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EN ISO 13790 in Mediterranean climate

1. Introduction

This article exposes the advantages of the International Standard ISO EN 13790 concerning the calculation of the energy behavior of buildings in Mediterranean climate.
In the last few years, several buildings with very low energy consumption have been built in Central and Southern Italy according to this standard[1], and with very good real behavior results according to the calculated values.
The great advantage of this standard is the simultaneity of accuracy and of simplicity of the calculating method, which is very convenient for the all daily routine of energy consultants in Mediterranean regions.[2]

ASSA office in Pisa/Italy, 2007
The energy concept has been developed according to EN ISO 13790 calculation standard (with WaVE and PHPP, Energy consultant: TBZ) Cooling demand: 5kWh/m2a; heating demand: 6kWh/m2a

CASA SABIN residential building in Vicenza/Italy, 2011
The energy concept has been developed according to EN ISO 13790 calculation standard (with WaVE and PHPP, Energy consultant: TBZ) Cooling demand: 2kWh/m2a; heating demand: 6kWh/m2a

EN ISO 13790 is a European standard for energy performance of buildings. It defines the calculation of energy use for space heating and cooling for residential and non-residential buildings.
Its actual denomination is: EN ISO 13790:2008.[3]
Its author is the Comité Européen de Standardisation (CEN). This standard has been approved by all countries of the European Union. This standard defines the method to calculate energy consumption, which is not only based on static calculation methods, but also on dynamic calculation methods. Therefore, it's also known as a standard defining energy balances by a hybrid way (quasi steady-state method: partly static – partly dynamic).
The interest of this standard is in fact this double line of energetic simulation, combining the advantages of static calculation methods and the dynamic ones.
Furthermore, it has developed from a simple standard for energy calculation (before named EN832), defined at the end of the last century (1998), to a more accurate standard (change of name into EN ISO 13790:2004) including non residential typologies, to arrive to the actual version 13790:2008, which does not only include the winter behavior of buildings, but also a very solid calculation method to reflect the buildings summer behavior. In fact, the summer definition of the energy balances has been proved recently as even more accurate to field measurements as the winter definition[4]!

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.
- monthly values of energy needs and energy use (informative);
- monthly values of 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.

The standard can either work as a one-zone model (e.g. residential), or as a multi-zone model (e.g. offices), so it is perfectly adapted to complex weather conditions to be encountered in Mediterranean climate. Also an intermittent energy system is defined.
A special weight has been given in the developing of this 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."[5]

2. Calculation procedure

The calculation procedure is divided in two parts. First of all, the energy balance of the passive building system is defined. This part evaluates the architectonic (=passive) energy quality of the building. Therefore, it offers for the architect a very good tool to enhance energy performance at an early stage of the design process. In a second term, the active HVAC system is defined to calculate the energy consumption of the building. This part allows also improving the active system design.

The passive building calculation includes the following concepts:

- Heat transmission between interior and exterior and through the building envelope

- Energy transfer via ventilation (natural and controlled)

- Internal heat gains due to occupancy, appliances, lightning etc.

- Solar heat gains: not only through windows, but also through opaque building elements

- Energy balance due to thermal mass of building element

- Energy demand for heating and cooling of the thermal zones[6]

The calculation method for the technical building system includes the following concepts:

- Efficiency of the active system: generation, storage, distribution, emission and control

- Energy (/heat) recovery of active system components, also ventilation system

- Renewable energy contribution

The standard defines the above mentioned quasi steady-state calculation method, but also an alternative for more accurate hourly dynamic calculation method.

3. Almost steady-state calculation method (=hybrid)

Given the fact that the hybrid calculation method is much more suitable for the daily work of energy-manager (architects and engineers) in Mediterranean countries, and also that this method has been proven as confidential on the theoretical level[7] and on the practical level[8], we present consequently the outstanding characteristics for the hybrid concept:

3.1 Utilization factor for heating and cooling

In the heating period, not all the internal and solar heat gains can be used for heating proposal. This is a dynamic (hourly) phenomena, that can be explained by the fact that this energy sometimes leads to an overheating (=not usable) energy excess.

EN ISO 13790 proposes therefore the use of a correlation factor (utilization factor) to correct this phenomenon.

The same procedure is proposed also for the cooling season, when a summer utilization factor is used to increase the cooling needs due to the fact that not all the energy losses of ventilation and transmission can be used at the same time.

The utilization factor is a function mainly of the heat-balance ratio and the thermal inertia[9] of the building. This factor is included in the main energy formula:

Energy demand for heating =

Sum of energy losses due to transmission and ventilation – (utilization factor x Sum of internal and solar energy gains).

Energy demand for cooling =

Sum of internal and solar energy gains – (utilization factor x Sum of transmission and ventilation heat losses).

3.2 Thermal inertia

To simulate the effect of the thermal inertia in a building, it's advisable to do this by hourly, dynamic simulations. EN ISO 13790 proposes though a simplified method, which is reliable for buildings with a good thermal insulation. This standard considers the thermal mass via the internal heat capacity of the whole building, expressed in Joule/Kelvin. Furthermore, in the calculation of the degree-days value, EN ISO 13790 takes into account the thermal mass effect with a dynamic correction factor, depending on the heat transmission coefficient (=U-values x surface) and the heat ventilation coefficient.

The standard also has segregated a method for the calculation of the dynamic U-value, defined now by the EN ISO 13786, considering the thermal mass of building elements in the U-value. This calculation method is mandatory now in Italy, and reflects in a very good way the specific Mediterranean climate conditions.

3.3 Heat transmission to the ground

The heat transmission to the ground depends among others on the thermal characteristic of the ground and to the annual-cycled energy transfer occurring in the ground region. This transmission process normally is calculated dynamically, but in our case, a quasi dynamic adjustment factor is calculated[10]. This adjustment factor is different for each month.

3.4 Heat transmission to adjacent sun spaces (greenhouse)

EN ISO 13790 provides also a simplified procedure to calculate an adjustment factor for adjacent sun-spaces (btr,x'), which takes into account the combined effect of heat transmission and solar radiation. Due to its popularity beneath architects, this feature could also be of importance in Mediterranean regions.

3.5 Free cooling and night time ventilation

Free cooling is a very efficient way of comfort control in summer, when the difference between night temperatures and ambient temperatures excesses a certain limit value[11].

EN ISO 13790 offers a sophisticated way of calculating the additional air flow rate of free cooling (night ventilation) depending on air temperature difference between outside and inside, on the wind velocity and on the opened surface of the windows and their situation in the building. Also the dynamic inertia effect of the building is taken into account.

3.6 Solar gains through opaque building elements

Energy balances due to solar radiation are not only calculated for the transparent building elements (windows), but also for the opaque elements (walls, roofs etc.). This concept is of a relevant importance for Mediterranean climate, where heat flows from the building to the sky (and inversely) could be of a relevant magnitude.
This heat flow is calculated depending on a shading factor, a form factor and on the outside surface absorption values[12].
Also thermal radiation to the sky in nighttime is included, depending on the emissivity for thermal radiation of the external surface and the arithmetic average of the surface temperature and the sky temperature, expressed in degrees centigrade.

3.7 Shading reduction factors

The shading reduction factor is calculated for the winter and summer season. Temporary shading elements are also included in the calculation process.

3.8 Heating/Cooling degree days (/hours)

In opposition to the simplified, static calculation methods, EN ISO 13790 offers a dynamic calculation concept for the degree-days (/hours) . Depending on the quality of the thermal envelope (U-value), the degree-days are changing their values by an iterative process.

3.9 n50 value for ventilation losses through infiltration

EN ISO 13790 is the first (and till now the unique) standard which includes the n50-procedure[13] to calculate the ventilation heat losses by infiltration (=not controlled ventilation). This method is a very practical (and not only theoretical) way to know about the buildings infiltration heat loss. In buildings with a very good thermal envelope, high infiltration heat losses could be of a very prejudicial effect for the overall energy behavior. The n50 value describes the infiltration heat losses by a accurate field measurement method.

4. Accuracy of the hybrid calculation system after EN ISO 13790

In the Annex H of the standard, there is a very good discussion to be found concerning the values a calculation tool should have on different theoretical and practical levels. The illustration below shows a scheme of these quality aspects to be evaluated as a function of the real situation (politically, legally, design, research...)

