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Building resilience through building codes
Secondary Level Requirements for Heating
and Cooling in European Building Codes

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Introduction

Requirements for the overall energy performance of buildings is a proven way to reduce the overall energy consumption in buildings and is the central element of the Energy Performance of Buildings Directive (EPBD). In combination with cost-optimality, energy performance has been a main driver in the development towards nearly zero energy buildings (NZEBS) in new constructions.

European Member States (MS) revise their energy performance regulations every 3-5 years. Half of the Member States have renewed these requirements over the last year (2015) and further building codes are being renewed this year (2016). This progress shows that Europe is taking positive steps towards having efficient overall building performance and nearly zero energy requirements.

However, energy performance and cost-optimality do not make a distinct separation between buildings elements with long lifespans and building elements, systems or automatics with a much shorter lifetime. Neither do they directly reflect the possibilities of later upgrading a building elements or building systems.

Buildings as such and most individual building elements have a lifespan of typically between 50 to 100 years, much longer than technical supply and distribution systems, including integrated renewable energy systems. Most building parts are difficult to improve after the building has been constructed. It can further be challenging to secure and maintain good performance based on systems and renewable energy for the whole lifetime of a building.

Therefore, even with today's price signals, focusing exclusively on energy performance and cost-optimality could lead to sub-optimisations of systems or renewable energy and leave buildings (the building envelope/fabric) with a low quality and/or efficiency. This could have a significant, negative impact on the performance of buildings for a very long time and it could lock-in energy efficiency potentials, even beyond 2050.

Secondary requirements for heating and cooling energy demands, set as maximum losses or gains, is an effective way to complement overall energy performance requirements by construction and is the way building codes can secure high efficiency at low costs over the whole lifespan of a building. This is described as *the 'energy efficiency first' principle*; reducing the energy demand of a building before finding smart ways to provide energy needed, including the use of active renewable energy sources. Improved building fabric is also a successful way to improve a building's resilience to climate change.

This study has been conducted by 2peach to identify the current nature and level of secondary building requirements for heating and cooling demands in Member States of the European Union, and to understand the main reasons why such requirements are in place. This paper highlights the findings and main conclusions of this study.

Heating and cooling is the largest end use of energy in Europe and in 2012 accounted for 50% (546 Mtoe) of Europe's final energy consumption.¹ Residential buildings are responsible for the largest part of the energy used in the European building sector. Heating and cooling is the dominant energy use in these buildings, with 85% of the total final energy consumption in the residential sector in Europe used for heating and cooling.² This study has therefore focused on the approach MS have taken to set secondary energy regulations for residential buildings.

Start prescriptive, develop towards performance

Most building codes started using prescriptive values setting maximum U-values or minimum R-values for the most essential building parts and only for new constructions. These codes offered straightforward guidance for constructors and advisers in the construction industry. Over time, the levels of U-values were tightened and reduced and many energy saving gains were seen by using these minimum values, this helped to standardise new constructions.

However, by time these prescriptive requirements became too restrictive, reducing the diversity of options for improvements and of the most optimal solutions. Countries therefore moved towards trade off codes or maximum heat losses to make their rules more efficient and cost-optimal. This allowed for more flexible solutions. Over time, building codes began to include technical systems first as maximum or minimum performance values for building parts and then as overall energy use in new construction expressed by the amount of energy to be supplied for heating and cooling.

The latest trends, especially in Europe, have moved towards overall performance based energy codes, which allows for maximum flexibility and use of the most cost-optimal technologies. Overall performance based energy codes are a key element of the Energy Performance in Buildings Directive and allow for the best and cost-optimal combination of, good building performance, sophisticated systems and renewable energy. They make it possible to find the most cost-optimal way to reach a certain level of performance, expressed as external supply based on fossil fuels.

When moving towards buildings that are nearby zero energy, overall energy performance demands for new buildings expressed in energy use or environment values need to be one of the corner stones, especially in combination with cost-efficiency.

Buildings have special needs

Buildings have the longest lifetime of normal commodities, especially the building fabric. Mistakes or wrong decisions made during the construction of the buildings that leaves opportunities for savings untouched in connection to building fabric can influence energy through a very long time.

The building fabric in particular is difficult to modify or improve after construction. Some parts can only be changed when large renovation or reconstruction projects are undertaken, however it might not be feasible to improve or upgrade other parts at all as the corresponding costs might be far too high compared to the energy and cost savings and value of the building. In some cases, it might be more rational to demolish the building rather than to improve it even if this is an unsustainable use of existing infrastructure. Once built, these building structures are difficult to improve or change.

Buildings fabric that are not energy efficient can further lead to other complications such as moisture problems or bad indoor climate, this can significantly impact comfort and have health implications. Correction of these problems, using measures to ensure efficiency can be costly and can significantly impede energy use. It is therefore essential to ensure a sufficient quality of building fabric when constructing, renovating and providing extensions to a building.

Focusing solely on cost-efficiency and the overall energy performance could bear the risk of building energy efficiency being optimised in a way where significant opportunities for optimising the energy efficiency of the building fabric are untouched and hence lost. As it is

difficult to make these improvements later, this could lead to the lock-in of large energy saving potentials.

Especially since some savings from technical systems, automatics and in some cases renewable energy can be very cost efficient, this could lead to an increased lock-in of building fabric efficiency if cost efficiency and overall energy performance are the only guidance.

As the setting of cost-optimal levels takes time and tends to lag behind the best options, it provides an opportunity to substitute savings in building fabric with better systems and renewable energy sources, which are more efficient than the expected levels and which present a cheaper option. The cost reductions for such measures, for example from onsite renewable energy supply, can impact the general efficiency substantially and also prevent the building from obtaining the maximum impact of efficiency in the sector.

There is therefore a need for specific measures to ensure the building fabric is efficient, especially since technology is developing fast and there is great focus on nearby zero energy buildings. Such regulations should build on the energy efficiency first principle and also provide guidance for energy efficient and intelligent building design. These systems are based on the idea of avoiding energy needs rather than supplying such needs in an efficient and sustainable way.

One of the key principles in this is Trias Energeticas³, is the focus firstly on reducing energy needs for heating, cooling and other energy needs in buildings including lighting. The second focus is on producing the energy needed using sustainable energy sources including renewable energy sources and then as a third element, to supply the remaining energy needed using fossil fuels that are as efficient as possible. The Trias Energeticas principle is described in a later section.

