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**Energy performance of buildings —  
Indicators for partial EPB  
requirements related to thermal  
energy balance and fabric features —**

**Part 2:  
Explanation and justification of ISO  
52018-1**

*Performance énergétique des bâtiments — Indicateurs pour  
des exigences PEB partielles liées aux caractéristiques du bilan  
énergétique thermique et du bâti —*

*Partie 2: Explication et justification de l'ISO 52018-1*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

ISO/TR 52018-2 was prepared by ISO technical committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 52018 series can be found on the ISO website.

## Introduction

### Relation between this document and the accompanying International Standard

For proper understanding of the present document, it is necessary to read it in close conjunction, clause by clause, with ISO 52018-1. Essential information provided in Part 1 is not repeated in this part. References to a clause refer to the combined content of that clause in both parts 1 and 2. Brief articles on the subject can be found in [20], [21] and [22].

### The set of EPB standards, technical reports and supporting tools

In order to facilitate the necessary overall consistency and coherence, in terminology, approach, input/output relations and formats, for the whole set of EPB-standards, the following documents and tools are available:

- a) a document with basic principles to be followed in drafting EPB-standards: CEN/TS 16628:2014, *Energy Performance of Buildings - Basic Principles for the set of EPB standards*[1];
- b) a document with detailed technical rules to be followed in drafting EPB-standards: CEN/TS 16629:2014, *Energy Performance of Buildings - Detailed Technical Rules for the set of EPB-standards*[2];

The detailed technical rules are the basis for the following tools:

- 1) a common template for each EPB standard, including specific drafting instructions for the relevant clauses;
- 2) a common template for each technical report that accompanies an EPB standard or a cluster of EPB standards, including specific drafting instructions for the relevant clauses;
- 3) a common template for the spreadsheet that accompanies each EPB (calculation) standard, to demonstrate the correctness of the EPB calculation procedures.

Each EPB standard follows the basic principles and the detailed technical rules and relates to the overarching EPB standard, ISO 52000-1 [3].

One of the main purposes of the revision of the EPB standards has been to enable that laws and regulations directly refer to the EPB standards and make compliance with them compulsory. This requires that the set of EPB standards consists of a systematic, clear, comprehensive and unambiguous set of energy performance procedures. The number of options provided is kept as low as possible, taking into account national and regional differences in climate, culture and building tradition, policy and legal frameworks (subsidiarity principle). For each option, an informative default option is provided ([Annex B](#)).

### Rationale behind the EPB technical reports

There is a risk that the purpose and limitations of the EPB standards will be misunderstood, unless the background and context to their contents – and the thinking behind them – is explained in some detail to readers of the standards. Consequently, various types of informative contents are recorded and made available for users to properly understand, apply and nationally or regionally implement the EPB standards.

If this explanation would have been attempted in the standards themselves, the result is likely to be confusing and cumbersome, especially if the standards are implemented or referenced in national or regional building codes.

Therefore each EPB standard is accompanied by an informative technical report, like this one, where all informative content is collected, to ensure a clear separation between normative and informative contents (see CEN/TS 16629[2]):

- to avoid flooding and confusing the actual normative part with informative content,

- to reduce the page count of the actual standard, and
- to facilitate understanding of the set of EPB standards.

This was also one of the main recommendations from the European CENSE project<sup>[17]</sup> that laid the foundation for the preparation of the set of EPB standards.

### **This document**

This document accompanies ISO 52018-1, which forms part of the set EPB standards.

The role and the positioning of the accompanied standard in the set of EPB standards is defined in the Introduction to ISO 52018-1.

General aspects of EPB indicators, requirements, ratings and certificates and application to the overall energy performance of buildings can be found in ISO 52003-1 <sup>[5]</sup> and ISO/TR 52003-2 <sup>[6]</sup>.

### **Accompanying spreadsheet**

Because in the accompanying document ISO 52018-1 no calculation procedures are defined, an accompanying calculation spreadsheet is not relevant.

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# Energy performance of buildings — Indicators for partial EPB requirements related to thermal energy balance and fabric features —

## Part 2: Explanation and justification of ISO 52018-1

### 1 Scope

This document refers to ISO 52018-1.

ISO 52018-1 gives a succinct enumeration of possible requirements related to thermal energy balance features and to fabric features. It also provides tables for regulators to report their choices in a uniform manner. This document provides many background considerations that can help both private actors and public authorities, and all stakeholders involved, to take informed decisions.

This document does not contain any normative provision.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 52018-1, *Energy performance of buildings – Indicators for partial EPB requirements related to thermal energy balance and fabric features – Part 1: Overview of options*

NOTE More information on the use of EPB module numbers, in all EPB standards, for normative references to other EPB standards is given in ISO/TR 52000-2.

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 52018-1 apply.

More information on some key EPB terms and definitions is given in ISO/TR 52000-2[4].

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 4 Symbols and subscripts

For the purposes of this document, the symbols and subscripts given in ISO 52018-1 apply.

More information on key EPB symbols and subscripts is given in ISO/TR 52000-2[4].

## 5 General aspects

This document is fully complementary to ISO 52018-1. For a good comprehension, before reading a clause in this document, the corresponding (succinct) clause in ISO 52018-1 should be read, as this document does not repeat the content of ISO 52018-1, but only provides additional information.

This document contains many straightforward considerations with which many readers may already be familiar. In order for the text to also provide full support to novices in the field, such basic considerations have nevertheless been included. On the other hand, commonly circulating argumentations that could not withstand the test of critical, rational analysis have been omitted. It is self-evident, by the very nature of the topic, that the treatment can never be fully exhaustive; many additional motivations, for instance influenced by specific local conditions, may influence the final choice of the mix of energy features and indicators for which requirements are set.

For each of the partial EPB features enumerated in ISO 52018-1, this document formulates background considerations with respect to the following aspects (in as far as applicable):

- possible motivations,
- possible indicators,
- comparable economic strictness of the requirements,
- practical points of attention,
- testing,
- new construction and renovation issues,
- exceptions,
- other.

Achieving a good indoor environmental quality is one of the major objectives when designing buildings (first and foremost for the people in the building, but also for the proper preservation of any –specific– goods in the building). The topic of indoor environment is thematically and technically closely related to the energy efficiency of buildings, and both aspects are therefore logically considered in an integrated manner when building regulations are established. All the partial EPB features discussed in ISO 52018-1 and in this document are listed in [Table 1](#) together with an indication whether indoor environment and/or energy efficiency is (are) usually the main motivation(s). (There may of course still be other possible reasons for setting a requirement, such as fabric preservation, but such other reasons are not visualized in the summary table.) Requirements on most EPB features may to a greater or lesser extent serve both purposes. The nuances are further discussed in each of the clauses.

**Table 1 — Overview of the different partial EPB features**

Clause	Partial EPB feature	Indoor environment	Energy efficiency
6	summer thermal comfort	X	(X)
7	winter thermal comfort	X	(X)
8	energy “need” for heating, or variants	(X)	X
9	energy “need” for cooling, or variants	(X)	X
10	combination of “needs”		X
11	overall thermal insulation of the envelope		X
12	thermal insulation of individual envelope elements	X	X
13	thermal bridges	X	X

Table 1 (continued)

Clause	Partial EPB feature	Indoor environment	Energy efficiency
14	window energy rating		X
15	airtightness	X	X
16	solar control	X	X

Often, an important consideration when setting EPB requirements is to achieve a strictness that is more or less cost optimal (at an assumed scenario of the future energy prices) for each individual construction project. This issue is explained in a general manner in ISO 52003-1[5] and ISO/TR 52003-2[6]. In this document, this aspect is discussed in a more practical manner for each of the EPB features.

## 6 Mix of EPB features with requirements

No additional information beyond ISO 52018-1.

## 7 Summer thermal comfort

### 7.1 Motivation

If there are complaints by the building users about the indoor environmental quality, it often includes summer thermal comfort. The occurrence of this problem can potentially be aggravated by EPB building regulations if these are not well-considered and well-equilibrated. Partial EPB requirements only dealing with the heating aspect may lead designer teams to maximize solar gains in winter, while neglecting the summer impact. And in uncooled buildings, or if active cooling would not be included in the overall energy performance assessment, even an overall EPB requirement can cause such single-sided design.

Setting a summer thermal comfort requirement may thus be an important complement in order to achieve a balanced, integral building design that performs well in all respects, both in winter and in summer. In addition, good summer indoor conditions strongly reduce the probability that active cooling will be installed later on during the lifetime of the building. In this manner such requirement thus also contributes in the long run to the energy saving goal.

### 7.2 Points of attention

Special consideration should be given to the potential issue that a diverging approach between uncooled and actively cooled buildings might result in unwanted consequences.

For instance, if overall EPB requirements and/or partial EPB requirements (e.g., on the cooling “need”) in actively cooled buildings are much more severe than in uncooled buildings, and if at the same time there is no attention in the building regulation for summer comfort in uncooled buildings, then the regulation might cause (especially in the segment of the construction market that is first cost dominated) an increase of uncooled building designs with uncomfortable summer conditions, resulting in the installation of (potentially less efficient) active cooling any time after construction.

Vice-versa, a requirement on summer thermal comfort in uncooled buildings that is not matched with (overall and/or partial) EPB requirements that equally impact cooled buildings, might possibly cause an undesired immediate shift in new construction towards actively cooled buildings for the sole reason of a regulatory requirement that is technically and/or economically more easily satisfied.

A possible approach to avoid such divergent regulatory treatment between uncooled and cooled buildings is to simply set for a given building category (such as dwellings, offices, schools, etc.) the same type of requirement and the same strictness for each building, independently of the fact whether or not the building is actively cooled. The requirement can either be a cooling “need” requirement (see [Clause 10](#)) for all buildings (so, also in buildings that are not actively cooled) or alternatively a

summer thermal comfort requirement for all buildings (whereby in the evaluation of this requirement, it is assumed that the conditioning system in actively cooled building is switched off). It goes without saying that if certain design variables (e.g., operable windows) are treated differently in both features, the choice for one or the other of both features will or will not stimulate good use of these technical measures.

NOTE Sometimes, the fear is expressed that setting a cooling “need” requirement also for uncooled buildings might be perceived (or misconstrued) by some market actors as an implicit regulatory message that active cooling is the reference. However, experience has shown that clear (and permanent) public communication surrounding the regulation can avoid this issue. Moreover, the significant extra cost of effectively installing an active cooling system also constitutes a strong constraint, especially since spare capital is rarely available at the time of construction.

An alternative way of avoiding any unwanted consequences is to complement a summer thermal comfort requirement for all uncooled buildings (which is sufficiently strict to be meaningful) with a (technically and economically equally strict<sup>1)</sup>) cooling need requirement (see [Clause 10](#)) for all actively cooled buildings.