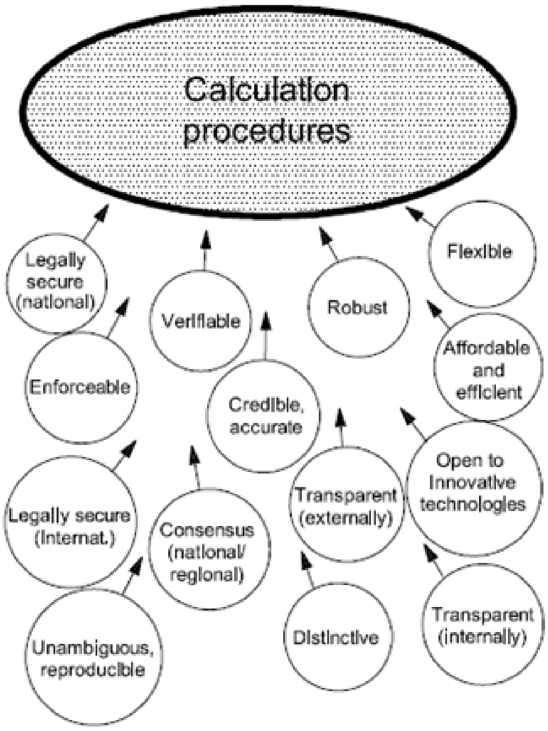
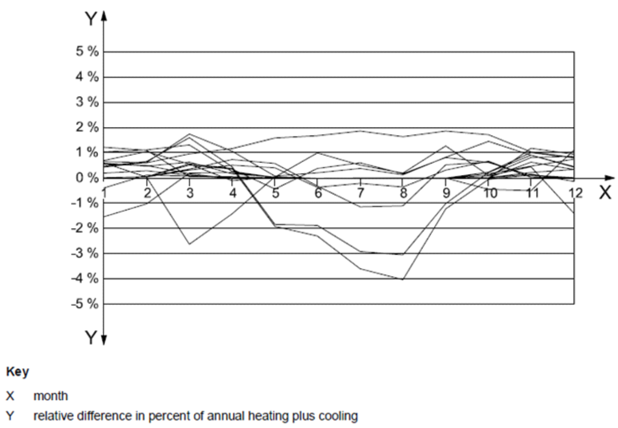


Illustration of various quality aspects for calculation procedures used in the context of building regulations, source: EN ISO 13790:2008(E)



Annex H4.4: Validation of the monthly calculating method: Reference calculation results for Rome

To finish with our article, we would like to cite two excerpts of the ISO EN 13790:

„…the results of the described methods are within the range of results of different dynamic models, in particular when the range of results includes the uncertainty due to influencing factors."

„The method described in this International Standard is particularly appropriate for comparison between building designs in order to determine the influence of various options on the energy use. "

Energy tools based on EN ISO 13790 like PHPP or WaVE have shown in detail the reliability of this standard, not only in theoretical aspects (as for example data entry schemes, suitability for not specialized engineers…), but also under real construction conditions.

These tools are in use already since more than 10 years in European countries. This experience should be taken into account in the developing of energy efficient buildings in the southern Mediterranean countries, respecting the desire of these countries to develop their own energy tools.

[1] With energy tools like WaVE (developped by tbz.bz) or PHPP (developed by Passivhausinstitut) based on ISO EN 13790

[2] Dynamic simulations may have their advantages for complexe buildings, but a big disadvantage due to a very cost intensive and complex calculation procedure.

[3] Prepared by Technical Committee ISO/TC 163 "Thermal performance and energy use in the built environment" in collaboration with Technical Committee CEN/TC 89 "Thermal performance of buildings and building components".

[4] In the international Passive House meeting in 2010, it was officialy confirmed by the Passive House Institue (analysing the real results), that the cooling calcultion method is even more accurate then the heating method

[5] Page 1, Scope

[6] Adiabatic cooling needs are not calculated by this standard

[7] Reference work: Passive Houses in South West Europe, autor: J.Schnieders, Passivhusinstitut, 2009

[8] Passive Houses designed and monitored by TBZ with ISO EN 13790 in central and southern Italy

[9] Calculated with the new dynamic mode of EN 13786

[10] Defined in the related standard 13789: adjustment factor btr,x

[11] Depending on Climate Cooling Potential CCP (Kh/night) of each region

[12] Depending amongst others on the physical value of the material, color and material surface structure

[13] Defined by the EN ISO 13829

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