

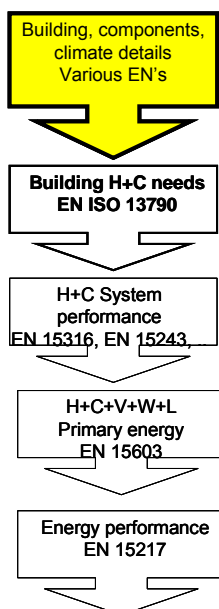
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H=heating; C=cooling;  
V=ventilators; W=hot water;  
L=lighting

*Fig. 1. The position of the series of thermal transmission standards related to the other standards for the EPBD.*

## Information paper for the series of EN ISO standards on thermal transmission properties of building components and building envelope

EN ISO 6946, 10077, 10211, 10456, 13370, 13786, 13789, 14683; EN 13947

This paper gives a short introduction to the series of international standards for calculating the thermal performance of building components and building elements.

It shows the relations between the standards and the main recent changes, which formed part of the mandate from the European Commission to CEN to develop standards to support the EPBD. It also introduces the main content and application of each of these standards, with details on the input and output data and links to the other CEN standards [1].

Special attention is paid to EN ISO 13370, heat transfer via the ground, because the new version of this standard has some important new features (monthly values suited for heating and cooling, clear split between area and edge heat transfer, procedures for dynamic simulation programs).

Common questions are answered in the FAQ section (chapter 8)

The latest versions of many of these standards were published in 2007.

### 1 > Scope of the standards

This Information Paper introduces international standards for the calculation of the thermal performance of building components. The overall transmission and ventilation heat loss coefficients are obtained by EN ISO 13789, which refers to other standards for the calculation of *U*-values.

The standards for  $U$ -values fall into two groups:

- simplified methods (EN ISO 6946, EN ISO 13370, EN ISO 10077-1, EN 13947), which can be used for components within the scope of those standards; and
- detailed methods (EN ISO 10211, EN ISO 10077-2), which can be used as an alternative, or for cases for which there is not an applicable simplified method.

The  $U$ -value of components, including windows and doors, can alternatively be established by measurement according to test methods cited in an applicable product standard.

Thermal bridges (at junctions between elements, etc) are covered in EN ISO 10211 and EN ISO 14683.

The standards in this group also include those for obtaining thermal values of building materials (EN ISO 10456).

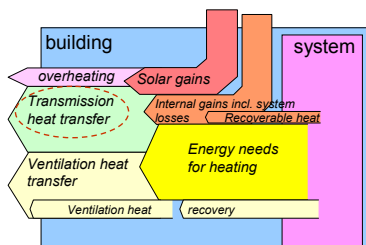


Fig. 2. The important place of transmission in the energy balance of the building

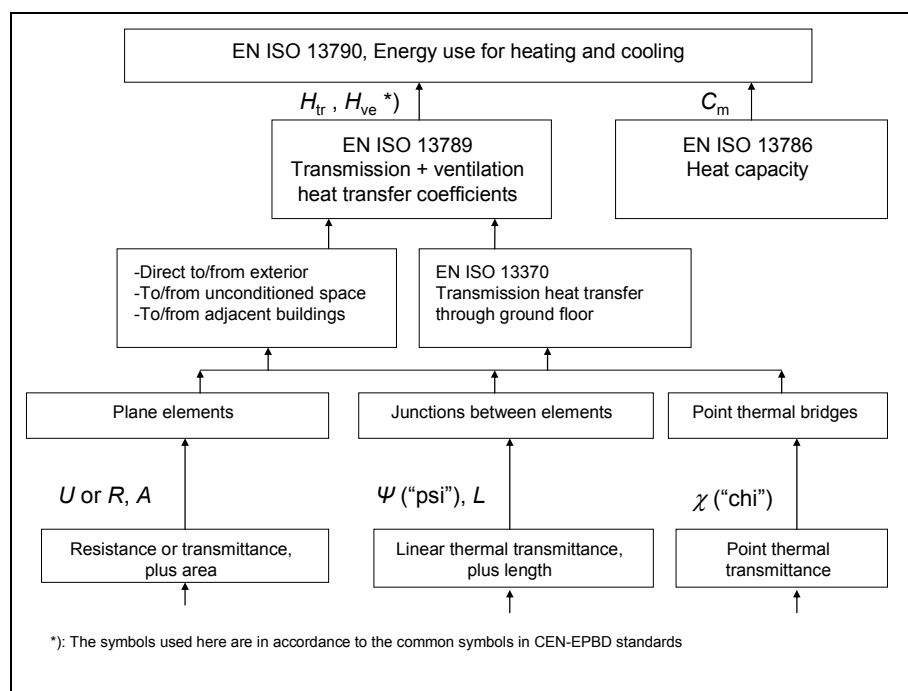


Fig. 3. Scheme 1: From the thermal transmission properties of building components or building elements to input at building level, when one of the simplified (monthly or hourly) calculation methods is chosen in EN ISO 13790.

In the case of detailed dynamic simulations, the component (or subcomponent) properties are used directly as inputs.

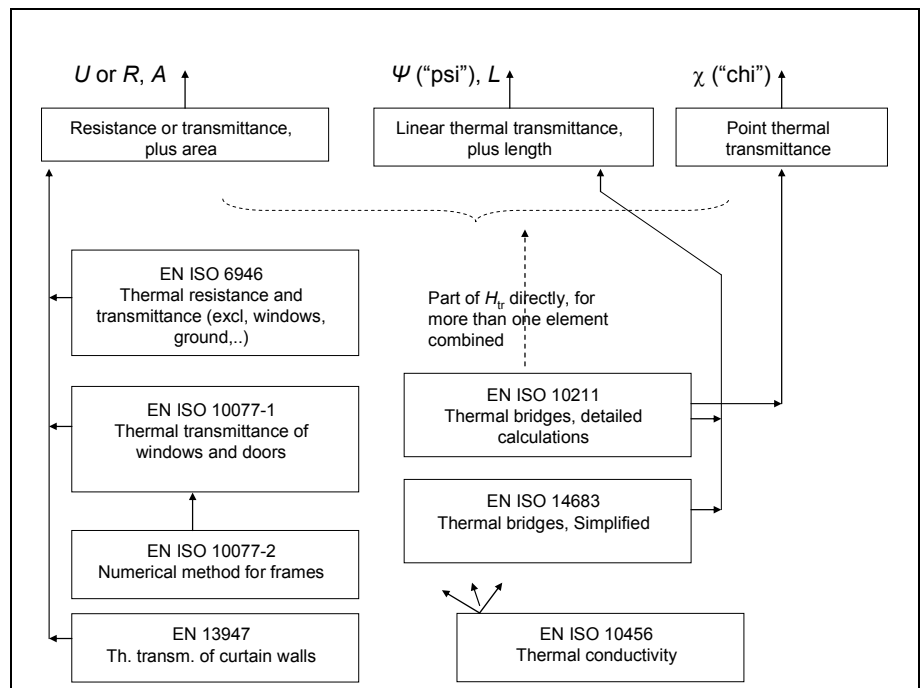


Fig. 4. Scheme 2: From material and subcomponent properties to properties of building components or building elements.

These international standards are applicable to buildings at the **design** stage and to **existing** buildings.



### Example of CEN-ISO cooperation:

For instance, ISO/TC 163, *Thermal performance and energy use in the built environment*, cooperates closely with CEN/TC 89, *Thermal performance of buildings and building components*. Many calculation and test methods have been subject to parallel approval in CEN and ISO. These include standards on hygrothermal and thermal properties of building materials and products, on calculation/presentation of climatic data, on thermal bridge calculation methods and on building energy calculations, including EN ISO 13790.

## 2 > History of the standards

The first series of standards on thermal and hygrothermal properties of building components and elements were prepared by ISO Technical Committee TC 163 in the 1980's, as a result of growing global concern on future fuel shortages and inadequate health and comfort levels in buildings. During the following decades these first standards were revised and new standards were added, to cope with new developments and additional needs. From the 1990's on, many of these standards were developed in close collaboration with CEN (see further on).

As part of the Mandate 343 of the EC to CEN to support the EPBD (2003), the series of standards were scrutinized to see which changes would be needed for the purpose of supporting the EPBD. This resulted in new versions of a number of standards, most of them published in 2007. The main new features in these versions are listed in the successive paragraphs below.

## 3 > European (CEN) standards and global (ISO) standards

### How can an ISO standard support the European Directive?

If an ISO standard is also an EN ISO standard, then it is a European standard just like any other EN (European) standard. To make it easier to understand the difference between ISO and CEN standards, some basic information is provided in the following sections.

### CEN versus ISO

CEN is the European Association of national standardization institutes, the so called National Standards Bodies (NSB's). These NSB's are responsible for contacts with the relevant market parties and with experts preparing

the CEN standards, in the same way as they are when preparing national standards.

ISO is the International Organization for Standardization, the counterpart of CEN at the global level.

### Cooperation

There is an agreement between CEN and ISO stipulating that they should not work on the same Work Items. New work can only be started in CEN if it is not already on the ISO programme and vice versa. CEN-TC's (Technical Committees) are encouraged to seek contact with related ISO-TC's, to agree on possible parallel voting. This means that the EN may become an ISO if accepted by ISO. Existing EN ISO's will preferably be maintained by related ISO-TC's. In cases where related ISO-TC's are not interested or are not assigning it enough priority, the CEN-TC will continue the normal 5 years maintenance schedule or accelerate it if necessary. It is obviously preferable that the same system of standards should be adopted in Europe and the rest of the world.

## 4 > Scope and position in the set of EPBD standards

### Scope

The main aims of this series of standards are:

- a) to clarify the international market through the harmonized definition of intrinsic characteristics of buildings;
- b) to help in judging compliance with regulations;
- c) to provide input data for calculation of annual energy use for heating or cooling buildings.

The result of the calculations can be used as input for calculation of annual energy use and heating or cooling load of buildings, for expressing the thermal transmission and/or ventilation characteristics of a building or for judging compliance with specifications expressed in terms of transmission and/or ventilation heat transfer coefficients.

These International Standards provide the means (in part) to assess the contribution that building products and services make to energy conservation and to the overall energy performance of buildings.

### Applications

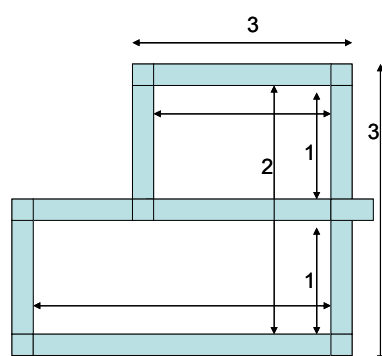
Special attention has been given to the suitability of these International Standards for use within the context of national or regional **building regulations**. This includes the calculation of an energy performance rating of a building, on the basis of standardized conditions, for an energy performance certificate. The result can have legal implications, in particular when it is used to judge compliance with **minimum energy performance levels**, which can, for instance, be required to obtain a building permit. For such applications, it is important that the calculation procedures be unambiguous, repeatable and verifiable.

### Limits of applicability

There are no specific limitations.

It is important to note that these standards allow different geometric measurement conventions, to be decided at national level; see figure 5 (left):

- > Internal dimension.
- > Overall internal dimension.



- 1 internal dimension
2. overall internal dimension
3. external dimension.

Fig. 5. Dimension system.

- > External dimension.

See EN ISO 13789. The choice between these conventions determines the dimensions (area  $A$ ) of the plane elements and -consequently- the value of the linear transmittance ( $\Psi$ -value) of junctions between elements. The  $\Psi$ -values will be smaller if external dimensions are used, because the heat flow through the plane element will be larger. The overall heat flow by thermal transmission is, of course, independent of these conventions. This shows that despite different conventions, the results can still be the same.

Note: a different matter is the definition of the conditioned floor area where it is used to normalize the energy performance rating; e.g. from  $EP$  in kWh to  $E_p$  in kWh/m<sup>2</sup>. In this case the result does depend on the convention used.

### Relationships with other parts/standards of the EPBD package

See figure 1 (first page, left).

- > This suite of standards provides the input on thermal transmission properties for the calculation of the energy needs for heating and cooling according to EN ISO 13790.
- > In addition, some of these standards provide the thermal transmission values for energy performance requirements on building component or building element level which may exist in a specific country or region.

## 5 > Principle of the methods

### Main structure of the calculation procedure

The main structure of the calculation procedure is summarized in the two schemes shown in figure 3 and figure 4, with the following international standards involved:

EN ISO 13789 Thermal performance of buildings – Transmission and ventilation heat transfer coefficients – Calculation method (ISO 13789:2007)

EN ISO 13786 Thermal performance of building components — Dynamic thermal characteristics – Calculation methods (ISO 13786:2007)

EN ISO 6946 Building components and building elements – Thermal resistance and thermal transmittance – Calculation method (ISO 6946:2007)

EN ISO 13370 Thermal performance of buildings – Heat transfer via the ground – Calculation methods (ISO 13370:2007)

EN 13947 Thermal performance of curtain walling – Calculation of thermal transmittance

EN ISO 10077-1 Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: General (ISO 10077-1:2006)

EN ISO 10077-2 Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames (ISO 10077-2:2003)

EN ISO 10211 Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations (ISO 10211:2007)

EN ISO 14683 Thermal bridges in building construction – Linear thermal transmittance – Simplified methods and default values (ISO 14683:2007)

EN ISO 10456 Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values (ISO 10456:2007)

There are two possibilities (with various combinations):

- > Calculation (\*) of the separate properties of plane building components or building elements, junctions between elements and point thermal bridges; these can then be summed to give the overall heat transmission properties of a complete building element or building envelope. The properties of the junctions and point thermal bridges are normally determined by numerical (2D or 3D) calculation.
- > Direct numerical calculation (\*) of the properties of complete building elements or building envelope.

(\*): Measurements are also an option. References to test methods are provided in these International Standards.

#### **Main inputs and outputs**

The **main inputs** needed for these International Standards are the following:

- > properties of materials.

The **main outputs** of these International Standards are the following:

- > thermal transmission properties of building components (such as a wall construction, window) and building elements (such as a facade, a roof);
- > heat transfer coefficient for the whole building (or part of a building).

The latter output is an input in EN ISO 13790, the calculation of the energy needs for heating and for cooling when one of the simplified (monthly or hourly) calculation methods is chosen in EN ISO 13790. In the case of detailed dynamic simulations, the component (or subcomponent) properties are used directly as inputs for the building simulation.

In (other) specific cases individual component properties are needed, for instance:

- > in case of minimum component requirements (*U*-value or *R*-value of the construction);
- > in case of multi-zone calculations with assumed thermal interaction between the zones (→ thermal transmission properties of the separating construction);
- > in case of a separation with another space when the temperature difference across the separation, relative to the temperature between indoor and outdoor environment cannot be known without more knowledge than only the overall thermal transmission properties.  
Example: sunspace.

## **6 > Short description of each standard**

### **EN ISO 13789 Thermal performance of buildings – Transmission and ventilation heat transfer coefficients – Calculation method (ISO 13789:2007)**

**CONTENT:** Specifies method and provides conventions for the calculation of the steady-state transmission and ventilation heat transfer coefficients of whole buildings and parts of buildings.

Applicable both to heat loss (internal temperature higher than external temperature) and to heat ‘gain’ (internal temperature lower than external temperature).

This second edition cancels and replaces the first edition (ISO 13789:1999) which has been technically revised.

The principal changes are:

- › the ventilation coefficient has been added to the transmission coefficient; the relevant procedures and (informative) data have been taken over from the previous version of ISO 13790 (2004). The calculation procedure is a simple equation, with the output being the ventilation heat transfer coefficient and the input the airflow rate. In Europe the air flow rate is to be determined according to EN 15242;
- › “loss” is replaced by “transfer” to allow for cases of cooling; see the more detailed explanation in the relevant Q&A in the list with FAQ further on in this paper.

This standard draws together the heat transfer values calculated for individual elements using the other standards (6946, 13370, 10211, 14683, 10077).

#### **EN ISO 13786 Thermal performance of building components – Dynamic thermal characteristics – Calculation methods (ISO 13786:2007)**

**CONTENT:** Specifies the characteristics related to dynamic thermal behaviour of building components and gives methods for their calculation.

#### **EN ISO 6946 Building components and building elements – Thermal resistance and thermal transmittance – Calculation method (ISO 6946:2007)**

**CONTENT:** Method of calculation of the thermal resistance and thermal transmittance of building components and building elements, excluding doors, windows and other glazed units, components which involve heat transfer to the ground, and components through which air is designed to permeate.

This second edition cancels and replaces the first edition (ISO 6946:1996) and later amendment, which has been technically revised. The revision was mainly to make corrections and provide better consistency with other standards.

#### **EN ISO 13370 Thermal performance of buildings – Heat transfer via the ground – Calculation methods (ISO 13370:2007)**

**CONTENT:** Gives methods of calculation of heat transfer coefficients and heat flow rates, for building elements in thermal contact with the ground, including slab-on-ground floors, suspended floors and basements. It applies to building elements, or parts of them, below a horizontal plane in the bounding walls of the building. Includes calculation of the steady-state part of the heat transfer (the annual average rate of heat flow), and the part due to annual periodic variations in temperature (the seasonal variations of the heat flow rate about the annual average).

This second edition cancels and replaces the first edition (ISO 13370:1998), which has been technically revised.

The main changes are:

- › Monthly thermal transmission properties enabling the calculation of the thermal transmission for heating season, but also for cooling.
- › Addition of new procedures to use the calculated properties as basis for modelling the dynamic heat flow through the ground floor and ground in hourly simulation programs.

- › Separation of plane elements and ground floor junctions, enabling the separation of ground floor product properties ( $U$ -value) and the properties ( $\Psi$ -values) of the connections between ground floor and wall.

More details are given in chapter 7.

#### **EN 13947 Thermal performance of curtain walling – Calculation of thermal transmittance**

**CONTENT:** Methods for calculating the thermal transmittance of curtain walls consisting of glazed and/or opaque panels fitted in, or connected to, frames. Detailed and simplified methods. Includes different types of glazing, frames of any material, different types of opaque panels clad with metal, glass, ceramics or any other material, thermal bridge effects at the rebate or joint between the glazed area, the frame area and the panel area.

This is the first edition of the standard. Note that this is an EN standard (adoption as international standard is currently under discussion).

#### **EN ISO 10077-1 Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: General (ISO 10077-1:2006)**

**CONTENT:** Specifies methods for the calculation of the thermal transmittance of windows and pedestrian doors consisting of glazed and/or opaque panels fitted in a frame, with and without shutters. Allows for different types of glazing, opaque panels, various types of frames, and where appropriate the additional thermal resistance for closed shutters.

This second edition cancels and replaces the first edition (ISO 10077-1:2000). The revision was mainly to make corrections and provide better consistency with other standards.

#### **EN ISO 10077-2 Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames (ISO 10077-2:2003)**

**CONTENT:** Specifies a method and gives the material data required for the calculation of the thermal transmittance of vertical frame profiles, and the linear thermal transmittance. Can also be used to evaluate the thermal resistance of shutter profiles and the thermal characteristics of roller shutter boxes.

This is the first edition (currently under review).

#### **EN ISO 10211 Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations (ISO 10211:2007)**

**CONTENT:** Sets out the specifications for a 3-D and 2-D geometrical model of a thermal bridge for the numerical calculation of heat flows and surface temperatures. Specifications include the geometrical boundaries and subdivisions of the model, the thermal boundary conditions and the thermal values and relationships to be used.

This second edition cancels and replaces the editions previously published in two parts (ISO 10211-1:1996 and ISO 10211-2:2001).

The revision was mainly to make corrections and provide better consistency with other standards.

### **EN ISO 14683 Thermal bridges in building construction – Linear thermal transmittance – Simplified methods and default values (ISO 14683:2007)**

**CONTENT:** Deals with simplified methods for determining heat flows through linear thermal bridges which occur at junctions of building elements. Specifies requirements relating to thermal bridge catalogues and manual calculation methods. Provides default values of linear thermal transmittance.

This second edition cancels and replaces the first edition (ISO 14683:1999).

The revision reviewed and amended the default values of linear thermal transmittance.

### **EN ISO 10456 Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values (ISO 10456:2007)**

**CONTENT:** This standard specifies methods for the determination of declared and design thermal values for thermally homogeneous building materials and products, together with procedures to convert values obtained under one set of conditions to those valid for another set of conditions. These procedures are valid for design ambient temperatures between -30 °C and +60 °C.

It gives conversion coefficients for temperature and for moisture. These coefficients are valid for mean temperatures between 0 °C and 30 °C.

It also gives design data in tabular form for use in heat and moisture transfer calculations, for thermally homogeneous materials and products commonly used in building construction.

This second edition cancels and replaces the first edition (ISO 10456:2000).

The revision incorporated tabulated values of thermal and moisture properties previously given in EN 12524. The data were reviewed and updated where appropriate.

## **7 > Spotlight on EN ISO 13370:2007, heat transfer via the ground**

Special attention is paid to EN ISO 13370, heat transfer via the ground, because the new version of this standard has some important new features:

- > **Monthly thermal transmission properties** enabling the calculation of the thermal transmission for heating season, but also for cooling.
- > Addition of new procedures to use the calculated properties as basis for modelling the dynamic heat flow through the ground floor and ground in **hourly simulation programs**.
- > Separation of plane elements and ground floor junctions, enabling the separation of **ground floor product** properties (*U*-value) and the properties (*Ψ*-values) of **connections** between ground floor and wall(s).

## More detailed explanation

### *Monthly properties, for heating and for cooling*

For steady state heat transmission between indoor and outdoor environments, the heat flow is proportional with the indoor-outdoor temperature difference. Consequently, for conventional building elements we may assume constant thermal properties, such as a  $U$ -value.

For the heat transmission through the ground floor the situation is more complicated: the monthly heat flow through the ground is strongly affected by the large inertia of the ground and consequently not a linear function of the monthly mean indoor-outdoor temperature difference. The edge of the floor, close to the wall separating the building from the external environment is affected the least by this inertia, the parts more distant from the wall are affected the most.

The integrated effect for the whole floor is determined by two non-linear equations:

- > Equation to determine the annual average heat flow per  $m^2$  of floor area through floor and ground. Output: steady state  $U$ -value of floor including the effect of the ground 'package', being a function of e.g.  $U$ -value and size of the floor itself and the thermal characteristics of the ground).
- > Equation to determine the periodic heat flow. Output: monthly values of the overall heat transfer coefficient through the ground floor,  $H_{g,m}$  (W/K).

Example:

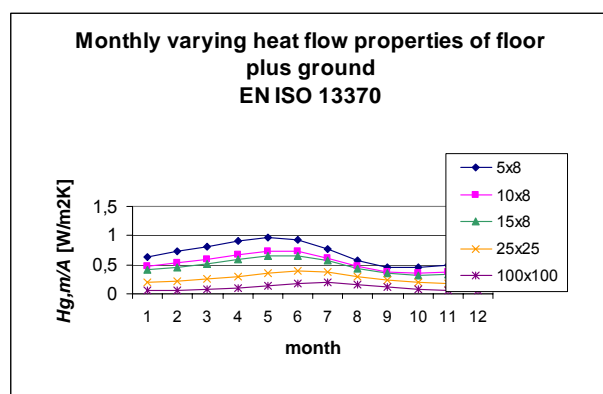


Fig. 6. Example of monthly varying heat flow properties of floor plus ground, per  $m^2$  floor area for different floor sizes (m x m)

### *Modelling the dynamic heat flow through the ground floor and ground in hourly simulation programs*

#### Problem

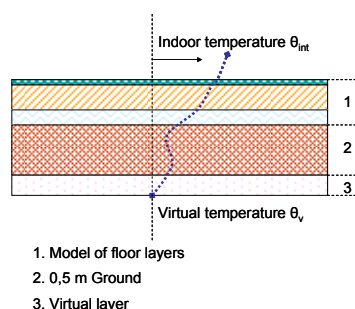
The algorithms to calculate the heat transmission through the floor and ground in dynamic simulation tools are very different, ranging from a strong simplification (such as a fixed temperature under the floor) to a detailed two or three dimensional dynamic calculation. Normally it will be difficult to compare and/or merit such tools against simplified (quasi-steady state) procedures. This is in particular a problem if such a tool is used in the context of energy performance regulations: it is not always clear if the same boundary conditions are used; it is not always evident that thermal bridges (e.g. wall-floor connection) are included in a similar

way as is prescribed in standards like the ones we present in this paper.

### Solution

Annex D (normative) of EN ISO 13370:2007 contains a simple procedure for dynamic simulation programs that links the input for the dynamic model to the properties gathered for the simplified (e.g. monthly) calculations.

The floor construction together with the ground is modelled as a single component, consisting of each layer in the floor construction plus 0,5 m depth of ground plus a virtual layer. The thermal resistance of the virtual layer is included so that the steady state thermal properties are respected. The boundary condition at the bottom of the virtual layer is a virtual temperature, based on the steady state and periodic heat transfer properties (including edge effects) as derived for the quasi-steady state methods. In this way the annual average and periodic heat flows are fully consistent with the quasi-steady state methods.



*Fig. 6. Illustration of the dynamic model for dynamic simulation programs in EN ISO 13370:2007 (normative annex D) matching the quasi-steady state methods.*

### Separation of plane and beam ground floor elements

In EN ISO 13370:2007 the approach becomes similar to the approach in the other standards of this suite of international standards. For manufacturers of ground floor elements and for designers it is important to be able to have a specification of the floor product properties which is independent of the floor size and independent of the details of the floor-wall junction. The floor size comes in as a logarithmic equation, because the effect of the inertia of the ground is a function of the distance from the floor edge.

## 8 > FAQ

**The standards on thermal properties of building components are ISO standards. How can these standards make reference to the set of European standards to support the EPBD?**

If an ISO standard is also an EN ISO standard, then it is a European standard just like any other EN (European) standard. As illustrated in this paper a CEN standard to support the EPBD is one of a series of standards that are mutually related and serve particular European (EPBD) needs; in particular: which are meant to be applied in the context of national building regulations. If, for this purpose, such an EN ISO standard needs to make a reference to another EN standard, then one may find in the standard a distinction between references to EN standards for use within the CEN area and references to ISO or national standards for use outside Europe (see e.g. EN ISO 13790, Info Paper P92). For the suite of international standards on thermal transmission properties, the main inputs and outputs are linked to other EN ISO standards, as figure 3 and figure 4 show, which means that these links are valid both within CEN and within ISO.

**Can the method be used for existing buildings?**

Yes, but some of the required input data may not be available at reasonable costs. For those cases, default values may be provided at national level, e.g. as function of type and age of construction.

**Why has the term “heat transfer” been introduced instead of “heat loss”?**

Heat is lost from a building or building part by transmission or ventilation, as a result of a positive temperature difference between the indoor and outdoor (or other) environments. However, if the indoor temperature of the considered building or building part is lower than the temperature of

the other environment (outdoor environment or another building part), the heat loss becomes negative. Therefore the more neutral term “heat transfer” was introduced from the 2007 versions of the EPBD related standards on. The downside of this is that now it must be explicitly stated which direction has the positive sign. By definition, if the heat flows from the considered building or building part to the other environment, it has a positive sign. NOTE: a negative heat loss should not be confused with “heat gain”. The term heat gain (see e.g. EN ISO 13790, energy use for heating and cooling) is used for solar and internal gains which are not a function of the indoor-outdoor temperature difference: if the indoor temperature rises, e.g. due to excess gains, the heat transfer by transmission and ventilation will automatically rise proportionally, but the solar and internal heat gains remain the same (compare the electric equivalent: a current through a resistor versus a current source).

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#### Why are the symbols in these EN ISO standards not always the same as in the CEN standards to support the EPBD?

For instance: the subscripts for transmission and ventilation are  $\tau$  and  $v$  in ISO and  $t_r$  and  $v_e$  in CEN.

There may be two reasons: 1) because the EN ISO standard was already published before the common symbols were agreed upon in CEN (which was in 2007); 2) because the ISO standard is closely linked to other ISO standards which use different symbols.

#### 9 > References

1. CEN/TR 15615, Explanation of the general relationship between various European standards and the Energy Performance of Buildings Directive (EPBD) - Umbrella Document, April 2008

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