The simple hourly method of prEN 13790: a dynamic method for the future

Jean-Robert Millet

Centre Scientifique et Technique du Bâtiment, France

Corresponding email: millet@cstb.fr

SUMMARY

The heat and cooling needs of a building considering climate, building envelop, energetic and ventilation system and indoor climate is at the heart of the set of CEN standards devoted to the application of the European directive

This new standard described two methods: a monthly one, improved from the previous version of 13790 standard, and a new one, based on an hourly calculation considering the thermal balance of the room at each step

Why is it a simple method? Basically, one must consider the final user position. Then, and whatever the calculation method is, a simple method must rely on simple input (easy to obtain, easy to understand), and outputs easy to check. The simple hourly methods aims to fulfil these points as its inputs are the same as for the monthly method.
One application is the new French RT2005 regulation applicable to building built after 1st September 2005.

INTRODUCTION

The European Energy Performance in Building Directive (EPBD, 2002) demands that before the year 2006 all Member States of the European Union implement energy performance (EP) regulations, including minimum EP requirements for all new buildings and EP certificates for all existing buildings when built, sold or rent. In a short period, a whole set of European (CEN) standards have been developed to facilitate the Member States with suitable calculation methods and/or performance criteria for calculation methods. These methods cover building transmission and ventilation heat loss, internal and solar gains, daylighting, heating and cooling demand, heating and cooling system losses, energy consumption for hot water production, ventilation systems and lighting. Evidently they also include renewable energy systems.

The directive explicitly states that the European Commission intends further to develop standards such as EN ISO 13790, also including consideration of air-conditioning systems and lighting. EN ISO 13790 ‘Calculation of Energy Use for Space Heating', EN ISO 13790, 2003) is the international standard for the calculation of the energy use for space heating for residential and non-residential buildings. It is the successor of the possibly still better known residential-only EN 832 'Calculation of energy use for heating – Residential buildings’.

THE PREN 3790 STANDARD

STRUCTURE OF THE STANDARD

The structure of the draft of the revised EN ISO 13790 (2) has been adapted to maximize the common use of procedures, conditions and input data, disregarding the type of method:

- Full description of a monthly (and seasonal) method for cooling, very similar to the method in the current EN ISO 13790:2003 for heating.
- Full description of a simple hourly method for heating and cooling, to facilitate easier introduction of hourly and weekly patterns (e.g. controls, user behaviour)
- For dynamic simulation methods: procedures concerning boundary conditions and on input data, that are consistent with the boundary conditions and input data for more simplified types of methods.

The latter is to ensure compatibility and consistency between the different types of methods.

The standard provides for instance common rules for the boundary conditions and physical input data irrespective of the chosen calculation approach.

BASIS OF THE HOURLY METHOD

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

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

In addition, the model provides the following:

making new development easy by using directly the physical behaviour to be implemented;

keeping an adequate level of accuracy, especially for room-conditioned buildings where the thermal dynamic of the room behaviour is of high impact.

The model used is based on an 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 makes a distinction between the internal air temperature and mean temperature of the internal (building zone facing) surfaces (mean radiant temperature). This enables its use in principle for thermal comfort checks and increases the accuracy for taking into account the radiative and convective parts of solar, lighting, and internal heat gains, although one should be aware that the results of the simple method at hourly level are not validated.

The calculation method is based on simplifications of the heat transfer between the internal and external environment, as shown in Figure 1.

