

MURE Database Case Study

A Comparison of Thermal Building Regulations in the European Union

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Wolfgang Eichhammer & Barbara Schlomann
Fraunhofer Institute for Systems and Innovation Research (FhG-ISI)
Karlsruhe, Germany

MURE Database Case Studies

MURE (Mésures d'Utilisation Rationnelle de l'Energie) is a database developed under the European Commission's SAVE Programme. It has three main functions;

- a qualitative database of measures undertaken by the 15 Member States of the EU to promote energy conservation in four sectors; households, transport, industry and tertiary;
- a quantitative database of energy related statistics and data related to energy saving technologies and actions in the 15 countries in each of the four sectors;
- a simulation tool which helps to carry out energy saving calculations in the four sectors by creating a bridge between the measures introduced and the related technologies or actions implemented.

The database has been developed by ISIS (Italy), March Consulting Group (UK), Inestène (France) and Fraunhofer Institute ISI (Germany). As with any database, the usefulness of MURE depends on it being able to provide up-to date and accurate information to users. In the light of this a series of case studies was initiated to demonstrate potential applications of the database.

This case study compares the thermal insulation regulations in the European Union in the residential sector.

Further information on the MURE Database can be obtained from:

Stefano Faberi ISIS, Italy
Fax: +39 6 321 3049 e-mail: isis@mclink.it

Edgard Bossoken Inestene, France
Fax: +33 1 45 89 73 57 e-mail: inestene@wanadoo.fr

Gillian Fenna/ Sarah Sidebottom March Consulting Group, UK
Fax: +44 161 848 0181 e-mail: sarahs@march-consulting.co.uk

Wolfgang Eichhammer/ Barbara SchlomannFhG-ISI, Germany
Fax: +49 721 6809 272 e-mail: ei@isi.fhg.de

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1. Introduction

This case study aims to compare the legislation relating to the thermal insulation of residential buildings in the 15 countries of the European Union. The first section gives an overview of the thermal building regulations which have been introduced in the past in Europe, essentially since the first oil price shock, up to the building regulations which are currently valid. For this purpose the study looks at information on insulation requirements, at when the regulations were introduced or amended, climatic conditions, the level of integration of the building system elements, the effect on energy consumption of each regulation update and whether further revisions are planned. The second section analyses the qualitative differences between the different building codes and how they integrate their objective to lower the energy consumption of buildings in the residential sector. The third section compares the performance of the different building regulations taking into account the different climatic conditions across the European Union. The final section gives a short outlook to further tightening of the building codes.

This case study has also benefited from a study for the German Federal Ministry of Economic Affairs to compare regulations for the rational use of energy across Europe.

2 Overview of thermal building regulations

Table 1 describes the structures of the regulations to reduce heating demand in buildings (regulations on thermal insulation) in a large number of the member states of the European Union. The following criteria were selected for the description:

- **Time**, at which regulations were introduced or revised in the past.
- **Degree day figures** for the respective country (on the basis of 20°C), which are a measurement of the severity of the climate.
- **Number of climatic zones** the country is divided into by the respective thermal insulation regulation, and for which there are different maximum values.
- **Stipulating different maximum values for fuel- and electrically-heated houses** in the thermal insulation regulation (the requirements for electrically heated houses are stricter due to the higher cost of electricity compared with other fuels).
- **Classification** of the thermal insulation legislation according to the degree to which the entire building system is integrated.
- **Assessment of the reduction of energy consumption** of each valid regulation compared with the previous level of thermal insulation (the figure is based on the theoretical reduction in new buildings with the same level of comfort and fittings, not on the stock of buildings as a whole with its varying structures).
- **Applicability** of the regulations to new buildings, new extensions to old buildings and to old buildings.
- **Planned revisions/tightening up** of the current legislation.

The regulations were classified into four groups which were distinguished by the different degree of integration of the building as a system. The more integrative an approach is, the greater the flexibility permitted in details. With an integrated approach, a simple coefficient can be provided for a building which can be directly converted into a certificate clearly showing the energy value of a building for everyone. However, this also increases the calculation demands on the building designers as well as the difficulties of proving that the maximum values have been kept.

The **unit approach** is the approach with the lowest level of integration and only considers the heat transmission through the building shell. It divides the building shell into its individual components (e. g. outer walls, roof, basement ceiling, windows, doors etc.) and states a maximum heat transmission value for each of these components separately. This heat transmission value is the so-called U-value, and it indicates the amount of heat that flows through a square metre of building

component with a temperature difference of 1 K (unit: Watt/m² K). This approach is characterised by a simple calculation method. Compliance with the thermal insulation regulation is limited to proving that certified building materials of a specified thickness have been used.

Giving an **average transmission through the building shell** (average U-value) represents a preliminary level of integration, which allows more flexibility. Instead of standardising each building component, it is sufficient to give a single value for the building shell. This results in greater flexibility as a higher heat transmission through one component (e.g. the walls) can be compensated for by better values of other components (e. g. the roof, or the windows). The disadvantage of the average transmission is that it can be more difficult to prove that the regulations have been kept than with the unitary approach.

The next integration level indicates **maximum values for the heating demand of a building**, which is a fundamentally more systematic approach than the previous two. Germany selected such an approach in its most recent Thermal Insulation Ordinance of 1994. Alongside the heat transmission through building components, ventilation losses, heat increases due to solar heat recovery and internal heat sources in the house are also included. With this approach, therefore, not just the building shell has to be optimised, but a reduction of the energy demand could be achieved via improved ventilation with lower heat losses or an increased use of passive solar energy through relevant architectural design. Understandably this approach was not followed in the first Thermal Insulation Ordinances in the 70s as, at that time, the transmission losses formed the largest loss factor alongside which, in a first approximation, the other contributions could be ignored. With today's highly insulated new buildings and the trend towards low energy houses, however, the other factors play an increasingly large role and it is reasonable to include them in the Ordinance. For ultra low energy houses, as aimed at in the next amendment of the Ordinance on Thermal Insulation, controlling ventilation losses and passive solar heat recovery will be the decisive factors for meeting the maximum values and for the reduction of additional costs. Just reducing the transmission losses alone would send building costs shooting up.

The final stage of integration (**fully integrated approach**) covers heating supply as well as heating demand and consequently results in the integration of the thermal insulation regulation with any heating systems regulation in a (Heating)Energy Conservation Regulation as is planned in Germany for 1999 and has already been realised in England, France and Italy.

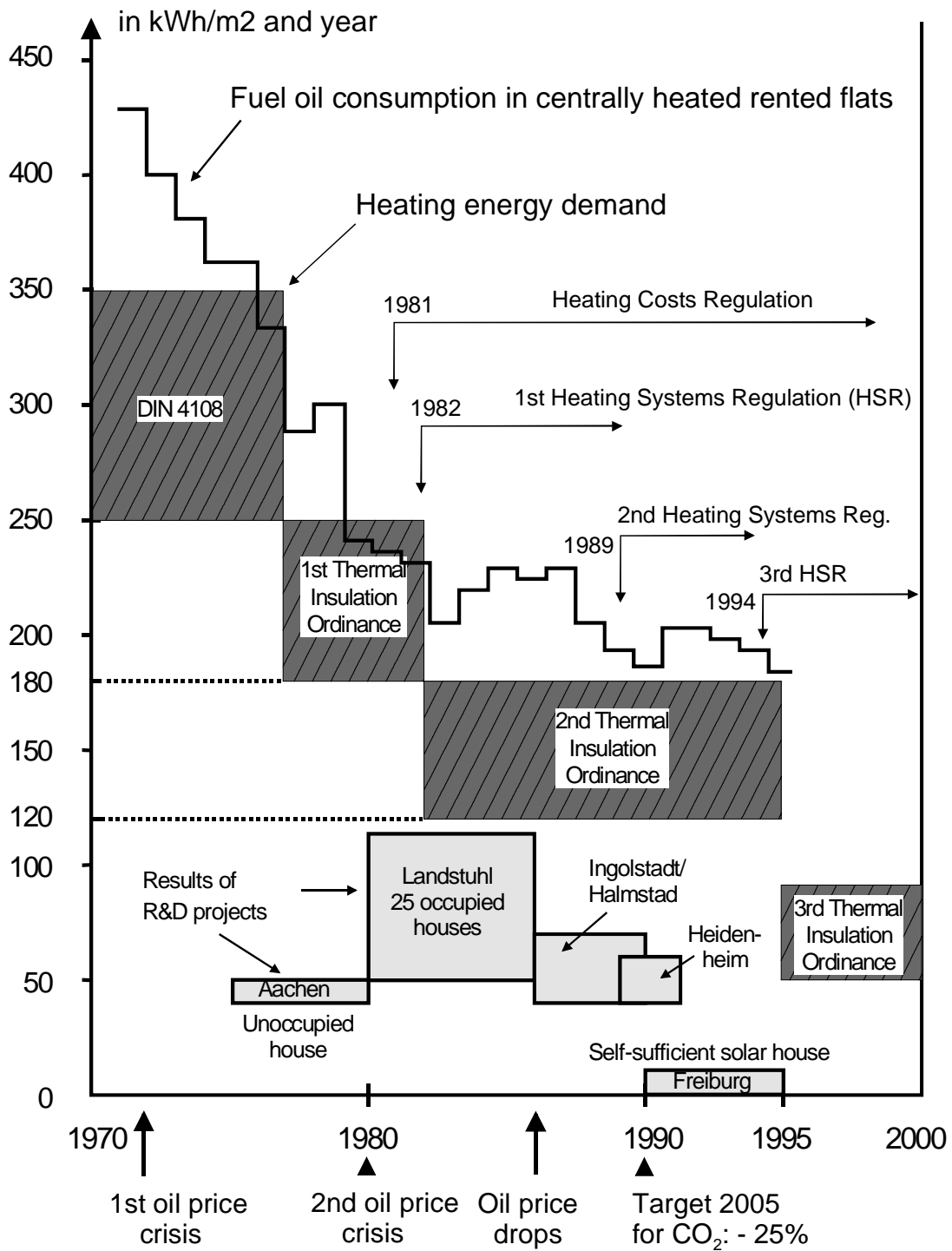


Figure 1 Interrelation between research, proof of technical feasibility and regulation using the example of Thermal Insulation Ordinances and Heating Systems Regulations in Germany

3 Analysis of thermal building regulations

As Table 1 shows, basically all EU countries have followed the same route of standardisation in thermal insulation, as well as the many different stages of thermal insulation ordinances. In most countries there are at least three stages, and the fourth or even fifth are expected soon.

There are a number of reasons why thermal insulation (and the household sector in general) is so strongly regulated, for example;

- the lack of a strong lobby to campaign against regulation as is the case in other sectors.
- the availability of a few easily comprehensible technologies with a long-term, very large potential of energy saving (the regulations are comparatively simple, even if the calculations can be extremely complicated).
- the fact that the building market is a national one to a large extent, i.e. international competitive factors play a small role.
- the international availability of technical developments which have been proven by research and which indicated the routes regulation should take. This interaction of research, proof of technical feasibility and regulation is shown in Figure 1.
- the occurrence of external events such as the two oil price shocks and the threat of the greenhouse effect which then trigger research efforts and regulation. Regulation often acts as a driving force for technology in such cases, as the requirements trigger off efforts which eventually lead to the more efficient technology being made available at the same cost (in some cases even at a lower cost).

3.1 Introduction and Revision on the Legislation

A comparison of the years in which the thermal insulation regulations were introduced shows similar causes as indicated in Figure 1: as a rule, the first regulation was introduced a few years after the first oil price crises (1976 - 1978); the second was made at the height of the second oil price crisis and the third occurred - with some delays due to the falling oil and gas prices - at the beginning of the 90s under the impression of the danger due to the greenhouse effect. The other regulations were triggered by fears that the respective government's own CO₂ targets could not be achieved and/or international commitments to CO₂ reduction could not be kept. This rhythm of regulation, which is related to direct external causes in almost all the countries, indicates that acting with foresight is an exception and that regulations are introduced or made stricter while under the impression of a

certain problem. Finland is one exception, where the cold climate provides enough incentive to save energy without compromising levels of comfort.

3.2 Climatic Conditions

The degree day figures for the individual countries indicate that the thermal insulation regulations cannot be directly compared with each other.

If the countries are further divided into individual regions, the range of degree day figures extends from under 400 in some regions of Spain up to 7600 in the far north of Finland. A suitable correction will be made in the next section which without the requirements of the individual thermal insulation ordinances cannot be compared.

Most countries limit themselves to one climatic zone when setting the maximum values in the respective ordinance on thermal insulation in spite of the relatively large variation among the degree day figures in their territory. The degree day figures in Finland fluctuate between 5577 and 7600; nevertheless, standard maximum values are laid down in the Finnish Thermal Insulation Ordinance. All the southern countries define several climatic zones (see Table 1). This may be connected to the fact that in these countries, the contrast between the coldest and the hottest region is perceived as being very great (in Italy, the values vary from below 600 up to above 3000 in the mountains), although the absolute variations of degree day figures are not greater than in Finland. This points to the fact that threshold values are being exceeded which are more noticeable in the lower range of degree day figures than in the upper one.

Italy is a particularly extreme example of division into climatic zones, as it even allows interpolations between the 6 main classes so that basically every town and every community has its own maximum value. A more precise division of the country into climatic zones has the advantage that regional conditions can be better accounted for. The regulation itself, however, is made more complicated and less easily comprehended.

3.3 Degrees of Integration

The largest differences between the thermal insulation regulations in the EU are to be found in the classification according to their integrative nature. Whereas the regulations traditionally start from the unit approach (easily comprehensible for the building designers and the legislators), some countries have already shown strong tendencies towards an integrative regulation. Other countries have extended the unit approach, or at most permitted global transmission coefficients, in order to incorporate more flexibility into the system.

The systems in France, England, Italy and Germany have progressed the most. The English system in particular has to be denoted exemplary with regard to the formulation of the regulation. It is true that the unit approach, the global transmission approach and the fully integrative approach are all permitted side by side, but in all three approaches the so-called Standard Assessment Procedure (SAP) must be carried out which results in an energy coefficient in which inflation-adjusted energy prices are also expressed alongside the main and secondary energies in the entire system of the building shell, heating, ventilation and solar heat recovery. These coefficients are easily comprehended by the user of a house (who is not aware of the complex calculation behind them). Due to this fact, in England, it is obligatory that new buildings be certified using this energy coefficient. When selling the building or when stipulating a rent, the certificate can be used as one element in the negotiation process.

3.4 Applicability

With respect to the applicability of the regulations, there are no differences between the countries: in all the countries, regulations are restricted to new buildings, or new extensions to existing buildings. Old buildings are not subject to any regulation in any EU country. The reason for this is the fact that the additional costs can be compensated via planning measures in new buildings whereas, in old buildings, the scope is much smaller. Social factors may play an additional role here.

Differences in setting maximum values for fuel- or electrically-heated houses are only found in France and Spain. This is probably due to the high share of electricity in the space heating of these two countries. Due to the high cost of electricity, the limits are fixed somewhat lower (e.g. in France between 5-15 %).

4 Evaluation of thermal building regulations

The requirements of the individual thermal insulation regulations are compared in Table 2. As the majority of the regulations are still based on the unit approach or global transmission coefficients (or provide for these two approaches alongside more integrative approaches), the layout in the Table was structured according to the requirements demanded of the individual building components. To allow a comparison with the integrative approaches, the energy demand of a **model house** has been calculated. A model house has the same geometry in all countries and is insulated to the current building regulations of each country or climatic zone. The penultimate line shows the energy requirement calculated from the individual building components; the last line gives the demand calculated from the integrative regulations. For reasons of simplicity, solar heat recovery, internal heat sources and ventilation losses were assumed to be equal and were removed. The main difference between the integrative approaches and the unit approach is to be found here however: whereas the former permit the requirements made of the building shell to be reduced by improvements to other parameters, e.g. the ventilation, there is no such flexibility with the unit approach. This limits the comparability of the approaches.

The calculations for the model house are preliminary, as problems are still encountered when including the ventilation loss (for this reason, the French values are not fully corrected for this influence).

For the southern countries which work with a number of climatic zones, an average zone was taken and labelled in accordance with the zone description in the respective thermal insulation regulation.

As a test, the requirements made of outer walls can be compared for those countries working with the unit approach as these usually make up the greatest share of the building shell. To correct for climate factors, these values have to be multiplied with the degree day figures (see Table 3). This value should be the same in all the countries with the same requirements. There are clear differences in the requirements; the Danish u-values for outer walls can be characterised as particularly low.

Table 3 Energy flow through an outer wall in the given country under the requirements of the respective thermal insulation regulations

Country	A (15a)	B/F	DK	SF	D	GR-B	IRL	L	NL	P-2	E-D	UK
Product of degree day figures and U-values for outer walls (kWh/m ² /a)	48,82	46,93	22,98	40,17	46,14	24,64	32,17	31,29	34,08	51,84	34,56	34,67

Source: own calculations

Since the comparison is only based on one building component, it is obviously simpler and more accurate to calculate, but less informative. In Figure 2, the values calculated for a model house are compared (with the above mentioned preliminary restrictions). This corresponds to the heating use in kWh per year and m³ house volume (the value could also be converted into m² living space; the German Thermal Insulation Ordinance stipulates a conversion factor of 0.32 for this calculation). The comparison shows that, even when regarded integrally, the Danish standards are very good compared with other countries. The southern countries tend to have lower standards of thermal insulation, i.e. the same house has higher losses (with the lower U-values of the southern country) in spite of the milder climate. This may also be due to the fact that the overall expenditure for heating in these countries is lower and that, for this reason, less is demanded of thermal insulation. The French figure is still problematic.

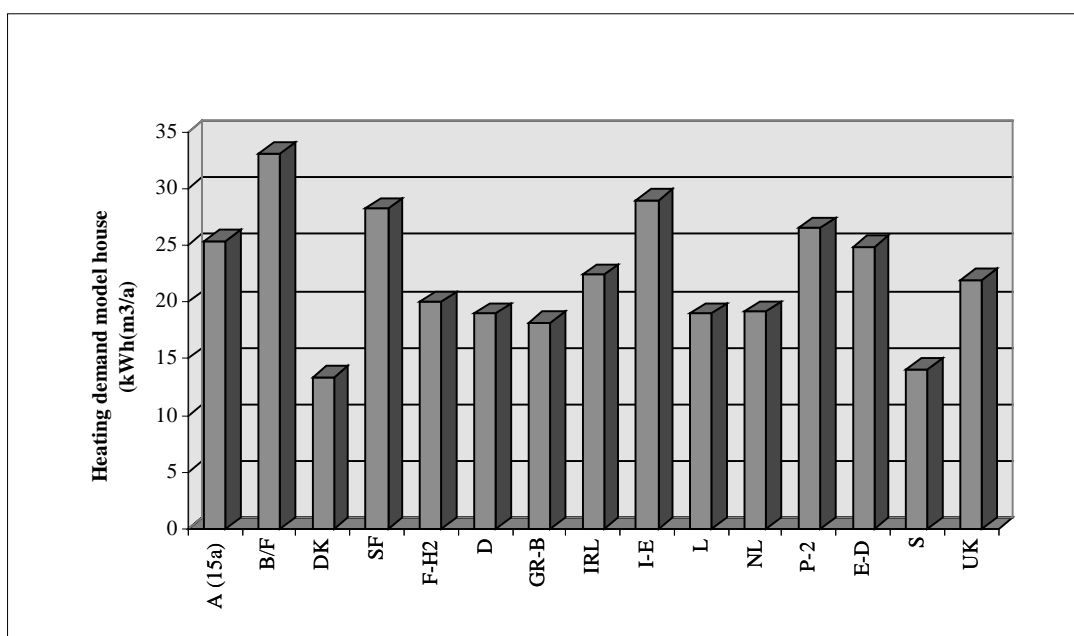


Figure 2 Heating demand of a model house in different countries or climatic zones (simplified calculation; not taking into account solar heat recovery, internal heat sources, ventilation losses; exclusion of the heating system from the integrative approaches).

The existing differences give rise to the question whether there is a need for co-ordination in the field of thermal insulation on an EU-wide basis. Different climates are not an obstacle to co-ordination and could, as is already the case in some countries, be accounted for in varying requirements in an otherwise standardised European regulation on thermal insulation.

A more subtle procedure for co-ordination could be oriented on the Austrian example, which permits separate thermal insulation ordinances for each state, but still imposes minimum standards for thermal insulation on a national level.

Co-ordination could take place not only with regard to setting maximum values, but also in the kind of approach pursued by the thermal insulation ordinances (integrability of the approach) as well as the calculation method.

Before answering the question on the need for co-ordination, it has to be asked what objective would be achieved by co-ordination. Usually there is a need for co-ordination if, without joint "rules", there are differences in the chances of the individual players in the game. This is especially true of markets which are internationally orientated to a large extent such as, for example, electrical appliances, which are offered by one manufacturer in different countries.

The housing and thermal insulation market, however, is nationally orientated to a large extent. *A priori* therefore there is no impetus for co-ordination. The fact that it is possible to establish energy coefficients using integrative approaches to label houses/apartments (building certificates) does not offer a lever for co-ordination as the buyer's market is also basically nationally oriented.

It is true that a certain natural co-ordination takes place with respect to the following four variables:

- the time at which new regulations are introduced (the external impetus is the same: oil price crisis, greenhouse effect; countries are like people and often follow the herd)
- integrative structures of the thermal insulation regulations (several smaller countries peek over their borders and orient themselves on larger neighbours)
- calculation methods
- setting maximum values (the same reasons as above).

In practice, however, the national approaches result in larger or smaller deviations from the natural co-ordination. In this context, it would be interesting to look into why Austria considered it necessary to introduce a national regulation. However, the dimensions of the country are much smaller than those of the EU and there are no cultural barriers so that, on a national level, it can be said that a uniform market exists here.

There are only two main reasons in favour of co-ordination. On the one hand it is obvious that there is a large energy savings potential in the household sector which, however, is only being tapped very slowly due to the long serviceable life of houses

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(as long as old houses are not refurbished). Thus it is especially important to set the maximum values for new buildings as low as is economically viable as houses, once built, will probably require heating at their present level for the next 50-100 years. Standards then act as the **driving force behind technology**. It is not very probable that sufficiently low values could be agreed upon throughout Europe in order to make progress with thermal insulation as the additional costs arising or not arising from thermal insulation measures are perceived differently in different countries.

The second reason concerns climate protection and the distribution of burdens among the countries. This is an argument in favour of a joint European formulation of regulations. The differences between the individual countries in this area are not enormous due to natural co-ordination. They are certainly much smaller than the differences permitted between the individual countries of the EU, for example, in the "burden sharing" to achieve the joint target of 15 % reduction of the CO₂ emissions by 2010 in comparison with 1990 (the spread ranges from a reduction of 25% for Germany or Austria up to a growth of 40 % in the CO₂ emissions for Portugal).

Both lines of argument favour a co-ordination at most in the longer term.

5 Future developments in thermal building codes

The timing of further developments in thermal insulation regulations, as far as these are predictable today, is given in Table 1, which is still incomplete. A series of countries are currently undergoing amendments or these are being discussed.

The amendments take three directions:

Firstly, several countries, which up to now have pursued the unit approach or the approach using a global transmission value, are discussing the introduction of more integrative approaches with reference to the thermal insulation regulations in other countries (e.g. Austria and Finland are two such countries).

Secondly, other countries are preparing to tighten up their thermal insulation regulations with reference to obligations of CO₂ reduction (e. g. Germany or Finland). In Germany's case the revisions are the strictest (it is planned to reduce the maximum values by 30 %), whereas Finland is content with 10 %. However, the values are so low here anyway due to the climatic conditions that economic and, to a certain extent, technical factors start to play a role. Interestingly, other countries perceive this threshold to be at significantly higher values. France argues that the maximum values cannot be reduced any more as the additional costs for increased insulation of new buildings could drive the price of new buildings up too high. This fear is contradicted by the experiences in Germany which have shown that alterations in the planning and construction of new buildings are able to offset the additional costs.

In Finland, as well as extending the development of thermal insulation regulation, in the longer term for the year 2003, the thinking is in terms of a European standardisation of calculation methods and thermal insulation regulations.

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Table 1 Household sector: overview of regulations to reduce the heating

Country	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Lux.	Netherlands	Portugal	Spain	Sweden	UK
Introduction of regulation	Reg. Level 1995	1985 (W) 1992 (F)	1972 1977 1982 1995	1976 1978 1985	1974 1982 1989	1977 1982 1994	1979	1991	1977 1986 1989	1979 1996	1991 1995	1990	1979	1980 1985 1994	1965 74/76 1985 1991 1994
Degree day figures (basis 20°C average)	4068	3259	3191	5978	2850	3845	1711	2979	2234	3259	3550	1800	1600	4355	3210
Number of climatic zones	1	1	1	1	3	1	3	1	6	1	1	3	5	1	1
Difference fuels/electricity	No	No	No	No	Yes	No	No	No	No	No	No	No	Yes	No	No
Classification															
<i>Unit approach building shell</i>	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes
<i>Avg. transmission building shell</i>	No	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes (91)	No	Yes	Yes	Yes
<i>Heating demand of building</i>	Disc. ¹	No	Yes	Disc. ¹	No	Yes	No	No	No	No	No	No	No	No	No
<i>Fully integrative approach</i>	Disc. ¹	No	No	Disc. ¹	Yes	Disc. ¹	No	No	Yes	No	Yes (95)	No	No	No	Yes
Reduction of energy consumption compared with previous stage	-20% - 40% ²		25%	10%	25%	30%	-	25%		30%			-		25%
Applicability															
<i>New buildings</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>New extensions to old buildings</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Old buildings</i>	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Revision planned for	-	1999 (F)	2005	1998+ 2003	1998	1999	-	>2000	-		1998+ 2001	-	1998	1998	2001

¹ "Disc." means that the corresponding approach is under discussion

² In the case of Austria the value fixed is a minimum standard which all regions (Bundesländer) have to fulfill. As some regions are more advanced than others the minimum standard would imply a (theoretical) worsening in their standards for some regions by up to 20 % in case they would only apply the minimum standard, whereas for other regions there would be an improvement of up to 40 %.

Source: MURE database, national thermal insulation regulations

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Table 2 Thermal insulation requirements of the regulations in EU countries

Country	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Lux.	Netherlands	Portugal	Spain	Sweden	UK
Climatic zone	15a	F	Country	Country	H2	Country	B	Country	E	Country	Country	2	D	Country	Country
Degree day figures	4068	3259	3191	5978	2600	3845	1711	2979	2234	3259	3550	1800	1600	4355	3210
Year of regulation	1995	1992	1995	1985	1989	1994	1979	1991	1993	1996	1991	1990 (update 1995)	1979	1994	1991 (update 1995)
Overview of U-values: W/m2															
In contact with air outside															
Outer walls	0.5	0.6	0.3	0.28		0.5	0.6	0.45		0.4	0.4	1.2	0.9		0.45
Windows/doors	1.9	3.5	1.8	2.1		0.7	3.5	3.6		2	1.8	4.2			3
Roof/ceiling	0.25	0.6	0.15	0.22		0.22	0.4656	0.25		0.3	0.4	0.8			0.2
Floor/basement floor	0.5	0.6	0.2	0.22		0.5	0.4656	0.45		0.4	0.4				0.35
In contact with unheated rooms/ ground															
Outer walls	0.7		0.4	0.36		0.35	1.8622	0.6		0.5	0.4		1.6		0.6
Windows/doors	1.9		1.8	2.1		0.7		3.6		3	1.8				3.3
Roof/ceiling	0.45		0.3	0.36		0.35	1.8622	0.6		0.4	0.4		1.2		0.6
Floor/basement floor	0.5	1.2	0.2	0.36		0.35	1.8622	0.6		0.5	0.4	0.8	1.2		0.6
Energy demand of a model house															
Elemental approach (kWh/m3/a)	25.39	33.11	13.36	28.21		18.95	18.17	22.38		18.97	20.60	26.51		14.13	21.99
Integrative approach (kWh/m3/a)		31.43	?		20.00	23.20	22.66	31.01	28.95		19.12		24.89		21.62

Source: MURE database, national thermal insulation regulations