U-VALUES
FOR BETTER ENERGY PERFORMANCE OF BUILDINGS

IN A NUTSHELL

The point of departure

Europe is facing a massive challenge to curb greenhouse gas emissions in a cost effective manner. Previous work by Ecofys for Eurima has demonstrated that whilst buildings account for 40% of all carbon dioxide emissions in the EU, simple measures such as roof and wall insulation have the potential to:

> reduce emissions by 460 million tonnes a year (more than Europe's total Kyoto commitment);
> reduce energy use by 3.3 million barrels of oil a day;
> save Europe 270 billion Euro a year in energy costs.

From a significant potential to a specific goal

Whilst the potential for reducing energy use and saving money is clear, what this means for Europe's thermal insulation requirements per region is not so clear. "U-values for Better Energy Performance of Buildings - Ecofys VII" therefore fills the gap by:

> Examining, based on a cost optimum and a climate change perspective, where thermal insulation standards should be set for 100 cities across Europe;
> Including the impact of thermal insulation on reducing cooling and heating energy demand.

Clear outcomes

The Ecofys VII study not only provides a clear perspective on where requirements should be set but also found that:

> Current national requirements for new residential buildings are not at optimum level from a cost effectiveness stand point and will not allow Europe to achieve its long term climate goals;
> Recommended U-values are identical for new as well as for existing buildings;
> In southern Europe good thermal insulation can dramatically reduce the need for cooling.

Putting this into practice

The results make a strong case for Europe wide minimum requirements for the energy performance of buildings. But legal requirements will only be a first step. Europe needs to also ensure that adequate financing is provided as well as proper skills training for the building chain.

DELIVERING A LOW CARBON ECONOMY

Europe's biggest challenge

Europe is facing an enormous challenge over the next decades to find ways to deliver a low carbon economy and at the same time living up to our commitments under the Lisbon Agenda to become the most competitive region in the world. To do so, Europe must dramatically reduce both its carbon dioxide emissions as well as its reliance on fossil fuels, whilst fostering growth and jobs.

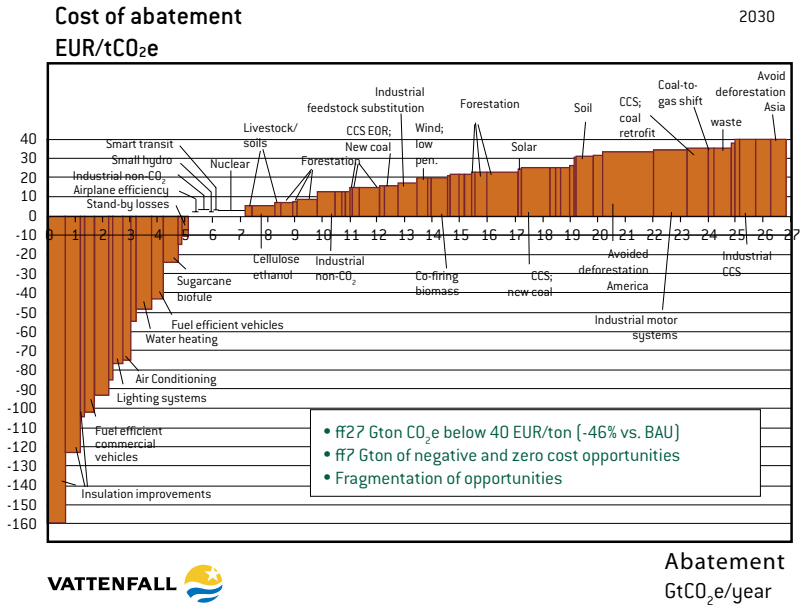
With European Heads of State having agreed, in March 2007, a binding and unilateral greenhouse gas emission reduction target of 20% by 2020, this challenge has become a legal requirement for the European Union. The question is no longer should it be done, but simply how can it be done.

