SIST

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Toplotne karakteristike stavb – Izračun potrebne energije za ogrevanje – Stanovanjske stavbe

Thermal performance of buildings - Calculation of energy use for heating - Residential buildings

Wärmetechnisches Verhalten von Gebäuden - Berechnung des Heizenergiebedarfs - Wohngebäude

Performance thermique des bâtiments - Calcul des besoins d'énergie pour le chauffage - Bâtiments résidentiels

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English version

Thermal performance of buildings - Calculation of energy use for heating - Residential buildings

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 89 "Thermal performance of buildings and building components", the secretariat of which is held by SIS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 1999, and conflicting national standards shall be withdrawn at the latest by July 1999.

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The calculation method presented in this standard is based on a steady state energy balance, but taking account of internal and external temperature variations and, through an utilisation factor, of the dynamic effect of internal and solar gains.

This method can be used for the following applications:

1) judging compliance with regulations expressed in terms of energy targets;
2) optimisation of the energy performance of a planned building, by applying the method to several possible options;

3) displaying a conventional level of energy performance of existing buildings;
4) 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;
5) predicting future energy resource needs on an national or international scale, by calculating the energy uses of several buildings representative of the building stock.

The user may refer to other European Standards or to national documents for input data and detailed calculation procedures not provided by this standard.

In some countries the calculation of energy use in buildings forms part of the national regulation. Information about national deviations from this standard due to regulations are given in annex ZB.

1 Scope

This standard gives a simplified calculation method for assessment of the heat use and energy needed for space heating of a residential building, or a part of it, which will be referred to as "the building".

This method includes the calculation of:

1) the heat losses of the building when heated to constant temperature;
2) the annual heat needed to maintain the specified set-point temperatures in the building;
3) the annual energy required by the heating system of the building for space heating.

The building may have several zones with different set-point temperatures. One zone may have intermittent heating.

The calculation period may be either the heating season or a monthly period. Monthly calculation gives correct results on an annual basis, but the results for individual months close to the end and the beginning of the heating season may have large relative errors. Annex K provides more information on the accuracy of the method.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of the publications apply to this European Standard only when incorporated in it or by amendment or revision. For undated references, the latest edition of the publication referred to apply.

prEN 410	Glass in building - Determination of luminous and solar characteristics of glazing
EN ISO 7345	Thermal insulation - Physical quantities and definitions (ISO 7345:1987)
prEN ISO 10077-1	Windows, doors and shutters - Thermal transmittance - Part 1: Simplified calculation method
EN ISO 13786	Thermal performance of building components - Dynamic thermal characteristics - Calculation method (ISO 13786:1997)
EN ISO 13789	Thermal performance of buildings - Transmission heat loss coefficient - Calculation method (ISO 13789:1997)

3 Definitions, symbols and units

3.1 Definitions

For the purpose of this standard, the definitions in EN ISO 7345 and the following definitions apply:

3.1.1 **external temperature**: Temperature of external air.

3.1.2 **internal temperature:** Arithmetic average of the air temperature and the mean radiant temperature at room centre (internal dry resultant temperature).

3.1.3 **set-point temperature**: Design internal temperature.

3.1.4 **intermittent heating:** Heating pattern where, during the course of time, the temperature is allowed to fall below the design temperature.

3.1.5 **heated space**: Rooms or enclosures heated to one or more given set-point temperatures.

3.1.6 **unheated space**: Room or enclosure which is not part of the heated space.

3.1.7 **thermal zone**: Part of the heated space with a given set-point temperature, throughout which the internal temperature is assumed to have negligible spatial variations.

3.1.8 **heat flow coefficient:** Heat flow rate between two thermal zones divided by the temperature difference between both zones.

3.1.9 **heat loss**: Heat transferred from heated space to the external environment by transmission and by ventilation, during a given period of time.

3.1.10 **heat loss coefficient**: Heat flow coefficient from the heated space to the external environment.

NOTE: The heat loss coefficient can be defined only for a single zone building.

3.1.11 **heat gain:** Heat generated within or entering into the heated space from heat sources other than the heating system.

3.1.12 **utilisation factor**: Factor reducing the total monthly or seasonal gains (internal and passive solar), to obtain the part of the useful gains.

3.1.13 **calculation period**: Time period considered for the calculation of heat losses and gains.

NOTE: Most used calculation periods are the month and the heating season.

3.1.14 **heat use:** Heat to be delivered to the heated space to maintain the internal set-point temperature of the heated space.

3.1.15 **energy use for heating:** Energy to be delivered to the heating system to satisfy the heat use.

3.2 Symbols and units

For the purpose of this standard, the following terms and symbols apply.

Table 1: Symbols and units

Symbol	Name of quantity	Unit
A	area	m^2
a	numerical parameter in utilisation factor	-
b	correction factor for unheated zones	-
C	effective heat capacity of a zone	J/K
c	specific heat capacity	J/(kg·K)
e	wind shielding coefficient	-
F	factor	-
f	coefficient related to wind exposure	-
g	total solar energy transmittance of a building element	-
H	heat flow coefficient, heat loss coefficient	W/K
h	surface coefficient of heat transfer	$W/(m^2·K)$
I	quantity of heat or energy per unit area	J/m^2
l	length	m
n	air change rate	s^{-1} or h^{-1}
Q	quantity of heat or energy	J
R	thermal resistance	$m^2·K/W$
T	thermodynamic temperature	K
t	time, period of time	s
U	thermal transmittance	$W/(m^2·K)$
V	volume of air in a heated zone	m^3
$\dot{V}$	air flow rate	m^3/s
α	absorption coefficient of a surface for solar radiation	-
β	fraction of the time period with fans on	-
γ	gain/loss ratio	-
δ	ratio of the accumulated internal-external temperature difference when the ventilation is on to its value over the calculation period	
ε	emissivity of a surface for thermal radiation	-
η	efficiency, utilisation factor for the gains	-
θ	Celsius temperature	°C
κ	factor related to heat losses of ventilated solar walls	
ρ	density	kg/m^3
	Stefan - Boltzman constant ($= 5,67 \times 10^{-8}$)	$W/(m^2·K^4)$
τ	time constant	s
Φ	heat flow rate	W
	point thermal transmittance	W/K
Ψ	linear thermal transmittance	W/(m·K)
ω	ratio of the total solar radiation falling on the element when the air layer is open to the total solar radiation during the calculation period	

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-hour [Wh] instead of joule.

Table 2: Subscripts

C	curtain	ex	exhaust	pp	peak power
D	direct	f	fan	r	radiative; recovered
F	frame	g	gains	s	solar, sunspace
G	ground	gc	control	sup	supply
P	related to power	ge	generation	t	total; technical
S	shading	h	heating; heated	u	unheated
T	transmission	i	internal	v	ventilation
W	wall	*j,k,m,n*	dummy integers	w	windows; water
V	ventilation	l	loss; layer	x	extra; additional
a	air; actual	nh	no heating	*y, z*	zone number
c	capacity	o	output	⊥	perpendicular
d	daily; distribution	p	partition wall	0	base; reference
e	external; emission	ps	permanent shading	50	at 50 Pa pressure difference

4 Outline of the calculation procedure and required data

4.1 Energy balance

The energy balance is defined as including the following (only sensible heat is considered):

- transmission and ventilation losses from the internal to the external environment;
- transmission and ventilation heat losses or heat gains with adjacent zones;
- the useful internal heat gains, that is the used heat output from the internal heat sources
- the used solar gains;
- the generation, distribution, emission and control losses of the heating system;
- the energy input to the heating system.

The terms of the energy balance are illustrated on Figure 1.

