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Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads —

Part 3: Calculation procedures regarding adaptive building envelope elements

Performance énergétique des bâtiments — Besoins d'énergie pour le chauffage et le refroidissement, les températures intérieures et les chaleurs sensible et latente —

Partie 3: Méthodes de calcul des éléments adaptables de l'enveloppe du bâtiment

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Foreword

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by ISO Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all the parts in the ISO 52016 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document, along with other international standards, assesses the overall energy performance of buildings (EPB). Throughout this document, this group of standards is referred to as the "set of EPB standards". A list of the standards in this set can be found on the EPB Center website.[1)]

All EPB standards follow specific rules to ensure overall consistency, unambiguity and transparency.

All EPB standards provide a certain flexibility with regard to the methods, the required input data and references to other EPB standards, by the introduction of a normative template in Annex A and Annex B with informative default choices.

The main target groups for this document are architects, engineers and regulators.

Further target groups are parties who want to motivate their assumptions by classifying the EPB for a dedicated building stock.

This document is also important for manufacturers and suppliers of adaptive building envelope elements.

Background information, including justification, explanation and demonstration of the calculation procedures in this document, is provided in ISO/TR 52016-4[2)].

The subset of EPB standards prepared under the responsibility of ISO/TC 163/SC 2 cover inter alia:

— calculation procedures on the overall energy use and EPB;

— calculation procedures on the internal temperature in buildings (e.g. in case of no space heating or cooling);

— indicators for partial EPB requirements related to thermal energy balance and fabric features;

— calculation methods covering the performance and thermal, hygrothermal, solar and visual characteristics of specific parts of the building and specific building elements and components, such as opaque envelope elements, ground floor, windows and facades.

ISO/TC 163/SC 2 cooperates with other Technical Committees for the details on, for example, appliances, technical building systems and indoor environment.

This document presents procedures for taking into account the effect of adaptive building envelope elements in the calculation of the energy needs for heating and cooling, internal temperatures and sensible and latent heat loads according to ISO 52016-1.

This document takes precedence if there is a conflict with any provision in ISO 52016-1.

NOTE 1 For instance some of the simplified calculation procedures in ISO 52016-1:2017, Annex G, *Dynamic transparent building elements,* are in conflict with the more refined procedures in this document.

Default references to EPB standards other than ISO 52000-1 are identified by the EPB module code number and given in Annex A (normative template in Table A.1) and Annex B (informative default choice in Table B.1).

EXAMPLE EPB module code number: M5–5, or M5–5.1 (if module M5–5 is subdivided), or M5–5/1 (if reference to a specific clause of the standard covering M5–5).

1) https://epb.center/support/documents.

2) Under preparation. Stage at the time of publication: ISO/WD TR 52016-4.

Table 1 shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in ISO 52000-1.

NOTE 2 In ISO/TR 52000-2[7] the same table can be found, with, for each module, the numbers of the relevant EPB standards and accompanying technical reports that are published or under preparation.

NOTE 3 The modules in Tables A.1 and B.1 represent EPB standards, although one EPB standard can cover more than one module and one module can be covered by more than one EPB standard, for instance a simplified and a detailed method respectively.

Table 1 — Position of this document (in casu M2-2 and M2-3), within the modular structure of the set of EPB standards

	Overarching		Building (as such)		Technical building systems									
Submodule	**Descriptions**		**Descriptions**		**Descriptions**	**Heating**	**Cooling**	**Ventilation**	**Humidification**	**Dehumidification**	**Domestic hot water**	**Lighting**	**Building automation and control**	**e.g. PV, wind**
sub1		**M1**		**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
1	General		General		General									
2	Common terms and definitions; symbols, units and subscripts		Building energy needs	ISO 52016-3 (this document)	Needs								a	
3	Applications		(Free) Indoor conditions without systems	ISO 52016-3 (this document)	Maximum load and power									
4	Ways to express energy performance		Ways to express energy performance		Ways to express energy performance									
5	Building categories and building boundaries		Heat transfer by transmission		Emission and control									
6	Building occupancy and operating conditions		Heat transfer by infiltration and ventilation		Distribution and control									

a The shaded modules are not applicable.