THE IMPACT OF BUILDINGS

An essential part of a low carbon economy

In Europe, buildings account for 40% of total energy use with transport and industry accounting respectively for 32% and 28%. This makes buildings Europe's largest source of greenhouse gas emissions.

However, since it is possible to cut energy use in buildings in half, through simple measures such as wall and roof insulation, buildings are arguably Europe's biggest energy wasters. Yet as insulation has been shown to be the most cost-effective measures to reduce CO_2 emissions [McKinsey report 2007], they have the potential to be turned from energy wasters into climate and money savers.



In the graph on the left insulation is the first, second and third most cost-effective measure to combat climate change. The McKinsey study quantifies and clarifies the principle that reducing energy demand in buildings should be the first priority, if Europe is serious about combating climate change cost effectively.

VATTENFALL

QUANTIFYING THE OPPORTUNITY OF ENERGY EFFICIENCY IN BUILDINGS

The Eurima Ecofys studies

Since 2002, Eurima has been working with Ecofys, an independent and international consultancy on energy efficiency, renewable energy and climate policy, to develop a deeper understanding of the potential from buildings. These studies have revealed that:

> Buildings account for 40% of Europe's CO_2 emissions but thermal insulation could cut emissions from heating by more than 40% [Ecofys I - 2002];

> The Energy Performance of Buildings Directive (EPBD) captures only 10% of the potential from buildings but a fully extended EPBD could reduce total emissions from buildings by 460 million tonnes a year, more than the EU commitment under the Kyoto Protocol [Ecofys II - 2004 and V - 2005];

> Capturing the full potential from buildings would save Europe 270 billion Euro a year in energy costs, based on an energy price of $70 a barrel of oil [Ecofys III - 2005, V - 2005 and VI - 2006], whilst creating up to an estimated 530,000* jobs. The potential at recent peak energy prices is even higher.

* Eurima estimate

U-VALUES FOR BETTER ENERGY PERFORMANCE OF BUILDINGS

The Eurima Ecofys VII study

While the previous studies gave an excellent overview of the cost-effective potential not only from energy efficiency in general but also from the current regulatory framework for buildings, two more elements could be added. Ecofys VII fills the gap by:

> Understanding insulation standards or U-values for a low energy Europe:

Although research has shown the benefits of insulation, it had not yet considered what this would mean for insulation standards. Ecofys VII considers how U-values can be improved and better contribute to deliver Europe's climate change objectives as well as to ensure a cost optimal level from a societal perspective.

> Understanding impact of insulation standards on cooling energy demand:

Previous calculations had not included the economic and climate benefits of insulation on reducing the energy demand for cooling in the residential sector. However, with the dramatic growth in the use of air conditioning and the likely increased temperatures in Europe, understanding the benefits of insulation on reduced cooling demand is essential for determining insulation standards for Europe.

Understanding U-values

U-value is a term used to describe the amount of heat loss that occurs through an element of construction such as a wall or window. The lower the U-value the less energy is lost and the better is its insulating characteristics: a wall with a U-value of 0.3 W/m².K is twice as well insulated as a wall with a U-value of 0.6 W/m².K.

U-values allow regulators to set values which are neither material nor system specific but can be achieved by different combinations.

U-values are also a first guide for a designer and architect in setting the thermal performance of the building envelope. Practice has taught us that modifying these dimensions at a later stage in the building process is difficult and costly. Therefore U-values for building components are important parameters in the design process.

RESULTS IN A NUTSHELL

1. Current standards are far from optimum

In almost all cases, current national energy performance requirements across Europe for wall, roof and floor are not in line either with what would be cost-effective or deliver the EU's long term climate objectives. This is the case for new building requirements and even more so for existing buildings.

