insulation regulations were triggered by the oil crises in the early Seventies. As the building sector is responsible for about 40% of Europe's total ultimate energy consumption [Green Paper 1995], regulations for the reduction of heat demand in buildings have proven to be an effective political energy saving strategy.

(1) Values on the insulation as such are not giving a characteristic information on the energy loss of a construction element. Due to different building systems and building traditions the overall energy loss may differ due to the total U-value and the climate conditions.

The energy consumption for the heating of buildings can be reduced by the appropriate combination of several measures:

- insulation of components: roof, wall and floor,
- application of insulating glazing
- air-tightness of buildings,
- orientation of buildings and rooms for the use of passive solar energy,
- use of an efficient and environment-friendly heating system,
- installation of comfortable and efficient ventilation,
- use of renewable energy as heating support,
- use of heat pumps as heating support.

Thermal insulation (combined with the application of energy saving windows) holds a key position among these measures, which lay the foundation of low-energy building. One of the basic rules for low-energy building is

- first to reduce the energy demand and then
- produce the remaining demand more effectively and
- where possible from renewable sources.

This principle is called the “Trias Energetica”.

Since the Rio de Janeiro conference in 1992 at the latest, environmental protection has become yet another motive for Europe’s energy saving endeavours. In addition to the target of cities and industrial regions to achieve a sulphur dioxide emission reduction in order to reduce air pollution, the world’s governments have committed themselves world wide to mitigate the greenhouse effect, which endangers the world climate, by reducing emissions of carbon dioxide and other greenhouse gases. As a consequence of the global environmental goals, the national requirements concerning low-energy building and the use of renewable energy have been strengthened.

3. ENERGY SAVING THROUGH THERMAL INSULATION OF BUILDINGS

In Northern Europe thermal insulation leads to particularly high energy savings, as the winter period requiring building heating is so long that an average of over 4,500 heating degree-days (2) a year has to be assumed [STOA 1998]. Since the Seventies, the national regulations of countries from this climatic zone, i.e. Finland, Norway and Sweden, have set ambitious requirements concerning energy saving in buildings. This led to requirements for building components comprising of the following U-values (See Table 1). The Swedish building regulations still serve as a model in Europe today.

Table 1: U-values for new buildings in the cool northern climatic zone (Estimated average values)

Insulation effect of building components	U-values From 1975 till 1990	U-values since 1991
Exterior wall	0.3 W/m^2K	0.20 W/m^2K
Roof	0.2 W/m^2K	0.15 W/m^2K
Floor	0.2 W/m^2K	0.15 W/m^2K

The SAVE-directive and the SAVE-program of the European Union promoted energy saving measures in the countries of the moderate central climatic zone and also initiated in the Southern European countries the introduction of state regulations concerning energy saving in buildings.

In Europe's moderate central climatic zone the average heating period comprises 3,500 heating degree-days a year [STOA 1998]. This climatic zone includes Belgium, Denmark, Germany, France, Great Britain, Ireland, Luxembourg, the Netherlands, Austria and Switzerland. The requirements for thermal insulation in these countries have experienced significant changes. After first regulations in the Seventies and Eighties a considerable standard has now been achieved, making it possible that very low-energy buildings such as passive houses with a heat demand of 15 kWh/a per square meter heated floor area [Feist 2002] (no longer requiring conventional heating systems) can be realized. Today, the recommended energetic standard in the moderate central climatic zone (Table 2) approaches the requirements of the countries in Northern Europe.

Table 2: U-values for new buildings in the moderate central climatic zone (Estimated average values)

Thermal insulation effect of structural components	U-values From 1975 till 1990	U-values since 1991
Exterior wall	1.0 W/m^2K	0.5 W/m^2K
Roof	0.5 W/m^2K	0.4 W/m^2K
Floor	0.8 W/m^2K	0.5 W/m^2K

(2) Heating degree-days means the sum of the daily determined difference between the room temperature and the outdoor temperature during daytime for each day of the year. I.e. every day of the heating period a difference is calculated by subtracting the average outdoor temperature from the room temperature. The resulting differences have to be added then for each day of the heating period.

Several developments have contributed to a further harmonisation of energy saving in building in Northern and Central Europe

- progress in European standardisation, e.g. the EU-standard EN 832,
- increasing exchange in the European common market both in the sector of companies and architects as well as exchange of building products and building methods,
- increasing acceptance of environment protection, climate protection and energy saving in the population.

In Southern Europe ("warm climatic zone" comprising Greece, Italy, Portugal and Spain) thermal insulation is spreading more slowly than in Northern ("cold climatic zone" comprising Denmark, Finland, Norway and Sweden) and Central Europe. Although in the warm southern climatic zone the buildings also have to be heated on average 1,800 heating degree-days a year [STOA 1998], awareness of the heating problem is not fully reflected in the technical equipment of buildings nor in the general awareness of the population: many buildings are not equipped with installed heating facilities, the users provide heating with mobile electric furnaces or liquefied petroleum cartridges. This attitude towards heating is also reflected by a limited acceptance of thermal insulation (compare Table 3), even if mandated by national regulations for new buildings.

Table 3: U-values for new buildings in the warm southern climatic zone (Estimated average values)

Thermal insulation effect of structural components	U-values From 1975 till 1990	U-values since 1991
Exterior wall	1.2 W/m²K	0.6 W/m²K
Roof	0.8 W/m²K	0.5 W/m²K
Floor	0.8 W/m²K	0.5 W/m²K

Figure 2 shows the corresponding energy losses for the different climatic zones. Although the northern countries have the coldest climatic conditions the energy losses per square meter loss area are minimised due to the reported U-values.