Table 1 *(continued)*

	Overarching		Building (as such)		Technical building systems									
Submodule	**Descriptions**		**Descriptions**		**Descriptions**	**Heating**	**Cooling**	**Ventilation**	**Humidification**	**Dehumidification**	**Domestic hot water**	**Lighting**	**Building automation and control**	**e.g. PV, wind**
sub1		**M1**		**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
7	Aggregation of energy services and energy carriers		Internal heat gains		Storage and control									
8	Building zoning		Solar heat gains		Generation and control									
9	Calculated energy performance		Building dynamics (thermal mass)		Load dispatching and operating conditions									
10	Measured energy performance		Measured energy performance		Measured energy performance									
11	Inspection		Inspection		Inspection									
12	Ways to express indoor comfort				BMS									
13	External environment conditions													
14	Economic calculation													

[a] The shaded modules are not applicable.

Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads —

Part 3: Calculation procedures regarding adaptive building envelope elements

1 Scope

This document specifies procedures for the calculation of the energy needs for heating and cooling, internal temperatures and sensible and latent heat loads of a building according to the hourly calculation methodology in ISO 52016-1. Additions or modifications of the calculations are provided in this document if the building envelope contains one or more adaptive building envelope elements (building envelope elements with adaptive components that are either environmentally or actively controlled as a function of specific conditions). The adaptive building envelope element replaces the transparent building element in the calculation according to ISO 52016-1.

The three types of adaptive building envelope elements covered in this document are:

— building envelope elements with dynamic solar shading;

— building envelope elements with chromogenic glazing;

— building envelope elements with an actively ventilated cavity.

Environmentally activated control is described for building envelope elements with chromogenic glazing, but can also occur for other types of adaptive building envelope elements. In that case the same approach applies as for environmentally activated chromogenic glazing.

This document is applicable to the assessment of the energy performance of buildings (EPB) (energy performance labels and certificates), including comparison between buildings and checking conformity with minimum energy performance criteria.

It is also applicable to assess the contribution of the adaptive building envelope element to the smart readiness of a building.

In addition, this document provides indicators for the impact of the adaptive building envelope element on the performance of the building compared to a reference building envelope element. It is applicable to buildings at the design stage, to new buildings after construction and to existing buildings in the use phase.

This document is not applicable to geometrically complex adaptive building envelope elements that can only be modelled as multiple coupled thermal zones.

NOTE The background to the selection of adaptive building envelope elements is given in ISO/TR 52016-4.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Thermal insulation — Physical quantities and definitions*

ISO 15099, *Thermal performance of windows, doors and shading devices — Detailed calculations*

ISO 52000-1, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures*

ISO 52016-1:2017, *Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 1: Calculation procedures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 9488, ISO 52000-1, ISO 52016-1, and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
adaptive building envelope element
building envelope or part of it with at least one layer having physical properties that can be adapted in a reversible way as a (passive, intrinsic) response to transient conditions or actively controlled to adjust to transient conditions or changing priorities

Note 1 to entry: A part of a building envelope can be a product or assembly consisting of single or multiple layers, usually with transparent components.

EXAMPLE 1 Examples of an adaptive building envelope element:

— a window or facade with *dynamic solar shading* (3.7) (blind or shutter);

— a window with *chromogenic glazing* (3.6);

— a window or façade with an *actively ventilated cavity* (3.8).

EXAMPLE 2 Examples of conditions:

— external, such as climate;

— internal, such as occupants' requirements;

— local, such as material temperature.

EXAMPLE 3 Example of physical properties:

— thermal;

— optical;

— structural.

EXAMPLE 4 Example of changing priorities:

— minimizing the building energy use;

— optimizing indoor environment conditions;

— minimizing glare;

— maximizing privacy.

3.2
actively controlled adaptive component
component with properties that vary as a function of specific situations or events, which can be the result of an active intervention

EXAMPLE Examples of such specific situations or events: set points (e.g. time, temperature, air flow, irradiance, illuminance), occupant intervention, complex algorithm.

3.3
environmentally activated adaptive component
component with properties that vary passively as a function of specific situations or events due to an intrinsic characteristic, without the possibility for an active intervention

EXAMPLE Examples of such specific situations or events: material temperature, irradiance or illuminance, solar position.

Note 1 to entry: Also known as passive or intrinsic control.