Other principles that secure resilient and holistic buildings can be described as Integrated or Intelligent Building Design.⁴ Examples of integrated intelligent design, intelligent or optimised buildings design can include 4 – 10 different steps. Some of the first of these steps is avoiding energy needs through good design, good energy efficiency of building fabric and optimal use of passive energy. The integrated or intelligent design principles are further illustrated in in a later section.

Methodology

This project looks into the trends in European Member States and attempts to find out how building code requirements for the building fabric are implemented in individual Member States. The study provides the overall background on current legislation relating to secondary building energy efficiency requirements across Europe.

The study does not claim to act as a statistical report on European building code requirements; it has been developed to investigate what the general trend is in Europe and why such secondary legislations for the building shell are implemented.

Building requirements are changing fast and, over recent years, building codes have been regularly updated, especially in 2015 and 2016. These revisions have been adopted in MSs as a part of their overall NZEB strategies, required by the EPBD from 2020 onwards. The latest EPBD Concerted Action Book,⁵ issued in 2016, focusing on trends up to 2014, includes country specific reports that provide details on each Member States' energy requirements, as set out in their building codes.⁶ This has been a valuable source for the project and also some of the existing databases.

On the other hand, the same book's Core Team Reports document that almost half of all European building codes were to be reviewed in 2015, and further a large group should be in 2016. The study therefore had to collect information directly from the new building codes, to ensure that the rationing is based on the latest trends.

Initially, some desk research was undertaken to look into existing material on the topic of energy efficiency requirements, such as the Concerted Action Book, the BPIE data hub for energy performance⁷ and the IEA energy efficiency database⁸. Research was then performed based on recent legislation, looking into new requirements that have been introduced within the most up-to-date building codes. The background research for the regulations and requirements, especially secondary demands, was undertaken in the building codes themselves, but also in different recent published material as aforementioned above. Briefly, material was collected from other sources and from local organisations to secure that important side legislation was not neglected. Finally, the information on requirements in building codes were controlled by local actors, including some member organisations of EURIMA. It was however not the intention to make a deep review of all European building legislation.

The study further focuses on new construction and on residential buildings, as these are, generally, the largest part of the building sector in the EU and the type of buildings where the building fabric actually has the largest relative and total influence on the energy consumption. Some of the codes also apply for commercial buildings and the trends from the study might also apply for non-residential buildings, but this has not been tested specifically in the study.

Additional parts of the research were to find out why such secondary requirements have been set and what the main drivers are. The study attempted to be wide ranging and to include many different types of countries and climates as well covering a very significant part of the construction of new residential buildings in the European Union. This study does not however claim to be exhaustive, as this would require intense research into the background of every European country and also to include the missing circa 10 countries and regions.

The EPBD and country legislation generally focuses on the overall building performance and requirements that ensure the development of buildings towards NZEB demands, as requested by the Energy Performance of Buildings Directive.⁹ It could therefore be expected that requirements for buildings tend to move away from such prescriptive requirements for the individual parts of the building shell and other demands for the building fabric (building or climate shell) and that such a trend would continue also into the future. The study tried to encompass such a development.

Reasons for the building shell requirements

A part of the project investigated the reasons why secondary requirements for the building shell have been set. However, the reasons for setting such rules are not always known, documented or publically available. Only in few cases, are they part of the building code for energy efficiency or directly documented in this, mostly they have to be reasoned when looking at the country strategies or general building legislation. Often these reasons may not even be documented or available in a country's open sources.

The research for this report therefore focused on getting the general picture of the reasoned requirements in place, rather than to document this in a detailed manner for each individual Member State based on extensive research.

Countries have adopted their secondary regulations for different or for multiple reasons and in some cases it seems as though the regulations for the building shell are set based on many

different reasons, based on a long history of building codes, and also on traditions. The results encourage for increased focus and further documentation of these reasons as they have a large impact on how buildings function, the understanding of comfort and values, as well as long-term aspects of a buildings' lifespan.

However, in a few cases, reasons are indicated directly, for example; requirements for comfort or health reasons, that is stated in direct connection to the maximum U-values or maximum values for line losses.

Overview of current national regulations

Twenty-five building codes for countries and regions were included in the research. They all focus on the building fabric in some way, but the secondary requirements for building fabric vary significantly among these Member States.

The different options chosen by each MS are illustrated in the following table¹⁰.

Table 1. Secondary requirements for heating and cooling in different countries and regions.

Choice by country	Maximum Heat Losses / Gains	Maximum U-values	Maximum Overall U-values ⁱ	Other Options
Austria	X	X		
Belgium (Brussels region)	X	X		
Belgium (Flemish Region)	X	X		
Belgium (Walloon Region)		X		
Bulgaria		X		
Check Republic		X		
Denmark	X	X		
Estonia	X		X	
Finland		X		
France ⁱⁱ				X
Germany	X			
Hungary		X		
Ireland		X		
Italy ⁱⁱⁱ				X
Latvia	X	X		
Lithuania		X		
Luxembourg		X		
Netherlands		X	X	
Poland		X		
Portugal	X	X		
Romania	X	X		
Slovenia	X	X		
Spain	X	X		
Sweden ^{iv}	x	x	X	
UK (England & Wales)		X		

ⁱ Overall U-values are calculated as a sum of U-value * area / total floor area.

ⁱⁱ France has a strong focus on Bio-climatic design and this includes the requirement for each building to deliver a bio-climatic report.

iii Italy includes U-value requirements in their overall calculation process, these are compared with a model building. These values can however to some extent be traded off against other improvements.

iv Sweden has U-value requirements only for very small buildings and maximum heat losses only for electric heated buildings.

There are three preferred options for the regulation of building fabric:

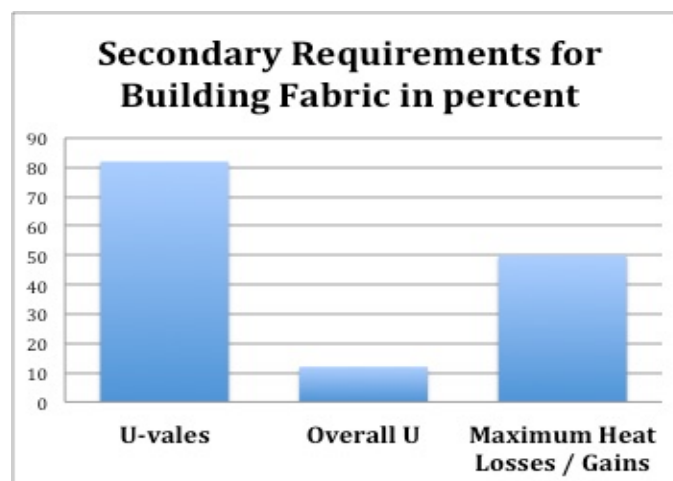
1. Maximum U-values,
2. Maximum overall U-values; and
3. Maximum heating losses and/or gains.