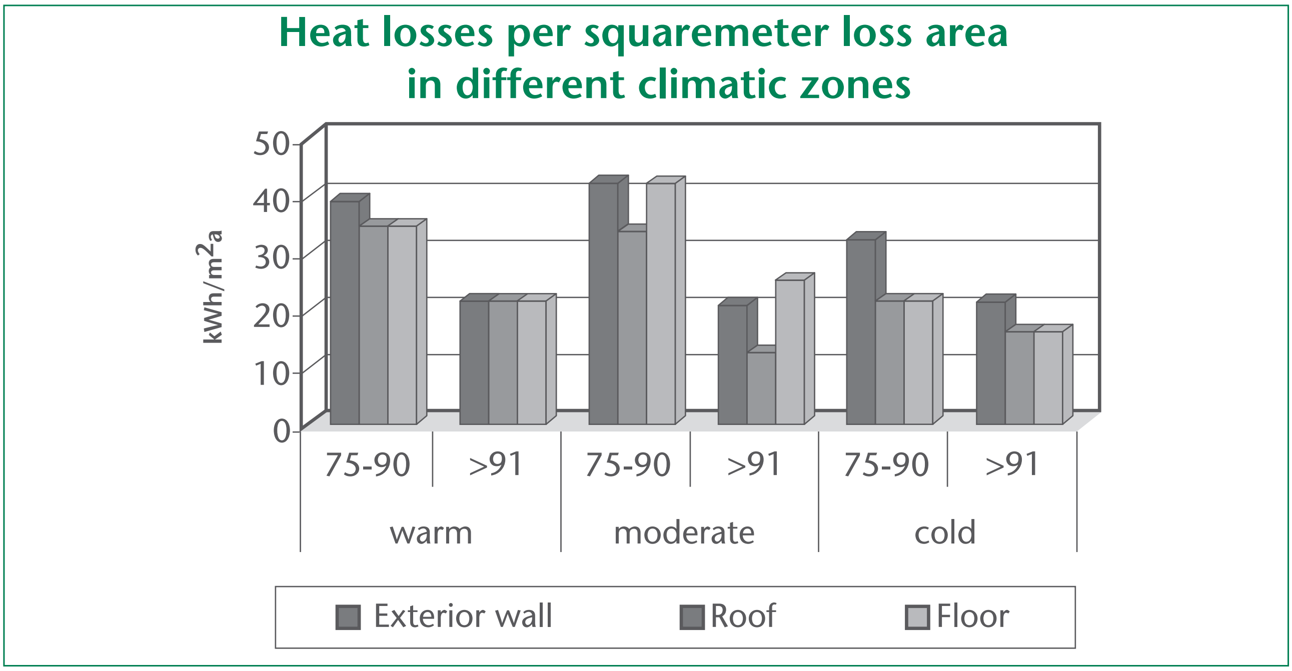

Figure 2: Overall energy loss subdivided for different climate conditions and building ages

For recognising the special contribution of thermal insulation to the reduction of energy consumption in the building sector Ecofys developed a calculation model based on energy balances of buildings.

The reported U-values are used as key indicators for the quality of thermal insulation in the model. In the model the low-energy building standard – adapted for the climate region and the age - is used as recommended level. The components of the model are explained in Annex I of this study (e.g. climatic zones, building age groups, building types, U-values for building types).

Reduction through existing Insulation

Table 5 contains a summary of the results. It is found that thermal insulation implemented in EURIMA-countries reduces energy consumption for heating of retrofitted insulated buildings and of those set up after 1975 by 43% compared to the fictitious scenario of no insulation used, which means a reduction of CO_2 emissions of the same size.

Potential reduction through future insulation retrofit

To create a common basis to judge the influence of different additional insulation measures described in this report the according energy reductions are compared to the energy consumption 2002 of the building stock in the Eurima countries.

Taking into account the different initial positions in the three climatic zones, we arrive at a potential value for energy saving of 42% through thermal insulation of existing buildings (referring to consumption of the total building sector in 2002) in the EURIMA-countries. Table 4 contains the values for the various climatic zones.

Table 4 Reduction potential of energy consumption and CO_2 emissions for building heating through future insulation retrofit of buildings set up before 1974

Energy consumption and CO_2 emissions for building heating	Energy consumption 2002 of Building stock in Eurima countries	Consumption reduction through retrofitted insulation	CO_2 emissions 2002 of Building stock in Eurima countries	Emission reduction through retrofitted insulation	Resulting reduction through retrofitted insulation
	[TWh/a]	[TWh/a]	[Mt CO_2/a]	[Mt CO_2/a]	[%]
In the cool climatic zone	148	43	46	14	29
In the moderate climatic zone	2,077	957	624	287	46
In the warm climatic zone	618	191	169	52	31
Total	2,843	1,192	839	353	42

Table 5: Reduction of energy consumption for building heating through existing thermal insulation implemented since 1975 compared to the existing energy consumption and the fictitious energy consumption of the un-insulated Eurima building stock

Energy consumption and CO_2 emissions for building heating	Energy consumption 2002 of Building stock in Eurima countries	Scenario: Energy consumption of Building stock with no insulation	Consumption reduction through implemented insulation	CO_2 -emissions 2002 of Building stock in Eurima countries	Scenario: CO_2-emissions of Building stock with no insulation	CO_2-emission reduction through implemented insulation	Energy- and CO_2-savings compared to building stock with no insulation
	[TWh/a]	[TWh/a]	[TWh/a]	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]	[%]
In the cool climatic zone	148	385	237	46	120	74	62
In the moderate climatic zone	2,077	3,624	1,547	624	1,089	465	43
In the warmer climatic zone	618	945	326	169	258	89	35
Total building stock Eurima	2,843	4,953	2,110	839	1,467	628	43

General development of the energy consumption of the Eurima building stock

The reduction of the energy consumption from improved thermal insulation can be viewed at from two angles. Compared with the fictitious preservation of non energy-efficient building a considerable improvement has been achieved. The absolute amount of energy consumption and thus also of CO_2-emissions has increased in the last decade, as the large number of newly erected buildings in every country has lead to an over-proportional rise in surfaces which require heating. This development mainly results from growing prosperity and hence larger specific living space area per capita. An end to this trend of increasing space demands and the resulting demand for heating energy is not yet visible.

In view of this development, high requirements for energy saving in buildings become more and more important, also in Southern Europe. Retrofitting buildings with thermal insulation set up before 1974 will prove to be of even greater importance.

During the last decades in the northern and central climatic zone 20 per cent of existing buildings have been renovated and equipped with thermal insulation.

The level of U-values, which is assumed in the calculation model, is listed in Annex I.

As renovation goes along with further measures such as e.g. modern sanitation and more efficient heating systems, it ensures the quality and market value of these buildings. As far as historical buildings are concerned, insulation still causes acceptance problems. However, generally it is assumed that some 70% of buildings erected before 1974 in these two climatic zones could be equipped with thermal insulation during the next 30 years. (3)

In order to tap this potential for energy saving and climate protection, many countries have developed regulations and programs to stimulate renovation including measures for energy saving. However, measures can only restrictedly be applied for the existing buildings, old buildings being protected by laws for the preservation of monuments. In Germany e.g., due to the energy saving law, only measures of economic effectiveness can be prescribed. Retrofitted thermal insulation can be more profitable, if it is combined with the necessary renewal of the respective structural components.

