Stimulation of better summer comfort and reduced energy consumption for cooling by EPBD implementation

# "Additional requirements related to summer comfort and air conditioning"

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# Table of Contents

# 1. Introduction

On of the objectives of WP7 is the collection analysis and guidance regarding additional requirements related to summer comfort and air conditioning in line with Article 4 of the EPBD.

These requirements can cover global, intermediate or individual aspects of the building performance. The actual values are commonly dependent of the climatic zone and/or the building type. The requirements of a certain country can include simultaneously limiting values at different aspects and/or levels.

The most **global level** refers to the overall energy performance of the building, in which the cooling energy (or $CO_2$ emissions for cooling) is included. The minimum requirement is expressed as a limiting value of the overall energy consumption or of the $CO_2$ emissions of the building.

The **second level** covers the energy efficiency use by use. In this case a minimum efficiency of the combined effect of the building envelope and the cooling system is fixed. Consequently, if the building is air conditioned, the minimum requirements, at this level, can be referred to limiting values of:

- Cooling energy consumption (final or primary energy).
- $CO_2$ emissions for cooling

In a **third level** the effect of the envelope and the HVAC systems can be independently limited. In this level, if the building is air-conditioned, the minimum requirements can be referred to:

Maximum cooling needs allowed.

Minimum efficiency (probably nominal EER) of the cooling system allowed.

Alternatively, if no cooling system exists, the minimum requirements can be referred to an overheating indicator. In this case, the limit value of the indicator is used to demonstrate that cooling will not be necessary.

Another possible requirement at this level is to fix a certain percentage of the cooling needs that have to be covered by renewable energies.

In the **forth level**, the cooling demand (or the overheating) is limited in a very indirect way, by limiting some relevant parameters that influence them, such as:

- A reduction of the solar gains
- A modulation of the solar gains
- A dissipation of the solar and internal gains via ventilation losses.

A questionnaire included in the annex has been distributed and answered by 10 participants or subcontractors of the ASIEPI project. The questionnaire includes general and specific information regarding present summer comfort and energy requirements in the national building regulations.

A summary of the results can be seen in the table below, for the four levels of requirements previously described.

| | Spain | Netherlands | Belgium Flanders | France | Portugal | Germany | Poland | Italy | Greece | U.K. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Limitations of the overall energy performance or $CO_2$ emissions of the building including cooling | NO | YES | YES | YES | YES | YES | NO | NO | YES | YES |
| 2. Independent limitations for cooling | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.1 Limitations regarding cooling needs | YES | NO | NO | NO | YES | NO | NO | NO | NO | NO |
| 3.2 Prescriptions regarding the use of renewable energies for cooling | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.3 Limitations regarding efficiency of cooling system | YES | NO | NO | NO | NO | NO | NO | NO | YES | NO |
| 3.4 Requirements regarding summer comfort in case of non-air conditioned buildings | NO | NO | NO | YES | NO | YES | NO | NO | NO | NO |
| 4.1. Limitations of the glazed area | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 4.2 Requirements regarding solar protection | YES | NO | NO | YES | YES | YES | YES | YES | YES | YES |
| 4.3 Other requirements for summer comfort | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO |

Detailed comments on every issue are in the next sections.

## 2. Question 1: Limitations of the overall energy performance or $CO_2$ emissions including cooling

The way of expressing the limitation can be absolute or relative as shown in the table below.

| | Netherlands | Belgium Flanders | France | Portugal | Germany | Greece | U.K. |
|---|---|---|---|---|---|---|---|
| Absolute values (for instance EP < x kWh/m2 ) or formula | X | X | | X | X | | |
| Relative values using a reference building | | | X | | X | X | X |

It can be seen that the way of express the requirements split between the fully performance approach and the reference building approach. In Germany both approaches coexist depending on the building type (reference building for non-residential).
In France the primary energy consumption of the residential buildings have to be simultaneously lower than the value of its reference building and of a certain value climatically dependent.

In most cases the absolute values or the characteristics of the reference building are building dependent and/or climatically dependent.

As we will see later, the way of include additional requirements in the regulations depends very much of this previous decision of using absolute or relative values for expressing the limitations.

## 3. Question 2: Independent limitations for cooling

None of the countries participating in the questionnaire have specific limitations

## 4. Questions 3.1 Limitations regarding cooling needs

| | Spain | Portugal |
|---|---|---|
| Absolute values (for instance EP < x kWh/m2 ) or formula | | X |
| Relative values using a reference building | X | |

From the participant's questionnaires, only Spain and Portugal have limitations of the cooling needs.
In Spain these limitations apply to residential and non-residential buildings. The cooling needs of the building have to be lower than the cooling needs of a reference buildings which envelope have reference values of solar shading depending on the orientation and the window area. The more critical the orientation (west, east, southwest, southeast) and the bigger the window area, the lower the solar energy transmittance of the window of the reference building. Besides, the solar energy transmittance of the windows of the reference building is climatically dependent (4 summer zones in Spain). When the cooling needs of a building are lower than 10% of its heating needs, the limitations of the cooling needs do not apply.

In Portugal, residential buildings have to prove cooling needs lower than fixed values (kWh/$m^2$) climatically dependent according to three summer zones). This limitation is previous to the global limitation of overall energy consumption of question 1.

## 5. Question 3.2 Prescriptions regarding the use of renewable energies for cooling

In general, in the calculation of energy performance, the positive effect of active solar system for cooling production or cooling production with the use of renewable energy resources is taken into account or promoted.

However, prescriptions have only be found in certain regions of Spain (Andalusia) where it is mandatory to supply 15% of the cooling needs of non residential buildings by using renewable energy sources, typically solar or biomass assisted absorption systems

## 6. Question 3.3 Limitations regarding efficiency of cooling system

Countries using the relative approach (reference building) to fix the requirements have to specify a specific efficiency to the reference cooling system. However this should not be considered as a limitation.

Direct limitations only exist for Greece, which establishes minimum requirements for the EER of the cooling system depending on the air conditioning type (split, package, chiller...) and the condensation mode (air based or water based).

For Spain there are two indirect limitations for all-air systems:
When the nominal cooling power is greater than 70 kW, it is mandatory to use free cooling from the outside air.
When the renovation of air is greater than 0.5 m3/s it is mandatory the recuperation of the energy in the exhaust air. The minimum efficiency of the recuperation is also fixed.

## 7. Question 3.4 Requirements regarding summer comfort in case of non-air conditioned buildings

There are different approaches to assess the risk of overheating in non-air conditioned buildings, although avoid overheating is a mandatory issue only in France, Germany and Belgium (Flanders).

In France, the indoor temperature reached by the object building during summer must be lower than the temperature of the reference building. Those temperatures are calculated for a reference warm day and corrected by sequential inertia. The calculation is made on basis of 7 days. For residential, the result of the 7th day is retained and for other cases, the 5th day (Friday) is retained

In Germany, there is a maximum allowable indoor temperature for non-air conditioned buildings that can be exceeded at 10 % of the occupancy time. The indoor temperature depends on the climatic region ranging between 27 degrees for the hottest region and 25 degrees for the coldest region. Occupancy time is defined as 24 hours/day for dwellings and 10 hours/day at 5 days/week for non-residential

In Belgium-Flanders, the number of hours above the allowable indoor temperature is weighted by taking into account the extent of this deviation using a degree-hours expression. This indicator of overheating may not be higher than 17500 Kh for residential buildings independently whether active cooling is installed or not. This requirement is not very strict. So, exceeding this maximum is considered absolutely unacceptable. If the requirement is not fulfilled, the design should be modified. If in the as-built reporting to the authorities at the end of construction, the requirement is still not satisfied,

an automatic financial fine ensues, proportional to the degree of transgression of the maximum value (0.48 euro per 1000 Kh and per $m^3$ volume that the maximum is exceeded).

An approach to take into account the periods of overheating in non-air conditioned buildings is to introduce a penalty of the energy consumption via a virtual cooling system. This is done for instance in Spain and Belgium (Flanders).

In Spain, there is a threshold value of the monthly cooling load. For every space in which the monthly cooling needs result lower then the threshold, it is assumed that cooling will not be requested in that month.. When the cooling needs are higher than the threshold, cooling energy consumption is calculated, with the actual cooling system (if it exists) or with a virtual low-efficiency equipment in case of non-air conditioned spaces.

In Belgium-Flanders the virtual system is activated as a function of the indicator of overheating may not be higher than 17500 Kh.
For dwellings, the method is as follows:
If no cooling is installed during the construction phase, but if the risk of overheating exceeds a certain threshold value, it is considered that the chances are real that active cooling will still be installed later on during the life-time of the building. Therefore, with a mounting value of the overheating indicator, an increasing probability is associated that active cooling will be installed later. The cooling needs are then multiplied with this conventional probability factor. Below the threshold value of 8000 Kh for the overheating indicator, the risk of overheating is considered so small that the conventional probability is set equal to zero. Above the maximum allowed value (17500 Kh) In between, it increases linearly from 0 to 1.

## 8. Questions 4.1 and 4.2 Limitations of the glazed area and Requirements regarding solar protection

| | Spain | France | Portugal | Germany | Poland | Italy | Greece | U.K. |
|---|---|---|---|---|---|---|---|---|
| 4.1. Limitations of the glazed area | YES | YES | NO | NO | NO | NO | NO | NO |
| 4.2 Requirements regarding solar protection | YES | YES | YES | YES | YES | YES | YES | YES |

As it can be seen, solar control appears as an additional requirement in many of the questionnaires. However, in countries with the reference building

approach (France, Greece, U.K. or Spain), the solar control requirements are usually implicit in the reference building and they can not be considered as mandatory.

Specific mandatory solar control requirements are explicit for instance in Germany and Portugal

In Germany, the solar control requirements (for non-air conditioned buildings) have to be proved at a zone level. The designer of a building has to document that the solar gains of a building or a zone does not exceed a limited value. This limited value depends on different influence factors like climatic region, building mass, night ventilation,

In Portugal, the requirements have to be assessed on a window level. There is a solar factor to be met for every window, depending on the climatic zone of the location, the inertia of the building and the orientation of the glazing.

## 9. Question 4.3 Other requirements for summer comfort

In Italy, the national code states that the surface mass (expressed in kg per square meters of envelope component) has to be heavier than 230 kg/m2 if the mean irradiance is higher than 290 W/m2 during the hottest month.

Intensive ventilation does not appear as a cooling or summer comfort requirement in any of the participant countries except in form of qualitative recommendations.

Obviously, in countries with the reference building approach, the reference building has specific values of inertia of the envelope and ventilation rates. In any case, intensive ventilation for passive cooling purposes only appear in the Spanish reference building which for the residential cases state for every space a value of 4 air changes per hour (ach) during night-time from June to September. Four ach is a conservative ventilation rate coming from a single side ventilation strategy.

## 10. Conclusions and recommendations

In general, it can be seen that cooling is included in the global requirements as a source of energy consumption or $CO_2$ emissions.

However, there are no specific requirements regarding cooling as an independent energy use and only two countries (Spain and Portugal) include a limitation of the cooling needs of the building. Greece is the only country that states specific limitations of the efficiency of the different cooling system.

A very noticeable issue is the treatment of summer comfort. Only Germany (for non-air conditioned buildings) and Belgium (Flanders) have explicit limitations of the overheating. France addresses an indirect limitation of the overheating risk via the reference building.
In other countries, for non-air conditioned buildings, avoid overheating is vaguely treated in form of recommendations but not as a mandatory issue. In some countries when overheating appears, there is a penalty of the energy consumption via a virtual cooling system.

Although solar control is mentioned in most questionnaires, specific mandatory solar control requirements are only explicit in two countries.

In general, it seems that although the concepts to be deal with regarding summer comfort and cooling are known, fixing them as mandatory requirements is a very difficult (or unnecessary) task and recommendations are largely preferred. This is the case of issues such as night ventilation or thermal inertia which do not appear as requirements but as recommendations except in Italy where thermal mass is required beyond certain levels of mean irradiance during the hottest month. This position is quite understandable due to the fact that both issues are time dependent and very difficult to quantify in a consistent way.

Even the relative approach which defines the requirements via the reference building can be seen as a way of providing recommendations about how to get the target. The real building can completely ignore such recommendations and compensate the extra cooling with other energy uses.

It seems also that cooling is basically a matter of the quality of the envelope and that the efficiency of the cooling systems and / or the use of alternative cooling techniques (such as night ventilation) are secondary.

In order to promote the use of passive cooling concepts and strategies and to anticipate undesirable effects of global warming, it is strongly recommended:

- A global requirement of energy consumption and/or $CO_2$ emissions in which cooling must be obviously included.
- Additional requirements limiting the cooling needs for air-conditioned buildings
- Additional requirements for non-air conditioned buildings limiting the overheating risk or, in a complementary way, clear indicators that allow identifying the necessity or not of air conditioning (for residential and non-residential buildings)...
- The inclusion of indicators about summer comfort mentioned above should be based on indoor temperature levels consistent to the adaptative comfort criteria of EN 15251.
- The inclusion of indicators about summer comfort mentioned above should be based on hourly calculations of the indoor temperatures at a zone level, due to the huge temperature differences that can exist between zones of the same building.

The use of additional requirements on a component level (shading factors) or the necessity of using certain strategies (ventilation rates or thermal inertia) is not recommended in general. It is considered that requirements that are too prescriptive reduce the free choice for alternative methods that may achieve the same result and that may be better feasible in a given individual project (in terms of practical application, cost effectiveness, personal preferences of the owner, etc.). On the other hand, these aspects are time dependent, ambiguous and in general more difficult to handle than those used for the heating mode such as U values or air-tightness.

The use of the absolute (fully performance) approach or the relative (reference building) approach to state the requirements have no specific aspects for cooling or summer comfort. Consequently, there are no special recommendations about the way of defining the requirements.

## 11. References


Hans Erhorn and Heike Erhorn-Kluttig
**Specific study in relation to the EPBD – Requirements in the EU Member States to summer comfort and energy consumption for cooling (EPBD Article 4)**
Fraunhofer-Institut für Bauphysik, Stuttgart - Holzkirchen - Kassel
August 2008

Gonçalves, H.:
**Summer requirements in building regulations. Report of Concerted Action "Supporting transposition and implementation of the Directive**
2002/91/EC CA – EPBD (2005 – 2007)
May 2007.

## ANNEX: Questionnaire sent to the participant countries

- **Question 1**: Are there limitations of the overall energy performance of the building including cooling?

If yes, please specify how this overall energy performance is defined: (check when applicable):

Primary energy:
$CO_2$ emissions:
Absolute values: (for instance EP < x kWh/$m^2$ )
Using reference building
Depends on the building type:
Depends on the climate:

Please, explain and provide some examples

- **Question 2**: Are there specific independent limitations for cooling?

If yes, please specify how this energy performance for cooling is defined: (check when applicable):

Primary energy:
$CO_2$ emissions:
Absolute values: (for instance EP < x kWh/$m^2$ )
Using reference building
Depends on the building type:
Depends on the climate:

Please, explain and provide some examples

- **Question 3**: Are there limitations regarding cooling needs?

If yes, please specify how these cooling needs are limited: (check when applicable):

Absolute values: (for instance EP < x kWh/$m^2$ )
Using reference building
Depends on the building type:
Depends on the climate:

Please, explain and provide some examples

- **Question 4**: Are there a prescription regarding the use of renewables for cooling

If yes, please specify (check when applicable)

A percentage of the cooling loads must be cover by renewables
The percentage depends on the building type
The percentage depends on the climate

Please explain which renewable energies are allowed and provide some examples

- **Question 5**: Are there limitations regarding efficiency of cooling system?

If yes, please specify how this efficiency is limited: (check when applicable):

Absolute values: (for instance EER > x % )
Depends on the building type:
Depends on the climate:

Please, explain and provide some examples

- **Question 6**: Are there requirements regarding comfort conditions

If yes, please specify (check when applicable):

There is a tolerable frequency of exceeding a certain level of indoor temperature
The level of indoor temperature is fixed.
The level of indoor temperature depends on the outdoor temperature (adaptative)
The level of indoor temperature depends on the air velocity (use of fans)

Please explain and provide some examples

- **Question 7**: Are there limitations of the glazed area? :

If yes, please specify how the **glazed area** is defined: (check when applicable)

**For the whole building:**
As a constant percentage of the floor area:
As a percentage of the floor area depending on the climate
As a percentage of the floor area depending on the building type
As a percentage of the floor area depending on the climate and the building type

As a constant percentage of the area of the facades:
As a percentage of the area of the facades depending on the climate
As a percentage of the area of the facades depending on the building type:
As a percentage of the area of the facades depending on the climate and the building type:

**For every façade**
As a constant percentage of the area of every façade
As a percentage of the area of every façade depending on the orientation
As a percentage of the area of every façade depending on the orientation and the climate
As a percentage of the area of every façade depending on the orientation and the climate and the building type

**For every orientation (by adding the area of the facades of every orientation)**
As a constant percentage of the area of every orientation
As a percentage of the area of every orientation depending on the climate
As a percentage of the area of every orientation depending on the building type
As a percentage of the area of every orientation depending on the climate and the building type

**Other**
Please explain

Please provide example of values for the applicable case

- **Question 8**: Are there limitations regarding solar protection? :

**8.1** Please specify what **elements or properties are included** in the definition of solar protection (check when applicable)

Glazing g-value
Frame g- value
Permanent elements (overhang, side fins)
Solar control devices (awnings, Venetian blinds, roller shades)
Remote obstacles (other buildings, trees)
Own building geometry:

**8.2** Please explain **how the values of the solar protection are defined and calculated**. (check when applicable)

Total solar energy transmittance including blocking of direct and diffuse solar radiation:
Total solar energy transmittance including only blocking of the direct solar radiation
It an average value for the whole summer:
It is an average value for a given month:
Other, please specify

**8.3 How the limitations are expressed?** The limit value of the solar protection required depends on: (check when applicable)

Percentage of glazed area
Orientation
Climate (climatic zone)
Building type:
Inertia (if yes, please indicate how the inertia is defined)
Other please, specify

**8.4** In practice, **how the user demonstrates compliance with the requirement of solar protection** (check when applicable)

Approved document or procedure
Approved tables and graphs
Approved software
Other, please specify

<u>Please provide example of values for the applicable case</u>

- **Question 9**: Are there other requirements for summer comfort? (Inertia, intensive ventilation…):

Please, explain and provide example of values

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