Another possible source of divergent treatment between cooled and uncooled buildings may occur on the level of the overall EPB requirement. If the quantitative limit to the overall EPB indicator is identical for both types (i.e., actively cooled and uncooled) of buildings, it will not correspond to the cost optimal level of energy efficiency measures for each of both types. A carefully differentiated quantitative limit may solve this issue. Another approach is to have the same quantitative overall EP requirement, but to include for uncooled buildings a fictitious cooling consumption in the overall EP calculation, whereby the regulation sets a fixed overall cooling equipment efficiency and a fixed primary energy factor to convert the calculated cooling need to primary energy. Setting these values slightly more favourable than the best current technologies, avoids that cooled buildings would more easily satisfy the overall EP requirement, and thus be stimulated by the regulation (apart from all the other decision influencing factors, such as higher – first and operational – costs, controlled thermal environment, etc.). A disadvantage of fictitious cooling is that the relation between the calculated and real consumption diminishes (also in a principle manner, apart from all the different boundary conditions). In [Annex D](#) a further developed and more nuanced methodology is described that makes use of a conventional probability of a later installation of active cooling related to the risk of overheating.

A totally different point of attention concerns the zoning. The risk of overheating may vary strongly from 1 room to another, depending on very many factors, such as the solar gains (there is for instance often 2 times more glazing in a corner room than in a room of the same size in the middle of the sidewall of the building) and the internal gains (e.g., due to a strong difference in occupation density, for instance an individual office versus a cinema hall). Individual evaluation of all (types of) rooms in a building is usually not considered feasible within the context of a regulation<sup>2)</sup>, and (much) larger zones are typically used for any calculation. The resulting aggregation and intrinsic averaging will of course fail to reveal local summer comfort problems in specific rooms.

Vice-versa, another potential issue of zoning is related to the unavoidable simplifications of the modelling and the consequences this may have on the calculation of single rooms or small zones.

EXAMPLE For instance, a room (e.g., a bathroom) in the centre of a dwelling (e.g., an apartment) may have little or no transmission heat transfer towards the outside, and the transmission transfer towards adjacent rooms in neighbouring conditioned zones may by convention be considered nil in the EPB modelling. Also the ventilation heat transfer coefficient of this room by itself may be very small or even zero. A value of the internal gains that is considered representative for the average of the dwelling as a whole may actually be quite large for a bathroom, but is nevertheless often imposed by the fixed calculation conventions. When the summer thermal comfort of the bathroom is then evaluated, such combination of factors in the modelling may cause unrealistic results and it may even be that a summer requirement (i.e., the maximal value of the summer indicator) is mathematically impossible to satisfy.

1) Or possibly stricter, if so desired.

2) Also, it would be difficult in a regulatory context to define differentiated internal gains for rooms with the same function, although this may in practice be one of the causes of local overheating.

When a summer thermal comfort requirement is imposed in the regulation, it may therefore be preferred to set it for sufficiently large zones. In residential buildings, it might be stipulated that the requirement always be evaluated for the entire dwelling or building unit (e.g., individual apartment) as whole, even if for other purposes smaller thermal zones are defined. But, for informative purposes only, it is of course still easily possible to evaluate (in a fully automated manner) the overheating indicator for each of the thermal zones apart, which have already been defined for other reasons. It is then up to the expertise of the programme user (assisted by the manual, help function, automated messages, etc.; and aided by his/her dedicated training and practical experience) to make a sound judgement whether a poor summer comfort indicator for a given zone reveals a true, physical problem, or whether it is caused by the intrinsic restrictions of the modelling (as in the bathroom example above).

### 7.3 Indicators

Several possible indicators can be considered for the summer thermal comfort.

For monthly calculations, the normalized non-useful gains for heating (which cause overtemperature above the heating set-point) have been shown to correlate well with the overheating above the thermal comfort limit.

For hourly calculations, a possible indicator is the number of hours (in h) on an annual basis that the free floating temperature exceeds a fixed reference temperature. Alternatively, the temperature weighted time (in Kh) above the fixed reference temperature can be used. The latter is a bit more sophisticated and increases more rapidly than the former (quadratic versus linear course). The latter thus better reveals the true extent of any summer discomfort problem and is therefore the preferred indicator. The fixed temperature that is chosen as reference will logically depend on the climate of the country or region.

NOTE 1 In buildings that satisfy a number of conditions (without active cooling, with operable windows, no strict dress code, etc.) a certain degree of user adaptation to high summer temperatures can occur. ISO 17772-1:2017, A.2 [Z] provides a model to evaluate the corresponding comfort level. For the buildings that fall within the application scope of the model, these calculations will of course give a much better indication of the summer comfort quality of the building, and are thus to be preferred for tailored design decisions. (But the important consideration with respect to the dependence of the result on the zoning (see 7.2) needs to be well kept in mind.).

NOTE 2 Because of its limited application range, the model in ISO 17772-1:2017, A.2 can however not be used to set a systematic regulatory requirement applicable to all buildings, e.g., to both actively cooled and uncooled buildings. For purely informative purposes, though, any EPB software could calculate (systematically and automatically or otherwise only upon request of the programme user) this indicator too. However, some extra user input might be needed if the aim is a calculation that is fully conform the adaptive comfort model. Apart from indicating the comfort class (I, II or III), the calculation could also provide a more continuous output, e.g., the temperature weighted time that the boundaries of class I are exceeded, so as to give finer feedback to designers on the impact of changing different variables.

### 7.4 Comparable economic strictness

For energy efficiency measures, a life cycle cost analysis allows to compare initial investments with all operational expenditures and thus to determine which set of technical measures is cost optimal. This can be the basis for setting requirements. For indoor environment aspects, such as summer thermal comfort, such economic analysis is in principle not applicable, as the benefits are difficultly quantifiable in monetary terms. A partial exception may be labour cost in offices and other workplaces: the loss of productivity due to thermal discomfort can be estimated (in a more or less rough manner) by means of (laboratory) experiments, or on the basis of experience, etc. This then in turn again allows a rudimentary economic optimization of summer comfort investments.

Alternatively, reasonable summer thermal comfort requirements may simply be taken as a starting point, and it can then be evaluated whether these are affordable in terms of investments. In many buildings (notably if the internal gains are not too high) judicious choice of window area, glazing type and orientation are an easy and relatively cheap means to limit overheating.

## 7.5 New construction/renovation

An overall summer thermal comfort regulatory requirement is most easily imposed in the case of new construction. For renovation, element level requirements, notably solar control (see [Clause 17](#)) usually prove more practical.

## 7.6 Exceptions

As illustrated in [7.3](#) by means of the bathroom example, the combination of the chosen indicator and the numerical strictness of the requirement should be thoroughly evaluated beforehand on a large sample of cases, so that a general requirement can be set with confidence. If still needed, rare individual cases can then still be granted exception on the basis of a general hardship clause in the EPB regulation, cf. ISO 52003-1[5].

## 8 Winter thermal comfort

Very similar considerations to those formulated for summer thermal comfort apply, mutatis mutandis, to winter thermal comfort. They are not repeated here in a rephrased manner, as the required adaptations are so self-evident that the reader will readily have an appropriate understanding.

It should be noted that due to the more general application of very low energy buildings the geographic area (seen on a global scale) where active heating (under whatever form) can be completely omitted, may extend over time.

**NOTE** It is obvious that, similar to the summer situation, also in winter user adaptation can occur, notably the use of warmer clothing (thick jumpers, thermal underwear, etc.), as is common in lower income countries with moderately cold winters. ISO 17772-1 [2] (or its CEN version EN 16798-1[8]), however, provides no model for that purpose, so that it does not allow for a more detailed assessment.

## 9 Energy need for heating, or variants

### 9.1 Motivation

The main motivation to set requirements on the energy “need” for heating is usually related to energy savings:

- In heating dominated climates, the factors affecting this “need” determine to a large extent the overall energy consumption of the building. In these regions, setting this partial requirement thus constitutes an important step towards achieving a good overall energy performance. This partial requirement is in line with the general philosophy of the “trias energetica” that first seeks to minimize the demand before looking in a second instance at appropriate and efficient heating systems, possibly making use of renewable energy.
- This heating “need” relates to a large extent or – potentially even fully, depending on its exact definition; see below– to the building fabric, i.e., the building as such, without technical systems. As it is, generally speaking, practically difficult and financially expensive to improve the energy performance of the fabric after initial construction, this partial requirement ensures that a basic energy performance will likely be achieved throughout the lifetime of the building. It counteracts the risk that an overall EPB requirement is initially primarily achieved with very advanced technical systems, but which are later – at the time of their replacement – substituted for by lower performance equipment, thus deteriorating the initial overall energy performance. Like other partial, fabric-related requirements (see following clauses), the heating “need” requirement thus ensures a certain degree of robustness of the overall energy efficient design.
- When the overall energy performance is expressed in another quantity than energy, e.g., in terms of CO<sub>2</sub> emissions, then a heating “need” requirement ensures that also the energy demand is kept moderate, even if low-CO<sub>2</sub> heating carriers are used.

A secondary objective of setting a heating “need” requirement may also be to guarantee to a certain extent a good indoor environmental quality in winter, as the “need” requirement requires due attention to the fabric and the ventilation provisions.

If no heating system is present, a requirement on the heating “need” (which is then fictitious) can still be imposed so as to ensure in an indirect manner reasonable thermal comfort in winter and thus to limit the probability that space heating is installed later on (e.g., in the form of electric resistance heating, which is relatively simple to install). And if space heating is nevertheless installed afterwards, such requirement ensures that its consumption will remain checked.

NOTE Such heating “need” requirement in the absence of a heating system constitutes a surrogate alternative to setting a requirement on the degree of thermal discomfort during the winter season under free floating temperature conditions, see [Clause 8](#).

## 9.2 Indicators

The total annual heating need (as sum of the need for the heating of the spaces and the need for the active preheating of hygienic ventilation air, see ISO 52018-1:2017, Clause 9) can be used as an indicator. This includes the effect of the actual ventilation system that is (being) implemented in the project, and energy efficient ventilation choices are thus stimulated.

Often however, a modified indicator is adopted for setting the partial EPB requirement on the heating “need”. Its calculation then does not take into account the real ventilation system but uses a predefined, fully fixed fictitious ventilation system instead. In this manner, the indicator becomes inert for the real ventilation system features and mainly reflects fabric related features: the thermal insulation and air tightness of the envelope, the thermal mass of the structure and the solar gains (including various forms of shading).