Government incentives can accelerate decisions for investments in the renewal of structural components.

Apart form energy saving retrofitted buildings meet the increased comfort requirements of users.

In the southern climatic zone, thermal insulation has been of little importance so far and in the near future the acceptance of such measures will only slowly increase in regions with particularly mild winters. Therefore it is assumed, that only half of the buildings set up before 1974 can be developed as a potential for energy saving through thermal insulation.

(3) Estimated based on IWU (1994).

4. CONTRIBUTIONS OF THERMAL INSULATION TO CLIMATE PROTECTION

Among other industrialised countries the European Union and Switzerland have committed themselves in the Kyoto Agreement to reduce their CO_2-emissions relative to the base year 1990 by 8 per cent till 2010. Norway, which already heavily relies on renewable energy, has a permitted growth of emissions by 1 per cent over the same period of time. Turkey has not yet accepted a reduction target.

The Kyoto Agreement does not specify to what extent the individual sectors should contribute to the targets of climate protection. Among the main sectors can be distinguished between industry, transport and the building sector, the latter composing of commercial, industrial buildings and public buildings.

Table 6: Shares of sectors in the total energy consumption in the European Union in 1998

Sector	Energy consumption in Mtoe	Share in %
Buildings	379	41
Industry	262	28
Transport	288	31

Source: [EC - Green Paper 1995]

Due to its high share in the energy consumption and to the great technical possibilities of energy saving, the buildings sector is of special importance for attaining the climate protection targets. Apart from energy saving, a replacement of energy carriers contributes essentially to the CO_2 reduction. Combining energy saving through thermal insulation with a changeover to heating with energy carriers without or with only low CO_2 emissions constitutes an optimal climate protection strategy for the buildings sector.

The contribution of these measures to climate protection is dependent on the existing compositions of energy carriers for the heating of buildings in the different climatic zones. The CO_2 emission factors of individual heating methods in Table 8 are taken from the GEMIS database and from the IPCC-Guidelines.

Table 7: CO_2 emission factors of individual heating methods related to supplied heat

Gas	0.267 kg/kWh
Oil	0.362 kg/kWh
Coal	0.343 kg/kWh
Electricity	0.536 kg/kWh
District Heating	0.167 kg/kWh (4)

Source: [Gemis 2002] and [Minett and Simon (COGEN) 2001]

These factors sum up all CO_2-emissions which arises in connection with the whole process chain from exploration, extraction and winning of the primary energy carriers, their transport, their processing, their conversion and distribution right up to their supply as heat for the consumer.

(4) Emission factor of district heating calculated by: Primary energy factor of district heating from GEMIS 0.59; losses in electricity grids 7 %, Emission factor of fuel mix from COGEN 0.264 kg/kWh

Renovation of buildings is often combined with the installation of a high efficient heating burner. However, a better efficiency of the heat production is not taken into account, due to the objective of the study to investigate the influence of insulation.

The specific contribution of thermal insulation to CO_2 emission reductions in different types of buildings was calculated using the Ecofys model characterizing different classes of buildings.

The results suggest differentiated conclusions on the effects of thermal insulation.

For the best possible use of energy saving potentials through thermal insulation in the buildings sector in the coming years between 2003 and 2010 following scenarios have been calculated:

a) buildings set up before 1974 and suitable for retrofitting insulation would be reconstructed energetically in accordance with the recommended standard with improved U-values. Two different extensions have been investigated:
   - retrofit of the building stock within the conventional retrofit cycles. Assuming a general retrofit cycle of 30 years (5), from 2003 until 2010 (8 years) about 8/30 of the total retrofit potential would be realized.
   - Retrofit of the total building stock until 2010 to show the overall potential of the reduction.

b) the new buildings are built in accordance with the recommended low-energy-house standard. Thereby two different scenarios have been investigated:
   - insulation according to existing building standards
   - insulation according to recommended standards

The model results are summarized in Table 8: It is estimated that in the EURIMA countries (EU-15, Switzerland, Norway and Turkey) annually

- 353 million tons of additional CO_2 emissions could be avoided in the EURIMA-countries, if in the case of retrofitted insulation the recommended standards were implemented, as the figures in Table 9 show,
- and CO_2 emissions could be reduced by 2 million tons per year, if all the new commercial buildings would be built following the recommended energy standards (compared to standard new commercial buildings)
- and by another 8 million tons per year, if the new residential buildings would also be built in accordance with the recommended standards (compared to standard new residential buildings).
- This results in a total annual potential for savings of CO_2 emission of 363 million tons, if the recommended energy standards in the case of retrofit and new buildings will be implemented. 78% of the reduction is caused by the insulation of walls, roofs and floors and 22% by high-efficient glazing.

The huge potential associated to the retrofitting of existing buildings with appropriate thermal insulation asks for additional political action in order to successfully mitigate greenhouse gas emissions. But also improved insulation in new buildings deserves additional attention despite its limited short-term reduction potential as it exhibits a trend-setting role in respect to the application of innovative energy savings technologies.

(5) This value is an estimated average, based on [IWU 1994].

Table 8: Comparison of CO_2 emissions for heating and reduction potentials of different insulation measures from 2002 to 2010

Sector	Fictitious CO_2-emissions new built houses 2003-2010 without insulation	Reduction of CO_2 emissions 2010 in new buildings with conventional standards compared to un-insulated new buildings	Reduction of CO_2 emissions 2010 in new buildings with recommended standards compared to un-insulated new buildings	Reduction of CO_2-emissions 2010 with retrofitted insulation according to the retrofit cycles	Reduction of CO_2 emissions with retrofitted insulation of the whole retrofitable building stock
	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]
In the cool climatic zone					
Residential buildings	10.1	8.7	8.8	2.5	9.6
Commercial buildings	1.9	1.3	1.4	1.1	4.0
In the moderate climatic zone					
Residential buildings	74.7	59.2	66.2	61.0	228.9
Commercial buildings	13.1	8.5	10.3	15.6	58.6
In warm climatic zone					
Residential buildings	12.9	10.0	11.1	11.8	44.3
Commercial buildings	1.8	0.9	1.4	2.2	8.1
Total	114.5	88.6	99.2	94.2	353.4

In the southern climatic zone the effects of improved thermal insulation on climate protection would be even more significant than calculated, as it also reduces the cooling demand of the houses in the summer period. For cooling air conditioning units are increasingly used. The reduced electricity consumption for cooling will become apparent in a positive way in the climate protection balance sheet. However it was not objective of the study to quantify the influence of thermal insulation on the need for cooling. In future cooling might be one of reason for an increasing energy demand and needs further investigation.