Often these are further supported by requirements for thermal bridges¹¹, maximum line losses¹² (losses between building parts) and requirements for minimum airtightness,¹³ as a way to ensure good quality and efficient buildings. Thermal bridges can be set as either separate values or as part of the total value for a building part, meaning that the u-values on average includes such parts. Line losses are however most commonly set as additional values. Requirements will often include these as well a maximum value and means to verify these values. Thermal bridges, line losses and airtightness become increasingly important as the energy consumption develops towards nearly zero energy levels.

Mainly, these requirements are based on requirements for major elements of the building shell, which have to be fulfilled on top of the requirements for the overall performance values for the whole buildings. These typically include at least walls, roofs, floors and often windows. In many cases these requirements also includes; values for doors, roof windows, walls towards ground, (cellar walls), cellar floors or multiple versions of building parts (for instance light or heavy construction).

Some countries work with a combined average U-value per floor area. This overall U-value is often calculated as the sum of the product of the individual U-values and the area of these divided with the total floor area of the residential building. This maximum value has then to be complied with the overall performance value. If the value is low, this automatically ensures high requirements for each individual part of the building fabric.

Figure 2, The use of different options in MS, as a per cent.



Values in this figure represent the number of building codes where these options were found in per cent of the total investigated codes.

The reasons for using each of the three options are different. U-values are mainly used to support a good indoor-climate and provide healthy buildings, by ensuring a high surface

temperature and reducing moisture problems. These U-values are often combined with values for thermal bridges and airtightness requirements. Maximum heat losses/gains are generally used to ensure good building fabric and low energy demand, while the overall U-values can contain a mixture of these two reasons.

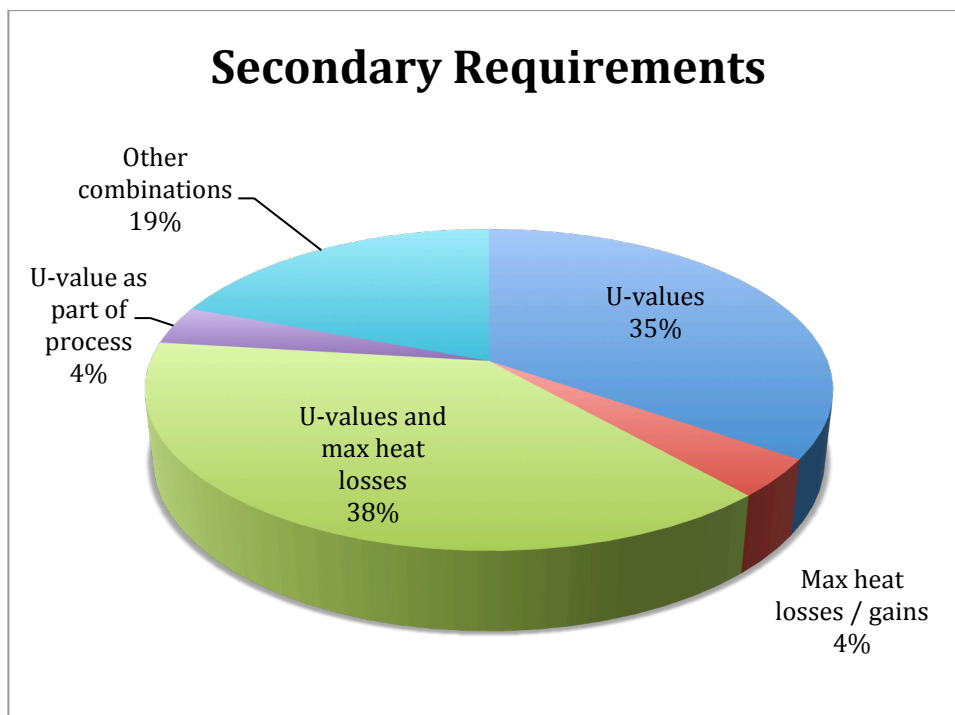
More than 80% of the building regulations have set minimum U-values to support the overall performance values and to ensure a minimum quality of the different building parts. This puts a strong emphasis on the quality of individual parts of the building and in particular walls, roofs, floors and windows.

Half of the Member States recognise the need for secondary requirements for heat losses and/or gains (Heating and Cooling Loads) in order to ensure good and efficient buildings over the building's whole lifetime. They have therefore set requirements for heat losses and gains as a secondary requirement on top of the overall performance requirements. These MS are spread out over Europe, but with a higher tendency in the northern and colder climates.

A few countries, similar to 12%, have overall U-values, which sets emphasis on the individual building parts, but still give some room for trade off between these. Countries who have set these overall U-values usually set them low, this therefore means that the actual possibility of trade off is very small, and all included parts; walls, roof, floors and windows need to have very low U-values to obtain the overall value. These come close to setting U-values for each part, but still do not leave much flexibility.

As it can be seen from the numbers in Figure 2, most countries or regions find that one of these options cannot stand-alone and they have set multiple options at the same time. Often, it is exactly these countries that also set maximum values for line losses, thermal bridge values or airtightness requirements. Figure 3 further shows the choice of countries based on these different options.

Figure 3. Illustration of the share of these different options and combinations.



The largest group of countries (38 %) combine requirements for maximal heat losses and heat gains and U-values for the individual building parts. Only one country has chosen to have only

maximal heat losses and/or heat gains as a requirement for the building shell and one country has chosen to have maximum values for heating, cooling and lighting.

The second largest group of countries (35 %) have secondary requirements in place, based on U-values for the individual building parts as the only option. These are typically set for major components such as walls, roof, floors and windows, but sometimes they are also set for additional building elements such as cellar walls, different type or roofs and different types of floors or outer walls, glazing areas or for cellar walls and floors.

One country (4%) only has U-values set as part of the process, giving a possibility to trade off with improved efficiency of other parts. The rest of the countries (19 %) have chosen to have a mix of different options such as overall U-values combined with either U-values or maximum heat losses/gains. One of these countries has chosen to combine all three. Another country further chose to combine a maximum value for heating, cooling and lighting.