NOTE 1 A practical consequence of such modified definition is that the heating “need” calculation then needs to be performed a second time: in addition to the calculation with the real ventilation system as part of the overall EPB assessment, a second calculation is performed with the fictitious ventilation system in order to determine the modified indicator.

Because this modified calculation doesn’t correspond any longer to the real heating need of the building, quotation marks are used for the word “need” throughout this text (as well as in ISO 52018-1) whenever the word can apply to either a real ventilation system or to an imposed, fictitious ventilation system. To avoid confusion in regulations, a dedicated term may be used for this indicator, e.g., “fabric energy efficiency for heating”.

In different countries, many variants have been applied for the fictitious ventilation system, ranging from a system with the highest possible heat losses to one with very low heat losses, e.g., from all-natural ventilation without any efficiency features (such as flow control) to all-mechanical systems with highly efficient heat recovery, and various intermediate options. There don’t appear to exist hard arguments in favour of any of the options, whence the many variants found in practice. The choice seems somewhat arbitrary, based on non-fundamental considerations.

Alternatively, the hygienic ventilation heat transfer coefficient can be set equal to a predefined numerical value (e.g., a fixed fraction of the maximal hygienic ventilation heat transfer), independently of any specified physical ventilation system. This has the advantage that no specific fictitious ventilation system needs to be named/defined. The description thus becomes technologically neutral. In the market a predefined fictitious reference system may by some actors erroneously be perceived (or on purpose be misconstrued) as a preferred choice (by the public authorities).

A limiting case of this approach is to artificially set the hygienic ventilation losses completely equal to zero. This has the additional advantage of being close to advanced, energy efficient ventilation systems (of whatever type), which generally increase their market share as the EPB requirements for new construction become ever tighter. In a further step, the internal gains are sometimes also omitted from the energy balance with the argument that they do not relate to the fabric.

It goes of course without saying that the strictness of the requirement should be set according to the hypotheses made for the fictitious ventilation system (or according to the fixed numerical value of the ventilation heat transfer) and for the internal gains, in order to achieve an appropriate obligation.

It should be noted however that the heat transfer due to the hygienic ventilation air flow is one of the factors determining the overall thermal balance, including the degree of utilization of the (internal and solar) gains. Calculating with a fictitious ventilation system that differs from the real one thus distorts the overall evaluation. This may result in suboptimal design decisions, when the project team does not heed the potential discrepancy between the real ventilation system in the building and the fixed one for the modified “need”. This observation is an argument to rather use the real heating need with the real ventilation system to set a requirement.

NOTE 2 The extent of the ventilation heat transfer (large or small, depending to the degree of energy efficiency of the ventilation system) influences the optimal value of all other factors affecting the thermal energy balance, such as the length of the heating season, the usefulness of the solar and internal heat gains, the effects of temperature set back and solar shading, etc.

It is customary to express the indicator as energy “need” for heating per useful floor area [kWh/m<sup>2</sup>]. In that case, special attention should be paid to set a variable requirement (i.e., not a constant value in terms of kWh/m<sup>2</sup>) if the purpose is to obtain a comparable strictness for all construction projects; this is further discussed in [9.3](#).

Alternatively, the ratio of the heating “need” (either the total value or per useful floor area) to a carefully chosen, varying reference value may be taken as indicator. When the reference value is judiciously calculated (either by an appropriate notional reference building or by a formula, see ISO 52003-1), then economically comparable requirements may ensue for all individual projects. The same ratio may immediately also be a good indicator of how well a specific design performs better or worse than the reference.

### 9.3 Comparable economic strictness

In [Annex D](#) the challenging issue of setting appropriate heating “need” requirements for each individual project is illustrated by means of a practical example. In a more abstract manner, the issue can be described as follows.

As discussed in ISO 52003-2, there are several advantages if for a given scenario of the future energy prices an EPB requirement is approximately equally strict in financial terms (life cycle cost) for all individual projects. The heating “need” strongly depends on the transmission and in/exfiltration heat losses, which are heavily correlated with the area of the thermal envelope. Also other factors, such as the ventilation rate per useful floor area (as assumed in the calculations) may significantly vary from one project to another. Depending on the building shape, the ratio of the envelope area to the useful floor area varies strongly, e.g., between a small, detached dwelling and a compact, centrally located apartment unit. As a result, it usually follows from detailed economic evaluations that for a given scenario of the energy price the cost optimal value of the heating “need” per useful floor area strongly varies from one project to another, to a significant extent (but usually not only!) depending on the ratio of the thermal envelope area to the useful floor area. The exact relation varies of course depending on the climate, assumed set point temperatures, et cetera. A heating “need” requirement expressed as a constant value per useful floor area therefore normally does not capture the cost effective potential of each individual project well. For some projects (usually the small, detached dwellings) such constant requirement may (technically and economically) be difficult to achieve. For other projects (e.g., individual compact apartments) the same quantitative requirement can be very easy to realize, and while not at all achieving the cost optimal value for that particular project. Such kinds of requirements do not constitute a balanced economic approach.

It should be noted that the shape of a building is usually only to a limited extent a design choice. Urban planning rules, the size and form of a parcel and many other factors often predetermine what type of building (e.g., a detached house or a row house, or its – compact or not – shape) can be constructed on a given lot. The building design team then only has limited leeway to act within the predefined confines. Choices with potentially an important impact on the building energy consumption have already been made when public authorities defined the urban planning rules. Trying to include in the

EPB requirements stimuli for compact shapes (for a given useful building size, e.g., as expressed by the useful floor area) may thus often have limited impact. Also, specifiers and designers don't always discern the implicit stimulus, as they typically first decide on the shape of the building, and then don't evaluate anymore which impact changes of the geometry have on the EPB features. A more effective argument to nudge specifiers and designers to minimize the thermal envelope area for a given floor area, might be the extra cost associated with extra (well-insulated and airtight) envelope area. This message of course needs to be communicated systematically and continuously (towards both lay builders and professional designers).

#### 9.4 New construction/renovation

A heating "need" requirement is usually applied to new buildings, in principle both residential and non-residential, but in practice more often the former than the latter.

As with all requirements that transcend element level, it appears much more difficult to set such a requirement in a sensible manner in the case of renovation. Some information necessary to perform the calculation may not be well known (e.g., thermal transmittance of existing walls) or can be difficult to measure (e.g., air tightness of a part of the building). Also, establishing an appropriate strictness of the requirement on a case by case basis (taking into account which parts are renovated, and the quality of those that are not) seems difficultly achievable in the context of a rigorous regulation.

#### 9.5 Exceptions

The heating "need" requirement is usually applicable to all projects that are subject to an overall energy performance requirement. Usually, no specific additional exceptions are defined in a general manner for this requirement. (In exceptional cases an overall hardship clause in the regulation can be used to grant exceptions on a project by project basis).

### 10 Energy need for cooling, or variants

Essentially the various considerations that apply to the energy "need" for heating are also valid for the cooling "need", while making the necessary adaptations. These reflections are not repeated here.

It is evident that this partial requirement is especially relevant in warm climates. However, also in more heating dominated climates it may be pertinent to set a cooling "need" requirement, independently whether in a building active cooling is actually installed or not. This is one way to create a counterweight against a one-sided design that focuses on the winter situation only, potentially creating comfort problems in summer (e.g., by maximising uncontrollable solar gains), and potentially leading to the installation of active cooling at a later date. Obviously, the same reasoning may vice-versa be valid for heating in cooling dominated climates.

NOTE Instead of using the fictitious cooling or heating "need" in uncooled or unheated buildings respectively, the degree of overheating or undercooling can be used, as discussed in [Clauses 7](#) and [8](#).

### 11 Combination of "needs"

A single combined requirement gives building designers freedom to shift between minimized winter and summer "needs", as long as the overall requirement remains satisfied. There is thus obviously no guarantee that each separately achieves a good performance, and if the objective of the requirement is also to contribute to a good indoor environmental quality (in particular in an unheated and/or uncooled building) a requirement on the combined "needs" by itself is not a good instrument.

Sometimes daylighting is also included in the combined needs. For a treatment of daylight in its own right and its impact on artificial lighting, see, e.g., EN 15193-1<sup>[16]</sup> or national regulations.

## 12 Overall thermal insulation of the thermal envelope

### 12.1 Motivation

In heating dominated climates, heat transfer caused by transmission through uninsulated envelope elements traditionally constitutes the major cause of the overall heating and energy consumption. Setting a requirement on the overall thermal insulation is thus a major step towards a lower energy consumption. Logically, in such climates this requirement has for several decades been among the most applied measures by public authorities. A good thermal insulation also contributes to a better indoor environmental quality, as is further discussed in [Clause 13](#). A requirement on the overall thermal insulation leaves freedom to the design team to choose which elements of the envelope are insulated better (within any restrictions imposed on individual elements, see [Clause 13](#)). At the same time it constitutes a strong stimulus to keep within limits the transparent areas (which as a rule have a much higher thermal transmittance than insulated opaque elements). Buildings with an excessive glazed area are thus discouraged, avoiding in this manner energy and comfort issues related to both the winter and summer (overheating) situation.

As an alternative to a direct overall thermal insulation requirement, the combination of a limit to the window area (expressed as a fraction of the useful floor area) and maximal thermal transmittances of each of the individual envelope elements (see [Clause 13](#)) can be used. This was much more common in the early days (typically in the 1970s) of the insulation regulations.

### 12.2 Indicators

The mean thermal transmittance of the thermal envelope ( $U_{mn}$ ) as defined in ISO 13789 [\[10\]](#) is often used as an indicator, whereby due attention should be paid to setting judicious requirements. This is further discussed in [12.3](#) and [Annex E](#).

Another option is to use the overall transmission heat transfer coefficient ( $H_{tr}$ ) as defined in ISO 13789 [\[10\]](#).

Alternatively, the ratio of the mean thermal transmittance (or of the overall transmission heat transfer coefficient) to a reference value ( $U_{mn}/U_{mn,ref}$  or  $H_{tr}/H_{tr,ref}$ ) can be used. The reference value can be given by a mathematical formula or a notional reference building.

**NOTE** In the past, the design heat loss (at conventionally fixed indoor and outdoor temperatures) has sometimes been used as alternative, because it takes into account the effect of unheated spaces and the ground resistance (as opposed to the thermal transmittance of the thermal envelope elements by themselves). However, since these effects have in due course been included in the overall transmission heat transfer coefficient ( $H_{tr}$ ) and thus also in the mean thermal transmittance ( $U_{mn}$ ), this is no longer a reason for using the design heat loss.

For explanation of ISO 52018-1:2017, Clause 12, Note 1, see [13.2](#).