The contribution of thermal insulation of existing and new buildings in all the building sectors of the European Union to the climate protection targets of the Kyoto Agreement are investigated in three different scenarios as can be seen in Table 9 and Figure 3.

Scenario 1: Reference Scenario

- No retrofit of the existing buildings built before 1974
- New building according to existing building codes

Scenario 2: Retrofit cycles

- Retrofit of the existing buildings built before 1974 within the retrofit cycles
- New building according to recommended building codes

Scenario 3: Retrofit of all retrofitable buildings

- Retrofit of all the retrofitable buildings (6) built before 1974
- New building according to recommended building codes

Table 9. Contribution of thermal insulation of existing and new buildings to the implementation of the Kyoto Agreement in the European Union

CO_2 emissions for space heating in the building stock	accordance Kyoto target 2010	Status 1990	Status 2002	2010 Refernce Scenario	2010 recommended standard for new building, insulation of existing buildings within retrofit cycles	2010 recommended standard for new building, total insulation of existing buildings
	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]	[Mt CO_2/a]
Space heating building stock	653	710	839	865	760	501

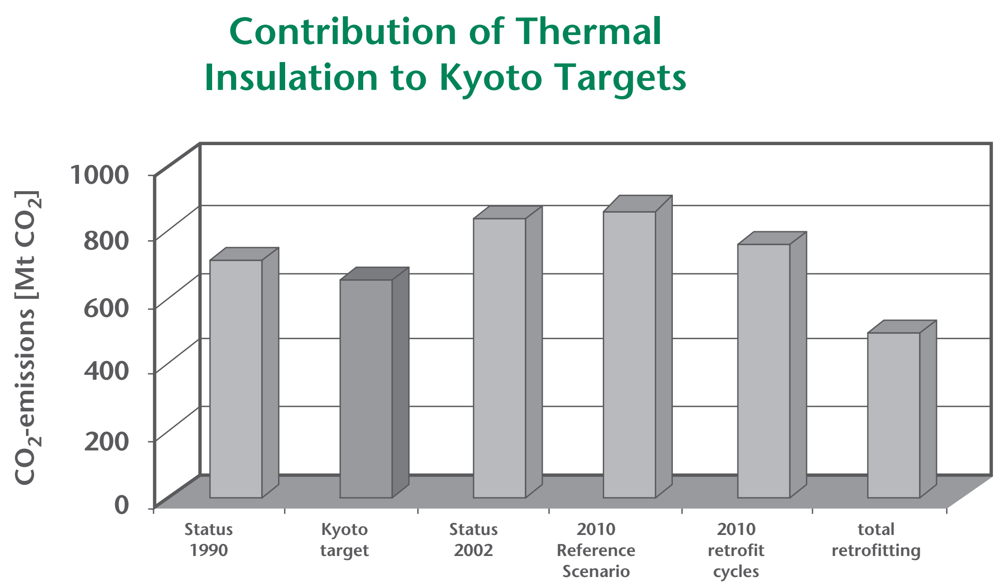

Figure 3: Effect of improved thermal insulation on emission in the European Union

(6) Retrofitable buildings means all buildings which are not retrofitted yet and which are no monuments or historic buildings

IMPLEMENTATION

This contribution to climate protection can only be achieved if additional political initiatives promote energy saving both in new buildings and in the existing building stock. The signatories to the Kyoto Agreement are requested to design government programs for the implementation of the climate protection goals.

The building sector is today generally expected to deliver higher than "Kyoto- reductions" as it turns out that emissions from a number of rapidly growing sectors like e.g. the transport sector are difficult to control.

The European Union is therefore currently implementing a new directive for the improvement of energy efficiency in building for its member states. The calculation methods for energetic building standards will be put on a common foundation. Generally, the methodology is to follow an integrated approach of structural thermal protection and building energy systems to carry out a primary energy evaluation of the measures and thus to take into account the influence of heat generation. Thermal insulation e.g. results in higher energy savings if heat is generated by electricity instead of gas. Both for new buildings and for the energy related renovation of existing buildings minimum standards are to be introduced. Furthermore it is intended to promote the certification of energetic standards of buildings and to increase public awareness for energy consumption by advertisements in much frequented buildings. For the countries of the European Union regulation is planned for the surveillance of heating boilers and technical heating and cooling systems for buildings.

5. ENERGY BALANCE OF INSULATION MATERIALS

Particularly low thermal conductivity and good compatibility with common structural designs are characteristics of products specially developed for thermal insulation. Mineral wool is one of Europe's most widespread insulation materials with outstanding features such as:

- cost-effective
- partly use of secondary raw materials,
- non combustible, fire safe
- good overall energy performance (relationship of production energy and energy saving effect during use).

In Central Europe the energetic amortisation of mineral wool insulation of a building amounts to 1.5 to 13 months [UBA 1998], i.e. after this time the amount of energy necessary for the whole production process is balanced out through energy savings in the heating of the buildings.

This is a fairly short period of time compared to the service life of thermally insulated structural components. The service life of the insulation of exterior walls,floors and roofs is set at 30 years (7), i.e. the energetic amortisation is low enough to be neglected in the evaluation of long-term thermal insulation energy saving effects.