The importance of these requirements is shown by the fact that all Member States recognise need for secondary legislation for the building shell at least for the residential building stock and that more than half of the countries have a combination of multiple options.

The initial focus should be to ensure a country has a good, efficient building stock and then that the overall energy use is moving towards nearby zero energy. It also includes many of the reasoning mentioned in the above section. None of the investigated building regulations have fully neglected the need for efficiency of the building shell, at least not for residential buildings. Compared to traditional building codes (pre EPBD) the focus on U-values and overall energy losses seems to have reduced (as these were key regulation in the past) and this could of course change further once the overall performance regulations mature.

The different types of options such as total heat losses and gains, overall U-values and individual U-values fits with different rationales, but comfort and health reasons are probably the most recognised factors, which correspond to the fact that U-values are the most commonly used option. U-values however support most of the rational mentioned above.

The individual types of measures

The individual types of secondary regulation for the building fabric all link to the standard procedures for calculation, which is used in all of the member states. They just link to different stages of this process.

Energy calculations for new residential buildings in all Member States include U-values and often the calculation of energy losses through all building parts starts with exactly area and U-values for the individual building parts. U-values therefore play a central role in the establishment of the overall heat losses or gains.

The next step of calculation takes into account the energy impacts of ventilation and gains by solar, internal heat gains, and other passive measures to create the overall heat and cooling needs for buildings. For most countries, these rules are more or less directly based on the CEN standards developed over the last 10 years.¹⁴

For some countries their energy needs are compared to a model building, which has the same shape, size and basic construction. Energy needs for a model building is calculated based on predefined U-values and other predefined characteristics. The actual requirement of the designed building needs to be better than the reference building. Examples on these model-building calculations are found in Germany and Italy.

Results from the calculations of the building fabric are then transformed into overall performance by calculations, which include efficiency in technical HVAC systems, automatics, and renewable energy sources etcetera. These calculations vary more and are usually adapted to national circumstances and the way the overall performance values are set.

The above secondary regulations for the building fabric are therefore all based on natural steps in the calculation process, which is anyway needed for the overall energy performance regulation. Values for each of these levels are included in the process either as input or as results in the first level of the calculations or can be found by a simple division with the floor area. Comparison with the values therefore requires very little effort from the constructors/advisors as well as the authority to control. Actually, they might even function as help or a check in this process.

U-values

There are multiple reasons to choose U-values, part of these are linked to traditional building codes that are based on prescriptive values, but U-values also have a merit of their own. First of all U-values can help to avoid moisture problems and other indoor quality issues. These are both linked to health and comfort and for many countries these qualities have been important both in the past and by setting the recent regulations.

U-values further have the benefit that they are easier to understand and to enforce than overall performance values for many of the actors. Especially for small constructors and in simple buildings these can be a means to regulate without too much complexity. In Sweden, the values are therefore used as a requirement only for very small and simple buildings (below 50 m²) and they are often linked to improvements and additional building works in many countries.

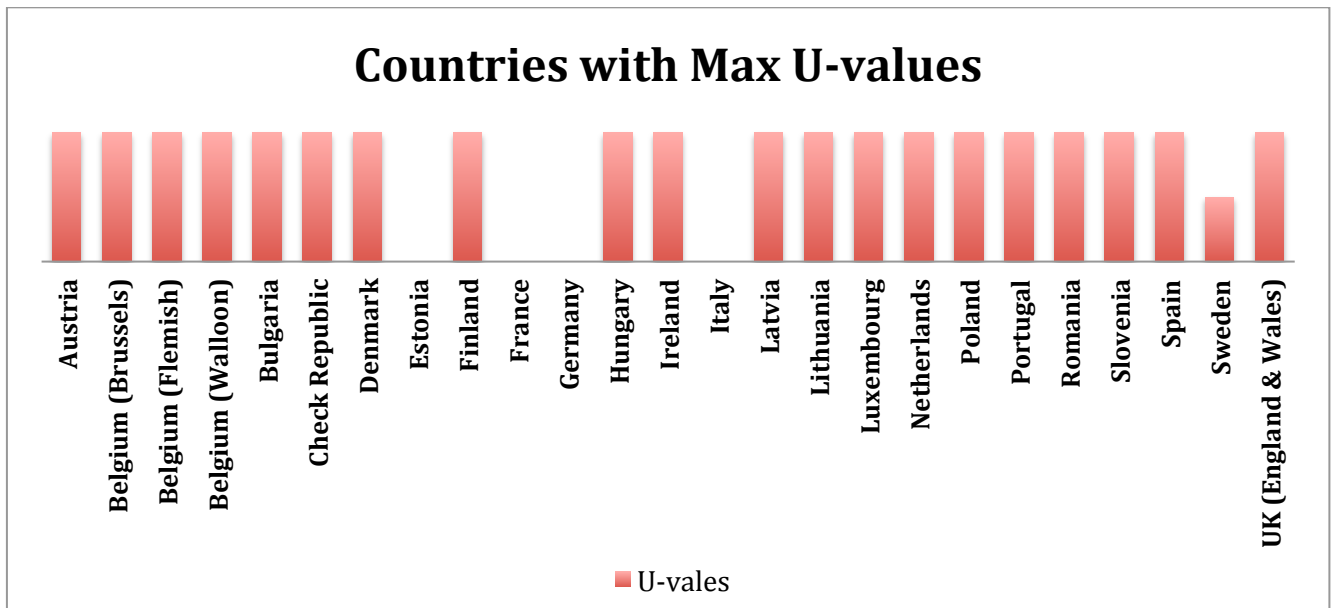
In combination with the long history and also educational initiatives U-values are a natural part of the building codes. This accounts in particular for northern and cold climates where these values date back to at least the 1930s and 1940s, when the first thermal regulations were set for comfort and health reasons.

U-values are further seen to be able to support some harmonisation and also simple guidance for especially smaller constructors and building owners. Countries often support these with simple guidelines on how to make constructions that fulfil these U-values for the individual parts.

These reasons are often integrated as part of the regulation, linking exactly the codes to comfort or health reasons. They also help to support a minimum performance of the building fabric, but this effect reduces however to a more limited importance as the overall performance goes towards nearby zero energy.

Many of the countries and regions have recognised the benefits of having U-values as part of the regulation and as much as 82 % of the tested countries were setting such maximum values as part of the secondary requirements.

Figure 4. Illustration of the countries that have maximum U-values.