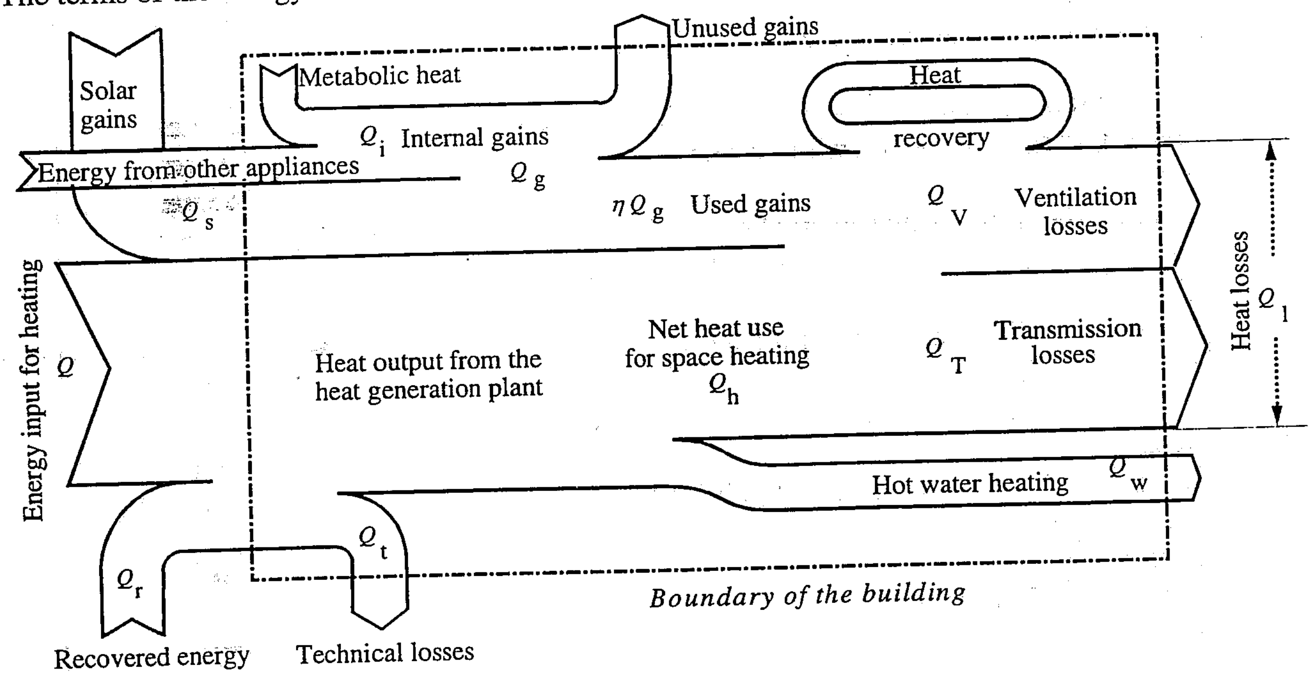

Figure 1: Annual energy balance of a building

4.2 Procedure

The calculation procedure for the building under consideration is listed below. In addition, the special approach given in annex A shall be followed when applying this standard to existing buildings.

1) define the boundaries of the heated space and, if needed, of different zones and unheated spaces, according to 4.3;

2) single zone building: calculate the heat loss coefficient of the heated space according to clause 5;
   multi-zone buildings: follow the procedure in annex B;

3) define the set-point temperature and, if any, the intermittence pattern;

4) for seasonal calculation, define or calculate the length and climatic data of the heating season, according to 8.2.

Then, for each calculation period:

5) calculate the heat losses, Q_l, :
   a) based on the assumption of constant internal temperature, according to clause 5;
   b) when relevant, based on intermittent heating according to 5.3;

6) calculate the internal heat gains, Q_i, according to 6.2;

7) calculate the solar gains; Q_s, according to 6.3;

8) calculate the utilisation factor for total gains, according to 7.2;

9) calculate the heat use, from equation (18);

Then, for the whole year:

10) calculate the annual space heating use, according to clause 8;

11) calculate the heating energy use taking into account the losses or the efficiency of the heating system, according to clause 9.

4.3 Definition of boundaries and zones

4.3.1 Boundary of the heated space

The boundary of the heated space consists of the walls, the lowest floor, and decks or roofs separating the considered heated space from external environment or from adjacent heated zones or unheated spaces. For purchased energy, the boundary is at the delivery point to the building or heating plant. For exhaust air with heat recovery, the boundary is the exit of the recovery unit.

4.3.2 Thermal zones

The heated space can be divided into thermal zones if necessary. When the heated space is heated to the same temperature throughout, and when internal and solar gains are relatively small or evenly distributed throughout the building, the single zone calculation applies.

The division in zones is not required when:

a) set-point temperatures of the zones never differ by more than 4 K, and
   it is expected that the gain/loss ratios differ by less than 0,4 (e.g. between south and north zones), or

b) doors between zones are likely to be open, or

c) one zone is small and it can be expected that the total energy use of the building will not change by more than 5 % by merging it to the adjacent larger zone.

In such cases, even if the set-point temperature is not uniform, the single zone calculation applies. Then the internal temperature to be used is:

$$\theta_i = \frac{\sum_z H_z \theta_{iz}}{\sum_z H_z} \qquad (1)$$

where:

θ_{iz} is the set-point temperature of zone z;

H_z is the heat loss coefficient of zone z, according to clause 5.

In other cases, in particular for buildings that include more than one type of premises under the same roof, the building is divided into several zones, and the calculation procedure given in annex B shall be used.

4.4 Input data

4.4.1 Source and type of input data

When no European Standard is given as a reference, the necessary information may be obtained from national standards or other suitable documents, and these should be used where available. The informative annexes to this standard give values or methods to obtain values when the required information is otherwise not available.

For optimisation of a planned building or retrofitting an existing building, the best available estimate for that particular building shall be used (see annex A). However, if no better estimates are available, conventional values can be used as first approximations.

For predicting the energy needs or judging compliance with standards, conventional values shall be used, in order to make the results comparable between different buildings.

The physical dimensions of the building construction shall be consistent throughout the calculation. Internal, external or overall internal dimensions can be used, but the same type shall be kept for the whole calculation and the type of dimensions used shall be clearly indicated in the report.

NOTE: Some linear thermal transmittances of thermal bridges depend on the type of dimensions used.

4.4.2 Building input data

The input data required for single zone calculation are listed below. Some of these data may be different for each calculation period (e.g. shading correction factors, airflow rates in cold months).

V internal volume of the heated space;
C internal heat capacity of the heated space, according to 7.2, or;
τ time constant of the heated space;
η_h heating system efficiency.

NOTE: Either C or τ is specified, not both.

4.4.3 Input data for heat loss

H_T transmission heat loss coefficient according to EN 13789

For ventilation losses, the following data are required:
$\dot{V}$ air flow rate from heated space to exterior;

For determination of this air flow rate, some of the following quantities can be used:
n_d design air change rate;
n_{50} air change rate at 50 Pa pressure difference;

$\dot{V}_f$ design air flow rate through ventilation fans;
η_v efficiency of the heat recovery system on exhaust air.

4.4.4 Input data for heat gains

Φ_i average internal heat gains during the calculation period;

For glazed envelope elements, the following data shall be collected separately for each orientation (e.g. horizontal and vertical south, north, etc.):

A area of opening in the building envelope for each window or door;
F_F frame factor, i.e. transparent fraction of the area A, not occupied by a frame;
F_C curtain factor, i.e. fraction of the solar radiation transmitted by permanent curtains;
F_s shading correction factor, i.e. average shaded fraction of the area A;
g total solar energy transmittance.

In contrast with EN ISO 13789 clause 5.2, daily average values of the thermal transmittance of windows with shutters, determined on the basis of the values given by EN ISO 10077-1 can be used to determine the heat loss.

NOTE: Collecting areas which do not provide heat directly to the heated volume (such as thermal solar collectors connected to a separate heat storage or photovoltaic cells) should not be taken into account at this stage. These are considered as part of the heating system.

Additional data should be collected for envelope elements containing heating devices and components collecting solar radiation, such as transparent insulation, ventilated solar walls, sunspaces, etc., as well as for calculation of the effect of intermittent heating. The required data are listed in the corresponding annexes.

4.4.5 Climatic data

θ_e monthly or seasonal average of external temperatures;
$I_{s,j}$ monthly or seasonal total solar radiation per unit area for each orientation, in J/m².

4.4.6 Occupancy data

θ_i set-point temperature;

Additional data should be collected when the effect of intermittent heating should be considered. These are listed in annex J

5 Heat losses at constant internal temperature

5.1 Principle

The total heat loss, Q_l, of a single zone building at uniform internal temperature, during a given period of time, is:

$$Q_l = H(\theta_i - \theta_e)\,t \qquad (2)$$

where:

θ_i is the set-point temperature;

θ_e is the average external temperature during the calculation period;

t is the duration of the calculation period;

H is the heat loss coefficient of the building:

$$H = H_T + H_V \qquad (3)$$

Where:

H_T is the transmission heat loss coefficient, calculated according to EN 13789 (for envelope elements incorporating ventilating devices, see annex C);

H_V is the ventilation heat loss coefficient (see 5.2).

NOTE: $(\theta_i - \theta_e)\,t$ is related to degree days defined in different ways in various countries.

Equation (2) can be adapted at a national level to allow for the use of degree days. The result of the adapted relation shall nevertheless be the same as that of equation (2) for any residential building.

5.2 Ventilation heat loss coefficient

5.2.1 Principle

The ventilation heat loss coefficient, H_V, is calculated by:

$$H_V = \dot{V} \rho_a c_a \tag{4}$$

where

$\dot{V}$ is the air flow rate through the building; including air flow through unheated spaces;

$\rho_a c_a$ is the heat capacity of the air per volume.

NOTE: If the air flow rate, $\dot{V}$, is in m³/s, $\rho_a c_a$ = 1200 J/(m³·K). If $\dot{V}$ is given in m³/h, $\rho_a c_a$ = 0,34 Wh/(m³·K).

The airflow rate, $\dot{V}$, can be calculated from an estimate of the air change rate, n, by:

$$\dot{V} = V n \tag{5}$$

where V is the volume of the heated space, calculated on the basis of the internal dimensions.

5.2.2 Minimum ventilation

For comfort and hygienic reasons a minimum ventilation rate is needed when the building is occupied. This minimum ventilation rate should be determined on a national basis, taking account of the building type and the pattern of occupancy for the building.

NOTE: When no national information is available, the recommended value for dwellings is:

$$n_{min} = 0,5\ \text{h}^{-1} \qquad \text{hence} \qquad \dot{V}_{min} = 0,5\ V\ \text{m}^3/\text{h} \tag{6}$$

In buildings equipped with demand controlled ventilation, in rooms with high ceilings and in buildings with long periods without occupants, the required air change rate could be lower.

5.2.3 Natural ventilation

The total ventilation rate shall be determined as the greater of the minimum ventilation rate $\dot{V}_{min}$ and the design ventilation rate $\dot{V}_d$:

$$\dot{V} = \max\ [\dot{V}_{min}\ ;\ \dot{V}_d] \tag{7}$$

NOTE: Where no national information is available the air change rate may be assessed from tables F.2 or F.3.

5.2.4 Mechanical ventilation systems

The total air flow rate is determined as the sum of the ventilation rate determined from the average air flow rates through the system fans when in operation, $\dot{V}_f$, and an additional air flow rate, $\dot{V}_x$, induced by wind and stack effect on untight envelope:

$$\dot{V} = \dot{V}_f + \dot{V}_x \tag{8}$$

For balanced ventilation systems, $\dot{V}_f$ is equal to the greater of the supply air flow rate, $\dot{V}_{sup}$, and exhaust air flow rate, $\dot{V}_{ex}$.

NOTE: When no national information exists, the estimation of the additional air flow rate, $\dot V_x$, can be calculated from:

$$\dot V_x = \frac{V \cdot n_{50} \cdot e}{1 + \frac{f}{e}\left[\frac{\dot V_{sup} \quad \dot V_{ex}}{V \cdot n_{50}}\right]^2} \qquad (9)$$

where:

n_{50} is the air change rate resulting of a pressure difference of 50 Pa between inside and outside, including the effects of air inlets;

e and f are shielding coefficients which can be found in Annex F

If there is a mechanical ventilation switched on for a part of the time, the air flow rate is calculated by:

$$\dot V = \dot V_0 (1 \quad \beta) + (\dot V_f + \dot V_x)\beta \qquad (10)$$

where:

$\dot V_f$ is the design air flow rate due to mechanical ventilation;

$\dot V_x$ is the additional infiltration air flow rate with fans on, due to wind and stack effect;

$\dot V_0$ is the air flow rate with natural ventilation, with fans off, including flows through ducts of mechanical system;

$\dot V_x'$ is the additional infiltration air flow rate with fans off, due to wind and stack effect;

$\dot V_x' = V\, n_{50}\, e$;

β is the fraction of the time period with fans on.

For mechanical systems with variable design airflow rate, $\dot V_f$ is the average air flow rate through the fans during their running time.

5.2.5 Mechanical systems with heat exchangers

For buildings with heat recovery from exhaust air to inlet air, the heat losses by the mechanical ventilation are reduced by the factor $(1-\eta_v)$ where η_v is the efficiency factor of the air to air heat recovery system. Thus the effective air flow rate for heat loss calculation is determined from:

$$\dot V = \dot V_f (1-\eta_v) + \dot V_x \qquad (11)$$

For systems with heat recovery from the exhaust air to the hot water or space heating system via a heat pump, the ventilation rate is calculated without reduction. The reduction in energy use due to heat recovery shall be allowed for in the calculation of the energy consumption of the relevant system.

5.3 Effect of intermittence

With intermittent heating, heat loss is reduced, due to lowering of the average internal temperature. Heat losses with intermittent heating may be calculated with equation (2), the set-point temperature being replaced by the average internal temperature. The reduction in heat losses can also be calculated directly.

NOTE: The heat loss with intermittent heating can be treated using national procedures. In the absence of suitable national information, annex J provides an appropriate procedure.