To assess the production energy of different insulation material, constructions with the same functional characteristic have to be compared. The following table gives an overview of the main characteristics of different insulation material:

Table 10: Amortisation of different insulation material

Material	Density	Thermal conductivity	Non renewable primary energy demand production	Amortisation moderate climatic zone
	[kg/m³]	[W/mK]	[kWh/m³]	[months]
Polystyrene	15-30	0.035-0.040	530-1050	7-20
Polyurethane	30-35	0.020-0.035	1140-1330	9-23
Mineral wool	20-140	0.035-0.045	100-700	1.5-13
Fibreboard	190-240	0.045-0.053	590-785	8-16
Cellulose	40-70	0.045	10-17	0.1-0.3

(source: [UBA 1998])

(7) This value is an estimated average, based on [IWU 1994]

6. LOW ENERGY COSTS THROUGH THERMAL INSULATION

The annual heating costs in the utilisation of buildings in all the EURIMA-countries generally has only a limited impact on economic decisions for buying or renting real estates. However, significant differences between heating costs in non-insulated old buildings and well insulated low-energy-buildings occur. The low heating costs in Northern and Central Europe can be attributed to the modernisation of the building stocks through heating system renovations and retrofitted thermal insulation as well as continually raised energetic standards for new buildings.

In some of the Northern and Central European countries low heating costs gain importance, as a surplus of buildings makes it necessary to obtain marketing advantages by providing buildings with special features. A further marketing argument is the expected rises in prices for "finite" fossil energy carriers, either due to an actual shortage on the market or due to increasing taxation in order e.g. to promote energy efficiency and climate protection.

The achievable heating cost reductions are the key source of financing for energy saving investments. Through retrofitted insulation of building stocks particularly high reductions can be achieved (Table 11). The costs for heating, which are assumed in the calculation model, are listed in Annex I.

Table 11: Average heating costs per square meter heated area in residential buildings as well as in commercial buildings

Sector	Average heating costs [EUR/m^{2}a]
cool climatic zone	
Residential buildings	8
Commercial buildings	6
moderate climatic zone	
Residential buildings	7
Commercial buildings	4
warm climatic zone	
Residential buildings	4
Commercial buildings	2

The existing thermal insulation in the EURIMA-countries reduces the energy costs for building heating by 43% according to the respective energy savings (see Table 5).

Ecofys investigated the effects of insulation on heating costs on the basis of its model. Using model houses, which are very common in EURIMA-countries, the possible reduction of heating cost can be put in concrete terms, as can be derived from Table 12. The calculations are based on the recommended standard for retrofitted thermal insulation measures using the renovation cycles of the structural components have expired.

According to Table 4 roughly 42 % of the energy costs for the heating of the whole residential building sector could be saved, if residential buildings with insufficient thermal insulation (those built before 1974) would be provided with a retrofitted improved thermal insulation.

To clarify the cost savings on the retrofitable building level the following table shows a representative example of the building stock (moderate climatic zone).

Table 12: Comparison of heating costs per square meter heated area before and after retrofitted thermal insulation without taking into account other energetic improvements.

Material	Heating costs without thermal insulation	Heating costs with thermal insulation	Reduction of heating costs	Specific Reduction of heating costs
	[EUR/m² a]	[EUR/m² a]	[EUR/m² a]	[%]
Model house, built before 1974				
One-family house	11	3	8	77
Multifamily house	6	2	5	75

The possibilities for cost reduction are particularly good in the case of single houses. These buildings are often occupied by the owners themselves, so a strong motivation to invest in thermal insulation and thus to enhance the value of the buildings is present. A different attitude and motivation can often be found in the case of multi-family residential buildings. Here, one is confronted with buildings consisting of rented flats whose heating costs are not paid by the owners themselves but by the tenants. As the investment costs for thermal insulation can usually only partly be transferred onto the tenants, building owners often need additional incentives to decide in favour of energetic renovation of their buildings. Particularly innovative energy saving construction types such as passive houses or the utilisation of solar energy systems are yet found mostly in one-family houses.

In the near future, a further spreading of thermal insulation will largely depend on national regulation. The specific energy savings measures will need to apply the principle of cost effectiveness. One criterion for the cost effectiveness of emission reductions in the building sector is an amortisation of investments during the service life of the structural components.

The amortisation time for investments into thermal insulation was calculated for a sample house in the moderate climatic zone (8). The average economic amortisation of the presently valid thermal insulation standards was determined to be about 8 years.

The lifetime of the insulation of roofs and of exterior walls extends to at least 20 to 30 years. Thus, the period of amortisation is far less than half of their technical life, i.e. a good economic efficiency of the measures is given which is ample justification for state requirements.

(8) For the calculation of amortisation times average energy prices were used. Capital costs were not considered.

7. ENERGY SAVING THROUGH THERMAL INSULATION IN THE PROCESS INDUSTRY

In the process industry insulation materials make an integral contribution to the safe, stable, economic and environmentally friendly production of fuels, chemicals and other industrial goods. Insulation materials for industrial pipes and the process industry add up to roughly one quarter of the European market for insulation products. Materials consisting of mineral fibres are the clearly dominant insulation materials in this sector due to their low price and non-flammability. The process industry uses insulation materials to prevent heat and cold losses partly for economic and environmental reasons but mainly to maintain stable process conditions, to protect workers and to avoid damages to the installation e.g. through fire or the radiation of heat.

It is important to note that a minimisation of the energy consumption connected to the transport of fluids in industrial processes requires a balancing of energy requirements in the subsequent process, transport energy (viscosities are strongly temperature dependent), heating energy and energy losses along the line of transport. It is also important to note that in many industrial plants an excess of process heat can often not be used for heating outside the production plant: e.g. supply into a district heating is not economically rewarded.

The resulting insulation thickness for high temperature pipes thus often exceeds the level resulting from a company's economic requirements. Pipes bearing fluids with only moderate over-temperatures on the other hand are often left non-insulated or with only minimal insulation. Significant losses of heat (or cold) also occur from flanges or valves if they are left non-insulated to ensure optimal accessibility in the case of emergencies or for service and maintenance. Removable covers and casings can help to conveniently and safely solve this problem.

Companies generally require pack back times of only a few years for any investment into energy savings. In Europe no legal framework currently exists for the dimensioning of insulation thickness in industrial applications on environmental grounds. The mandated level of insulation applied is fully determined by safety requirements. A number of international standards and guidelines exists to support the planner and installer of industrial insulation applications (e.g. ISO 12241:1998, BS 5422:1990, DIN 4140, VDI 5022 or the respective AGI-Worksheets of the Q Series).

Estimates of the potential for emission reductions from an increased use of thermal insulation in industrial applications and associated costs can currently not be made due to the heterogeneity of the sector and the various objectives controlling the use of thermal insulation within the industry. Virtually no data is available on the levels of installed insulation in different industries and countries. Further analysis and a consultation of stakeholders is clearly needed to arrive at a more robust picture of further emission reduction potentials and associated costs.

8. COMBINATION OF THERMAL INSULATION WITH RENEWABLE ENERGIES

Throughout Europe technical systems combining thermal insulation with the use of renewable energies offer a potential for CO_2-neutral heating and cooling of buildings. Especially solar and biomass energy have proven to be suitable renewable energy carriers. This combination not only preserves natural resources but a nearly 100% avoidance of CO_2 emissions can be achieved.

As most renewable energies are still relatively cost-intensive at present, the heat demand should be first of all reduced cost effectively by thermal insulation to meet the remaining heat demands with a renewable energy supply. Therefore, with the application of thermal insulation the basic foundation for a sensible implementation of renewable energies has been laid.

In the heating process of buildings, solar district heating requires low temperatures to enable the storage system to work at high efficiency levels. Because of technical and economic reasons, solar heating of buildings requires a very low heat demand in the connected buildings. As a minimum requirement, the architecture has to take the recommended energetic standards for the cool and moderate climatic zone into account.

In Europe's warm climatic zone energy is required both for heating and cooling of buildings. For the heating, a sufficient amount of solar energy is available but due to the shortness of the heating period high investments in complex heat supply technologies are often not justified. For this climatic zone combined solar systems for heating and cooling still have to be developed. To reduce the increasing energy consumption especially for cooling a good insulation of buildings delaying and reducing the heating-up of buildings is recommendable.

9. CONTRIBUTIONS OF THERMAL INSULATION TO CLIMATE PROTECTION IN EASTERN EUROPE

For many decades building stocks in Eastern Europe have often not received the necessary maintenance measures. From the Sixties till the beginning of the Nineties in all the Eastern European countries extended building structures with prefabricated industrial structural technology were erected and connected to district heating systems. The buildings were hardly insulated and showed high heat losses through windows and joints. The heating systems could not be controlled in each apartment, which lead to additional energy losses.

Today, the countries of Eastern Europe undergo a reform process toward the implementation of market-economy structures. Energy saving in building heating is one of many economic problems in all of these countries as they are obliged either to do without the expensive energy imports or to rely on exporting of energy produced by themselves.

The construction market in Eastern Europe grows faster than the economy of these countries. There is a great demand for higher comfort housing and more private space for households. In Poland, where the integration process is going with high speed, the average apartment size is today 30 m^2 less than in Western Europe, as can be seen in Table 13.

Table 13: Expenses of Polish and other domestic customers in the European Union for heating

Country	Available household income 2001	Average apartment size (9)	Heating costs	Monthly expenditures for heating	Share of heating costs of income
	[EUR/month]	[m²]	[EUR/ m²a]	[EUR/month]	[%]
Poland	544	62	3.90	20	4
European Union	1,729	90	6.40	57	3

For new buildings, in the previous years a set of national regulations for thermal insulation and heating of buildings have been issued which are almost comparable to the regulations of the European Union, see e.g. the building requirements in Poland (Table 14).

The structure of the building stock and the evolving policies and measures on energy saving are fairly similar across the Eastern European countries. A lack of reliable data, however, currently precludes a quantitatively conclusive assessment.

(9) Eurostat, surveys 1995 and 1996, Polish governmental statistics.

Table 14: U-values for new buildings in Poland (10).

Thermal protection effects of structural components	U-values 1997
Exterior wall	0.5 W/m^2a
Roof	0.3 W/m^2a
Floor	No requirements

There is a great need to catch up on the installation of new heating systems in the existing stocks and on the retrofitted thermal insulation of these buildings. However, for all these pressingly necessary energy saving investments these countries are unfortunately lacking capital.

A starting-point for possible future financial models are the expenses for heating of residential and commercial building users in Poland.

The existing large technical energy saving potentials combined with high expenditures for energy consumers creates favourable economic amortisation periods for retrofitted thermal insulation measures, which could be suitable for setting up private financing models. Financing models for investment in infrastructure in Eastern Europe require, however, a safe and secure legal framework, which is only slowly developing in these countries.

(10) Polish Government, Ministry regulations 1997.

10. OUTLOOK

This analysis assesses the current contribution and future potential of thermal insulation in buildings to the reduction of fossil fuel consumption and associated CO_2-emissions. A differentiated model of the building stock in the three main European climatic regions was developed and applied. It is found that the largest potential for energy savings exists the building stock erected in the (pre-1974) era before mandated thermal insulation standards came into place. Significant reduction potentials along with an important trend-setting role were identified for the application of low-energy standards for new buildings.

The current trend in policies and technical standards on thermal insulation moves towards an integrated perspective on energy efficiency based on combinations of various constructive and technical options. The calculations carried out under this study permit to quantify the effect of current (and future levels) of thermal insulation in comparison to a status without the application of thermal insulation materials. This differentiated perspective makes it possible to highlight the special ecological and economic importance of appropriate insulation to policy makers and owners of buildings.

Insulation materials make valuable contributions to ensure safe, reliable, economic and energy-efficient operations in a wide number of industrial processes, e.g. in refineries or the chemical industry. Relevant data were found to be too sparse to arrive at meaningful quantitative estimates on the role of insulation materials in saving energy within the process industry. It is however, important to note that required amortisation times for energy efficiency measures within very cost conscious sector are much shorter in comparison to those mandated for the building sector. Further in-depth analysis is clearly warranted to determine energy and emissions savings potentials and respective costs.

The Eastern European economies in transition and parts of Southern Europe are still at an earlier stage of energy efficient building. The availability of respective statistical information especially for Eastern Europe is extremely poor. A preliminary analysis however clearly indicated that large potentials exist for energy savings and emission reductions in the stock of existing buildings. Taking into account the difficult economic situation many of these countries continue to be in, it is evident that dedicated policies and measures will need to put in place to harvest these potentials. These instruments should be designed ahead of these countries' accession to the EU.

A wider penetration of climate friendly materials and technologies in Southern Europe is likely to also require dedicated policies determining priority packages of energy savings measures in these countries. The fundamental attractiveness of a combination of advanced thermal insulation and utilisation of renewable energies is likely to apply here as well as in the cold and moderate climatic zones of Europe.

During the course of this project it became also apparent that an accelerated implementation of different kinds of energy efficiency measures in the building sector will require refined analytical instruments including dynamic bottom-up policy analysis models comprising sufficient technological detail and a validated reference database.

