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Energy performance of buildings — Calculation of energy use for space heating and cooling

Performance énergétique des bâtiments — Calcul des besoins d'énergie pour le chauffage et le refroidissement des locaux

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Foreword

ISO 13790 was prepared by Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, the secretariat of which is held by SIS, in cooperation with Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/343), and supports essential requirements of EU Directive 2002/91/EC on the energy performance of buildings (EPBD).

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 13790 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*.

This second/third/... edition cancels and replaces the first/second/... edition (ISO 13790:2004), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

Introduction

Editorial remarks:

Blue highlighted: editorial or technical point of attention, to be solved by the authors

Editorial notes:

Note that for some part the symbols and subscripts have already been adapted "at the last minute" to the proposed common list of symbols and subscripts for CEN BT WG173 (dd July 8, 2006); but not yet all (in particular not yet in the figures)

Note that the numbering of figures, tables and equations has not yet been checked and updated

Yellow highlighted: to point the reader to specific changes compared to the ISO/DIS version; the number of changes were too many to mark all changes using the Word revision mode. Consequently, the authors marked only the major changes and if similar changes occur at several locations: only at first location.

This standard is one of a series of calculation methods for the design and evaluation of thermal and energy performance of buildings.

It presents a coherent set of calculation methods at different levels of detail, for the energy use for the space heating and cooling of a building and the influence of the heating and cooling system losses, heat recovery and the utilisation of renewable energy sources.

In combination with other EPBD[1)] related standards (see scheme in Figure 1), this standard can be used for the following applications:

a) judging compliance with regulations expressed in terms of energy targets (via the design rating, see EN 15203);

b) comparing the energy performance of various design alternatives for a planned building;

c) displaying a standardised level of energy performance of existing buildings (the calculated rating, see EN 15203);

d) assessing the effect of possible energy conservation measures on an existing building, by calculation of the energy use with and without the energy conservation measure (see also EN 15203);

e) predicting future energy resource needs on a regional, national or international scale, by calculating the energy use of typical buildings representative of the building stock.

References are made to other international standards or to national documents for input data and detailed calculation procedures not provided by this standard.

Main changes compared to ISO 13790:2004:

Unlike ISO 13790:2004, *Thermal performance of buildings – Calculation of energy use for space heating* whose scope was restricted to simplified methods for space heating, this standard integrates both space

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1) DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings

heating and cooling and methods with different levels of detail. The most important changes in this standard compared to ISO 13790:2004 are:

— throughout the whole document statements and equations that were only true for the heating mode have been changed to accommodate both heating and cooling modes;

— throughout the whole document all texts that were only true for monthly or seasonal calculations have been changed to accommodate monthly, seasonal, as well as hourly calculation methods;

— the structure of the document has been adapted to maximize the common use of procedures, conditions and input data, irrespective of the calculation method;

— a monthly (and seasonal) method for cooling, similar to the method in ISO 13790:2004 for heating, has been provided;

— a simple hourly method for heating and cooling, to facilitate direct introduction of hourly, daily or weekly patterns (e.g. controls, user behaviour), has been included;

— for dynamic simulation methods, procedures concerning boundary conditions and input data have been included, that are consistent with the boundary conditions and input data for the seasonal, monthly and simple hourly methods;

— the whole document has been scrutinised to check its applicability within the context of building regulations, which require a minimum of ambiguities and subjective choices; where needed, possibilities are offered for national choices, depending on the purpose/application of the calculations (see list above) and on type or complexity of the building.

The flowchart in Figure 1 gives an outline of the calculation procedure and its links with other EPBD related standards. WI 4, etc. refers to the work items covered by Mandate M/343. For titles of these work items see Clause 2.

The main inputs needed for this standard are:

— Transmission and ventilation properties;

— Heat gains from internal heat sources, 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 building into different zones for the calculation (different systems may require different zones);

  — Energy losses dissipated or recovered in the building (internal heat gains, recovery of ventilation heat loss);

  — Air flow 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 standard are:

- 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);
- Auxiliary energy use for heating, cooling and ventilation systems.

Additional outputs are:

- (Informative) monthly values of energy needs and energy use;
- (Informative) monthly values of main elements in the energy balance (transmission, ventilation, internal heat gains, solar heat);
- Contribution of renewable energy sources;
- System losses (from heating, cooling, hot water, ventilation and lighting systems), recovered in the building.

Fout! Objecten kunnen niet worden gemaakt door veldcodes te bewerken.

Figure 1 — Flow chart of calculation procedure and links with other standards

Energy performance of buildings — Calculation of energy use for space heating and cooling

1 Scope

<check: Not only in Intro (=informative), also in Scope: primarily for EPBD-type of calculations ➔ extra attention for reproducibility etc.>This standard gives calculation methods for assessment of the annual energy use for space heating and cooling of a residential or a non-residential building, or a part of it, which will be referred to as "the building".

This method includes the calculation of:

1) the heat transfer by transmission and ventilation of the building or building zone when heated or cooled to constant internal temperature;

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

3) the annual energy needs for heating and cooling, to maintain the specified set-point temperatures in the building;

4) the annual energy use for heating and cooling of the building, including auxiliary energy for heating, cooling and ventilation, based on input from the relevant system standards referred to in this standard and specified in annex A.

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

The calculation interval is either one month or one hour. For residential buildings the calculation can also be performed on the basis of the heating and/or cooling season. Monthly calculation gives sufficiently 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.

The standard also gives an alternative simple hourly method, using hourly user schedules (such as temperature set-points, ventilation modes, or operation schedule of movable solar shading). This method produces hourly results, but the results for individual hours or individual months are not validated; the results for individual hours can have large relative errors and for monthly results the same applies as for the monthly method.

Also procedures are given for the use of more detailed simulation methods to ensure compatibility and consistency between the application and results of 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.

The standard has been developed for buildings that are (assumed to be) heated and/or cooled for the thermal comfort of people, but can be used for other types of buildings or types of use (e.g. industrial, agricultural, swimming pool), as long as appropriate input data are chosen and the impact of special physical conditions on the accuracy is taken into consideration.

NOTE 1 For instance because a special model is needed but missing.

This also accounts for a section in a building that is dominated by process heat (e.g. indoor swimming pool, computer/servers room, kitchen in restaurant, ..).

Depending on the purpose of the calculation, it may be nationally decided to provide specific calculation rules for spaces that are dominated by process heat (e.g. indoor swimming pool, computer/servers room or kitchen in restaurant).

NOTE 2 For instance in case of building energy certificate and/or building permit; e.g. by ignoring the process heat or use default process heat for certain processes (e.g. shops: freezers, lighting in shop-window).

The calculation procedures in this standard are restricted to sensible heating and cooling. The energy use due to humidification shall be calculated in the relevant standard on the energy performance of ventilation systems as specified in annex A; similarly, the energy use due to dehumidification shall be calculated in the relevant standard on the energy performance of space cooling systems as specified in annex A.

The calculation shall not be used to decide whether mechanical cooling is needed or not.

The main focus of the standard is on the use within the context of building regulations. Consequently, this standard aims to provide the right balance between accuracy, transparency, robustness and reproducibility. To accommodate the application for different situations, this standard offers different choices.

For the choices given in this standard where it is explicitly stated that decisions may be made at national level, it is up to national bodies to exclusively choose (assign) a specific option, depending on the region in the country, the type of building and its use, and on the purpose of the assessment.

NOTE 3 For instance the choice for a specific option when checking compliance with minimum energy performance requirements and for energy performance certification.

Annex J provides some information on the accuracy of the method.

This standard is applicable to buildings at design stage and to existing buildings. The input data directly or indirectly called for by this standard should be available from the building files or the building itself. If it is not the case, it is explicitly stated at relevant places in this standard that it may be decided at national level to allow for other sources of information. In this case the user shall report which input data has been used and from which source.

NOTE 4 For instance for the purpose of calculating the energy performance rating for a building energy performance certificate. The formulation aims to exclude the misuse of this escape route for those cases (e.g. very recently built buildings or buildings with a "dossier-as-built") where the full input data should be available.

2 Normative references

The following referenced documents are indispensable for the application 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 7345:19xx, *Thermal insulation – Physical quantities and definitions*

ISO 6946:2006[2)] , *Building components and building elements – Thermal resistance and thermal transmittance – Calculation method*

ISO 10077-1:2006[2)], *Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: General*

ISO 13370:2006[2)], *Thermal performance of buildings – Heat transfer via the ground – Calculation methods*

2) Revised version to be submitted for final vote in 2006

ISO 13786:2006[2)], *Thermal performance of buildings – Dynamic thermal characteristics – Calculation method*

ISO 13789:2006[2)], *Thermal performance of buildings – Transmission and ventilation heat transfer coefficients – Calculation method*

ISO 15927-4:2006, *Hygrothermal performance of buildings – Calculation and presentation of climatic data – Part 4: Hourly data for assessing the annual energy use for heating and cooling*

ISO 9050:19xx, *Glass in building – Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

ISO 15099:2003, *Thermal performance of windows, doors and shading devices – Detailed calculations*

EN 410, *Glass in buildings – Determination of luminous and solar characteristics of glazing*

EN 13363-2, *Solar protection devices combined with glazing – Calculation of solar and light transmittance – Part 2: Detailed calculation method*

prEN 13947, *Thermal performance of curtain walling – Calculation of thermal transmittance*

wi 4draft EN 15203[3)] , *Energy performance of buildings – Assessment of energy use and definition of ratings*

wi 7draft EN 15316-1[3)], *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies – Part 1: General*

wi 8draft EN 15316-2.1[3)], *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies – Part 2.1: Space heating emission systems*

wi 9draft EN 15316[3)], *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies –*
Part 2.2.1: Boilers
Part 2.2.2: Heat pumps
Part 2.2.3: Heating generation – Thermal solar systems
Part 2.2.4: Performance and quality of CHP
Part 2.2.5: Performance and quality of district heating and large volume systems
Part 2.2.6: Performance of other renewables (heat and electricity)
Part 2.2.7: Space heating generation – Biomass combustion systems

wi 10draft EN 15316-2.3[3)], *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies – Part 2.3: Space heating distribution systems*

wi 11draft EN 15316-3.1[3)], *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies – Part 3.1: Domestic hot water systems, including generation efficiency and the tap water requirements*

wi 13draft EN 15193-1[3)], *Energy performance of buildings – Energy requirements for lighting – Part 1: Lighting energy estimation*

wi 17draft EN 15265[2)], *Thermal performance of buildings – Calculation of energy use for space heating and cooling – General criteria and validation procedures for detailed calculations*

wi 20/21draft EN 15241[3)], *Ventilation for buildings – Calculation methods for energy requirements due to ventilation systems in buildings*

wi 18/19draft EN 15242[2)], *Ventilation for buildings – Calculation methods for the determination of air flow rates in buildings including infiltration*

3) To be submitted for final vote in 2006

~~EN 13465, *Ventilation for buildings – Calculation methods for the determination of air flow rates in dwellings*~~<replaced by EN 15242>

wi 12draft EN 15243[3],, Ventilation for buildings – Calculation of room temperatures and of load and energy for buildings with room conditioning systems – System energy calculation

3 Terms and definitions

For the purposes of this standard, the terms and definitions in ISO 7345 and the following apply.

3.1
calculation period
discrete time interval for the calculation of the energy need for heating or cooling

NOTE The discrete time interval for the calculation is one hour or one month. For residential buildings the calculation may also be performed for the heating and/or cooling season.

3.2
heating and cooling season
period of the year during which a significant amount of energy for heating or cooling is needed

NOTE The lengths of the heating and cooling seasons are determined in different ways, depending on the calculation method. The season lengths are used to determine the operation period for e.g. auxiliary energy and special ventilation (e.g. free or night time cooling) provisions.

3.3 temperature
3.3.1
external temperature
temperature of external air

NOTE For transmission heat transfer calculations, the radiant temperature of the external environment is supposed equal to the external air temperature; long-wave radiation to the sky, from building elements facing the sky, is calculated separately, see 11.3.4 and/or 11.4.6.

3.3.2
internal temperature
arithmetic average of the air temperature and the mean radiant temperature at the centre of the considered zone

NOTE This is the approximate operative temperature according to ISO 7726, *Ergonomics of the thermal environment – Instruments for measuring physical quantities*. This value is close to the dry resultant temperature in EN ISO 6946.

3.3.3
set-point (of the internal) temperature
minimum intended internal temperature, assumed for the calculation of the energy need for heating, or maximum intended internal temperature, assumed for the calculation of the energy need for cooling.

NOTE The values are specified at national level, depending on the type of space and purpose of the calculation. See also definition of conditioned space. For monthly and seasonal methods: the value of the set-point can include adjustment for intermittency, as specified in 13.1.1

3.3.4
set-back temperature
set-point temperature to be maintained during reduced heating and/or cooling periods

3.4
conditioned space
room or enclosure that for the purpose of the calculation is assumed to be heated and/or cooled to given set-point temperature or set-point temperatures.

NOTE The conditions are specified nationally, depending on the type of space and purpose of the calculation.

3.5
unconditioned space
room or enclosure which is not part of the conditioned space

3.6
(building) energy need for heating or cooling
heat to be delivered to, or to be extracted from, the conditioned space by a heating or cooling system to maintain the set-point temperature during a given period of time

NOTE The energy need may include additional heat transfer resulting from non-uniform temperature distribution and non-ideal temperature control, if they are taken into account by increasing (decreasing) the set-point temperature for heating (cooling) and not included in the heat transfer due to the heating (cooling) system.

3.7 energy
3.11.1
auxiliary energy
electric energy used by heating, cooling and/or domestic water systems to transform and transport the delivered energy into the useful energy

NOTE This includes energy for fans, pumps, electronics, etc., but not the energy that is transformed. Pilot flames are considered as part of the energy use by the system.

3.11.2
energy use for space heating or cooling
<1) check new common definitions (in U.D. expected July 2006) 2) check if output uses correct terms>

energy input to the heating or cooling system, including auxiliary energy and thermal system losses, to satisfy the energy need for heating or cooling respectively

NOTE In contrast with delivered energy, energy use covers non-renewable and renewable energy sources.

3.11.3
delivered energy for space heating or cooling
<check new common definitions (in U.D. expected July 2006)>

energy supplied to the building through the building boundary from the last market agent

NOTE See EN 15203/15315 for more explanation.

3.8
intermittent heating or cooling
heating or cooling pattern where normal heating or cooling periods alternate with periods of reduced or no heating or cooling

3.9
Unoccupied period
Period of several days or weeks without heating or cooling, e.g. due to holidays.

3.10
conditioned zone
part of the conditioned space with a given set-point temperature or set-point temperatures, throughout which the internal temperature is assumed to have negligible spatial variations and which is controlled by the same systems for heating, cooling and ventilation

3.11
(calculation) zone
part of the conditioned space that for the purpose of the calculation is assumed to form a conditioned zone

3.12 (building) heat transfer coefficient

NOTE 1 Definitions from ISO 13789.

3.11.1

(building) heat transfer coefficient (general)

factor of proportionality of heat flow governed by a temperature difference between two environments; specifically used for heat transfer coefficient by transmission or ventilation

NOTE In contrast with a *heat gain*, the driving force for *heat transfer* is the difference between the temperature in the considered space and the temperature of the environment at the other side (in case of transmission) or the supply air temperature (in case of ventilation).

3.11.2

transmission heat transfer coefficient

heat flow rate due to thermal transmission through a building ~~element~~construction, divided by the temperature difference between the environment temperatures on either side of the ~~element~~construction

NOTE By convention, the sign of the heat flow is positive if the heat flow direction is outgoing from the considered space (heat loss).

3.11.3

ventilation heat transfer coefficient

heat flow rate due to air entering the space either by infiltration or ventilation, at (supply) temperature different from the air temperature in the space, divided by the temperature difference between the internal air and the supply air temperature

NOTE The sign of the coefficient is always positive. By convention, the sign of the heat flow is positive if the supply air temperature is lower than the internal air temperature (heat loss).

3.13 heat gains

3.12.1

heat gains (general)

heat generated within or entering into the conditioned space from sources other than energy intentionally utilised for heating, cooling or hot water preparation

NOTE 1 The sources include internal heat sources and solar heat sources. The heat extracted from the building, from negative sources (sinks), is included as gain with a negative sign. In case of heat gains, the difference between the temperature of the considered space and the temperature of the source is not the (prime) driving force for the heat flow. This is the basic difference with heat flows due to transmission or ventilation heat transfer; .see also annex K and [2].

NOTE 2 For summer conditions heat gains with a positive sign constitute extra heat load to the space (and vice versa).

3.12.2

internal heat gains

heat provided within the building by occupants (sensible metabolic heat) and by appliances such as lighting, domestic appliances, office equipment, etc., other than energy intentionally utilised for heating, cooling or hot water preparation

NOTE Including energy dissipated by space heating and cooling systems and hot water system that is not considered as utilised for heating, cooling or hot water preparation. Including heat from (warm) or to (cold) process sources that are not controlled for the purpose of heating or cooling or domestic hot water preparation. The heat extracted from the building, from the indoor environment to cold sources (sinks), is included as gain with a negative sign.

3.12.3

solar heat gains

heat provided by solar radiation entering, directly or indirectly (after absorption in building elements), into the building through windows, opaque walls and roofs, or passive solar devices such as sunspaces, transparent insulation and solar walls

NOTE Active solar devices such as solar collectors are considered as part of the heating system.

3.14
solar irradiation
incident solar heat per area over a given period

3.15
gain utilisation factor
reduction factor on the total monthly or seasonal heat gains into the building or building zone applied in the monthly or seasonal calculation to obtain the resulting reduction of the building energy need for heating

NOTE Or applied in the monthly or seasonal heat balance applied in the monthly or seasonal calculation of the building energy need for cooling if the alternative method described in annex D is used

3.16
loss utilisation factor
reduction factor on the total monthly or seasonal heat transfer from the building or building zone applied in the monthly or seasonal monthly or seasonal calculation to obtain the resulting reduction of the building energy need for cooling

NOTE The traditional term "loss", which originally refers to the heating mode only, is retained for the utilisation factor for losses; if the losses are "negative", there is no utilisation.

3.17
calculation with coupled zones
multi-zone calculation with thermal coupling between zones: any heat transfer by thermal transmission and/or by ventilation and/or by air infiltration between zones is taken into account

3.18
calculation with uncoupled zones
multi-zone calculation without thermal coupling between zones: any heat transfer by thermal transmission or by ventilation or by air infiltration between zones is not taken into account

3.19
projected area of solar collecting elements (e.g. windows)
area of the projection of the surface of the element on a plane parallel to the transparent or translucent part of the element

NOTE In case of non-flat elements: the area of the imaginary smallest plane connecting the perimeter of the element

3.20
projected area of frame elements (e.g. window frames)
area of the projection of the frame element on a plane parallel to the glazing or panel that is held by the frame

3.21
thermal technical system losses
Thermal system losses from the technical equipment for heating, cooling and domestic hot water (not including lighting and ventilation) to its surroundings and which is not directly taken into account within the (sub-)system

NOTE The system losses can become an internal heat source or sink in the building in which case (part of) the system loss may be recovered

3.22
recoverable system losses
part of the system losses which may be recovered to lower the energy use for heating or the energy use for cooling respectively.

3.23
ventilation heat recovery
heat recovered from the exhaust air

3.24

heat balance ratio

Monthly or seasonal heat gains divided by the monthly or seasonal heat transfer

4 Symbols and abbreviations

<Updated to the common list of symbols and subscripts for CEN BT WG173, version July 8, 2006, but to be checked and cleaned>

Table 1 — Symbols and units

Symbol	Quantity	Unit
A	area	m²
a	numerical parameter in utilisation factor	-
B	correction factor for an unconditioned adjacent space	-
C	effective heat capacity of a conditioned space	J/K
c	specific heat capacity	J/(kg·K)
d	layer thickness	m
F	factor	-
g	total solar energy transmittance of a building element	-
E_{sol}	Solar irradiance	W/m^2
E	Energy	MJ
H	heat transfer coefficient	W/K
h	surface coefficient of heat transfer	W/(m²·K)
L	length	m
N	number	
Q	quantity of heat	MJ
R	thermal resistance	m²·K/W
T	thermodynamic temperature	K
t	time, period of time	Ms
U	thermal transmittance	W/(m²·K)
V	volume of air in a conditioned zone	m³
q	airflow rate	m³/s
Φ	heat flow rate, thermal power	W
Z	heat transfer parameter for solar walls	W/(m²·K)
α	absorption coefficient of a surface for solar radiation	-
γ	Heat balance ratio	-
ε	emissivity of a surface for long-wave thermal radiation	-
η	efficiency, utilisation factor	-
κ	factor related to heat losses of ventilated solar walls	-
θ	Celsius temperature	°C
ρ	density	kg/m³
σ	Stefan-Boltzmann constant (σ = 5,67 × 10^{-8})	W/(m²·K^4)
τ	time constant	h
χ	heat capacity per area	J/(m²·K)

NOTE Hours can be used as the unit of time instead of seconds for all quantities involving time (i.e. for time periods as well as for air change rates), but in that case the unit of energy is Watt-hours [Wh] instead of Joules. In most equations MJ are used instead of J for quantities of heat or energy and Ms instead of seconds for time.

Table 2 — Subscripts

<Updated to the common list of symbols and subscripts, version July 8, 2006, but to be checked and cleaned>

C	cooling, capacity, calculation, convective	e	exterior, envelope	r	radiative; recovered
C,n	cooling need, or building need for cooling	i	Internal (temperature)	red	reduced
f	frame	gr	ground		
H	heating			s	supply (of air)
H,n	heating need, or building need for heating			sh	shading
HC,n	Heating and/or cooling need; building need for heating and/or cooling	hol	Holidays, long unoccupied period	se	surface external
L	Lighting (system)				
V	Ventilation (system)			si	surface internal
W	hot water (system or need)				
Tot	Total			ss	surface-sky average
Th	Thermal	f	form, final		
gn	gains				
ls	loss	h	hemispherical	sys	system
tr	Transmission (heat transfer)	*i,j,k,m,n*	dummy integers		
ve	Ventilation (heat transfer)	l	layer		
int	Internal (heat gains)			ut	utilised
sol	Solar (heat gains)	O	outdoor obstacles		
		P	related to power		
		m	metabolic, month, mass	nut	Non-utilised
		mn	mean	u	unconditioned
a	air	an	annual		
A	appliances	o	overall	w	window
aux	auxiliary	p	partition wall	*y, z*	zone number
bh	boost heating	pp	peak power	⊥	perpendicular
c	structure	ps	permanent shading	0	base; reference
d	design; daily, direct				

5 Outline of the calculation procedures

5.1 Energy balance of building and systems

The building energy needs for heating and cooling of the building are calculated on the basis of the heat balance of the building or building zones.

This energy need for heating and cooling is the input for the energy balance of the heating and cooling system.

The energy balance is split into the energy or heat balance at the building level and the energy balance at the system level.

A multi-step calculation may be required, to be defined at national level, for instance to account for interactions between different zones (e.g. sharing the same system(s) and/or dissipation from the same system) or between the systems and the building energy balance (e.g. dissipated heat from systems affecting the heat balance of the building), see 7.2.4.

5.2 Main structure of calculation procedure

The main structure of the calculation procedure is summarised below. More details on the calculation procedures are presented in the relevant individual clauses.

1) Choose the type of calculation method, according to 5.4.

2) Define the boundaries of the total of conditioned spaces and the unconditioned spaces, according to 6.2.

3) If required, define the boundaries of the different calculation zones, according to 6.3.

4) Define the indoor conditions for the calculations (clause 13) and the external climatic (annex G) and other environmental data inputs.

5) Calculate, per period and building zone, the energy need for heating, $Q_{H,n}$, and the energy need for cooling, $Q_{C,n}$.

6) Combine the results for different periods 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, according to Clause 14. Combine the results for different building zones with different systems.

7) Calculate the operational length of the heating and cooling season, according to 7.3.

8) Depending on the application and type of building (to be decided nationally), it may be required to perform the calculation of the energy need for heating and cooling in multiple steps, for instance to account for interactions between the building and the system, or between adjacent zones. The procedures are given in 7.2.4.

Properties or (conservative) default values can be different for the heating and cooling mode.

With the monthly method, heating and cooling in same month can be calculated by calculating 12 months heating mode and 12 months cooling mode.

NOTE 1 For the calculation steps, see Figure 2.

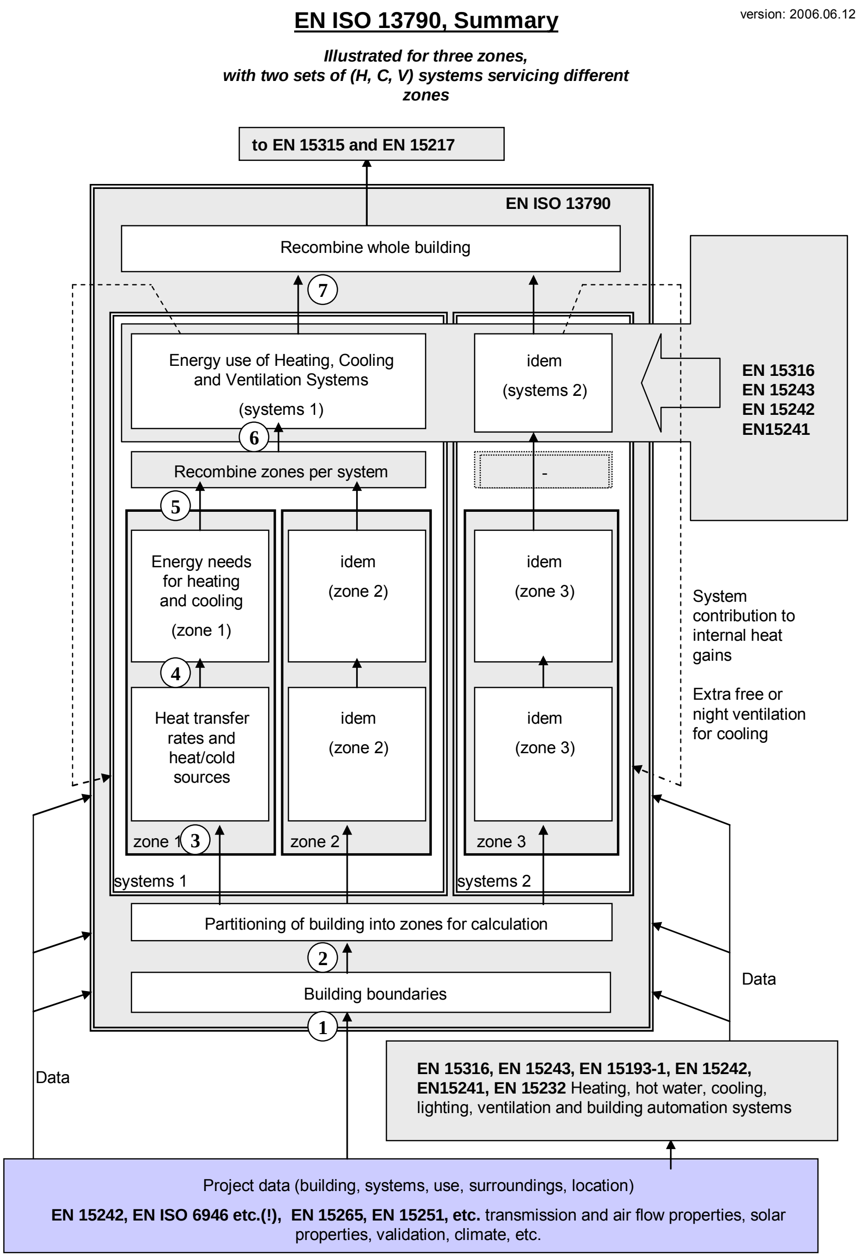

Figure 2 – Flow chart of main calculation steps

5.3 Energy balance at the building level

The energy (heat) balance at the building or building zone level includes the following terms (only sensible heat is considered):

— transmission heat transfer between the conditioned space and the external environment, governed by the difference between the set point temperature (temperature of the conditioned space) and the external temperature;

— transmission and ventilation heat transfer between adjacent zones, governed by the difference between the set point temperature (temperature in the conditioned zone) and the internal temperature in the adjacent space;

- ventilation heat transfer (by natural ventilation or by a mechanical ventilation system), governed by the difference between the set point temperature (temperature in the conditioned space) and the supply air temperature;
- 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 building or zone is heated, a heating system supplies heat in order to raise the internal temperature to the required minimum level (set-point for heating);
- energy need for cooling: if the building or zone is cooled, a cooling system extracts heat in order to lower the internal temperature to the required maximum level (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.

The calculation procedures in this standard are restricted to sensible heating and cooling; see also 5.6.

In the heat balance over a longer period (e.g. a month) the accumulation term can be ignored.

5.4 Different types of calculation methods

There are two basic types of method:

- quasi-steady state methods, calculating the heat balance over a sufficiently long enough time to ignore heat stored and released (typically: one month or a whole season), but taking the dynamic effects into account by an empirically determined gain and/or loss utilisation factor;
- dynamic methods, calculating the heat balance with short periods (typically one hour); taking into account the heat stored in and released from the mass of the building.

This standard covers three different types of methods:

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

A maximum consistency in the application (and thus in the results) of these three types of methods is ensured by a maximum of common procedures and descriptions, boundary conditions and input data.

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.

The alternative simple method, for hourly calculations, has been added to facilitate the calculation using hourly user schedules (such as temperature set-points, ventilation modes, operation schedule of movable solar shading and/or hourly control options based on outdoor or indoor climate conditions). This method produces hourly results, but the results for individual hours are not validated and individual hourly values can have large relative errors.

The procedures for the use of more detailed simulation methods ensure compatibility and consistency between the application of 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.

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

NOTE This choice will typically depend on the use of the building (residential, office, etc.), the complexity of the building and/or systems, the application (EP requirement, EP certificate or recommended EP measures, other). See annex J: about the need to maintain a balance between accuracy, transparency, robustness and reproducibility.

5.5 Main characteristics of the different methods

5.5.1 Dynamic methods

In the dynamic methods an instantaneous surplus of heat during the heating period has the effect that the internal temperature rises above the set-point, thus removing the surplus heat by extra transmission, ventilation and accumulation, if not mechanically cooled. Also, a thermostat setback or switch-off may not directly lead to a drop in the internal temperature, due to the inertia of the building (heat released from the building mass). A similar situation applies to cooling.

A dynamic method models the thermal resistances, thermal capacitances and internal and solar heat gains in the building or building zone. There are numerous methods to do so, ranging in complexity from simple to very detailed. There are other standards (e.g. prEN wi 17) describing detailed simulation methods or performance criteria for such methods. This standard provides the environment of standardised boundary conditions and standardised input and output data that enables compatibility and consistency between the different methods. In this standard one simple hourly method is fully specified: a three node hourly method.

5.5.2 Quasi-steady state methods

In the quasi-steady state methods, the dynamic effects are taken into account by introducing correlation factors:

For heating, a utilisation factor for the internal and solar heat gains takes account for the fact that only part of the internal and solar heat gains is utilised to decrease the energy need for heating, the rest leading to an undesired increase of the internal temperature above the set-point.

NOTE 1 See annex K for a more detailed explanation of the concept of the gain utilisation factor for heating.

The effect of thermal inertia in case of intermittent heating or switch-off is taken into account separately; see Clause 13.

For cooling there are two different ways to represent the same method:

a) utilisation factor for losses (mirror image of the approach for heating)

A utilisation factor for the transmission and ventilation heat transfer takes account of the fact that only part of the transmission and ventilation heat transfer is utilised to decrease the cooling needs, the “non-utilised” 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).

b) utilisation factor for gains (similar as for heating)

A utilisation factor for the internal and solar heat gains takes account for the fact that only part of the internal and solar heat gains is compensated by thermal heat transfer by transmission and ventilation, assuming a certain maximum internal temperature. The other ("non-utilised") part leads to cooling needs, to avoid an undesired increase of the internal temperature above the set-point.

NOTE 1 See annex K for a more detailed explanation of the concept of the gain or loss utilisation factors for cooling.

The effect of thermal inertia in case of intermittent cooling or switch-off is taken into account separately; see Clause 13.

This standard specifies in the category of quasi-steady state methods a monthly and seasonal method for heating and cooling (presentation type a). The alternative formulation for the monthly cooling method (presentation type b) is presented in Annex D.

More details are presented in the next clauses.

5.6 Energy balance at the level of the system services

The building energy need for heating and cooling is satisfied by the energy supply from the heating and cooling systems.

At the system level the energy balance for heating and cooling, if applicable, includes:

— energy need for heating and cooling of the building or building zone;

— energy from renewable energy systems;

— generation, storage, distribution, emission and control losses of the space heating and cooling systems;

— energy input to the space heating and cooling systems;

— special: energy output from the space heating or cooling systems (export; e.g. electricity from a combined heat and power installation).

The system energy balance may also include energy recovered in the system from various sources.

The system energy use is described in Clause 14. More details on the energy use at system level are provided in the relevant system standards, according to annex A.

The calculation procedures in this standard are restricted to sensible heating and cooling. The energy use due to humidification shall be calculated in the relevant standard on the energy performance of ventilation systems as specified in annex A; similarly, the energy use due to dehumidification shall be calculated in the relevant standard on the energy performance of space cooling systems as specified in annex A.

5.7 Overall energy balances for building and systems

The main terms of the (time-average) energy balance for heating and cooling are schematically illustrated in a series of diagrams in annex M.

6 Definition of boundaries and zones

6.1 General

The procedures in this clause apply to all calculation methods: seasonal, monthly, simple hourly and dynamic simulation methods.

First, the boundaries of the building for the calculation of energy needs for heating and cooling shall be defined (clause 6.2).

Secondly, the building shall, if necessary, be divided into calculation zones (clause 6.3).

For the purpose of energy performance rating, according to the relevant standards according to annex A, the calculated energy use for heating and/or cooling needs to be related to the floor area. In addition, some of the input values are not known at individual building zone level and need to be proportionally allocated to the individual zones, for instance using the useful floor area of each zone as weighting factor. Finally, some input data are available at individual building space level and need to be aggregated to building or building zone level. Clause 6.4 provides the calculation procedures for the useful floor area which is consistent with the boundaries of the building and (if applicable) with the partitioning into zones.

6.2 Boundary of the building for the calculation

6.2.1 Procedures

The boundary of the building for the calculation of the energy need for heating and/or cooling consists of all the building elements separating the conditioned space or spaces under consideration from the external environment (air, ground or water) or from adjacent buildings or unconditioned spaces.

Spaces which are not conditioned may be included within the boundary of the building but in that case they shall be regarded as conditioned spaces.

NOTE Note also that a conditioned space may be an actually unconditioned space that for the purpose of the calculation is assumed to be conditioned, see definition in Clause 3.

6.3 Thermal zones

6.3.1 General

It might be necessary to partition a building into different zones, with separate calculation of the energy need for heating and cooling for each zone.

Depending on the conditions as specified in 6.3.2:

— the whole building may be modelled as a single zone, or:

— the building may be partitioned into several zones (multi-zone calculation), accounting for thermal coupling between the zones, or:

— the building may be partitioned into several zones (multi-zone calculation), taking no account of thermal coupling between the zones.