3.4
environmentally activated adaptive building envelope element
building envelope element with one or more environmentally activated adaptive components

3.5
actively controlled adaptive building envelope element
building envelope element with one or more actively controlled adaptive components

3.6
chromogenic glazing
glazing with optical and visual properties that can vary (passively or actively) as a function of a specific environmental condition

EXAMPLE

— thermochromic glazing (passive);

— thermotropic glazing (passive).

— photochromic glazing (passive);

— electrochromic glazing (active);

— liquid crystal glazing (active);

— suspended particle device (active).

3.7
dynamic solar shading
product installed to provide or modify characteristics (e.g. thermal, visual, security level) of a window, door, curtain walling or facade, to which it is applied

EXAMPLE

— internal blind (e.g. venetian blind, roller blind, vertical blind, pleated blind, honeycomb blind);

— external blind (e.g. vertical roller blind, external venetian blind);

— integrated blind (e.g. venetian blind, roller blind);

— blind in a closed cavity façade (e.g. unventilated);

— shutters (e.g. roller shutter, wing shutter, concertina shutter).

Note 1 to entry: Adapted from EN 12216:2018, 3.1.

3.8
actively ventilated cavity
cavity between two layers of glazings, or similar material, that is part of a building envelope element that can be intentionally ventilated with the purpose to exchange heat between the air and these layers or the internal environment

EXAMPLE Naturally, hybrid or mechanically ventilated cavity

— in a double envelope facade,

— in a window with integrated venetian or roller blinds, and

— with fixed or operated vent openings.

Note 1 to entry: A building envelope element with ventilation openings that can be operated to control ventilation of the building or building part, without thermal interaction within the building envelope element itself, is not considered as an *adaptive building envelope element* (3.1) with actively ventilated cavity. This also applies to ventilative cooling, which is a complementary potential technique to decrease the need for mechanical cooling and to increase thermal comfort.

3.9
simplified adaptive building envelope element
adaptive building envelope element (3.1) that is described with a model in which the thermal, daylight and solar properties, for a given state, can be pre-calculated

Note 1 to entry: The same (simplified) model as used to describe a transparent building element in ISO 52016-1:2017, 6.5.7.4.

3.10
detailed adaptive building envelope element
adaptive building envelope element (3.1) that is described with a more complex model than a *simplified adaptive building envelope element* (3.9)

Note 1 to entry: For a given state, the thermal, daylight and solar properties of the adaptive building envelope element depend on the conditions. These are calculated at each time interval on the basis of the model and the properties of the individual components.

3.11
illuminance
<at a point of a surface> quotient of the luminous flux incident on an element of the surface containing the point, divided by the area of that element

Note 1 to entry: This is expressed in lux, 1 lx = 1 lm·m^{-2}.

[SOURCE: ISO 16817:2017, 3.12, modified — Symbols were removed.]

3.12
daylight illuminance
E_v
illuminance produced by daylight

4 Symbols, subscripts and abbreviated terms

4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1 and the following apply.

Table 2 — Symbols

Symbol	Name of quantity	Unit
A	area	m^2
a_{sol}	solar absorption coefficient	—
b	temperature reduction factor	—
E_v	daylight illuminance	lx
g	total solar energy transmittance	—
H	height	m
h	surface coefficient of heat transfer	$W/(m^2 \cdot K)$
I_{sol}	solar irradiance	W/m^2
L	Length, width	m
N	number of items (integer only)	—
P	probability	—
Q	quantity of heat	kWh[a]
q	heat flow density	W/m^2
q_V	air (volume) flow rate	m^3/h
R	thermal resistance	$m^2 \cdot K/W$
T	thermodynamic temperature	K
T	accumulated over- or under-temperature	K·h
t	time	s [a]
U	thermal transmittance	$W/(m^2 \cdot K)$
θ	Celsius temperature	°C
Φ	heat flow rate, heat load, power	W

[a] Hours (h) are used as the unit of time instead of seconds when aggregating heat or energy flow (W) to quantity of heat or energy (kWh).

4.2 Subscripts

For the purposes of this document, the subscripts given in ISO 52000-1 apply.

In addition, subscripts from ISO 52016-1 that apply to this document are given in Table 3.

NOTE Relevant subscripts already given in ISO 52000-1 are included, if necessary, for the understanding of this document.