11. LITERATURE

Caleb Management Services: Thermal insulation and its role in carbon dioxide emission reduction, Bristol 1997

ECI, T. Fawcett, K. Lane, B. Boradman, Lower carbon futures for European households, Country pictures, EU, Oxford, March 2000

Eichhammer, W. & B. Schlomann,
Fraunhofer Institute for Systems and Innovation Research (FhG-ISI):
MURE Database Case Study: A comparison of thermal building Regulations in the European Union, Karlsruhe 2001

EURIMA (European Insulation Manufacturers Association): Workshop "Promoting Energy Efficiency for a Sustainable European Energy System", Brussels 2002

Europäische Akademie für städtische Umwelt: Umwelttechnische Sanierung von Plattenbausiedlungen, Kooperation Berlins mit mittel- und osteuropäischen Städten Berlin 1996

European Commission: Green Paper for Renewable Energies, Luxemburg 1995

Eurostat: Energy consumption in households, European Union and Norway, 1995 survey, Central and eastern European countries, 1996 survey, 1999 edition, Luxembourg

Eurostat: Energy prices, data 1990-2001, 2002 edition, EC, Theme 8 Environment and Energy, Luxembourg

Eurostat: Yearbook A statistical eye on Europe data 1990-2001, edition 2001
Employment in Europe 2001, recent trends & prospects, July 2001, EC, DG for employment and social affairs
Feist, W.: Gestaltungsgrundlagen Passivhäuser; Darmstadt 2000

Feist, W., Passivhaus Institut: Wirtschaftlichkeitsuntersuchung ausgewählter Energiesparmaßnahmen im Gebäudebestand, Darmstadt 1998

Finnish Ministry of the Environment, Housing statistics in the European Union 2001, Helsinki, October 2001

Gemis; Globales Emissions-Modell Integrierter Systeme, Öko-Institut, Darmstadt 2002

IEA statistics, Energy balances of OECD countries 1997-1998, 2000 edition

IEA statistics, Electricity information 2000, OECD / IEA

IWU (Institut Wohnen und Umwelt): Empirische Überprüfung der Möglichkeiten und Kosten, im Gebäudebestand und bei Neubauten Energie einzusparen und die Energieeffizienz zu steigern, Darmstadt 1994

Joosen, S. and K. Blok, Ecofys: Economic Evaluation of sectoral emission reduction objectives for climate change, Economic evaluation of carbon dioxide emission reduction in the household and services sectors in the EU, Utrecht 2001

Minett and Simon: The Environmental Aspects of Cogeneration in Europe, documentation of the Congress "Power Plants 2001", Brussels 2001

Polish Government: Ministry regulations about heat exchange coefficients, Journal of Acts, 29. 10. 1997

STOA1998; van Velsen, A.F.M., O. Stobbe, K. Blok, A. H. M. Struker, MTI and Ecofys: Building regulations as a means of requiring energy saving and use of renewable energies, Scientific and technical options assessment (STOA) for European Parliament, Utrecht 1998.

UBA; Ökoinstitut, Bauhaus Universität Weimar, Institut für Industrielle Bauproduktion: Der Kumulierte Energieaufwand (KEA) im Baubereich - Erarbeitung von Basisdaten zum Energieaufwand und der Umweltbelastung von energieintensiven Produkten und Dienstleistungen für Ökobilanzen und Öko-Audits, Darmstadt, Karlsruhe, Weimar, for the German Umweltbundesamt (UBA), 1999.

Several Internet sites containing supplementary data to the official EU information:

www.stat.gov.pl/english, for Polish statistics

www.eia.doe.gov/emeu/cbecs for comparison with United State statistics about commercial buildings

www.swiss-energy.ch for Swiss statistics

www.environ.ie/housing for Irish housing statistics

www.be.no/beweb/english for Norwegian statistics

ANNEX I: MODEL DESCRIPTION

To make exact statements concerning energy saving through thermal insulation a model displaying the actual condition and future developments in the European building stock should be developed. It would not only be necessary to determine the floor space of the buildings but also heating conditions, geometries, the next renovation cycle term and the climatic dates of the buildings.

Such modelling can only be carried in a simplified manner, the necessary data determination involving too much work comparatively. This is why a simplified calculation model was assumed for the determination of energy saving potentials and this must be taken into account when evaluating the accuracy of the results. However, the results provide safe indicators of the probable size of energy saving potentials. The statements concerning energy saving through thermal insulation are based on a calculation model structuring the building stock in a simplified manner.

Building types

The building types single houses and multiple dwellings as well as industrial and public buildings are each illustrated by a model house.

- Model house 1: Two-storey row-end-house in massive construction technique with a storey surface of 120 m²
- Model house 2: Four-storey multiple dwelling with in massive construction with a surface of 1.637 m²
- Model house 3: Four-storey office building in massive construction with a surface of 3.000 m².

Climatic zones

The different climatic conditions in Europe have been summed up in three climatic zones. The southern cool climatic zone comprises the following countries: Finland, Norway and Sweden. To the moderate central climatic zone belong countries as Belgium, Denmark, Germany, France, Great Britain, Ireland, Luxembourg, the Netherlands, Austria and Switzerland, and the southern warm zone includes Greece, Italy, Portugal, Spain and Turkey.

According to the STOA report [STOA 1998] the following heating degree-days were assumed for the different climatic zones.

	Heating degree days [Kd/a]
Warm climatic zone	1800
Moderate climatic zone	3500
Cold climatic zone	4500

Building age groups

The building stock has been subdivided into three building age groups, which differ substantially due to the respective valid regulations and the insulation standard connected to them.

- Buildings set up before 1975 (subdivided into buildings already energetically redeveloped and buildings in their initial condition)
- Buildings set up between 1975 and 1990
- Buildings set up after 1990.

Characterisation of the European building stock: (11)

	building age	total	one family house	apartment house	office buildings
	year	[Million m²]	[Million m²]	[Million m²]	[Million m²]
Cold climatic zone	< 1975	727	333	191	202
	1975-1990	222	102	58	62
	1991-2002	186	86	49	52
	2002-2010	94	43	25	26
Moderate climatic zone	< 1975	9,486	4,773	1,993	2,720
	1975-1990	2,623	1,320	551	752
	1991-2002	1,978	995	416	567
	2002-2010	1,167	587	245	335
Warm climatic zone	< 1975	3,116	1,197	1,184	735
	1975-1990	1,945	748	739	459
	1991-2002	1,316	506	500	310
	2002-2010	528	203	201	125

U-values of the building types

According to climatic zone and building age group, different insulation standards and their respective U-values have been applied:

U-values [W/m²K]	Built before 1975 Not retrofitted	Built before 1975 Already retrofitted	Recommended retrofitting standard	Built from 1975 until 1990	Built after 1991	Recommended standard new buildings
Cold climatic zone						
Roof	0.50	0.20	0.20	0.20	0.15	0.15
Facade	0.50	0.30	0.20	0.30	0.20	0.20
Floor	0.50	0.20	0.20	0.20	0.15	0.15
Windows	3.00	1.60	1.30	2.00	1.60	1.3
Moderate climatic zone						
Roof	1.50	0.50	0.20	0.50	0.40	0.15
Facade	1.50	1.00	0.30	1.00	0.50	0.25
Floor	1.20	0.80	0.40	0.80	0.50	0.30
Windows	3.50	2.00	1.30	3.50	2.00	1.3
Warm climatic zone						
Roof	3.40	1.00	0.50	0.80	0.50	0.3
Facade	2.60	1.40	0.60	1.20	0.60	0.5
Floor	3.40	1.00	0.50	0.80	0.50	0.4
Windows	4.20	3.50	2.00	4.20	3.50	2.0

(11) Main source for residential sector: Finnish Ministry of the Environment, Housing statistics in the European Union 2001; main source for office buildings: Eurostat, statistical yearbook 2001 and Employment in Europe 2001.

It should be noted that the applied values are only roughly established and some of them had to be estimated despite extensive data investigation. For an exact determination of saving potentials through thermal insulation a detailed building typology of Europe would be necessary.

Calculation of energy saving

In the calculations it has been departed from the actual energy consumption for room heating in buildings in the EURIMA countries for the years 1990 and 2000. In order to take into account annual weather conditions the values have been adjusted by using the respective heat degree-days.

For the different model buildings, which were subdivided according to building type, building age group, insulation standard and weather condition, the respective saving potentials for thermal insulation (excl. replacement of windows) have been determined. The calculations are based on the EN 832 standard. The amount of energy saving through thermal insulation determined for the model houses has been projected to the energy consumption values in the EURIMA-countries, related to the floor spaces. In order to determine the CO_2 emissions the average annual utilisation degrees of heating systems have been assumed for each energy carrier.

Energy mix and emission factors:

To calculate the CO_2-emissions the following European mix for heat was assumed:

Energy carrier	Emission factor (12)	Share cold climatic zone (13)	Share moderate climatic zone	Share warm climatic zone
Gas	0.267 kg/kWh	0.9%	44.3%	32.1%
Oil	0.362 kg/kWh	24.8%	28.4%	31.7%
Coal	0.343 kg/kWh	0.1%	5.3%	1.9%
Electricity	0.536 kg/kWh	25.9%	6.6%	2.5%
District Heating	0.167 kg/kWh (14)	48.4%	15.4%	31.8%

The CO_2 factors sum up all CO_2-emissions which arise in connection with the whole process chain from exploration, extraction and winning of the primary energy carriers, their transport, their processing, their conversion and distribution right up to their supply as heat for the consumer.

(12) CO_2-emission factors are taken from the [GEMIS 2002] database and from the IPCC-Guidelines.

(13) The shares for different climatic zones are taken from [Eurostat 99]

(14) Emission factor of district heating calculated by: Primary energy factor of district heating from [GEMIS 2002] 0.59; distribution losses 7 %, Emission factor of fuel mix 0.264 kg/kWh [Minnet and Simon, 2001].

Calculation of energy prices

To calculate the energy costs the following European average prices were assumed (15) :

Energy prices	residential sector [EURO/MWh]	commercial sector [EURO/MWh]
Gas	39.20	29.94
Oil	39.20	29.94
Coal	39.20	29.94
Electricity	138.84	85.60
District heating	29.94	29.94

Used energy data

The forecast for the energy consumption of buildings in 2002 is based on IEA statistics for 1998 and average annual per cent change in the period 1998 and 2005. The energy consumption for space heating of buildings is derived from various literature sources (among others Eurostat and Lower carbon futures) and if possible determined at country level.

For the energy consumption data of the residential sector and the commercial and public services sector are also used IEA statistics in this study.

The data of the reference year 1990 and 2010 are slightly different from the data used in the sectorial objective study due to:

- statistical source that has been used (PRIMES database (sectoral objective study) versus IEA statistics (Eurima study),
- three additional countries (EU-15 (sectorial objective study) versus EU-15, and Norway, Switzerland and Turkey (Eurima study).

(15) Eurostat, Energy prices, 2002.

ANNEX II: ORIGINAL QUESTIONS BY EURIMA

1. For every MJ / KWh used to manufacture insulation, ... MJ / KWh are saved each year by the use of insulation.
2. Insulation of existing buildings could save an estimate of .... in Eurima's member countries.
3. Existing insulation in Eurima's member countries reduces energy use and carbon emissions by ...%.
4. Increased insulation could save .....% of the target carbon emissions in the residential sector of the Kyoto Treaty.
5. If all commercial buildings were built to recommended standards, carbon emissions would be reduced by ...... tons.
6. If insulation standards would meet recommended levels, ... additional carbon emissions could be eliminated in Eurima's member countries.
7. For every ton of CO_2 emitted in the production of insulation, ... tons of CO_2 is avoided over a period of 30 years by the use of insulation.
8. Existing insulation in Eurima's member countries reduces energy costs by ...%.
9. Upgrading insulation in under-insulated residential buildings, would save approx. ....% of the heating costs.
10. If insulation standards would meet recommended levels in new residential buildings, the energy costs could be reduced in Eurima's member countries by an additional .... % or ...... Euros.
11. Upgrading insulation in the industrial and commercial sector would save an additional ....
12. The average energy payback of existing insulation standards is less than 1 year.
13. Upgrading insulation in the process industry could save ....
14. Insulation of building and use alternative energies are complementary because …

EUROPEAN INSULATION MANUFACTURERS ASSOCIATION
Avenue Louise 375, Box 4 - B-1050 Brussels
Tel.: + 32 2 626 20 90 - Fax: + 32 2 626 20 99
E-mail: info@eurima.org
Website: www.eurima.org

12/2002