This clause applies to all calculation methods (simple or detailed), but for detailed methods further partitioning may apply.

The boundary of a building zone consists of all the building elements separating the conditioned space or spaces under consideration from the external environment (air, ground or water), from adjacent conditioned zones, from adjacent buildings or from unconditioned spaces.

6.3.2 Criteria for partitioning into zones

6.3.2.1 Criteria for single zone calculation

Small unconditioned spaces may be included within a conditioned zone but in that case they shall be regarded as conditioned area.

Partitioning of the building into thermal zones is not required if all of the following conditions apply to spaces within the building:

a) set-point temperatures for heating of the spaces differ not more than 4 K;

NOTE See definition in clause 3: set-point is minimum respectively maximum temperature *assumed for the calculation*. Specifications are given in clause 13.

b) the spaces are all not mechanically cooled or all mechanically cooled and set-point temperatures for cooling of the spaces differ not more than 4 K;

c) the spaces are serviced by the same heating system (if any) and the same cooling system (if any), as specified by the relevant standard on heating systems as specified in annex A;

d) if there is a ventilation system, as specified by the relevant standard on ventilation systems as specified in annex A, and at least 80% of the floor areas of the spaces are serviced by the same ventilation system (the other spaces are then considered to be serviced by the main ventilation system);

NOTE 1 This 80 %-rule is introduced to avoid the situation that extra zones need to be defined to cater for small spaces like corridors and storage rooms with different ventilation systems.

e) the amount of ventilation in the spaces in m^3 per m^2 floor area per unit of time, as specified by the relevant standard on ventilation air flow as specified in annex A, differs by not more than a factor of 4 within 80% of the floor area or the doors between the spaces are likely to be frequently open.

NOTE 2 Zoning based on expected large differences in the heat balance ratio for the heating mode or for the cooling mode is desirable, but not taken into account in the list above because the heat balance ratio itself depends on the zoning and the calculation of the input data is too labour intensive (especially in determining areas of building elements) to be done several times or room by room.

If one or more of these conditions do not apply, the building is divided into different zones in a way that all of the conditions apply to the individual zones.

However, rules for partitioning the building into thermal zones may also be defined at national level, for instance to take into account specific requirements of national or regional building regulations and/or to take into account the application.

Depending on the purpose of the calculation, it may be nationally decided to provide specific calculation rules for spaces that are dominated by process heat (e.g. indoor swimming pool, computer/servers room or kitchen in restaurant).

NOTE 3 For instance in case of building energy certificate and/or building permit; e.g. by ignoring the process heat or use default process heat for certain processes (e.g. shops: freezers, lighting in shop-window).

NOTE 4 For instance to ensure reproducibility in case of minimum energy performance requirements; to ensure the right balance between accuracy and costs in case of inspection of an (old) existing building. See also annex J.

NOTE 5 Within a specific building zone there may still be heat dissipating from or to a distribution system of a heating or cooling system servicing another building zone that passes the zone under consideration.

The calculation procedure for a single zone calculation is given in 6.3.3.1.

6.3.2.2 Criteria for multi-zone calculation without thermal coupling between zones

If the building is partitioned into different zones, it is to be decided nationally whether it is allowed to calculate each zone independently using the single zone procedure for each zone and assuming adiabatic boundaries between the zones. This is defined as a multi-zone calculation without thermal coupling between zones. The calculation procedure is given in 6.3.3.2.

NOTE The decision whether to ignore thermal coupling between zones can depend on the purpose of the calculation and/or the complexity of the building and its systems.

6.3.2.3 Criteria for multi-zone calculation with thermal coupling between zones

If neither the single zone calculation, nor the multi-zone calculation without thermal coupling between zones, applies, the calculation shall be performed as a multi-zone calculation with thermal coupling between zones.

NOTE For complying with building regulations one should note that a multi-zone calculation with interactions between the zones: (a) requires significantly more and often arbitrary input data (on transmission properties and air flow direction and size) and (b) requires compliance with constraints in the building regulations on the zoning rules (freedom of internal partitioning, definitions of zoning in case of combined use (e.g. a hospital generally includes also a office section, a restaurant section, et cetera). A further complication may be the involvement of different heating, cooling and ventilation systems for different zones, that adds to the complexity and arbitrariness of the input and modelling.

The calculation procedures are given in 6.3.3.3.

6.3.3 Zone calculation

6.3.3.1 Single zone calculation

Set-point temperatures:

If the single zone calculation applies, the set-point temperature for heating to be used is:

$$\theta_{\mathrm{i,h}} = \frac{\sum_{s} A_{\mathrm{fl},s}\,\theta_{\mathrm{i},s,h}}{\sum_{s} A_{\mathrm{fl},s}} \tag{1}$$

where

$\theta_{\mathrm{i,h}}$ is the set-point temperature for heating of the building or building zone, in °C;

$\theta_{\mathrm{i},s,\mathrm{h}}$ is the set-point temperature for heating of space s, determined according to Clause 13,in °C;

$A_{\mathrm{fl},s}$ is the useful floor area of space s, determined according to 6.4, in m^2.

If the single zone calculation applies, the set-point temperature for cooling to be used is:

$$\theta_{\mathrm{i,c}} = \frac{\sum_{s} A_{\mathrm{fl},s}\,\theta_{\mathrm{i},s,c}}{\sum_{s} A_{\mathrm{fl},s}} \tag{2}$$

Where

$\theta_{\mathrm{i,c}}$ is the set-point temperature for cooling of the building or building zone, in °C;

$\theta_{\mathrm{i},s,\mathrm{c}}$ is the set-point temperature for cooling of space s, determined according to Clause 13, in °C;

$A_{\mathrm{fl},s}$ is the useful floor area of space s, determined according to 6.4, in m^2.

The averaging is either on seasonal or monthly average data or on hourly data, depending on the type of method and the corresponding procedures in Clause 13.

Other input data:

If the single zone calculation applies and the zone contains spaces with different building use (internal heat gains, lighting hours, ventilation hours, ventilation rates, etc) the area weighted average values of the parameters related to building use shall be used, in the same way as this is done for the set-point temperature.

The averaging is either on seasonal or monthly average data or on hourly data, depending on the type of method and the corresponding procedures in the relevant Clauses.

6.3.3.2 Multi-zone calculation, no thermal coupling between zones

For a multi-zone calculation without thermal coupling between zones (calculation with uncoupled zones), any heat transfer by thermal transmission or by air movement is not taken into account.

The calculation with uncoupled zones is regarded as an independent series of single zone calculations.

For zones sharing the same heating and cooling system, the energy need for heating and cooling is the sum of the energy need calculated for the individual zones (see Clause 14).

For zones not sharing the same heating and cooling system, the energy use for the building is the sum of the energy use calculated for the individual zones (see Clause 14).

6.3.3.3 Multi-zone calculation, thermal coupling between zones

For a multi-zone calculation with thermal coupling between zones (calculation with coupled zones) any heat transfer (by thermal transmission or by air movement) is taken into account.

The procedures for a calculation with coupled zones are given in Annex B.

NOTE See the note in 6.3.2.3 on this type of calculation. Consequently, the procedure is normally used only for special situations.

6.4 Determination of useful floor area, A_{fl}

The floor area within the boundary of the building is the useful floor area A_{fl} of the building. The type of dimension system used to calculate A_{fl} (internal dimensions, external dimensions or overall internal dimensions) may be determined at national level, but has to be specified. The same applies to possible parts of the floor area within the boundary of the building which are or are not part of the useful floor area A_{fl}.

NOTE Parts of the floor area within the boundary of the building which possibly are not part of the useful floor area A_{fl} are e.g. areas of the floor where the space has a height less than a specified height, and the area of supporting walls. Parts of the floor area within the boundary of the building which possibly are part of the useful floor area A_{fl}. are e.g. area of non-supporting walls.

If applicable, the useful floor area of a building zone is determined similarly for each calculation zone in the building. The sum of useful floor areas of all zones shall be equal to the useful floor area of the building.

If necessary, the useful floor area of a space in the building or building zone is determined similarly for each space in the building or building zone. The sum of useful floor areas of all spaces in the building or building zone shall be equal to the useful floor area of the building or building zone.

7 Building energy need for space heating and cooling

7.1 Calculation procedure

The calculation procedure depends on the type of calculation method, but the assumptions (on environment conditions, user behaviour and controls) and the basic physical data shall be the same for each of the type of calculation methods (seasonal, monthly, simple hourly and detailed simulation methods).

There are three steps of the calculation:

— calculation of the energy need for heating and cooling;

— calculation of the season length for the operation of season-dependent provisions;

— possible repetition of the calculation due to the interaction of the building and system or for other informative or normative reasons as specified in the relevant clause.

See Table 4.

Table 3 — Calculation procedure for the energy need for space heating and cooling for the different types of methods

Type of method	Calculation of energy need for heating and cooling	Calculation of season length for operation of provisions	Multiple steps
Seasonal or monthly method	Clause 7.2.1	Clause 7.3	Clause 7.2.4
Simple hourly method	Clause 7.2.2	Clause 7.3	Clause 7.2.4
Detailed simulation method	Clause 7.2.3	Clause 7.3	Clause 7.2.4

The calculation procedure to obtain the energy need for space heating and cooling of the building or building zone is summarised below. This part of the procedure describes more in detail Step 4) of the main calculation procedure as presented in 5.2.

1) calculate the indoor conditions, according to Clause 13 and the climate conditions according to annex G and other relevant environmental data inputs;

2) calculate the characteristics for the heat transfer by transmission, according to Clause 8;

3) calculate the characteristics for the heat transfer by ventilation, according to Clause 9;

4) calculate the internal heat gains, according to Clause 10;

5) calculate the solar heat gains, according to Clause 11;

6) calculate the dynamic parameters, according to Clause 12.

With the monthly method, heating and cooling in the same month can be calculated by calculating 12 months heating mode and 12 months cooling mode; each with own parameter values (e.g. ventilation, heat recovery, …).

7.2 Energy need for heating and cooling

7.2.1 Monthly and seasonal methods

7.2.1.1 Energy need for heating

For each building zone, the energy need for space heating for each calculation period (month or season) is calculated according to:

$$Q_{H,n} = Q_{H,ls} - \eta_{H,gn} \cdot Q_{H,gn} \tag{3}$$

subject to $Q_{H,n} \geq 0$

where (for each building zone, and for each month or season):

$Q_{H,n}$ Is the building energy need for heating, in MJ;

$Q_{H,ls}$ is the total heat transfer for the heating mode, determined according to 7.2.1.3, in MJ;

$Q_{H,gn}$ are the total heat gains for the heating mode, determined according to 7.2.1.3, in MJ;

$\eta_{H,gn}$ is the dimensionless gain utilisation factor, determined according to 12.2.1.

If applicable, corrections shall be applied to account for intermittency, according to 13.1.1 and for unoccupied periods, according to 13.1.4.

The energy need for latent heating (humidification) is not included in this calculation.

NOTE 1 The gain utilisation factor, $\eta_{H,gn}$, is explained in 5.5.2. It is a function of mainly the heat balance ratio and the thermal inertia of the building as illustrated in the graph in 12.2.1.1.

Calculation period:

For the seasonal method the calculation period shall be the fixed heating season length, as explained in 7.2.1.4. For the monthly method, the calculation period is one month.

NOTE 2 Informative annex K.3 provides a method for determining the fixed season length for the seasonal method.

7.2.1.2 Energy need for cooling

For each building zone, the energy need for space cooling for each calculation period (month or season) is calculated according to:

$$Q_{C,n} = Q_{C,gn} - \eta_{C,ls} \cdot Q_{C,ls} \tag{4}$$

subject to $Q_{C,n} \geq 0$

where (for each building zone, and for each month or season)

$Q_{C,n}$ Is the building energy need for cooling, in MJ;

$Q_{C,ls}$ is the total heat transfer for the cooling mode, determined according to 7.2.1.3, in MJ;

$Q_{C,gn}$ are the total heat gains for the cooling mode, determined according to 7.2.1.3, in MJ;

$\eta_{C,ls}$ is the dimensionless utilisation factor for heat losses, determined according to 12.2.1.

If applicable, corrections shall be applied to account for intermittency, according to 13.1.2 and for unoccupied periods, according to 13.1.4.

The energy need for latent cooling (dehumidification) is not included in this calculation.

NOTE The principle of the utilisation factor for losses, $\eta_{L,C}$, is explained in 5.5.2 (cooling, method a). It is a function of mainly the loss-gain ratio and inertia of the building as illustrated in the graph in 12.2.1.2. A negative value for $Q_{L,C}$ is allowed: in that case the utilisation factor will have the value 1 and consequently the negative losses are added as gains. See further explanation in annex K.

Calculation period:

For the seasonal method the calculation period shall be the fixed cooling season length, as explained in 7.2.1.4. For the monthly method, the calculation period is one month.

NOTE 2 Informative annex K.3 provides a method for determining the fixed season length for the seasonal method.

7.2.1.3 Total heat transfer and heat gains

The total heat transfer, Q_L, of the building zone for a given calculation period, is given by[4)]:

$$Q_{ls} = Q_{tr} + Q_{ve} \tag{5}$$

where (for each building zone and for each calculation period):

Q_{ls} is the total heat transfer, in MJ;

Q_{tr} is the total heat transfer by transmission, determined according to Clause 8, in MJ;

Q_{ve} is the total heat transfer by ventilation, determined according to Clause 9, in MJ;

The total heat gains, Q_G, of the building zone for a given calculation period, are:

$$Q_{gn} = Q_{int} + Q_{sol} \tag{6}$$

where (for each building zone and for each calculation period):

Q_{gn} are the total heat gains, in MJ;

Q_{int} is the sum of internal heat gains over the given period, determined according to Clause 10, in MJ;

Q_{sol} is the sum of solar heat gains over the given period, determined according to Clause 11, in MJ.

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4) In an alternative method, heat transfer is attributed to the heat gains, Q_g instead of to Q_L, if the heat transfer has a negative value over the period considered.

7.2.1.4 Seasonal method: fixed length of heating and cooling season for the heat balance calculation

The fixed length of the heating season is needed for the calculation of total heat transfer and total heat gains during the heating season. This fixed length is directly linked to the parameters that determine the values of the gain utilisation factor (12.2.1).

This length may be determined at national level and may be chosen rather arbitrary, but not too short. The gain utilisation factor as function of the heat balance ratio (the gain utilisation factor curves) depends on the choice of this fixed length. Consequently, the same fixed season length shall be used as used for the development of these curves.

Annex K contains a method that may be used to determine the fixed length of the heating and cooling season for the seasonal method.

7.2.2 Simple hourly method

7.2.2.1 Principle

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:

- Making new development easy by using directly the physical behaviour to be implemented;
- Keeping a 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 x 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 (room 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.

The calculation method is based on the simplifications of the heat transfer between the internal and external environment as shown in Figure 4.

The heating and/or cooling need is found by calculating each hour the need for heating or cooling power $\Phi_{HC,n}$ (W, counted positive for heating and negative for cooling), that needs to be supplied to or extracted from the internal air <air??> node (θ_{i}) to maintain a certain minimum or maximum air temperature (set-point).

Heat transfer by ventilation is connected directly to the air temperature node θ_{i} (°C) and to the node representing the supply air temperature $\theta_{sup,air}$. Heat transfer by transmission is split into the window part, H_{w}

(W/K), taken as having zero thermal mass, and the remainder containing thermal mass, H_{op} (W/K), split into two parts H_{em} and H_{ms}. Solar and internal heat gains are distributed over the air node, θ_l), the central node θ_s (a mix of θ_l and mean radiant temperature θ_m) and the node representing the mass of the building or building zone θ_m. The thermal mass is represented by a single thermal capacity C_m (J/K) located between H_{ms} and H_{em}. A coupling conductance is defined between the internal air node and the surface node. The heat flow rate due to internal heat sources Φ_I (W) and the heat flow rate due to solar heat sources Φ_S (W) are split between the three nodes.

The hourly energy needs for heating and/or cooling, $Q_{HC,n}$ (MJ) are obtained by multiplying $\Phi_{HC,n}$ (W) with 0.036; similar for the internal and solar heat gains Q_I and Q_S (MJ).

NOTE "Window part" is here a generic term. It also includes doors and all glazed elements of the building envelope, but none of the insulated opaque components.

< For set-point temperature: A variable factor should be allowed, with default value 50:50 air:mean radiant.>

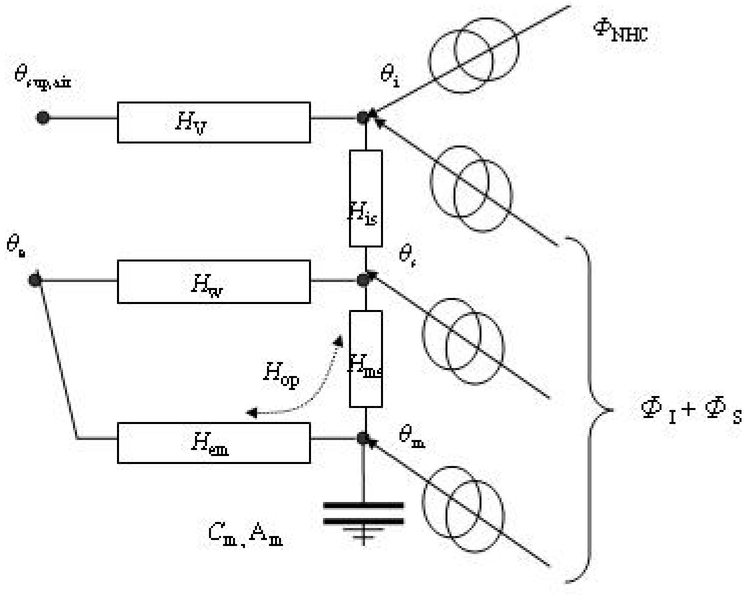


Figure 3 — Five resistances, one capacitance (5R1C) model

<subscripts to be updated>

7.2.2.2 Main variables

The main variables for the model are:

— the thermal transmission coefficients of doors, windows, curtain walls and glazed walls, H_w,and of opaque building elements, H_{op}, obtained from 8.3 and split into H_{em} and H_{ms} according to 12.2.2;

— the ventilation characteristics H_v and $\theta_{sup,air}$ obtained from 9.3;

— the coupling conductance H_{is};

— the internal heat capacity C_m is obtained from 12.3.1, in J/K.

The coupling conductance H_{is} is equal to

$$H_{is} = h_{is} \, A_t \tag{7}$$

with $A_t = R_{at} \cdot A_{fl}$

where

H_{is} is the coupling conductance between nodes i and s, in W/K;

A_t is the area of all surfaces facing the room, in m^2;

A_{fl} is the useful floor area, according to 6.4, in m^2;

h_{is} is the heat transfer coefficient between nodes i and s, with fixed value h_{is} = 3,45, in W/(m^2·K);

R_{at} is the dimensionless ratio between the internal surfaces area and the floor area. R_{at} can be assumed to be equal to 4.5.

For a given hour, all values are known, except $\Phi_{HC,n}$ which has to be calculated.

Full details are given in the respective clauses. The full set of equations is given in Annex C.

The monthly heating and cooling energy need is obtained by summing the hourly heating and cooling energy need, as described in 14.1.

7.2.2.3 Calculation of heat flows from internal and solar heat sources

As shown in annex C.2, the heat flows from internal and solar heat sources are split between the air node θ_i and the internal nodes θ_s, θ_m as follows:

$$\Phi_{ia} = 0{,}5\,\Phi_i \qquad \text{(equation C.1)}$$

$$\Phi_m = \frac{A_m}{A_t}(0{,}5\,\Phi_I + \Phi_S) \qquad \text{(equation C.2)}$$

$$\Phi_{st} = \left(1 - \frac{A_m}{A_t} - \frac{H_{es}}{9{,}1\,A_t}\right)(0{,}5\,\Phi_{int} + \Phi_{sol}) \qquad \text{(equation C.3)}$$

The heat flow rate from internal heat sources Φ_{int} is obtained from Clause 10 and the heat flow rate from solar heat sources Φ_{sol} (W) is obtained from Clause 11.

A_m and A_t are obtained from 7.2.2.1.

7.2.2.4 Length of heating and cooling season

The length of heating and cooling seasons (number of days or hours) are determined by averaging the heating or cooling need over the previous 4 weeks. The start and end of the heating and cooling seasons is determined with a threshold value of 1 W/m^2 floor area.

The length of cooling season can be reduced by an extra (energy consuming) provision such as mechanical or natural night ventilation or free cooling; consequently, for the operation period of such provision it is necessary to calculate the length of the cooling season without this provision or count the hours of operation of such provision.

NOTE The length of heating and cooling season is needed to know the number of hours of operation of certain systems with auxiliary energy use (e.g. pumps, fans)

7.2.3 Detailed simulation method

Dynamic methods used for the calculation of energy need of heating and cooling shall have passed the validation tests according to the relevant standards containing validation tests for detailed simulation methods as specified in annex A.

In addition, for the aspects not covered by the validation tests, in case of comparison of the energy performance level of buildings and/or for checking compliance with national or regional building regulations, the procedure shall be used as prescribed in, or referred to from, this standard.

Consequently, the calculation shall be performed according to:

— partitioning into zones, see 6.3;

— transmission heat transfer characteristics, see Clause 8;

— ventilation heat transfer characteristics, see Clause 9;

— internal heat gains, see Clause 10;

— solar heat gains, see Clause 11;

— dynamic parameters, see Clause 12;

— internal conditions, see Clause 13.

NOTE 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. If there is a conflict with the procedures in this standard, this may lead to differences in the results that remain undetected and therefore lead to variability of results. Such tools are in general difficult to check. Relevant aspects include:

- (dynamic) heat transfer via the ground, including thermal bridges;

- non-adiabatic internal walls and floors (in preparation in EN 15265??);

- 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.

7.2.4 Multiple steps

Type of methods:

Due to interactions between building and system, between zones and/or other interactions, multiple steps may be required for the calculation.

Depending on the type of calculation method, these iterations may be performed at hourly level or at monthly or seasonal level.

To account for interaction between building and systems:

The heat gains (including negative gains, from heat sinks) comprise the heat from the heating and cooling system. Before the dissipated heat from the heating and cooling system can be calculated, it may be necessary to calculate first the energy needs for heating and cooling without these elements in the internal heat gains.

With this information, the dissipated heat from the heating and cooling system can be calculated, followed by a second and final calculation of the energy needs for heating and cooling.

NOTE 1 In principle, a full iteration would be required, but a full iteration will not lead to an improvement of the overall accuracy of the result and a two-step approach suffices.

NOTE 2 The result of the first step also gives insight in the performance of the building without the influence of the heating and cooling system.

Consequently, depending on the application and type of building, to be decided nationally, it may be required to perform the calculation of the energy need for heating and cooling in two or more steps: first a calculation without dissipated heat from the heating and cooling system (when this cannot be predicted without knowing the heating and cooling needs), followed by a calculation or iteration including dissipated heat from the heating and cooling system, based on the information from the first calculation.

In case of a single step calculation, it may also be decided at national level to apply the following simplified approach: adjust specific system losses directly at the system level to account for recovered losses at building level and disregard these as input in the building energy balance.

NOTE 1 The latter approach may lead to significant errors if the effect of the recovered losses on the building energy balance is large or strongly different from the situation on which the adjustment was based.

To quantify seasonal special provisions:

Similarly, depending on the application and type of building, to be decided nationally, it may be required to perform the calculation of the energy need for cooling in two or more steps: first a calculation without free cooling or night cooling by ventilation, followed by a calculation with free cooling or night cooling by ventilation for those periods where the first calculation indicated that one or both of these are a feasible option to decrease the energy need for cooling.

To quantify effect of imperfect temperature control:

It may also be nationally decided to repeat the calculation with variations on the input data to quantify effects of imperfect temperature control.

To account for interaction between zones:

In case of a multi-zone calculation with thermally coupled zones according to 6.3.2.3, an iteration is required as well.

To obtain breakdown into components:

Optionally, it may also be relevant to repeat the overall calculation, e.g. by successively excluding specific elements in the calculation, to quantify the effect of specific elements on the result. In particular:

— the building energy need for heating and cooling in absence of a heat recovery unit in mechanical ventilation system: this will provide a result more closely related to the performance of the building itself, although a complete separation will not be possible, because the building will still contain specific design choices related to heat recovery, such as a higher air tightness;

— the building energy need for heating and cooling in absence of renewable energy sources in the building; for instance: replacing the windows by a reference set of windows: having a reference (neutral) orientation, size and (optionally) a reference thermal transmittance.

NOTE 3 When a number of alternative energy saving measures are being considered, the order in which the measures are successively added in the calculation will affect the calculated individual effect of each measure.

7.3 Length of heating and cooling seasons for operation of season-dependent provisions

a) Monthly method:

Heating season:

In absence of a national method, the actual length of heating season to ascertain the number of hours of operation of certain season-dependent provisions (e.g. pumps, fans) can be determined on the basis of the monthly values for the heat balance ratio for the heating mode γ_{H}, determined according to 12.2.1.1, in the following way:

The actual length of the heating season is equal to

$$L_{\mathrm{H}} = \sum_{m=1}^{m=12} f_{\mathrm{H},m} \tag{8}$$

With:

L_{H} is the actual length of the heating season, in number of months

$f_{\mathrm{H},m}$ is the fraction of the month that is part of the heating season.

Determine f_{H} for each month as follows:

Determine first the limit value of the heat balance ratio for the heating mode $\gamma_{\mathrm{H,lim}}$, with the following equation:

$$\gamma_{\mathrm{H,lim}} = (a_{\mathrm{H}} + 1) / a_{\mathrm{H}} \tag{9}$$

With:

a_{H} is a dimensionless numerical parameter depending on the time constant of the building, determined according to 12.2.1.1.

NOTE 1 The value for $\gamma_{\mathrm{H,lim}}$ corresponds to the point at the *ideal* gain utilisation curve with gain utilisation factor equal to the *actual* gain utilisation factor at γ_{H} = 1. A lower curve (less utilisation, higher a_{H}) leads to a higher limit; in an ideal situation the limit is $\gamma_{\mathrm{H,lim}}$ = 1: the gain utilisation factor =1 and the monthly heat gains are just enough to compensate the monthly heat losses by transmission and ventilation heat transfer. See Figure 5.

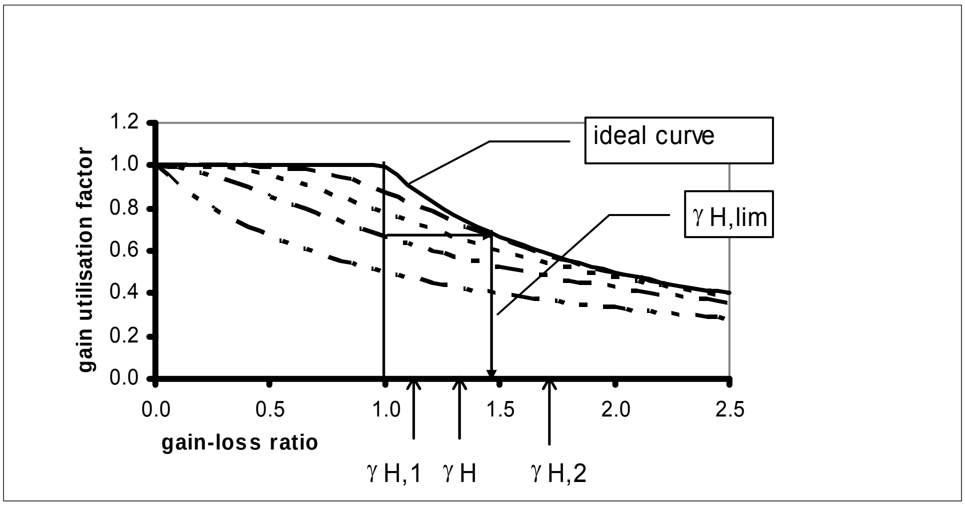


Figure 4 – Illustration of the procedure to determine the actual length of the heating season (monthly method)

And determine for each month:

— The value of γ_H at the beginning and end of the month, as the mean value of γ_H for the considered month and the previous month and the mean value of γ_H for the considered month and the next month (previous month for January is December; next month for December is January). The lowest of the two values is called $\gamma_{H,1}$ the highest is called $\gamma_{H,2}$. Negative values of γ_H shall be replaced by the value from the nearest month with positive value of γ_H .

— If $\gamma_{H,2} < \gamma_{H,lim}$ the whole month is part of the heating period: $f_H = 1$;

— If $\gamma_{H,1} > \gamma_{H,lim}$ the whole month is outside the heating period: $f_H = 0$;

— Otherwise: a fraction of the month is part of the heating period:

  — If $\gamma_H > \gamma_{H,lim}$: $f_H = 0,5 \cdot (\gamma_{H,lim} - \gamma_{H,1}) / (\gamma_H - \gamma_{H,1})$;

  — If $\gamma_H \leq \gamma_{H,lim}$: $f_H = 0,5 + 0,5 \cdot (\gamma_{H,lim} - \gamma_H) / (\gamma_{H,2} - \gamma_H)$.

Cooling season:

In absence of a national method, the actual length of the cooling season to ascertain the number of hours of operation of certain season-dependent provisions (e.g. pumps, fans) can be determined on the basis of the monthly values for the heat balance ratio for the cooling mode γ_C, determined according to 12.2.1.2, in the following way:

NOTE 2 The procedure is similar as the procedure for the heating mode, but with $1/\gamma_C$ instead of γ_H:

The actual length of the cooling season is equal to

$$L_C = \sum_{m=1}^{m=12} f_{C,m} \tag{10}$$

With:

L_C is the actual length of the heating season, in number of months

f_C is the fraction of the month that is part of the cooling season.

Determine $f_{C,m}$ for each month as follows:

Determine first the limit value of the heat balance ratio for the cooling mode $\gamma_{C,lim}$, with the following equation:

$$(1/\gamma_C)_{\lim} = (a_C + 1)/a_C \quad (11)$$

With:

a_C is a dimensionless numerical parameter depending on the time constant of the building, determined according to 12.2.1.2.

NOTE 3 The value for $(1/\gamma_C)_{lim}$ corresponds to the point at the *ideal* loss utilisation curve with loss utilisation factor equal to the *actual* loss utilisation factor at $1/\gamma_C = 1$. A lower curve (less utilisation, higher a_C) leads to a higher limit; for the ideal curve the limit is $(1/\gamma_C)_{lim} = 1$: the loss utilisation factor =1 and the monthly heat losses by transmission and ventilation heat transfer are just enough to compensate the monthly heat gains.

And determine for each month:

— The value of $1/\gamma_C$ at the beginning and end of the month, as the mean value of $1/\gamma_C$ for the considered month and the previous month and the mean value of $1/\gamma_C$ for the considered month and the next month (previous month for January is December; next month for December is January). The lowest of the two values is called $(1/\gamma_C)_1$, the highest is called $(1/\gamma_C)_2$. Negative values of $1/\gamma_C$ shall be replaced by the value from the nearest month with positive value of $1/\gamma_C$.

— If $(1/\gamma_C)_2 < (1/\gamma_C)_{lim}$ the whole month is part of the cooling period: $f_C = 1$;

— If $(1/\gamma_C)_1 > (1/\gamma_C)_{lim}$ the whole month is outside the cooling period: $f_C = 0$;

— Otherwise: a fraction of the month is part of the cooling period:

  — If $(1/\gamma_C) > (1/\gamma_C)_{lim}$: $f_C = 0{,}5 \cdot [(1/\gamma_C)_{lim} - (1/\gamma_C)_1] / [(1/\gamma_C) - (1/\gamma_C)_1]$;

  — If $(1/\gamma_C) \le (1/\gamma_C)_{lim}$: $f_C = 0{,}5 + 0{,}5 \cdot [(1/\gamma_C)_{lim} - (1/\gamma_C)] / [(1/\gamma_C)_2 - (1/\gamma_C)]$.

b) Seasonal method:

The actual length of the heating and cooling season depends on the heat balance ratio and thermal inertia. These lengths are needed to know the number of operation hours of certain season-dependent provisions (e.g. pumps, fans).

A calculation method to determine the actual length of the heating and cooling season may be determined at national level. In absence of a national method, the fixed length of the heating respectively cooling season (see annex K.3) may be used as a conservative number.

8 Heat transfer by transmission

8.1 Calculation procedure

The calculation procedure depends on the type of calculation method, but the assumptions (on environment conditions, user behaviour and controls) and the basic physical data shall be the same for each of the type of calculation methods (seasonal, monthly, simple hourly and detailed simulation methods). See Table 4.

Table 4 — Calculation procedure for thermal transmission heat transfer for the different types of methods

Type of method	Total heat transfer by transmission	Transmission heat transfer coefficients	Input data and boundary conditions
Seasonal or monthly method	Clause 8.2	Clause 8.3	Clause 8.4
Simple hourly method	Not applicable	Clause 8.3	Clause 8.4
Detailed simulation method	Not applicable [a)]	Not applicable [a)]	Clause 8.4
a): but compliance with steady state properties is to be demonstrated			

8.2 Total heat transfer by transmission per building or building zone

For the monthly and seasonal method, the total heat transfer by transmission is calculated for each month or season and for each zone z:

For heating: $Q_{tr} = \Sigma_k \{H_{tr,k} \cdot (\theta_{I,H} - \theta_{e,k})\} \cdot t$ (8)

For cooling: $Q_{tr} = \Sigma_k \{H_{tr,k} \cdot (\theta_{I,C} - \theta_{e,k})\} \cdot t$

where (for each building zone z and for each calculation period)

Q_{tr} is the total heat transfer by transmission, in MJ;

$H_{tr,k}$ is the heat transfer coefficient by transmission of element k to adjacent space(s), environment or zone(s) with temperature $\theta_{e,k}$, determined according to 8.3, in W/K,

$\theta_{I,H}$ is the set-point temperature of the building or building zone for heating, determined according to Clause 13, in degrees Celsius;

$\theta_{I,C}$ is the set-point temperature of the building or building zone for cooling, determined according to Clause 13, in degrees Celsius;

$\theta_{e,k}$ is the temperature of the adjacent space, environment or zone of element k, determined according to 8.3, in degrees Celsius;

t is the duration of the calculation period, determined according to Annex G, in Ms.

NOTE The heat transfer or part of the heat transfer may have a negative sign during a certain period.

8.3 Transmission heat transfer coefficients

8.3.1 General

The values for the heat transmission coefficient, $H_{T,k}$, of element k shall be calculated according to ISO/DIS 13789:2005, taking into account the standards for specific elements, such as windows (ISO/DIS 10077-1:2004), walls and roofs (ISO/DIS 6946:2005), curtain walls (prEN 13947), ground floor (ISO/DIS 13370:2006), with separate values for temperature $\theta_{e,k}$ of the adjacent space(s), environment or zone(s) of element k, for the following situations:

<more structure would be nice? E.g.: subdivided per type of element or per referred standard>

— **Heat transmission to external environment**: the temperature $\theta_{e,k}$ is the value for the temperature of the external environment θ_e, determined according to Annex G. For the simple hourly method a distinction is needed between on the one hand light building elements (windows, doors, curtain walls, other glazed elements), and on the other hand heavy building elements.