2. Climate and cost can work together

The report found that at current energy prices (i.e. at or above $70 a barrel) the cost optimum level of insulation for new and existing buildings is also the level that is needed to deliver the study's goal setting of an ambitious 85% reduction in greenhouse gas emissions from buildings by 2050. This is good news as it demonstrates that in the field of energy efficiency in buildings a focus on a well insulated thermal envelope can match both Europe's climate objectives and its goal within the Lisbon Agenda of becoming the most competitive region in the world.

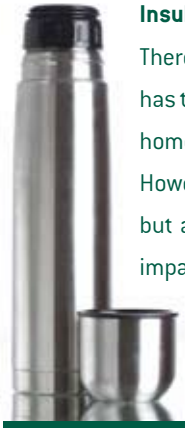
3. Good thermal insulation can also keep you cool

In order to understand what are cost optimum insulation levels, it was important to better understand the impact of thermal insulation on reducing the need for cooling. The results were surprising and demonstrated that:

> A sound package of thermal insulation can reduce cooling demand by up to 75%;

> Roof insulation has a very positive effect on reducing heat gain due to the large amount of solar energy that falls on the roof;

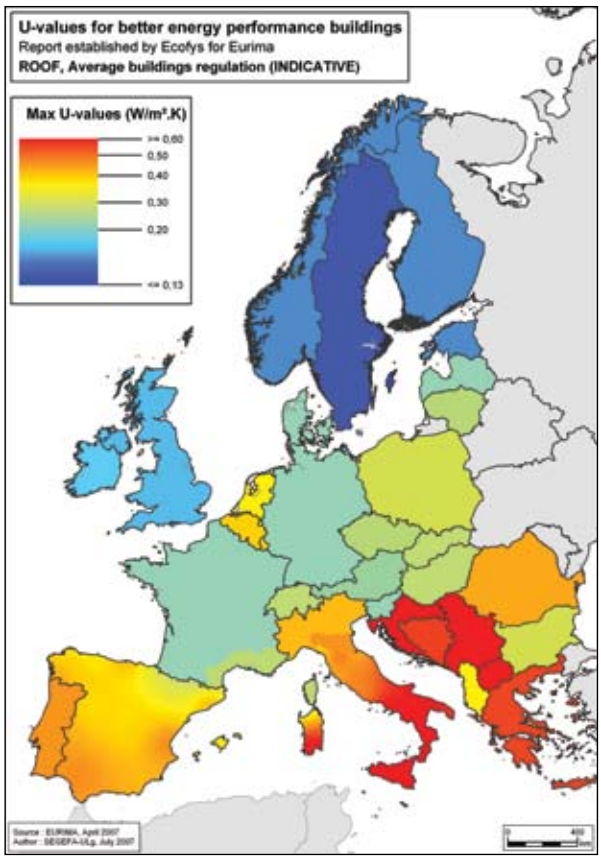
> In buildings that lack a high mass and high thermal inertia (e.g. thin walls or timber constructions) the impact of additional insulation is significant, so much so, that their performance becomes comparable with that of a well insulated high mass building.

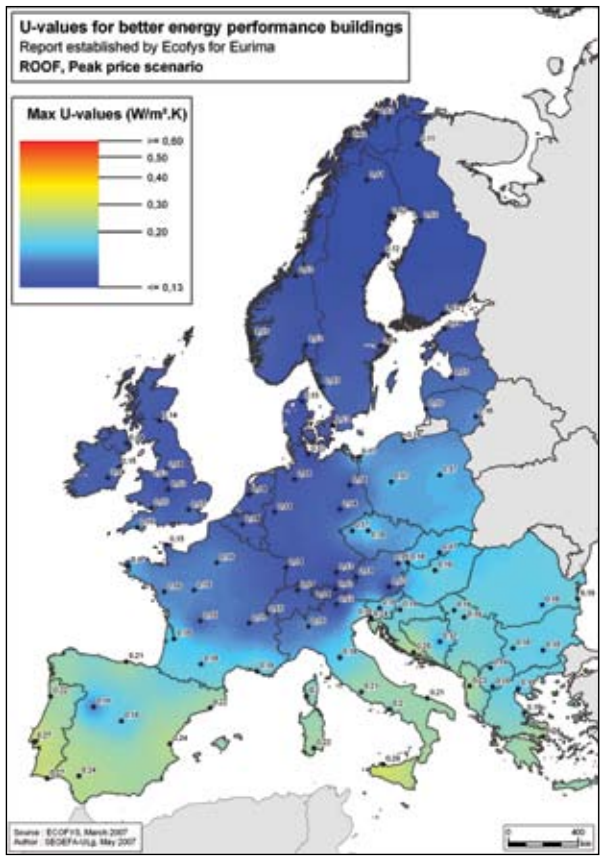


Insulation - a thermos bottle for your home

There is often a misconception of the role of insulation on cooling (warm climates) because insulation has typically been used in cold countries to keep buildings warm. Due to this, insulation's role in keeping homes warm in the winter is well understood but not its ability to keep homes cool in the summer. However in reality, insulation in buildings acts like a thermos mug, keeping hot drinks warm in winter but also keeping cold drinks cool in summer. Ecofys VII not only confirms this, but also clarifies the impact that insulation can have on reducing the need for cooling. The study demonstrates that the impact of insulation on cooling is very robust, with a significant impact occurring even if the building design is not itself optimised for cooling, for example if there is a lack of shading or high internal heat gains.

HOW BLUE ARE U?





The map on the left shows where national buildings' regulations for roof currently lie across Europe; the more the colour moves from red to dark blue the better the building needs to be insulated according to requirements.

The map on the right describes the results of Ecofys VII: U-values based on cost-optimum. Here there are only shades of blue and green, showing that the whole of Europe must move towards significantly better insulated homes and buildings.

A RECOMMENDATION TO EUROPE

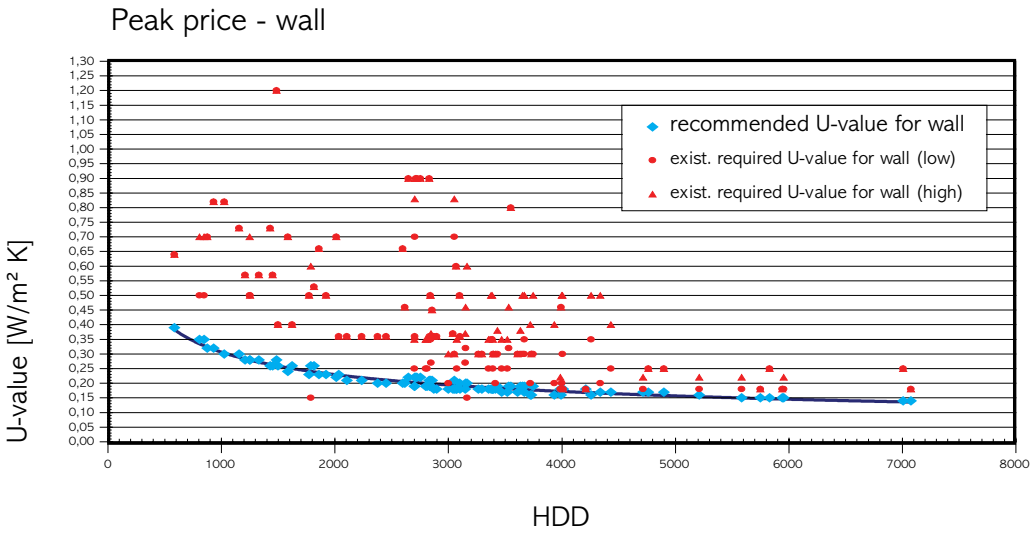
Ecofys VII provides a number of important findings. Based on these, Eurima has drawn-up a number of important recommendations that should be taken into consideration in upcoming policy developments.

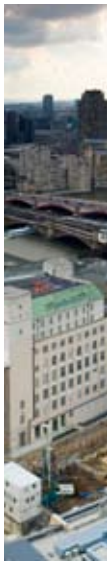
1. Current regulations for new buildings are wasting money

From a climate change perspective and from a cost-optimum perspective current standards for new build are far below what is necessary. In the 100 cities and towns from across the EU that were considered most were not up to standard.

CONCLUSION: If Europe is serious about achieving a 20% reduction in greenhouse gas emissions by 2020, regulations for new build need to be dramatically improved. In its Energy Efficiency Action Plan, the European Commission proposes that Europe should move to very low energy (or Passive House) standards by 2015. The results of Ecofys VII are very much in line with this, and should be taken as setting milestones on our way to delivering very low energy houses by 2015.

The graph below compares current thermal insulation requirements across the EU for walls (red dots) versus what a cost optimum level should be based on the peak price scenario of $70 a barrel used in the study (blue dots). On the bottom axis, the number of heating degree days is expressed (HDD); therefore, cities towards the left are warmer climates and to the right in colder climates. What is clear from the graph is that both in warm and cold climates, many current requirements are a long way from being cost optimum.





2. The lack of standards for existing buildings must be addressed

When a decision is taken to renovate a building component, such as a roof or wall, previous Ecofys studies demonstrated that this is the most cost-effective opportunity to also improve its thermal insulation levels. Ecofys VII however provides clear results on what the level of thermal performance should be once a decision is taken to undergo a major renovation of a building component and to ensure that the most cost optimum level of insulation is applied.

CONCLUSION: Given that every renovation is a once in thirty years opportunity to improve the thermal insulation levels of a building, it is critical that standards are developed for existing buildings to ensure that this renovation cycle will seize the huge potential for cost and climate savings. Ecofys VII demonstrates that standards can be set in such a way that will provide savings for individuals and help Europe achieve its climate objectives.

3. Time is not on our side

To achieve an 80% reduction in greenhouse gas emissions by 2050 will take almost immediate action in buildings. With new buildings only representing 1% of the building stock and with the normal renovation cycle for buildings being 30 years, there is no time to lose in terms of bringing both new build and renovation standards up to speed. Between 2010 and 2020, we will be constructing and renovating the buildings we will live in, in 2050!

CONCLUSION: In order to have a realistic chance of achieving an 85% reduction in energy use in buildings by 2050, the report suggests that U-value requirements need to be in line with the cost optimum level as soon as possible. Such requirements being an essential complement to the whole building approach taken by the Energy Performance of Buildings Directive and will ensure minimum standards for the building envelope.

4. There are challenges ahead

Given the lack of time and the need to rapidly transform Europe's building stock towards very low energy buildings a number of challenges become evident from this research.

> **A better regulatory framework is needed:** The research demonstrates that current regulations will not deliver long term climate objectives and are not at a cost-optimum level both for new buildings and where they are in place for existing buildings. Europe's Member States need to put in place a regulatory framework that is based on an economic cost-optimum, as defined in Ecofys VII, as an additional minimum standard for new buildings, on the route to low energy houses or Passive Houses. The revision of the current EPBD also should aim at ensuring that Member States will establish minimum energy performance requirements to be met or exceeded when buildings or buildings components are renovated and for installations that will be replaced.

> **Organisational support is crucial:** The challenge that Europe is facing, particularly for the renovation of buildings, cannot be met by regulation alone. In addition, local support structures will be essential to support individuals to renovate their buildings up to high standards and ensure that building professionals can receive the necessary training.

> **Up front financing and tax credits:** Loan schemes, which provide a building owner with the means to invest in building improvements without having to use cash resources, are more effective and efficient than most subsidy plans. Again, financial schemes and other incentives work best when supported by organisational structures. Landlords and commercial building owners have difficulty securing sufficient benefits from building improvement investments. Tailored tax breaks improve the cost/benefit ratio for building owners, and ensure that landlords, as well as tenants profit from investments.

> **Understanding is needed:** Particularly in the area of very low energy and Passive Houses there are a number of misconceptions among the general public as well as building professionals about their cost and associated problems. At the same time many of the benefits are not understood. To ensure a transition towards such buildings, these misconceptions need to be addressed.

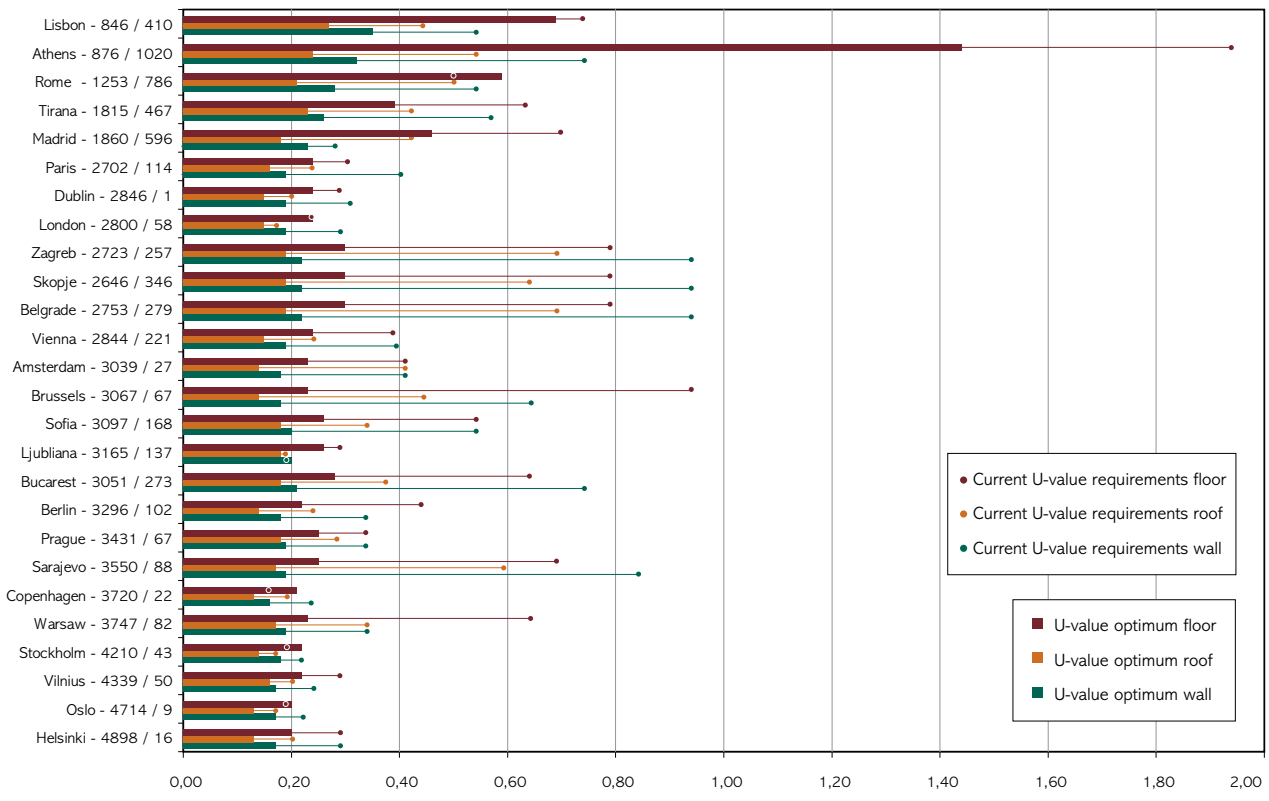
> **Buildings in warm climates need to be specifically addressed:** the study covers all countries in Europe and shows that the biggest gap between today's regulations and recommended energy performance are found in southern Europe. Given the lack of awareness of the role that insulation can play in reducing the need for cooling, there needs to be a major effort in southern Europe to raise awareness and bring building regulations in line with the findings of Ecofys VII.

BEHIND THE HEADLINES – GETTING INTO DETAIL

Better standards – how do European cities compare

The Ecofys VII study examined insulation standards from the perspective of U-values. The graph below, compares current U-value requirements in Europe for 25 capital cities (dots) and plots them against the values that would be needed to achieve a cost optimum situation. As can be seen, for most European cities the current standards are far from adequate. Although the building regulations are usually set at a national or regional level, it is clear that across the board there is need to significantly improve requirements.

Of particular interest is that the need for better requirements applies across the whole of the EU, from north to south and east to west. This convergence of need, suggests that there is a case to be made for developing a European approach to solving this problem. Moreover, as reducing energy use in buildings is critical to delivering common European goals including reducing dependence on foreign energy supplies, tackling climate change and ensuring Europe is competitive within the global economy, the case for EU action is clear.



BEHIND THE CALCULATIONS – HOW WERE THE CALCULATIONS MADE

Scenario 1 – A cost based approach

To examine appropriate U-values for Europe from a cost optimised perspective a number of elements needed to be defined. These included:

> Choosing appropriate energy price scenarios - two scenarios were used:

- **Scenario 1 - IEAWorld Energy Outlook (2006):** The International Energy Agency's World Energy Outlook price scenario was used as the base line. This scenario presumes a price of $46 a barrel of oil and evolution until 2036.
- **Scenario 2 – Peak price scenario:** This scenario takes the recent peak price of $70 a barrel of oil and uses this as the basis for the calculation. This takes into account a constant price until 2036.

> Defining an approach to compare upfront costs to long term cost savings: a standard lifecycle analysis was performed that presumed that the investments made for insulation would be amortised over a 30 year period (normal renovation cycle) and that roof, wall and ground floor insulation would be applied. In practice, insulation will last the lifetime of the building (i.e. over 70 years) and therefore this approach arguably underestimates the benefits from insulation.

> Setting an approach for the upfront capital costs: coupled capital costs were used so that the applied insulation is presumed to take place as part of a renovation or a new installation.

> Choosing the right regional mix: the study analysed 100 cities and it was important to ensure that the costs reflected the local conditions. To do this, the energy mix for heating, the different investment costs for local building constructions and of course the local climate conditions were included.

Defining Cost Optimum – Limits and Boundaries

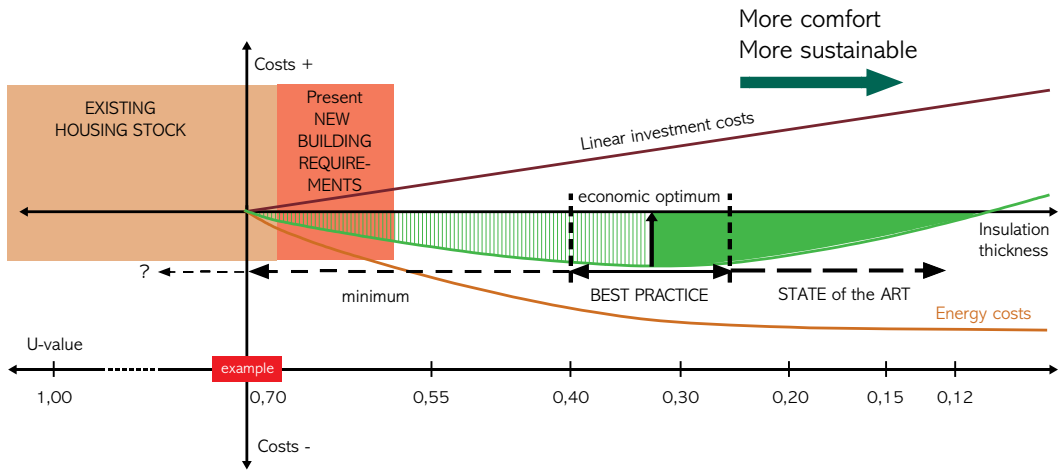
The green line on the graph below demonstrates the cost benefit curve (negative costs correspond to savings) for thermal insulation requirements based on subtracting the investment costs (red line) from the energy cost savings (orange line). The Best Practice Zone is the area where the total savings are at their optimum. Any U-value to the left or to the right of the Best Practice Zone, means that a home owner would be gaining less money over the lifetime of the investment. As the graph shows, most new building requirements in Europe are left of the Best Practice Zone and therefore costing home owners money and existing housing stock levels are significantly below the Best Practice Zone.

To understand how the different cost savings and investments costs work one needs to consider that:

> **No complimentary savings were included:** often when insulation levels are increased, it reduces the need for complimentary energy actions (i.e. a smaller boiler or no air conditioning unit). These cost benefits were not taken into account.

> **Pure cost no other benefits:** the calculation also does not include climate mitigation benefits or other societal benefits.

> **The impact of a flat line:** as can be seen from the graph, the area left and right of the cost optimum position is very flat, suggesting that a significantly increased level of insulation will still deliver an almost cost optimum situation. This is important when considering different climate policies as measures beyond the cost-optimum position, while still cost effective, will deliver even greater potential for reduction of greenhouse gas emissions.



Scenario 2 - A climate change approach

For determining what U-values are needed to achieve Europe's climate change objectives, the study took as a starting point the European Union's view that a 60-80% cut in emissions is needed by 2050. Based on this and given that buildings are the biggest energy user in Europe, that thermal insulation is the most cost effective climate mitigation measure and is readily available, Ecofys considered that it would be appropriate to assume that buildings should make an 85% contribution to the overall target. If we take into account the evolution of energy mix, the 85% target becomes 82%.

Based on this ambition level, the study considered what U-values would be needed for the European housing stock in order to achieve such reductions. As the study presumes that the normal renovation cycle for buildings is 30-40 years, to be confident to meet an 82% reduction by 2050, these regulations should be applied from 2010.

For both scenarios

> Climate conditions a basis for both scenarios: in order to understand the benefit that a given insulation level would deliver in terms of either reduced costs or reduced energy use, the report analysed the energy loss through the main building components wall, roof and floor for the climate conditions, (i.e. number of cooling degree days and the number of heating degree days) for the cities investigated.

> A component rather than whole house approach: Both the Energy Performance of Buildings Directive and the very low energy or Passive Houses approach consider the building as a whole rather than component by component. At the same time in most EU countries this overall integrated approach is complemented with specific requirements for components, including U-values for roofs, walls and floors.

The Ecofys VII looked only at components both in terms of setting energy performance requirements as well as examining cost-effectiveness. This was done to simplify the analysis but also because the starting point of an energy efficient building is the correct thermal envelope (i.e. walls, roof and floor). The McKinsey study confirms the fact that thermal insulation is the place to start and Ecofys VII aims to explain where to go or more precisely where is the optimum level of insulation to achieve Europe's climate goals and best economical result.

A component approach is also important for ensuring that the renovation of existing buildings is appropriately addressed, as often when renovating an existing building it is common that a single component is changed at a time rather than the whole building. In such circumstances it is critical to have component requirements to ensure that these are done in line with climate and cost objectives. Ecofys VII provides such information, as the cost curves are also valid for renovation, given that once a decision has been taken to improve or install insulation, what is of interest is what amount of insulation would provide a cost-optimum solution.

To download the full report visit: www.eurima.org/europeandU

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European Insulation Manufacturers Association

Avenue Louise 375, Box 4 • BE 1050 Brussels, Belgium

Tel +32 (0)2 626 20 90 • Fax +32 (0)2 626 20 99 • www.eurima.org

design: www.morris-chapman.com

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