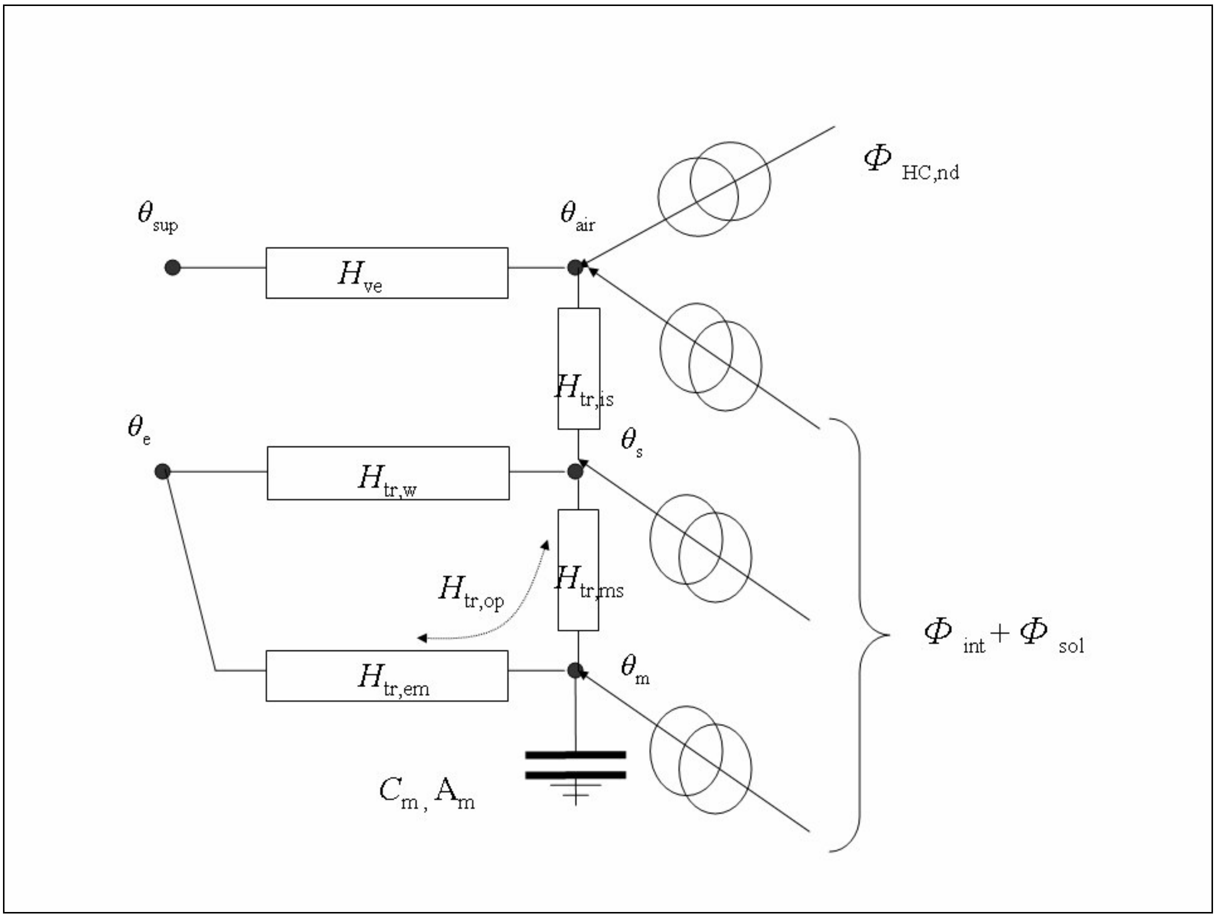


Figure 1 – 5R1C model

The heating and/or cooling need is found by calculating for each hour the need for heating or cooling power ΦHC,nd (expressed in watts and counted positive for heating and negative for cooling), that needs to be supplied to or extracted from the internal air node (□air) to maintain a certain minimum or maximum set-point temperature. The set-point temperature is a weigthed mean of air and mean radiant temperature. The default weighting factor is 0,5 for each.

Heat transfer by ventilation, Hve, is connected directly to the air temperature node θint, expressed in degrees Celsius, and to the node representing the supply air temperature θsup.

Heat transfer by transmission is split into the window part, Htr,w, expressed in watts per kelvin, taken as having zero thermal mass, and the remainder, Htr,op, expressed in watts per kelvin, containing the thermal mass which in turn is split into two parts: Htr,em and Htr,ms. Solar and internal heat gains are distributed over the air node, θair, the central node, θs (a mix of θair and mean radiant temperature θr,mn) and the node representing the mass of the building zone θm. The thermal mass is represented by a single thermal capacity, Cm, expressed in megajoules, located between Htr,ms and Htr,em. A coupling conductance is defined between the internal air node and the central node. The heat-flow rate due to internal heat sources, θint, expressed in watts, and the heat-flow rate due to solar heat sources, □sol, expressed in watts, are split between the three nodes.