Table 3 — Subscripts from ISO 52016-1 that apply to this document

Subscript	Term	Subscript	Term	Subscript	Term
a	air	int	internal or indoor[c]	s	surface
an	annual	i	internal	se	surface external
C	cooling[a]	L	lighting[a]	r	radiation, radiative
c	structure, construction element	ld	load	re	radiative external (~r;e)
c	convection, convective	lim	limited	set	set-point

[a] Type of energy use (energy service).

[b] The subscript "e" is used for the term "external", in contrast with "internal", but if there is a risk of confusion between "external" to (for instance) a construction in general and "external", meaning outdoor environment, then the term "outdoor" is recommended for the latter.

[c] The subscript "int" is used for the term "internal", in contrast with "external", but if there is a risk of confusion between "internal" in a construction and "internal" in a building or thermal zone, then the term "indoor" is recommended for the latter.

Table 3 *(continued)*

Subscript	Term	Subscript	Term	Subscript	Term
calc	calculation	lr	long-wave radiation	sh	shading
ce	convective external (~c;e)	m	monthly	sht	shutter
ci	convective internal (~c;i)	mn	mean	sol	solar
day	daily	n	normal to surface	spec	specific
dayl	daylight	nd	need	st	state
e	external or outdoor[b]	noc	unoccupied period	sup	supply
eff	effective	oc	occupants	sys	system
el	element	occ	occupied period	tot	total
gl	glazing, glazed element	oel	opaque element	tr	transmission (heat transfer)
H	heating[a]	op	operative, opaque	V	visual
ht	heat transfer	p	projected	ve	ventilation (heat transfer)
i,j,k,z	indexes	ri	radiative internal (~r;i)	w	window
hyst	hysteresis			zt	thermal zone
				dglare	daylight glare

[a] Type of energy use (energy service).

[b] The subscript "e" is used for the term "external", in contrast with "internal", but if there is a risk of confusion between "external" to (for instance) a construction in general and "external", meaning outdoor environment, then the term "outdoor" is recommended for the latter.

[c] The subscript "int" is used for the term "internal", in contrast with "external", but if there is a risk of confusion between "internal" in a construction and "internal" in a building or thermal zone, then the term "indoor" is recommended for the latter.

NOTE In this document subscripts that are indexed (counting 1, 2, ...) can be found written in two ways:

— the comprehensive way: by adding an index (e.g. *i*) to the subscript, separated by a comma and written in italics, e.g. "w,*i*", for a variable related to a window, for window element *i*;

— the short way: as the subscript itself written in italics.

EXAMPLE "*m*" is the monthly value of a variable, for the month *m*;

— this is short for "m,*i*": the monthly value of a variable, for the month *i*.

Similarly, if there is no risk of confusion, it is also possible to write: "*wi*" instead of "w,*i*".

Addition subscripts given in Table 4 apply.

Table 4 — Additional subscripts

Subscript	Term	Subscript	Term	Subscript	Term
adapt	adaptive	limHE	operative temperature limit between heating and neutral mode	stA, stB, ...	states of a specific dimension of variation (A, B are placeholders for more specific subscripts
chro	chromogenic	limRL	upper limit for low radiation mode	vest	ventilation related state
close	closed	limRH	lower limit for high radiation mode		

Table 4 *(continued)*

Subscript	Term	Subscript	Term	Subscript	Term
limCO	operative temperature limit between neutral and cooling mode	limTH	limit between high and very high operative temperature		
limGY	lower limit for glare mode	limTN	limit between fine and high operative temperature		
limLL	limit between normal and low daylight mode	st	state; in case of variations in more than one dimension: a unique combination of states in each dimension		

4.3 Abbreviated terms

For the purposes of this document, the abbreviated terms given in ISO 52000-1:2017, Clause 4 and Table 5 below apply.

Table 5 — Abbreviated terms

Abbreviated term	Term
AVF	active ventilated façade
CCD	charge-coupled device
DGP	daylight glare probability
HVAC	heating, ventilation and air conditioning
n.a.	not applicable
PIR	passive infrared
ZT	thermal zone

5 Description of the method

5.1 Output of the method

The output of the calculation is the output of the hourly calculation methodology of ISO 52016-1:2017, 6.1.

Additional output consists of key performance indicators to show the difference between the performance of the thermal zone with the adaptive building envelope element against reference or other building envelope elements.

5.2 General description of the method

The calculation procedure consists of the following steps:

Step 1:

Identify the type of adaptive building envelope element (6.4).

Step 2: