Information paper for the EN ISO standard on energy use for heating and cooling

EN ISO 13790 (Energy performance of Buildings – Energy use for space heating and cooling)

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This paper gives a short introduction to the international standard EN ISO 13790 for calculating the energy use for space heating and cooling. It contains explanations of the background of the standard (including the cooperation between CEN and ISO), the general structure of the standard and the calculation methods, with details on the input and output data and links to the other CEN standards.
Common questions are answererd in the FAQ section (chapter 10)
The standard was published in March 2008.

More information can be found at the CENSE project website:
www.iee-cense.eu

Similar Information Papers on CENSE and/or other European projects can be found at the Buildings Platform website:
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1 > Scope of the standard

This International Standard specifies calculation methods for the assessment of the annual energy use for space heating and cooling of a residential or a non-residential building, or a part of it.
It presents a coherent set of calculation methods of the energy needs for heating and cooling at different levels of detail. It includes the influence of the recoverable thermal losses of technical building systems such as the heating and cooling systems.
This standard provides, in interaction with the relevant system standards, the input needed for the "top level" standard EN 15603 which collects the different energy uses (heating, cooling, lighting, ventilation and domestic hot water) and which converts it to primary energy. In turn, the output of EN 15603 is used as input for EN 15217 which specifies the correct way to express the energy performance of buildings (EP number and classes) and the energy performance certificate (templates and content). This International Standard is applicable to buildings at the **design** stage and to **existing** buildings.

2 > History of the standard

In the early '90's of the previous century, the European standard EN 832 was developed: "*Thermal performance of buildings - Calculation of energy use for heating - Residential buildings*". The core of the standard was a **monthly** or seasonal calculation method, using the so-called 'utilization factor' approach for **heating**, for **residential** buildings only.

Its successor was EN ISO 13790:2004, which was expanded to include **non-residential** buildings (at the time of the EPBD still a draft standard, hence: prEN 13790).

EN ISO 13790 and EPBD:

Citation from the EPBD, recital (11): "*The Commission intends further to develop standards such as EN 832 and prEN 13790, also including consideration of air-conditioning systems and lighting.*"

What does the EPBD mean by prEN 832 and prEN 13790?
Read **chapter 2** (History)

EUROPEAN COMMISSION
Directorate-General for Energy and Transport

As part of the Mandate 343 of the EC to CEN to support the EPBD, a new version of the standard was published in March 2008. The main new features in this version are listed in the left column:

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

How can an ISO standard support the European Directive?

This is a very relevant question. See chapter 10 for a detailed answer. 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 standardisation 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 program 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-EN if accepted by ISO. Existing EN'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 core of the procedure is the calculation of the energy needs for space heating and cooling. However, this calculation requires a number of preceding steps. These are also covered in the standard, using input from other relevant CEN standards.

The calculation of the energy needs is in general performed at the level of a zone in a building (e.g. in case different parts of the building are serviced by different types of systems). Therefore the calculated energy needs for heating and cooling of a zone are first combined with the non-recoverable thermal losses from the heating and cooling systems of that zone. Finally, the energy uses for all zones are summed to provide the energy use for the whole building.

This method includes the calculation of:

a) the heat transfer by transmission and ventilation of the building zone when heated or cooled;

b) the contribution of internal and solar heat gains to the building heat balance;

c) the annual energy needs for heating and cooling, to maintain the specified set-point temperatures in the building – latent heat not included;

d) the annual energy use for heating and cooling of the building, using

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

International Organization for Standardization

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. For instance 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.

Main new features in EN ISO 13790:

The main new features in the new version of EN ISO 13790 (2008):

- Calculation of energy use for space **cooling**;
- Also a **simple hourly** method for heating and cooling has been added.
- To create a **level playing field** irrespective of the chosen calculation approach, **common rules** for the boundary conditions and physical input data have been added, which also apply to the use of dynamic simulation methods.
- Special attention has been given to their suitability for use within the context of national or regional **building regulations**.

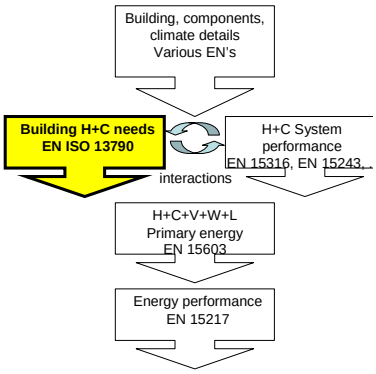


Fig. 1. The location of EN ISO 13790 in the set of EPBD standards

input from the relevant system standards

The building can have several zones with different set-point temperatures, and can have intermittent heating and cooling.

Different options for the calculation of energy needs

EN ISO 13790 covers, in a modular way, three different options with respect to the type of method:

- a fully described **monthly** quasi-steady-state calculation method (plus, as a special option, a seasonal method);
- a fully described **simple hourly** dynamic calculation method;
- calculation procedures for **detailed (**e.g. hourly) dynamic **simulation methods**.

See chapters 6, 7 and 8 for more explanation. It is up to national bodies whether to choose a specific option for mandatory use, e.g. depending on the region in the country, the type of building and its use, and on the purpose of the assessment.

Applications

Special attention has been given to the suitability of this International Standard 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.

A special situation is the calculation of the energy performance in the case of **old existing buildings**. For such buildings, gathering the full required input on the composition of the building and systems may be very labour-intensive. To accommodate the application for these situations, this International Standard offers different choices. Depending on the application, a choice can be made at the national level to provide the right balance between accuracy and data collection costs for the given situation.

Limits of applicability

The standard itself does not contain a detailed simulation method, nor validation criteria for the use of detailed simulation methods; see chapter 8 for the rationale.
The calculation procedures in this standard are restricted to sensible heating and cooling. The energy use for humidification is calculated in the relevant standard on the energy performance of ventilation systems (EN 15241); similarly, the energy use for dehumidification is calculated in the relevant standard on the energy performance of space cooling systems (EN 15243).

Relationships with other parts/standards of the EPBD package

See figure 1 (left).

This standard provides, in interaction with the relevant system standards, the input needed for the "top level" standard EN 15603 which collects the different energy uses (heating, cooling, lighting, ventilation and domestic hot water) and which converts it to primary energy. In turn, the output of EN 15603 is used as input for EN 15217, which covers the way to express the energy performance of buildings (EP number and classes) and the energy performance certificate (templates and content).

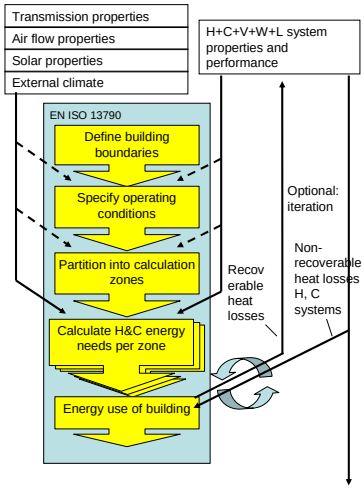


Fig. 3. The calculation procedures in EN ISO 13790 and the input/interaction with other standards

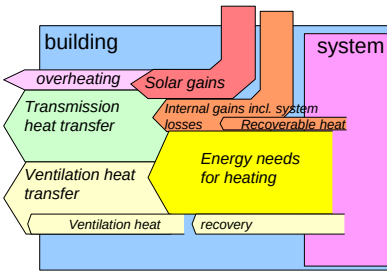


Fig. 4. Flow diagram showing the energy need for heating and cooling as function of the energy balance (simplified)

5 > Principle of the methods

Main structure of the calculation procedure

The main structure of the calculation procedure is summarized below (see figure 3 (left)).

a) Choose the type of calculation method (see chapter 4: monthly or seasonal, simple hourly or detailed simulation method).

b) Define the overall boundaries of all the conditioned spaces and unconditioned spaces.

c) If required, define the boundaries of the different calculation zones.

d) Define the internal conditions for the calculations (set-point temperatures, ..), the external climate and other environmental data inputs.

e) Calculate, for each time step and building zone, the energy need for heating, $Q_{H,nd}$, and the energy need for cooling, $Q_{C,nd}$. This step is described below in more detail.

f) Combine the results for different time steps and different zones serviced by the same systems and calculate the energy use for heating and for cooling, taking into account the dissipated heat of the heating and cooling systems.

g) Combine the results for different building zones with different systems.

h) Calculate the operational length of the heating and cooling seasons.

i) It may be decided at national level, depending on the application and type of building, to require that the calculation of the energy need for heating and cooling is performed in multiple steps, for instance to account for interactions between the building and the system, or between adjacent zones.

Properties or (conservative) default values can be different for the heating and cooling mode. With the monthly method, heating and cooling in the same month can be established by calculating 12 months heating mode and 12 months cooling mode.

Steps b) through e) require input from other standards; for instance: the presence of different types of ventilation systems normally requires a split into different zones.

Steps a) through e) normally require additional specific nationally defined rules, related to the national/regional building regulations; for instance on the building boundary, on the indoor temperature set-points, etc.

The core of the calculation: energy need for heating and cooling

The calculation of the energy need for heating and cooling a building zone is based on the energy (heat) balance at the building zone level. This includes the following terms (only sensible heat is considered; see fig. 4 (left)):

- transmission heat transfer between the conditioned space and the external environment, governed by the difference between the temperature of the conditioned zone and the external temperature;
- ventilation heat transfer (by natural ventilation or by a mechanical ventilation system), governed by the difference between the temperature of the conditioned zone and the supply air temperature;
- transmission and ventilation heat transfer between adjacent zones, governed by the difference between the temperature of the conditioned zone and the

internal temperature in the adjacent space;

- internal heat gains (including negative gains from heat sinks), for instance from persons, appliances, lighting and heat dissipated in, or absorbed by, heating, cooling, hot water or ventilation systems;
- solar heat gains (which can be direct, e.g. through windows, or indirect, e.g. via absorption in opaque building elements);
- storage of heat in, or release of stored heat from, the mass of the building;
- energy need for heating: if the zone is heated, a heating system supplies heat in order to raise the internal temperature to the required minimum level (the set-point for heating);
- energy need for cooling: if the zone is cooled, a cooling system extracts heat in order to lower the internal temperature to the required maximum level (the set-point for cooling).

NOTE The heat transfer to the external environment is negative when the external temperature is higher than the internal temperature.

The building energy balance may also include energy recovered in the building from various sources, such as recovered ventilation heat losses and recoverable losses from heating and cooling systems.

In the heat balance over a longer period (e.g. a month), the net amount of heat stored in, or released from, the building mass, resulting from dynamic behaviour, becomes negligible.

Why should we use a simplified (e.g. monthly) method?

While we could use a detailed simulation method with (if needed) simplified input?

An answer to this and other **frequently asked questions** can be found in **chapter 10**.

An overview of advantages and disadvantages of different types of methods, depending on the application, is given in the Buildings Platform Information Paper P026.

Main input and output

The **main inputs** needed for this International Standard are the following:

- transmission and ventilation properties;
- heat gains from internal heat sources, and solar properties;
- climate data;
- description of building and building components, systems and use;
- comfort requirements (set-point temperatures and ventilation rates);
- data related to the heating, cooling, hot water, ventilation and lighting systems:
- partition of the building into different zones for the calculation (different systems may require different zones);
- energy losses dissipated and recoverable or recovered in the building (internal heat gains, recovery of ventilation heat loss);
- airflow rate and temperature of ventilation supply air (if centrally pre-heated or pre-cooled) and associated energy use for air circulation and pre-heating or pre-cooling;
- controls.

The **main outputs** of this International Standard are the following:

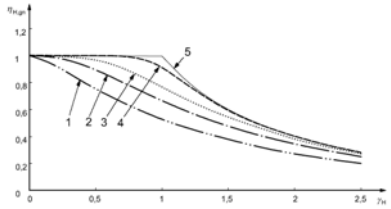
- annual energy needs for space heating and cooling;
- annual energy use for space heating and cooling;
- length of heating and cooling season (for system running hours) affecting the energy use and auxiliary energy of season-length-dependent technical building systems for heating, cooling and ventilation.

Additional outputs are the following:

- monthly values of energy needs and energy use (informative);
- monthly values of the main elements in the energy balance, e.g. transmission, ventilation, internal heat gains, solar heat;

- contribution of passive solar gains;
- system losses (from heating, cooling, hot water, ventilation and lighting systems), recovered in the building.

Monthly method:
The monthly calculation method is one of the options in the new EN ISO 13790. Figure 5 shows the well-known "gain utilization factor" ($\eta_{H,g}$) as a function of the heat balance ratio (γ_H) and building inertia.



Key: 1 → 5 = low → high inertia
Fig. 5. Gain utilization factor curves for heating

A similar approach, with a "loss utilization factor", has been introduced for space cooling.

6 > Monthly method.

In the monthly and seasonal methods, the dynamic effects are taken into account by introducing correlation factors.

For heating, a utilization factor for the internal and solar heat gains takes account of the fact that only part of the internal and solar heat gains is utilized to decrease the energy need for heating, the remaining, non-utilized part leads to an undesired increase of the internal temperature above the set-point.

For cooling, the recommended approach is to use the "mirror image" of the approach for heating, the method with a utilization factor for losses: a utilization factor for the transmission and ventilation heat transfer takes account of the fact that only part of the transmission and ventilation heat transfer is utilized to decrease the cooling needs, because the “non-utilized” transmission and ventilation heat transfers occur during periods or intervals (e.g. nights) when they have no effect on the cooling needs occurring during other periods or moments (e.g. days).

The monthly calculation gives correct results on an annual basis, but the results for individual months close to the beginning and the end of the heating and cooling season can have large relative errors.

7 > Simple hourly method.

The alternative simple method for hourly calculations has been added to facilitate the introduction of hourly user schedules (such as temperature set-points, ventilation modes, the operation schedule for any movable solar shading and/or hourly control options based on outdoor or indoor climatic conditions) and/or (optionally) hourly system data.

The simple hourly calculation method is a new option in the new EN ISO 13790. Figure 6 shows the model:

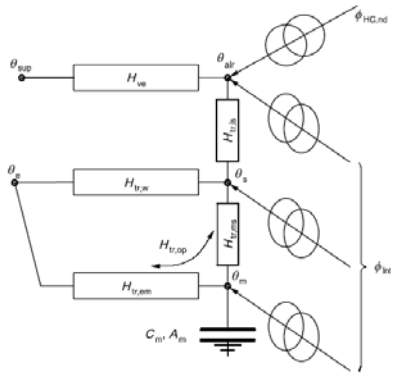


Fig. 6. Illustration of the simple hourly model (five resistances, one capacitance)

The model used is based on a simplified (three node) equivalent resistance-capacitance (R-C) model. It uses an hourly time step and all building and system input data can be modified each hour using schedule tables (in general, on a weekly basis).

The model is a simplification of a dynamic simulation, with the following intention:

- the same level of transparency, reproducibility and robustness as the monthly method:
- a clearly specified, limited set of equations, enabling traceability of the calculation process;
- a reduction of the input data as much as possible;
- unambiguous calculation procedures;
- the main advantage over the monthly method is that the hourly time intervals enable direct input of hourly patterns.

This method produces hourly results, but the results for individual hours are not validated and individual hourly values can have large relative errors.

8 > Detailed simulation method.

A dynamic method models thermal transmission, heat flow by ventilation, thermal storage and internal and solar heat gains in the building zone, typically on an hourly basis. There are numerous methods for this, ranging

Detailed simulation methods versus simplified methods:

The standard provides a "level playing field' for the fully described simplified methods (seasonal, monthly, simple hourly) and dynamic simulation methods. This concerns for instance:

- partitioning into zones;
- transmission heat transfer characteristics;
- ventilation heat transfer characteristics;
- internal heat gains;
- solar heat gains;
- dynamic parameters;
- internal conditions.

Relevant aspects include:

- (dynamic) heat transfer to the ground, including thermal bridges;
- non-adiabatic internal walls and floors;
- linear thermal bridges;
- air flows between building zones;
- solar shading by, and reflection from, overhangs, fins and external obstacles;
- angle-dependent solar properties of windows;
- hourly calculation of air infiltration.

in complexity from simple to very detailed. Other standards describe detailed simulation methods or performance criteria for such methods. However, there are no CEN or ISO standards with validation criteria covering a whole building and system calculation and suitable for obtaining the reproducibility that is necessary for the use within the context of building regulations, except for the calculation of the energy needs for heating and cooling in a single zone (EN 15265).

This standard provides procedures for the use of more detailed simulation methods that provide compatibility and consistency with the fully described monthly, seasonal and simple hourly methods. This concerns for instance standardized boundary conditions and standardized input and output data (see left column).

In particular when the calculation results are to be used in the context of checking for compliance with building regulations, it is important that calculation tools are checked in full detail on compliance with the general procedures, boundary conditions and input data. Relevant aspects are listed in the left column.

9 > Which method to choose?

At the national level, it may be decided which of these three types of method are mandatory or are allowed to be used, depending on the application (purpose of the calculation) and building type.

This choice typically depends on the use of the building (residential, office, etc.), the complexity of the building and/or systems, the application (energy performance requirement, energy performance certificate or recommended energy performance measures, other). See Buildings Platform Information Paper P026 about the need to maintain a balance between accuracy, transparency, robustness and reproducibility.

10 > FAQ

This is an ISO standard. How can this standard make reference to the set of European standards to support the EPBD?

The question is very relevant: 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. For use outside Europe, the references to other CEN standards would not be appropriate. In EN ISO 13790 this has been solved by concentrating all references to other standards in one normative annex (Annex A) which provides for the "CEN area": references to CEN (EN or EN ISO) standards and for "elsewhere": references to ISO standards or, in absence of ISO standards, to national standards.

Why should we use a simplified method, while we could use a detailed simulation method with (if needed) simplified input?

In particular in the context of building regulations it is essential that a prescribed method is verifiable and legally secure and that there is consensus on the procedures. Therefore, transparency, robustness and reproducibility are important quality aspects which may hinder the choice of a detailed simulation tool. An overview of advantages and disadvantages of different types of methods, depending on the application, is given in the Buildings Platform Information Paper P026.

Why are different methods offered?

Each method has its own applications: the seasonal method is the simplest,

but it is applicable only in climates where seasons are clearly defined, the monthly method is easy to use in buildings without or with small intermittence effects, while the simple hourly method is of more general use, but requires hourly meteorological and use data and, despite the fact that it produces hourly results, it is based on a simplified model with only the monthly results validated. Concerning the pro's and con's of a detailed simulation method: see chapter 8 and the previous question. The choice is strongly related to the (national) application and may depend on the type and complexity of the building.

Are national annexes always required?

Choices have to be made at the national level. In several countries this is or will be done, at least for the time being, in a practical way, by copying the relevant parts of EN ISO 13790 as national standard, adding further specifications.

See also the Information Paper on the practical use of CEN standards (P90).

Are the methods validated?

The monthly method and the simple hourly method have indeed been validated by comparison to detailed calculations and to the actual energy use of several buildings (monthly values). The monthly method for heating has been in use since 1990. See annex H of the standard.

What is the difference between the monthly method and a degree day method?

This is explained in detail in annex I.5 of the standard. The main difference is that the degree day method contains an implicit assumption about the effect of internal and solar gains on the heat balance (independent of the specific building), while this effect is explicitly taken into account in the monthly method (as a function of the building parameters).

Can the method be used for existing buildings?

Yes, see e.g. the remarks made in chapter 4.

How can I find more information on the origin and rationale of the monthly method?

See annex I of the standard for more background information

How can I find more technical information

See annex H and Annex I of the standard and the bibliography at the conclusion of the standard.

11 > References

1. EN ISO 13790, Energy performance of buildings – Calculation of energy use for space heating and cooling, ISO, March 2008

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