The hourly energy needs for heating and/or cooling, QHC,nd, expressed in megajoules, are obtained by multiplying ΦHC,nd, expressed in watts, by 0,036. Similarly, the internal and solar heat gains, Qint and Qsol, expressed in megajoules, are obtained by multiplying Φint and Φsol respectively, expressed in watts, by 0,036.

VALIDATION TESTS

PRESENTATION OF THE PREN 15265 STANDARD (1)

This standard was prepared by the TC89 WG6 group. It specifies a set of assumptions, requirements and validation tests for procedures used for the calculation of the annual energy needs for space heating and cooling of a room in a building where the calculations are done on an hourly basis or less.

The standard does not impose any specific numerical technique for the calculation of the room heating or cooling need and the internal temperatures of a room.

The purpose of this standard is to validate calculation methods used to:

- describe the energy performance of each room of a building;
- provide energy data to be used as interface with system performance analysis) HVAC, lighting, domestic hot water, etc).

The validation procedure is used to check the energy need for space heating and cooling based on a transient sensible heat balance model, taking into account:

the external surface heat balance
the conduction through the building envelope
the thermal capacities of external and internal structures
the internal surface heat balance
the air heat balance
the heat balance solution method

All other aspects are given either by prescribed boundary conditions or by input data and are not part of the model validation. It is assumed that prescriptive calculation models have to be used according to existing European standards.
The system performance analysis and moisture balance are not within the scope of this standard.

VALIDATION TESTS

This standard does not impose any specific numerical technique for the calculation of the room heating or cooling load and the internal temperatures of a room.
For the validation of any existing or new numerical solution to the assumptions and the procedures defined in this standard, the procedures included in this clause shall be satisfied. For the validation tests specified in this clause, the results provided by any numerical solution model shall be within the range indicated for each test.

The internal dimensions of the room are: length = 3,6 m; depth = 5,5 m; height = 2,8 m. The external wall including window glazing is facing West. The areas of the components of the reference room are given in Table 2.

Table 1 — Areas of reference room components

	External wall	Window Glazing	Internal wall left	Internal wall right	Internal wall back	Floor	Ceiling
Area (m^2)	3,08	7,0	15,4	15,4	10,08	19,8	19,8

The solar parameters (considered here as independent of the solar angle) of the glazing component are given in Table 2:

Table 2 — Solar parameters of the window glazing components

Component	Transmittance	Reflectance	Absorptance
Shading	0,20	0,50	0,30
Pane	0,84	0,08	0,08

For opaque components the following values are taken:

solar absorptance of all wall surfaces □sr = 0,6

solar absorptance of the roof

αsr = 0,9

The thermophysical characteristics of the window components are:

a) Shaded DP - Double pane glass with external shading device (Figure 2):

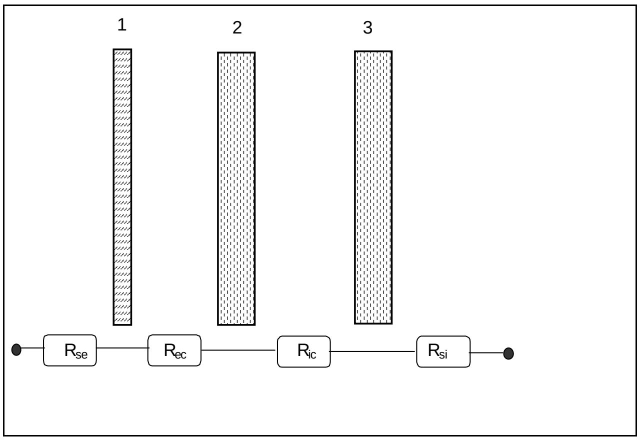


Figure 2 — Double pane window glazing with external shading

Thermal resistances including convection and long wave radiation:

external surface Rse = 0,0435 m2.K/W

cavity between external blind and external pane Rcav = 0,080 m2.K/W

cavity between external pane and internal pane Rie = 0,173 m2.K/W

internal surface Rsi = 0,125 m2.K/W

Thermal transmittance of the glazing system Ug = 2,37 W/(m2.K)

Total solar energy transmittance of the glazing systemg = 0,20

b) DP - Double pane glass without external shading device (Figure 3):

Thermal resistances:

external surface Rse = 0,0435 m2 K/W

cavity between external pane and internal pane Rie = 0,173 m2 K/W

internal surface Rsi = 0,125 m2 K/W

Thermal transmittance of the glazing system Ug = 2,93 W/(m2K)
Total solar energy transmittance of the glazing systemg = 0,77

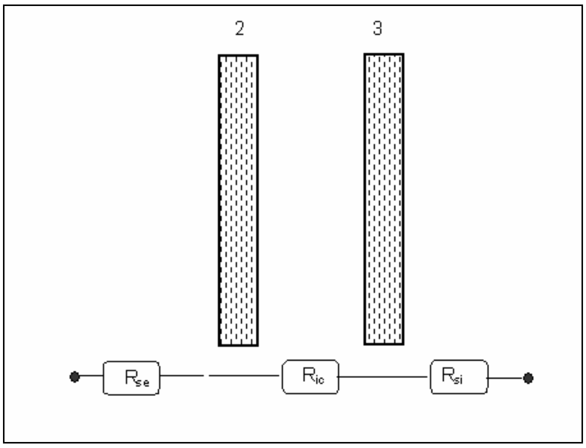


Figure 3 — Double pane window glazing without shading device

The thermophysical characteristics of the walls, ceiling and floor are given in Table 3.

Table 3 — Thermophysical properties of the opaque components
(order of layers from external to internal)

	d m	λ W/(m·K)	ρ kg/m³	cp kJ/(kg·K)
Type 1 (external wall)				
outer layer	0,115	0,99	1800	0,85
insulating layer	0,06	0,04	30	0,85
masonry	0,175	0,79	1600	0,85
internal plastering	0,015	0,70	1400	0,85
Type 2 (internal wall)				
gypsum plaster	0,012	0,21	900	0,85
mineral wool	0,10	0,04	30	0,85
gypsum plaster	0,012	0,21	900	0,85
Type 3c (ceiling)				
plastic covering	0,004	0,23	1500	1,5
cement floor	0,06	1,40	2000	0,85
mineral wool	0,04	0,04	50	0,85
concrete	0,18	2,10	2400	0,85
Type 3f (floor)				
concrete	0,18	2,10	2400	0,85
mineral wool	0,04	0,04	50	0,85
cement floor	0,06	1,40	2000	0,85
plastic covering	0,004	0,23	1500	1,5
Type 4c (ceiling/roof)				
plastic covering	0,004	0,23	1500	1,5
cement floor	0,06	1,40	2000	0,85
mineral wool	0,04	0,04	50	0,85
concrete	0,18	2,10	2400	0,85
mineral wool	0,10	0,04	50	0,85
acoustic board	0,02	0,06	400	0,84
Type 4f (floor)				

acoustic board	0,02	0,06	400	0,84
mineral wool	0,10	0,04	50	0,85
concrete	0,18	2,10	2400	0,85
mineral wool	0,04	0,04	50	0,85
cement floor	0,06	1,40	2000	0,85
plastic covering	0,004	0,23	1500	1,5
Type 5 (roof)				
rain protection	0,004	0,23	1500	1,3
insulating	0,08	0,04	50	0,85
concrete	0,20	2,1	2400	0,85

The hourly mean values of climatic data are given in an annex of the satndard, starting on 1st January and ending on 31st December.
The latitude is 49° and the values are given in solar time.

RESULTS AND DISCUSSION

The results for heating, QH, and cooling, QC, (expressed in kWh) are provided for the complete year (the hourly pattern of the calculated internal temperatures is not part of the validation) and compared to reference values by calculating: Different software were used to produce the reference results which are given in Tables 5 and 6.

rQH = abs(QH - QH,ref) / Qtot,ref
rQC = abs(QC – QC,ref) / Qtot,ref

Three levels of accuracy can be checked with levels: A,B,C. The validation tests are complied if for each of the cases 5 to 12 (8 test cases) :

Level A : rQH $\leq$ 0,05 and rQC $\leq$0,05
Level B : rQH $\leq$ 0,10 and rQC $\leq$0,10
Level C : rQH $\leq$ 0,15 and rQC $\leq$0,15

Table 4 — Reference results for tests 1 to 4 (informative)

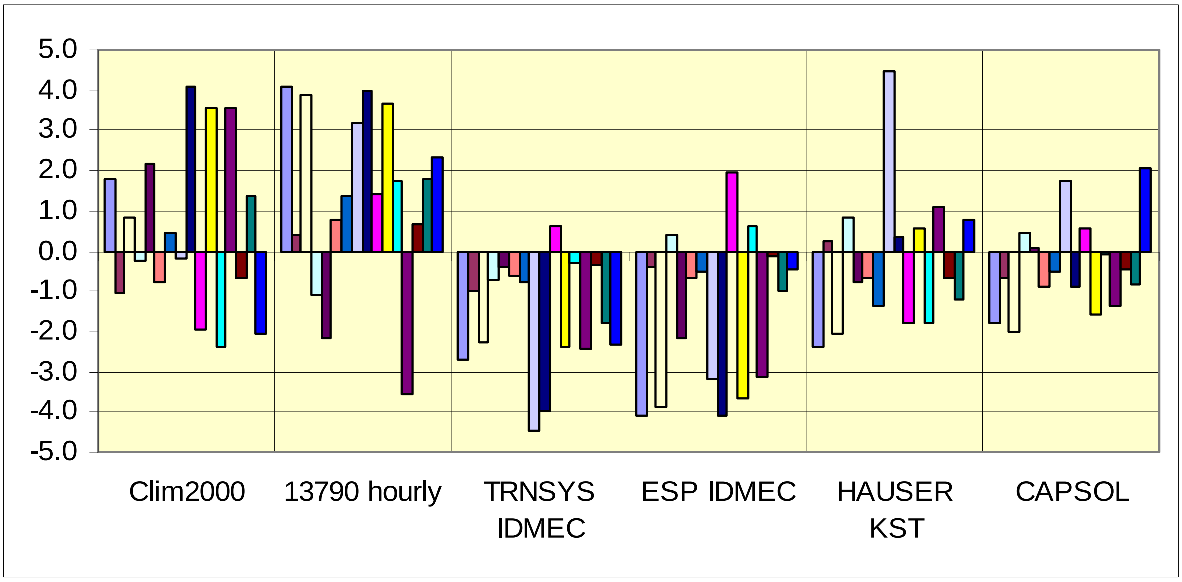
Test	QH,ref kWh	QC,ref kWh	Qtot,ref kWh
1	748,0	233,8	981,8
2	722,7	200,5	923,2
3	1368.5	43,0	1411,6
4	567,4	1530,9	2098,3

Table 5 — Reference results for tests 5 to 12 (normative)

test n°	QH,ref kWh	QC,ref kWh	Qtot,ref kWh
5	463,1	201,7	664,8
6	509,8	185,1	694,9
7	1067,4	19,5	1086,9
8	313,2	1133,2	1446,4
9	747,1	158,3	905,4
10	574,2	192,4	766,6
11	1395,1	14,1	1409,3
12	533,5	928,3	1461,8

The results obtained by different computer codes are shown in figure 3

Figure3 : results of test cases for different methods



The 13790 hourly method, though more simplified than the majority of the other ones, provides results with, as the other ones, the best level of accuracy (A).

CONCLUSION

The European Energy Performance in Building Directive (EPBD) requires methods for the calculation of the energy performance for use in the context of building regulations. A pair of simplified methods have been developed for the calculation of the energy needs for heating and cooling of buildings. A revised version of EN ISO 13790 has been prepared in which a level playing field is created for both simple and detailed methods, by introducing a coherent set of procedures with respect of boundary conditions and assumptions that applies to different types of methods. Validation tests show that the hourly simplified method is well suited for calculation both heating and cooling needs and therefore to be used in both warm, moderate and cold European climates while keeping input data as the same level of simplicity (and the robustness) than monthly ones..

REFERENCES

1 - prEN 15265 " Thermal performance of buildings — Calculation of energy needs for space heating and cooling — General criteria and validation procedures " CEN TC89 WG6

2 - ISO/FDIS 13790 "Energy performance of buildings — Calculation of energy use for space heating and cooling" CEN TC 89 WG4