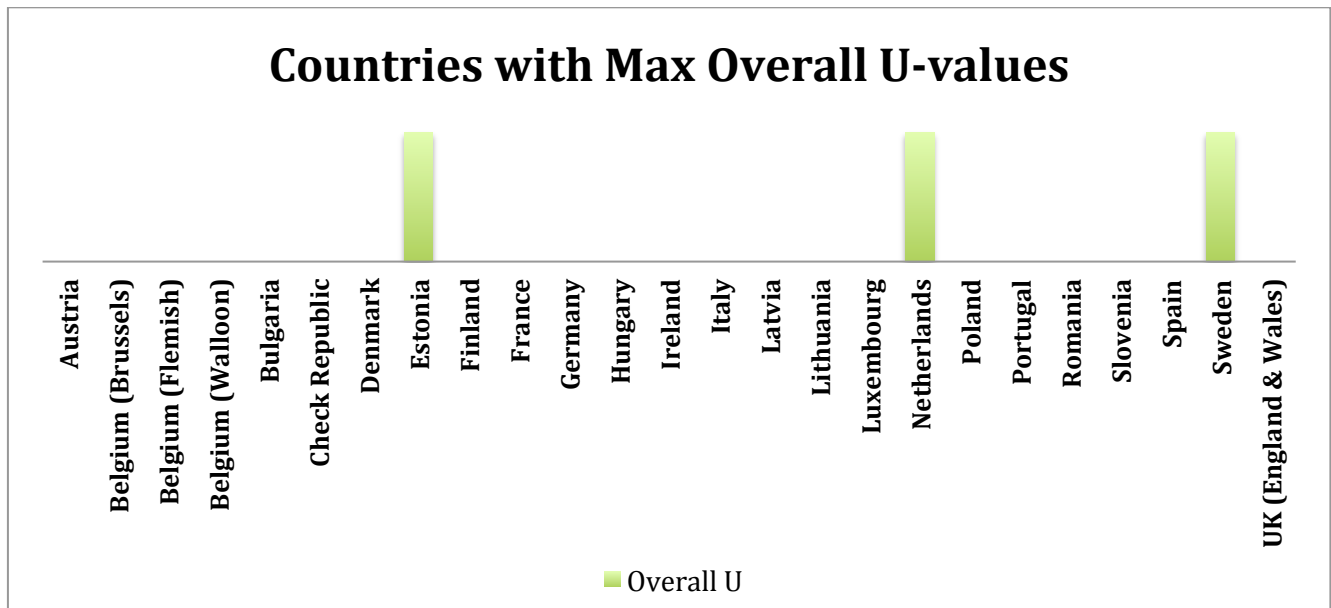
In many countries the U-values also serve as reference and demands for very small buildings or extensions where handling of overall energy performance might be too complicates. U-values further serve as an indication for improvement or smaller renovation works.

Overall u-values

As trends go towards higher and higher efficiency of the building stock and as U-values decrease towards very low values, these seem to become too binding for the industry and they need to be replaced by systems that gives more flexibility. Some countries have in this process chosen to opt for overall U-values, setting combined U-values based on the floor area.

These U-values reflect both the thermal resistance of building parts and the form or ration between surface and floor area. In dense and compact buildings it is easier to fulfil these maximum requirements. Typically they are calculated as a wedged value for the main U-values for walls, floors, roofs and windows, based on the size of the different building parts in m². The overall U-values are indicated in losses in watt per m² per kelvin similar to traditional U-values. Countries using maximum overall U-values can be seen in Figure 5.

Figure 5. Illustration of the countries using overall u-values.



As most of these set U-values are very low (around 0,35 – 0,4), as sum of the different building parts, this actually request very low U-values for all parts. It does however allow for some trade off between, for instance, windows and other building parts. The U-values are typically set to include line losses and/or other thermal bridges, making the values even stricter.

In general the overall U-values are calculated based on a total heat loss or heat gain calculation, which is then divided by the floor area. In this way these values come close to the same result as the maximum heat and cooling requirements, where the total heat and cooling loss is often calculated as a value per m² floor area multiplied with the floor space, but then often corrected by the heat gains through sunlight and internal loads.

Maximum heat losses and / or gains

The last set of calculated values for the building fabric is set as maximum values for heating and cooling losses. These typically add the total losses of energy, which needs to be supplied, plus the heat gains, which needs to be removed. Normally the heat gains and losses are corrected by passive measures allowing for use of natural heat gains and/or natural cooling.

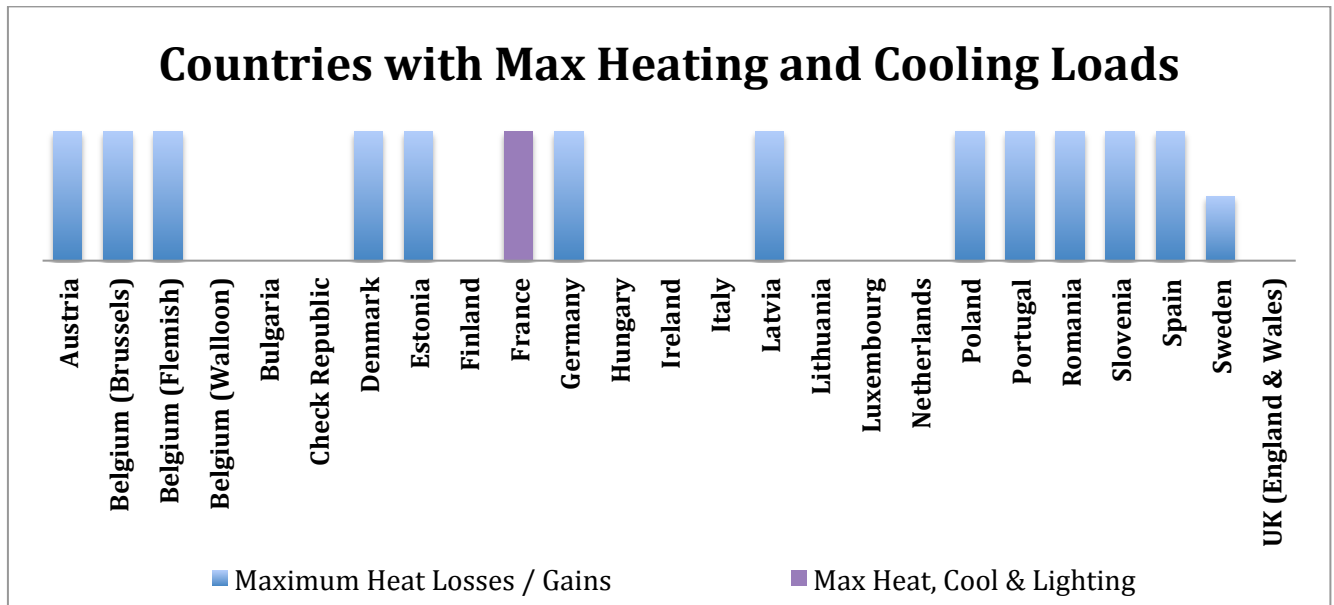
These values reflect the last levels of calculation of the building fabric including passive measures. In other words, they simulate the reaction of the building before technical HVAC systems are added and the active heat and cooling loads that need to be supplied by these.