For each window the frame area fraction shall be determined according to ISO/DIS 10077-1:2004. As an alternative it may be nationally decided to permit a fixed frame area fraction for all windows in the building.

NOTE 1 E.g, for heating dominated climates a suitable national procedure may be: for each window the value shall be chosen to be either 0.30 or 0.20, whichever leads to the highest U-value of the window.

~~— **Heat transmission to adjacent conditioned zone**: the temperature~~ $\cancel{\theta_{e,k}}$ ~~is the set-point temperature of the adjacent zone;~~<was added by editorial reviewer after submission by WG! Is not correct!; see further on>

— **Heat transmission to adjacent unconditioned space**: the temperature $\theta_{e,k}$ is the value for the temperature of the external environment θ_e, determined according to Annex G. In the calculation of the heat transmission coefficient to an adjacent unconditioned space a reduction factor, *b*, shall be used to account for the reduced temperature difference compared to heat transmission to the external environment, according to ISO/DIS 13789:2006. However, default values for the reduction factor, *b*, may be defined at national level, depending on the type of building and/or application.

NOTE 2 National default values may for instance be defined in case of inspection of old existing buildings where gathering the full required input would be too labour-intensive for the purpose, related to cost-effectiveness of gathering the input..

— **Heat transmission to adjacent sunspace (greenhouse)**: for the heat transmission the same procedure shall be followed as for an adjacent unconditioned space.

NOTE 2 The effect of solar radiation on the temperature of the attached sunspace is taken into account as part of the calculation of the solar heat gains (Clause 11; see also Annex F)

However, simplified methods for the combined effect of heat transmission and effect of solar radiation may be defined at national level, depending on the type of building and/or application.

NOTE 1 A national simplified method may for instance be defined in case of inspection of existing buildings where the full method would be too labour-intensive for the purpose.

— **For calculation with coupled zones**, heat transmission to adjacent conditioned space(s): the temperature $\theta_{e,k}$ is the value for the temperature of the adjacent space(s), determined according to Annex B;

— **For calculation with uncoupled zones**, heat transmission to other conditioned zones is not applicable;

— **Heat transmission to the ground**: temperature $\theta_{e,k}$ is the value for the temperature of the external environment θ_e, determined according to Annex G. The values for $H_{tr,gr}$ are different per month. Alternatively, it may be decided at national level to allow seasonal values. These values will be different for heating and cooling period. This difference occurs in monthly and seasonal calculations as well as in simple hourly calculations.

NOTE 3 For heat transfer to the ground according to ISO/DIS 13370:2006 there is a monthly variation in the values for $H_{tr,gr}$ because $H_{tr,gr}$ includes implicitly the steady state (perimeter-related) and periodic (area-related) effects of heat flow through the ground. This monthly variation also applies to dynamic simulation methods, if the method from ISO/DIS 13370:2006 annex D is applied, as described further on..

— **Heat transmission to adjacent buildings**: the temperature $\theta_{e,k}$ is the value for the internal temperature of the adjacent building, based on proper data from the adjacent building and its use. It may be determined on a national basis if, depending on the purpose of the calculation, this element in the heat transmission may be ignored.

NOTE 4 For instance because of legal restrictions that do not allow that the characteristics of other buildings (which may be subject to change) have an influence on whether the legally required minimum energy performance level is maintained.

Thermal bridges:

The heat transmission covers area-related heat loss by transmission, as well as linear and point thermal bridges, determined according to ISO/DIS 13789:2005, irrespective of the type of method (seasonal, monthly, simple hourly or detailed simulation methods). <check!: there is no reference to this clause for detailed simulation methods!>For detailed simulation methods it is permitted to apply a method that gives heat transfer rates that are equivalent with the rates obtained according to ISO/DIS 13789:2005. Compliance with steady state properties is to be demonstrated.

Heating and cooling mode:

In the case of different properties for the heating and cooling mode, separate H_T values shall be used for each mode. This is for instance applicable for windows with movable shutters or different summer and winter modes, ground floor losses, heat losses to attached greenhouse (sunspace).

Special elements:

See 8.4.3 for specific details for special elements.

8.3.2 Effect of nocturnal insulation

When shutters are present the values for the heat transmission coefficient, $H_{tr,k}$, of the concerning window within element k can be reduced. The reduction is based on:

— the thermal transmittance of the window without shutter, U_w, in W/(m²K),

— the thermal transmittance of the window with shutter, U_{w+s}, in W/(m²K),

— the pattern in which the shutter is opened and closed,

as described in 8.4.2.

8.4 Input data and boundary conditions

8.4.1 General principles

Seasonal, monthly and simple hourly methods:

For seasonal, monthly and simple hourly calculations, except for specific cases, all physical characteristics are specified in 8.3 and in the documents to which that subclause refers, as input data for obtaining the thermal transmission coefficients and environment conditions.

Dynamic simulation methods:

For dynamic simulations the breakdown of the building envelope into area elements and line and point elements shall lead to the same overall areal, linear and point thermal transmission values as obtained in 8.3 for the other methods.

In addition to that, the assumptions (on environment conditions, user behaviour and controls) and the basic physical data shall be the same as described in 8.3 and in the documents to which that subclause refers.

8.4.2 Effect of nocturnal insulation

All methods

Whether the effect of nocturnal insulation may be taken into account is to be decided at national level, depending on the type of building and application. If so, it shall be done according to the following procedures:

Seasonal or monthly methods:

For a seasonal or monthly method, the effect of nocturnal insulation such as a shutter shall be taken into account by the dimensionless fraction of accumulated temperature difference, derived from the hourly pattern.

$$U_{\text{w,corr}} = U_{\text{w+s}} \cdot f_{\text{s}} + U_{\text{w}} \cdot (1 - f_{\text{s}}) \tag{9}$$

where

$U_{\text{w,corr}}$ is the reduced thermal transmittance of window and shutter, in W/(m²·K);

$U_{\text{w+s}}$ is the thermal transmittance of window and shutter together, in W/(m²·K);

f_{s} is the dimensionless fraction of accumulated temperature difference counted over the time intervals with the shutters closed, <rephrase!; separate alinea! Equation?! Simplified: time-average; see other comments: informative annex!> derived from the hourly pattern of the shutter, as determined in this clause, and the hourly pattern of the difference between internal and external temperature, as determined according to Clause 13;

U_{w} is the thermal transmittance of window without shutter, in W/(m²·K).

For the hourly values, see below under "All methods".

Because of the climate dependency, values for f_{s} shall be defined at national level, if necessary with a regional differentiation.

In case of old existing buildings where gathering the full required input would be too labour intensive for the purpose, related to cost effectiveness of gathering the input, the following simple methods/input may be used [followed by the simple method/input]. Specification of the conditions for allowing this simple method/input may be made at national level, depending on the purpose of the calculation. In that case the user shall report which method/input has been used and from which source.

<similar at least for:

Categories of thermal mass of the building

Default values for heat from internal heat sources

Default g-values of windows, etc.

In EN ISO 13790 or in the standards called from EN ISO 13790 (input providers):

- Clause 8.3: Thermal bridges: if unknown, it would not be correct to ‘punish’ EP by very conservative default values => typical values needed (note: values depend on insulation level…)

- Clause 8.3: Areas and detailed properties of constructions, sunspaces (also annex F), etc.: simplified input should be allowed

- Clause 11.4.5: Typical values for solar absorption coefficients, etc.

NOTE For instance for the purpose of building energy certificate.

-->

Simple hourly or detailed simulation methods:

For the simple hourly method and detailed simulation methods, the effect of nocturnal insulation shall be taken into account directly by the hourly pattern in combination with the calculation values of the thermal transmittance of windows with and without shutters.

For the hourly values, see below under "All methods".

All methods:

The calculation value of the thermal transmittance of the window is $U_{\mathrm{w+s}}$ from sunset until 7 am for all days for which the average day temperature is less than 10 °C and the thermal transmittance of the window is U_{w} for all other hours

where

$U_{\mathrm{w+s}}$ is the thermal transmittance of window and shutter together, in W/(m²·K);

U_{w} is the thermal transmittance of window without shutter, in W/(m²·K).

Other patterns can be distinguished at national level. Patterns can be different for weekdays and weekend days and for different building functions.

8.4.3 Special elements

Special methods are needed to calculate the influence of special elements:

— **Ventilated solar walls**: see Annex E.

— **Other ventilated envelope elements**: see Annex E.

— **Internal heat sources with a heat flow that is a predominant function of the internal temperature**: If a heat source of a potentially significant magnitude is a predominant function of the internal temperature, e.g. a source temperature that is close to the internal temperature (such as a water tank maintained at a specified temperature), the amount of heat transferred is strongly dependent on the temperature difference between source and internal environment. In that case the source shall not be added to the internal heat gains, but the heat transfer shall be added to the heat transfer by transmission, determined in Clause 8. The temperature $\theta_{e,k}$ is the value for the temperature of the source and the value for the heat transmission coefficient, $H_{tr,k}$ of the element is the product of exposed source area (m^2) and the heat transfer coefficient ($W/(m^2 \cdot K)$).

9 Heat transfer by ventilation

9.1 Calculation procedure

The calculation procedure depends on the type of calculation method, but the assumptions (on environment conditions, user behaviour and controls) and the basic physical data shall be the same for each of the type of calculation method (seasonal, monthly, simple hourly and detailed simulation methods). See Table 5.

Table 5 — Calculation procedure for ventilation heat transfer for the different types of methods

Type of method	Total heat transfer by ventilation	Ventilation heat transfer coefficients	Input data and boundary conditions
Seasonal or monthly method	Clause 9.2	Clause 9.3	Clause 9.4
Simple hourly method	Not applicable	Clause 9.3	Clause 9.4
Detailed simulation method	Not applicable [a)]	Not applicable [a)]	Clause 9.4
a): but compliance with steady state properties is to be demonstrated			

9.2 Total heat transfer by ventilation

For the seasonal or monthly method, the total heat transfer by ventilation from the conditioned space is calculated for each month or season and for each zone z:

For heating: $Q_{ve} = \Sigma_k \{f_t \cdot H_{ve,k} \cdot (\theta_{I,H,z} - \theta_{s,k})\} \cdot t$ (10)

For cooling: $Q_{ve} = \Sigma_k \{f_t \cdot H_{ve,k} \cdot (\theta_{I,C,z} - \theta_{s,k})\} \cdot t$

where (for each building zone z and for each calculation period)

Q_{ve} is the total heat transfer by ventilation, in MJ;

f_t is the time fraction of operation over the calculation period (full time: $f_t = 1$), determined according to 9.3;

$H_{ve,k}$ is the heat transfer coefficient by ventilation of air of flow element k entering the zone with supply temperature $\theta_{s,k}$, determined according to 9.3, in W/K,

$\theta_{I,H}$ is the set-point temperature of the building or building zone for heating, determined according to Clause 13, in degrees Celsius;

$\theta_{I,C}$ is the set-point temperature of the building or building zone for cooling, determined according to Clause 13, in degrees Celsius;

$\theta_{s,k}$ is the supply temperature of the air flow element k entering the building or building zone by ventilation or infiltration, determined according to 9.3, in degrees Celsius;

t is the duration of the calculation period, determined according to Annex G, in Ms.

NOTE 1 The heat transfer or part of the heat transfer may have a negative sign during a certain period; in that case heat is added to the building (zone).

NOTE 2 The additional energy required by the ventilation system for e.g. providing the air flow and pre-heating and/or pre-cooling the air before it enters the building or building zone is to be determined according to the relevant standard on ventilation systems as specified in annex A and added to the energy use in Clause 14.

9.3 Ventilation heat transfer coefficients

9.3.1 General

The values for the ventilation heat transfer coefficient, $H_{ve,k}$, of air flow element k or for the volume flow rate $q_{V,k}$, shall be taken from the relevant standard on ventilation systems as specified in annex A, with separate values for the supply temperature $\theta_{s,k}$ of airflow k, and separate values for the time fraction of operation f_t or hourly schedule of operation for the following situations:

— It is to be decided at national level whether (simple hourly method) and how (all methods) a given **hourly schedule** is converted to a (weighted) mean time fraction of operation or whether the input data are differentiated over the day (different per hour) and/or over the week (different schedule per day).

— **Ventilation including air infiltration from exterior**: the supply temperature $\theta_{s,k}$ is the value of the temperature of the external environment θ_e according to Annex G;

— **Ventilation including air infiltration from adjacent unconditioned space or greenhouse (sunspace)**: the supply temperature $\theta_{s,k}$ is the value of the temperature of the external environment θ_e, according to Annex G;

NOTE In the calculation of the heat transmission coefficient to adjacent unconditioned space a reduction factor, *b*, is used to account for the reduced temperature difference compared to heat transmission to the external environment (see ISO/DIS 13789:2005). The effect of solar radiation on the temperature of the attached sunspace is taken into account as part of the calculation of the solar heat gains (Clause 11; see also Annex F).

— **For calculation with coupled zones**, ventilation including air infiltration from adjacent conditioned space(s): the supply temperature $\theta_{s,k}$ is the value of the temperature of the adjacent space, according to Annex B;

— **Ventilation from a mechanical ventilation system**: the supply temperature $\theta_{s,k}$ is the value of the supply temperature of the air as it leaves the central air handling unit and enters the building or building zone, determined according to the relevant standard on ventilation systems as specified in annex A. For heat recovery units<necessary to make the split between AHU and HRU?>, see also more details in 9.4.2. In case of central pre-heating or pre-cooling, where the energy use for pre-heating or pre-cooling is calculated separately, the supply temperature is the temperature after the central pre-heating or pre-cooling.<Similar as for heat recovery (see 9.4.2): Add NOTE and add to clause 5.2 : then the building energy need is no pure need anymore; unless separately calculated without pre-heating or pre-cooling…>

Alternatively, it may be decided at national level, depending on the application, to use as supply temperature the external air temperature according to annex G.

NOTE In the latter case it is implicitly assumed that the heating or cooling system servicing the building or building zone provides the heat or cold for pre-heating or pre-cooling.

In case of old existing buildings where gathering the full required input would be too labour intensive for the purpose, related to cost effectiveness of gathering the input, default values for the supply temperature, depending on system characteristics, may be defined at national level. In that case the user shall report which method/input has been used and from which source.

The values obtained from the relevant standards on the amount of air flow and on ventilation systems according to annex A shall be based upon the same climate as used for the calculation in this standard, as specified in Annex G.

In case of old existing buildings where gathering the full required input would be too labour intensive for the purpose, related to cost effectiveness of gathering the input, simplified values for the airtightness of the building may be defined at national level. In that case the user shall report which method/input has been used and from which source. Examples are given in annex I. <to be completed; and then: use air infiltration equations from wi 18/19???>.

In cases where the volume flow rate is given as input, instead of the ventilation heat transfer coefficient, $H_{\mathrm{ve},k}$, the ventilation heat transfer coefficient, $H_{\mathrm{ve},k}$, can be calculated for each month or season and for each zone z from:

$$H_{\mathrm{ve},k} = \rho_{\mathrm{a}} c_{\mathrm{a}} q_{\mathrm{ve},k} \tag{11}$$

where

$H_{\mathrm{ve},k}$ is the heat transfer coefficient by ventilation of air of flow element k entering the zone with supply temperature $\theta_{\mathrm{s},k}$, in W/K;

$q_{\mathrm{ve,k}}$ is the airflow rate through the conditioned space, determined according to the relevant standard as specified in annex A, in m^3/s;

$\rho_{\mathrm{a}}\, c_{\mathrm{a}}$ is the heat capacity of air per volume = 1200 J/(m^3·K).

The time fraction of operation of the air flow element k ($f_{\mathrm{t},k}$)shall also be obtained from the same source.

Simple hourly method:

If the zone receive airflows from different sources (for example from outdoor and from the ventilation system), H_{ve} is, at each hour, the sum of the airflows, and $\theta_{\mathrm{s,air}}$ is, at each hour, the average of the temperatures of the different air sources weighted by the air flows.

9.3.2 Heating and cooling mode:

In cases of different properties for the heating and cooling mode, separate values shall be used. This is for instance applicable for different summer and winter ventilation modes, heat recovery units and heat transfer to attached greenhouse (sunspace).

9.3.3 Special elements:

See 9.4.4 for specific details for special elements.

9.4 Input data and boundary conditions

9.4.1 General principles

Seasonal, monthly and simple hourly methods:

For seasonal, monthly and simple hourly calculations, except for specific cases, all physical characteristics are calculated in 9.3 and in the documents to which that clause refers.

Dynamic simulation methods:

For dynamic simulations the (possibly hourly varying) air flow and supply air temperature values shall be consistent with the air flow and supply air temperature values as obtained in 9.3 for the other methods<rephrase to avoid impression that simpler methods are leading; it is the input requirements that is leading>.

In addition, for dynamic hourly calculations the assumptions (on environment conditions, user behaviour and controls) and the basic physical data shall be the same as described in 9.3 and in the documents to which that clause refers.

9.4.2 Heat recovery unit

Because, if present, a heat recovery unit is usually an important element in the heat balance of the building zone (strongly influencing the utilisation of heat gains, overheating, and such), the effect of the use of heat recovery units on the supply air temperature shall be taken into account in the calculation of the energy needs for heating and cooling and cannot be dealt with via a separately determined correction factor.

NOTE 1 See Note 2 in 5.2 on the optional extra (informative) calculation of the energy needs for heating and cooling without heat recovery.

Heat recovery from exhaust air is taken into account by replacing the external temperature θ_e with the supply temperature, obtained from the relevant standard on ventilation systems as specified in annex A (as function of building zone temperature and efficiency of the heat recovery).

NOTE 2 Additional energy, e.g. for defrosting, but also energy needed to power the fan, shall be added separately, see 14.3.4.

In determining input data needed for this standard, the following shall be taken into account:

— The values for the ventilation heat transfer coefficient, $H_{V,k}$, or for the volume flow rate $q_{V,k}$, for the supply temperature $\theta_{s,k}$ and for the additional energy (for fan power, de-frost, etc.) shall be based upon the same climate as used for the calculation in this standard, as specified in Annex G.

— If the heat recovery unit has a heat exchanger control without overheating control function (either dynamic, or on a seasonal basis), this shall be properly accounted for in the value of the supply temperature $\theta_{s,k}$.

— If the heat recovery unit is switched off or if the heat exchanger is bypassed to prevent the risk of freezing of the unit, this shall be properly accounted for in the supplied data; if applicable, the data on additional other sources of ventilation air shall be provided, to avoid an overestimation of the performance of the heat recovery unit and/or underestimation of the amount of ventilation flow rate.

9.4.3 Free cooling and night time ventilation during cooling mode

In case of ventilation for free cooling and/or night time ventilation during the cooling period, the extra ventilation can be taken into account as follows.

Monthly and seasonal methods:

For the monthly and seasonal method, during the cooling mode period, the average extra volume flow rate and adjustment factors for temperature difference, for dynamic effects and for effectiveness shall be calculated according to Equation (15).

$$\Delta q_{\mathrm{ve},k} = c_{\mathrm{temp}} c_{\mathrm{dyn}} c_{\mathrm{effect}} q_{\mathrm{ve}.k,\mathrm{extra}} \tag{12}$$

where

$\Delta q_{\mathrm{ve,k}}$ is the extra term for the airflow rate into the conditioned space, in m^3/s;

c_{temp} is a dimensionless adjustment factor for night versus 24 hour temperature difference in case of night time ventilation; unless otherwise stated the value is c_{temp} = 1,0;

c_{dyn} is a dimensionless adjustment factor for dynamic (inertia) effects; unless otherwise stated the value is c_{dyn} = 1,0;

c_{effect} is a dimensionless adjustment factor for effectiveness;

$q_{\mathrm{ve,k,extra}}$ is the time average <or better: add time of operation, as for the other flows or the other way around: always "24x7" time average?!?!> extra airflow rate through the conditioned space due to the free or night time ventilation, in m^3/s.

The values of the adjustment factors and the extra air flow rate have to be based upon the basic data and hourly patterns given below under "All methods".

All methods:

During the cooling mode period, the daily and weekly pattern shall be specified and the extra volume flow rate, as extra input to the calculation method.

At national level, the use of the extra flow rate may also be described as controlled by external or internal parameters, such as the external or internal temperature.

NOTE In case of simplified hourly or detailed simulation methods<but here we are in "all methods!!"> the use of parameter values from the previous time interval, to avoid the need for iteration, may lead to serious oscillation problems if no special precautions are taken, such as the introduction of suitable relaxation factors.

The amount of extra airflow rate due to night time ventilation, $q_{\mathrm{ve,extra}}$, may be calculated either according to the relevant standard as specified in annex A, or provided at national level based on the type of buildings, building use, climate, exposition, etc.

The extra airflow rate due to free or night time ventilation, $q_{\mathrm{ve,extra}}$, is added to the airflow rate, $q_{\mathrm{V},k}$, from 23 pm until 7 am for all days in the cooling season< whole season? Or per period? Or: may be dep. On temp.differenece?>.

On national level other patterns can be distinguished. Patterns can be different for weekdays and weekend days and can depend on the use of the building.

Values for the adjustment factors c_{temp} and c_{dyn} may be determined at national level; see examples in annex I. Annex I also gives a method to calculate the effective period.

>>for Annex I: Try to work in the following terms and 'rules' (from 15232):
i) Night cooling: the amount of outdoor air is set to its maximum during the unoccupied period provided: 1) the internal temperature is above the set-point for the comfort period, 2) the difference between the interrnal temperature and the external temperature is above a given limit;
ii) Free cooling the amount of outdoor air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation is performed on the basis of temperatures;
iii) H,x- directed control: the amount of outdoor air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation are performed on the basis of temperatures and humidity (enthalpy).

9.4.4 Special elements

Special methods are needed to calculate the influence of special elements:

— **Ventilated solar walls**: see Annex E;

— **Other ventilated envelope elements**: see Annex E;

— **Heat pump using ventilation exhaust air as source**: if the air flow rate needed for proper functioning of the heat pump in its intended application (e.g. to heat tap water) is higher than the air flow rate which would have been used as input for the calculation, the higher value shall be used.

10 Internal heat gains

10.1 Calculation procedure

Internal heat gains, heat gains from internal heat sources, including negative heat gains (dissipated heat from internal environment to cold sources or 'sinks'), consist of any heat generated in the conditioned space by internal sources other than the energy intentionally utilised for space heating, space cooling or hot water preparation.

The internal heat gains include:

— metabolic heat from occupants and dissipated heat from appliances;

— dissipated heat from lighting devices;

— heat dissipated from or absorbed by hot and mains water and sewage systems;

— heat dissipated from or absorbed by heating, cooling and ventilation systems;

— heat from or to processes and goods.

The calculation procedure depends on the type of calculation method, but the assumptions (on environment conditions, user behaviour and controls) and the input data shall be the same for each of the type of calculation methods (seasonal, monthly, simple hourly and detailed simulation methods). See Table 6.

Table 6 — Calculation procedure for internal heat gains for the different types of methods

Type of method	Overall internal heat gains	Internal heat gain elements	Input data and boundary conditions
Seasonal or monthly method	Clause 10.2	Clause 10.3	Clause 10.4
Simple hourly method	Clause 10.2	Clause 10.3	Clause 10.4
Detailed simulation method	Not applicable	Clause 10.3	Clause 10.4

10.2 Overall internal heat gains

Monthly and seasonal method:

For the monthly and seasonal method, the heat gains from internal heat sources in the considered building zone for the considered month or season are calculated from:

$$Q_{\text{int}} = \{\sum_k \Phi_{\text{int,mn},k}\} \cdot t + \{\sum_l (1-b_l)\Phi_{\text{int,mn},u,l}\} \cdot t \tag{13}$$

<check: DvO: for sunspaces: only if condition of 13789 annex A is met?!>where

Q_{int} is the sum of internal heat gains during the considered month or season, in MJ;

b_l is the reduction factor for the adjacent unconditioned space with internal heat source l, defined in ISO/DIS 13789:2005;

$\Phi_{\text{int,mn},k}$ is the time-average heat flow rate from internal heat source k, determined according to 10.3, in W;

$\Phi_{\text{int,mn,u},l}$ is the time-average heat flow rate from internal heat source l in the adjacent unconditioned space, determined according to 10.3, in W;

t is the length of the considered month or season, according to Annex G, in Ms.

An adjacent unconditioned space is an unconditioned space outside the boundaries of the zones for the calculation of the energy needs for heating and cooling. In the case of an unconditioned space adjacent to more than one conditioned zone, the value of the heat flow rate by internal heat source l in the unconditioned space, $\Phi_{\text{i,mean,u},l}$, shall be divided between the conditioned zones, weighted according to the floor areas per conditioned zone which are determined in 6.4.

Simple hourly method:

For the simple hourly method, the heat flow rate from internal heat sources in the considered building zone is calculated for each hour from:

$$\Phi_{\text{int}} = \sum_k \Phi_{\text{int},k} + \sum_l (1-b_l)\Phi_{\text{int},u,l} \tag{14}$$

Alternatively, it may be nationally decided to calculate the heat flow rate from internal heat sources in the considered building zone as time-average over a given period:

$$\Phi_{\text{int}} = \sum_k \Phi_{\text{int,mn},k} + \sum_l (1-b_l)\Phi_{\text{int,mn},u,l} \tag{15}$$

where

Φ_{int} is the sum of heat flow rates due to internal heat gains, in W;

b_l is the reduction factor for the adjacent unconditioned space with internal heat source l, defined in ISO/DIS 13789:2005;

$\Phi_{int,k}$ is the hourly heat flow rate from internal heat source k, determined according to 10.3, in W;

$\Phi_{int,u,l}$ is the hourly heat flow rate from internal heat source l in the adjacent unconditioned space, determined according to 10.3, in W;

$\Phi_{int,mn,k}$ is the time-average heat flow rate from internal heat source k, determined according to 10.3, in W;

$\Phi_{int,mn,u,l}$ is the time-average heat flow rate from internal heat source l in the adjacent unconditioned space, determined according to 10.3, in W.

10.3 Internal heat gain elements

All methods:

The heat gains from internal heat sources in a specific building or building zone <or (unconditioned) space?> are calculated from<for each hour? Or: ", if applicable: daily and/or weekly pattern"?>:

$$\Phi_{nt} = \Phi_{int,Oc} + \Phi_{int,A} + \Phi_{int,L} + \Phi_{int,WA} + \Phi_{int,HVAC} + \Phi_{int,Proc} \quad (16)$$

where

Φ_{int} is the sum of heat flow rate from internal heat sources, in W;

$\Phi_{int,Oc}$ is the heat flow rate from occupants, determined according to 10.4.2, in W;

$\Phi_{int,A}$ is the heat flow rate from appliances, also determined according to 10.4.2, in W;

$\Phi_{int,L}$ is the heat flow rate from lighting, determined according to 10.4.3, in W;

$\Phi_{int,WA}$ is the heat flow rate from hot and mains water and sewage, determined according to 10.4.4, in W;

$\Phi_{int,HVAC}$ is the heat flow rate from heating, cooling and ventilation systems, determined according to 10.4.5, in W;

$\Phi_{int,Proc}$ is the heat flow rate from processes and goods, determined according to 10.4.6, in W.

The principles for the calculation are:<check!>

— Part of the heat dissipated in a system may be recovered either in the building or in the system itself, or in another system. This standard considers only the heat recovered in the building.

— For reasons of simplification, minor amounts of heat dissipated in a system that are actually recovered in the building may be ignored in the calculation of the building energy need for heating and/or cooling and, instead, be dealt with in the calculation of the performance of the system by adequate adjustment factors.

NOTE 1 For internal heat gains that are significant compared to the order of magnitude of the heat balance terms of the building this simplification is not allowed, because the heat gains directly affect the utilisation of the heat gains, indoor temperature overshoot, et cetera.

— A cold source, removing heat from the building (zone), shall be treated as a source, with a negative value.

— If a heat source of a potentially significant magnitude has a heat flow that is a predominant function of the temperature difference between source and internal environment, the heat from this source shall not be added to the internal heat gains, but the heat transfer shall be added to the heat transfer by transmission, determined in Clause 8.

NOTE 2 For instance a source at constant temperature 25 °C will *supply* a large amount of heat to the space when the space is at 16 °C, it will supply no heat at all when the space itself is at 25 °C and it will *extract* heat when the room is at higher temperature.

All methods:

The given calculation procedures, assumptions (on environment conditions, user behaviour and controls) and input data in 10.4 shall be applied for each of the type of calculation methods (seasonal, monthly, simple hourly and detailed simulation methods).

Monthly and seasonal methods:

<check against changes above>Either direct input of average values over calculation period, or time-average of hourly values.

Simple hourly and detailed simulation methods:

<check against changes above>For the simple hourly method, the same time-average values shall be used as for the monthly method. As an alternative, hourly data from 10.4 may be used<what about week schedule?! Check also relation with intermittency: if not occupied during weekend>. For detailed simulation methods hourly data from 10.4 shall be used. As an alternative, the same time-average values may be used as for the monthly method.

NOTE 3 In practice, due to lack of reliable input data, the use of more detailed (including hourly) data does not necessarily lead to a higher accuracy.

10.4 Input data and boundary conditions

10.4.1 General

It may be decided at national level to ignore the heat flow rate by internal heat source in unconditioned spaces (except sunspaces) , in case of existing building if…etc..

For existing buildings, if the given calculation procedures in this clause are too labour intensive for the purpose, a simplified procedure may be defined at national level. In absence of national values, the values from Annex I may be used.

NOTE Annex I provides examples of national input data: tables with typical occupancy patterns and associated values for the various internal heat sources.

10.4.2 Metabolic heat from occupants and dissipated heat from appliances

Hourly and weekly schedules of heat flow rate for metabolic heat from occupants, $\Phi_{int,Oc}$ and dissipated heat from appliances, $\Phi_{int,A}$ shall be determined on national basis, as a function of building use, (optionally) occupancy class and purpose of the calculation.

For detailed simulation methods the thermal radiative and convective portions are each 50 %, unless otherwise stated.

10.4.3 Dissipated heat from lighting devices

The value for the heat flow rate from lighting, $\Phi_{\mathrm{int,Ll}}$, is the sum of:

- The value for the heat flow rate from the luminaires, calculated as a fraction of the energy consumption of lighting systems calculated according to the relevant standard on lighting systems as specified in annex A. A fraction < 1 is allowed in case the heat is directly removed by exhaust ventilation via the luminaries, according to a procedure to be defined at national level <assuming that EN 15193-1 will not provide guidance>; this heat shall be accounted for as heat source in the ventilation system.<also if it goes to outside??>

- The value for the heat flow rate from other lighting elements that are not covered in the previous category, such as decorative lighting, removable lighting, special-task lighting, building-grounds lighting, process-related lighting. For these other lighting elements, values may be specified on a national basis, depending on building use and purpose of the calculation.

For detailed simulation methods the thermal radiative and convective portions are each 50 %, unless otherwise stated.

10.4.4 Heat dissipated from or absorbed by hot and mains water and sewage systems

The heat flow rate from hot and mains water and sewage systems, $\Phi_{\mathrm{I,WA}}$, is the sum of:

$$\Phi_{\mathrm{int,WA}} = \Phi_{\mathrm{int,W,circ}} + \Phi_{\mathrm{int,W,other}} + \Phi_{\mathrm{int,MW}} \qquad (17)$$

with

$$\Phi_{\mathrm{int,HW,circ}} = q_{\mathrm{int,W,circ}} \cdot L_{\mathrm{W,circ}} \qquad (18)$$

where

$\Phi_{\mathrm{int,WA}}$ is the heat flow rate from hot and mains water and sewage systems, in W;

$\Phi_{\mathrm{int,W,circ}}$ is the heat flow rate from a permanent hot water circulation system, in W;

$\Phi_{\mathrm{int,W,other}}$ is the heat flow rate from hot water systems, excluding hot water circulation, in W;

$\Phi_{\mathrm{int,MSW}}$ is the heat flow rate from mains water and sewage, in W;

$q_{\mathrm{int,W,circ}}$ is the heat flow rate from the hot water circulation system per m length, in W/m;

$L_{\mathrm{W,circ}}$ is the pipe length of the hot water circulation system in the building zone considered, in m.

Heat from permanent hot water circulation:

The value for the heat flow rate from a permanent hot water circulation system per m length, $q_{\mathrm{I,HW,circ}}$, shall be obtained from the relevant standard on hot water systems as specified in annex A. The length, $L_{\mathrm{HW,circ}}$, shall include the length of the return-pipes, unless explicitly otherwise specified.

Heat from (other) hot water, mains water and sewage:

The value for the heat flow rate from the hot water system other than hot water circulation, $\Phi_{l,HW,other}$, and the value for the heat flow rate from mains water and sewage, $\Phi_{l,MSW}$, shall be obtained from the relevant standard on hot water systems as specified in annex A. Alternatively, it may be specified on a national basis, depending on building use and purpose of the calculation, that the sum of these two heat flow rates ($\Phi_{l,HW,other}$ + $\Phi_{l,MSW}$) may be neglected.

For detailed simulation methods the thermal radiative and convective portions are each 50 %, unless otherwise specified.

Alternative option:

As an alternative, to be decided at national level, for reasons of simplification, minor amounts of heat dissipated in the hot water system that are actually recovered in the building may be ignored in the calculation of the building energy need for heating and/or cooling and, instead, be dealt with in the calculation of the performance of the system by adequate adjustment factors.

This alternative option is permitted only if it can be ensured that this will not lead to underestimation of energy needs for cooling and/or the thermal discomfort.

10.4.5 Heat dissipated from or to heating, cooling and ventilation systems

The heat flow rate from or to heating, cooling and ventilation systems due to dissipation, $\Phi_{int,HVAC}$, is the sum of:

$$\Phi_{int,HVAC} = \Phi_{int,H} + \Phi_{int,C} + \Phi_{int,V} \tag{19}$$

where

$\Phi_{int,HVAC}$ is the heat flow rate from space heating, cooling and ventilation systems, in W;

$\Phi_{int,H}$ is the heat flow rate from the space heating system(s), in W;

$\Phi_{int,C}$ is the heat flow rate from the space cooling system(s), in W;

$\Phi_{int,V}$ is the heat flow rate from the ventilation system(s), in W.

For detailed simulation methods the thermal radiative and convective portions are each 50 %, unless otherwise stated.

NOTE The heat flow rate is counted positive if from the system to the indoor environment; it is counted negative if from indoor environment to the system, e.g. the heat flow rate to cold pipes of the cooling system.

Space heating system:

The value for the heat flow rate from the space heating system, $\Phi_{l,HS,}$ consists of heat dissipated in the building zone considered, from auxiliary energy sources (such as a pump, fan and/or electronics) and heat dissipated from emission<not emission?!>, circulation, distribution, storage and generation of the heating system(s).

The value shall be obtained from the relevant standard on space heating systems as specified in annex A either (to be decided nationally) variable per hour (only for detailed simulation methods or simple hourly method), or as average value per month or average over the heating season.

Alternative option:

As an alternative, for reasons of simplification, to be decided at national level, minor amounts of heat dissipated in the space heating system that are actually recovered in the building may be ignored in the calculation of the building energy need for heating and cooling and, instead, be dealt with in the calculation of the performance of the heating system by adequate adjustment factors.

