Building resilience through building codes

Secondary Level Requirements for Heating and Cooling in European Building Codes

Highlights and Lessons Learned

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Introduction:

The energy performance of buildings is a good 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.

Most Member States (MS) revise their regulations on energy performance 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 is progress is a great step towards good overall performance and nearly zero energy requirements.

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

Buildings and most individual building elements have a long lifespan, typically between 50 to 100 years, much longer than technical supply 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) 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 lock-in energy efficiency potentials, even beyond 2050.

Setting 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 the only 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 energy demand before smart ways to provide the energy needed is found. 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 some of the 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 and heating and cooling is dominant 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.

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 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 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 requires 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.

Overview of current national regulations:

The secondary requirements for heating and cooling and building fabric U-values vary significantly among Member States. The different options chosen by each MS are illustrated in the following table[3].

Table on secondary heating and cooling demands:

Choice by country	Maximum Heat Losses / Gains	Maximum U-vales	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 extend 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 bridges, line losses (losses between building parts) and airtightness, as a way to ensure good quality and efficient buildings.

Figure on the use of options in MS, as a per cent:
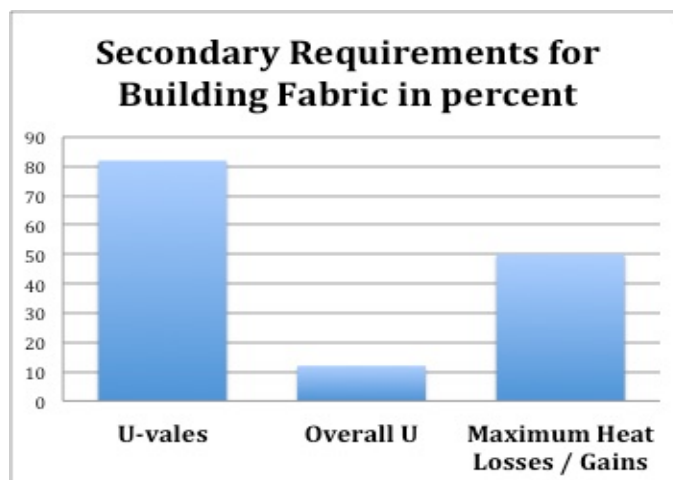
The reasons for using each of the three options are different. U-values are mainly used to support a good indoor-climate and provide healthy buildings, by ensuring a high surface temperature and reducing moisture problems. These U-values are often combined with values for thermal bridges and airtightness 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.

Half of the Member States recognise the need for secondary requirements for heat losses and 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.

Illustration of countries with maximum heat losses and / or gains:
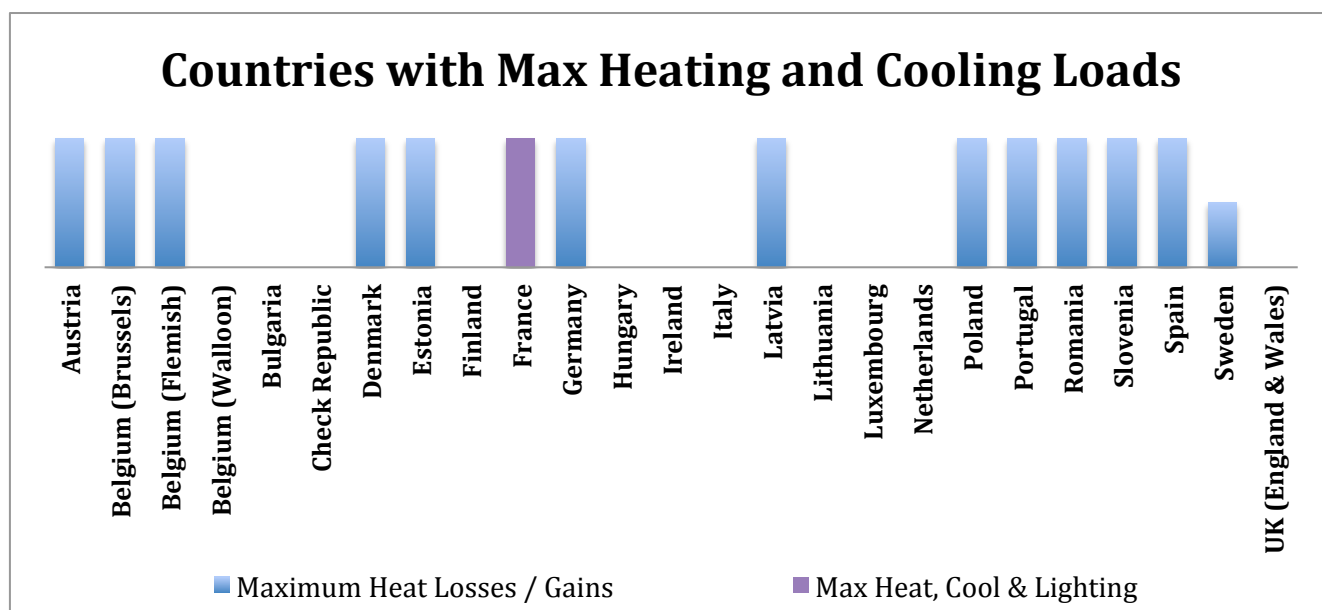
The French requirements are set as a bioclimatic coefficient, $Bbio_{max}$, for heating, cooling and lighting depending on the bioclimatic conditions for the building.[4]

Heat losses are often compensated by heat gains in cold climates, while heat gains 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.

Having U-values alone, as secondary requirements, might not be enough to ensure good building fabric especially when these buildings develop towards nearly zero energy, where the balance between gains and losses becomes a crucial part of the equation. In these buildings, a holistic design also necessitates for ambitious requirements for air-tightness, ventilation and thermal bridges to be met. It finally requires a good balance between these different elements.

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.

The overall picture of the secondary regulations for the building shell in the different countries can be seen in the following graph.

Illustration of Member States choice of secondary requirements:
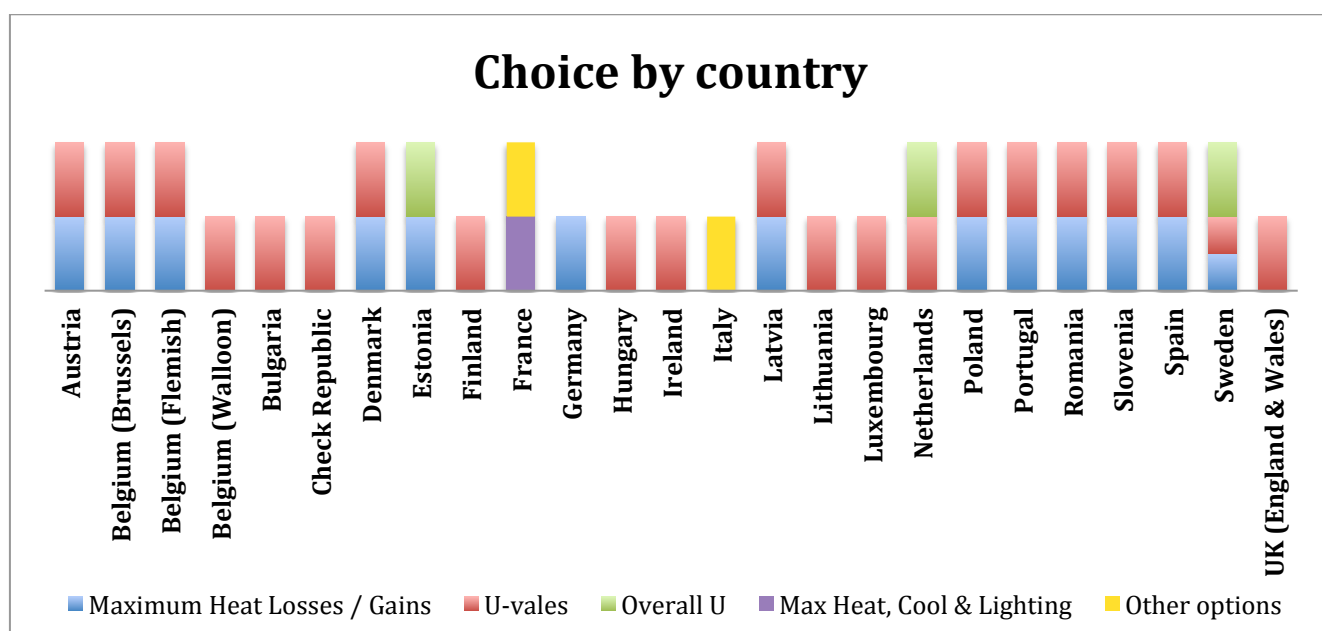
The blue area represents the countries that have chosen to implement Maximum Heat Loss/Heat Gain requirements, the red are shows countries that have maximum U-values set in their latest building requirements. As can be seen in the graph above, more than a third of the MS combine these two options. Often the requirements become tighter as the level moves from U-values to maximum heat losses and then to overall performance, still leaving flexibility.

A few countries work with overall U-values, which combine some elements of heating and cooling losses and individual U-values. Only a few countries have no specific maximum values and consider their building fabric in terms of U-values and maximum heat losses and gains only as part of their overall performance calculation.

Combined approaches allow for more flexibility in building design, notably by enabling trade-offs between various components of the building envelope. This is particularly important when moving towards high-performing buildings, whereby the over-prescription of U-values can prevent developers from finding the best technical and economic compromises. Under such combined approaches, a maximum heating and cooling requirement must play an essential role in ensuring the overall quality of the building envelope.

Both France and Italy have chosen other options. In France, the approach is fully based on bio-climatic design, , integrating heating, cooling and lighting needs, with recommendations for the minimum performance of the building fabric. In Italy, the approach is based on a model building, which has a strong focus on U-values and building performance.

Importantly, all countries include the calculation of heating and cooling needs as part of their overall performance calculation. These elements are usually the first part of the calculation, which translates U-values and other specific values into an overall heat loss and heat gain from solar and internal loads. The calculation of heat losses follows strict and similar procedures in most countries. Most Member States base this calculation on CEN/ISO standards.[5] However, cooling loads can be calculated in different ways and in some cases these values are not calculated directly, but are estimated values based on the total heat gains and possible use of these.

Setting heating and cooling requirements would therefore not create a need for new calculations within the MS, only for these values to be compared with a set maximum.

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

[4] The Bbio coefficient is calculated depending on region, altitude and other bioclimatic factors. Lighting in multiplied with 5, while heating and cooling is multiplied with 2.

[5] ISO 13790, standard for Energy performance of buildings - Calculation of energy use for space heating and cooling.

Conclusion:

Buildings are complex and their different elements have different lifespans. Many parts of the building itself are difficult to change and improve after construction. As there is a 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 requirement to ensure a resilient 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, ventilation, supports the evolution towards nZEBs designed in a holistic and sustainable manner. This is based on the energy efficiency first principle and enables 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, these requirements are set as maximum heat losses and/or values for heat gains from the building itself.

However, These requirements could 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 secondary requirements for maximum heat losses and gains (Maximum Heating and Cooling Loads) to be included as secondary requirements in future energy performance building regulations.

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

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