Heat losses are often compensated by heat gains in cold climates, while heat gains through sunlight and internal loads cause a specific problem in hot and cooling-based countries or climatic zones within a country. Heat gains are therefore the main focus in these areas.

Maximum heating and cooling loads gives a large possibility to trade off different measures, which can include increasing or decreasing windows size, avoiding heat losses, avoiding or optimizing heat gains, depending on needs. It also allows full flexibility to optimise specific building parts and use of passive measures.

More than half of the countries (50 %) and regions have chosen to use such requirements directly as secondary requirement in the building legislation for new residential buildings.

Figure 6, Illustration of countries with maximum heat losses and / or gains:



The French requirements set maximum values for heating, cooling and lighting needs all together. This gives the possibility of optimising windows for both heat gain/protection and for use of optimal day lighting. Sweden is marked as half because such requirements only account for buildings with heating based on electrical sources, including heat pumps.

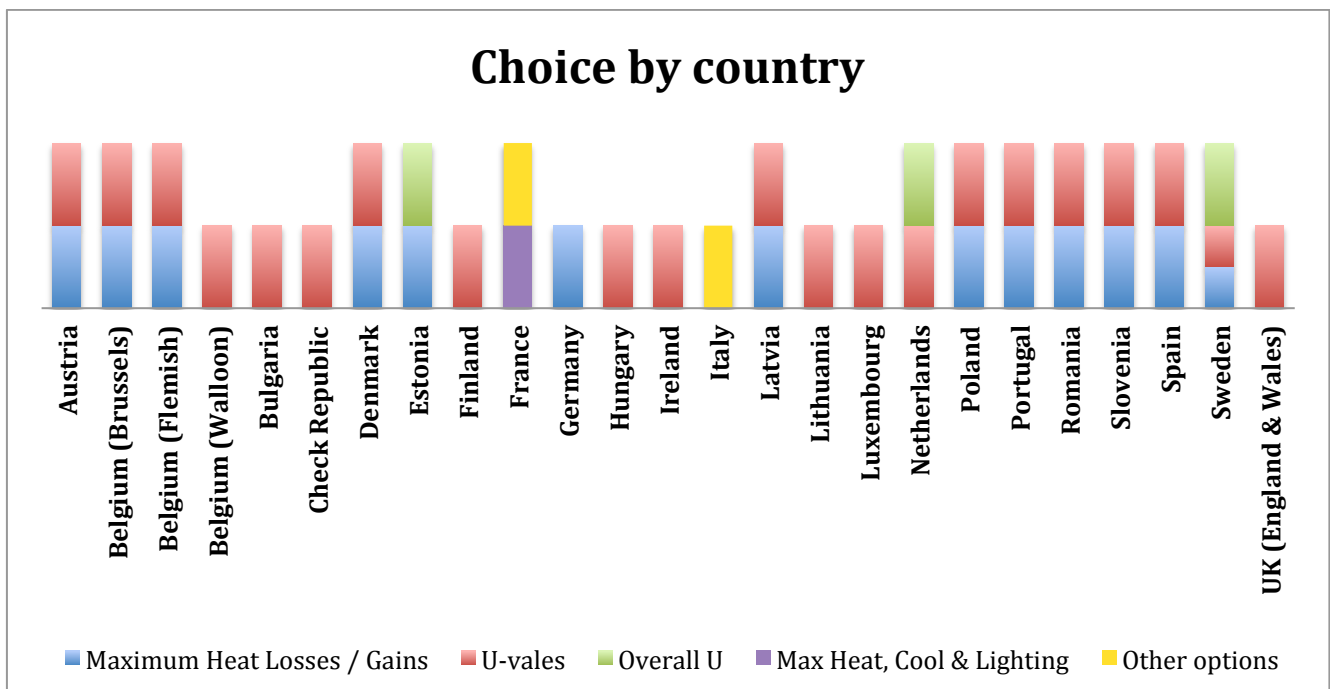
Using maximum heating and cooling needs gives the maximum flexibility for regulation of building fabric and also the maximum control of different elements as both active improvements of building parts, thermal bridges and passive measures can be fully integrated. These method can therefore include all elements of the building themselves and allow for the latest integration of the saving potential.

Combining multiple measures

A very large proportion of the countries combine multiple requirements for the building fabric. It is especially popular to combine maximum U-values and maximum heat losses and/or gains. This group counts for 38 % of all the countries investigated.

Further a few countries combine U-values and overall U-values; or overall U-values and maximum heat losses and/or gains. Figure 7 illustrates the overall choice by countries and especially the countries, which have chosen multiple options.

Figure 7. Illustration of Member States' choices of secondary requirements.



Many of the countries, which already combine multiple requirements for the building fabric, also combine this with specific demands for thermal bridges and requirements for airtightness testing. A large group of countries and regions therefore indicate that there is a need for multiple sets of requirements to ensure an appropriate quality of the building fabric.

As these values are used in the general calculation of energy performance, the need for additional work by advisors and construction companies are deemed to be minor. Similarly, these secondary requirements for buildings can in many cases help the authorities in the control of compliance as the secondary values often are easier to understand and control as the total overall energy performance.

Many countries see the need for multiple demands, where U-values help to ensure a good indoor climate and healthy buildings, while demands for maximum heat losses support and ensure good quality buildings in general.

Countries with multiple secondary demands for the building fabric are also often among those who set requirements for airtightness and focus on thermal bridges. These countries therefore seem in particular active around the quality of buildings.

Some special exemptions

Sweden

Sweden has different regulations for different buildings. One of the key elements in these regulations is overall U-values, which supplement requirements for overall performance. Further, there are special rules for eclectic heated buildings including those with heat pumps, where special requirements for maximal heating and cooling demands are applied.

Furthermore, the Swedish requirements are adapted to the different regions of Sweden and values are set different for these 3 climatic zones. Sweden also has a strong compliance regime, which includes post occupancy regulation and special ways to promote zero and nearby zero energy buildings.

France

France has an approach that is fully based on bio-climatic design; integrating heating, cooling and lighting needs, with recommendations for the minimum performance of the building fabric. The process includes special bioclimatic indicators and reports, which apply for all buildings. Values are set as a bioclimatic coefficient, $B_{bio_{max}}$, for heating, cooling and lighting depending on the bioclimatic conditions for the building.¹⁵

Values for different zones of France are set based on heating and cooling degree-days and also on the altitude of the constructed buildings. U-values and other specifics the French system highly rely on recommendations and the involvement of different privately organised actors including the industry.

Italy

In Italy, the building legislation has recently changed and new legislation is coming into place. These highly rely on energy performance and on model buildings. A very central part of these instructions are based on U-values and these are modified for the different climatic zones of Italy.

A special case for Italy is that the major inhabited parts of the country change from clearly heating based regions to highly cooling based regions, but with a very significant variation from summer to winter. The many regions of Italy therefore play a central role in building codes, which are differently implemented in each of these. The basic rule is that national rules need to be adapted in case no regional specifications are developed.

It has not been possible in this study to analyse each of the regions in details. Italy is therefore highly represented as other options, which could change by deeper studies of these regions.

Very small buildings

The directive on Energy Performance in Buildings allows for some exemptions from the general rules and for residential buildings these are in particular buildings with less than 50 m². Many other countries follow the Swedish example where these small buildings (under 50 m²) and very small extensions are exempted from the general rule for energy performance calculation. In some of these countries U-values are similarly used for guidance or control of such small buildings or extensions.

Recognising intelligent design

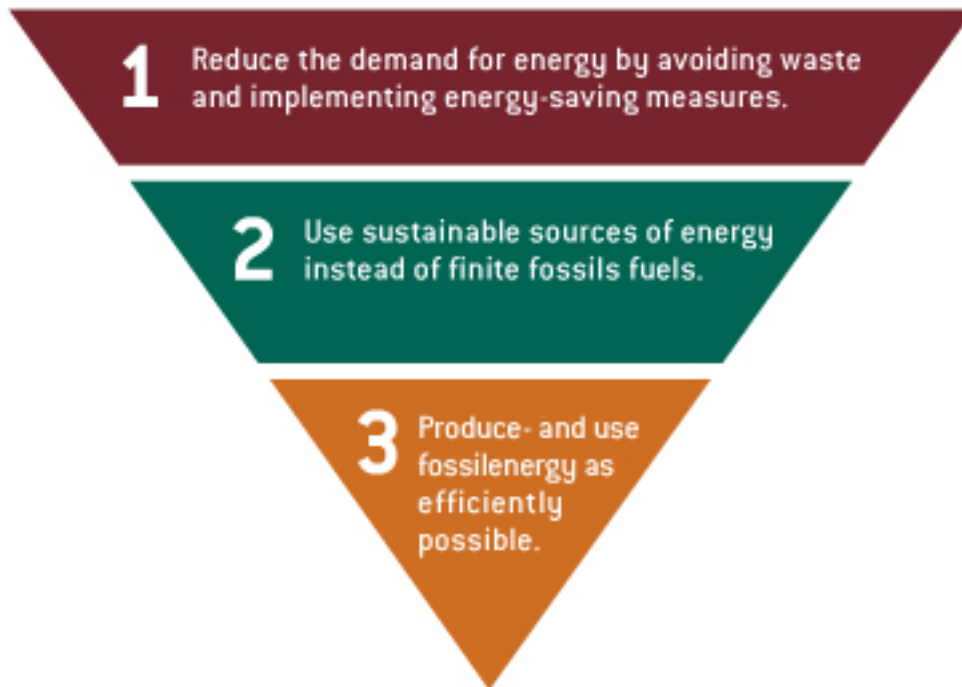
The setting of secondary requirements for building efficiency documents the understanding of the need to ensure energy efficiency is a first priority, especially for the building shell. It therefore supports the different design guides focusing strongly on passive design, Trias Energeticas and integrated or intelligent design.

Trias Energeticas

Trias Energetica is separated into 3 parts illustrated by a triangle or an upside down pyramid with 3 steps.

Figure 8. Trias Energetica Illustration. (EURIMA)

The Trias Energetica concept:
the most sustainable energy is saved energy.



This illustration is sourced from EURIMA¹⁶ and shows the Trias Energetica as a process where the highest emphasis is made on the first part where energy consumption is reduced through passive measures.

Maximum heating and cooling requirements are linked to the first part of the Trias Energetica and supports that this first part is given significant attention throughout the construction chain.

Intelligent design

The energy efficiency first principle can also be developed into good energy performance in different steps, sometimes referred to as Integrated or Intelligent Design of Buildings. This type of system can be illustrated in many different ways, but typically has at least 5-7 steps.

These steps are:

- An efficient building through the design of the building itself including form and shape (*avoid energy needs*)
- Efficient building components (*reduce energy demands*)
- Passive design features, which reduce the need for energy use (*substitute energy use*)
- Optimisation of the energy balance including reuse or avoiding of internal loads (*right balance*)
- Efficient supply systems and technical systems in general (*efficient supply*)

- Supply with as much renewable energy as possible (*use renewable sources*)
- Reduced the impact of the use of fossil fuels (*clean energy*)

The first three of these steps will ensure that a building's energy needs are low using the right balance of low energy demand by an energy efficient building shell combined with use of passive energy to heat, cool or ventilate buildings.

The second part will ensure that energy is not wasted in the process of supplying or destitution of energy. Further, wasted energy should be reused as much as possible.

The last two steps will ensure that the rest of energy will be supplied by renewable energy or as clean a fossil fuel as possible. The mean is to ensure the remaining energy is supplied as sustainable and clean as possible.

Integrated design also calls for strong collaboration between the different actors in the design process (an integrated team) and generally they include revisions and interactions between the different parts. In some systems this is described shorter (perhaps in 4 steps) or in longer versions, with 10 or more steps.

Secondary building codes for the building shell supports the first and perhaps the second of these steps. A set of maximum U-values will primarily support the first step, while an energy frame can support both the first and the second step.

When both the maximum energy losses flow and/or heat gains are part of the regulation they strongly support the first three steps on this list.

Maximum heating and cooling requirements are linked to the four first steps of this intelligent design chain and supports the first part being given significant attention in all parts of the construction chain.

Key findings

- **Requirements for energy performance are a good way to reduce overall energy consumption and move to NZEB.** Requirements for the energy performance of buildings are imperative to reduce the overall energy consumption in buildings and have been the main driver in the development towards NZEB buildings.
- **The building envelope needs to be optimised before upgrading the technical and renewable energy systems.** Overall energy performance requirements can however lead to optimising technical systems and renewable energy without properly reflecting the needed efficiency of the building itself. This can lead to an insufficient quality of the building itself and decreased energy efficiency over time.
- **Overall performance needs to be complemented with secondary requirements on heating and cooling.** Secondary requirements for heating and cooling support high quality and efficiency of buildings. This combination of requirements is the solution to secure efficiency, comfort, and low energy use throughout a building's lifespan.
- **≥90 % of MS have set requirements for the building fabric.** MS generally recognise the need for secondary requirements; more than 90 % of all MS have some kind of specific requirement in place for the building fabric, at least in the residential sector.
- **≥80 % of MS have set U-values for building parts.** More than 80 % of the MS use minimum requirements to ensure the efficiency of building parts in form of specific maximum U-values. These are primarily set for comfort and health reasons, to support good indoor climate and to avoid moisture problems.
- **50 % of MS have set requirements for overall heat losses/gains.** Around half of MS recognise the need to set requirements for overall heat losses and/or heat gains for the building in order to secure the quality and efficiency of the building fabric. The main reason is that buildings stand for a very long time, usually much longer than technical supply systems, including integrated renewable energy systems.
- **Many MS recognise the need to complement overall performance requirements with maximum values for losses/gains as well as U-values for individual building parts.** Often, these requirements become more stringent as they move from building parts to the whole building fabric and then to overall energy performance.
- **Secondary requirements for heating and cooling are easier to understand.** It is further recognised that secondary requirements for buildings concerning heating and cooling can be easier to understand for small enterprises and building owners; these can also be easier to enforce.
- **All member states have a calculation procedure that calculates the heating and cooling needs first.** All MS require a calculation of heat losses and heat gains. In some cases, these are compared to a fixed maximum. In other cases, these are compared to a model building or just used for the overall energy performance calculation; which could however easily be turned into a fixed H&C maximum requirement.

Conclusion

Buildings are complex and their different elements have diverse lifespans. Most parts of the building fabric last for a very long time in comparison to parts of HVAC systems. Many parts of the building itself are difficult to change and improve after construction. Lost opportunities for the building fabric can therefore lead to a lock-in of energy use for a long time. As there is a Europe-wide development towards cost-optimal and nearly zero energy levels and as overall performance evolves, it is important to bear in mind the risk of sub-optimisation of systems and the need for secondary requirements to ensure a resilient and sustainable building fabric.

Requirements for heating and cooling through maximum heat gains and losses offer an efficient way to support low energy demand and resilient building fabric over time. Combining these requirements with other requirements such as air-tightness, thermal bridges and ventilation supports the evolution towards nZEBs designed in a holistic and sustainable manner.

Guidance on energy first principles could be based on Trias Energetica or Integrated/Intelligent Design principles. These are based on the energy efficiency first principle and enables at the same time flexibility in the choice of solutions.

Most MSs recognise the need to set special requirements for the building fabric. In around half of the countries studied, these requirements are set as maximum heat losses and/or values for heat gains from the building itself, but there is a trend and concern that the focus on these could slowly be reduced.

These requirements could therefore easily disappear, which could have a significant impact on the quality and long-term efficiency of the European building stock, on the thermal comfort of occupants, and could lead to a lock-in of energy consumption and lost energy savings over time. This impact would go beyond 2030 and even 2050.

Additionally, all countries calculate heat losses and heat gains as part of their process for calculating their building's overall energy performance. This is normally used as the first step for calculating overall performance and most countries follow CEN/ISO standards for these. A requirement for maximum heat losses and/or for values on gains could simply be based on this part of the calculation and would therefore not require any additional calculations.

Based on the findings of this report, it is recommended for requirements for maximum heat losses and gains (Maximum Heating and Cooling Loads) to be included as secondary requirements in future energy performance building regulations.

¹ European Commission, 2016, “Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU Strategy for Heating and Cooling.”

² European Commission, 2016, “Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU Strategy for Heating and Cooling.”

³ Trias Energetica – a system for design of buildings based on three elements, often illustrated as a triangle or a pyramid

⁴ Integrated or intelligent design – a systems for design based on a holistic approach with combination and integration of elements. Systems include steps for design process and this can range from 4 (ISBE) to more than 10 (WGBC).

⁵ Concerted Action Energy Performance of Buildings, 2016 Implementing the Energy Performance Directive (EPBD)

⁶ CA EPBD website; <http://www.epbd-ca.eu/>

⁷ BPIE Data Hub for Energy Performance of Buildings, <http://www.buildingsdata.eu/>

⁸ IEA Policies & Measures Database, <https://www.iea.org/policiesandmeasures/>

⁹ Directive 2010/31/EU of the European Parliament and of the council of 19 May 2010 on the energy performance of buildings (recast) in multiple languages, <http://eur-lex.europa.eu/legal-content/en/ALL/?uri=celex%3A32010L0031>

¹⁰ Main sources; National and regional Buildings Codes, supporting legislation, NEAPS and national action plans for building efficiency.

¹¹ Part of a building part with less resistance towards transparency on energy, leading to a bridge for energy transmission.

¹² Losses from intersection between building parts or from special building parts such as foundations where such losses can be measured as transmission in w per K per meter.

¹³ Airtightness usually set as a specific requirement for pressure loss when building is under increased pressure. For instance metered by a so-called Blower-door test.

¹⁴ See CENSE website under Intelligent Energy Europe, <https://ec.europa.eu/energy/intelligent/projects/en/projects/cense>

¹⁵ The Bbio coefficient is calculated depending on region, altitude and other bioclimatic factors. Lighting is multiplied with a factor 5, while heating and cooling is multiplied with 2.

¹⁶ Trias Energetica as described by EURIMA; <http://www.eurima.org/energy-efficiency-in-buildings/trias-energetica>

This study, 'European Building Codes: Secondary Level Requirements for Heating and Cooling', has been undertaken by Jens Laustsen and Sophie Shnapp, 2peach. Further information and research can be found in the full report, which can be downloaded from www.2peach.com

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