This alternative option is permitted only if it can be ensured that this will not lead to underestimation of energy needs for heating, cooling and/or the thermal discomfort.

Space cooling system:

The value for the heat flow rate from or to the cooling system, $\Phi_{\mathrm{I,CS}}$, consists of heat from auxiliary energy sources (such as a pump, fan and/or electronics), dissipated in the considered building zone, and heat dissipated to cold emission<not emission?!>, circulation, distribution, storage and generation parts of the cooling system(s).

The value shall be obtained from the relevant standard on cooling systems as specified in annex A, either (to be nationally)variable per hour (only for detailed simulation methods or simple hourly method), or as average value per month or average over the cooling season.

Alternative option:

As an alternative, for reasons of simplification, to be decided at national level, minor amounts of heat dissipated to the cold parts of the space cooling system that are actually recovered in the building may be ignored in the calculation of the building energy need for heating and cooling and, instead, be dealt with in the calculation of the performance of the cooling system by adequate adjustment factors.

This alternative option is permitted only if it can be ensured that this will not lead to underestimation of energy needs for heating, cooling and/or the thermal discomfort.

Ventilation system:

The value for the heat flow rate in the considered building zone from the ventilation system, $\Phi_{\mathrm{I,VS}}$, consists of heat, dissipated in the considered building zone, from the ventilation system(-s).

The value shall be obtained from the relevant standard on ventilation systems <or air flow rate?> as specified in annex A, either, to be decided at national level, variable per hour (only for detailed simulation methods or simple hourly method), or as average value per month or average over the heating season and cooling season respectively. Heat dissipated in air supplied to the building zone shall be taken into account by a raise in the supply temperature <Comments NEN: shd be counted as internal heat gains; to be communicated with prEN wi 20/21>, to be obtained from the relevant standard on air flow rates and/or on the relevant standard on ventilation systems as specified in annex A and shall not be counted as an internal heat source.

NOTE Internal heat from ventilation systems not taken into account in the supply temperature could include heat dissipated from a fan-motor outside the air-stream or from fans circulating the air locally.

Alternative option:

As an alternative, for reasons of simplification, minor amounts of heat dissipated in the ventilation system that are actually recovered in the building may be ignored in the calculation of the building energy need for heating and cooling and, instead, be dealt with in the calculation of the performance of the ventilation system by adequate adjustment factors.

This alternative option is permitted only if it can be ensured that this will not lead to underestimation of energy needs for heating, cooling and/or the thermal discomfort.

Iteration steps:

Before the dissipated heat from the heating and cooling system can be calculated, it might be necessary to calculate first the energy needs for heating and cooling without these elements in the internal heat gains. See 7.2.4.

10.4.6 Heat from or to processes and goods

The heat flow rate from or to processes and goods, $\Phi_{\mathrm{I,PROC}}$, consists of heat from or to specific processes in the considered building zone and/or goods entering the building zone. The values may be determined on a national basis, depending on building use and purpose of the calculation.

For detailed simulation methods the thermal radiative and convective portions are each 50 %, unless otherwise stated.

If a heat source of a potentially significant magnitude has a source temperature that is close to the internal temperature, the actually transferred amount of heat is strongly dependent on the temperature difference between source and indoor environment. In that case the heat shall not be added to the internal heat gains, but the heat transfer shall be added to the heat transfer by transmission, determined in Clause 8.

11 Solar heat gains

11.1 Calculation procedure

Heat gains from solar heat sources result from the solar radiation normally available in the locality concerned, the orientation of the collecting areas, the permanent shading, the solar transmittance and absorption and thermal heat transfer characteristics of collecting areas. The coefficient that includes the characteristics and the area of the collecting surface (including the impact of shading) is called the effective collecting area.

The calculation procedure depends on the type of calculation method, but the assumptions (on environment conditions, user behaviour and controls) and the input data shall be the same for each of the type of calculation methods (seasonal, monthly, simple hourly and detailed simulation methods). See Table 7.

Table 7 — Calculation procedure for solar heat gains for the different types of methods

Type of method	Overall solar heat gains	Solar heat gain elements	Input data and boundary conditions
Seasonal or monthly method	Clause 11.2	Clause 11.3	Clause 11.4
Simple hourly method	Clause 11.2	Clause 11.3	Clause 11.4
Detailed simulation method	Not applicable	Not applicable<check!>	Clause 11.4

11.2 Overall solar heat gains

Monthly and seasonal method:

For the monthly and seasonal method, the heat gains from solar sources in the considered building zone for the considered month or season are calculated from:

$$Q_{\mathrm{sol}} = \{\sum_{k} \Phi_{\mathrm{sol,mn},k}\} \cdot t + \{\sum_{l} (1 - b_{l}) \Phi_{\mathrm{sol,mn},u,l}\} \cdot t \qquad (20)$$

where

Q_{sol} is the sum of solar heat gains during the considered month or season, in MJ;

b_l is the reduction factor for the adjacent unconditioned space with internal heat source l, defined in ISO/DIS 13789:2005;

$\Phi_{sol,mn,k}$ is the time-average heat flow rate from solar heat source k, determined according to 10.3, in W;

$\Phi_{sol,mn,u,l}$ is the time-average heat flow rate from solar heat source l in the adjacent unconditioned space, determined according to 10.3, in W;

t is the length of the considered month or season, according to Annex G, in Ms.

An adjacent unconditioned space is an unconditioned space outside the boundaries of the zones for the calculation of the energy needs for heating and cooling. In the case of an unconditioned space adjacent to more than one conditioned zone, the value of the heat flow rate by solar heat source l in the unconditioned space, $\Phi_{sol,mn,u,l}$, shall be divided between the conditioned zones, weighted according to the floor areas per conditioned zone which are determined in 6.4.

It may be decided at national level to ignore the heat flow rate by internal heat source in unconditioned spaces (except sunspaces), in case of existing building if……etc..

Simple hourly method:

For the simple hourly method, the heat flow rate from solar heat sources in the considered building zone is calculated for each hour from:

$$\Phi_{sol} = \sum_k \Phi_{sol,k} + \sum_l (1 - b_l)\Phi_{sol.u,l} \tag{21}$$

Alternatively, it may be nationally decided to calculate the heat flow rate from solar heat sources in the considered building zone as time-average over a given period:

$$\Phi_{Sol} = \sum_k \Phi_{Sol,mn,k} + \sum_l (1 - b_l)\Phi_{Sol,mn,u,l} \tag{22}$$

where

Φ_{sol} is the sum of heat flow rates due to solar heat gains, in W;

b_l is the reduction factor for the adjacent unconditioned space with solar heat source l, defined in ISO/DIS 13789:2005;

$\Phi_{sol,k}$ is the hourly heat flow rate from solar heat source k, determined according to 11.3, in W;

$\Phi_{sol,u,l}$ is the hourly heat flow rate from solar heat source l in the adjacent unconditioned space, determined according to 11.3, in W;

$\Phi_{sol,mn,k}$ is the time-average heat flow rate from solar heat source k, determined according to 11.3, in W;

$\Phi_{sol,mn,u,l}$ is the time-average heat flow rate from solar heat source l in the adjacent unconditioned space, determined according to 11.3, in W.

11.3 Solar heat gain elements

11.3.1 General

Add: collecting areas, shading,

Also included in this clause: sky radiation,

etc.

The collecting areas to take into consideration are the glazing, the external opaque elements, the internal walls and floors of sunspaces, and walls behind a transparent covering or transparent insulation. The characteristics depend in general on climate, time and location dependent factors such as the sun position, ratio between direct and diffuse solar radiation. Consequently, the characteristics in general vary over time, both hourly and over the year. As a result, adequate mean or conservative values shall be selected that are appropriate for the purpose of the calculation (heating, cooling and/or summer comfort).

Heat flow by solar gains

$$\Phi_{\mathrm{sol,k}} = F_{\mathrm{s,o},k} A_{\mathrm{s},k} E_{\mathrm{s},k} - F_{\mathrm{r},k} \Phi_{\mathrm{r,k}} \qquad (23)$$

where

$\Phi_{\mathrm{sol},k}$ are the solar heat gains through building element k, in W.

$F_{\mathrm{s,O},k}$ is the shading reduction factor for external obstacles for the solar effective collecting area of surface k, determined according to 11.4.4.

$A_{\mathrm{s},k}$ is the effective collecting area of surface k with given orientation and tilt angle, in the considered zone <or building or space?>, determined according to 11.3.2 (glazings), 11.3.3 (opaque building elements) and Annex F (special elements), in m^2;

$E_{\mathrm{s,k}}$ is the solar irradiance, the total energy of the solar irradiation during the calculation period per m² of collecting area of surface k, with given orientation and tilt angle, determined according to Annex G, in W/m^2;

F_{r} is the form factor between the element and the sky determined according to 11.4.6;

$\Phi_{\mathrm{r},k}$ is the extra heat flow due to thermal radiation to the sky from building element k, determined according to 11.3.4, in W.

NOTE The solar effective collecting area, A_{s} is the area of a black body having the same solar heat gain as the surface considered.

11.3.2 Effective solar collecting area of glazed elements

The effective solar collecting area of a glazed envelope element (e.g. a window) is:

$$A_{\mathrm{s}} = F_{\mathrm{sh,g}}\, g_{\mathrm{g}}\, (1 - F_{\mathrm{F}})\, A_{\mathrm{w,p}} \qquad (24)$$

where

$A_{\mathrm{s},k}$ is the effective collecting area of the glazed element, in m^2;

$F_{\mathrm{sh,g}}$ is the shading reduction factor for movable shading provisions, determined according to 11.4.3;

g_g is the total solar energy transmittance of the transparent part of the element, determined according to 11.4.2;

NOTE The transparent part of the element may contain clear glazing, but also (permanent) scattering or solar shading layers.

F_F is the frame area fraction, ratio of the projected frame area to the overall projected area of the glazed element, determined according to 11.4.5;

$A_{w,p}$ is the overall projected area of the glazed element (e.g. window area), in m^2.

11.3.3 Effective collecting area of opaque building elements

The net solar heat gains of opaque elements without transparent insulation during the heating season can be only a small portion of the total solar heat gains and are partially compensated by radiation losses from the building to clear skies. However, for dark, poorly insulated surfaces, or large areas facing the sky, the solar heat gains through opaque elements can become important.

For summer cooling or summer thermal comfort calculations, the solar heat gains through opaque building elements should not be underestimated. On the other hand, if thermal radiation losses are expected to be important, the transmission heat loss can be augmented at the same time, which is represented by a correction factor to the effect of the solar heat gains. Solar heat gains of opaque elements with transparent insulation are treated in H.2.

The effective solar collecting area of an opaque part of the building envelope is:

$$A_s = \alpha_{S,c} R_{se} U_c A_c \tag{25}$$

where

A_s is the effective collecting area of the opaque part, in m^2;

$\alpha_{S,c}$ is the dimensionless absorption coefficient for solar radiation of the opaque part, obtained from ??;

R_{se} is the external surface heat resistance of the opaque part, determined according to ISO/DIS 6946:2005, in m^2·K/W;

U_c is the thermal transmittance of the opaque part, determined according to ISO/DIS 6946:2005, in W/(m^2·K);

A_c is the projected area of the opaque part, in m^2.

11.3.4 Thermal radiation to the sky

The extra heat flow due to thermal radiation to the sky for a specific building envelope element, Φ_r is:

$$\Phi_r = R_{se} U_c A_c h_f \Delta\theta_{er} \tag{26}$$

where

Φ_r is the extra heat flow due to thermal radiation to the sky, in W;

R_{se} is the external surface heat resistance of the element, determined according to ISO/DIS 6946:2005, in m^2·K/W;

U_c is the thermal transmittance of the element, determined according to ISO/DIS 6946:2005, in W/(m²·K);

A_c is the projected area of the element, in m².

h_r is the external radiative heat transfer coefficient, determined according to 11.4.6, in W/(m²K);

$\Delta\theta_{er}$ is the average difference between the external air temperature and the apparent sky temperature, determined according to 11.4.6, in °C.

If the building element contains a layer that is (e.g. naturally) ventilated with external air and the U-value is calculated with the assumption that the thermal resistance between this vented layer and the external environment can be neglected, the solar transmittance using equation (26) will be overestimated. To avoid overestimation, a corrected *U*-value should be used in equation (26) in which the vented layer is not considered as a short cut.

NOTE E.g. in case of roofs with (vented) roof-tiles, calculated with ISO/DIS 13789:2005.

11.3.5 Solar heat gains of sunspaces

The effective collecting area of sunspaces, which have in most cases several collecting areas, cannot be calculated in a simple way. Annex F gives a method to calculate the passive solar heat gains of sunspaces <too loose! ➔ gives the method, by allow national method, as in 8.3!!; to be mentioned also in annex F? Yes, to be sure..>.

<At national level…., for existing buildings….>

11.4 Input data and boundary conditions

11.4.1 General

All methods:

It may be decided at national level to ignore the effective solar collecting area in unconditioned spaces (except sunspaces), in case of existing buildings if…etc.

It may be decided at national level to ignore or include the solar heat gains through window frames, to be calculated according to ISO 15099.

11.4.2 Solar energy transmittance of glazing

In principle, the total solar energy transmittance g in Equation (24) is the time-averaged ratio of energy passing through the unshaded element to that incident upon it. For windows or other glazed envelope elements with non-scattering glazing, the relevant standard on the optical properties of multiple glazings as specified in annex A provides a method to obtain the solar energy transmittance for radiation perpendicular to the glazing. This value, g_n, is somewhat higher than the time-averaged transmittance, and a correction factor, F_w, shall be used:

$$g = F_w \, g_n \tag{27}$$

<hourly or monthly/seasonal average?!>

In case of existing buildings, if …etc.: default values of *g* for windows with and without solar shading; related to what is normative in annex E or F!! and what is informative in annex I.

NOTE < to be considered: move some parts to normative procedure (e.g. which principle to be respected in the angle-of-incidence correction for glazings and windows with shading devices)

Something like: "In absence of national values, the following values shall be taken: 75% direct (beam), 45° solar height 0° azimuth + 25% isotropic diffuse. In case of movable blinds: blind position (if possible: no direct transmission, max. light transmission and/or view through".> g-values and guidance for the correction factor are given in Annex I, with a distinction between conservative values for heating and for cooling mode, together with typical solar transmission factors for global radiation.

The relevant standards <actually: not both..; see comment above> on the optical properties of window systems as specified in annex A provide methods of determination of the total solar energy transmittance of glazing equipped with solar protection devices.

11.4.3 Movable shading provisions

Monthly method and seasonal method:

For the monthly method and seasonal method, the shading reduction factor for movable shading provisions, $F_{\text{sh,g}}$, shall be derived as:

$$F_{\text{sh,g}} = [(1 - f_{\text{with}})g_{\text{w}} + f_{\text{with}} g_{\text{w+sh}}] / g_{\text{w}} \tag{28}$$

where

g_{w} is the total solar energy transmittance of the window, when the solar shading is not in use;

$g_{\text{w+sh}}$ is the total solar energy transmittance of the window, when the solar shading is in use;

f_{with} is the weighted fraction of the time with the solar shading in use, e.g. as a function of the intensity of incident solar radiation (thus: climate, season and orientation dependent).

The weighted fraction of the time that the solar shading is in use, f_{with}, is determined on the basis of the basic input data and hourly patterns as given below under "All methods".

NOTE 1 Values of f_{with} are determined at national level. Examples are given in Annex I. EN 15232 describes different types of control systems.

Simple hourly method and detailed simulation methods:

For the simple hourly method and detailed simulation methods the hourly values of g_{w} and $g_{\text{w+s}}$ shall be used; see below under "All methods".

<better: choose nationally: hourly or monthly/seasonal average?!; see as done for internal heat gains? Differentiate g-vale, shading, …; to be nationally decided>

All methods:

For all methods the solar shading shall be taken as being switched on if the intensity of the solar radiation on the surface at the given hour exceeds 300 W/m^2 and switched off if the hourly value is below this value.

NOTE 2 The time that the solar shading is open and closed is climate dependent.

Alternatively the criterion for switching may be determined on a national level, and may differentiate between types of solar control, such as:

— No control (not relevant here; is included in g-value of window)

— Manual operation

— Motorised operation

— Blind automatic control

11.4.4 External shading reduction factors

The external shading reduction factor, $F_{sh,O}$, which is in the range 0 to 1, represents the reduction in incident solar radiation due to permanent shading of the surface concerned resulting from:

— other buildings;

— topography (hills, trees etc.);

— overhangs;

— other elements of the same building;

— external part of the wall where the glazed element is mounted.

The shading reduction factor is defined by:

$$F_{sh,O} = \frac{E_{s,ps,mean}}{E_{s,mean}} \tag{29}$$

where

$E_{s,ps;mean}$ is the average solar irradiance actually received on the collecting plane shaded by the external obstacle(s) during the heating season, W/m^2;

$E_{s;mean}$ is the average solar irradiance on the collecting plane without shading, in W/m^2.

It may be decided at national level, depending on specific conditions (such as type of external obstacles) to use a fixed shading reduction factor for different windows in the building with the same orientation.

In case of existing buildings, if etc.….; needed? Better: in annex I, but is informative anyway?!>

Unless otherwise specified nationally?! But allow more precise: the specify first the more precise method; even then it is not the most detailed: e.g. only diffuse, non-spectral,….> the calculation of the shading reduction factors shall be based upon the following simplification:

Direct solar radiation is obstructed by the obstacle; diffuse and ground reflected radiation remains unchanged. This is equivalent to obstacles that, by reflection, produce the same amount of solar radiation as they obstruct.

For specific applications, tabulated shading reduction factors may be prescribed at national level, depending on….

NOTE Annex I provides some information on shading reduction factors.

11.4.5 Frame area fraction

For each window the frame area fraction shall be determined according to ISO/DIS 10077-1:2004.

As an alternative it may be nationally decided to use a fixed frame area fraction for all windows in the building.

NOTE For instance, in case of heating dominated climates, 0.20 or 0.30, whichever gives the highest *U*-value, see 8.3.1, or a fixed value of 0.30; for cooling dominated climates e.g. a fixed value of 0.20.

11.4.6 Extra heat transfer by thermal radiation to the sky

<Here or in intro? Or at bottom?: To be nationally decided: ignore or not, or ignore together with solar heat gains through opaque elements>

The values for the form factor between the element and the sky:

F_r= 1 for an unshaded horizontal roof;

F_r= 0,5 for an unshaded vertical wall.

The external radiative heat transfer coefficient, h_r may be approximated as:

$$h_r = 4\,\varepsilon\,\sigma\,(\theta_{ss} + 273)^3 \tag{30}$$

where

ε is the emissivity for thermal radiation of the external surface;

σ is the Stefan-Boltzmann constant: $\sigma = 5{,}67 \times 10^{-8}$ W/(m²·K⁴);

θ_{ss} is the arithmetic average of the surface temperature and the sky temperature, in °C.

To a first approximation, h_r can be taken equal to 5 ε W/(m²·K), which corresponds to an average temperature of 10 °C.

When the sky temperature is not available from climatic data, the average difference $\Delta\theta_{er}$ between the external air temperature and the sky temperature should be taken as 9 K in sub-polar areas, 13 K in the tropics and 11 K in intermediate zones.

At national level, default values may be given for the necessary input data, depending on the application and type of building.

NOTE Examples are given in annex I.

12 Dynamic parameters

12.1 Calculation procedure

A dynamic method models the thermal resistances, thermal capacitances and heat gains from solar and internal heat sources in the building or building zone. There are numerous methods to do so, ranging in complexity from simple to very detailed. The simple hourly method combines the thermal capacity of the building or building zone into a single resistance-capacitance pair.

In the monthly and seasonal methods, the dynamic effects are taken into account by introducing the gain utilisation factor for heating and the loss utilisation factor for cooling. The effect of inertia in case of intermittent heating or switch off is taken into account separately; see Clause 13.

Although the calculation procedure depends on the type of calculation method, the assumptions (on environment conditions, user behaviour and controls) and the input data shall be the same for each of the type of calculation methods (seasonal, monthly, simple hourly and detailed simulation methods). See Table 8.

Table 8 — Calculation procedure for dynamic parameters for the different types of methods

Type of method	Dynamic parameters	Input data and boundary conditions
Seasonal or monthly method	12.2	0
Simple hourly method	12.2	0
Detailed simulation method	Not applicable	0

12.2 Dynamic parameters

12.2.1 Monthly and seasonal method

12.2.1.1 Gain utilisation factor for heating

The gain utilisation factor for heating, η_H is a function of the heat balance ratio, γ_H and a numerical parameter, a_H that depends on the building inertia, according to the following equation:

if $\gamma_H \neq 1$:
$$\eta_{G,H} = \frac{1-\gamma_H^{a_H}}{1-\gamma_H^{a_H+1}} \tag{31}$$

if $\gamma_H = 1$:
$$\eta_{G,H} = \frac{a_H}{a_H + 1} \tag{32}$$

if $\gamma_H < 0$:
$$\eta_{G,H} = 1/\gamma_H \tag{35}$$

with

$$\gamma_H = \frac{Q_{H,gn}}{Q_{H,ls}} \tag{33}$$

where (for each month or per season and for each building zone)

$\eta_{H,gn}$ is the dimensionless gain utilisation factor for heating;

γ_H is the dimensionless heat balance ratio for the heating mode:

$Q_{H,ls}$ is the total heat transfer for the heating mode, determined according to 7.2.1.3, in MJ;

$Q_{H,gn}$ are the total heat gains for the heating mode, determined according to 7.2.1.3, in MJ;

a_H is a dimensionless numerical parameter depending on the time constant, τ_H, defined by:

$$a_{\mathrm{H}} = a_{\mathrm{H},0} + \frac{\tau_{\mathrm{H}}}{\tau_{\mathrm{H},0}} \tag{34}$$

where

$a_{\mathrm{H},0}$ is a dimensionless reference numerical parameter, determined according to Table 9;

τ_{H} is the time constant of the building or building zone, determined according to 12.2.1.3, in h;

$\tau_{\mathrm{H},0}$ is a reference time constant, determined according to Table 9, in h.

the parameter values are empirical values and may be determined at national level; in absence of national values the given tabulated values may be used (to be decided at national level, depending on the purpose of the calculation).

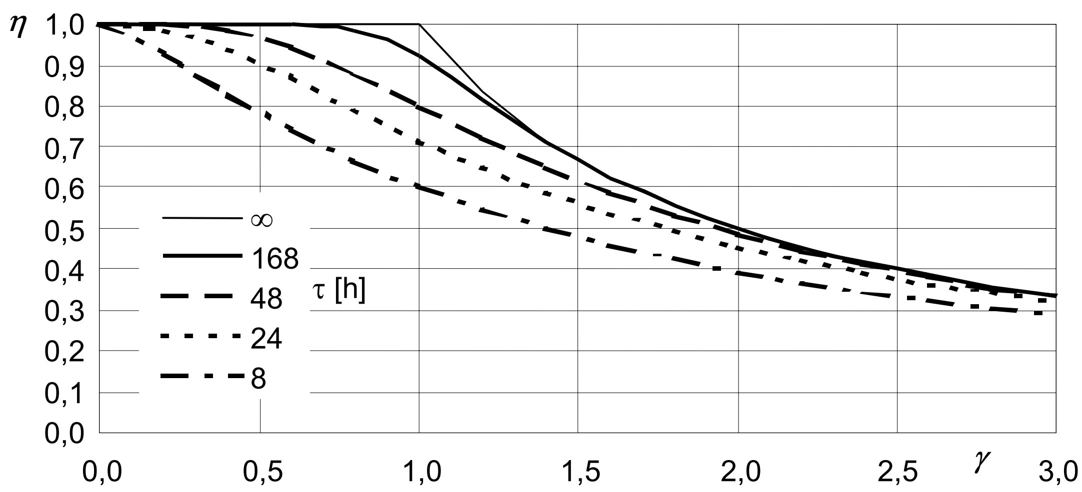
NOTE 1 See also annex K for explanation and derivation and annex J for justification and future conversion.

Table 9 — Values of the numerical parameter $a_{0,\mathrm{H}}$ and reference time constant $\tau_{0,\mathrm{H}}$

Type of building		$a_{\mathrm{H},0}$	$\tau_{\mathrm{H},0}$ (h)
	Continuously heated buildings (more than 12 hours per day) such as residential buildings, hotels, hospitals, homes and penitentiary buildings monthly calculation method	1,0	15
	Seasonal calculation method	0,8	30
Values of $a_{\mathrm{H},0}$ and $\tau_{\mathrm{H},0}$ may also be provided at national level.			

Figure 5 illustrates gain utilisation factors for monthly calculation periods and for various time constants for type I and type II buildings.

NOTE 2 The gain utilisation factor is defined independently of the heating system characteristics, assuming perfect temperature control and infinite flexibility. A slowly responding heating system and a less-than-perfect control system can significantly affect the use of the heat gains.



Key

η gain utilisation factor
τ time constant of the building
γ heat balance ratio

Figure 5 – Gain utilisation factor for heating mode, for 8 hours, 1 day, 2 days, 1 week and infinite time constants, valid for monthly calculation period

12.2.1.2 Loss utilisation factor for cooling

The loss utilisation factor for cooling, η_C, needed for the monthly or seasonal cooling method, is a function of the heat balance ratio for cooling, γ_C and a numerical parameter, a_C that depends on the building thermal inertia, according to the following equation:

if $\gamma_C > 0$ and $\gamma_C \neq 1$:
$$\eta_{C,ls} = \frac{1-\gamma_C^{-a_C}}{1-\gamma_c^{-(a_c+1)}} \quad (35)$$

if $\gamma_C = 1$:
$$\eta_{C,ls} = \frac{a_C}{a_C+1} \quad (36)$$

if $\gamma_C < 0$:
$$\eta_{L,C} = 1 \quad (37)$$

with

$$\gamma_C = \frac{Q_{C,gn}}{Q_{C,ls}} \quad (38)$$

where (for each month or per season and each building zone)

$\eta_{C,ls}$ is the dimensionless utilisation factor for heat losses;

γ_C is the dimensionless heat balance ratio for the cooling mode;

$Q_{C,ls}$ is the total heat transfer by transmission and ventilation for the cooling mode, determined according to 7.2.1.3, in MJ;

$Q_{C,ls}$ are the total heat gains for the cooling mode, determined according to 7.2.1.3, in MJ;

a_C is a dimensionless numerical parameter depending on the time constant, τ_C, defined by:

$$a_C = a_{C,0} + \frac{\tau_C}{\tau_{C,0}} \quad (39)$$

where

$a_{C,0}$ is a dimensionless reference numerical parameter, determined according to Table 10;

τ_C is the time constant of the building or building zone, determined according to 12.2.1.3, in h;

$\tau_{C,0}$ is a reference time constant, determined according to Table 10, in h.

Values of $a_{C,0}$ and $\tau_{C,0}$ are given in Table 10. They can also be provided at national level.

The parameter values are empirical values and may be determined at national level; in absence of national values the given tabulated values may be used (to be decided at national level, depending on the purpose of the calculation)

NOTE 1 See also annex K for explanation and derivation and annex J for justification and future conversion.

Table 10 — Values of the numerical parameter $a_{0,C}$ and reference time constant $\tau_{0,C}$

Type of building		$a_{C,0}$	$\tau_{C,0}$ (h)
	Continuously cooled buildings (more than 12 hours per day) such as residential buildings, hotels, hospitals, homes and penitentiary buildings monthly calculation method	1,0	15
	Seasonal calculation method	0,8	30
Values of $a_{C,0}$ and $\tau_{C,0}$ may also be provided at national level.			

NOTE 2 The loss utilisation factor is defined independently of the cooling system characteristics, assuming perfect temperature control and infinite flexibility. A slowly responding cooling system and a less-than-perfect control system may significantly affect the utilisation of the losses.

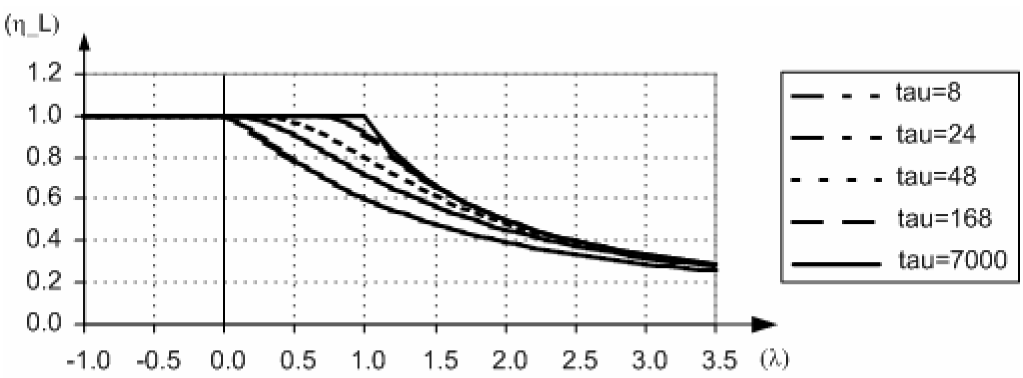


Figure 6 illustrates loss utilisation factors for monthly calculation periods and for various time constants.

Key **<adapt illustration: gamma instead lambda!>**

η_L loss utilisation factor

γ heat balance ratio

Figure 6 – Loss utilisation factor for 8 hours, 1 day, 2 days, 1 week and infinite time constants, valid for monthly calculation period of continuously cooled buildings

12.2.1.3 Building time constant

The time constant of the building or building zone, τ_H, characterises the internal thermal inertia of the conditioned zone during the heating respectively cooling period. It is calculated from:

$$\tau = \frac{C'_m / 3600}{H_m} \tag{40}$$

where

τ is the time constant of the building or building zone for both the heating and/or cooling mode, in h;

C'_m is the corrected internal heat capacity of the building, calculated according to 12.3.1, in J/K;

H_m is the internal coupling coefficient for the thermal mass, calculated according to 0, in W/K.

Alternatively, it may be nationally decided, for specific applications and building types, to use default values as function of the type of construction. In absence of national values, the values from 12.3.1.2 may be used. The values can be approximate, and a relative uncertainty ten times higher than that of the heat transfer is acceptable.

12.2.1.4 Coupling to thermal mass

<Original procedure, simplified, but see also revised procedure below as proposed by TNO>

The internal coupling coefficient for the thermal mass of the building or building zone is obtained as follows:

$$H_m = (H_{tr} + H_{ve}) \tag{41}$$

With H_{tr} and H_{ve} calculated as the annual average values <how??> of the heat transfer coefficients determined in.8.3 (transmission) and 9.3 (ventilation) respectively <no combined value available?>.

<Draft revised procedure, to be discussed:>

The internal coupling coefficient for the thermal mass of the building or building zone is obtained as follows:

$$H_m = 1/(1/H_{is} + 1/H_{ms})$$

with H_{is} and H_{ms} the coupling coefficients as calculated for the simple hourly method, in 7.2.2.2 and 12.2.2 respectively.

NOTE Changed compared to ISO 13790:2003, because $H_{L,H}$ changes monthly or per season: transmission: e.g. ground floor heat transfer (varies periodically according to revised ISO 13370:2006); ventilation: e.g. heat recovery, free or night cooling. The choice for $H_{L,H}$ was not primarily based on precise physics, but on the wish for a crude but simple solution. The solution is however not simple anymore. Moreover, there is a need for consistency with the simple hourly method.

Alternatively, it may be nationally decided, for specific applications and building types, to use default values as function of the type of construction. In absence of national values, the values from 12.3.1.2 may be used. The values can be approximate, and a relative uncertainty ten times higher than that of the heat transfer is acceptable.

12.2.2 Simple hourly method; coupling to thermal mass

The split of the transmission heat transfer coefficient for opaque elements H_{op} into H_{em} and H_{ms} (see 7.2.2) is obtained as follows:

$$H_{em} = 1/(1/H_{op} - 1/H_{ms}) \tag{42}$$

and:

$$H_{ms} = h_{ms} \cdot A_m \tag{43}$$

where

H_{ms} is the coupling conductance between nodes m and s, in W/K;

h_{ms} is the heat transfer coefficient between nodes m and s, with fixed value h_{ms} = 9,1, in W/(m^2·K);

A_m is the effective mass area, in m^2.

The effective mass area A_m, is calculated as follows:

$$A_m = C_m^2 / (\Sigma A_j \cdot \chi_j^2) \quad (44)$$

Where

A_m is the effective mass area, in m^2;

C_m is the internal heat capacity, determined according to 12.3.1, in J/K;

A_j is the area of the element j, determined according to 12.3.1, in m^2;

χ_j is the internal heat capacity per area of the building element j, determined according to 12.3.1, in J/(m^2·K).

Alternatively, it may be nationally decided, for specific applications and building types, to use default values as function of the type of construction. In absence of national values, the values from 12.3.1.2 may be used. The values can be approximate, and a relative uncertainty ten times higher than that of the heat transfer is acceptable.

12.3 Boundary conditions and input data

12.3.1 Monthly, seasonal and simple hourly method

12.3.1.1 Internal heat capacity of the building

For the monthly and seasonal method, the corrected internal heat capacity of the building or building zone, C'_m, is calculated by summing the corrected heat capacities of all the building elements in direct thermal contact with the internal air of the zone under consideration:

$$C'_m = \Sigma \chi'_j A_j \quad (45)$$

For the simple hourly method, the internal heat capacity of the building or building zone, C_m, is calculated by summing the heat capacities of all the building elements in direct thermal contact with the internal air of the zone under consideration:

$$C_m = \Sigma \chi_j A_j \quad (46)$$

Where

C'_m is the corrected internal heat capacity, in J/K;

χ'_j is the corrected internal heat capacity per area of the building element j, determined according to annex A of ISO 13786 with maximum effective thickness as given in Table 11 and applying the correction for the effect of surface resistance according to A.3 in ISO 13786, in J/(m^2·K);

C_m is the internal heat capacity, in J/K;

χ_j is the internal heat capacity per area of the building element j, determined according to annex A of ISO 13786 with maximum effective thickness as given in Table 11, in J/(m²·K);

A_j is the area of the element j, in m².

Table 11 – Maximum thickness to be considered for internal heat capacity

Application	Maximum thickness m
Determination of the gain or loss utilisation factor	0,10
Effect of intermittence	0,03

Alternatively, it may be nationally decided, for specific applications and building types, to use default values as function of the type of construction. In absence of national values, the values from 12.3.1.2 may be used. The values may be approximate, and a relative uncertainty ten times higher than that of the heat transfer is acceptable.

12.3.1.2 Default values for dynamic parameters

In absence of national values, the following values may be used:

Table 12 – Default values for dynamic parameters

	Monthly and seasonal method			Simple hourly method	
Class[1)]	H_m (W/K)	C'_m (J/K)	τ (h)	A_m (m²)	C_m (J/K)
Very light	$9.2 \cdot A_{fl}$	$60\ 000 \cdot A_{fl}$	1.8	$2.5 \cdot A_{fl}$	$80\ 000 \cdot A_{fl}$
Light	$9.2 \cdot A_{fl}$	$83\ 000 \cdot A_{fl}$	2.5	$2.5 \cdot A_{fl}$	$110\ 000 \cdot A_{fl}$
Medium	$9.2 \cdot A_{fl}$	$124\ 000 \cdot A_{fl}$	3.7	$2.5 \cdot A_{fl}$	$165\ 000 \cdot A_{fl}$
Heavy	$9.9 \cdot A_{fl}$	$195\ 000 \cdot A_{fl}$	5.5	$3.0 \cdot A_{fl}$	$260\ 000 \cdot A_{fl}$
Very heavy	$10.4 \cdot A_{fl}$	$278\ 000 \cdot A_{fl}$	7.4	$3.5 \cdot A_{fl}$	$370\ 000 \cdot A_{fl}$
1):May be specified at national level					

<tau values too low!!!>

NOTE Explanation is given in annex I.

12.3.2 Detailed simulation methods

The same basic data for the building envelope shall be used as required for the monthly, seasonal or simple hourly method as described in the previous clause.

In addition, for dynamic hourly calculations the assumptions (on environment conditions, user behaviour and controls) and the basic physical data shall be the same as described in 9.3 and in the documents to which that clause refers.

The heat capacities and thermal resistances of all layers of all building elements shall be based upon the same layers as used in 8.3 to calculate the overall transmission heat transfer coefficients.

13 Indoor conditions

There are different modes for heating and cooling to consider, such as:

— Continuous heating and/or cooling at constant set-point.

— Night time and/or weekend reduced set-point or switch off.

— Unoccupied periods (e.g. holidays).

— Complicated situations, such as periods with boost modes, with (optionally) a maximum heating or cooling power during the boost period

The procedures are partly general and partly applicable to specific types of methods only. A summary is given in the following table.

Table 13 — Calculation procedures for the different heating and/or cooling modes, for the different types of methods

Type of method	Continuous or quasi-continuous heating or cooling	Intermittent heating or cooling[1)]	Unoccupied periods	Complicated situations[2)]
Seasonal method	Clause 13.1.1	Clause 13.1.2	Method less applicable[1)]	Method less applicable[1)]
Monthly method	Clause 13.1.1	Clause 13.1.2	In addition: Clause 13.1.4	Method less applicable[1)]
Simple hourly method	Clause 13.1.3	Clause 13.1.3	In addition: Clause 13.1.4	Clause 13.1.3
Detailed simulation method	Clause 13.1.3	Clause 13.1.3	In addition: Clause 13.1.4	Clause 13.1.3

1) If not meeting the conditions for calculation as continuous heating or cooling as given in Clause 13.1.1.

2) Such as periods with reduced heating or cooling power, boost modes, with (optionally) a maximum heating or cooling power during the boost period.

NOTE It may be decided at national level to add an estimation of the effect of inaccurate temperature control by an increase in set-point temperature $\Delta\theta_{\mathrm{I,H}}$ in the heating mode and a decrease in the cooling mode, $\Delta\theta_{\mathrm{I,C}}$.

13.1 Calculation procedures

13.1.1 Continuous and quasi-continuous heating or cooling mode, monthly and seasonal method

Continuous heating and/or cooling:

For continuous heating during the whole heating period one shall use as set-point temperature of the building or building zone, $\theta_{\mathrm{I,H}}$, the set-point temperature for heating (degrees Celsius).

For continuous cooling during the whole cooling period one shall use as set-point temperature of the building or building zone, $\theta_{\mathrm{I,C}}$, the set-point temperatures for cooling (degrees Celsius).

NOTE 1 For the monthly method the actual mean internal temperature may be higher in the heating mode, due to instantaneous overheating; however, this is taken into account by the gain utilisation factor; similarly for the cooling mode: the actual mean internal temperature may be lower, due to instantaneous high heat losses.

Quasi-continuous heating and/or cooling:

Intermittent heating and/or cooling shall be considered as continuous heating and/or cooling with adjusted set-point temperature if one or more of the following conditions apply:

Mode A:

The time average of the set-point temperatures shall be used as set-point temperature for the calculation if:

— the set-point temperature variations between normal heating or cooling and reduced heating or cooling periods are less than 3 K;

— and/or if the time constant of the building (see 12.2.1.3) is less than 0.2 times the duration of the shortest reduced heating period (for heating) or cooling period (for cooling) .

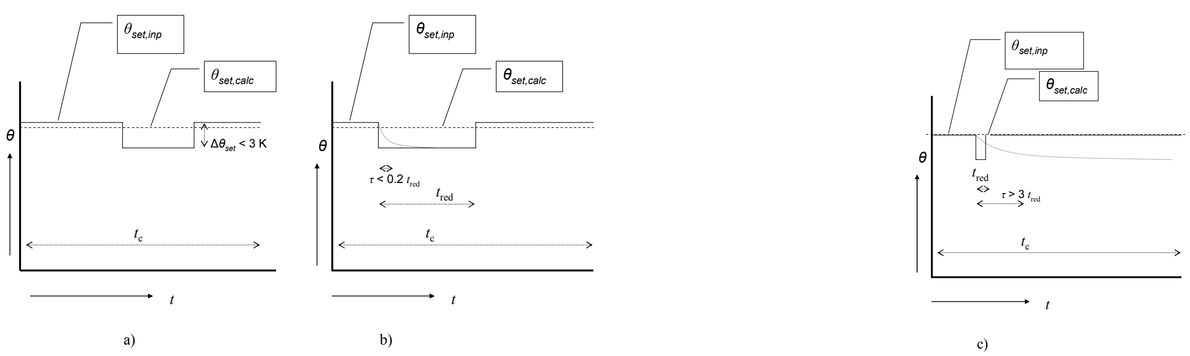
See illustration in Figure 7 a and b.

Mode B:

The set-point temperature for the normal heating mode shall be used as the set-point temperature for the calculation for all periods if the time constant of the building (see 12.2.1.3) is greater than three times the duration of the longest reduced heating period.

See illustration in Figure 7 c.

Similarly, the set-point temperature for the normal cooling mode shall be used for all periods if the time constant of the building (see 12.2.1.3) is greater than three times the duration of the longest reduced cooling period.



Key

$\theta_{set,inp}$ set-point temperature provided as input

$\theta_{set,calc}$ set-point temperature for the calculation

t time

Similar illustration applies for cooling (with reduced set-point higher than normal set-point instead of lower)

t_c representative part of the calculation period

Figure 7 – Example of quasi-continuous heating

For the correction for an unoccupied (e.g. holiday) period: see 13.1.4.

The values of the set-points shall be determined in accordance with 13.2.

13.1.2 Corrections for intermittency, monthly and seasonal method

Heating:

In case of intermittent heating which does not fulfil the conditions in the previous clause, the energy need for heating is calculated according to:

$$Q_{H,n} = a_{red,H} \cdot Q_{H,n,N} + (1 - a_{red,H}) \cdot Q_{H,n,B} \quad (47)$$

where

$Q_{H,n}$ is the energy need for heating, taking account of intermittency, in MJ;

$Q_{H,n,N}$ is the energy need for heating, calculated according to 0, assuming for all days of the month the control and temperature set-point for the normal heating period, in MJ; <check: also e.g. mechanical ventilation and internal heat gains?>

$Q_{H,n,B}$ is the energy need for heating, calculated according to 0, assuming for all days of the month the control and temperature set-point for the intermittency period, in MJ;

NOTE 1 In case of zero heating during the intermittency period, $Q_{H,n,B}$ is simply zero.

$a_{red,H}$ is the dimensionless reduction factor for intermittent heating, determined according to Equation (45);

The reduction factor for intermittent heating, $a_{red,H}$ is calculated as follows:

$$a_{red,H} = 1 - b_{red,H} \; (\tau_{H,0} / \tau) \cdot \gamma_H \cdot (1 - f_{N,H}) \quad (48)$$

with minimum value: $a_{red,H} = f_{N,H}$ and maximum value: $a_{red,H} = 1$.

where

$a_{red,H}$ is the dimensionless reduction factor for intermittent heating;

$f_{N,H}$ is the fraction of the number of hours in the week with a normal heating set-point (no reduced set-point or switch-off), e.g. (5x14)/(7x24)=0.42;

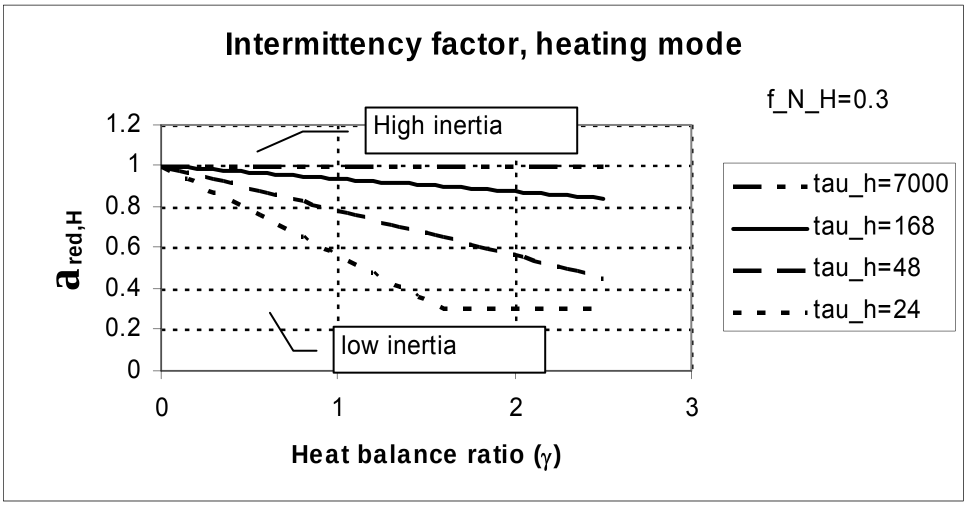
$b_{red,H}$ is an empirical correlation factor; value $b_{red,H}$ = 3;

τ is the time constant of the building or building zone, determined according to 12.2.1.3, in h;

$\tau_{H,0}$ is the reference time constant for the heating mode, determined according to 12.2.1.1, in h;

γ_H is the heat balance ratio for the heating mode, determined according to 12.2.1.1.

NOTE 4 For long intermittency periods such as holidays, the equation is equal to the general procedure given for unoccupied periods in 13.1.4.



Key

1 High inertia

2 Low inertia <add units; use same symbols as in text; add different $f_{n,C}$ values; adapt for heating>

Figure 8 – Illustration of reduction factor for intermittent heating

The heating system is supposed to deliver sufficient heating power to enable intermittent heating.

Cooling:

In case of intermittent cooling which does not fulfil the conditions in the previous clause, the energy need for cooling is calculated according to:

$$Q_{C,n} = a_{red,C} \cdot Q_{C,n,N} + (1 - a_{red,C}) \cdot Q_{C,n,B} \tag{49}$$

where

$Q_{C,n}$ is the energy need for cooling, taking account of intermittency, in MJ;

$Q_{C,n,N}$ is the energy need for cooling, calculated according to 0, assuming for all days of the month the control and temperature set-point for the normal cooling period, in MJ;<check: also e.g. mechanical ventilation and internal heat gains?>

$Q_{C,n,B}$ is the energy need for cooling, calculated according to 0, assuming for all days of the month the control and temperature set-point for the intermittency period, in MJ;

NOTE 2 In case of zero cooling during the intermittency period, $Q_{C,n,B}$ is simply zero.

$a_{red,C}$ is the dimensionless reduction factor for intermittent cooling, determined according to Equation (45);

The reduction factor for intermittent cooling, $a_{red,C}$ is calculated as follows:

$$a_{red,C} = 1 - b_{red,C} \ (\tau_{C,0} / \tau) \cdot \gamma_C \cdot (1 - f_{N,C}) \tag{50}$$

with minimum value: $a_{red,C} = f_{N,C}$ and maximum value: $a_{red,C} = 1$.

where

$a_{red,C}$ is the dimensionless reduction factor for intermittent cooling;

$f_{N,C}$ is the fraction of the number of days in the week with, at least during daytime, normal cooling set-point (no reduced set-point or switch-off) (e.g. 5/7);

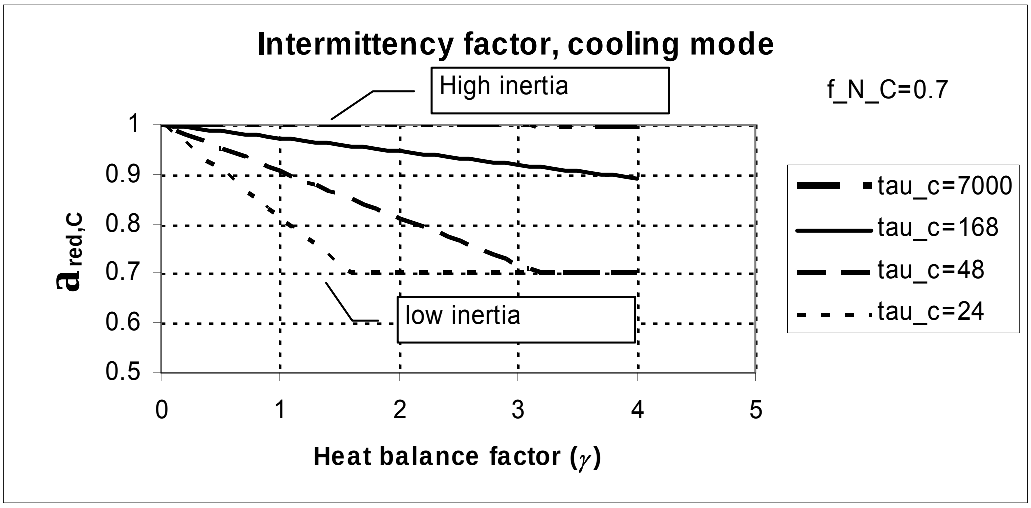
$b_{red,C}$ is an empirical correlation factor; value $b_{red,C}$ = 3;

τ is the time constant of the building or building zone, determined according to 12.2.1.3, in h;

$\tau_{C,0}$ is the reference time constant for the cooling mode, determined according to 12.2.1.2, in h;

γ_C is the heat balance ratio for the cooling mode, determined according to 12.2.1.2.

NOTE 4 For long intermittency periods such as holidays, the equation is equal to the general procedure given for holidays in 13.1.4.



Key

1 High inertia

2 Low inertia <add units; use same symbols as in text; add different $f_{n,C}$ values>

Figure 9 – Illustration of reduction factor for intermittent cooling

The cooling system is supposed to deliver sufficient cooling power to enable intermittent cooling.

Heating and/or cooling:

Alternatively, it may be decided at national level to use a national method for taking into account the effect of intermittency.

For the correction for an unoccupied (e.g. holiday) period: see 13.1.4.

The values of the set-points shall be determined in accordance with 13.2.

13.1.3 Set-points, simple hourly and detailed simulation methods

For continuous heating during the whole heating period the internal operative temperature of the building or building zone, θ_i, shall be the set-point temperature for heating (degrees Celsius).

For continuous cooling during the whole cooling period the internal operative temperature of the building or building zone, θ_i, shall be the set-point temperature for cooling (degrees Celsius).

For intermittent heating and/or cooling the set-points shall be based upon hourly and weekly schedules, taking into account reduced set-points, switch off periods and (if applicable) periods with boost modes, with (optionally) a maximum heating or cooling power during the boost period.

For the simple hourly method the air temperature may be used for the set-point instead of the operative temperature?yes, why?

NOTE 1 prEN wi 31, *Criteria for the indoor environment, including thermal, indoor air quality (ventilation), light and noise*, requires that the temperature setting should be based on operative temperature, because the operative temperature is more closely related to the comfort temperature than the air temperature. See Annex C for calculation of the operative temperature for the simple hourly method.

For the correction for an unoccupied (e.g. holiday) period: see 13.1.4.

The values of the set-points shall be determined in accordance with 13.2.

13.1.4 Corrections for unoccupied period (monthly, simple hourly and detailed simulation methods)

In some buildings, such as schools, unoccupied periods during the heating or cooling season, such as holiday periods, lead to a reduction in space heating or cooling energy use.

The heating and cooling needs during an unoccupied period are calculated as follows: for the month which contains a holiday period, perform the calculation two times: a) for normal<not normal, but occupied!!?> heating/cooling settings); and b) for unoccupied settings; and then interpolate the results linearly according to the time fraction of unoccupied mode versus normal mode, using the following equation:

$$Q_{H,n} = f_{N,H} \cdot Q_{H,n,N} + (1 - f_{N,H}) \cdot Q_{H,hol} \tag{51}$$

$$Q_{C,n} = f_{N,C} \cdot Q_{C,n,N} + (1 - f_{N,C}) \cdot Q_{C,hol} \tag{52}$$

where

$Q_{H,n}$ is the energy need for heating, taking into account unoccupied periods, in MJ;

$Q_{C,n}$ is the energy need for cooling, taking into account unoccupied periods, in MJ;

$Q_{H,n,N}$ is the energy need for heating, calculated according to 0, assuming for all days of the month the control and thermostat settings for the normal heating period, in MJ;

$Q_{C,n,N}$ is the energy need for cooling, calculated according to 0, assuming for all days of the month the control and thermostat settings for the normal cooling period, in MJ;

$Q_{H,n,hol}$ is the energy need for heating, calculated according to 0, assuming for all days of the month the control and thermostat settings for the unoccupied period, in MJ;

$Q_{C,n,hol}$ is the energy need for cooling, calculated according to 0, assuming for all days of the month the control and thermostat settings for the unoccupied period, in MJ;

$f_{N,H}$ is the fraction of the number of days in the month with normal heating mode (e.g. 10/31);

$f_{N,C}$ is the fraction of the number of days in the month with normal cooling mode (e.g. 10/31).

The input data shall be determined in accordance with 13.2.

13.2 Boundary conditions and input data

The values for the set-points may be determined at national level, depending on application and building type. In absence of national values, the default values from annex I may be used.

<add something on existing buildings>

Details speficying when and how unoccupied periods can or shall be taken into account may be determined at national level, depending on application and building type.

14 Energy use for space heating and cooling

14.1 Annual energy need for heating and cooling, per building zone

The annual energy need for heating and cooling for the given building zone is calculated by summing the calculated energy need per period, taking into account possible weighting for different heating or cooling modes as defined in 13.1.2 and/or 13.1.4:

$$Q_{\mathrm{H,n,an}} = \sum_i Q_{\mathrm{H},n,i} \quad \text{and} \quad Q_{\mathrm{C,n,an}} = \sum_j Q_{\mathrm{C},n,j} \tag{53}$$

where

$Q_{\mathrm{H,n,an}}$ is the annual energy need for heating of the considered zone, in MJ;

$Q_{\mathrm{H,n},i}$ is the energy need for heating of the considered zone per calculation period (hour or month), determined according to 7.2, in MJ;

$Q_{\mathrm{C,n,an}}$ is the annual energy need for cooling of the considered zone, in MJ;

$Q_{\mathrm{C,n},j}$ is the energy need for cooling of the considered zone per calculation period (hour or month), determined according to 7.2, in MJ.

The length of heating and cooling season determining the operation period of certain system components is obtained from the respective sub-clauses in Clause 7.

14.2 Annual energy need for heating and cooling, per combination of systems

In case of a multi-zone calculation (with or without thermal interaction between zones), the annual energy need for heating and cooling for a given combination of heating, cooling and ventilation systems servicing different zones is the sum of the energy needs over the zones zs that are serviced by the same combination of systems:

$$Q_{\mathrm{H,n,an},zs} = \sum_z Q_{\mathrm{H},n,\mathrm{an},z} \quad \text{and} \quad Q_{\mathrm{C,n,an},zs} = \sum_z Q_{\mathrm{C,n,an},z} \tag{54}$$

where

$Q_{\mathrm{H,n,an},zs}$ is the annual energy need for heating for all building zones zs serviced by the same combination of systems, in MJ;

$Q_{\mathrm{H,n,an},z}$ is the annual energy need for heating of zone z, serviced by the same combination of systems, determined according to 14.1,in MJ;

$Q_{C,n,an,zs}$ is the annual energy need for cooling for all building zones zs serviced by the same combination of systems in MJ;

$Q_{C,n,an,z}$ is the annual energy need for cooling of zone z, serviced by the same combination of systems, determined according to 14.1,in MJ.

14.3 Total system energy use for space heating and cooling and ventilation systems

14.3.1 General

<terms to be harmonised, following common definitions in Umbrella Document to be expected July 2006>

In case of a single combination of heating, cooling and ventilation systems in the building, or per combination of systems, the annual energy use for heating, $Q_{H,sys}$, and the annual energy use for cooling, $Q_{C,sys}$, including system losses, are determined as a function of the energy needs for heating and cooling from the relevant standards on heating and cooling systems as specified in annex A. One may choose between the following three ways of presentation:

Option a):

Directly as total energy use of the system, $Q_{H,sys,i}$ and $Q_{C,sys,i}$ per energy carrier i, including or separately the auxiliary energy use, expressed in MJ.

Option b):

As sum of energy needs for heating, $Q_{H,n,i}$, heating system loss, $Q_{H,sys,ls,i}$ and auxiliary energy of the heating system, $Q_{H,sys,aux,i}$, per energy carrier i, expressed in MJ. The losses and auxiliary energy comprise generation, transport, control, distribution, storage and emission.

Similar for cooling: $Q_{C,n,i}$, $Q_{C,sys,ls,i}$, and $Q_{C,sys,aux,i}$.

Option c):

The system heat losses are indicated via an overall system efficiency. In this case, the following conversion can be made:

$$Q_{H,sys} = \frac{Q_{H,n}}{\eta_{H,sys}} \quad \text{and} \quad Q_{C,sys} = \frac{Q_{C,n}}{\eta_{C,sys}} \tag{55}$$

where

$Q_{H/C,sys}$ is the energy use for the heating or cooling system including system losses, in MJ;

$Q_{H/C,n}$ is the energy need for heating or cooling, serviced by the considered heating system, according to 14.2, in MJ;

$\eta_{H/C,sys}$ is the overall system efficiency for the heating or cooling system, including generation, electronics, transport, storage, distribution and emission losses, except if reported separately as auxiliary energy.

These three options should lead to the same result and the choice is only a matter of convenience and/or convention. The first option (a) is however to be preferred, because it is the most straightforward leading to the overall energy use.

14.3.2 System losses

The energy loss shall preferably be given as total losses plus the system losses that are recovered in the system.

NOTE 1 The system losses that are recovered in the building (as positive or negative heat gains from hot or cold sources) are already taken into account in the energy need for heating and cooling.

NOTE 2 In case of more than one energy carrier it may not be evident what part of the energy used from the individual energy carrier is utilised and what part is lost.

NOTE 3 For buildings with co-generation, it is not straightforward to attribute the fuel used to the heat and electricity produced and the system loss. This splitting should nevertheless be performed as well as reasonably possible.

NOTE 4 System losses for the cooling system may include heat dissipated from the indoor environment to the cold parts of the system (emission, storage, distribution, control) and/or heat dissipated to the hot parts of the system (generation, transport, electronics,…); part of the heat dissipated to the cold parts of the system may be recovered in the building, as mentioned above.

The system losses also include the additional building heat loss due to non-uniform room temperature distribution and non-ideal room temperature control, if they are not already taken into account in the set-point temperature, in MJ.

NOTE 5 Taking into account the operation period, depending on the length of the heating season.

14.3.3 Results, per cluster of zones and for the whole building

<at least the table will become informative; check what is needed as minimum (e.g. for outside CEN area!)>
The results shall be reported in Table 14 and, if applicable, the table is repeated for different systems servicing different zones and summed for the different tables to obtain the values for the whole building.

The rows and columns in Table 14 shall be adapted for the building concerned. The columns include the relevant energy carriers. Separate tables shall be completed per cluster of zones in case different systems service different (clusters of) zones.

The result can be used in EN 15203/15315. In EN 15203/15315 other energy usages, energy produced and exported and weighting factors are added to obtain the total overview. Consequently, a more detailed table may be provided, as suggested in the informative annex X of EN 15203/15315 <just speculating upon a possible direction in the development of EN 15203/15315>.

<check: energy use includes renewable energy (in contrast with delivered energy)?! ➔ still always complete overview needed, as for the 15203/15215 tables?>

NOTE 1 See also Figures M.1-M.6 for an overview of all options related to energy use for heating and cooling.

Table 14 — Accounting energy uses, per combination of systems or whole building*)

Energy carrier / Use of energy	Energy needs	Oil *)	Gas	Coal	District heating	District cooling	Wood	Electricity	Carrier *n*
Heating needs									
Heating system energy use									
Heating system losses									
Cooling needs									
Cooling system energy use									
Cooling system losses									
Vent.system, zones A									
Vent.system, zones B									
Sub-total									
Total									

This table contains the result for: *(fill in: zones Z or Y with same combination of systems, or sum for whole building)*	
Explanation:	
***)**	**Examples of energy carriers; to be adapted to specific situation**
	Not applicable
*): If applicable, this table shall be completed per cluster of zones that are serviced by the same combination of systems as distinguished in 14.2. A similar table shall be completed for the whole building, summing the results of the clusters of zones.	

For the energy use by the ventilation systems, see 14.3.4.

Extra attention shall be paid to:

- (de-)humidification: the system standards should give the combined sensible and latent heat, if applicable.

- Correct book-keeping for system losses in case of combined heating and DHW systems

See 14.3.5 for other special considerations.

14.3.4 Additional annual energy use by ventilation system

The additional annual energy required by the ventilation system is to be determined according to the relevant standard on ventilation systems as specified in annex A. This includes among others:

— Energy use for fans;

— Energy use for de-frosting of heat recovery units;

— Energy use for central pre-heating supply air; see also 9.3.1<check if this is sufficiently covered >;

— Energy use for central pre-cooling supply air; see also 9.3.1<check if this is sufficiently covered >.

14.3.5 Special considerations

Two or more heating systems servicing same zone(s)

In case of absence in the relevant heating system standards in annex A of a procedure on the combined effect of two or more heating generators servicing the same building zone(s) in an alternating mode, the energy need for heating the zone(s) shall be split into two parts:

$$Q_{H,n,pref} = f_{pref} \cdot Q_{H,n} \text{ and } Q_{H,n,npref} = (1 - f_{pref}) \cdot Q_{H,n} \quad (56)$$

where

$Q_{H,n,pref}$ is part of the energy need for heating that is supplied by the preferentially operated heating appliance, in MJ;

$Q_{H,n,npref}$ is part of the energy need for heating that is supplied by the non-preferentially operated heating appliance(s), in MJ;

f_{pref} is the year averaged fraction of the total heat supply, that is supplied by the preferentially operated heating appliance, determined according to national procedures taking into account the heating load of the building (zones) and the heating capacity of the preferentially operated heating appliance.

The system energy use shall be determined for $Q_{H,n,pref}$ and $Q_{H,n,npref}$ separately, attributing the associated heating systems.

NOTE Two or more heating generators are common practice e.g. in case of combined heat and power systems and heat pumps, where a secondary boiler with lower efficiency covers the peak loads; typical f_{pref} values range from 0 to 1 for heat pumps and from 0,15 to 0,60 for CHP.

15 Report

15.1 General

A report giving an assessment of the annual heating and cooling energy use of a building obtained in accordance with this standard shall include at least the following information.

If the calculation is performed to check compliance with regulation, standardised input data provided by the regulation are used, and no error analysis is performed.

Otherwise, an estimate of the accuracy of input data shall be given, and an error analysis shall be performed to estimate the uncertainty resulting from inaccuracy of the input data.

15.2 Input data

All input data shall be listed and justified, e.g. by reference to international or national standards, or by reference to the appropriate annexes to this standard or to other documents. When the input data are not the standard data, an estimate of the accuracy and source of input data shall also be given.

In addition, the report shall include:

reference to this standard;

the purpose of the calculation (e.g. for judging compliance with regulations, optimising energy performance, assessing the effects of possible energy conservation measures, or predicting energy resource needs on a given scale);

a description of the building, its construction and its location;

specification of the zone partitioning, if any, that is the allocation of rooms to each zone;

a note indicating whether the dimensions used are internal, or external or overall internal;

a note indicating which method (detailed simulation, simple hourly, monthly or seasonal) was used and, if seasonal, the assumed fixed length of the heating and cooling season;

a note on how any thermal bridges have been taken into account;

for the monthly, seasonal or simple hourly methods, H_{tr}, H_{ve}, A_s and C_m for each zone, for each month.

15.3 Results

15.3.1 For each building zone and each calculation period:

15.3.2 For the monthly or seasonal method

For heating mode:

Total heat transfer by transmission;

Total heat transfer by ventilation;

Total internal heat gains;

Total solar heat gains;

Energy need for heating;

Energy use for heating.

For cooling mode.

Total heat transfer by transmission;

Total heat transfer by ventilation;

Total internal heat gains;

Total solar heat gains;

Energy need for cooling;

Energy use for cooling.

15.3.3 For simple hourly or detailed simulation methods

If the calculation (simple hourly or detailed method) uses dynamic (e.g. hourly) system properties, the energy needs should be calculated by assuming ideal system in separate calculation.

For each building zone and month:

Total heat transfer by transmission and ventilation, $Q_{H,ls}$ and $Q_{C,ls}$;

Total internal heat and solar gains, $Q_{H,gn}$ and $Q_{C,gn}$;

Energy need for heating;

Energy need for cooling;

Energy use for heating;

Energy use for cooling.

Depending on the purpose of the calculation, it may be decided at national level to report in parallel the results from a monthly method as a first order check on the input and calculation process.

For detailed simulation methods the heat transfer and heat gains are difficult to separate.

A way of providing separate results is to perform three extra calculations (see [2] in the Bibliography):

Case 0: normal calculation to obtain $Q_{H,n,0}$ and $Q_{C,n,0}$.

Case 1: as case 0, but zero internal and solar heat gains, to obtain $Q_{H,n,1}$ and $Q_{C,n,1}$

Then as an approximation: $Q_{H,ls} = Q_{H,n,1}$ and $Q_{C,ls} = Q_{C,n,1}$

Case 2: as case 0, but a high set-point for heating and a low set-point for cooling, such that all heat gains are utilised in heating mode and all losses are utilised in cooling mode, to obtain $Q_{H,n,2}$ and $Q_{C,n,2}$

Case 3: as case 2, but with zero internal and solar heat gains, to obtain $Q_{H,n,3}$ and $Q_{C,n,3}$.

Then as an approximation: $Q_{H,gn} = (Q_{H,n,3} - Q_{H,n,2})$ and $Q_{C,gn} = (Q_{C,n,3} - Q_{C,n,2})$

NOTE This procedure may introduce some random and systematic deviations, but in absence of a reliable alternative it could be the only robust check of the calculation input and process.

a) Deviations may be introduced if (some of) the properties are a function of the local conditions.

b) Deviations may occur due to e.g. heat sources that remain out of side in the dynamic method; for instance, part of the solar or internal heat that is absorbed in the floor (wall or roof), goes to the ground (thence to the outside), without having been detected as contribution to the heat balance of the heated or cooled space.

c) The result of steps 2 and/or 3 can be a small difference between two large and almost equal numbers and therefore subject to a large relative error.

15.3.4 For the whole building

In case of a single zone building: see above for the report per building zone.

For a single zone or multi-zone building: the annual energy use for heating and cooling, plus the details as given in Table 14.

NOTE 1 Guidance and comments on the accuracy of the calculation method is given in Annex J.

NOTE 2 Additional information may be required at national level.

Annex A
(normative)

Parallel routes in normative references

This standard contains specific parallel routes in referencing to other international standards, in order to take into account existing national and/or regional regulations and/or legal environments while maintaining global relevance.

The standards that shall be used as called for in the successive clauses are the following:

<to be checked for completeness; search whole standard for references to this annex A>

Table A.1 — Normative references

Clause **(in this standard)**	**Subject**	**CEN area*)**	**Other**
(6.3.3)	(Zoning rules)	(H,V and C standards)	National standards or other appropriate documents
7.2.3	Validation of detailed simulation methods	EN 15265	National standards or other appropriate documents
8.3.1	Thermal transmission curtain walls	EN 13947	National standards or other appropriate documents
8.3.1	Thermal transmission glazings window frames whole window	EN 673 EN ISO 10077-2 <or refer to ISO 13789 and have parallel paths there?> See also note a)	ISO 10292 ISO 10077-2 ISO 15099 <or refer to ISO 13789 and have parallel paths there?>
9.3	Ventilation heat transfer coefficient and supply temperature	EN 15242 and/or EN 15241	National standards or other appropriate documents
9.4.2	Energy performance or supply temperature of heat recovery unit	EN 15241	National standards or other appropriate documents
10.4.3	Internal heat sources, contribution from lighting	EN 15193-1	National standards or other appropriate

	systems		documents
10.4.4	Internal heat sources, contribution from hot water systems	EN 15316-3	National standards or other appropriate documents
10.4.5	Internal heat sources, contribution from H, V and C systems	If applicable: H: EN 15316-2 V: EN 15241 C: EN 15243 Otherwise: national standards	National standards or other appropriate documents (and/or ISO TC205?)
11.4.2	Solar transmittance of glazings, windows with solar shading devices, …	EN 410, EN 13363-2 (plus note when and how to use)	ISO 9050 ISO 15099 (plus note when and how to use)
?<check ref.>	Set-point temperature due to control systems	(EN 15251),	National standards or other appropriate documents
Clause 14	System losses for H, V and C systems	If applicable: H: EN 15316-2 V: EN 15241 C: EN 15243 Otherwise: national standards	National standards or other appropriate documents (and/or ISO TC205?)
Annex F (informative??)	Solar transmittance	EN 410, EN 13363-2 (plus note when and how to use)	ISO 9050 ISO 15099 (plus note when and how to use)
NOTES a) The thermal transmittance or *U*-value on the CE-marking, based on the product standard EN 14351-1 shall not be used. Quote from prEN 14351-1:2005: *Where detailed calculation of the heat loss from a specific building is required, the manufacturer shall provide accurate and relevant, calculated or tested thermal transmittance values (design values) for the size(s) in question.*			

*): CEN area: all member bodies?? bound by CEN agreement?? (and/or EPBD?)…..

Do we need to add?: in case of EN ISO standards: CEN area refers to EN version, others to ISO version? (sometimes the EN ISO standards have an extra annex or page with specific procedures.

Annex B
(normative)

Multi-zone calculation with thermal coupling between zones

B.1 General

A multi-zone calculation with thermal coupling between zones (calculation with coupled zones) is only to be used with care, for special situations.

NOTE A multi-zone calculation with interactions between the zones: (a) requires significantly more and often arbitrary input data (on transmission properties and air flow direction and size) and (b) requires compliance with constraints in the building regulations on the zoning rules (freedom of internal partitioning, definitions of zoning in case of combined use (e.g. a hospital generally includes also a office section, a restaurant section, et cetera). A further complication may be the involvement of different heating, cooling and ventilation systems for different zones, that adds to the complexity and arbitrariness of the input and modelling.

B.2 Simple hourly method

In case of a multi-zone calculation with thermal coupling between zones (calculation with coupled zones) the RC network is modified as follows, depending on the heat exchanges taken into account.

1) Air flow exchanges

Air flow in one direction only

In this case the air flow passes from thermal zone 1 to thermal zone 2. For a given hour, the calculation is done first for zone 1 and its air temperature is used to calculate the thermal behaviour of zone 2.

Air flow in both directions

In this case, due, for example, to doors opening, zones 1 and 2 are considered as a single zone.

2) Heat flow through internal partitions

The aim is to take into account heat flows through walls and floors between adjacent zones. The boundary conditions are modified to calculate an equivalent H value and external temperature. The boundary condition of each adjacent room is the θ_{st} temperature node calculated at the previous hour.

<Physically meaningful dynamic coupling may be not always simple with simple hourly method, e.g. in case of two coupled zones separated by a heavy weight intermediate floor that contains most of the thermal mass..>

The RC network is modified as follows:

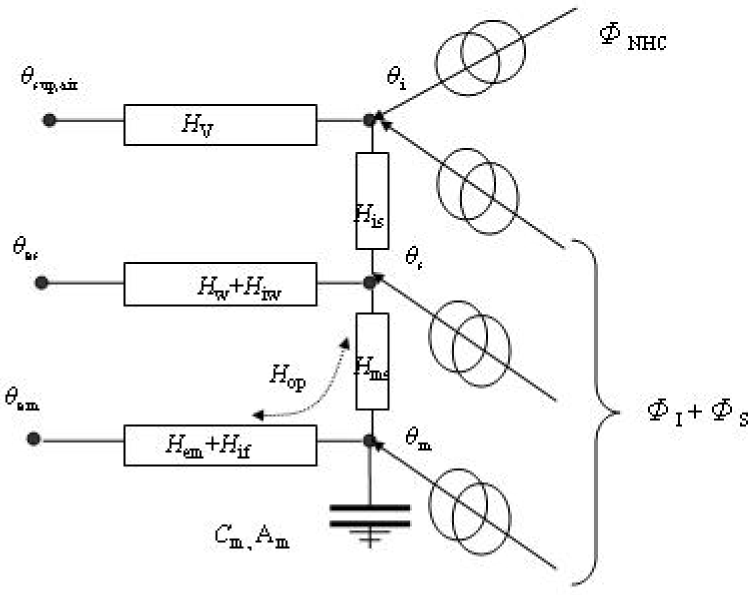


Figure B.1 — Modified RC network

$\theta_{es} = \theta_e\, H_{window} + \theta_{ar}\, H_{iw} \,/\, (H_{window}+H_{iw})$

$\theta_{em} = \theta_e\, H_{em} + \theta_{ar}\, H_{if} \,/\, (H_{em}+H_{if})$

with

θ_{ar} is the internal temperature of the adjacent zone at the previous hour, in °C;

H_{iw} is the heat transfer through internal walls connected to the adjacent zone, determined according to B.4, in W/K;

H_{if} is the heat transfer through floors connected to the adjacent zone, determined according to B.4, in W/K.

The partitioning into thermally coupled zones and the input data shall be described in the report.

NOTE In case of strong thermal interactions between the zones, the method can lead to oscillations; in that case iteration is needed<compare other remark on this: need for relaxation!?!>.

B.3 Monthly method

In case of a multi-zone calculation with thermal coupling between zones (calculation with coupled zones), the procedure, based on monthly calculation periods, is as follows.

In addition to the data needed for the single zone or uncoupled zone calculation, inter-zone data are collected, according to B.4.

Add to the heat transfer by transmission and ventilation of zone z the following terms:

$Q_{tr,zy} = H_{tr,zy}(\theta_{z,H/C} - \theta_{y,mn})t$

$Q_{\text{ve,z}\rightarrow\text{y}} = H_{\text{ve,z->y}}(\theta_{\text{z,H/C}} - \theta_{\text{y,mn}})t$

where $\theta_{\text{y,mn}}$ represents the actual mean temperature in an adjacent zone *y*, including any overheating (heating mode) or undercooling (cooling mode).

NOTE 1 It is important to note that for zone y the actual mean temperature is to be used. In zone *z* itself the set-point temperature $\theta_{\text{z,H}}$ for heating and $\theta_{\text{z,/C}}$ for cooling is to be used. Taking the set-point temperature for zone *y* instead of the actual mean temperature would result in significant errors in case of strong interactions between the zones. In the zone *z* itself, the actual mean temperature is not an input parameter in the calculation of the energy balance, but an implicit result of the utilisation of heat gains or heat losses.

<continue from here with adapting the subscripts>

NOTE 2 These contributions to Q_{L} also change the heat balance ratio for heating and/or cooling mode.

The actual mean temperature in zone *y* is obtained with the following equations:

Heating mode:

$$\theta_{y,\text{mean}} = \frac{Q_{\text{G,H}} + Q_{\text{NH}} + \sum_k (H_{\text{L},H,k}\,\theta_{\text{a},k})}{\sum_k H_{\text{L},H,k}} \quad \text{(B.1)}$$

Cooling mode:

$$\theta_{y,\text{mean}} = \frac{Q_{\text{G,C}} - Q_{\text{NC}} + \sum_k (H_{\text{L},C,k}\,\theta_{\text{a},k})}{\sum_k H_{\text{L},C,k}} \quad \text{(B.1)}$$

where

$Q_{\text{H,n}}$ is the building energy need for heating for zone y, determined according to 7.2.1.1, in MJ;

$H_{\text{L,H},k}$ is the element *k* in the total heat transfer coefficient for the heating mode for zone y, determined according to 7.2.1.3, in MJ;

$Q_{\text{G,H}}$ are the total heat gains for the heating mode for zone y, determined according to 7.2.1.3, in MJ;

$Q_{\text{C,n}}$ is the building energy need for cooling for zone y, determined according to 0, in MJ;

$H_{\text{L,C},k}$ is the element k in the total heat transfer coefficient for the cooling mode for zone y, determined according to 7.2.1.3, in MJ;

$Q_{\text{G,C}}$ are the total heat gains for the cooling mode for zone y, determined according to 7.2.1.3, in MJ;

$\theta_{\text{a},k}$ for an element k of transmission heat transfer: the temperature at the other side of the element, $\theta_{\text{e},k}$;
for an element k of ventilation heat transfer: the temperature of the air supply, $\theta_{\text{a,sup},k}$.

NOTE 3 The same equation may be used for an unconditioned zone.

The calculation of the energy needs for heating and cooling shall be done in an iterative way (usually two or three steps is sufficient):

— 1) Use as initial assumption that the actual mean temperature in each zone is equal to the set-point temperatures for heating or cooling for that zone, determined according to Clause 13

— 2) Calculate the energy needs for heating and cooling for each zone, taking into account the contribution of the heat transfer by transmission and/or ventilation between the zones, as described above;

— 3) On the basis of these results, calculate for each zone the actual mean temperature, as described above.

— 4) If the actual mean temperature of any of the zones differs more than an acceptable minimum criterion (e.g. 0,3 °C), repeat from step 2); otherwise the iteration is completed successfully.

NOTE 4 This method is described (including computerised model and validation results), for the heating mode, in [11].

The partitioning into thermally coupled zones and the input data shall be described in the report.

B.4 All methods: input data

The heat transfer coefficients between the zones z and y are:

$H_{\mathrm{T},zy}$ is the transmission heat transfer coefficient between zones z and y, in W/K;

$H_{\mathrm{V},z\to y}$ is the ventilation heat transfer coefficient from zone z to zone y, in W/K;

$H_{\mathrm{V},y\to z}$ is the ventilation heat transfer coefficient from zone y to zone z, in W/K.

NOTE The ventilation heat transfer coefficient $H_{\mathrm{V},z\to y}$ differs from $H_{\mathrm{V},y\to z}$ if the air flow rate is not the same in two directions.

where

$$H_{\mathrm{V},z\to y} = \rho_{\mathrm{a}} c_{\mathrm{a}} q_{z\to y} \tag{B.1}$$

$$H_{\mathrm{V},y\to z} = \rho_{\mathrm{a}} c_{\mathrm{a}} q_{y\to z} \tag{B.2}$$

$q_{z\to y}$ is the net air flow rate from zone z to zone y, in $\mathrm{m^3/s}$

$q_{y\to z}$ is the net air flow rate from zone y to zone z, in $\mathrm{m^3/s}$

Annex C
(normative)

Full set of equations for simple hourly method

C.1 Introduction

<"TO CHECK: *In general on Annex C: the set of equations on the simple hourly method have been re-checked to ensure that the equations are fully transparent and reproducible in itself, without any ambiguity for programmers. Also checked 7.2.3.1 for inconsistencies with annex C.* ***C.2 has been added in the main text 7.3.2?!***">

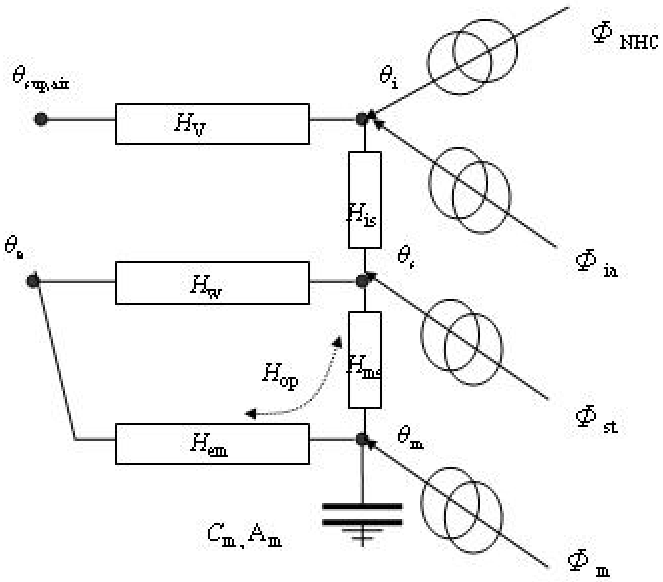


Figure C.1 — RC network heat flows

The general scheme and equations are presented in 7.2.2.

This annex describes the additional calculation procedure for calculating:

— the internal and solar heat gains to the internal nodes (C.2);

— the temperature nodes when $\Phi_{HC,n}$ is known (C.3);

— the actual heating or cooling need $\Phi_{HC,n,ac}$ and the corresponding iternal temperatures taking into account the possibility of imposing a maximum available heating or cooling power (C.4).

C.2 Calculation of heat flows from internal and solar heat sources

The heat flow rates from internal and solar heat sources are split between the air node θ_i and the internal nodes θ_s, θ_m as follows:

$$\Phi_{ia} = 0{,}5\Phi_i \tag{C.1}$$

$$\Phi_m = \frac{A_m}{A_t}(0{,}5\Phi_I + \Phi_S) \tag{C.2}$$

$$\Phi_{st} = \left(1 - \frac{A_m}{A_t} - \frac{H_{es}}{9{,}1\,A_t}\right)(0{,}5\Phi_I + \Phi_S) \tag{C.3}$$

The heat flow rates from internal and solar heat sources Φ_I and Φ_S (W) are derived by dividing Q_I and Q_S (MJ) by 0.036.

Q_I are obtained from 9.4.1<check!>. Q_S are obtained from Clause 11.

A_m and A_t are obtained from 7.2.2.1.

C.3 Determination of the air and operative temperatures for a given value of $\Phi_{HC,n}$

The solution model is based on a Crank-Nicholson scheme considering a time step of one hour. The temperatures are the average over one hour except for $\theta_{m,t}$ and $\theta_{m,t-1}$ which are instantaneous values at time t and t - 1.

For a given time step, $\theta_{m,t}$ is calculated at the end of the time step from the previous value $\theta_{m,t-1}$ by :

$$\theta_{m,t} = [\theta_{m,t-1}\,(10^{-6}\,C_m - 0{,}5\,(H_3+H_{em}) + \Phi_{mtot}] \,/\, [10^{-6}\,C_m + 0{,}5\,(H_3+H_{em})] \tag{C.4}$$

with

$$\Phi_{mtot} = \Phi_m + H_{em}\,\theta_e + H_3\,[\Phi_{st} + H_{window}\,\theta_e + H_1\,((\Phi_{ia}+\Phi_{HC,n})\,/\,H_v\,)+\theta_{airin})]\,/\,H_2 \tag{C.5}$$

$$H_1 = \frac{1}{1/H_v + 1/H_{is}} \tag{C.6}$$

$$H_2 = H_1 + H_{window} \tag{C.7}$$

$$H_3 = \frac{1}{1/H_2 + 1/H_{ms}} \tag{C.8}$$

H_{em}, H_{window}, H_v (W/K) and θ_e, θ_{airin} (°C) are obtained from Clauses 8 and 9.

C_m (MJ) is obtained from Clause 12.

For the time step considered, the average values of nodes temperatures are given by:

$$\theta_m = (\theta_{m,t} + \theta_{m,t-1})\,/\,2 \tag{C.9}$$

$$\theta_s = [\,H_{ms}\,\theta_m + \Phi_{st} + H_{window}\,\theta_e + H_1\,(\theta_{airin} + (\Phi_{ia} + \Phi_{HC,n})\,/\,H_v\,)]\,/\,(\,H_{ms} + H_{window} + H_1\,) \tag{C.10}$$

H_{ms} (W/K) is obtained from 7.2.3.2.

$$\theta_i = [H_{is}\ \theta_s + H_v\ \theta_{airin} + \Phi_{ia} + \Phi_{HC,n})] / (H_{is} + H_v) \qquad (C.11)$$

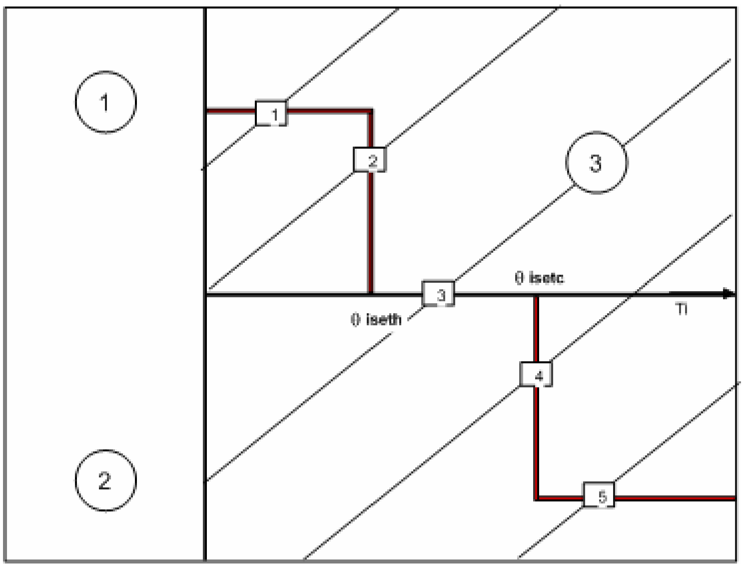
and the operative temperature (average between air and mean radiant temperature) by

$$\theta_{op} = 0{,}3\ \theta_i + 0{,}7\ \theta_s \qquad (C.12)$$

<Comment UK: "Operative temperature should be equal weighting or air and radiant temperatures." Reply CSTB: " equation is correct as θs is a combination air and mean radiant temperature weighted by the internal surface convective and radiative coefficient">

C.4 Calculation of air temperature[5] and required heating or cooling power

C.4.1 General description



Key for encircled numbers

1 maximum heating

2 maximum cooling

3 room behaviour

key for squared numbers refer to the 5 situations described below

Figure C.2 – Room behaviour versus system behaviour

For each hour, the RC network enables the calculation of the internal temperature θ_i for any heating or cooling demand applied $\Phi_{HC,n}$. The resolution scheme is such that θ_i is a linear function of $\Phi_{HC,n}$.

For a given hour, the room behaviour line is known by applying equations described in C.3 for two values of $\Phi_{HC,n}$.

[5] Operative temperature can also be calculated.

The heating and cooling power delivered to the room can be represented on the same graph by the $\theta_{i\ set}$ temperatures and the maximum available heating and cooling power (which can vary for each hour)[6].

The resulting indoor temperature and heating and cooling demand is the intersection of the two curves.

Five situations can occur:

7) The room requires heating and the heating power in not sufficient to obtain the set-point. The heating need is limited to the maximum available heating power and the calculated indoor temperature is lower than the heating set-point $\theta_{iseth.}$ This usually happens in the boost period.

8) The room requires heating and the heating power in sufficient. The internal temperature is equal to θ_{iseth} and the calculated heating need is lower than its maximum value.

9) The room requires neither heating nor cooling (free floating conditions). No heating or cooling is applied, and the internal temperature is calculated.

10) The room requires cooling and the cooling power is sufficient. The internal temperature is equal to θ_{isetc} and the calculated cooling need is lower than its maximum value.

11) The room requires cooling and the cooling power is not sufficient. The cooling need is limited to the maximum available cooling power. The calculated internal temperature is higher than the cooling set-point θ_{isetc}.

C.4.2 Calculation procedure

The procedure calculates θ_{iac}, the actual internal temperature, and $\Phi_{HC,n,ac}$, the actual heating or cooling power. In all cases, the value of $\theta_{m;t}$ (see Equation (C.8)) is also calculated and stored, as it is used for the following time step.

Step 1: Check if cooling or heating is needed (case 3 of Figure C.2)

Take $\Phi_{HC,n}$ = 0 and apply Equations (C.7) to (C.11)

Name θ_i as θ_{i0} (θ_{i0} is the air temperature in free floating conditions)

If $\theta_{iseth} \leq \theta_{i0} \leq \theta_{isetc}$, no heating or cooling is required so that $\Phi_{HC,n,ac} = 0$ and $\theta_{i,ac} = \theta_{i0}$, and no further calculations are needed.

If not apply step 2.

Step 2: Choose the set-point and calculate the heating or cooling need

If $\theta_{i0} > \theta_{setc}$, take $\theta_{set} = \theta_{setc}$

If $\theta_{i0} < \theta_{seth}$, take $\theta_{set} = \theta_{seth}$ <add conditions: set-points with enough distance to prevent oscillations>

Apply Equations (C.7) to (C.11) taking $\Phi_{HC,n} = \Phi_{HC,n10}$ with $\Phi_{HC,n10} = 10\ A_{fl}$

A_{fl} is obtained from 6.3.2.

Name θ_i as θ_{i10} (θ_{i10} is the air temperature obtained for a heating power of 10 W/m^2).

[6] The scheme could be modified to take into account a maximum heating or cooling power depending on internal temperature.

Calculate $\Phi_{HC,n,un}$ (unlimited heating or cooling need to obtain the set-point requirement; $\Phi_{HC,n,un}$ is positive for heating and negative for cooling).

$$\Phi_{HC,n,un} = \Phi_{HC,n10} (\theta_{set} - \theta_{i0}) / (\theta_{10} - \theta_{i0}) \tag{C.13}$$

Step 3: Check if the available cooling or heating power is sufficient (case 2 or case 4 of Figure C.2)

If $\Phi_{HC,n,un}$ is between Φ_{Hmax} (maximum heating power) and Φ_{Cmax} (maximum cooling power),

$\Phi_{HC,n,ac} = \Phi_{HC,n,un}$

$\theta_{i,ac} = \theta_{set}$

and the calculation is completed.

If not apply step 4.

Step 4: Calculate the internal temperature (case 1 or case 5 of Figure C.2).

If $\Phi_{HC,n,un}$ is positive, take $\Phi_{HC,n,ac} = \Phi_{Hmax}$. If $\Phi_{HC,n,un}$ is negative, take $\Phi_{HC,n,ac} = \Phi_{Cmax}$

Calculate $\theta_{i,ac}$ by using Equations (C.5) to (C.9).

NOTE In this case, the set-point temperature is not attained.

The energy need for heating or cooling for a given hour (MJ), $Q_{HC,n}$ is equal to 0.036 $\Phi_{HC,n,ac}$. The value is positive in case of heating need and negative in case of cooling need.

Annex D
(normative)

Alternative formulation for monthly cooling method

D.1 Introduction

Instead of the formulation for the monthly cooling method based on the loss utilisation factor, an alternative formulation may be used, based on the gain utilisation factor. Both formulations are identical, provided that the parameter values are the same and the same quantities are used for the total heat gains and total heat losses that determine the heat balance ratio.

The difference between the two formulations is that the formulation based on the loss utilisation factor allows "negative" heat losses. Negative heat losses may occur if for (parts of) the transmission the monthly average external temperature or adjacent building zone temperature, and/or for ventilation losses the supply temperature, exceeds the building zone temperature.

NOTE The formulation based on loss utilisation factor has as additional advantage that it shows explicitly how the heat losses contribute to the reduction of the energy need for cooling.

D.2 Alternative formulation for energy need for cooling

As introduced in 5.5.2 the Equation (4) to determine the cooling need can be reformulated to obtain the following equation:

$$Q_{C,n} = (1 - \eta_{G,C})\, Q_{G,C} \tag{D.1}$$

subject to $Q_{C,n} \geq 0$

where (for each building zone and for each month)

$Q_{C,n}$ is the building energy need for cooling, in MJ;

$Q_{L,C}$ is the heat transfer for the cooling mode[7], determined according to 7.2.1.3, in MJ;

$Q_{G,C}$ are the heat gains for the cooling mode, determined according to 7.2.1.3, in MJ;

$\eta_{G,C}$ is the dimensionless gain utilisation factor for the cooling mode, determined according to D.3.

NOTE 1 If the same input and the same parameter values are used, Equation (D.1) leads to the same results as Equation (4).

NOTE 2 $Q_{L,C}$ does not appear directly in the equation, but indirectly via $\eta_{G,C}$.

NOTE 3 The gain utilisation factor, η_G, has been introduced in 5.5.2 (cooling, method b). The curves are similar to the curves for the gain utilisation curves for the heating mode; see illustration in Figure D.1. In the next clause it is shown how $\eta_{G,C}$ can be derived from $\eta_{L,C}$ by a simple conversion formula and vice versa.

---

[7] See footnote in 0

D.3 Length of cooling season

See 7.2.2.4.

D.4 Gain utilisation factor for cooling

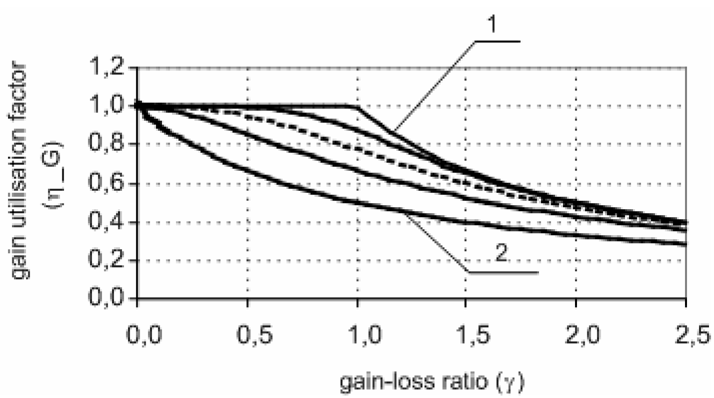
The gain utilisation factor needed for the alternative formulation of the monthly cooling method according to D.2 is determined analogous to the gain utilisation factor for heating in 12.2.1.1, by replacing "heating" by "cooling" and subscript H by subscript C, with the following changes:

$a_{0,C}$ is a dimensionless reference numerical parameter, determined according to Table 10 in 12.2.1.2;

$\tau_{0,C}$ is a reference time constant, determined according to Table 10 in 12.2.1.2.

NOTE 1 The equation does not provide values for the gain utilisation factor, η_G, in case of negative heat balance ratio, which can occur if the losses include parts with high internal, adjacent and/or supply temperature. The method in 0 has no such limitation.

NOTE 2 The gain utilisation factor, η_G, has been introduced in 5.5.2 (cooling, method b). The curves are similar to the curves for the gain utilisation curves for the heating mode.



<to be improved>

Key

1 high inertia ratio

2 low inertia ratio

η_G gain utilisation factor

γ heat balance ratio

Figure D.1 — Examples of gain utilisation curves for cooling (alternative formulation)

Provided that the same parameter values (a_C and τ_c) are used, a simple formula converts between the two formulations for the cooling mode:

$$\eta_{G,C} = \eta_{L,C} / \gamma_{G,C}$$

NOTE 3 See also footnote in 0: if the clustering of heat gains in Q_G and heat transfer elements in Q_L is different from the clustering in 0, the heat balance ratio will be different; consequently the calculated energy need for cooling will also differ, although the difference can be small.

Annex E
(normative)

Heat loss of special envelope elements

E.1 Ventilated solar walls (Trombe walls)

E.1.1 General

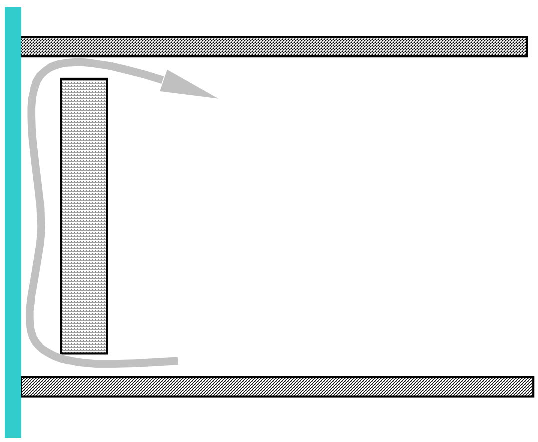


Figure E.1 — Air flow path in a ventilated solar wall

The following applies to walls designed to collect solar energy, according to Figure E.1, where

- the air flow is stopped automatically when the air layer is colder than the heated space, and
- the air flow rate is set mechanically at a constant value, $\dot{V}$, when the air layer is warmer than the heated space.

The heat loss coefficient of such a wall is:

$$H = H_0 + \Delta H \tag{E.1}$$

where

H_0 is the heat loss coefficient of the non ventilated wall;

ΔH is an additional heat loss coefficient to be calculated according to E.1.3.

<add sentence on cooling mode: cut off ventilation to indoor air, and/or what?? if effectively shaded>

<double envelope facades are more urgent, but no procedures proposed yet….>

E.1.2 Required data

A area of the ventilated solar wall;

R_i internal thermal resistance of the wall, between the air layer and the internal environment;

R_e external thermal resistance of the wall, between the air layer and the external environment;

R_l thermal resistance of the air layer;

$\dot{V}$ set value of the air flow rate through the ventilated layer;

h_c and h_r : respectively the convective and radiative surface heat transfer coefficients in the air layer;

$Q_{g,sw}$ solar heat gains of the air layer during the calculation period: $Q_{g,sw} = I_w A_{s,sw}$

$Q_{L,al}$ heat loss of the air layer during the calculation period: $Q_{L,al} = U_e A (\theta_l - \theta_e) t$

E.1.3 Calculation method

Calculation of heat loss is based on set-point and external temperatures. Solar heat gains are calculated according to F.3 in Annex F. The additional heat loss coefficient of such a wall is calculated by:

$$\Delta H = \rho_a c_a \dot{V} \left[\frac{U_e}{U_i} \right]^2 \delta \kappa \tag{E.2}$$

where

$\rho_a c_a$ is the heat capacity of air per volume;

U_i and U_e are the internal and external thermal transmittances:

$$U_i = \frac{1}{R_i + \frac{R_l}{2}} \quad \text{and} \quad U_e = \frac{1}{R_e + \frac{R_l}{2}} \tag{E.3}$$

δ is the ratio of the accumulated internal-external temperature difference when the ventilation is on, to its value over the whole calculation period. It is given in Figure E.2.

This ratio can be calculated by:

$$\delta = 0{,}3\gamma_{al} + 0{,}03(0{,}0003^{\gamma_{al}} - 1) \tag{E.4}$$

where γ_{al} is the ratio of the solar heat gains $Q_{g,sw}$ to the heat loss of the air layer, $Q_{l,al}$ during the calculation period.

κ is a factor defined by:

$$\kappa = \left[1 - \exp\left(\frac{-AZ}{\rho_a c_a \dot{V}} \right) \right] \tag{E.5}$$

where Z is a parameter defined by:

$$\frac{1}{Z} = \frac{h_r}{h_c (h_c + 2h_r)} + \frac{1}{U_i + U_e} \tag{E.6}$$

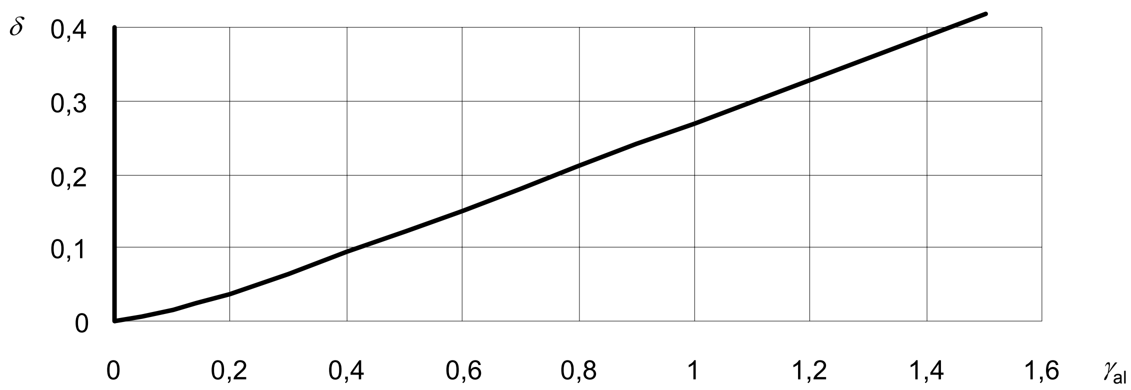


Figure E.2 — Ratio δ of the accumulated internal-external temperature difference when the ventilation is on, to its value over the whole calculation period, as a function of the gain/load ratio of the air layer, γ_{al}

E.2 Ventilated envelope elements

E.2.1 General

Circulating ventilation air within parts of the building envelope (wall, window, roof) decreases the overall heat losses by heat recovery, although the transmission heat loss is increased in these building envelope elements. This overall effect can be expressed through an equivalent heat exchanger between exhaust and supply air. The efficiency of this equivalent heat exchanger can be calculated with the simplified method given in E.5, which is applicable under the following conditions:

- the air flow is parallel to the envelope surface (see Figure E.3);
- the thickness of the air layer is between 15 mm and 100 mm;
- the air permeability of the remaining parts of the envelope is low, so that most (about 90 %) of the air circulating through the building passes through the ventilated envelope element;
- the ventilation system meets the requirements in Table E.1;
- air supply, if natural, is controlled through adjustable or self controlled inlets located on the internal part of the envelope.

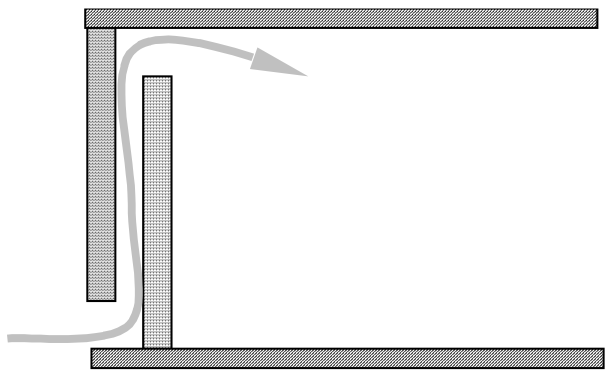


Figure E.3 — Air path in the wall

Table E.1 — Ventilation requirements for the application of the method

Shielding class	Requirement
No shielding	Mechanical exhaust and supply
Moderate	Mechanical exhaust or supply
Heavy shielding	No requirement

NOTE This method mainly applies where supply air is circulated within the building envelope elements. Exhaust air can also be used, provided that suitable provisions are made to avoid condensation.

E.2.2 Calculation method

The efficiency factor of the equivalent air-to-air heat exchanger is:

$$\eta_{\mathrm{v}} = \frac{U_0^2}{U_{\mathrm{i}} U_{\mathrm{e}}} \kappa \qquad \text{(E.7)}$$

where

U_{i} and U_{e} are respectively the thermal transmittances of the internal and external parts of the envelope element containing the air space;

U_0 is the thermal transmittance of this envelope element, assuming the air space is not ventilated;

κ is the factor defined by Equation (E.5).

This efficiency factor of the equivalent air-to-air heat exchanger is always less than 0,25.

Annex F
(normative)

Solar heat gains of special elements

F.1 Introduction

<add complete list of the special elements in the following clauses>

<add: what to do for cooling mode

TH: if gains in sunspace according to simplified option, then ignore add.gains. Summer: reduced direct gains by ignoring sunspace <what's that??>>

F.2 Unconditioned sunspaces

F.2.1 General

The following applies to unconditioned sunspaces adjacent to a conditioned space, such as conservatories and attached greenhouses separated by a partition wall from the conditioned space.

If the sunspace is heated, or if there is a permanent opening between the conditioned space and the sunspace, it shall be considered as part of the conditioned space, and this annex does not apply. The area to be taken into account for the heat transfer and solar heat gains is the area of the external envelope of the sunspace.

<add: what to do for cooling mode>

F.2.2 Required data

The following data shall be collected for the transparent part of the partition wall (subscript w), and for the sunspace external envelope (subscript e):

F_F frame area fraction;

F_S shading correction factor;

g effective total solar energy transmittance of glazing;

A_w area of windows and glazed doors in the partition wall;

A_e area of sunspace envelope.

In addition, the following data shall be assessed:

A_j area of each surface, j, absorbing the solar radiation in the sunspace (ground, opaque walls; opaque part of the partition wall has subscript p);

α_j average solar absorption factor of absorbing surface j in the sunspace;

I_i solar irradiance on surface i during the calculation period(s);

U_p thermal transmittance of the opaque part of the partition wall;

U_{pe} thermal transmittance between the absorbing surface of this wall and the sunspace.

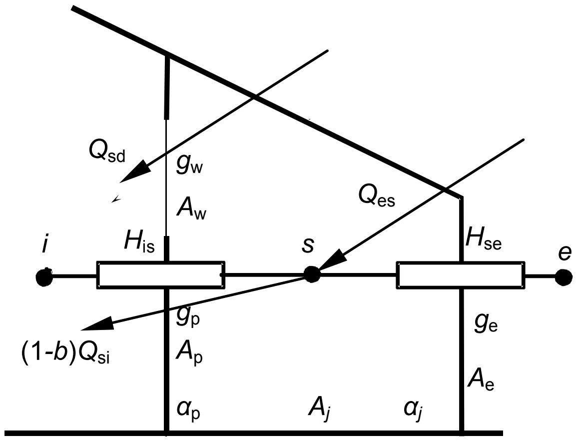


Figure F 1 — Attached sunspace with solar heat gains and heat transfer coefficients, and electrical equivalent network

F.2.3 Calculation method

The heat transfer by transmission and ventilation is calculated according to Clauses 8 and 9 for an unconditioned space. The solar heat gains entering the conditioned space from the sunspace, Q_{ss}, are the sum of direct heat gains through the partition wall, Q_{sd}, and indirect heat gains, Q_{si}, from the sunspace heated by the sun:

$$Q_{ss} = Q_{sd} + Q_{si} \tag{F.1}$$

It is assumed, in a first approximation, that the absorbing surfaces are all shaded in the same proportion by external obstacles and by the outer envelope of the sunspace.

The direct solar heat gains Q_{sd} are the sum of heat gains through the transparent (subscript w) and opaque (subscript p) parts of the partition wall:

$$Q_{sd} = I_p F_S\, F_{Fe}\, g_e \left(F_{Fw} g_w A_w + \alpha_p\ A_p \frac{U_p}{U_{pe}} \right) \tag{F.2}$$

The indirect heat gains are calculated by summing the solar heat gains of each absorbing area, j, in the sunspace, but deducting the direct heat gains through opaque part of the partition wall:

$$Q_{si} = (1 - b)\, F_S\, F_{Fe}\, g_e \left(\sum_j I_j\ a_j\ \ A_j - I_p \alpha_p\ A_p \frac{U_p}{U_{pe}} \right) \tag{F.3}$$

The weighting factor (1 - b), defined in ISO/DIS 13789:2005, is that part of the solar heat gains to the sunspace which enters the conditioned space through the partition wall.

F.3 Opaque elements with transparent insulation

F.3.1 General

<add: what to do for cooling mode>

F.3.2 Required input data

A total area of the element;

A_t area of the element covered with transparent insulation;

R_i thermal resistance of the opaque element behind transparent insulation;

R_t thermal resistance of transparent insulation;

$g_{t,\perp}$ total solar energy transmittance of transparent insulation (normal incidence);

$g_{t,h}$ total solar energy transmittance of transparent insulation (diffuse-hemispherical incidence);

R_{al} thermal resistance of the air layer (closed) between the opaque element and transparent insulation;

R_{si} internal thermal surface resistance;

R_{se} external thermal surface resistance;

F_S shading correction factor.

Depending on the type of transparent insulation the following quantity is required (it is not required for products that include a solar absorber):

α absorptance of the opaque element behind transparent insulation.

F.3.3 Derived properties

U thermal transmittance of the element, from environment to environment;

U_{te} external thermal transmittance of the element, from the surface facing the transparent insulation product to external environment;

g_t effective total solar energy transmittance of the transparent insulation product;

F_F reduction factor due to non-transparent frame area of the transparent insulation.

F.3.4 Calculation method

The heat loss is calculated according to Clause 8, as for usual envelope elements, including possible thermal bridges in framed constructions. The solar heat gains of an opaque element with transparent insulation, having the orientation j, are calculated for month m according to 11.2 using an effective collecting area.

The frame area fraction is determined from the total area, A, of the element:

$$F_F = \frac{A_t}{A} \tag{F.4}$$

The following thermal transmittances are needed for the efficiency factor to be calculated:

$$U_{\text{te}} = \frac{1}{R_{\text{se}} + R_{\text{t}} + R_{\text{al}}}$$

$$U = \frac{1}{R_{\text{se}} + R_{\text{t}} + R_{\text{al}} + R_{\text{i}} + R_{\text{si}}} \qquad \text{(F.5)}$$

The calculation of the effective total solar energy transmittance depends on the type of the transparent insulation. It takes into account the angle of incidence of direct solar radiation, using the coefficients $c_{\text{j,m}}$ of Table F 1.

For products with non-negligible solar energy transmittance, the effective value is proportional to the absorptance of the opaque element behind transparent insulation:

$$g_{\text{t},j,m} = \alpha \left(g_{\text{t,h}} - c_{j,m}\, g_{\text{t},\perp} \right) \qquad \text{(F.6)}$$

For transparent insulation with negligible solar transmittance (e.g. products with solar absorber included) the value determined from measurements shall only be modified to take account of the thermal resistance, R_{g}, of the air gap between the transparent insulation and the opaque element:

$$g_{\text{TI},j,m} = \frac{R_{\text{se}} + R_{\text{t}}}{R_{\text{se}} + R_{\text{t}} + R_{\text{g}}} \left(g_{\text{t,h}} - c_{j,m}\, g_{\text{t},\perp} \right) \qquad \text{(F.7)}$$

The effective collecting area for orientation j and month m is:

$$A_{\text{s},j,m} = A\, F_{\text{S}}\, F_{\text{F}}\, \frac{U}{U_{\text{t}}}\, g_{\text{t},j,m} \qquad \text{(F.8)}$$

The heat gains are added to the other solar heat gains.

Table F.1 — Coefficients $c_{j,m}$ for calculation of the effective total solar energy transmittance of transparent insulation using the measured values for normal and hemispherical incidence (for vertical walls)

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
S	-0,105	-0,067	-0,023	0,042	0,073	0,089	0,094	0,062	0,005	-0,054	-0,093	-0,105
SW/SE	-0,034	-0,027	-0,010	0,002	0,022	0,037	0,036	0,013	-0,015	-0,025	-0,034	-0,026
W/E	0,054	0,033	0,016	-0,012	-0,005	-0,002	-0,012	-0,007	-0,001	0,024	0,049	0,052
NE/NW	0,002	0,008	0,016	0,030	0,018	0,013	0,013	0,024	0,033	0,014	0,004	0,000
N	0,000	0,000	0,000	0,011	0,021	0,031	0,042	0,012	0,000	0,000	0,000	0,000

F.4 Ventilated solar walls (Trombe walls)

F.4.1 General

<add: what to do for cooling mode>

F.4.2 Required data

The following applies to ventilated solar walls as defined in E.1.

In addition to data listed in E.2, the following input data are needed:

F_F frame area fraction;

F_S shading correction factor;

α absorption coefficient of the surface behind the air layer;

g total solar energy transmittance of the glazing covering the air layer.

F.4.3 Calculation method

The additional heat loss for ventilated solar walls is calculated according to E.2. Solar heat gains are calculated according to 11.2 using an effective collecting area:

a) if the ventilated layer is covered by an opaque external layer:

$$A_S = A \alpha F_S F_F \frac{U_0}{h_e} \left[1 + \frac{U_0}{U_i^2} \rho_a c_a \frac{\dot{V}}{A} \kappa \omega \right] \quad \text{(F.9)}$$

<check if still in line with updated main equations!!>where

U_i and κ are calculated according to E.3,

ω is the ratio of the total solar radiation falling on the element when the air layer is open to the total solar radiation during the whole calculation period; ω is given in Figure F 2. It can be calculated by:

$$\omega = 1 - \exp(-2{,}2\gamma_{al}) \quad \text{(F.10)}$$

where γ_{al} is the heat balance ratio of the air layer during the calculation period

$$U_0 = \frac{1}{R_i + R_l + R_e} \quad \text{(F.11)}$$

is the thermal transmittance of the wall.

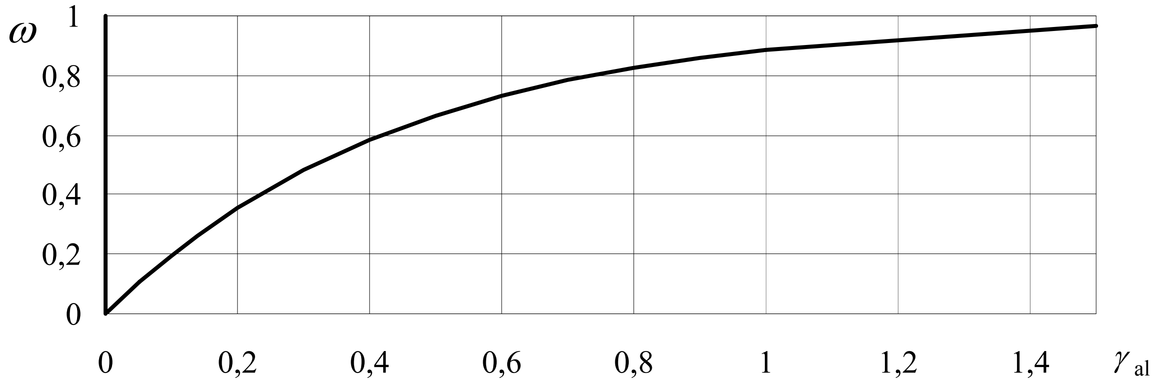


Figure F.2 — Ratio ω of the total solar radiation falling on the element when the air layer is open to the total solar radiation during the calculation period, as a function of the heat balance ratio of the air layer, γ_{al}

b) if the air layer is covered by glazing:

$$A_{\mathrm{S}} = A\,\alpha\,F_{\mathrm{S}}\,F_{\mathrm{F}}\,g_{\mathrm{w}}\left[U_0\,R_{\mathrm{e}} + \frac{U_0^2\,R_{\mathrm{i}}}{U_{\mathrm{i}}\,U_{\mathrm{e}}}\rho_{\mathrm{a}}\,c_{\mathrm{a}}\,\frac{\dot{V}}{A}\kappa\,\omega\right] \tag{F.12}$$

NOTE This procedure is implicit: equations (F.9) and (F.10) should be used in an iterative process to calculate the solar heat gains, starting with γ_{al} = 1.

F.5 Ventilated envelope elements

F.5.1 General

If the supply air for ventilation is taken through envelope elements, it can be heated on one hand by the transmission heat loss through the element (see E.2) and on the other hand by solar radiation absorbed either by the external opaque pane or by the internal surface of the air layer if this layer is covered by glazing.

<add: what to do for cooling mode>

F.5.2 Required data

In addition to data listed in E.2, the following input data are necessary:

A area of the element;

F_{F} frame area fraction;

F_{S} shading correction factor;

a absorption coefficient of the surface receiving the solar radiation;

R_{i} internal thermal resistance of the wall, between the air layer and the internal environment;

R_{e} external thermal resistance of the wall, between the air layer and the external environment;

R_{l} thermal resistance of the air layer;

$\dot{V}$ air flow rate through the ventilated layer;

h_{e} surface heat transfer coefficient at external surface;

g total solar energy transmittance of the glazing covering the air layer;

h_{c} convective surface heat transfer coefficient in the air layer;

h_{r} radiative surface heat transfer coefficient in the air layer.

F.5.3 Calculation method

The efficiency of the equivalent heat exchanger is calculated according to E.4. Solar heat gains are calculated according to 11.2 with the following effective collecting areas:

a) if the ventilated layer is covered by an opaque external layer:

$$A_\mathrm{s} = A \alpha F_\mathrm{S} F_\mathrm{F} \frac{U_0}{h_\mathrm{e}} \left[1 + \frac{U_0}{U_\mathrm{i}^2} \rho_\mathrm{a} c_\mathrm{a} \frac{\dot{V}}{A} \kappa \right] \tag{F.13}$$

b) if the air layer is covered by glazing:

$$A_\mathrm{s} = A \alpha F_\mathrm{S} F_\mathrm{F} g_\mathrm{w} \left[U_0 R_\mathrm{e} + \frac{U_0^2 R_\mathrm{i}}{U_\mathrm{i} U_\mathrm{e}} \rho_\mathrm{a} c_\mathrm{a} \frac{\dot{V}}{A} \kappa \right] \tag{F.14}$$

Annex G
(normative)

Climate related data

G.1 Common data

Length of time periods:

Period	Number of days	Number of hours	t in Ms	Period	Number of days	Number of hours	t in Ms
January	31	744	2,6784	July	31	744	2,6784
February	28	672	2,4192	August	31	744	2,6784
March	31	744	2,6784	September	30	720	2,592
April	30	720	2,592	October	31	744	2,6784
May	31	744	2,6784	November	30	720	2,592
June	30	720	2,592	December	31	744	2,6784
Heating season	See 7.3	Days $\times$ 24	Days $\times$ 24 $\times$ 3,6 $\times$ 10^{-3}				
Cooling season	See 7.3	Days $\times$ 24	Days $\times$ 24 $\times$ 3,6 $\times$ 10^{-3}				

G.2 Climate data

Hourly climatic data are needed:

— for the actual calculations (simple hourly method, detailed simulation methods), or

— for the preparation of monthly climatic values and climate dependent coefficients (all methods, including monthly and seasonal methods) < ➔ better: split what is needed when?!…>

These data shall comprise at least:

Hourly external air temperature, in °C;

Hourly global solar radiation at a horizontal plane, in W/m^2;

Indicators needed for the conversion of global solar radiation at a horizontal plane to incident radiation at vertical and tilted planes at various orientations, such as hourly direct solar radiation at a plane normal to the solar beam and cloudness.

Solar height and azimuth

and, if relevant,

Local or meteorological wind speed, in m/s;

Wind direction

Albedo

Relative humidity of external air

Hourly data for a representative year shall be selected from recent weather files following the procedures of ISO 15927-4.

The choice of weather station may be decided nationally, depending on the purpose of the calculation (e.g. a standard weather station in case of calculations for an energy performance certificate or for checking compliance with a minimum energy performance level in the building regulations.

NOTE Methods of calculation and presentation of climatic data are given in ISO 15927, Hygrothermal performance of buildings – Calculation and presentation of climatic data <as Note??>.

The conversion of global solar radiation at a horizontal plane to incident radiation at vertical and tilted planes at various orientations shall be done according to the procedure in EN?? ISO xxx?? <the standard that describes the Perez model: breakdown into components: beam, circumsolar, homogeneously diffuse, near-horizon, ground-reflected, and the goniometric equations and Perez-coefficients for the conversion>

Check: which of the following standards is appropriate and which is missing in this list

Thomas Frank: 15927-1 annex A, based on hrly data from the 90's.

New Perez coefficients available (Solar Energy)?

EN ISO 15927-1:2003	Hygrothermal performance of buildings – Calculation and presentation of climatic data – **Part 1:** Monthly means of single meteorological elements (ISO 15927-1:2003)
TC 89 609	Hygrothermal performance of buildings – Calculation and presentation of climatic data – **Part 2**: Hourly data for design cooling load (ISO/CD 15927-2)
prEN ISO 15927-3	Hygrothermal performance of buildings – Calculation and presentation of climatic data – **Part 3:** Calculation of a driving rain index for vertical surfaces from hourly wind and rain data (ISO/CD 15927-3)
prEN ISO 15927-4 (N 912)	Hygrothermal performance of buildings – Thermal performance of climatic data – **Part 4:** Hourly data for assessing the annual energy use for heating and cooling (ISO/FDIS 15927-4)
prEN ISO 15927-5	Hygrothermal performance of buildings – Calculation and presentation of climatic data – **Part 5**: Data for design heat load for space heating (ISO/FDIS 15927-5)
prEN ISO 15927-6	Hygrothermal performance of buildings – Calculation and presentation of climatic data – **Part 6**: Accumulated temperature differences (degree days) (ISO/DIS 15927-6)

<Explain (if not done yet): how will climate data inputs for monthly and seasonal methods be treated?>

Annex H
(informative)

Void

H.1 xxx

<<Keep the number for time being, as reserve..>>

Annex I
(informative)

Simplified methods and standard input data

I.1 Introduction

This annex contains simplified methods and standard input data on a number of calculation elements. In general these can be used in absence of national values.

<<To be completed:

add simplified methods

- move in: solar shading calculation from prEN ISO DIS annex G>>

<check all references in main text to annex I and add, where announced, simplified methods and examples of national methods>

The order follows the order of the main part of the standard (…, transmission, ventilation, internal heat gains, solar heat gains, dynamic properties, ..)

I.2 Simplified methods and data related to heat transfer by thermal transmission

<to be completed>

I.3 Simplified methods and data related to heat transfer by ventilation

<to be completed>

I.4 Simplified methods and data related to internal heat gains

I.4.1 Input data for internal heat gains from persons and appliances

Hourly and weekly schedules of heat flow rate for metabolic heat from occupants and dissipated heat from appliances shall be determined on national basis, as a function of building use, (optionally) occupancy class and purpose of the calculation.

In absence of national values, the values from this annex may be used. This section of the annex contains detailed values for residential buildings and offices and more global values for a number of building uses.

Table I.7 — Heat flow rate from occupants and appliances; default values in absence of national values; detailed values for residential buildings

Residential buildings

Days	Hours	Living room plus kitchen $(\Phi_{\mathrm{i,OCC}} + \Phi_{\mathrm{i,APP}}) / A_{\mathrm{fl}}$ W/m^2	Other conditioned areas (e.g. bedrooms) $(\Phi_{\mathrm{i,OCC}} + \Phi_{\mathrm{i,APP}}) / A_{\mathrm{fl}}$ W/m^2
Monday - Friday	07.00 – 17.00	8,0	1,0
	17.00 – 23.00	20,0	1,0
	23.00 – 07.00	2,0	6,0
	Average	9,0	2,67
Saturday - Sunday	07.00 – 17.00	8,0	2,0
	17.00 – 23.00	20,0	4,0
	23.00 – 07.00	2,0	6,0
	Average	9,0	3,83
Average		9,0	3,0

Table I.8 — Heat flow rate from occupants and appliances; default values in absence of national values; detailed values for offices

Offices			
Days	**Hours**	**Office spaces (60 % of useful floor area)** $(\Phi_{\mathrm{i,OCC}} + \Phi_{\mathrm{i,APP}}) / A_{\mathrm{fl}}$ W/m^2	**Other rooms, lobbies, corridors (40 % of useful floor area)** $(\Phi_{\mathrm{i,OCC}} + \Phi_{\mathrm{i,APP}}) / A_{\mathrm{fl}}$ W/m^2
Monday - Friday	07.00 – 17.00	20,0	8,0
	17.00 – 23.00	2,0	1,0
	23.00 – 07.00	2,0	1,0
	Average	9,50	3,92
Saturday - Sunday	07.00 – 17.00	2,0	1,0
	17.00 – 23.00	2,0	1,0
	23.00 – 07.00	2,0	1,0
	Average	2,0	1,0
Average		7,4	3,1
Where $(\Phi_{\mathrm{i,OCC}} + \Phi_{\mathrm{i,APP}})$ is the heat flow rate from persons and appliances, in W; A_{fl} is the useful floor area, defined in 6.4, in m².			

Table I.9 — Heat flow rate from occupants; default values in absence of national values; global values as function of occupation density, non-residential

Class of occupation density	m^2 useful floor area per person	Simultaneity	$\Phi_{\mathrm{i,occ}} / A_{\mathrm{fl}}$ W/m^2

I	1,0	0,15	15
II	2,5	0,25	10
III	5,5	0,27	5
IV	14	0,42	3
V	20	0,40	2

Where

$\Phi_{i,occ}$ is the heat flow rate from persons, in W;

A_{fl} is the useful floor area, defined in 6.4, in m².

Table I.10 — Heat flow rate from appliances; default values in absence of national values; global values as function of building use, non-residential

Building use	Heat production appliances during operation time $\Phi_{i,APP} / A_{fl}$ W/m²	Fraction of time present f_{app}	Average heat flow rate from appliances $\Phi_{i,APP} / A_{fl}$ W/m²
Office	15	0,20	3
Education	5	0,15	1
Health care, clinical	8	0,50	4
Health care, not clinical	15	0,20	3
Catering	10	0,25	3
Shop	10	0,25	3
Assembly	5	0,20	1
Accommodation	4	0,50	2
Cell and penitentiary	4	0,50	2
Sports	4	0,25	1

Where

$\Phi_{i,APP}$ is the heat flow rate from appliances, in W;

A_{fl} is the useful floor area, defined in 6.4, in m².

For detailed simulation methods the thermal radiative and convective portions are each 50 %, unless otherwise stated.

<Adopt also the data from annex C in wi 4 (2005 version)>

I.5 Simplified methods and data related to solar heat gain

I.5.1 Total solar energy transmittance for glazing

<for heating mode; what to do for cooling mode?>

The energy transmission through transparent surfaces depends on the type of glass. The total solar energy transmittance defined in EN 410 is calculated according to EN 13363-2 for solar radiation perpendicular to the glazing, g_n. Table I.1 provides some indicative values for normal incidence, assuming clean surface and normal, untainted glass.

For hourly and monthly calculations, a value averaged over all angles of incidence is needed. The factor F_w defined in 11.4.2 is approximately:

$$F_w = \frac{g}{g_n} = 0{,}9$$

<upgrade to normative part and differentiate for shading devices?!! See also note below! E.g calculate with WIS and adopt: "in absence of national values: …" More general: average value per month or season, taking into account also diffuse and ground-reflected radiation: add illustration of venetian blind?!>

It depends on type of glass, latitude climate and orientation.

NOTE For windows with slat types of solar shading devices the values according to EN 13363-2 may substantially underestimate (by factor 2 or 3) the solar energy transmittance, because direct transmittance between the slats (as occurring from diffuse and/or ground reflected solar radiation) is ignored.

Table I.1 — Typical values of total solar energy transmittance for common types of glazing

Glazing type	$g_\perp$
Single glazing	0,85
Double glazing	0,75
Double glazing with selective coating	0,67
Triple glazing	0,7
Triple glazing with 2 selective coatings	0,5
Double window	0,75

I.5.2 Effect of permanent curtains

<for heating mode; what to do for cooling mode?>

Curtains placed "permanently" (e.g. not movable) inside or outside the windows reduce the global transmission of solar radiation. Some reduction factors are given in Table I.2. These factors are multiplied by the total solar energy transmittance of the glazing to obtain the *g*-factor of the glazing with permanent curtain. "Permanently" means in this context: usually also in operation during daytime.

Table I.2 — Reduction factors for some types of curtains

Curtain type	Optical properties of curtain		Reduction factor with	
	absorption	transmission	curtain inside	curtain outside
White venetian blinds	0,1	0,05	0,25	0,10
		0,1	0,30	0,15
		0,3	0,45	0,35
White curtains	0,1	0,5	0,65	0,55
		0,7	0,80	0,75
		0,9	0,95	0,95
Coloured textiles	0,3	0,1	0,42	0,17
		0,3	0,57	0,37
		0,5	0,77	0,57
Aluminium coated textiles	0,2	0,05	0,20	0,08

<add symbol: Fsh??>

Movable curtains and movable solar protections are taken into account in the utilisation factor <Attention!!: for heating mode>.

I.5.3 Shading correction factors

I.5.3.1 Principle

The shading correction factor can be calculated from:

$$F_S = F_h \, F_o \, F_f \qquad \text{(I.2)}$$

where

F_h is the partial shading correction factor for the horizon;

F_o is the partial shading correction factor for overhangs;

F_f is the partial shading correction factor for fins.

<for heating mode; what to do for cooling mode?>

I.5.3.2 Shading from horizon

The effect of shading from the horizon (e.g. the ground, trees and other buildings) depends on horizon angle, latitude, orientation, local climate and heating season. Shading correction factors for typical average climates and a heating season from October to April are given in Table I.3, for three latitudes and four window orientations. Interpolation can be used for other latitudes and orientations. The horizon angle is an average over the horizon facing the facade considered.

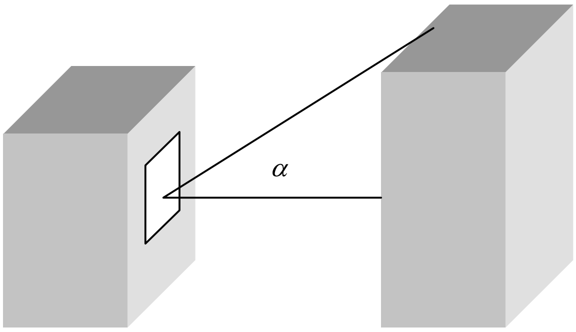


Figure I.1 — Horizon angle, α

<for heating mode; what to do for cooling mode?>

Hourly calculation method:

It is assumed that the horizon mask modifies only the direct solar radiation. This is consistent with the general assumption, see 11.4.4)

F_{fh} is calculated by

if $S_h < \alpha$ $F_h = (1 - R_{dir} / R_{tot})$

otherwise $F_h = 1$

where

S_h is the solar height;

R_{dir} is the direct solar radiation on the facade;

R_{tot} in the total radiation on the façade.

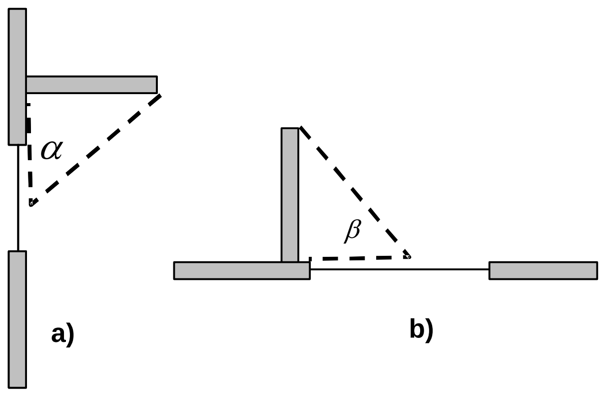
Monthly or seasonal method

Table I.3 — Partial shading correction factor for horizon, F_h

Horizon angle	45° N lat.			55° N lat.			65° N lat.		
	S	E/W	N	S	E/W	N	S	E/W	N
0°	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10°	0,97	0,95	1,00	0,94	0,92	0,99	0,86	0,89	0,97
20°	0,85	0,82	0,98	0,68	0,75	0,95	0,58	0,68	0,93
30°	0,62	0,70	0,94	0,49	0,62	0,92	0,41	0,54	0,89
40°	0,46	0,61	0,90	0,40	0,56	0,89	0,29	0,49	0,85

I.5.3.3 Shading from overhang and fins

The shading from overhangs and fins depends on overhang or fin angle, latitude, orientation and local climate. Seasonal shading correction factors for typical climates are given in Tables I.4 and I.5.



a) Vertical section b) Horizontal section

Key

α overhang angle

β fin angle

Figure I.2 — Overhang and fin

Hourly methods:

It is assumed that the shading affects direct and diffuse radiation but not reflected radiation.

For overhangs, the partial reduction coefficient for direct radiation. F_{ohdir}. and for diffuse radiation, F_{ohdif}, are calculated by

$$F_{\mathrm{ohdir}} = \max(0;\ 1 - (0{,}5 \tan(\alpha) / \tan(90 - S_{\mathrm{h}}))) \qquad \text{(I.3)}$$

$$F_{\mathrm{ohdif}} = 1 - (\alpha/90) \qquad \text{(I.4)}$$

The F_{oh} coefficient is calculated by

$$F_{\mathrm{oh}} = (F_{\mathrm{ohdir}}\, R_{\mathrm{dir}} + F_{\mathrm{ohdif}}\, R_{\mathrm{dif}} + 1 - R_{\mathrm{tot}}) / R_{\mathrm{tot}} \qquad \text{(I.5)}$$

where R_{dif} is the ratio of the diffuse radiation for the given orientation

Monthly and seasonal methods

<for heating mode; what to do for cooling mode? Request to add columns for 35°; who has data?>

Table I.4 — Partial shading correction factor for overhang, F_{o}

Overhang angle	45° N lat.			55° N lat.			65° N lat.		
	S	E/W	N	S	E/W	N	S	E/W	N
0°	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
30°	0,90	0,89	0,91	0,93	0,91	0,91	0,95	0,92	0,90
45°	0,74	0,76	0,80	0,80	0,79	0,80	0,85	0,81	0,80
60°	0,50	0,58	0,66	0,60	0,61	0,65	0,66	0,65	0,66

Table I.5 — Partial shading correction factor for fins, F_f

Fin angle	45° N lat.			55° N lat.			65° N lat.		
	S	E/W	N	S	E/W	N	S	E/W	N
0°	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
30°	0,94	0,92	1,00	0,94	0,91	0,99	0,94	0,90	0,98
45°	0,84	0,84	1,00	0,86	0,83	0,99	0,85	0,82	0,98
60°	0,72	0,75	1,00	0,74	0,75	0,99	0,73	0,73	0,98

The values of Table I.5 are valid for fins on one side.

For South facing windows, for the given latitudes, with fins on both sides, the two shading correction factor are to be multiplied.

For East and West facing windows the shading correction factor is valid for fins at the South end of the window. Fins at the North end of the window, for the given latitudes, do not lead to a shading correction factor.

I.5.4 Movable solar shading reduction factors

<for heating mode; what to do for cooling mode?>

The weighted fraction of the time that the solar shading is in use or not in use are dependent on the climate and on the season or month. For each climate a table can be produced with values for $F_{S,G}$ for a variety of orientations and tilt angles of the window. The resulting table can contain values per month or one average value for the cooling season to be used for each month. An example is given in Table I.6

This table is a copy of the table used in Denmark [3] for the so called 'solar shading potential efficiency factor', which is determined in a comparable way, but represents not f_{up} or f_{down} but $g_{w,s}$, determined with a fixed value for g_{w+s} and g_w (the g-values of the window with (the value 0 is used) and without solar shading) using a criterion for switching of intensity of incident solar radiation of 150 W/m^2. <<to be done: convert the numbers from g to F?!>>

Table I.6 — Example of table for the movable shading reduction factor, $F_{Sh,G}$ (taken from Denmark

Solar shading

	0,00 -	Shading factor											
		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1	90 n	1,00	1,00	1,00	1,00	0,98	0,96	0,98	1,00	1,00	1,00	1,00	1,00
2	90 nø/nv	1,00	1,00	0,94	0,66	0,51	0,53	0,57	0,69	0,84	1,00	1,00	1,00
3	90 ø/v	0,41	0,48	0,36	0,34	0,29	0,32	0,34	0,29	0,36	0,36	0,42	0,53
4	90 sø/sv	0,22	0,37	0,25	0,32	0,26	0,32	0,32	0,24	0,31	0,28	0,26	0,34
5	90 s	0,20	0,36	0,26	0,32	0,29	0,32	0,33	0,23	0,30	0,24	0,23	0,31
6	45 n	1,00	1,00	0,99	0,98	0,63	0,39	0,58	0,93	1,00	1,00	1,00	1,00
7	45 nø/nv	1,00	1,00	0,87	0,47	0,31	0,28	0,32	0,40	0,71	1,00	1,00	1,00
8	45 ø/v	0,82	0,65	0,41	0,31	0,22	0,21	0,24	0,25	0,37	0,48	0,74	0,96
9	45 sø/sv	0,33	0,43	0,29	0,24	0,18	0,17	0,19	0,16	0,29	0,29	0,32	0,47
10	45 s	0,26	0,39	0,25	0,23	0,18	0,16	0,17	0,14	0,26	0,25	0,28	0,37
11	0 -	1,00	0,78	0,44	0,27	0,19	0,16	0,18	0,19	0,38	0,58	0,93	1,00

I.6 Simplified methods and data related to dynamic parameters

Explanation of default values given in 12.3.1.

Effective mass coupling coefficient, H_m for monthly and seasonal methods:

H_{is} = 3.45 At; At = 4.5 Afl; Hms = 9.1 Am;

Am is derived from <??see simple hrly method>

. 1/Hm = 1/His + 1/Hms

Cm is derived from <see simple hrly method?!, but depends on unknown specs of the classes ☺)>

The corrected internal heat capacity for monthly and seasonal method: $C'_m = 0.75\ C_m$

NOTE This correction is based on calculations that the equivalent areal heat capacity (annex A.3 of ISO 13786) can be as low as 50% of the uncorrected value. On the other hand, the operative internal temperature is by approximation equal to the arithmetic mean of air and surface temperature. Therefore only half of the correction is needed. Note that a rough approximate of the internal heat capacity is sufficient for the purpose (see 12.3.1).

I.7 Simplified methods and data related to indoor conditions (internal temperature set-points)

I.7.1 Explanation of intermittency correction for seasonal and monthly methods

The correction for intermittency for the monthly method for cooling is based on the following.

Due to the diurnal pattern of the weather, and the effect of the building thermal inertia, an evening/night thermostat setback or switch-off has in general a relatively much smaller effect on the energy need for cooling than a thermostat setback or switch-off has on the heating energy need. This leads to differences in the calculation procedures.

This implies that a thermostat setback or switch-off during evening/night will result in only a small or no decrease in energy need for cooling, unless during very warm months or in the case of high internal heat gains, in combination with small heat losses.

In a simple but robust way, the correction factor takes into account that the impact of the intermittency on the energy need for cooling is a function of the length of the intermittency period, the amount of heat gains compared to the amount of heat transfer (heat balance ratio) and the building inertia. See illustration in Figure 9.

I.7.2 Typical values and patterns for internal temperature set-points

Examples of set-point temperatures and intermittency patterns for different building types, to be used in absence of national values.

<to be completed>

Measured values have to be **used with care**, because the measured internal temperature is not the same as set-point due to effects such as overheating, intermittency, inertia, imperfect control. These effects should not be implicitly taken into account in the set-point, because they are explicitly taken into account in the calculation method (e.g. monthly or seasonal method: overheating in utilisation factor, intermittency: in set-point adjustment and/or correction factor; simple hourly and detailed simulation methods: in the set-point schedule.

Annex J
(informative)

Accuracy of the method

J.1 Introduction

<<To be revised: more focus on validation; copy parts from Montreal paper>>

J.2 Propagation of errors

The accuracy of the method, that is the extent to which the results of the calculation correspond with the actual energy use of the building, depends mainly on the quality of the input data, and some of these data (e.g. the air change rate) are often not known precisely.

The uncertainty of input data propagates through the formulae and equations, resulting in a generally larger relative error in the results. In particular, when the heat gains are high, the small heat use results from the subtraction of two large numbers, and the factor multiplying the uncertainty on load and heat gains becomes large. Error analysis has shown that when the heat balance ratio is 0,75, this factor is between 4 and 7, depending on the time constant of the building. In this case, uncertainty of 5 % on heat loss will result in an uncertainty of 20 % to 35 % on heat use.

Therefore it is advisable, when the annual heat use is less than one third of the heat losses, to take great care with input data, and to perform an error analysis taking account of the uncertainties of the input data.

When this standard is used to judge compliance with regulations expressed in terms of energy targets, the calculation is based on conventionally well defined input data. In this case, the error analysis is not necessary.

J.3 Comparison with actual buildings

In particular, the calculations are made using conventional assumptions about the behaviour of the occupants and airflow rates. In practice, these factors may change the energy use from 50 % to 150 % of the calculated average value, and even more in terraced houses and blocks of flats, where moderate temperature differences between adjacent zones often result in noticeable heat transfer between them.

J.4 Comparison between building designs

The method described in this standard is particularly appropriate for comparison between proposed buildings, in order to determine the influence of various options on the energy use. Insofar as these options are taken into account in the calculation, their relative influence is well predicted.

J.5 Comparison with dynamic numerical models

When the same set of input data is used for all models, the annual energy use calculated by the simple hourly method and the monthly and seasonal methods described in this standard are, on the average, in very good agreement with the results from a fully dynamic numerical model. 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 (like interaction between zones, air infiltration, dynamic heat transfer to ground floor, thermal bridges, solar shading by external obstacles, etc.) for which the choice of an accurate and practical method, also for a detailed numerical model, is to some extent arbitrary.

J.6 Comparison between users of the standard

It has been shown, by round robin tests, that different users may obtain results differing by as much as 20 % for the same building in the same climate, for the following reasons:

- the standard allows for input data defined on a national basis, which may differ between users;
- the standard allows different calculation methods (e.g. single- or multi-zone);

the user may provide different input data from the same source (e.g. by taking dimensions from a drawing).

J.7 Balanced accuracy

Include paragraph on “balanced accuracy” and the specific needs for energy calculations in the context of building regulations (see e.g. [12])

J.8 Validation

J.8.1 General

J.8.2 Validation monthly calculation method

Including validation results of the monthly method according to prEN 15265 (WI 17) (with additionally Stockholm and Rome climates) (as given in [13])

J.9 Validation simple hourly calculation method

Validation results on the simple hourly method (Paris climate); including warning about use of hourly values (meeting prEN 15265 does not mean that hourly values are validated!) . Plus a remark on applicability for more extreme climates. See also comments and replies on the scope (clause 1).

J.9.1 Validation simulation methods

See Enper [12] about points of attention in context of building regulations (reproducibility, transparency, robustness

Annex K
(informative)

Explanation and derivation of monthly or seasonal utilisation factors

K.1 Xxxx

Text

<<To be completed>>

K.2 Explanation

K.2.1 Introduction

In the quasi-steady state (monthly or seasonal) methods, the dynamic effects are taken into account by introducing correlation factors:

For heating, a utilisation factor for the internal and solar heat gains takes account for the fact that only part of the internal and solar heat gains is utilised to decrease the energy need for heating, the rest leading to an undesired increase of the internal temperature above the set-point. In this approach, the heat balance ignores the non-utilised heat gains, which is counterbalanced by the fact that it ignores at the same time the resulting extra transmission and ventilation heat transfer from the space considered due to the increased internal temperature above the set-point.

The effect of thermal inertia in case of intermittent heating or switch-off can be taken into account by introducing an equivalent internal temperature which deviates from the set-point or a correction on the calculated heat need.

For cooling there are two different ways to represent the same method:

a) utilisation factor for losses (mirror image of the approach for heating)

A utilisation factor for the transmission and ventilation heat transfer takes account of the fact that only part of the transmission and ventilation heat transfer is utilised to decrease the cooling needs, the “non-utilised” 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).

In this approach, the heat balance ignores the non-utilised transmission and ventilation heat transfer; this is counterbalanced by the fact that it ignores that the cooling set-point is not always reached. With this formulation it is explicitly shown how the heat transfer attributes to the reduction of the building energy needs for cooling.

b) utilisation factor for gains (similar as for heating)

A utilisation factor for the internal and solar heat gains takes account for the fact that only part of the internal and solar heat gains is compensated by thermal heat transfer by transmission and ventilation, assuming a certain maximum internal temperature. The other (“non-utilised”) part leads to cooling needs, to avoid an undesired increase of the internal temperature above the set-point.

In this approach, the heat balance ignores the utilised heat gains, which is counterbalanced by the fact that it ignores all transmission and ventilation heat transfer. <Germany: is not correct: are not ignored>

The effect of thermal inertia in the case of intermittent cooling or switch-off is taken into account separately (depending on the conditions: by introducing an adjusted set-point or an adjustment on the calculated cooling needs; see Clause 13.

This standard specifies in the category of quasi-steady state methods a monthly and seasonal method for heating and cooling (presentation type a). The alternative formulation for the monthly cooling method (presentation type b) is presented in Annex D.

Next: energy balance equations

K.2.2 Energy balance equations

Full and reduced energy balance equations; illustration of dynamics.

See e.g. also ISO TC163 WG11 noted vDijk 2006 on incompatibility of degree days with utilisation factor approach!

Explanation of heat losses and gains:

Heat balance ratio = gains/heat transfer

"gains"; actually all heat flows (positive or negative) driven by (true or by approximation) constant heat flux; usually the main terms are the solar and internal heat gains

"heat transfer": all heat flows (positive or negative) driven by temperature difference (➔ by approximation proportional with internal temperature in the considered building or building zone; usually the main terms are transmission and ventilation heat transfer.

the parameter values are empirical values and may be determined at national level; in absence of national values the given tabulated values may be used (to be decided at national level, depending on the purpose of the calculation); (*)

The next clause presents instructions how to generate parameter values for the monthly method

(*): Note: due to the ‘level playing field’ created by this standard, and with the instructions how to generate parameter values for the monthly method, it is expected that in a few years time there will be more experience to come to further harmonisation

K.3 Derivation of utilisation factors from dynamic simulations

K.3.1.1 Introduction

To be completed

K.3.1.2 Procedures

Compare analysis of results from simulation tools:

A way of providing separate results is to perform three extra calculations (see [2] in the Bibliography):

Case 0: normal calculation to obtain $Q_{H,n,0}$ and $Q_{C,n,0}$.

Case 1: as case 0, but zero internal and solar heat gains, to obtain $Q_{H,n,1}$ and $Q_{C,n,1}$

Then as an approximation: $Q_{H,ls} = Q_{H,n,1}$ and $Q_{C,ls} = Q_{C,n,1}$

Case 2: as case 0, but a high set-point for heating and a low set-point for cooling, such that all heat gains are utilised in heating mode and all losses are utilised in cooling mode, to obtain $Q_{H,n,2}$ and $Q_{C,n,2}$

Case 3: as case 2, but with zero internal and solar heat gains, to obtain $Q_{H,n,3}$ and $Q_{C,n,3}$.

Then as an approximation: $Q_{H,gn} = (Q_{H,n,3} - Q_{H,n,2})$ and $Q_{C,gn} = (Q_{C,n,3} - Q_{C,n,2})$

To be completed: get utilisation factor: (see also explanation at figures M.1 and M.5)

NOTE This procedure may introduce some random and systematic deviations, but in absence of a reliable alternative it could be the only robust check of the calculation input and process.

a) Deviations may be introduced if (some of) the properties are a function of the local conditions.

b) Deviations may occur due to e.g. heat sources that remain out of side in the dynamic method; for instance, part of the solar or internal heat that is absorbed in the floor (wall or roof), goes to the ground (thence to the outside), without having been detected as contribution to the heat balance of the heated or cooled space.

c) The result of steps 2 and/or 3 can be a small difference between two large and almost equal numbers and therefore subject to a large relative error.

K.3.2 Conversion monthly to seasonal utilisation factors

For the conversion from monthly utilisation factors to the seasonal utilisation factors the following equation may be used:

For heating:

<equation>

For cooling:

<equation>

With $m1 \ldots mn$ being the fixed length of the heating respectively cooling season, to be decided nationally.

Where:

…Is the

….Is

Important: use fixed season length

It is important to realise that for calculating the utilisation factor for the seasonal method the season lengths should be fixed and e.g. not made dependent on the heat balance ratio. The actual length of the season is determined by the utilisation factor. For instance: if the fixed length of the heating season is such that in reality a number of months are included without heating needs, then the gain utilisation factor will automatically get a low value to compensate the extra solar and internal gains that are introduced in the seasonal heat balance by the months without heating needs.

K.3.3 Seasonal method – Fixed length of heating and cooling season

K.3.3.1 Introduction

The fixed length of the heating and cooling seasons is needed for the calculation of total heat transfer and total heat gains during the heating and cooling seasons, as explained in 7.2.1.4.

This length may be determined at national level and may be chosen rather arbitrary, but not too short. The gain utilisation factor as function of the heat balance ratio (the gain utilisation factor curves) depends on the choice of this fixed length. Consequently, the same fixed season length shall be used as used for the development of these curves.

Similarly, the fixed length of the cooling season is needed for the calculation of total heat transfer and total heat gains during the cooling season.

K.3.3.2 Fixed length of heating season for the heat balance calculation

The first and last days of the heating season, hence its duration and its average meteorological conditions, can be fixed at national level for a geographic zone and typical buildings. The heating season includes all days for which the heat gains, calculated with a conventional utilisation factor, η_1, do not balance the heat transfer, that is when:

$$\theta_{\mathrm{ed}} \leq \theta_{\mathrm{id}} - \frac{\eta_1 Q_{\mathrm{Gd}}}{H_{\mathrm{L}} \quad t_{\mathrm{d}}} \qquad \text{(K.1)}$$

where

θ_{ed} is the daily average external temperature;

θ_{id} is the set-point temperature;

η_1 is the conventional gain utilisation factor calculated with γ = 1;

Q_{Gd} is the daily average internal and solar gains, obtained from??, in MJ;

H_{L} is the heat transfer coefficient of the building or building zone, according to ?? for month ??, in W/K;

t_{d} is the duration of the day, that is 24 h or 0.0864 Ms.

The heat gains for Equation (K.1) may be derived from a conventional national or regional value of the daily global solar radiation at the limits of the heating season. The monthly average values of daily temperatures and heat gains are attributed to the 15th day of each month. Linear interpolation is used to obtain the limiting days for which Equation (K.1) is verified.

K.3.3.3 Fixed length of cooling season for the heat balance calculation

The first and last days of the cooling season, hence its duration and its average meteorological conditions, can be fixed at national level for a geographic zone and typical buildings. The cooling season includes all days for which the positive heat transfer, calculated with a conventional utilisation factor, η_1, do not balance the heat gains.

$$\theta_{\mathrm{ed}} \leq \theta_{\mathrm{id}} - \frac{\eta_1 Q_{\mathrm{Gd}}}{H_{\mathrm{L}} \quad t_{\mathrm{d}}} \qquad \text{(K.2)}$$

where

θ_{ed} is the daily average external temperature;

θ_{d} is the set-point temperature;

η_1 is the conventional gain utilisation factor calculated with γ = 1;

Q_{Gd} is the daily average internal and solar gains, obtained from??, in MJ;;

H_L is the heat transfer coefficient of the building or building zone, according to ?? for month ??, in W/K;

t_d is the duration of the day, that is 24 h or 0.0864 Ms.

The heat gains for Equation (K.1) may be derived from a conventional national or regional value of the daily global solar radiation at the limits of the heating season<why not just apply the input rules??>. The monthly average values of daily temperatures and heat gains are attributed to the 15th day of each month. Linear interpolation is used to obtain the limiting days for which Equation (K.1) is verified.

K.4 Relation between overheating and gain utilisation factor

<to be adapted to cooling mode, loss utilisation factor and to be completed>

The real loss is equal to:

$$Q_{H,ls,,real} = (H_{tr} + H_{ve}) \times (\theta_{i;real} - \theta_e) \times t \tag{7}$$

$\theta_{i,real}$ is the real (in contrast to set point) mean indoor temperature (°C).

Furthermore, we define the **accumulated overtemperature ATO**, the difference between the real indoor temperature and the minimum set point temperature for heating, summed over all hours of the given period:

$$ATO_H = (\theta_{i;real} - \theta_{i;H}) \times t/0.0036 \tag{8}$$

Remark:

in [1, 2, 3] the term dT_A is introduced instead of ATO, dT_A is the “mean overtemperature” (ATO = dT_A x number of hours).

Note: 1/0.0036 is just the conversion from Ms (due to MJ) to hours.

In the same way, the **relative overtemperature dT_R** is by definition the mean real temperature difference between indoor and outdoor, divided by the temperature difference based on the minimum set point temperature.

$$dT_{R,h} = (\theta_{i;real} - \theta_e) / (\theta_{i;H} - \theta_e) \tag{9}$$

Now it is easy to see, that:

$$Q_{H,ls,real} = Q_{H,ls} \times dT_{R,H} \tag{10}$$

Apart from this we can derive:

$$Q_{H,ls,real} - Q_{H,ls} = (H_{tr} + H_{ve}) \times \{(\theta_{i;real} - \theta_e) - (\theta_{i;H} - \theta_e)\} \times t$$

$$Q_{H,ls,real} - Q_{H,ls} = (H_{tr} + H_{ve}) \times (\theta_{i;real} - \theta_{i;H}) \times t$$

$Q_{H,ls,real}$ - $Q_{loss,h}$ = $(H_{tr} + H_{ve}) \times 0.0036\ ATO_H$ (11)

Note: 0.0036 is just the conversion from hours to Ms (due to MJ)

In addition it is evident that the heat flows over the given period should be in balance, and consequently the real loss minus the gains should be equal to the heating demand:

$Q_{H,n} = Q_{H,ls,,real} - Q_{H,gn}$ (12)

Because we also knew that:

$Q_{H,n} = Q_{H,ls} - \eta_{H,gn} \times Q_{H,gn}$

We can place an equal sign between the right hand sides of both equations, to obtain:

$Q_{H,ls,real} - Q_{H,gn} = Q_{H,ls} - \eta_{H,gn} \times Q_{H,gn}$

Or:

$Q_{H,ls,real} - Q_{H,ls} = Q_{H,gn} - \eta_{H,gn} \times Q_{H,gn}$

And so:

$(H_{tr} + H_{ve}) \times 0.0036\ ATO_H = (1 - \eta_{H,gn}) \times Q_{H,gn}$ (13)

Note: 0.0036 is just the conversion from hours to Ms (due to MJ)

Note:

From this we can also derive, by divided both left and right hand term by $Q_{H,ls}$:

$dT_{R,H} = \gamma\ (1 - \eta_{H,gn}) + 1$ (14)

which allows us, if we want, to convert $\eta_{H,gn}$ in $dT_{R,H}$ and vice versa. We will see further on (annex) where this comes in conveniently.

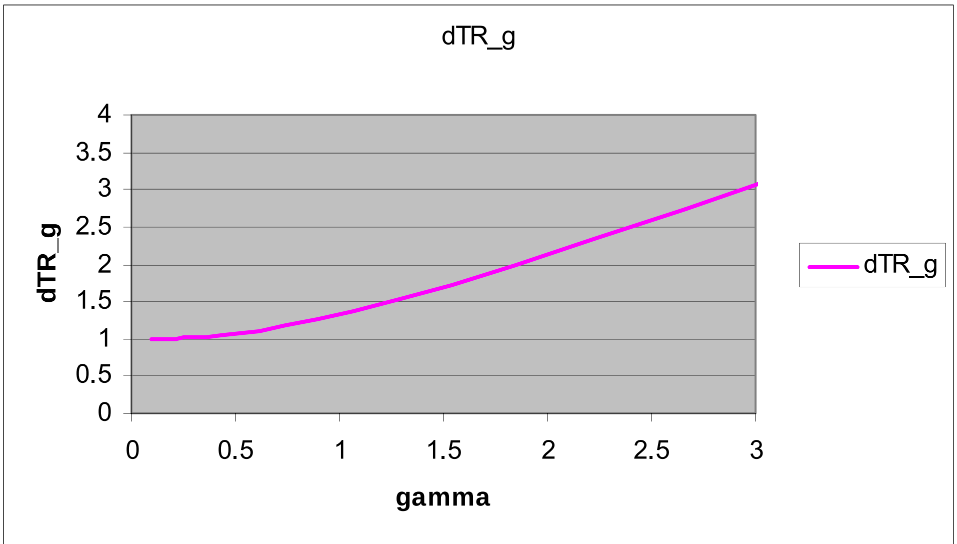


Figure 15.1 Example of curve for the relative overtemperature $dT_{R,g}$ as function of gain-loss ratio γ_h (for a = 2.12 h).

Equation 13 actually tells us that the superfluous heat (left) is equal to the un-utilized gains (right): all heat gains that are not utilized lead to a higher temperature than minimally asked for.

In this context the mean temperature rise is therefore:

$$ATO_H = (1/0.0036)\,(1 - \eta_{H,gn})\times Q_{H,gn} / (H_{tr} + H_{ve}) \qquad (15)$$

Note: 1/0.0036 is just the conversion from Ms (due to MJ) to hours.

We use here the word **superfluous heat** instead of **overheating**, because it includes the higher temperature that occurs during night time setback compared to the situation without gains. Same for **overtemperature** instead of **excess-temperature**.

See the following illustration:

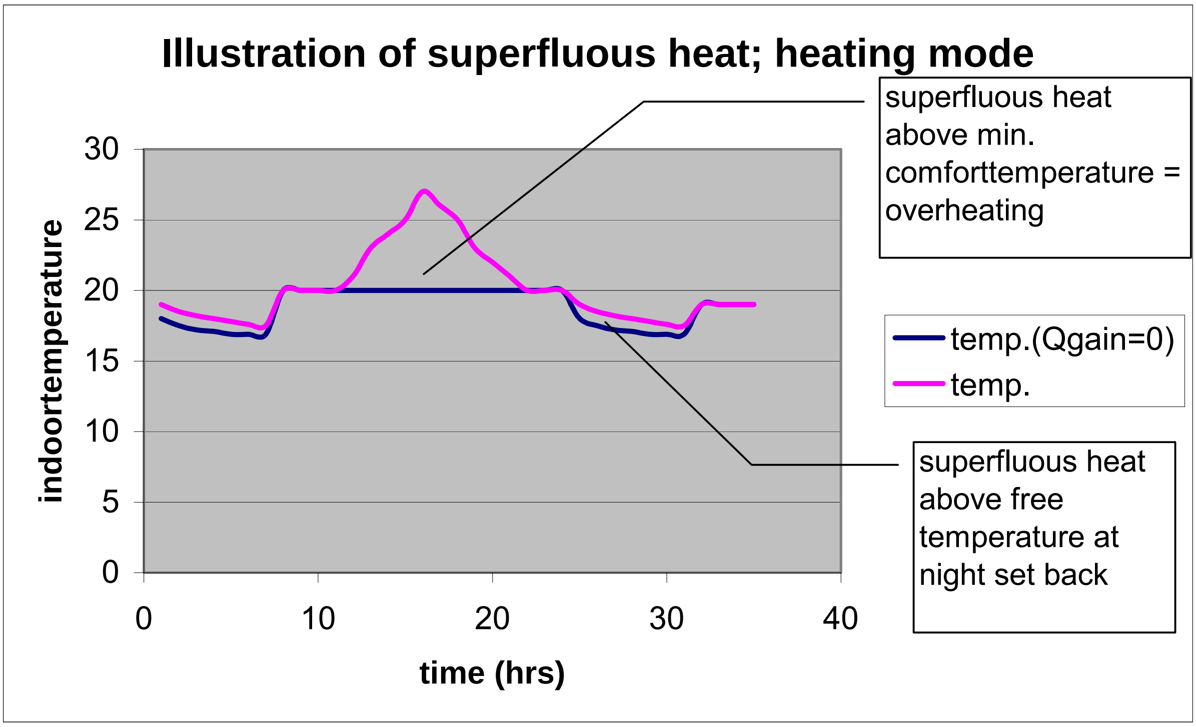


Figure 15.2 Illustration of daily pattern of indoor temperature with and without heat gains

Annex L
(informative)

Worked out example; monthly method

L.1 Introduction

Text

<<To be completed: >>

L.2 Background of example

<<To be completed one of the test cases of prEN 15265, with intermittent heating and cooling >>

L.3 Example

<<To be completed>>

Annex M
(informative)

Flow charts of the calculation procedures

M.1 Introduction

The main terms of the (time-average) energy balance for heating and cooling are schematically illustrated in the following clauses, for heating and cooling separately. First a simple situation is presented, followed by a detailed version where 'all possible' energy flows are shown.

KEY to figures M.1 – M.6

a) See explanation in text

b) Heat recovered in the **building**, coming from heating **system** losses (e.g. from hot pipes)

c) Per energy carrier

d) Heat recovered in the ventilation system, from ventilation losses (heat recovery unit)

e) Heat recovered in the **system**, coming from **building** losses (e.g. heat recovered from building construction to ventilation system)

f) -

g) See explanation in text

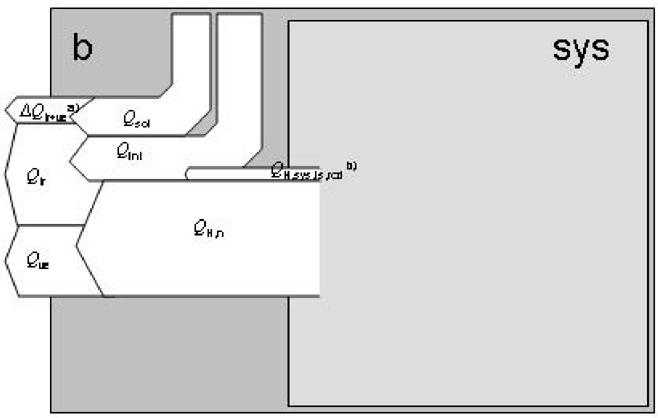
h) Cold recovered in the **building,** coming from the cooling **system** losses (e.g. from cold pipes)

M.2 Heating mode, simple situation

See clause 4 for the symbols and subscripts.

Explanation, building part:

- Heat balance:
  - The energy need for heating is given by the difference between the transmission and ventilation heat transfer (heat losses) and the heat gains from solar and internal sources.
  - The diagram is valid for steady state: the heat balance is taken over a sufficiently long enough time to ignore heat stored and released (typically: one month or a whole season)
  - By convention, the transmission and ventilation heat transfer Qls = Qtr + Qve is calculated on the basis of the intended minimum internal temperature, the **set-point temperature**.
  - The **actual time-average (mean) internal temperature** may be higher, due to instantaneous overheating. Consequently, the actual heat losses calculated (or measured) from this actual mean internal temperature are also higher than those calculated on the basis of the set-point temperature. This is represented by the term ΔQtr+ve.
  - Note that for the monthly or seasonal ‘utilisation factor’ method (EN ISO 13790) this ΔQtr+ve is equal to the non-utilised part of the solar and internal heat gains (1- ηgn) Qgn = ΔQtr+ve. This gives the basic equation: QH,n = Qls – ηgn* Qgn
- Explicitly shown is the heat loss from the heating system that is recovered in the building as part of the internal heat gains. The internal heat gains also consists of heat from other systems and appliances and metabolic heat from persons.



Simple case, heating, building part

Figure M.1 – Energy balance, building part: heating mode; simple situation

Explanation, system part:

The energy need for heating the building is covered by the heating system output (resource energy), with additional output from a solar heating system (renewable energy).

The system losses are partly recovered in the building, as shown already on the previous diagram.

System losses that are recovered within the system are not shown in this diagram: they would appear as a loop within the system: losses going out and coming in again.

The delivered energy may consist of different energy carriers, that each have to be counted separately. We have shown electric energy explicitly, because that is often the second energy carrier (e.g. for auxiliary energy).

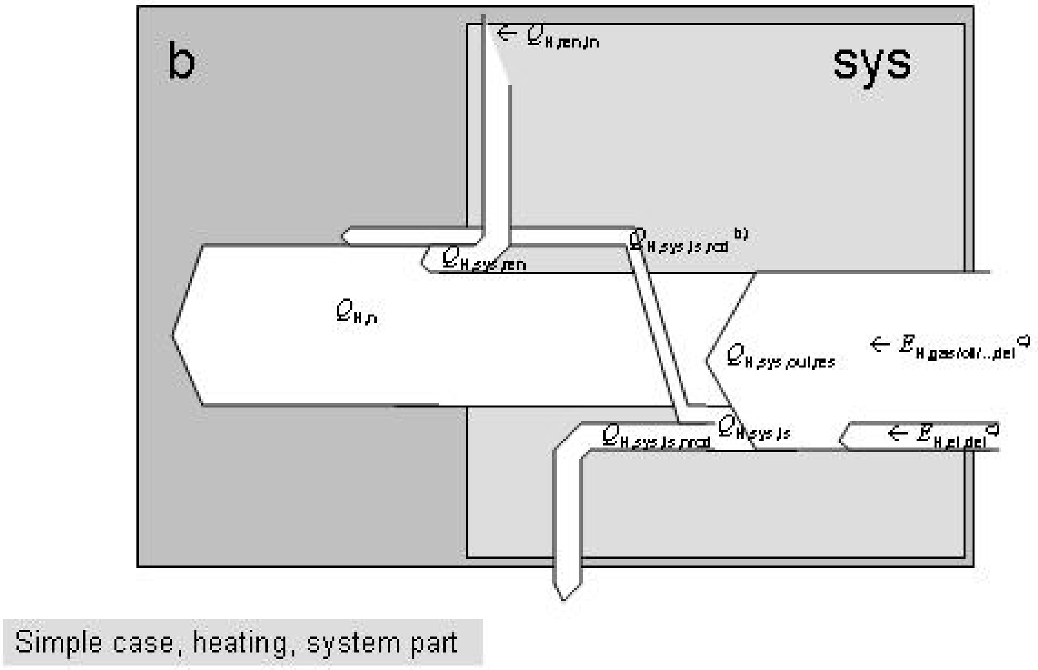


Figure M.2 – Energy balance, system part: heating mode; simple situation

M.3 Heating mode, detailed situation

See clause 4 for the symbols and subscripts.

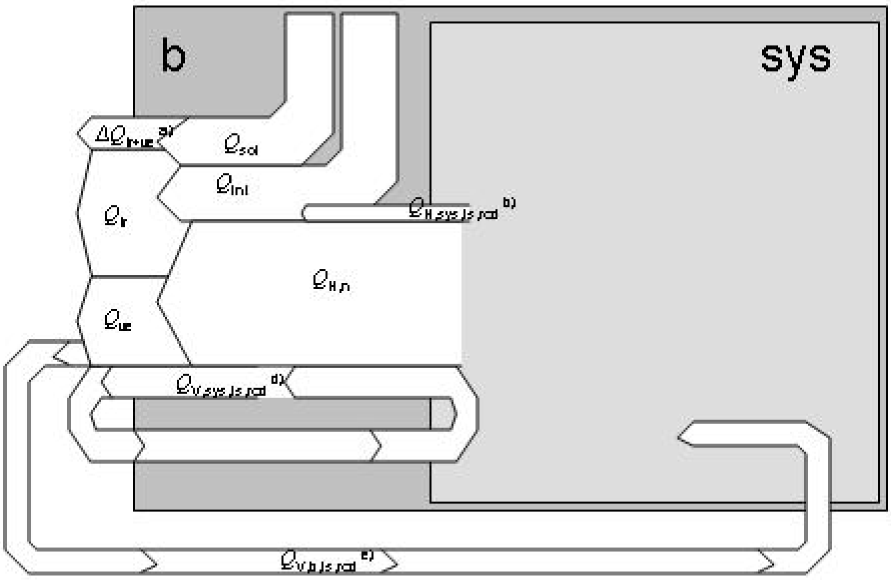
Explanation, building part:

Two elements have been added compared to the simple case:

Heat recovery of ventilation heat losses (*Q*V,sys,ls,rcd); part of the heat loss by ventilation is recovered in a heat recovery unit (pre-heat of the supply air). This is a typical example of the interaction between the **building** and the **system**

Another example of such interaction, but less common, is heat recovered in the **system**, coming from **building** losses (*Q*V,b,ls,rcd); for instance heat recovered from the building construction which is used in the ventilation system (e.g. Trombe wall or dynamic thermal insulation, if connected to ventilation system)

Note: this type of interaction is more common for cooling: pre-cooling of ventilation air via cool building construction; not shown in the diagrams for cooling to avoid too high complexity



"All-in" case, heating, building part

Figure M.3 – Energy balance, building part: heating mode; all possible flows

Explanation, system part:

We see the same two elements with the interaction between system and building as in the previous diagram.

Several elements have been added to the system compared to the simple case:

Renewable electricity, e.g. to be used as auxiliary energy.

Export of heat and electricity, from the (non-renewable) resources and from the renewable energy sources. Note that the subscript for the energy use (H) has been deleted: it is not relevant or even unknown for which use the heat or electricity is exported

The heating system may also use heat from other systems (e.g. recovered losses), in this case illustrated by input from the hot water system (QW,sys,ls,rcd)

System losses that are recovered within the system are not shown in this diagram: they would appear as a loop within the system: losses going out and coming in again

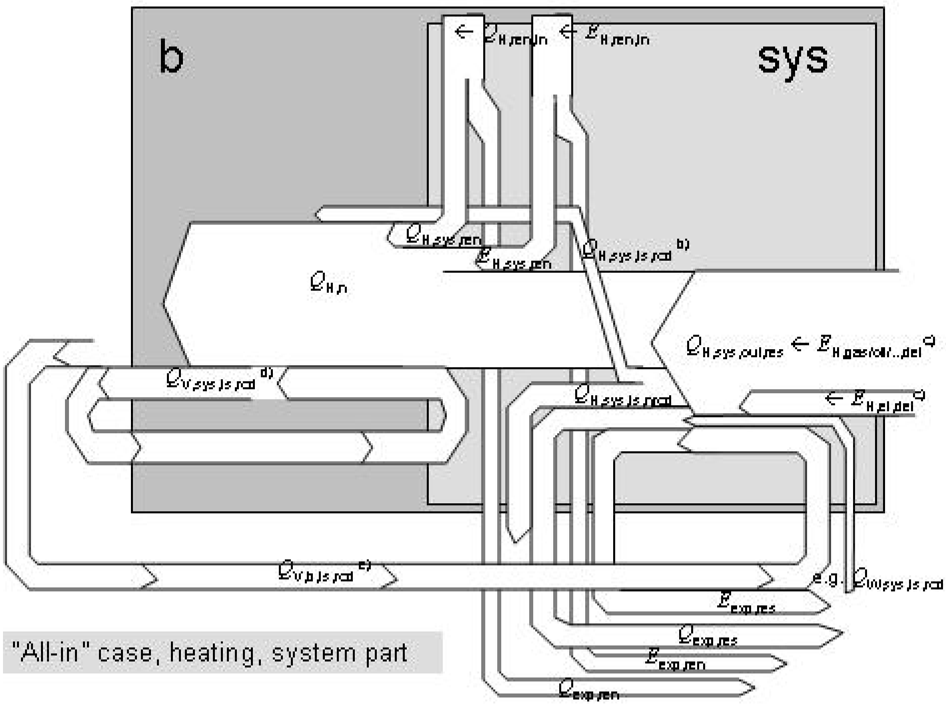


Figure M.4 – Energy balance, system part: heating mode; all possible flows

M.4 Cooling mode, 'medium' case

See clause 4 for the symbols and subscripts.

Explanation, building part:

- Because we deal with cooling, the energy need arrow is pointing outward: heat extracted from the building by the cooling system
- Heat balance:
  - The energy need for cooling is given by the difference between the transmission and ventilation heat transfer (heat losses) and the heat gains from solar and internal sources.
  - The diagram is valid for steady state: the heat balance is taken over a sufficiently long enough time to ignore heat stored and released (typically: one month or a whole season)
  - By convention, the transmission and ventilation heat transfer $Q_{ls} = Q_{tr} + Q_{ve}$ is calculated on the basis of the intended maximum internal temperature, the **set-point temperature**.
  - The **actual time-average (mean) internal temperature** may be lower, due to instances with lower temperatures than the set-point. Consequently, the actual heat losses calculated (or measured) from this actual mean internal temperature are also lower than those calculated on the basis of the set-point temperature. This is represented by the term $-\Delta Q_{tr+ve}$.
  - Note that for the monthly or seasonal 'utilisation factor' method (EN ISO 13790) this ΔQ_{tr+ve} is equal to the 'non-utilised' part of the heat losses by transmission and ventilation $\eta_{gn} * Q_{ls} = \Delta Q_{tr+ve}$. This gives the basic equation: $Q_{C,n} = Q_{gn} - \eta_{ls} * Q_{ls}$
- Explicitly shown is the heat loss from the cooling system that is recovered in the building: the cold parts of the distribution system may lead to a negative heat source (heat sink) which is taken into account as a negative term in the internal heat gains.

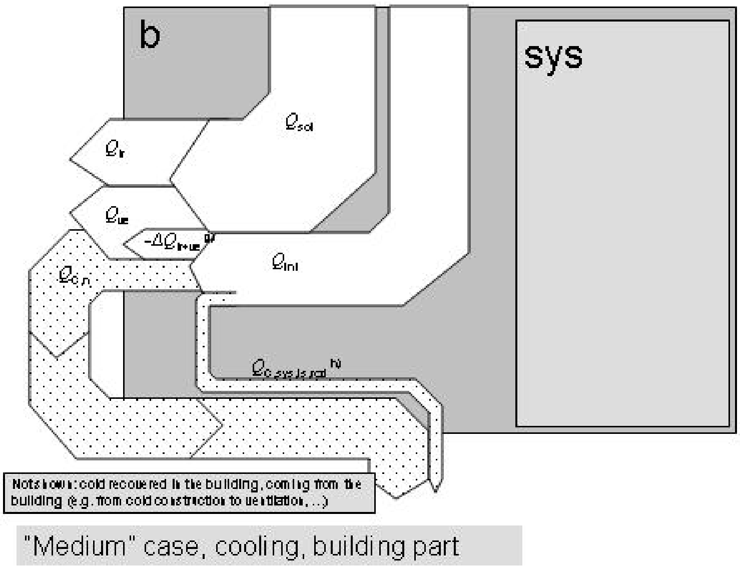


Figure M.5 – Energy balance, building part: cooling mode, 'medium' case with respect to complexity

Explanation, system part:

- The cooling system consists of an ‘energy supply’ part (blanc arrows; usually ‘warm’) and a cold part (dotted arrows)
  - For evident reasons, the losses in the warm part shall be distinguished from the losses in the cold part.
- The system has to supply energy to cover the energy need for cooling, plus the non-recovered losses and the losses recovered in the building (see previous diagram), plus exported cold (if any).
- The supplied energy can be thermal (renewable heat, gas, oil, ..) and/or electric (renewable, resources)
- The delivered energy may consist of different energy carriers, that each have to be counted separately. We have shown electric energy explicitly, because that is often the second energy carrier (e.g. for auxiliary energy). We have shown separately *E*C,el,del and *E*C,gas/oil/..,del to emphasise this.
- System losses that are recovered within the system are not shown in this diagram: they would appear as a loop within the system: losses going out and coming in again

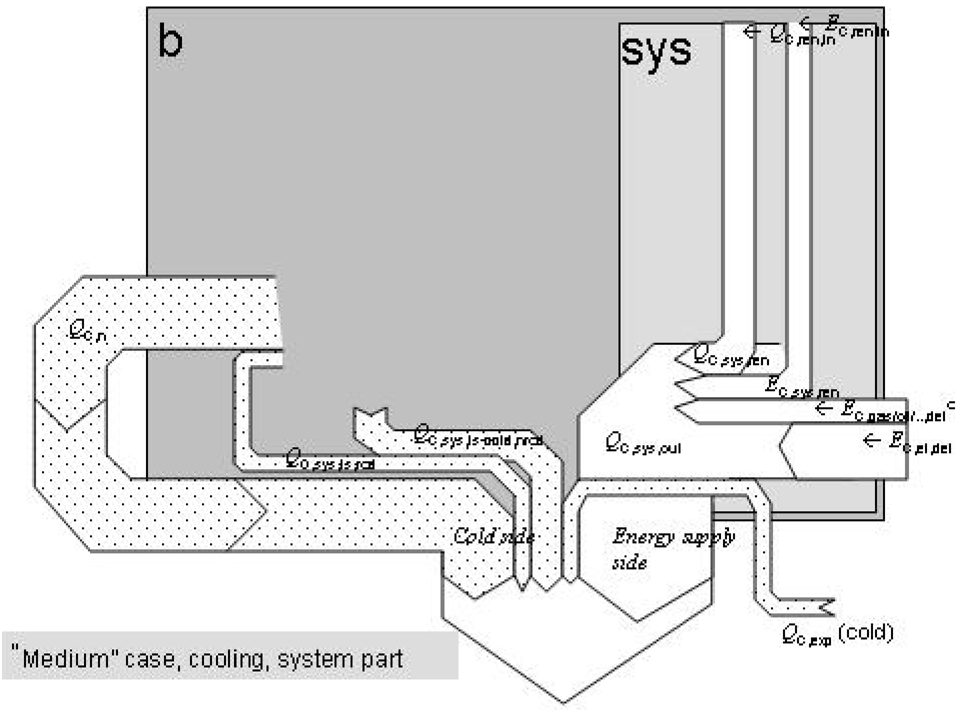


Figure M.6 – Energy balance, system part: cooling mode, 'medium' case with respect to complexity

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