### 12.3 Comparable economic strictness

A constant value as requirement for the mean thermal transmittance usually does not result in economically optimal requirements for all buildings. The same is true for an overall transmission heat transfer requirement that simply increases proportionally with the size (as indicated by the volume or the by useful floor area) of the (insulated part) of the building.

Instead, since several decades it has been considered appropriate in many countries to give allowance for a reasonable amount of glazing, which is typically considered proportional to the useful floor area. In this manner, the maximal value of the overall transmission heat transfer increases linearly with the useful floor area (but not proportionally to it). Or correspondingly, the maximal value of the mean thermal transmittance increases linearly (but not proportionally) with the ratio of the useful floor area to the envelope area ( $A_{use}/A_{env}$ ). Alternatively, the inverse ratio ( $A_{env}/A_{use}$ ) is often used. Obviously, the maximal value of the mean thermal transmittance is then inversely proportional to this ratio, plus a constant value. As an alternative to the useful floor area, the volume (which on the average correlates

quite well with the useful floor area, through the mean floor height) has in the past also often been used as basis to (implicitly) set the window allowance.

The motivation for this well proven approach is further explained and illustrated in [Annex E](#).

#### 12.4 New construction/renovation

This requirement is usually applied to new buildings, both residential and non-residential.

In the case of renovation, the more straightforward and more common approach is to impose thermal transmittance requirements on individual elements (see [Clause 13](#)), possibly in combination with a limit on the total window area of the building unit (e.g., 25 % of the useful floor area).

In the case of renovation, more design flexibility (in terms of window area and/or thermal transmittance of individual elements) can be given by allowing project teams to alternatively opt for an overall requirement on the transmission heat transfer coefficient of all new, replaced and renovated elements. The requirement logically corresponds to the value obtained by applying the simple approach thermal transmittance and window area requirements to the project at hand. Also see [Annex E](#) for the underlying philosophy.

#### 12.5 Intermediate forms between overall and individual thermal insulation

In the early days of the building energy regulations (mostly in the 1970s), several variants of thermal insulation requirements have been explored that cover parts of the thermal envelope (but more than individual elements). These include:

- the heat transfer coefficients of individual rooms;
- the mean thermal transmittance of all walls, including the windows (but thus excluding roof/ceiling and floor heat transfer);
- the mean thermal transmittance of all opaque parts of the envelope.

Most of these variants have not been in application for a long time, and have usually been supplanted by overall thermal insulation requirements covering the entire thermal envelope. Note that the last requirement in the list above does not stimulate considerate use of window area.

Another variant is to set a common requirement for all elements of a certain type taken together (e.g., all walls or all roofs). This is further discussed in [13.3](#).

### 13 Thermal insulation of individual elements of the thermal envelope

#### 13.1 Motivation

Good thermal insulation may provide several benefits: not only does it reduce energy consumption, it also contributes to a better indoor environmental quality. In certain climates moisture transport and accumulation within the envelope (and fabric preservation) are also specific points of attention. These 3 aspects (and possibly others) can all be taken into consideration when setting requirements on the thermal insulation of envelope elements.

Low internal surface temperatures increase the local relative humidity and thus the deposition of dust, the risk of mould growth and the danger of surface condensation. These aspects are treated in ISO 13788. A special point of attention are local cold spots due to thermal bridges, cf. [Clause 14](#).

Low internal surface temperatures also diminish the thermal comfort of occupants due to lowered and asymmetric thermal radiation exchange and due to cold internal airflows.

In heating dominated climates the cost optimal degree of insulation of opaque elements seems usually (but depending on energy prices, insulation cost, etc.) much better than the insulation level

that is needed for a good indoor environmental quality. So, for opaque elements requirements set on the basis of the economic energy savings normally also appear to guarantee sufficiently high internal surface temperatures. For transparent elements, it may technically and economically be more difficult to realize low thermal transmittances. If the internal surface temperatures are deemed insufficiently high (depending on the glazing used, outdoor climate, etc.), appropriate positioning of the heat emission elements (usually below the transparent elements) is generally used to achieve good thermal comfort.

### 13.2 Indicators

The temperature factor  $f_{R_{si}}$ , as defined in ISO 13788, is most often used to characterize an envelope element with respect to the internal surface temperature. However, since it may be difficult to accurately determine its value at all local cold spots of the thermal envelope, e.g., at all thermal bridges (cf. [Clause 14](#)), it may not be obvious to use it as a strict criterion in the context of an EPB regulation. Also, it may not be easy to satisfy strict requirements at all points of the envelope, e.g., at the edge of multiple (double, triple, etc.) glazing.

Requirements on the thermal insulation of elements are most often expressed in terms of the thermal transmittance ( $U$ ). For opaque elements, sometimes also the total thermal resistance ( $R_{tot}$ ) or the surface to surface thermal resistance ( $R_{c;op}$ ), i.e., without surface resistances, are used; both are defined in ISO 6946 [9]. There appears no strong reason to prefer one or the other of the 3 options. In the case of renovation, the resistance of the insulation layer (which is to be added) is sometimes used in certain situations.

Explanation of ISO/TR 52018-1:2017, Clause 12, Note 1: The area of building elements and their thermal transmittance, as well as the lengths and thermal transmittances of linear thermal bridges and the thermal transmittances of point thermal bridges need to be obtained from or via the same source, because the values depend on the choice of dimensions (internal, external, etc.), in such a way that the overall thermal transmittance is the same ("communicating vessels"). These quantities are calculated in other standards and listed in ISO 13789[10] as part of centralized data transfer to destination modules such as ISO 52018-1. Another reason is to facilitate as alternative (e.g., for existing buildings) an aggregated input, such as the overall heat transfer coefficient for all thermal bridges combined.

### 13.3 Points of attention

Various points of attention with respect to the setting of thermal insulation requirements in the context of a regulation are discussed here (how to formulate the requirements precisely, et cetera). Many aspects are more or less self-evident, but are nevertheless mentioned explicitly for the sake of better completeness.

It may be that requirements with respect to different aspects (e.g., indoor environmental quality and energy savings) are treated in completely different places (e.g., indoor environmental quality in national standards or other technical reference documents and energy efficiency in buildings regulations). It goes without saying that mutual coherence and reference may then be an important point of attention.

A first technical point of attention is to clearly specify in the regulation at which inclination angle of the element the value (of  $U$ ,  $R_{tot}$  or  $R_{c;op}$ ) should be evaluated. The surface resistances and the resistance of internal air (or gas) layers (or voids) depend on the direction of the heat flow (conventionally divided in 3 discrete categories: upward, horizontal and downward, cf. for instance ISO 6946[9]). For opaque elements the real position (and heat flow direction) of the element can normally be used without problem, and this is generally done. However, in the product documentation of glazings, typically only the thermal transmittance ( $U_g$ ) in vertical glass position (i.e., horizontal heat flow) is given. The value for upward (or downward) heat flow is generally not available in the product catalogues. Nor is the necessary information systematically disclosed (notably the thermal emissivities and gas composition) that would allow to calculate the thermal resistance of the gas layer at any given inclination. Therefore, the insulating requirements for transparent elements (whether for the element as a whole, including the frame and any other parts, or for the glazing by itself) are usually formulated by convention for a vertical position. (The real heat loss will be larger in the case of roof windows.) Alternatively, conversion conventions for non-vertical positions may be defined.

A further point of attention is the extent to which all thermal bridges that are part of an element are included in the calculation of the thermal transmittance (or  $R_{\text{tot}}$  or  $R_{\text{c,op}}$ ). When they are not rigorously and systematically considered (and normally thus not integrated in downstream calculations of the energy “needs” and overall energy performance either), there will be no regulatory incentive to develop and apply improved solutions for these details.

NOTE 1 The thermal bridges that occur within the area of an element are sometimes called the embedded or the areal thermal bridges, which are to be differentiated from the peripheral thermal bridges occurring at the junctions between elements.

Another point of attention is whether the requirement applies to each element individually, or whether it is valid for the (area weighted) average of all elements of a given type, e.g., all walls, or all roof parts. The following considerations can be formulated with respect to a requirement on the average value per type:

- In principle, it allows a bit more design freedom: a lesser insulation of some parts can be compensated for by a better than average insulation of other parts. This consideration is sometimes used to justify somewhat stricter average requirements.
- However, especially in the case of small renovations, there may only be a couple of elements (or even only one single element) in a given class, so that the possibility of interchange is limited or inexistent. At least for renovation, the requirements should thus be set in such a manner that they are also feasible for each individual element.
- The possibility to compensate between different elements also introduces some risk that some parts are very poorly insulated, resulting in low internal surface temperatures and the attendant issues.

So, all in all, the application of an insulation requirement on the average value of an entire class of elements appears to have unclear added value.

NOTE 2 Some countries combine both approaches. For instance, for some types of elements each individual element must satisfy the requirement, for other types only the average of all elements must comply. Or a different approach can apply to residential and to non-residential buildings. Or to new construction and to renovation.

A related point of attention may be elements with a local variation of the thermal transmittance due to insulation layers of variable thickness (e.g., to create slope on a flat roof), see ISO 6946:2017, Annex E [9]. For energy efficiency values the average thermal transmittance serves well, but if the insulation is in one or more extreme points very thin or zero, there may be undesirable local cold spots. To avoid this, a local insulation requirement may be imposed for all points of the element. This may for instance also apply to gutters of flat roofs.

A special point of attention are cavity structures that separate heated spaces, e.g., between row houses or between (acoustically decoupled) apartment units within an apartment building. It is generally assumed that the heat transfer is between the heated spaces (if at different temperature). However, it has been experimentally observed that air flows can create important extra heat transfer. External air entering and leaving the cavity (due to thermal stack effects and/or wind forces) through peripheral openings exposes the internal walls to a lesser or greater extent to outside temperatures. And internal convection flows within a closed cavity can transport energy from conditioned to unconditioned parts of the building, e.g., from the ground and first floors to an unheated attic, bypassing the floor insulation of the attic.

NOTE 3 This issue has been well documented in the UK (see for instance [23]), and integrated in their building regulation since 2010.

NOTE 4 Hollow structures in contact with the outside can also constitute a pathway for air leakage to the internal environment (through leaks between the cavity and the indoors) causing energy losses and possibly thermal comfort problems. Normally, this shows up in airtightness measurements.

To eliminate this problem, the regulations can prescribe that the cavity be hermetically sealed in a careful manner all around the perimeter of the conditioned zone and possibly in addition that it be fully filled with a flexible insulation material. If there is no such requirement, it is appropriate to include the external heat transfer of these internal cavity walls in all energy performance calculations, cf. ISO 13789:2017, 7.3 and Table A.3[10].

Further, it should be specified whether for components in contact with adjacent unheated spaces (sunspaces, attics, garages, etc.) the same thermal insulation requirements apply as for elements in contact with the outside air, or whether special (laxer) requirements apply.

NOTE 5 An alternative approach could be to specify that not the thermal transmittance as such, but its product with the adjustment factor  $b$  (cf. ISO 13789:2017, [10] 7.5), must comply with the same requirements as elements in contact with the outside air (i.e.,  $b.U < U_{max}$ ). In heating dominated climates, a slightly more accurate approach could in principle be to consider the product with the square root of  $b$  ( $\sqrt{b}.U < U_{max}$ ), but the result is usually not so different. (And all other uncertainties involved in the determination of the adjustment factor  $b$  may not warrant this degree of detail.)

For transparent elements equipped with shutters, it should be specified whether the insulation requirements apply to the element with the shutter in open or closed position, or to a (weighted) average of both. From the point of view of winter comfort, it is desirable that also in open position the internal surface temperature is sufficiently high, calling for a requirement on the open position. (But for the further EPB calculations, it may of course be assumed that the shutters are closed a certain fraction of the time.)

Finally, it should be noted that element types for which no requirements are set, can be executed at will. Examples may be letter boxes integrated in walls, (closable) ventilation openings or garage doors. It may be appropriate though to:

- include in the regulation a note that draws the attention to the fact that these elements also represent energy losses (transmission transfer and possibly air leakage) and can cause indoor environmental issues (e.g., cold drafts);
- specify whether, and if so how, these elements need to be integrated in the further EPB calculations.

### 13.4 Comparable economic strictness

In heating dominated climates, the financially optimal insulation level of opaque elements is only to a minor extent influenced by the heat transfer via other paths (transmission through all other elements, hygienic ventilation and in/exfiltration) and by the quantity of (internal and solar) gains. It is thus possible to set sensible thermal insulation requirements for each individual element, independent of each specific project context (see Annex F).

The primary factors affecting the optimum are usually the overall heating system efficiency, energy prices and the marginal cost of extra insulation around the cost optimal point, i.e., how much does the initial investment cost increase or decrease if the insulation is made somewhat thicker or thinner around the optimal thickness. It does not depend on the initial resistance of the element without insulation (e.g., of an existing wall) or on the initial cost of starting to apply insulation (at first a thin layer). The marginal investment cost obviously does not only include the cost of the extra insulation material itself and the modified costs of labour, but also possible secondary costs (in the case of a cavity wall for given internal dimensions: longer wall ties, somewhat broader foundations, somewhat wider roof, somewhat larger outer leaf, etc.).

In view of achieving an overall optimal allocation of investments, it is desirable that the thermal insulation requirements of different types of elements (walls, roofs, etc.) correspond to their own financial optimum depending on the typical marginal insulation cost of each type. Thus, if typical marginal insulation costs in a given country warrant it, different classes and subclasses of envelope elements may be defined, e.g., imposing differentiated requirements between flat and pitched roofs.

### 13.5 New construction/renovation

Because each element is evaluated independently of the features of the remainder of the project, this type of thermal insulation requirements can easily be applied both to new construction and to renovation or extension. For renovation, the regulation should define precisely under which conditions the requirement applies (e.g., full replacement only, or also in the case of certain kinds of works on elements, e.g., renewal of an external wall rendering, when external insulation can be applied). Detailed

rules may be needed to define when exceptions can be invoked (e.g., lack of space for the external insulation).

As indicated in the previous paragraph, the economic optimum only depends in secondary order on the other energy flows making up the heating need balance. However, if these effects are taken into account (usually more remaining heat loss in existing buildings), as well as different typical overall heating system efficiencies (generally less efficient for existing buildings), for a given type of element (e.g., walls) slightly stricter insulation requirements could economically be justified in the case of renovation. Some regulations introduce such differentiation.

### 13.6 Exceptions

Usually, some exceptions are allowed. In this instance, it seems important to draw the attention of the designers to the indoor environmental aspects, which may still require sufficient insulation (in as far as no separate requirements apply for this purpose).

One way to express the exceptions is to enumerate them explicitly (e.g., glass entrance doors, or shop windows).

Another, more general way is to express them as a fraction (e.g., 1 %) of the area that is subject to the individual thermal insulation requirements. Sometimes the useful floor area is taken as reference. If an element is subject to more than 1 requirement, for instance one on the glazing by itself and another on the window as a whole, the regulations have to specify whether or not the corresponding areas are both considered for determining the reference area for the fractional exception.

It should be noted that in the case of renovations where small areas may be concerned, the fractional exception rule does not allow for much deviation.

## 14 Thermal bridges

### 14.1 General

Clause 14 only deals with the thermal bridges at the junction of 2 or more elements. See [13.3](#), Note 1 for a distinction between these peripheral thermal bridges and the areal or embedded thermal bridges (e.g., wall ties), which are here considered as part of the insulation of the elements.

### 14.2 Motivation

The different objectives that are valid for the thermal insulation of individual elements, as discussed in [13.1](#), also largely hold true for thermal bridges.

Because room air circulation is usually reduced in internal corners, the internal heat transfer coefficients are locally lower. Combined with geometrical features (e.g., resulting in the heat flux fanning out towards the outside) and possibly the local use of other, less insulating materials, the lowest internal surface temperatures often occur in corners. As the area of the surfaces involved (around the corner) is usually limited, the depressed temperatures normally do not affect the thermal comfort of the occupants very much. However, the risk of dust fouling, mould development and condensation is increased, and for these reasons avoiding thermal bridges in corners is thus a prime point of attention. It should be said though that in new construction problems rarely occur if the insulation layers of the different flanking elements connect in a sufficiently continuous manner.

### 14.3 Requirement setting

As the proper quantification of thermal bridges is not so easy, strictly and systematically verifying compliance with any requirement (both by the project team and – in the case of control – by the building authorities) may be quite laborious. Setting requirements may therefore not be obvious if strict enforcement of the regulation is envisaged.

The temperature factor,  $f_{Rsi}$ , qualifies low internal surface temperatures. Simplified calculation methods (as used for determining the overall heat transfer) are usually not adequate to evaluate the value of the temperature factor with sufficient accuracy in view of avoiding surface condensation, etc. Numerical calculations according to the relevant standard under EPB module M2-5.2 are then needed.

NOTE The EPB standard under module M2-5.2 is ISO 10211 [11].

When requirements on linear thermal transmittances,  $\Psi$ , are set, rules can be defined concerning which junctions need (and/or those that do not need) to be evaluated, e.g. depending on the degree of continuity of the insulation layer.

Point thermal transmittances,  $\chi$ , where 3 (or more) elements join, are usually neglected in the calculations of the overall thermal transmittance. This is especially true if the overall heat transfer coefficient is calculated on the basis of external dimensions (and thus also the external length is used for the linear thermal transmittances). It, therefore, seems rather uncommon to have regulatory requirements on point thermal transmittances. The issue of low surface temperatures can better be controlled by means of a temperature factor, as discussed above.

#### 14.4 Alternative routes

In order to stimulate in the building regulation in a pragmatic manner that attention be paid to a reasonable continuity of the insulation layer at all joints and corners between the different elements, an approach along the following major lines has given positive experiences in some countries.

In this instance, no requirements as such are imposed on thermal bridges. Instead, a framework is created that ensures that the influence of thermal bridges is certainly integrated in the calculation of the overall heat transfer coefficient (and thus automatically in the downstream calculations of the energy “needs” for heating and cooling and of the overall energy performance). Without such scheme, it is otherwise often observed that thermal bridges are not at all or not fully accounted for in the calculations, even if the regulation and calculation method in principle prescribe a rigorous treatment.

NOTE In such scheme, it is thus not forbidden to have thermal bridges performing very poorly, since there is no explicit requirement. However, this can be strongly dissuaded by a penalising factor in the calculations (as explained below), and it goes without saying that the designers remain fully responsible for any damage that might be caused by poor design (e.g., mould growth).

In their practical implementation, this kind of schemes vary from one country to another, but some common features often return.

First, a choice is offered to the design team between 3 options.

- a) Either a quite penalising automatic surplus ( $\Delta H_{tr,a}$ ) is added to the heat transfer coefficient (while further disregarding in the context of the energy performance regulation the actual – maybe poor – execution of the joints and corners).
- b) Or some semi-quantitative rules with respect to “acceptably good design” (see further discussion below) are respected, and then only a small automatic surplus ( $\Delta H_{tr,b}$ ) is added to the heat transfer coefficient. Any other non-conform junction or corner is additionally taken into account with a linear or point thermal transmittance value. Or any junction for which proof is produced that it performs better than the limit value (see below), can get a bonus.
- c) Or all junctions and all corners are integrated into the calculation with their linear or point thermal transmittance value.

In methods a) and b) the automatic surplus is each time fixed by the regulation, typically expressed by the following formula:

$$\Delta H_{tr,i} = \Delta U_i \cdot A_{env}$$

where

- $\Delta H_{tr,i}$  is the surplus heat transfer coefficient, for method i, in W/K;
- $\Delta U_i$  is the surplus thermal transmittance, in W/(m<sup>2</sup>·K);
- $A_{env}$  is the area of the envelope of the part of the building for which the surplus heat transfer coefficient is calculated, e.g., a thermal zone, in m<sup>2</sup>;
- index  $i$  can take the values “a” or “b”, depending on the method that applies.

The surplus thermal transmittance ( $\Delta U_i$ ) is defined by the regulation and it is logical that its value is variable depending on the ratio of the useful floor to envelope area to account for the typical window area (see also [Clause 12](#)) and the associated thermal bridge effects.

In methods b) and c), the linear thermal transmittance values can be determined according to any of the methods listed in the relevant standard under EPB module M2-5.2 and/or additional rules and/or (e.g., very simple) additional default values.

NOTE 1 The EPB standard under module M2-5.2 is ISO 14683 [\[12\]](#).

NOTE 2 Obviously, it is important to stress in the method itself, and in all communication surrounding it, that the design team remains fully responsible for any indoor environment issue (e.g., potential problems associated with the low internal surface temperatures) related to thermal bridges. The simplified assessment methods are strictly limited to the scope of the EPB assessment and don't waive any responsibility with respect to other aspects. This is particularly true for method a).

Second, for method b) an “acceptably good” junction or corner should be defined. The basic idea is usually the sufficient continuity of the insulation layer, mostly described in simple rules that can easily be evaluated without calculation. The precise definition may be according to (a country specific selection of) the following criteria:

- 1) The linear or point thermal transmittance remains below a limiting value. (Although it concerns a kind of “requirement”, it should be confused with an absolute requirement that forbids worse junctions. Here, in the context of option b), it only concerns a criterion to fall in the category “good design”. Worse executions are still possible, if they are taken into account separately in the overall calculation.)
- 2) The insulation layers of all flanking elements are in sufficient direct contact with each other.
- 3) One or more intermediate materials of sufficient resistance establish sufficient contact between the flanking insulation layers.
- 4) The path length not going through an insulation layer should exceed a minimal value (e.g., in the case of certain types of foundations).
- 5) The junction or corner follows a prescribed composition according to a catalogue (whereby precise rules may need to be defined for acceptable variations in terms of dimensions, thermal conductivities, etc., of each of the different material present in the node).
- 6) A particular composition of a junction has been accredited through preliminary evaluation by a designated neutral instance (in particular suitable for very repetitive construction, e.g., by large construction companies).
- 7) Still other variants.

#### 14.5 New construction/renovation

In the case of renovations, junctions or corners may be much more difficult to evaluate and to resolve, notably at the contact line between existing and new/renovated elements. For this reason, there usually seem to be no requirements in the regulation. Instead only complementary guidance is formulated.

## 14.6 Further information

More information on the treatment of thermal bridges in EPB regulations can be found in the reports of the ASIEPI project<sup>[18]</sup>.

## 15 Window energy performance

### 15.1 Motivation

A requirement on the thermal insulation of transparent elements does not take into account the impact of solar gains and any ventilation heat transfer through the elements. A more integral approach that includes these other factors may in principle provide a more balanced overall energy evaluation. But it might possibly be at the expense of the thermal comfort aspect, notably the indoor surface temperature factor (namely when the overall energy requirements can be satisfied with less insulating glazing).

In particular the impact of solar gains on the heating and cooling “needs” (see [Clauses 9](#) and [10](#)) and on the thermal comfort (see [Clauses 7](#) and [8](#)) depends on many other influencing factors, such as the total window area. In new buildings a much more precise evaluation is made in the further, integral EPB calculations that take into account the many project specific features (overall window area and orientation, external shading, thermal mass, overall heat transfer, internal gains, etc.). Given the great number of assumptions that intrinsically need to be made to evaluate the window energy performance of a single element by itself, such requirement thus does not seem very appropriate in new construction. If applied at all, it would seem to be more appropriate in the case of renovations.

### 15.2 Indicators

ISO 18292<sup>[13]</sup> provides a methodology for both the heating and cooling aspects of the window as a whole in residential buildings. The indicators are based on a reference building.

ISO 14438<sup>[14]</sup> defines a so-called energy balance value E, taking into account the thermal transmittance and solar gains of the glazing only, considering the heating season only.

### 15.3 Points of attention

If such a requirement is included in the regulation, following aspects should be clearly defined by the regulators.

- Is the fenestration energy performance an absolute requirement? Or is it a free choice alternative to a thermal insulation requirement?
- Does the requirement apply to heating only, to cooling only, or to the (possibly weighted) combination of both?
- Should the evaluation be performed for the real orientation and tilt? Or is an average value for all orientations and tilts applicable to all windows (so that it can be evaluated independent of its real position)?
- The many boundary conditions for the calculation should be precisely defined.

### 15.4 New construction/renovation

As mentioned in [15.1](#), there are other, much better requirements that can be set in new buildings to make an integral evaluation of the precise impact windows on the total energy needs and thermal comfort in a project specific manner. It is therefore rather in the case of renovations that this type of requirement could provide some added value compared to mere thermal transmittance requirements (but bearing in mind the many simplifications that come with it).

## 16 Airtightness

### 16.1 Motivation

Good airtightness can contribute to a good indoor environment, fabric preservation and energy savings.

Air leaks in the thermal envelope can create uncomfortable cold draughts during the heating season, or unpleasant warm air streams in summer in air conditioned buildings. Apart from the disturbing direct exposure of people to these air flows, in/exfiltration can also contribute to uncomfortable overall indoor temperatures when the building is not conditioned (overheating in summer in buildings without air conditioning, and/or low temperatures in winter in unheated buildings).

Moist air permeating through the envelope (in either direction) can (depending on the climate and on many other influencing factors) potentially give rise to internal condensation and other related problems.

A good overall air tightness strongly reduces the risk of single, large leaks, and thus the probability of serious discomfort, condensation, et cetera due to leaks in the thermal envelope. However, it is clear that it does not provide an absolute guarantee that these leakage-caused issues will never occur anymore in a building that has a generally good airtightness (since significant local leakage may remain at specific points).

Uncontrolled air leakage through the envelope may also strongly interfere with the controlled hygienic ventilation, causing the indoor air quality (IAQ) objectives of the ventilation system design not to be met in practice. This issue by itself is sometimes considered a sufficient reason to impose in the regulation a quantitative airtightness requirement, in combination with systematic proof of compliance by means of mandatory airtightness testing in every new construction project.

Finally, the in/exfiltration constitutes a term in the heating and cooling thermal energy balances that may be significant if the overall airtightness is poor. Depending on the climate, it may be quite cost-effective already from this perspective only to pay due attention to the avoidance of air leaks.

### 16.2 Indicator and comparable economic strictness

The (extra) cost of achieving good airtightness may depend on many different factors, such as the type of construction (masonry walls, timber frame constructions, etc.). In all cases, however, it appears technically and economically not too difficult to avoid (or to tighten posteriorly) the major, large air leaks, on condition of giving it from the start due attention during both the design and the execution phase. In construction contexts where previously little or no attention was paid to airtightness, improvements by a factor of 2 to 3 have often shown to be easily achievable.

However, if there is too much uncertainty about an equitable requirement (technically, economically, functionally, etc.) for all buildings, as an alternative option it may be considered to make only the airtightness measurement itself mandatory (without imposing a quantitative requirement on the result). In combination with a proper valorisation of the measured airtightness in the EPB assessment method (which implies a judiciously chosen default value) and a sufficiently strict overall EPB requirement, such mandatory measurement may provide a sufficient stimulus to also achieve reasonable air tightness levels, while avoiding overly strict or lax requirements in individual projects. By making the measurement itself obligatory, all actors in the construction sector can be expected to systematically and rapidly progress on the learning curve.

When taking the decision to make air tightness measurements mandatory, the corresponding costs and benefits should be taken into careful consideration. The outcome may strongly depend on the climate. It should also be ensured that sufficient operational testing capacity is present by the time

the measurements become mandatory. This can be achieved by a combination of different preparatory measures, such as:

- ensure that the EPB assessment method gives correct reward to a good air tightness (including the setting of a reasonably negative default value), so that the market is already spontaneously stimulated in this manner;
- announce the measure sufficiently in advance so that private actors have the time to develop the required testing capacities (purchase of equipment, training of personnel, etc.);
- stimulate the early development of the testing market by means of temporary financial incentives;
- organize or facilitate training and general awareness raising;
- if the market does not spontaneously adhere to rigorous quality standards of testing, organize appropriate compliance verification (e.g., control testing of random samples), cf. also [16.4](#);
- make the air tightness measurement mandatory in a stepwise manner, starting with certain (sub) categories of buildings only.

In a first, very rough approximation, the leakage can be expected to be proportional to the total area of the thermal envelope. As the envelope area per useful floor area or the envelope area per volume vary greatly from one building to another depending on its shape (compact or elongated, etc.) and its size (large or small), it is evident that a constant value requirement for the specific leakage rate per useful floor area ( $q_F$ ) or for the air change rate ( $n$ ) does not constitute a comparable technical and economic strictness. Practical experience has amply shown that a requirement on an air change rate expressed as a constant maximum value can relatively easily (actually, often too easily) be satisfied in large buildings, but requires much more (and sometimes excessive) effort in small buildings. The specific leakage rate per useful floor area ( $q_F$ ) or the air change rate ( $n$ ) are thus not so suited for imposing equitable requirements by means of a constant value. Although still rough, the specific leakage rate per thermal envelope area ( $q_E$ ) has proven to be a better indicator for the airtightness quality and to be a better indicator for setting a constant value requirement. Over the years, a tendency towards the use of the specific leakage rate per thermal envelope area as criterion can thus be observed in many regulations.

### 16.3 New construction/renovation

If an airtightness requirement is set, it appears that there is little difficulty to impose a (reasonable) value to all new constructions (which may initially be not too strict, and tightened later on). For renovations this seems much less evident, unless it concerns a very thorough refurbishment of the entire building, so that all parts of the envelope can be dealt with in terms of airtightness.

In the case of renovation, there is another point of attention. Old buildings often have no dedicated hygienic ventilation provisions. Acceptable IAQ then often depends on conscious airing by the building users and/or on infiltration. When for instance old, leaky windows are replaced by airtight new ones, experience has shown that in some cases serious IAQ-problems arise. It may therefore be appropriate to require dedicated, controllable ventilation provisions (e.g., trickle vents) in the case of renovation.

### 16.4 Measurement

Envelope airtightness is one of the few partial energy performance features that can relatively easily be measured with reasonable accuracy at acceptable effort and cost. Since good airtightness not only depends on proper design (e.g., of connection details between elements) but also to a significant extent on careful execution, a systematic measurement of the achieved performance for each project provides the highest level of confidence with respect to the actual airtightness effectively achieved upon completion.

Like any other data input in energy performance calculations, correct airtightness measurement results are essential. If the market does not spontaneously adhere to rigorous quality standards for the measurements, public authorities should also perform random control measurements to verify

correct measurement and reporting (in the same way as they may check any other input data of an EPB assessment). Alternatively, it can be specified in the regulation that airtightness measurements for EPB reporting must be performed in the context of a certification scheme, which logically also includes random control measurements.

**NOTE** Assumed compliance with a given quantitative requirement can also be based on a quality assurance scheme without systematic measurement. Such schemes have been implemented in some countries, which has resulted in mixed experiences. The factors that make a quality assurance scheme more successful appear to be related to its specific practical characteristics, such as the availability of technical details, selection and size of the sample to be regularly tested, self and third-party control procedures, evaluation and reporting, etc.

ISO 9972:2017, 5.2<sup>[15]</sup> defines 3 possible measurement methods, which are briefly described as follows:

- 1) test of the building in use;
- 2) test of the thermal envelope;
- 3) test for a specific purpose.

The difference resides in the treatment of the intentional openings in the envelope: windows and doors, openings for natural or mechanical ventilation and other openings (mailboxes, combustion devices, etc.). Depending on the method, each of these types of openings either is left open, or is closed, or is sealed. Method 3 is a method for which the specifications still need to be defined.

When an airtightness measurement is done to obtain (or verify) an input for EPB calculations, it is obvious that the measurement method should be in precise correspondence with the EPB model. For instance, if the air flow through open combustion devices is already explicitly taken into account in the EPB calculations, then it is logic to seal these openings during the airtightness test, and vice-versa. Method 3 allows to define test conditions precisely adjusted to each EPB calculation method.

If in addition a quantitative airtightness requirement is imposed, it is logic that the same testing conditions apply. Otherwise 2 separate measurements (and 2 corresponding building preparations) would need to be performed.

It appears that for the final result of the test (either as input for the EPB calculations and/or as verification of an explicit requirement) the average value of the pressurization and depressurization is the preferred option. One reason is that the extra effort to perform a second measurement series is relatively small (compared to work needed for the preparation of the building and for the installation of the measurement equipment). Another reason is that with both measurements any irregularities (either in the building envelope behaviour or in one of the measurements) can more easily be detected. ISO 9972<sup>[15]</sup> also recommends performing both sets of measurements.

For the reference pressure  $p_r$  2 major practices seem to have emerged so far.

- Either a value in the middle of the typical measurement range (often 50 Pa) is taken. This has the advantage that the result is less sensitive to the measurement variation of outlying points.
- Or a low pressure is used, corresponding to the typical pressure that an average building is exposed to in the course of a year (e.g., 4 Pa). This can be used as direct input into the EPB calculation (without the need for a further reduction in the calculation). It has the advantage that any unusual slope of the airtightness curve (as a function of the pressure difference) is reflected in the EPB calculations.

## 16.5 Further information

More information on the treatment of airtightness in EPB regulations can be found in the reports of the ASIEPI project<sup>[19]</sup>.

## 17 Solar control

Solar gains can represent a significant part of the summer heat load in a building. Limiting them thus constitutes an important means to achieve energy efficiency. It may help to make active cooling superfluous altogether, or otherwise it reduces the energy need for cooling.

Solar protection can contribute in several manners to a better indoor environment. First of all, it can improve visual comfort by filtering direct solar radiation (avoiding blinding, reflection on computer screens, etc.). Secondly, it can reduce direct insolation of persons, which can be a major cause of thermal discomfort. Thirdly, it reduces the general indoor temperature if there is no active cooling.

Although solar gains have an important influence on the summer behaviour of a building, it goes without saying that solar protection devices are not at all the only determining factor. Many other factors also come into play: window area and orientation, type of glazing (and its total solar energy transmittance), external shading by the environment and by the building itself, internal gains (e.g., by the lighting system), accessible thermal mass, intensive ventilation (e.g., airing through windows or other, dedicated large ventilation openings), etc. The relative importance of all these factors can vary strongly from one building to another. Therefore, a more global requirement (notably with respect to the summer thermal comfort, see [Clause 7](#), and/or the energy “need” for cooling, see [Clause 10](#)) is generally more adequate and gives more design freedom, allowing for an optimized mix of measures for each individual project (depending on cost effectiveness, practical feasibility, personal preferences of the builder and/or designer, etc.). Generally speaking, such overall result-oriented, performance-based approach may be preferable to a prescriptive imposition of specific means.

Sometimes, minimum requirements are set with respect to solar control as a precondition to install active cooling, especially in the case of retrofitting. This has the advantage that the solar control investment must be made in any case. It may then appear (either by calculated evaluation, or by practical experience if the investments are staged, which appears recommendable in non-critical applications) that this measure of reducing the solar gains suffices by itself to achieve acceptable summer thermal comfort. The installation of active cooling is then avoided altogether. When there is still a need to install active cooling, the cooling system can be kept smaller and thus cheaper (immediately offsetting some of the initial cost of the solar control devices) and more practical to install. And its energy consumption later will of course be lower too.

## Annex A (informative)

### Input and method selection data sheet — Template

#### A.1 General

This subclause in the accompanying document is a common subclause for all EPB standards. In ISO 52018-1 it is a normative annex. The explanation on [Annex A](#) of the accompanying standard in this Annex is informative.

More information and explanation on the concept of [Annex A](#) and [Annex B](#) for all EPB standards is given in ISO/TR 52000-2.

#### A.2 References

This subclause in the accompanying document is a common subclause for all EPB standards.

More information and explanation on the concept of the normative references to other EPB standards via Table A.1 (normative template) and Table B.1 (informative default choices) of the accompanying document is given in ISO/TR 52000-2.

#### A.3 Mix of partial energy performance requirements

No additional information beyond the accompanying document.

#### A.4 Partial energy performance requirements

No additional information beyond the accompanying document.

#### A.5 Label model

No additional information beyond the accompanying document.

## Annex B (informative)

### Input and method selection data sheet — Default choices

#### B.1 General

This subclause in the accompanying document (ISO 52018-1) is a common subclause for all EPB standards.

More information and explanation on the concept of Annex A and Annex B for all EPB standards is given in ISO/TR 52000-2.

#### B.2 References

This subclause in the accompanying document is a common subclause for all EPB standards.

The references, identified by the module code number, are given in Table B.1 of ISO 52018-1.

More information and explanation on the concept of the normative references to other EPB standards via Table A.1 (normative template) and Table B.1 (informative default choices) is given in ISO/TR 52000-2.

#### B.3 Mix of partial energy performance requirements

As in all EPB standards, the template in Annex A of ISO 52018-1 is applicable to different applications and building types, as explained in A.1 of ISO 52018-1.

**EXAMPLE** Applications: design of a new building, certification of a new building, renovation of an existing building, certification of an existing building.  
Buildings types: small or simple buildings and large or complex buildings.

A distinction in values and choices for different applications or building types can be made:

- by adding columns or rows (one for each application), if the template allows;
- by including more than one version of a table (one for each application), numbered consecutively as a, b, c, ... For example: Table NA.3a, Table NA.3b;
- by developing different national/regional data sheets for the same standard. In case of a national annex to the standard these will be consecutively numbered (Annex NA, Annex NB, Annex NC, ...).

In B.3 of ISO 52018-1 the second option is used, by introducing Table B.2a and Table B.2b. The same can be found in B.4 of ISO 52018-1: Table B.3a, Table B.4a, ..., Table B.9a, Table B.9b, etc.

In this case the tables with addition “a” are applicable to new buildings and the tables with addition “b” are applicable to existing buildings.

In this way the integrity of the template of Annex A is not violated. If these Tables would have been numbered Table B.2, Table B.3, Table B.4, etc., instead of Table B.2a, Table B.2b, Table B.3a, etc., the numbering would no longer be in line with the template of Annex A.

#### **B.4 Partial energy performance requirements**

See B.3 for the rationale behind the numbering of the Tables.

#### **B.5 Label model**

No additional information beyond the accompanying document.

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## **Annex C** (informative)

### **Regional references in line with ISO Global Relevance Policy**

Annex C of ISO 52018-1 contains specific parallel routes in referencing standards, in order to take into account existing national and/or regional regulations and/or legal environments while maintaining global relevance.

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## Annex D (informative)

### Example method for integrating fictitious cooling into the overall EPB indicators

In [7.2](#) the issue is discussed of a well-considered and balanced treatment of cooled and uncooled buildings. One of the possible methods is to include fictitious cooling using a conventional probability based on the degree of overheating. This method is described in this Annex. It can slightly stimulate buildings without active cooling. It has the advantage of further stimulating good design for summer comfort (beyond any explicit requirement that is set). It also moderately discourages the installation of active cooling.

The method works as follows:

- First, in both actively cooled and uncooled buildings the summer thermal comfort is quantitatively evaluated (in actively cooled buildings of course calculated with a freely floating upper temperature, i.e., as if the active cooling were turned off). A maximum limit may be imposed that is maybe not too strict (and for instance in non-residential buildings still – just – achievable without operable windows, but with an otherwise stringent summer design).
- Next, a conventional weighting factor for the installation of cooling is defined:
  - For actively cooled buildings, its value is, of course, 1.
  - For uncooled buildings, its value increases (e.g., linearly) between 0 (or, e.g., 0.25<sup>3)</sup>) and 1 when going from a threshold value<sup>4)</sup> to the limit value of the summer indicator. This is illustrated in [Figure D.1](#). This weighting factor can be considered as a kind of (statistically averaged) probability that active cooling might be installed in the building later in the course of its lifetime. Designs remaining under the threshold thus don't get a penalty, and those exceeding the threshold level receive an increasing penalisation, but never more than actively cooled buildings.
- Finally, the overall EPB indicators are always calculated with (effective or fictitious) cooling, taking into account the weighting factor. For the fictitious cooling a fixed overall cooling equipment efficiency and a fixed primary energy factor are applied that can be chosen somewhat more favourable than the best overall active cooling system on the market.

Both types of buildings (actively cooled and uncooled) are then submitted to the same overall energy performance requirement. In this manner, uncooled buildings are always treated somewhat less strict (and thus slightly stimulated by the regulation) than actively cooled buildings. At the same time a clear regulatory stimulus is created for a good summer design that performs distinctly better than the limit value, and even better than the threshold value, which constitutes de facto a kind of quality label. However, the strength of the regulatory signal obviously depends on the relative importance of the (fictitious) cooling in the overall energy use, and may thus be quite low in cool summer climates.

NOTE Different boundary conditions (e.g., with respect to the use of operable windows) can apply to the calculation of the overheating indicator on the one hand and of the cooling “need” on the other hand.

3) A step function has the advantage of creating a clearer and stronger stimulus to design the building under the threshold value.

4) Corresponding to a very good summer comfort, e.g., almost no overheating.

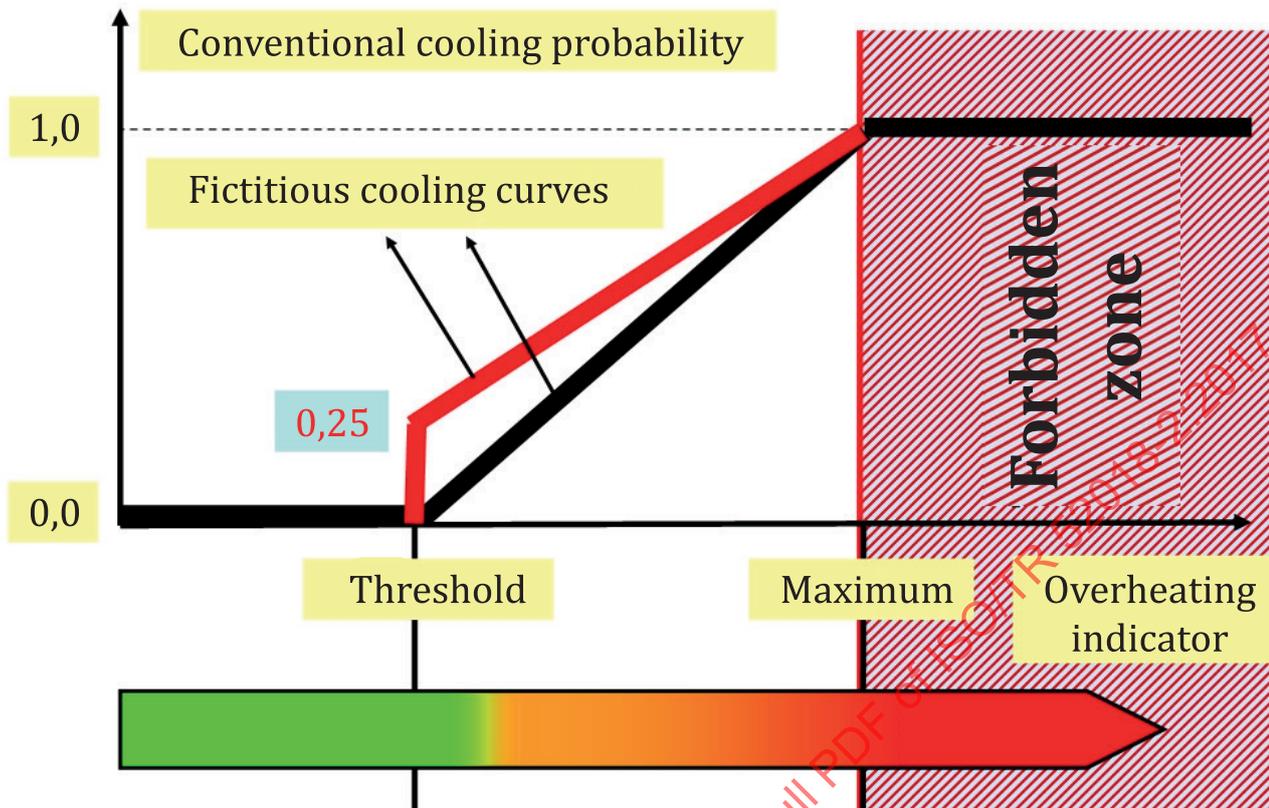


Figure D.1 — Example of a conventional weighting factor for fictitious cooling

## Annex E (informative)

### Illustration of the variable value of the heating need per useful floor area for a given set of technical measures

Annex E illustrates in a practical manner the general principle described in 9.3. The concrete example is based on the Belgian EPB assessment method for dwellings (status 2013) and more than 200 real Belgian dwelling geometries (including single apartments and some studios).

NOTE 1 The Flemish Energy Agency is gratefully acknowledged for giving its kind permission to use its calculation tool with dwelling database to generate these graphs. Also [Figure E.3](#) results from the Flemish EPB regulation.

NOTE 2 A similar example for the primary energy use is given in ISO/TR 52003-2[6].

From detailed calculations of the cost optimal energy performance for different dwellings, it is usually found that the package of technical measures (insulation of different elements, airtightness level, boiler efficiency, etc.) that corresponds to the optimal point (in terms of life cycle cost) is quite similar for different dwelling geometries (shapes and sizes, e.g., detached or row houses). The same finding usually also appears to be true for other categories of buildings (offices, schools, etc.). As a result, if the package of technical measures is formulated well, imposing as requirement the output of the EPB assessment method with the optimal package as input leads to an economically comparable strictness for different projects. In practice, this can be done either by means of a notional reference building or by means of a mathematical formula reflecting the set of measures. Both approaches are equivalent, as explained in ISO 52003-1[5] and ISO/TR 52003-2[6].

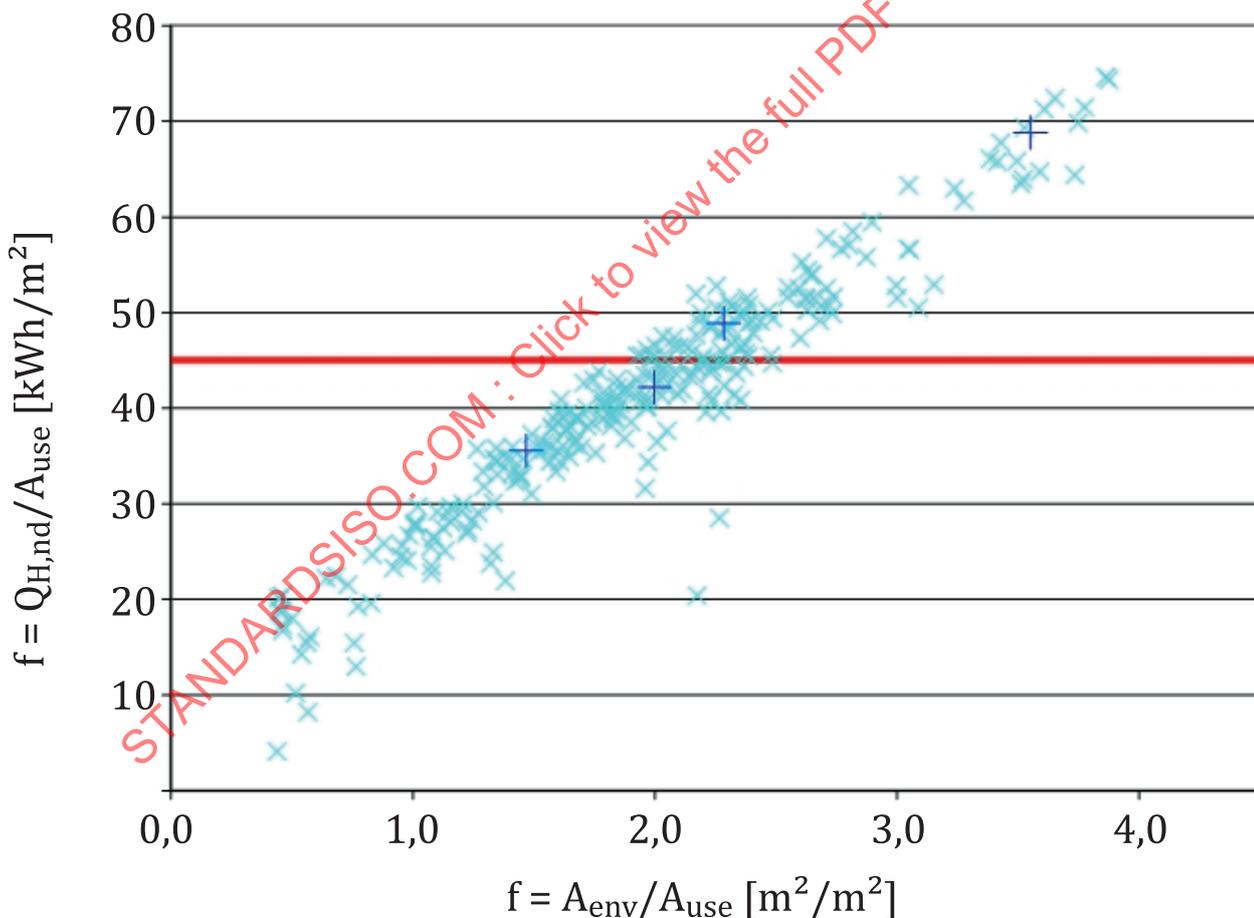
In [Figure E.1](#), the specific heating need is calculated by means of the Belgian assessment method for more than 200 real dwelling geometries for a given set of technical hypotheses, corresponding to the results of the cost optimal calculations on 4 sample dwellings (indicated as dark blue crosses + symbols).

NOTE 3 The abscissa gives the ratio of the envelope area to the useful floor area for the building unit, which is sometimes called the building shape factor (symbol  $f$ ). Small values (i.e., to the left of the axis) are typical for deep, centrally located apartments or studios (e.g., with only 1 external facade). Large values (i.e., to the right of the axis) are typical for small, detached houses.

When considering all points (x-marks in the graph), it can be seen that the specific heating need corresponding to the set of technical hypotheses (and thus probably also in good approximation to the individual cost optimal value) varies greatly, depending among others on the ratio of the useful floor to envelope area. There is a factor of approximately 4 difference between the highest (approximately 80 kWh/m<sup>2</sup>) and lowest (approximately 20 kWh/m<sup>2</sup>) points. Setting a constant requirement, e.g., the intermediate value of 45 kWh/m<sup>2</sup> (horizontal, bold, red line), would mean that some dwellings (towards the right of the x-axis) would need to do much more effort, most likely well beyond the cost optimum, and that other dwellings (towards the left of the x-axis) would satisfy the requirement with easy technical measures, not at all achieving what would be cost optimal for their particular project. The example illustrates that it is recommendable to investigate in any technical analysis of the requirements, the full range of all possible building geometries, including the extreme cases, in any technical analysis of the requirements. In the economic evaluations, it also seems advisable to include a few limit cases, rather than to restrict the analysis to typical buildings, deemed representative for the “average” of the stock (as is at present common practice, as illustrated by the 4 blue + symbols in the graphs).

This example illustrates that it is very important to formulate the requirements in a well-thought manner if the purpose is to arrive at economically comparable performance requirements for all individual projects.

NOTE 4 The individual points form a narrow cloud, but not a precise line. This is due to the fact that, apart from the envelope area (which is the dominant determining factor due to transmission and in/exfiltration heat transfer), there are other variables that influence the calculated heating need. In the Belgian model, it is notably the hygienic ventilation rate, which is not simply proportional to the useful floor area, but which shows a strongly nonlinear dependency on the dwelling size. (Small dwellings and apartments have a relatively high specific ventilation flow rate, mainly because there is a constant minimum value required for certain types of rooms, independent of their size.) Because in the set of technical measures that is at the basis of [Figure E.1](#) the hygienic ventilation losses are already reduced to 40 % of their nominal value (due to heat recovery and/or demand control), the effect is not so pronounced. In [Figure E.2](#), the results of different packages of technical measures are shown, with from top to bottom (i.e., from package 1 to package 6) ever better values for the thermal insulation, the thermal envelope air tightness and the hygienic ventilation energy efficiency. The lowest cloud of points (package 6) corresponds very roughly to a typical “passive house” set of measures (for each of the mentioned variables apart, not for the specific heating need as a whole). The upper 3 clouds are with the full hygienic ventilation losses. It can be seen that the dispersion is much larger. Towards the left, these clouds have 2 branches: the upper for small apartments, the lower for very large residential buildings. Other factors could still come into play to explain the cloud, for instance internal gains that in the Belgian model are not linearly proportional to the useful floor area and varying window areas and orientations. It is obviously important to give due consideration to each of the influencing factors when setting requirements, so that well-balanced requirements are obtained for all individual projects and works.



**Figure E.1 — Energy need for heating for different dwelling geometries for a given set of technical measures as a function of the building shape factor**

[Figure E.3](#) shows the results of many 10000s of dwellings that were subject to the EPB regulation (data from the file that each project must submit electronically to a central register). Here, the x-axis is the