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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 latentes - Partie 3: Procédures de calcul concernant les éléments de l'enveloppe adaptative 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 documents 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 belongs to the family of international standards to assess the overall energy performance of buildings. Throughout this document, this group of standards is referred to as the “set of EPB standards”.

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 building energy performance 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 52016-4¹.

The subset of EPB standards prepared under the responsibility of ISO/TC 163/SC 2, *Thermal performance and energy use in the built environment — Calculation methods*, cover inter alia:

- calculation procedures on the overall energy use and energy performance of buildings;
- 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 52106-1.

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.

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.

¹ Under preparation. Stage at the time of publication: ISO/WD TR 52016-4.

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 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. See also Tables A.1 and B.1.

Table 1 — Position of this document (in casu M2-5 and M2-8), within the modular structure of the set of EPB standards

| Submodule | Overarching | | Building (as such) | | Technical building systems | | | | | | | | | |
|-----------|---|----|---|-------------|------------------------------------|---------|---------|-------------|----------------|------------------|--------------------|----------|---------------------------------|--------------|
| | Descriptions | M1 | Descriptions | M2 | Descriptions | Heating | Cooling | Ventilation | Humidification | Dehumidification | Domestic hot water | Lighting | Building automation and control | 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 | Needs | | | | | | | | a | |
| 3 | Applications | | (Free) Indoor conditions without systems | ISO 52016-3 | 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 | | | | | | | | | |
| 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 | | Load dispatching and | | | | | | | | | |

| | | | | | | | | | | | | | | |
|----|---------------------------------|--|-----------------------------|--|-----------------------------|--|--|--|--|--|--|--|--|--|
| | | | (thermal mass) | | 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 | | | | | | | | | | | | | |

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 (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 1 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 [for windows with scattering glazing and/or solar shading devices]

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

ISO 52022-3, Energy performance of buildings — Thermal, solar and daylight properties of building components and elements — Part 3: Detailed calculation method of the solar and daylight characteristics for solar protection devices combined with glazing

NOTE 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).

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 a 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 (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 such as thermal, visual, security level, of a window, door, curtain walling or facade to which it is applied

EXAMPLE

- Internal blind (venetian blind, roller blind, vertical blind, pleated blind, honeycomb blind, ...)
- External blind (vertical roller blind, external venetian blind,...)
- Integrated blind (venetian blind, roller blind, ...)

- Blind in a closed cavity façade (unventilated)
- Shutters (roller shutter, wing shutter, concertina shutter, ...)

NOTE 1 to entry Definition is copied from the definition for blind, awning, shutter in EN 12216:2018, 3.1 — Examples were added.

3.8

actively ventilated cavity

cavity between two layers of glazings or similar material that are 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
- 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, $1 \text{ lx} = 1 \text{ lm}\cdot\text{m}^{-2}$.

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

3.12

Daylight illuminance

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 ·K) |
| I_{sol} | solar irradiance | W/m ² |
| L | Length, width | m |
| N | number of items (integer only) | — |
| 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 ·K/W |
| T | thermodynamic temperature | K |
| T | accumulated over- or undertemperature | K·h |
| t | time | s |
| U | thermal transmittance | W/(m ² ·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 |
| 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 | ve | ventilation (heat transfer) |
| ht | heat transfer | p | projected | w | window |
| i,j,k,z | indexes | ri | radiative internal (~r;i) | zt | thermal zone |

^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.

For instance "*w,i*", for a variable related to a window, for window element *i*;

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

For instance: "*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: "*w,i*" instead of "*w,i*".

Finally, the 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 | V | visual (daylight) |
| close | closed | limRN | lower limit for high radiation mode | V | ventilation |
| limCO | operative temperature limit between neutral and cooling mode | limTH | limit between high and very high operative temperature | vest | ventilation related state |
| limGY | lower limit for glare mode | limTN | limit between fine and high operative temperature | | |
| limDL | 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 Annex C and Table 5 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:

- If the adaptive building envelope element is “simplified”: gather the input data of the adaptive building envelope element (see 6.4.3).
- If the adaptive building envelope element is “detailed”: determine the details of the model the adaptive building envelope element and gather the input data of its components (see 6.4.4).

Step 3:

Connect the model of the adaptive building envelope element to the model of the thermal zone in ISO 52016-1 (see 6.5).

Step 4:

Select the control scenario

Select the control type (see 6.6)

EXAMPLE 1 Environmentally activated or actively controlled (manual, motorized, automated)

For an environmentally activated adaptive building envelope element (see 6.7)

For an actively controlled adaptive building envelope element (6.8), with the following sub-steps:

- a) Select the applicable conditions and events for the control and select which methods apply to identify the conditions and events (6.8.2)
- b) Select the applicable sensors to detect the conditions or events and gather the associated extra input data (6.8.3).
EXAMPLE 2 Solar irradiance or illuminance meter; clock + location + algorithm to identify sun position
- c) Selection of methods to identify the conditions or events (6.8.4)
EXAMPLE 3 For daytime versus night time: measured solar irradiance, calculated sun path or pre-calculated table with sunrise and sunset.
- d) Apply the reference control scenario (6.8.7), based on a number of assumptions and rules (6.8.5 and 6.8.6).
EXAMPLE 4 Roller blinds fully extended when high solar irradiance.

- e) Specify the criteria (values) for the conditions and events as a function of control type, space category and other factors (6.8.76.8.7).

Step 5:

Perform the hourly calculation according to ISO 52016-1 with the additions and adaptations from Step 1 through Step 4 (see 6.9)

Step 6:

Post-processing of the output of the calculation (6.10).

NOTE 1 Worked examples are provided in ISO 52016-4.

The overviews of all output data with indication of the possible destination (6.1) and all input data with indication of the source (6.3) enable to check the overall consistency between related EPB standards, where the output of one EPB standard is needed as input for the other.

NOTE 2 This conforms to the common template for each of the EPB standards.

The first steps of the calculation procedure are more generic than needed for the specific reference control scenarios. In this way the calculation procedures are ready to cover other, e.g. more novel and complex technologies, in a later update.

6 Calculation method

6.1 Output data

subclause 6.1 provides the overview of all output data. When and how these output data are produced is specified in 6.4 to 6.10.

NOTE This subclause conforms to the common template for each of the EPB standards. It enables to check input-output relations between the EPB standards and availability of output data.

The output of the calculation is given in ISO 52016-1:2017, 6.1 (Table 2 to Table 10). Additional output is given in Table 6. This Table lists the key performance indicators for the difference between the performance of the thermal zone with the adaptive building envelope element against reference or other building envelope elements.

Table 6 — Output data: key performance indicators of the adaptive building envelope element against a reference element

| Description | Symbol | Unit | Validity interval ^a | Intended destination module ^b | Varying ^c |
|--|---------------------------|-------------------------|--------------------------------|--|----------------------|
| Absolute difference in annual (a) heating, (b) cooling and (c) heating plus cooling needs per m ² useful floor area of the thermal zone, zt | $\Delta Q_{H/C/HC;nd;zt}$ | kWh/(m ² .a) | - ∞ to ∞ | M2-4 | N |
| Relative difference in annual (a) heating, (b) cooling and (c) heating plus cooling needs per m ² useful floor area of the thermal zone, zt | $dQ_{H/C/HC;nd;zt}$ | % | - ∞ to ∞ | M2-4 | N |

| Description | Symbol | Unit | Validity interval ^a | Intended destination module ^b | Varying ^c |
|--|--|----------------------|--------------------------------|--|----------------------|
| Absolute difference in annual (a) low resp. (b) high temperatures: accumulated hours of indoor operative temperature of the thermal zone z_t , during occupancy below 20°C resp. above 25°C ^d | $\Delta T_{\text{low/high};z_t;\text{an}}$ | K·h | $-\infty$ to ∞ | M2-4 | N |
| Relative difference in annual (a) low resp. (b) high temperatures: accumulated hours of indoor operative temperature of the thermal zone, z_t , during occupancy below 20°C resp. above 25°C ^d | $dT_{\text{low/high};z_t;\text{an}}$ | % | $-\infty$ to ∞ | M2-4 | N |
| Monthly or annual mean thermal transmittance or U -value of the adaptive building envelope element w , weighted by indoor-outdoor temperature difference | $U_{w;mn;m/\text{an}}$ | W/(m ² K) | 0 to 5 | M2-4 | Y (M) |
| Monthly or annual mean solar transmittance or g -value of the transparent part of the adaptive building envelope element w , weighted by incident irradiance ^e | $g_{gl;mn;m/\text{an}}$ | - | 0 to 1 | M2-4 | Y (M) |
| Monthly or annual mean daylight transmittance, τ_V of the transparent part of the adaptive building envelope element w , weighted by incident illuminance ^e | $\tau_{V;gl;mn;m/\text{an}}$ | - | 0 to 1 | M2-4 | Y (M) |
| <p>^a Practical range, informative.</p> <p>^b Informative.</p> <p>^c "Varying": value can vary over time: different values per time interval, for instance: hourly values or monthly values (not constant values over the year).</p> <p>^d In the context of the improvement of the set of EPB standards, specifications for a winter and summer thermal comfort score is under preparation, based on EN 16798-1, to replace this performance indicator in the future.</p> <p>^e with subscript gl instead of w for the optical properties, because the daylight and solar properties are per m² of projected transparent area.</p> | | | | | |

6.2 Calculation time intervals

The calculation time intervals shall be hourly.

If daily, monthly, yearly data are needed, they may be aggregated from hourly data by taking the monthly mean or monthly total values and adding the subscript corresponding with the period (d, m, an). The number of hours per month can be aggregated in the same way.

NOTE 1 The hourly time interval corresponds to the time intervals needed for energy calculations and the availability of hourly integrated solar irradiance data. If data on shorter time intervals is available, the method can be applied to shorter time intervals.

NOTE 2 For glare prevention, the hourly time interval can be too large, possibly leading to an unrealistically optimistic scenario. As mitigation, a conservative criterion for glare risk is applied.

A simplified monthly calculation can be developed at national level on the basis of statistical evaluation of a range of test cases calculated with the hourly method. The principles of a simplified method are provided in ISO 52016-1:2017, Annex G.

6.3 Input data

6.3.1 General

subclause 6.3 provides the overview of all input data. When and how these input data are needed is specified in 6.4 to 6.10.

NOTE This subclause conforms to the common template for each of the EPB standards. It enables to check input-output relations between the EPB standards and availability of input data from other sources.

Input data for calculation according to ISO 52016-1:2017, 6.3 shall be used with additions as shown in 6.3.2, 6.3.4 and 6.3.5.

6.3.2 Input data of a simplified adaptive building envelope element

The list of input data of the adaptive building envelope element as given in ISO 52016-1:2017, Table 14 for transparent building elements (including windows or curtain walls), for the hourly calculation procedures, applies with the following differences:

The thermal, daylight and solar properties for each state, *st* as specified in 6.6 are listed in Table 7.

Table 7 — Input data for the thermal, daylight and solar properties of a simplified adaptive building envelope element

| Name | Symbol | Unit | Validity interval ^a | Origin ^b | Varying ^c |
|--|-----------------|-----------------------|--------------------------------|---------------------|----------------------|
| Thermal transmittance of the adaptive building envelope element, for each state <i>st</i> | $U_{w;st}$ | W/(m ² ·K) | 0 to 10 | M2-5 | Yes |
| Total solar energy transmittance of the transparent part of the adaptive building envelope element, for each state <i>st</i> | $g_{gl;st}^d$ | - | 0 to 1 | M2-8 | Yes |
| Daylight transmittance of the transparent part of the adaptive building envelope element, for each state <i>st</i> | $T_{V;gl;st}^d$ | - | 0 to 1 | M2-8 | Yes |

- a Practical range, informative
 b For example: EPB module or (e.g. product) standard or "local" (type, geometry)
 c "Varying": value can vary over time: different values per time interval, for example: hourly values or monthly values (not constant values over the year)
 d with subscript *gl* instead of *w* for the optical properties, because the daylight and solar properties are per m² of projected transparent area.

NOTE An adaptive building envelope element with actively ventilated cavity is as a rule considered as a detailed adaptive building envelope element using a complex model. But a simplified approach, as described in 6.4.3.3 is possible. In that case no extra input data are needed: the impact of heat exchange related to air circulation in and through the adaptive building envelope element is implicitly taken into account in the thermal and solar properties as listed in Table 7.

6.3.3 Input data of a detailed adaptive building envelope element

The list of input data of the adaptive building envelope element as given in ISO 52016-1:2017, Table 14 for transparent building elements (including windows or curtain walls) for the hourly calculation procedures, applies with the following differences:

The thermal, daylight and solar properties cannot be pre-calculated. Instead, a complex model (more complex than the model for a transparent building element in ISO 52016-1) is used, with the thermo-optical properties of the components of the transparent building element as input data, where applicable for each state, *st*. These input data are listed in Table 8.

Table 8 — Input data for the thermo-optical properties of the components of a detailed adaptive building envelope element

| Name | Symbol | Unit | Validity interval ^a | Origin ^b | Varying ^c |
|--|---------------------|-----------------------|--------------------------------|---------------------|----------------------|
| For the adaptive building envelope element <i>w</i> ^d : | | | | | |
| The number of nodes of the model | $N_{w;pt}$ | - | 2 to 10 | M2-8 | No |
| Convective heat transfer coefficient internal surface | $h_{w;ci}$ | W/(m ² ·K) | 0 to 50 | M2-5 | Yes |
| Long-wave radiative heat transfer coefficient internal surface | $h_{w;ri}$ | W/(m ² ·K) | 0 to 50 | M2-5 | Yes |
| Thermal conductance between two nodes <i>pli</i> and <i>plj</i> | $h_{w;pli;plj}$ | W/(m ² ·K) | 0 to 1000 | M2-8 | Yes |
| Convective heat transfer coefficient external surface | $h_{w;ce;st}$ | W/(m ² ·K) | 0 to 50 | M2-5 | Yes |
| Long-wave radiative heat transfer coefficient external surface | $h_{w;re;st}$ | W/(m ² ·K) | 0 to 50 | M2-5 | Yes |
| Effective solar absorptance of each node | $a_{sol;gl;eff;st}$ | - | 0 to 1 | M2-8 | Yes |
| Direct solar transmittance, for each state <i>st</i> | $\tau_{sol;gl;st}$ | - | 0 to 1 | M2-8 | Yes |

| | | | | | |
|--|------------------|---|--------|------|-----|
| Daylight transmittance, for each state <i>st</i> | $\tau_{V;gl;st}$ | - | 0 to 1 | M2-8 | Yes |
| e | | | | | |

a Practical range, informative
 b For example: EPB module or (e.g. product) standard or "local" (type, geometry)
 c "Varying": value can vary over time: different values per time interval, for instance: hourly values or monthly values (not constant values over the year)
 d with subscript *gl* instead of *w* for the optical properties, because the optical properties are per m² of projected transparent area.
 e In exceptional cases more input data can be required, depending on the details of the adaptive building envelope element, such as thermal capacity per node and transmittance for long-wave radiation per node

For adaptive building envelope elements with actively ventilated cavity the required air flow related input data are listed in Table 9:

Table 9 — Input data for the air flow related properties of an adaptive building envelope elements with actively ventilated cavity

| Name | Symbol | Unit | Validity interval ^a | Origin ^b | Varying ^c |
|--|-------------|-------------------|--------------------------------|---------------------|----------------------|
| If naturally ventilated: the location and size of the vent openings as required in M2-8, per ventilation state, <i>vest</i> | See M2-8 | See M2-8 | See M2-8 | M2-8 | Yes |
| If mechanically ventilated: the air flow rate between specific nodes or internal or external environment, per ventilation state, <i>vest</i> | $q_{V;i;j}$ | m ³ /s | 0 to ∞ | M2-8 | Yes |

For adaptive building envelope elements with actively ventilated cavity the following input data apply, in addition to the input data already needed for ISO 52016-1:

The modes of ventilation as listed in Table 10.

Table 10 — Ventilation modes for adaptive building envelope elements with actively ventilated cavity

| Name | Description | Identifier |
|---|-------------|----------------------------|
| Applied ventilation mode, per state <i>vest</i> | a | AVF-mode_XXXX ^a |
| ... | | |

^a Choice between options given in 6.4.3.3

The type of ventilation as listed in Table 11.

Table 11 — Ventilation type for adaptive building envelope elements with actively ventilated cavity

| Name | Description | Identifier |
|---|--------------|----------------------------|
| Applied ventilation type | ^a | AVF-type_XXXX ^a |
| ^a XXXX is the placeholder for the options given in 6.4.3.3 | | |

6.3.4 Control related input data

The applied control type shall be provided according to Table 12.

Table 12 — Control type

| Name | Description | Identifier |
|---|--------------|-------------------------|
| Applied control type | ^a | CNTRL_XXXX ^a |
| ^a XXXX is the placeholder for the options given in 6.6 | | |

The number and description of states is listed according to Table 13.

Table 13 — List of states

| State number ^a | Description of state | Optionally: Numbering and description per dimension of states (see 6.4.3) ^{ab} | | | |
|---------------------------|----------------------|---|------------------------|-------------------|------------------------|
| | | Substate A number | Description substate A | Substate B number | Description substate B |
| 1 | | | | | |
| 2 | | | | | |
| ... | | | | | |
| ... | | | | | |
| ... | | | | | |
| ... | | | | | |

^a: The table may be extended with extra rows and columns if needed.
^b: More than one dimension is for instance a venetian blind (a) retracted or extended with (b) slats open or closed; or: a combination of internal and external blind.

For actively controlled adaptive building envelope elements the sensors applied for the control shall be listed according to Table 14, selected from the options given in 6.8.3.

Table 14 — List of sensors applied for the control

| Variable | Symbol | Unit |
|----------|--------|------|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

For actively controlled adaptive building envelope elements, the methods applied to identify the conditions or events shall be listed according to Table 15, selected from the options given in 6.8.4.

Table 15 — Applied methods to identify the conditions or events

| Mode | As assumed (in practice) ^a | As modelled in the calculation ^b | Comment ^c |
|--|---------------------------------------|---|----------------------|
| DAY-MODE <i>Daytime or night time</i> | | | |
| HC-MODE <i>Heating, neutral or cooling mode of the thermal zone</i> | | | |
| TINT MODE <i>Operating temperature</i> | | | |
| RAD-MODE <i>Level of solar irradiance or illuminance</i> | | | |
| OCC-MODE <i>Occupancy</i> | | | |
| GLARE-MODE <i>Glare occurrence</i> | | | |
| DAYL-MODE <i>Low daylight</i> | | | |
| HFLW-MODE <i>Heat flow direction</i> | | | |
| ^a Select from the options given in 6.8.4 identified as MC1, MC2, ..., resp. AC1, AC2, ... ^b Select from the options given in 6.8.4 identified as MM1, MM2, ..., resp. AM1, AM2, ... ^c Optional, informative | | | |

All input data needed for the control are already available as input data needed for the hourly calculation, except, depending on the type and further specifications of the control, additional input data may be needed, as specified in 6.6 for environmentally activated adaptive building envelope elements and in 6.8 for actively controlled adaptive building envelope elements, as listed in Table 16.

Table 16 — Control related additional input data

| Name | Symbol | Unit | Validity interval ^a | Origin ^b | Varying ^c |
|---|--|--------------------|--------------------------------|---------------------|----------------------|
| Internal operative temperature | $\theta_{\text{int;op}}$ | °C | 0 to 50 | ISO 52016-1 | Yes |
| For environmentally activated building envelope elements: the environmental condition ^d , for each state <i>st</i> | X_{st} ^d | [...] ^d | ... ^d | Product | Yes |
| For environmentally activated building envelope elements: half of the hysteresis | $\Delta X_{\text{st;hyst}}$ ^d | [...] ^d | ... ^d | Product | No |
| Position (height, width and distance) of occupant relative to the adaptive building element ^e | $H_{\text{occ}}, L_{\text{occ}}, D_{\text{occ}}$ | m | 0 to 10 | local | No |

^a Practical range, informative
^b For example: EPB module or (e.g. product) standard or "local" (type, geometry)
^c "Varying": value can vary over time: different values per time interval, for instance: hourly values or monthly values (not constant values over the year)
^d Placeholder for the environment condition (e.g. the glazing temperature)
^e Position of head, in case of estimation of glare risk if using geometrical position of occupant versus sun

6.3.5 Climatic input data

Depending on the type and further specifications of the control, as specified in 6.8 for actively controlled adaptive building envelope elements, the climatic input data listed in Table 17 apply, in addition to the input data already needed for ISO 52016-1.

Table 17 — Additional climatic input data

| Name | Symbol | Unit | Validity interval ^a | Origin ^{b,d} | Varying ^c |
|-----------------------|-------------|---------|--------------------------------|-----------------------|----------------------|
| Wind velocity | $v_{w;a;t}$ | m/s | 0 to +50 | M1-13 | Yes |
| Wind direction | $z_{w;e;t}$ | degrees | 0 to 360 | M1-13 | Yes |
| Cloudiness of the sky | - | okta | 0 to 1 | M1-13 | Yes |

^a Practical range, informative
^b For example: EPB module or (e.g. product) standard or "local" (type, geometry)
^c "Varying": value can vary over time: different values per time interval, for instance: hourly values or monthly values (not constant values over the year)
^d Some of the conditions of use can be adapted by system specific input

6.3.6 Constants and physical data

All relevant constants and physical data are listed in ISO 52016-1:2017, 6.3.

6.3.7 Input data from Annex A (Annex B)

Annex A contains the normative template for choices in references, methods and input data. Informative default choices in references, methods and input data are given in Annex B, respecting the template of Annex A.

All these choices and input data are indispensable for the application of this document.

6.4 Properties of the adaptive building envelope element

6.4.1 General

A distinction is made between a simplified (model of the) adaptive building envelope element and a detailed (model of the) adaptive building envelope element, as explained in 6.4.2.

NOTE For readability it is called simplified or detailed adaptive building envelope element, although it actually concerns the model of the adaptive building envelope element that is simplified or detailed. There is a relation between the complexity of the element and the complexity of the model, but different levels of model simplifications are possible.

If the adaptive building envelope element consists of sections that have the same properties, but which can be individually controlled, then each section shall be modelled as a separate adaptive building envelope element, because at a given time interval each section can be in a different state.

More specific details are given per category of technology in 6.4.3 for a simplified adaptive building envelope element and in 6.4.4 for a detailed adaptive building envelope element.

6.4.2 Simplified or detailed adaptive building envelope element

6.4.2.1 Simplified adaptive building envelope element

A simplified adaptive building envelope element is defined in **Error! Reference source not found.** It is described with a model in which the thermal, daylight and solar properties, for a given state, can be pre-calculated. This model is based on the following assumptions:

- a) the thermal, daylight and solar properties (for each state) are considered to be independent of the environmental conditions, by defining fixed boundary conditions for conditions such as temperature, sun position, cloudiness and solar irradiance level.
- b) the thermal mass is neglected;
- c) the secondary solar energy transmission is approximated as a contribution to the direct solar energy transmission to the internal environment (thermal zone).

NOTE 1 See ISO 52022-3 or ISO 15099. More explanation can be found in ISO/TR 52016-4.

NOTE This is illustrated in ISO/TR 52016-4. The reason for simplification c) is to avoid that for the hourly calculation method more input data are needed than for the monthly calculation method. Without this simplification the threshold to use the hourly calculation method would be higher, which would have an adverse impact on the road towards more realistic calculations.

Because of these assumptions, the number of nodes in the model is limited to 2 (internal and external surface).

Because of assumption a) the thermal, daylight and solar properties of the adaptive building envelope element can be pre-calculated and provided as input values.

6.4.2.2 Detailed adaptive building envelope element

A detailed adaptive building envelope element is defined in 3.10. It is described with a more complex model than the model for a simplified adaptive building envelope element. This is the case if one of the following assumptions apply:

- a) the thermal or solar properties (for a given state) are a function of the environmental conditions, such as indoor or outdoor temperature, sun position, cloudiness or the solar irradiance.
- b) the number of layers is higher than 2 (internal and external surface) and cannot be mathematically reduced to 2, because either:
 - 1) the temperature of one of the additional layers is needed as input;
 - 2) the thermal, daylight or solar properties of the adaptive building envelope elements at a given hour depend on the temperature of one or more of the additional layers; such layer can include the air layer in a cavity;
- c) the thermal mass cannot be neglected, because the element contains a layer with significantly higher mass than a glazing or blind.

EXAMPLE

ad a):

(1) this actually applies already for an adaptive building envelope element with venetian blinds (sun position), or internal blinds (temperature dependent air circulation behind the blind), but typically this is approximated by calculating the value for a standard situation;

(2) an adaptive building envelope element with a wide closed cavity: the thermal resistance is significantly temperature dependent due to local air circulation;

ad b1): an adaptive building envelope element with thermochromic glazing;

ad b2): an adaptive building envelope element with a naturally ventilated cavity in which the air flow is a function of the air and adjacent surface temperatures (buoyancy);

ad c): an adaptive building envelope element with a massive opaque panel on part of the area.

6.4.3 Properties of a simplified adaptive building envelope element

6.4.3.1 Adaptive building envelope element with dynamic solar shading

If an adaptive building envelope element can be adapted in two or more dimensions, states within one dimension can be specified by introducing a separate subscript, for instance:

N_{stA} is the number of primary states of the adaptive building envelope element;

N_{stB} is the number of secondary states of the adaptive building envelope element;

N_{stC} is the number of tertiary states of the adaptive building envelope element.

stA , stB , are the placeholders for more specific subscripts.

stC , ..

In any case, the subscript st is used for each unique combination of states.

EXAMPLE 1 Venetian blinds down (e.g.: $B_{st} = 2$) combined with horizontal slats (e.g. $slat_{st} = 1$) is e.g. combined state $st = 3$.

Commonly available dimensions of states for an adaptive building envelope element with dynamic solar shading, depending on the product or assembly, are listed in Table 18.

Table 18 - Commonly available dimensions of states for an adaptive building envelope element with dynamic solar shading

| Dimension of states | Description | Examples |
|----------------------------|---|---|
| Primary | Covering the transparent area or not | - Retracted, partially extended or fully extended venetian or roller blind. - Retracted, partially extended or fully extended curtain - Retracted, partially extended or fully extended shutter |
| Secondary, option 1 | Change of properties | - Slat position of venetian blinds (open, partially closed, closed). - Shift in position of duo blind (from a specific maximum to a specific minimum transparency). - Second blind with different properties. |
| Secondary, option 2 | A secondary solar shading component, covering the transparent area or not | As primary |
| Tertiary | A combination of primary, secondary option 2 and secondary option 1 | A combination of the examples above |

If there are more than two states per dimension, the intermediate states can be used in the control scenario to find a balance for conflicting desired properties.

NOTE 1 In the control scenarios (6.8) the fine-tuning is used (a) to find a balance between thermal aspects (energy and thermal comfort) and lighting aspects (daylight access and view out) and (b) to avoid glare while maintaining daylight access and view out.

Venetian blind:

In case of venetian blind intermediate states apply to the tilt angle of the slats (if movable), between the two extremes: open or closed.

The number of intermediate states and corresponding position of the slats may be chosen freely, within the technological possibilities of the product, taking into account the following considerations:

- The optimum slat position to maximize daylight and view out while optimizing solar control and minimizing glare risk, can be specified at each hour. It is a function of the position of the sun in relation to the assumed position of the occupants and the position and optical properties of the adaptive building envelope element.
- Alternatively, a fixed slat position can be assumed that is conservative with respect to minimization of glare risk and with respect to solar heat gain (during heating mode), because the solar and daylight transmittance is not very sensitive for the precise slat angle if in partly closed position.

In a simplified approach, the slats are fixed in such a position that direct solar (beam) transmittance is blocked.

EXAMPLE2 In case of vertical adaptive building envelope elements, a slat angle of 45° works well in hot seasons for most climates.

NOTE 2 See ISO/TR 52016-4, including reference to the results of Swiss research on the optimization of slat position.

NOTE 3 In the case of venetian blinds with the slats in such a position that direct solar radiation is fully blocked, the solar energy transmission by diffuse radiation and by ground-reflected radiation can be significantly more than the total solar energy transmittance at normal incidence, $g_{gl;n}$ would suggest.

Roller blind:

In case of a roller blind, intermediate states apply to adjusting the portion of the area that is covered by the blind.

The number of intermediate states and corresponding position of the blind may be chosen freely, within the technological possibilities of the product, taking into account the following considerations:

- The optimum position to maximize daylight and view out while optimizing solar control and minimizing glare risk can be specified at each hour. It is a function of the position of the sun in relation to the assumed position of the occupants and the position and properties of the adaptive building envelope element.
- Alternatively, a fixed position can be assumed that is conservative with respect to minimization of glare risk and with respect to solar heat gain (during heating mode).
- To find a balance between thermal aspects (energy and thermal comfort) and lighting aspects (daylight access and view out) the position of the blind is arbitrary.

NOTE 4 See further explanation in ISO/TR 52016-4.

Consequently, the properties required as extra input for the calculation involving an adaptive building envelope element with dynamic solar shading, are:

| | |
|------------------|---|
| $U_{w,st}$ | is the thermal transmittance of the adaptive building envelope element in state st , to be determined according to ISO 52016-1:2017, 6.5.8.3, for each state of variation, st , in $W/(m^2 \cdot K)$; |
| $g_{gl;st}$ | is the total solar energy transmittance of the transparent part of the adaptive building envelope element in state st , to be determined according to ISO 52016-1:2017, 6.5.13.2, for each state of variation, st . |
| $\tau_{V;gl;st}$ | is the daylight transmittance of the transparent part of the adaptive building envelope element in state st , determined according to the same procedure as used for the determination of $g_{gl;st}$; |
| N_{st} | is the number of states covering the range of variations in properties; Minimum value: $N_{st} = 2$ Maximum value: the number of states shall not exceed the technical possibility to operate at intermediate states. |

Alternatively, if technically possible and if the properties are known as a continuous function of the variation, the calculation can be performed with a continuous variation: $N_{st} = \infty$.

NOTE 5 For actively controlled adaptive building envelope elements, a hysteresis is not an input data as for the environmentally activated adaptive building envelope elements. For actively controlled adaptive building envelope elements hysteresis is specified in the control scenario.

6.4.3.2 Adaptive building envelope elements with chromogenic glazing

6.4.3.2.1 Environmentally activated chromogenic glazing

Environmentally activated control applies to certain types of chromogenic glazings, in which the optical properties vary with the material state.

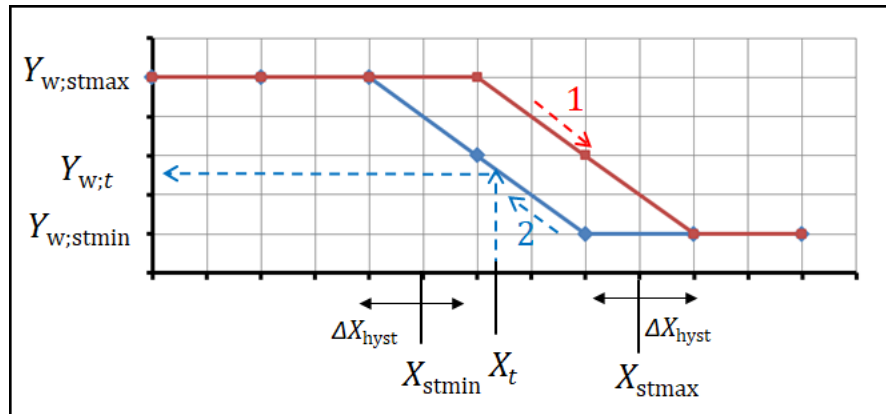
EXAMPLE The optical properties change as the result of a change in glazing temperature (thermochromic, thermotropic) or as the result of a change in incident solar irradiance.

The optical properties are assumed to be a continuous linear function of the environmental conditions between a minimum and maximum value, leading to linear daylight and solar properties of the adaptive building envelope element.

However, a non-linear variation of such properties can be assumed, if manufacturer data are available, demonstrating that there is a significant difference from this linearity. In that case the number of states shall be increased in such a way that linearization between two successive states can be assumed.

The properties are given for each state, *st*. The corresponding conditions are identified with the same subscript *st*.

The change between states can involve a hysteresis. In that case the property of the adaptive building envelope element is still a unique function of the environmental condition, but with different values depending on the direction of the change of the environmental condition. This is illustrated in Figure 1.



Key

Y property of the adaptive building envelope element
 X environmental parameter

- 1 increasing X -values
- 2 decreasing X -values

Figure 1 — Different states of adaptive building envelope element with environmentally activated chromogenic glazing

NOTE A worked example for chromogenic glazing is presented in ISO/TR 52016-4.

In case of a stepwise instead of a gradual state change, X_{stmax} is equal to X_{stmin} .

The properties required as extra input for the calculation involving an environmentally activated glazing, are:

$Y_{w;st}$ is the property of the adaptive building envelope element at each state st ; in case of a continuous linear function there are two states corresponding to the minimum and maximum achievable by the chromogenic glazing.

The properties Y_{gl} required to perform the calculation within this document are:

$g_{gl;st}$ is the total solar energy transmittance of the transparent part of the adaptive building envelope element, g_{gl} , determined according to ISO 52016-1:2017, 6.5.13.2, for each state st ;

$\tau_{V;gl;st}$ is the daylight transmittance of the transparent part of the adaptive building envelope element for each state st , determined according to the same procedure as used for the determination of $g_{gl;st}$.

X_{st} is the environmental conditions X , corresponding to the state of the property $Y_{w;st}$ of the adaptive building envelope element.

EXAMPLE for a thermochromic glazing the environmental conditions X , required are the glazing temperatures (ϑ_{Ystmin} and ϑ_{Ystmax} , respectively), corresponding to the start and the end of the thermochromic cycle.

ΔX_{hyst} The difference in X_{st} -values due to hysteresis, to be obtained from manufacturers data. In case such data are not available, the following conservative default value shall be assumed.

For thermochromic glazing: $\Delta X_{\text{hyst}} = 30 \text{ K}$.

For photochromic glazing: $\Delta X_{\text{hyst}} = 150 \text{ W/m}^2$.

N_{st} is the number of states of the chromogenic glazing covering the range of variations in glazing properties.

In case of a continuous linear function: $N_{\text{st}} = 2$.

Otherwise, the value is determined as function of the technology (non-linear or discrete values).

6.4.3.2.2 Actively controlled chromogenic glazing

The optical properties of adaptive building envelope elements with actively controlled chromogenic glazing are assumed to be in discrete states between a minimum and maximum tinting level.

The properties required as extra input for the calculation involving an actively controlled chromogenic glazing, are:

$Y_{w;st}$ is the property of the adaptive building envelope element at each state st .

More specifically, the properties Y_{gl} required to perform the calculation within this document are:

$g_{gl;st}$ is the total solar energy transmittance of the transparent part of the adaptive building envelope element, g_{gl} , determined according to ISO 52016-1:2017, 6.5.13.2, for each state st ;

$\tau_{V;gl;st}$ is the daylight transmittance of the transparent part of the adaptive building envelope element for each state st , determined according to the same procedure as used for the determination of $g_{gl;st}$.

N_{st} is the number of states covering the range of variations in properties;

The minimum number of states is $N_{\text{st}} = 2$, representing the minimum and maximum glazing properties achievable by the chromogenic glazing.

Otherwise, the value is determined as function of the technology (non-linear or discrete values).

The number of states shall not exceed the technical possibility to operate at intermediate states.

Alternatively, if technically possible and if the properties are known as a continuous function of the variation, the calculation can be performed with a continuous variation: $N_{\text{st}} = \infty$.

6.4.3.3 Adaptive building envelope elements with actively ventilated cavity

6.4.3.3.1 Ventilation properties and modes

An adaptive building envelope element with actively ventilated cavity is a building envelope element in which ventilation through one or more cavities of the building envelope element adds an extra dimension to the adaptive states.

Usually an adaptive building envelope element with actively ventilated cavity contains a combination of active solar shading as presented in 6.4.3.1 with a ventilated cavity or cavities. In this document the procedures are worked out for this combination.

The main parameter to define the different ventilation states is the direction of the air flow, as presented in Table 19.

NOTE 1 The mode depends on the need to harvest or to reject solar gain that is absorbed in the cavity, or to stay in a buffer mode. This is decided in 6.8 as part of the control scenario.

– Table 19 – Basic ventilation modes

| Name | Air flow direction | Intended effect during heating mode | Intended effect during cooling mode | Identifier AVF_Mode = |
|----------------------|--|--|--|--------------------------|
| Buffer mode | No ventilation via the cavity | To create a thermal buffer to decrease heat transmission to the outside. | If outdoor air temperature higher than temperature in the thermal zone: to create a thermal buffer to decrease heat transmission to the inside. | AVF_BUF |
| Exhaust mode | From internal environment via the cavity to external environment | To use exhaust air to warm up the internal surface with air from the thermal zone. | If cavity warmed up by solar radiation: to use exhaust air to reject solar heat. | AVF_IE |
| Supply mode | From external environment via the cavity to internal environment | If cavity warmed by solar radiation: to use supply air to harvest solar heat. | If outdoor air temperature lower than temperature in the thermal zone and if cavity not heated by solar radiation: to use supply air to bring in cool air (ventilative cooling). | AVF_EI |
| Internal circulation | From internal environment via the cavity to internal environment | If cavity warmed by solar radiation, to harvest solar heat. Otherwise, to warm up the internal surface. | -- | AVF_II |
| External circulation | From external environment via the cavity to | -- | If cavity warmed up by solar radiation: to reject solar heat. | AVF_EE |

| | | | | |
|--|----------------------|--|--|--|
| | external environment | | Otherwise, if outdoor air temperature lower than temperature in the thermal zone: to cool down the internal surface. | |
|--|----------------------|--|--|--|

The calculation of the air flow rate depends on the type of ventilation. The distinguished types are presented in Table 20:

Table 20 – Type of ventilation

| Name | Description | Identifier AVF_Type = |
|------------------------|--|--------------------------|
| Natural ventilation | Natural ventilation through the cavity, with air flow rate being a function of the geometry and local conditions (air pressure difference, temperatures), actively controlled by movable vents | AVF_NAT |
| Hybrid ventilation | Partly natural, partly mechanical ventilation | AVF_HYB |
| Mechanical ventilation | Mechanical ventilation through the cavity, with air flow rate actively controlled by the ventilation system | AVF_MECH |

Depending on the type of ventilation, the following parameters define the ventilation related states:

If AVF_Type = NAT A discrete number of N_{vest} states, with for each state the size of the ventilation openings in inner and outer skins, aiming at a specific air flow mode (see Table 16).

NOTE 2 The calculation of the actual air flow rate is described in 6.4.4.

If AVF_Type = MECH A discrete number of N_{vest} states, with for each state the air flow direction (covering one or more of the modes of Table 16) and air flow rate as specified below.

NOTE 3 The modes require certain ventilation openings. It is assumed that these are set correctly for each individual state.

If AVF_Type = HYB Combination of properties for natural and mechanical ventilation.

NOTE 4 See further explanation in ISO/TR 52016-4 .

where:

N_{vest} is the number of ventilation related states of the adaptive building envelope element.

In case of a double skin façade, with one of the skins being partly opaque, the façade shall be modelled as two separate segments, each representing a cross section of the facade.

NOTE 5 In case of a cavity that extends over the two segments, this simplification can lead to a bias in the estimation of the heat exchange; in that case it would be better to model the cavity as a whole. Also, in ISO 15099 this is however not foreseen. For such facades a more adequate approach can be to model the façade as two or more coupled zones, using a detailed building simulation tool.

6.4.3.3.2 Thermal and solar properties

In general, the adaptive building envelope element with actively ventilated cavity falls in the category of detailed adaptive building envelope elements: the thermal and solar properties cannot be pre-calculated, but have to be calculated each hour using the complex model and component properties as described in 6.4.4.

NOTE The cavity ventilation leads to heat exchange inside the cavity which in turn leads to a change in thermal and solar properties of the adaptive building envelope element. This change in thermal and solar properties is a non-linear function of air flow rate and in case of natural ventilation the air flow rate interacts dynamically and non-linearly with the cavity temperatures.

Only if the thermal, daylight and solar properties can be pre-calculated for each state, this type of adaptive building envelope element falls in the category of simplified adaptive building envelope elements. This requires some simplifications, which is acceptable if clearly reported.

In this case the pre-calculated thermal, daylight and solar properties of the adaptive building envelope element are required as input data for each combination of states. This includes the ventilation related states, presented in the form of the ventilation modes and (optionally), different levels of air flow rates within a given mode. The impact of the heat exchange due to the air flow circulation is included in the thermal and solar properties.

The properties required as extra input for the calculation involving an adaptive building envelope element with actively ventilated cavity, if approximated as a simplified adaptive building envelope element, are:

- $U_{w;st}$ is the thermal transmittance of the adaptive building envelope element including the impact of the heat exchange due to the air flow circulation, in state st , to be determined according to the procedure in ISO 15099, in $W/(m^2 \cdot K)$;
- $g_{gl;st}$ is the total solar energy transmittance of the transparent part of the adaptive building envelope element, including the impact of the heat exchange due to the air flow circulation, in state st , to be determined according to the procedure in ISO 15099;
- $\tau_{V;gl;st}$ is the daylight transmittance of the transparent part of the adaptive building envelope element in state st , to be determined according to the same procedure as used for the determination of $g_{gl;st}$.
- N_{st} is the number of states covering all combinations of variations of the dynamic solar shading and the actively ventilated cavity.

6.4.4 Model and properties of a detailed adaptive building envelope element

The complex model for a detailed adaptive building envelope element implies that one or more of the thermal, daylight or solar properties depend on the actual conditions. Consequently, the thermal, daylight and solar properties of the adaptive building envelope element for a given state cannot be pre-calculated. As a consequence, the component properties are needed as input instead of the thermal, daylight or solar properties of the adaptive building envelope element as a whole.

Except for thermal capacity, such a model can be found in ISO 52022-3, or, if a wider application range is needed, in ISO 15099.

NOTE 1 The application ranges of these two documents are described in ISO/TR 52016-4 .

For the purpose of this document, a simplification compared to ISO 15099 or ISO 52022-3 is justified: the spectral and detailed directional optical properties shall be aggregated to non-directional and non-spectral component properties, to make them fit as input for this document.

Simplified formulae can replace the detailed angular optical models from ISO 52022-3 and ISO 15099 and the detailed optical modelling of parallel slats (ISO 15099) can be replaced by an approximating formula.

NOTE 2 Angle dependent optical properties are simplified to fixed optical properties for a representative situation (solar incidence angle and ratio direct:diffuse radiation), unless more specific data are imperative for the technology. When relevant and feasible, to avoid errors due to different angle dependent properties of the individual components, the aggregation is done at the level of the whole assembly including the adaptive component and other transparent components such as glazings.

In addition, for the optical properties (transmittance, reflectance) of venetian blinds as function of the sun position and slat angle approximating formulae can be used. See examples in ISO/TR 52016-4 , including reference to the results of a Swiss research on this topic.

In case of an adaptive building envelope element with actively ventilated cavity the air cavity can - depending on the specific design and purpose- be connected to the exterior or interior environment or to other cavities.

NOTE 3 The calculation of the thermal and solar properties of building elements in ISO 15099 includes this calculation of the impact of the air circulation in a cavity on the heat transfer and, for a naturally ventilated cavity, the calculation of the air flow rate.

NOTE 4 This impact is also included in the calculation procedures of ISO 52022-3, but not for the calculation of the thermal properties, such as the U -value.

NOTE 5 Input data for ISO 52022-3 or ISO 15099 are the size of the vents, the cavity width and height and the porousness of the skin. For natural ventilation, the air flow rate is calculated as an intrinsic function of the environment conditions (temperature, wind [if applicable]) and geometry (opening sizes, cavity width).

NOTE 6 The ventilation needs for the building zone are determined in the relevant standard under module M5-5 (Table A.1). This determines the need of air supply or air exhaust or no air supply or exhaust via the adaptive building envelope element.

Thermal capacity can be added to each node of the model as described in the formulae for opaque building elements in ISO 52016-1:2017, 6.5.6.3.

6.5 Connection of the model of the adaptive building envelope element to the model of the thermal zone of ISO 52016-1

6.5.1 Simplified adaptive building envelope element

The model of the adaptive building envelope element is integrated in the model for the calculation of the overall thermal balance of a thermal zone as given in ISO 52016-1:2017, 6.5.7.

6.5.2 Detailed adaptive building envelope element

The model of the adaptive building envelope element can also be integrated in the model for the calculation of the overall thermal balance of a thermal zone as given in ISO 52016-1:2017, 6.5.7, but with a few modifications:

- In case the internal surface of the adaptive building envelope element is not opaque for long-wave radiation, extra thermal radiation links from the nodes of the adaptive building envelope element to the other internal surfaces of the thermal zone.
- In case of a ventilated cavity:
 - the heat transfer to the internal environment shall be extended with a term $q_{v,k}$ for the heat transfer by ventilation by air coming from cavity k .
 - the air flow rate that originates from the external environment shall be counted as contribution to the air flow coming from outside. The effect on the thermal balance is already taken into account by the previous list item.

The calculation of the variable component properties as function of the parameters defining the state shall be performed iteratively until convergence is reached on the calculated properties less or equal to 0,03.

NOTE The value of 0,03 is chosen to reflect manufacturing tolerances.

6.6 Selection of control type

Four control types are distinguished, each with a different level of complexity, in line with the four classes in ISO 52120-1 [9]. See Table 21.

Table 21 – Control types

| Level | Name | Description | Identifier CNTRL_TYPE = |
|-------|---|---|----------------------------|
| 0 | Environmentally activated control | Also known as passive control: activated by a specific environment condition | CNTRL_PAS |
| 1 | Manual operation with manual control | Manual operation requiring an effort or a force EXAMPLE 1 By crank or cord. | CNTRL_MAN |
| 2 | Motorized operation with manual control | The operation is motorized but requires a manual activation EXAMPLE 2 Remote or wall switch. For active chromogenic glazing, manual | CNTRL_MOT |

| | | | |
|---|--------------------|--|--------------|
| | | operation is not applicable and ‘motorized’ shall be read as ‘driven by electric power’. | |
| 3 | Automated control | Rule based, open or closed loop control, using one or more input variables. In an open-loop controller the control action from the controller is independent of the “process output”: the state of the adaptive building envelope element that is being controlled. It does not use feedback to determine if its output has achieved the desired goal of the input command(s) or process set point(s). Usually the automated control allows a manual override by the occupant(s). | CNTRL_AUTO |
| 4 | Integrated control | More complex functions, with e.g. predictive algorithms or combined with control of HVAC and lighting, including feedback to determine if its output has achieved the desired goal. | CNTRL_INTEGR |

From these four control types, the type that applies best to the adaptive building envelope element and how it is controlled shall be selected for the calculation.

For level 4, integrated control, no reference control scenario is specified in this document.

6.7 Modelling of the control of the environmentally activated adaptive building envelope element

Depending on the technology, the change of states can be discrete or continuous.

If the optical properties of the adaptive building envelope element can be described as a continuous linear function of the environmental conditions, the optical property of the adaptive building envelope element $Y_{w;t}$ as function of the environmental conditions at time t is given in Formula (1):

$$Y_{w;t} = \frac{X_t - X_{stmin} + \left(\frac{\pm\Delta X_{st,hyst}}{2}\right)}{X_{stmin} - X_{stmax}} * (Y_{w;stmin} - Y_{w;stmax}) + Y_{w;stmin} \quad (1)$$

Where:

Y_w is the adaptive building envelope element property as introduced in 6.4.3.2.1;

X is the environmental parameter as introduced in 6.4.3.2.1.

$\Delta X_{st,hyst}$ is the hysteresis in the environmental parameter as introduced in 6.4.3.2.1, with:
 $\pm\Delta X_{st,hyst}$ is $+\Delta X_{st,hyst}$ if $X_{st;t}$ is higher than the value at the previous time interval and
 $\pm\Delta X_{st,hyst}$ is $-\Delta X_{st,hyst}$ if $X_{st;t}$ is lower than the value at the previous time interval.

This is illustrated in Figure 1 in 6.4.3.2.1.

NOTE A worked example with $X_{st} = I_{sol}$ is presented in ISO/TR 52016-4 .

If the change of states is discrete, the optical property of the adaptive building envelope element $Y_{w,t}$ changes if the environmental condition at time t has reached the next state.

6.8 Modelling of the control scenario for the actively controlled adaptive building envelope element

6.8.1 General

Reference control scenarios are specified in 6.8.7 for different control types, different adaptive building envelope elements and different space categories (residential and non-residential).

The reference control scenarios shall be used to compare different options.

NOTE 1 In practice, the control scenarios of actively controlled adaptive building envelope elements vary widely in complexity. They also vary with the aim to optimize for a specific building or space category, orientation or composition of the adaptive building envelope element. The reference control scenario aims to create a level playing field.

A minimum control time frequency of 1 h is considered, according to the time interval of the calculation procedure in this document.

A customized control scenario may be used, instead of the reference control scenarios given in 6.8, but, to safeguard a fair comparison, under the following conditions:

- the user shall perform and report the calculation for the reference control scenario as a baseline;
- details of the customized scenario shall be included in the report.

NOTE 2 Some details can be privileged information that is sensitive for competition.

Each of the control scenarios is composed of conditions and events (6.8.2) that, in a specified combination, can lead to a change of the state of the adaptive building envelope element.

In case of manual control, the conditions and events are detected by the occupant(s). In the calculation, the detection by the occupant is simulated by the detection by one or more sensors (6.8.3).

In case of automated control, the conditions and events are detected by one or more sensors (6.8.3).

The methods used for the detection of the conditions and events are specified in 6.8.4.

6.8.2 Selection of conditions and events

The conditions and events that are used in this document for the control scenarios are listed in Table 22.

Table 22– Conditions and events distinguished for the control, with identifiers

| Description | Identifier | Value1 | Value2 | Value3 | Comment |
|-----------------------|------------|--------|--------|--------|--|
| Daytime or night time | DAY-MODE | DA | NI | n.a. | Daytime (DA; after sunrise) or night time (NI; after sunset) |

| | | | | | |
|---|------------|--------|---------|-------|---|
| Heating or cooling mode of the thermal zone | HC-MODE | HE | NE | CO | <p>Heating (HE) or cooling (CO) load; in absence of heating or cooling system: thermal zone temperature exceeding lower resp. upper limit</p> <p>NE = neutral: no heating or cooling load or only small heating or cooling load</p> <p>During cooling mode, an additional parameter can be the internal operative temperature exceeding a specific threshold value.</p> |
| Operating temperature | TINT-MODE | TN | TH | TV | Operating temperature of the thermal zone: TN = no excess, TH = high; TV = very high |
| Level of solar irradiance or illuminance | RAD-MODE | RL | RH | n.a. | Low (RL) or high (RH) solar irradiance or illuminance with values depending on control type (see 6.6). If in between: no state change. |
| Occupancy | OCC-MODE | OCC-AW | OCC-SLP | UNOCC | <p>OCC-AW = space is occupied, occupants are awake</p> <p>OCC-SLP = space is occupied, occupants are sleeping</p> <p>UNOCC = space is unoccupied</p> <p>NOTE Difference between OCC-SLP and UNOCC: during OCC-SLP the occupants still require thermal comfort and indoor air quality</p> |
| Glare occurrence | GLARE-MODE | GY | GN | n.a. | Protection against glare is needed (GN), not needed (GN) |

| | | | | | |
|--|---------------|-------|--------|------|---|
| Daylight level | DAYL-MODE | DN | DL | n.a. | Daylight level is fine (DN) or low (DL) |
| Heat flow direction | HFLOW-MODE | HFLIN | HFLOUT | n.a. | Inward (HFLIN) or outward (HFLOUT) heat flow. |
| Conditions that can be imposed, if applicable: | | | | | |
| Peak shaving required | PEAK-MODE | PKY | PKN | n.a. | PKY = peak shaving is required ^a |
| Protection against view in required | NOVIEWIN-MODE | NVWY | NVWN | n.a. | Protection against view in is required (NVWY) or not (NVWN) |
| ^a Peak shaving: energy gets the highest priority, for instance to avoid that a certain peak of electricity extracted from the grid becomes exceeded. This requires input from the energy meter and the maximum allowed peak. This can be a predetermined value (e.g. based on a contract) or a dynamic value imposed by the electricity company. In the control scenario it will, if applicable, override, e.g. the daylight and view out requirements. | | | | | |

6.8.3 Selection of sensors

The types of sensors that are assumed in this document to detect specific conditions or events are presented in Table 23.

NOTE Some of the sensors serve more than one purpose. For example, a solarimeter, as input for detecting daytime, detecting glare and detecting a specific level of solar irradiance.

Table 23 – Possible sensors for the control

| Variable | Symbol | Unit | Comment |
|--|----------------|------------------|-----------------------------|
| External | | | |
| External solar irradiance on adaptive building envelope element (total hemispherical, perpendicular to adaptive building envelope element) | $I_{sol;w}$ | W/m ² | Part of climatic input data |
| External global horizontal solar irradiance | $I_{sol;hor}$ | W/m ² | Part of climatic input data |
| External global illuminance on adaptive building envelope element (total hemispherical, perpendicular to adaptive building envelope element) | $E_{V;e;w}$ | lx | Calculated from irradiance |
| External global horizontal illuminance | $E_{V;e;hor}$ | lx | Calculated from irradiance |
| External (outdoor) air temperature | $\theta_{e;a}$ | °C | Part of climatic input data |
| Cloudiness of the sky | | okta | Part of climatic input data |

| | | | |
|--|----------------------|-----|-----------------------------|
| Wind speed at location | u_{wind} | m/s | Part of climatic input data |
| Internal | | | |
| Indoor air temperature | $\theta_{int;a}$ | °C | Calculated |
| Internal operative temperature | $\theta_{int;op}$ | °C | Calculated |
| Temperature set-point for heating | $\theta_{int;set;H}$ | °C | Part of input data |
| Temperature set-point for cooling | $\theta_{int;set;C}$ | °C | Part of input data |
| (Sensible) hourly heating load | $\Phi_{H;ld}$ | W | Calculated |
| (Sensible) hourly cooling load | $\Phi_{C;ld}$ | W | Calculated |
| Occupancy | Oc | - | Part of input data |
| Internal horizontal daylight illuminance on work plane | $E_{V;int;wp}$ | lx | Calculated ^a |
| Internal daylight illuminance behind the adaptive building envelope element | $E_{V;int;w}$ | lx | Calculated ^a |
| Any other building parameter depending on the technology (i.e. surface temperature of the glazing, amount of transmitted direct solar radiation) | | | Calculated ^a |
| ^a : Special calculation | | | |

6.8.4 Selection of methods to identify the conditions or events

Tables 24 to 31 provide, for each of the possible modes, the methods that can be chosen to identify a specific condition or event. The choice depends on the conditions and functionality of the applied technology.

NOTE 1 As these tables show, different methods are possible to identify a specific condition or event. A method can be simple or more complex, depending on the function and on the type and position of sensor(s). A method can be replaced by an alternative method with the same function and applicability.

A distinction is made between the control process assumed in practice (MC1, MC2, ...; AC1, AC2, ...) and the way this process is modelled in the calculation (MM1, MM2, ...; AM1, AM2, ...).

NOTE 2 If this distinction would not be made, the calculation model could make use of detailed knowledge that in practice does not exist, e.g. the actual occupancy, specific temperatures (that are calculated by the model, but that are in practice not measured). This would not lead to a realistic control scenario.

In case of manual control, the methods MM1, MM2, ... describe how the condition or event that is noticed by the occupant(s) (MC1, MC2, ...) is simulated in the calculation.

In case of automated control, the methods AM1, AM2, ... describe how the condition or event that is noticed by the automated control (AC1, AC2, ...) is simulated in the calculation.

The tables provide default options. If another option than a default option is chosen and if this option is not worked out in detail in this document, the details shall be described in the calculation report.

Table 24 –Methods to identify the conditions and events for daytime or night time (DAY-MODE: DA or NI)

| Manual control, manual or motorized operation | |
|---|-------------|
| Assumed occupant’s observation | Modelled as |

| Method MC1: The occupant visually observes daylight or darkness. | Method MM1 (default): One of the following equivalent methods: – Sunrise & sunset time is calculated daily. – The solar height above or below zero is calculated hourly. – The solar irradiance is calculated hourly, using an arbitrary low value as indicator. Method MM2: – Fixed hours for daytime and night time are specified for the full year. |
|---|--|
| Method MC2: The occupant favours to keep fixed hours for daytime and night time for the full year. | Method MM3: Fixed hours for daytime and night time are specified for the full year. |
| Automated control | |
| Assumed automated control | Modelled as |
| Method AC1: The external global illuminance $E_{V,e}$ or solar irradiance I_{sol} is measured with a sensor on a horizontal or any other plane. For this application such sensor only needs to detect an arbitrary low threshold value. | Method AM1 (default): Same as Method AC1 for the assumed automated control, with calculated instead of measured external global illuminance or irradiance. |
| Method AC2: The sun path is calculated, based on location and time and determine if solar height is above (> sunrise) or below zero (> sunset). No sensor involved, except time. | Method AM2: Same as Method AC2 for the assumed automated control. |
| Method AC3: Fixed hours for daytime and night time are specified for the full year. | Method AM3: Same as Method AC3 for the assumed automated control. |

Table 25 –Methods to identify the conditions and events for heating, neutral or cooling mode of the thermal zone (HC-MODE: HE, NE or CO)

| Manual control, manual or motorized operation | |
|---|--|
| Assumed occupant’s observation | Modelled as |
| Method MC1: The occupant remembers the mode from the previous day or over a longer period | Method MM1 (default): To simulate the occupant’s observation, Method AM1 from automated control is used. |
| Automated control | |
| Assumed automated control | Modelled as |
| Method AC1: If during the previous day: – the heating needs of the thermal zone, $Q_{H;nd;24}$, were larger than the cooling needs $Q_{C;nd;24}$; – or, in case of absence of heating system, the indoor operative temperature $\theta_{int;op;24}$ is lower than a low limit, $\theta_{int;op;24;limHE}$ | Method AM1 (default): Same as Method AC1 for the assumed automated control, with heating and cooling need or indoor temperature calculated by ISO 52016-1. |

| | |
|---|--|
| <p>Then: Heating mode (HE)</p> <p>If during the previous day:</p> <ul style="list-style-type: none"> – the cooling needs of the thermal zone, $Q_{C,nd;24}$, were larger than the heating needs $Q_{H,nd;24}$; – or, in case of absence of cooling system the indoor operative temperature $\theta_{int;op;24}$ is higher than a high limit, $\theta_{int;op;24;limCO}$ <p>Then: Cooling mode (CO)</p> <p>Otherwise: Neutral mode (NE)</p> <p>The low limit $\theta_{int;op;24;limHE}$ and high limit $\theta_{int;op;24;limCO}$ of $\theta_{int;op;24}$ can vary as part of the specific control scenario in 6.8.6.</p> <p>The previous day is specified as the most recent completed 24 h period starting at 07h00 in the morning.</p> | |
| <p>Method AC2:</p> <p>If during the previous day:</p> <ul style="list-style-type: none"> – the time-average outdoor air temperature, $\theta_{e;a;24}$ is lower than a low limit, $\theta_{e;a;24;limHE}$, Then: Heating mode (HE) – the time-average outdoor air temperature, $\theta_{e;a;24}$ is higher than this low limit, $\theta_{e;a;24;limHE}$, but lower than a high limit, $\theta_{e;a;24;limCO}$ Then: Neutral mode (NE) – the time-average outdoor air temperature, $\theta_{e;a;24}$ is higher than this high limit, $\theta_{e;a;24;limCO}$ Then: Cooling mode (CO) <p>The values for the low limit $\theta_{e;a;24;limHE}$ and high limit $\theta_{e;a;24;limCO}$ can vary as part of the specific control scenario in 6.8.6.</p> <p>The previous day is specified as the most recent completed 24 h period starting at 07h00 in the morning.</p> | <p>Method AM2:</p> <p>Same as Method AC2 for the assumed automated control.</p> |

Table 26 –Methods to identify the conditions and events for the operating temperature of the thermal zone (TINT-MODE: TN, TH or TV)

| Manual control, manual or motorized operation | |
|--|--|
| Assumed occupant’s observation | Modelled as |
| <p>Method MC1:</p> <p>The occupant senses the operating temperature $\theta_{int;op}$ as fine (TN), as high (TH) or as very high (TV).</p> | <p>Method MM1 (default):</p> <p>To simulate the occupant’s observation, the calculated operating temperature is used.</p> |

| | |
|--|--|
| The limit between TN and TH, $\theta_{int;op;limTN}$ and the limit between TH and TV $\theta_{int;op;TH}$ can vary as part of the specific control scenario in 6.8.6. | |
| Automated control | |
| Assumed automated control | Modelled as |
| Method AC1: The operating temperature $\theta_{int;op}$ is measured. The limit between 'fine' and 'high', $\theta_{int;op;limTN}$ and the limit between 'high' and 'very high' $\theta_{int;op;limTH}$ can vary as part of the specific control scenario in 6.8.6. | Method AM1 (default): Same as Method AC1 for the assumed automated control, with calculated instead of measured operating temperature. |

Table 27 –Methods to identify the conditions and events for the level of solar irradiance or illuminance (RAD-MODE: RL or RH)

| | |
|--|--|
| Manual control, manual or motorized operation | |
| Assumed occupant's observation | Modelled as |
| Method MC1: The occupant visually observes the illuminance through the window as high or low. | Method MM1 (default): Specific levels of calculated external solar irradiance at the plane of the adaptive building envelope element are used (with hysteresis) as thresholds to decide if the irradiance or illuminance is high or low. |
| Automated control | |
| Assumed automated control | Modelled as |
| Method AC1: The external illuminance, $E_{V;e;w}$, is measured on the plane of the adaptive building envelope element and is considered low if it is lower than a lower limit, $E_{V;limRL}$, and high if it is higher than a high limit $E_{V;limRH}$. Alternatively, the external solar irradiance $I_{sol;tot;w}$ is measured. For the conversion from solar irradiance to illuminance and vice versa the following conversion formula, from ISO 52010-1, applies: $E_{V;e} = K_V \cdot I_{sol;tot} \quad (2)$ where <ul style="list-style-type: none"> $E_{V;e}$ is the external global illuminance on a surface, in lx; K_V is the global luminous efficacy, in lm/W; $I_{sol;tot}$ is the total solar irradiance on the same surface, in W/m². With $K_V = 115$ lm/W, the average value for different types of sky. | Method AM1 (default): Same as Method AC1 for the assumed automated control, with calculated instead of measured external illuminance or irradiance. |

| | |
|---|---|
| <p>The values for the low limit $E_{V;limRL}$ and high limit $E_{V;limRHh}$ vary as part of the specific control scenario in 6.8.6.</p> | |
| <p>Method AC2: As alternative to Method AC1, a horizontal sensor is used, to measure $E_{V;e;hor}$ or $I_{sol;tot;hor}$.</p> <p>This method has not been worked out in this document.</p> <p>NOTE In this case a larger uncertainty occurs in the conversion to irradiance or illuminance on a vertical or tilted plane, so more conservative criteria are needed.</p> | <p>Method AM2: Same as Method AC2 for the assumed automated control, with calculated instead of measured external illuminance or irradiance.</p> |

Table 28 –Methods to identify the conditions and events for occupancy (OCC-MODE: OCC-AW, OCC-SLP, UNOCC)

| Manual control, manual or motorized operation | |
|--|---|
| Assumed occupant’s observation | Modelled as |
| <p>Method MC1: The occupant is actually present in the space and is capable to activity, or the occupants is actually present in the space but not capable to activity (e.g. sleeping), or the occupant is actually absent</p> | <p>Method MM1 (default): Actual occupancy detection is not possible, so an actual occupancy has to be modelled. The same method is used as Method AM1 for automated control.</p> |
| Automated control | |
| Assumed automated control | Modelled as |
| <p>Method AC1: A sensor is used that detects the presence of occupants.</p> <p>EXAMPLE A PIR-based motion detector.</p> <p>NOTE An assumed occupation schedule is an optional alternative method, but this method is ignored. It would lead to different results.</p> | <p>Method AM1 (default): Actual occupancy detection is not possible, so an actual occupancy has to be modelled. In this method this is done by using a pre-determined occupation schedule with superposed fixed pre-determined hours of absence. This method is included in ISO 52016-1 based on input regarding conditions of use (per space category) from EN 16798-1.</p> <p>NOTE This is also the reason for not simplifying the night time hours (Table 20).</p> <p>Method AM2: Actual occupancy detection is not possible, so an actual occupancy has to be modelled. In this method this is done by using a pre-determined occupation schedule with superposed pre-determined quasi randomly chosen hours of absence</p> |

| | |
|---|---|
| <p>Method AC2 It is assumed that the automated control contains a programmed occupancy schedule, which can include bedtime when relevant.</p> <p>NOTE This implies that the actual occupancy is ignored. However, the option of a user intervention is foreseen.</p> | <p>Method AM3: Same as Method AC2 for the assumed automated control.</p> |
|---|---|

Table 29 –Methods to identify the conditions and events for glare occurrence (GLARE-MODE: GN or GY)

| Manual control, manual or motorized operation | |
|--|---|
| Assumed occupant’s observation | Modelled as |
| <p>Method MC1: It is assumed that the occupant has a specific position and visually experiences glare or not.</p> | <p>Method MM1 (default): To simulate the occupant’s experience, the same method is used as Method AC1 for automated control.</p> <p>NOTE The threshold value can be different.</p> |
| Automated control | |
| Assumed automated control | Modelled as |
| <p>Method AC1: The Daylight Glare Probability, <i>DGP</i>, is assessed, based on the external hourly daylight illuminance using the formula: $DGP = 6,22 \cdot 10^{-5} E_{V,e;w} + 0,184 \quad (3)$ where $E_{V,e;w}$ is the external daylight illuminance on the adaptive building envelope element, in lx. If the <i>DGP</i> exceeds a specific limit, DGP_{limGY}, it is assumed that protection against glare is needed. The value of DGP_{limGY} can vary as part of the specific control scenario in 6.8.6.</p> <p>NOTE See ISO/TR 52016-4 for background information.</p> | <p>Method AM1 (default): Same as Method AC1 for the assumed automated control, with calculated instead of measured external illuminance or irradiance</p> |
| <p>Method AC2: A simplified geometric approach, estimating the vertical illuminance on the occupant, using the estimated hourly solar illuminance level and direction, the position and view direction of the occupant, combined with the geometrical data and daylight transmittance of the adaptive building envelope element.</p> <p>This model only works if the position of the occupants is more or less predefined. In that case it can be calculated if the sun is in the line of sight of (one of) the occupant(s) and what is the level of illuminance on the occupant’s eyes.</p> | <p>Method AM2: Same as Method AC2 for the assumed automated control, with calculated instead of measured external illuminance or irradiance</p> |

| | |
|--|--|
| <p>This method has not been worked out in this document.</p> <p>NOTE See ISO/TR 52016-4 for examples</p> | |
| <p>Method AC3: Estimation of the glare risk by direct measurement (e.g. indoor CCD camera into direction of the window).</p> <p>This method has not been worked out in this document.</p> <p>NOTE See ISO/TR 52016-4 for examples</p> | <p>Method AM3: Same as Method AC3 for the assumed automated control, with calculated instead of measured external illuminance or irradiance</p> |

Table 30 –Methods to identify the conditions and events for low daylight (DAYL-MODE: DN or DL)

| Manual control, manual or motorized operation | |
|---|---|
| Assumed occupant’s observation | Modelled as |
| <p>Method MC1: It is assumed that the occupant has a specific position and visually experiences too low daylight level.</p> | <p>Method MM1 (default): To simulate the occupant’s experience, the same method is used as Method AC1 for automated control.</p> <p>NOTE The threshold value can be different.</p> |
| Automated control | |
| Assumed automated control | Modelled as |
| <p>Method AC1: The internal illuminance at desk level, $E_{V,int;desk}$ (in lx) is estimated with a simplified formula: $E_{V,int;desk} = a_{dayl} \cdot \tau_{V;gl} \cdot H_{gl;1m} \cdot E_{V,e;w} + b_{dayl} \quad (4)$ where $E_{V,e;w}$ is the external daylight illuminance on the adaptive building envelope element, in lx; $\tau_{V;gl}$ is the daylight transmittance of the transparent part of the adaptive building envelope element; a_{dayl} is a coefficient, in 1/m; b_{dayl} is a coefficient, in lx; $H_{gl;1m}$ is the height of the transparent area of the adaptive building envelope element above 1 m from the floor, in m. If $E_{V,int;desk}$ falls below a specific limit, $E_{V,int;desk;limDL}$ it is considered to be low. The value of $E_{V,int;desk;limDL}$ can vary as part of the specific control scenario in 6.8.6.</p> <p>NOTE See ISO/TR 52016-4 for background information.</p> | <p>Method AM1 (default): Same as Method AC1 for the assumed automated control, with calculated instead of measured external illuminance or irradiance</p> |

Table 31 – Methods to identify the conditions and events for heat flow direction (HFLW-MODE)

| Manual control, manual or motorized operation | |
|---|---|
| Assumed occupant's observation | Modelled as |
| Method MC1: Not applicable. | Method MM1: Not applicable. |
| Automated control | |
| Assumed automated control | Modelled as |
| Method AC1: Simplified approach: the measured indoor operative temperature, $\theta_{int;op}$ and outdoor air temperature, $\theta_{e;a}$ are used to guess whether the heat flow through the window is inward or outward: If $\theta_{int;op} > \theta_{e;a}$: outward heat flow, otherwise: inward heat flow | Method AM1 (default): Same as Method AC1 for the assumed automated control, but with calculated indoor operational temperature and outdoor air temperature as input data. |
| Method AC2: Detailed approach: a simplified thermo-optical model of the adaptive building envelope element is used to estimate if the heat flow at the given moment is inward or outward. Depending on the details of the chosen method this requires one or more sensors, such as indoor and outdoor temperature and solar irradiation. This method has not been worked out in this document. | Method AM2: Same as Method AC2 for the assumed automated control, but with calculated instead or measured sensor values as input data. |

6.8.5 Basic rules for the reference control scenario

6.8.5.1 General

For the reference control scenarios, the following basic assumptions and rules apply

6.8.5.2 Individual modes

1. DAY-MODE, RAD-MODE, GLARE-MODE: No difference is made between measurement of external total solar irradiance or measurement of external global illuminance on the adaptive building envelope element. Formula (2) presented in Table 27 is used for the conversion between these two variables.
2. HC-MODE: during heating mode, solar heat is harvested and during cooling mode solar heat is rejected.
3. OCC-MODE:
 - a. In case of manual control: if the space becomes unoccupied or occupied with occupants sleeping, the state remains unchanged.
 - b. In case of the automated control:
 - i. in case of residential spaces: the automated control does not have a presence detection. This implies that for residential buildings, during daytime, the need for daylight and view out is also taken into account if the space is unoccupied;
 - ii. in case of non-residential spaces: the automated control has a presence detection. This implies that for non-residential buildings, during daytime, the need for daylight and view out is only taken into account if the space is occupied.

4. During daytime and if occupied with occupants awake the need for daylight and view out is taken into account, unless this is overruled by glare protection (GLARE-MODE) or by peak shaving (PEAK MODE).
5. But: Peak shaving (PEAK MODE) is ignored in the reference control scenario.
6. GLARE-MODE:
 - a. for residential spaces glare is ignored, because of the possible variation in occupants' positions;
 - b. for non-residential spaces: in case of glare problem, the adaptive building envelope element is darkened, in a way that depends on the technology.
7. NOVIEWIN-MODE: it depends on the space category whether protection against view in is taken into account.
8. User behaviour:
 - a. in case of manual control: if occupied with occupants awake, a fraction of the occupants does not respond; see 6.8.6 for more details;
 - b. in case of manual control: during daytime and if occupied with occupants awake. a fraction of the occupants changes the state to less dark, if the internal environment becomes too dark due to darkening of the adaptive building envelope element; see 6.8.6 for more details;
 - c. in case of automated control: during daytime and if occupied with occupants awake. a fraction of the occupants intervenes if the internal environment becomes too dark due to automatic darkening of the adaptive building envelope element; see 6.8.6 for more details.

6.8.5.3 Combinations of choices

1. The description and differentiation of states can be different for different types or compositions of adaptive building envelope elements.
2. The main combinations of choices during daytime, occupied, with occupants being awake, are presented in Table 32. The combinations of choices for unoccupied and night time are more diverse, but less complex. Therefore, those combinations are presented for each reference control scenario separately in 6.8.7.2.

6.8.5.4 Limit values of the control parameters

1. The limit values for manual control and operation are the same or more conservative than for motorized operation.
2. The limit values for manual control and motorized operation are the same or more conservative than for automated control.
3. The limit values can be different for different space categories.
4. The limit values can be different for different types or compositions of adaptive building envelope elements.

Table 32 –Basic scheme for the reference control scenarios during daytime and occupied with occupants awake

| HC-MODE | TINT-MODE | RAD-MODE | GLARE-MODE | DAYL-MODE | State (qualitative) | If manual control: Occupant fraction not-responding | If automated control: Occupant intervention fraction | |
|---------|-----------|----------|------------|-----------|------------------------|---|--|--|
| HE | -- | -- | GN | -- | Lightest | Fraction keeps dark | | |
| | | | GY | -- | Darkest | Fraction keeps light | | |
| CO | TN | -- | GN | -- | Lightest | Fraction keeps dark | | |
| | | | GY | DN | -- | Darkest | Fraction keeps light | |
| | | | | DL | -- | Dark(est) ^a | Fraction keeps light | Fraction intervenes to get more daylight |
| | | | TH | RL | GN | -- | Lightest | Fraction keeps dark |
| | RH | GY | | DN | -- | Darkest | Fraction keeps light | |
| | | | DL | -- | Dark(est) ^a | Fraction keeps light | Fraction intervenes to get more daylight | |
| | TV | RL | -- | -- | -- | Lightest | Fraction keeps dark | |
| | | | | DN | -- | Darkest | Fraction keeps light | |
| | | RH | -- | -- | -- | Lightest | Fraction keeps dark | |
| | | | | DL | -- | Dark(est) ^a | Fraction keeps light | Fraction intervenes to get more daylight |

^a If manual control: with correction in case of too low daylight.

6.8.5.5 Adaptive building envelope elements with actively ventilated cavity

1. If feasible, given the specific technology, the air flow through the cavity is guided as to either harvest solar heat, reject solar heat, or to warm up or cool down the internal surface, depending on the heating or cooling mode (HC-MODE), low or high solar irradiance level (RAD-MODE) and direction of the heat flow through the adaptive building envelope element (HFLOW-MODE).
2. (Part of) the ventilation air for the thermal zone can be supplied to or extracted from the thermal zone via the cavity or cavities of the adaptive building envelope element. Or the air is only circulating via the cavity or cavities to the same (internal or external) environment. This is decided in ISO 52016-1 as part of the overall energy and air quality considerations for the thermal zone and the type of ventilation system.

6.8.6 Modelling of the user behaviour

6.8.6.1 General

In case of manual control, the reference control scenario assumes a specific rational and active occupant behaviour. In practice, however, a certain fraction of occupants is less active. In the reference control scenario this is taken into account by assuming that a fraction of the occupants will not change the state of the adaptive building envelope element as otherwise assumed in the control scenario.

In case of automated control, the reference control scenario assumes that the occupants intervene if the internal daylight illuminance becomes too low due to the automated control. In practice, however, a

certain fraction of occupants can be less active. In the reference control scenario this is taken into account by the option that a fraction of the occupants will not change the state of the adaptive building envelope element as otherwise assumed in the control scenario.

NOTE These considerations are based on international research as explained in ISO/TR 52016-4 .

To take these less active occupants into account in the calculation, one of the following three approaches can be chosen. If another option than the default approach 1 is chosen, the details of the used approach shall be described in the calculation report.

6.8.6.2 Approach 1 (default)

The fraction of occupants deviating from the assumed rule is translated into: the standard occupant(s) leave a fraction of the adaptive building envelope element unchanged.

NOTE This is the simplest approach. Although this is an approximation of the real situation, this approach is justified in absence of a better practical approach.

6.8.6.3 Approach 2

The fraction of occupants deviating from the (assumed) rule is translated into: the standard occupant(s) deviate from the assumed rule during a fraction of the calculation period. For instance, if the fraction is 1/N: for one day per each N days period.

Approach 2 has not been worked out in this document.

NOTE This is a similar approach as approach 1, but more risky to be less reproducible and less transparent.

6.8.6.4 Approach 3

The fraction of occupants deviating from the (assumed) rule is taken into account by having two separate calculations, one calculation with the standard occupant(s) following the assumed rules and a second calculation with the standard occupant(s) deviating from the assumed rules. In this approach the output of both calculations, in terms of the energy performance and thermal comfort, needs to be combined by taking the weighted average. In a more refined version, intermediate user behaviour can be taken into account by additional calculations with subsequent more refined weighting.

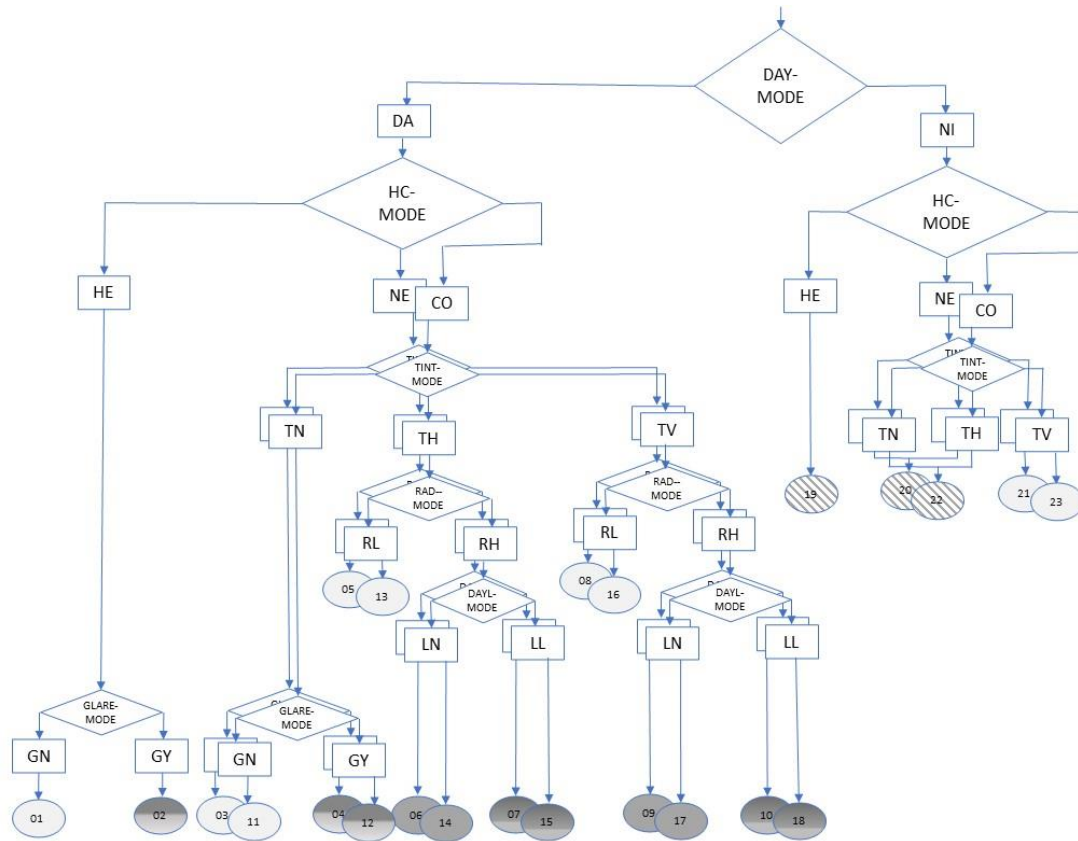
Approach 3 has not been worked out in this document.

NOTE This is a more detailed approach, but less practically feasible.

6.8.7 Reference control scenarios

6.8.7.1 General parameter values

Figure 2 shows a flow diagram with the main elements of the reference control scenarios: the various conditions that ultimately leads to a specific state. As shown in the diagram the total number of possible states is 23. However, not all choices are always applicable and the resulting states are not necessarily all different. This depends on the combination of type of adaptive transparent building envelope element, type of control and space category.



Key:

The identifiers are specified in 6.8.2, Table 23

Figure 2 - The main elements of the reference control scenarios

The parameter values that are specified for the reference control scenarios are given in Table 33.

NOTE Many are the same for all scenarios. These could have been integrated in the description of the methods in 6.8.4, but by specifying the values here it is easier to differentiate the values when needed in future versions of this document.

Table 33 — Parameter values specified for the reference control scenarios

| Mode | For method | Parameter (see Table 21) | Value | Unit |
|---|------------------|----------------------------|-------|------|
| DAY-MODE (see Table 24) <i>Daytime or night time</i> | -- | No parameters | | |
| HC-MODE (see Table 25) <i>Heating, neutral or cooling mode of the thermal zone, in case of absence of heating or cooling system</i> | MM1, AM1 | $\theta_{int;op;24;limHE}$ | 20 | °C |
| | | $\theta_{int;op;24;limCO}$ | 23 | °C |
| | AM1 ^b | $\theta_{e;a;24;limHE}$ | 12 | °C |
| | | $\theta_{e;a;24;limCO}$ | 16 | °C |
| TINT MODE (see Table 26) <i>Operating temperature</i> | MM1, AM1 | $\theta_{int;op;limTN}$ | 22 | °C |

| | | | | |
|--|----------|---|-------------------|-----|
| | | $\theta_{int;op;limTV}$ | 24 | °C |
| RAD-MODE (see Table 27) <i>Level of solar irradiance or illuminance</i> | MM1, AM1 | Varies per situation, see 6.8.6 | | |
| OCC-MODE (see Table 28) <i>Occupancy</i> | MM1, AM1 | The occupancy pattern is defined in ISO 52016-1 | | |
| GLARE-MODE (see Table 29) <i>Glare occurrence</i> | MM1 | DGP_{limGY} | 0,46 ^a | -- |
| | AM1 | DGP_{limGY} | 0,46 ^a | -- |
| DAYL-MODE (see Table 30) <i>Low daylight</i> | MM1, AM1 | a_{dayl} | ^c | 1/m |
| | | b_{dayl} | ^c | lx |
| | MM1 | $E_{V,int;desk;limDL}$ | 300 | lx |
| | AM1 | $E_{V,int;desk;limDL}$ | 300 | lx |
| HFLW-MODE (see Table 31) <i>Heat flow direction</i> | -- | No parameters | | |
| ^a This corresponds with $E_{V;e,w} = 4500$ lx. ^b Is not a default choice. ^c To be determined. | | | | |

6.8.7.2 Reference control scenarios for adaptive building envelope elements with active solar shading or chromogenic glazing

The reference control scenarios for adaptive building envelope elements with active solar shading or chromogenic glazing are specified in Annex C, for different combinations of control types, types of adaptive building envelope elements and space categories (residential and non-residential).

6.8.7.3 Additional reference control scenarios for adaptive building envelope elements with actively ventilated cavities

For adaptive building envelope elements with actively ventilated cavities, Table 34 provides a set of default rules for the ventilation modes. These default rules may be replaced by rules that fit to the intended and possible functionalities of the technology.

Table 34 –Default basic scheme, adaptive building envelope elements with actively ventilated cavity; manual or automated control

| DAY-MODE | HC-MODE | | RAD-MODE | HFLOW MODE | Main function | AVF-MODE = | NOTES |
|----------|---------|--|----------|------------|--------------------------|-------------------------------|-------|
| DA | HE | | RL | -- | Warm up internal surface | AVF-IE or ^a AVF-II | |

| | | | | | | | |
|--|----|----|----|----------------------------|----------------------------------|----------------------------------|--|
| | | | RH | -- | Harvest solar heat | AVF-EI or ^a AVF-II | |
| | CO | | RL | Outward flowing | Cool down cavity | AVF-EI or ^a AVF-EE | |
| Inward flowing | | | | Cool down internal surface | AVF-IE or ^a AVF-II | | |
| | | RH | -- | Reject solar heat | AVF-IE or ^a AVF-EE | | |
| NI | HE | | | -- | Warm up internal surface | AVF-IE or ^a AVF-II | |
| | CO | | | Outward flowing | Cool down cavity | AVF-EI or ^a AVF-EE | |
| | | | | Inward flowing | Cool down internal surface | AVF-IE or ^a AVF-II | |
| ^a Depending whether (part of) the ventilation air for the thermal zone is to be supplied or extracted via the cavity or cavities of the adaptive building envelope element, according to ISO 52016-1. | | | | | | | |

NOTE Worked out examples are given in ISO/TR 52016-4 .

6.9 Hourly calculation procedures

Apply the hourly calculation procedures according to ISO 52016-1:2017, 6,5, with the additions and adaptations specified in the previous clauses of this document.

6.10 Post-processing: performance characteristics

The post-processing of the calculation results can include for instance:

- “Statistics” on the use of the different states of the adaptive building envelope element.
- Impact indicator (for a specific application or reference situation).
- Indicator for smartness or smart readiness.

Key performance indicators are:

For the thermal zone with the adaptive building envelope element, z_t :

The difference between the calculated annual energy needs for heating and cooling against a reference element or against the same adaptive building envelope element but with different control strategies, expressed as:

- Difference in annual heating needs, absolute: $\Delta Q_{H;nd;zt}$ [kWh/(m².a)] and relative: $dQ_{H;nd;zt}$ [%].
- Difference in annual cooling needs, absolute: $\Delta Q_{C;nd;zt}$ [kWh/(m².a)] and relative: $dQ_{C;nd;zt}$ [%].
- Difference in annual heating plus cooling needs, absolute: $\Delta Q_{HC;nd;zt}$ [kWh/(m².a)] and relative: $dQ_{HC;nd;zt}$ [%].

Difference between the calculated thermal comfort against a standard reference element, expressed as for instance:

- low temperatures: accumulated hours of indoor operative temperature during occupancy below 20°C, absolute: $\Delta T_{low;zt;an}$ [K.h] and relative: $dT_{low;zt;an}$ [%].
- high temperatures: : accumulated hours of indoor operative temperature during occupancy above 25°C, absolute: $\Delta T_{high;zt;an}$ [K.h] and relative: $dT_{high;zt;an}$ [%].

NOTE In the context of the improvement of the set of EPB standards specifications for a winter and summer thermal comfort score is under preparation, based on EN 16798-1, to replace this performance indicator in the future. See ISO TR 52016-4 for more details.

Annual or monthly time average value of the thermo-solar properties of the transparent part of the adaptive building envelope element, weighted by a relevant parameter indicating the conditions. In particular:

- Mean thermal transmittance or U -value of the adaptive building envelope element, in W/(m² K), weighted by indoor-outdoor temperature difference, in K;
- Mean solar transmittance or g_{gl} -value of the transparent part of the adaptive building envelope element,, weighted by incident total solar irradiance $I_{sol;gl}$ in W/m²;
- Mean daylight transmittance, $\tau_{V;gl}$ of the transparent part of the adaptive building envelope element, weighted by incident external; global illuminance, $E_{V;e;gl}$ in lx.

However, these key performance indicators shall not be regarded as product information: they are only valid for the given combination of building, climate, conditions of use and control (type and specifications).

7 Quality control

The following checks can be made to increase confidence in correct implementation of the calculation procedures of this document:

- Perform one or a few calculations with a fixed extreme state of the adaptive building envelope element to check if the result is plausible.
- Analyse during representative short time series the subsequent changes of the state of the adaptive building envelope element as a function of the parameters in the control scenario, to check the plausibility of the changes.

8 Conformance check

A conformance check shall be done to see if the calculation procedure is applicable and has been applied correctly and that the calculation assumptions and the input data are correct.

For input data gathered through other EPB documents, conformance checks shall be done according to each document.

Specific additional procedures:

- Include in the report a general description of the building, the adaptive building envelope element, the control type and the set of indoor and outdoor conditions.
- List all input data and selected options and additional details (see 6.8.1, 6.8.4) to ensure traceability.
- Report basic intermediate results in the calculation report.
- Perform and report the characteristics as a result of the post-processing according to 6.10.
- In case of using a customized control scenario, this shall be explicitly reported when presenting the results of the calculation.
- If the output of this document is used to compare different (static or adaptive) building envelope elements, it shall be carried out so that the calculations that are compared are based on the same building and building use and same climate. The functionality of the envelope elements needs to be considered in this comparison, which can include thermal and visual comfort.

Annex A (normative)

Input and method selection data sheet — Template

NOTE This annex conforms to the common template for each of the EPB standards, including recently proposed modifications

A.1 General

The template in Annex A of this document shall be used to specify the choices between methods, the required input data and references to other standards.

NOTE 1 Following this template is not enough to guarantee consistency of data.

NOTE 2 Informative default choices are provided in Annex B.

NOTE 3 The template in Annex A is applicable to different applications (e.g. the design of a new building, certification of a new building, renovation of an existing building and certification of an existing building) and for different types of buildings (e.g. small or simple buildings and large or complex buildings). A distinction in values and choices for different applications or building types can be made:

- by adding columns or rows (one for each application), if the template allows;
- by including more than one version of a table (one for each application), numbered consecutively as a, b, c, ...
For example: Table NA.3a, Table NA.3b.

NOTE 4 ISO/TR 52016-4 contains a reference to show how to fill in a national annex or national datasheet specifically for the application of an EPB standard in the context of national or regional building codes.

The shaded fields in the tables are part of the template and consequently do not allow the input of data.

A.2 References

The references, identified by the EPB module code number, are given in Table A.1 (template).

Table A.1 — References

| Reference | Reference document ^a | |
|---|---------------------------------|--------------------------------------|
| | Number | Specific application (if applicable) |
| M1-6 | | |
| M1-8 | | |
| M1-13 | | |
| M2-4 | | |
| M2-5 | | |
| M2-8 | | |
| M5-5 | | |
| M9-1 | | |
| M10-1 | | |
| ^a If a reference comprises more than one document, the references can be differentiated. | | |

In this document there are no national choices for Annex A other than Table A.1.

Annex B (informative)

Input and method selection data sheet — Default choices

B.1 General

The template in Annex A of this document shall be used to specify the choices between methods, the required input data and references to other standards.

NOTE 1 Following this template is not enough to guarantee consistency of data.

NOTE 2 Informative default choices are provided in this annex.

NOTE 3 The template in Annex A is applicable to different applications (e.g. the design of a new building, certification of a new building, renovation of an existing building and certification of an existing building) and for different types of buildings (e.g. small or simple buildings and large or complex buildings). A distinction in values and choices for different applications or building types can be made:

- by adding columns or rows (one for each application), if the template allows;
- by including more than one version of a table (one for each application), numbered consecutively as a, b, c, ...
For example: Table NA.3a, Table NA.3b.

NOTE 4 ISO/TR 52016-4 shows how to fill in a national annex or national datasheet specifically for the application of an EPB standard in the context of national or regional building codes.

The shaded fields in the tables are part of the template and consequently do not allow the input of data.

B.2 References

The references, identified by the EPB module code number, are given in Table B.1.

Table B.1 — References

| Reference | Reference document ^a | |
|---|---------------------------------|--|
| | Number | Specific application (if applicable) |
| M1-6 | ISO 17772-1 EN 16798-1 | |
| M1-8 | ISO 52000-1 | |
| M1-13 | ISO 52010-1 | |
| M2-4 | ISO 52018-1 | |
| M2-5 | ISO 10077-1 | For windows without ventilated cavity |
| | ISO 15099 | For windows without ventilated cavity, outside CEN area ^b For windows with ventilated cavity |
| M2-8 | ISO 9050 | For non-scattered glazings, outside CEN area ^b |
| | EN 410 | For non-scattered glazings, within CEN area ^b |
| | ISO 15099 | For windows with scattering glazing and/or solar shading devices |
| | ISO 52022-3 | For normal incidence angle, within CEN area ^b |
| | ISO 52022-3 or ISO 15099 | For normal incidence angle, outside CEN area ^b |
| M5-5 | EN 16798-7 | |
| M9-1 | EN 15193-1 | |
| M10-1 | ISO 52120-1 | |
| a If a reference comprises more than one document, the references can be differentiated. | | |
| b CEN area: Countries whose national standards body is a member of CEN. Attention is drawn to the need for observance of EU Directives transposed into national legal requirements. | | |

In this version there are no national choices for Annex A other than Table A.1

Annex C (normative)

Reference control scenarios for adaptive building envelope elements with active solar shading or chromogenic glazing

Reference control scenarios for different control types, different adaptive building envelope elements and different space categories (residential and non-residential), see 6.8.7.2 for details.

Table C.1 gives the low and high solar radiation levels, expressed as daylight illuminance (klux). The conversion factor from daylight illuminance to irradiance and vice versa is given by Formula (2) presented in Table 27.

Table C.1 – Low and high solar radiation levels, as function of HC-mode and TINT-mode

| RAD-mode, expressed in daylight illuminance, $E_{V,e,w}$ (klux) | | | | | | | | |
|---|--------------|-----------|--------------|-----------|--------------|-----------|--------------|-----------|
| | NE-TH | | NE-TV | | CO-TH | | CO-TV | |
| Description (id) | RL | RH | RL | RH | RL | RH | RL | RH |
| ExRoChr-MAN-RES | 37,5 | 72,5 | 37,5 | 72,5 | 37,5 | 72,5 | 22,5 | 47,5 |
| ExRoChr-MOT-RES | 30,0 | 60,0 | 30,0 | 60,0 | 30,0 | 60,0 | 17,5 | 33,0 |
| ExRoChr-AUT-RES | 30,0 | 60,0 | 15,0 | 30,0 | 15,0 | 30,0 | 10,0 | 15,0 |
| ExVen-MAN-RES | 37,5 | 72,5 | 37,5 | 72,5 | 37,5 | 72,5 | 22,5 | 47,5 |
| ExVen-MOT-RES | 30,0 | 60,0 | 30,0 | 60,0 | 30,0 | 60,0 | 17,5 | 33,0 |
| ExVen-AUT-RES | 30,0 | 60,0 | 15,0 | 30,0 | 15,0 | 30,0 | 10,0 | 15,0 |
| ExRoChr-MAN-OFF | 37,5 | 72,5 | 37,5 | 72,5 | 37,5 | 72,5 | 22,5 | 47,5 |
| ExRoChr-MOT-OFF | 30,0 | 60,0 | 30,0 | 60,0 | 30,0 | 60,0 | 17,5 | 33,0 |
| ExRoChr-AUT-OFF | 30,0 | 60,0 | 15,0 | 30,0 | 15,0 | 30,0 | 10,0 | 15,0 |
| ExVen-MAN-OFF | 37,5 | 72,5 | 37,5 | 72,5 | 37,5 | 72,5 | 22,5 | 47,5 |
| ExVen-MOT-OFF | 30,0 | 60,0 | 30,0 | 60,0 | 30,0 | 60,0 | 17,5 | 33,0 |
| ExVen-AUT-OFF | 30,0 | 60,0 | 15,0 | 30,0 | 15,0 | 30,0 | 10,0 | 15,0 |

Key:
 Ex = external or integrated'
 Ven = venetian blind
 RoChr = roller blind or chromogenic glazing
 RES= = residential space
 OFF = office space
 MAN, MOT, AUT: see 6.66.6
 HE, NE, CO: see 6.8.26.8.2
 TN, TH, TV: see 6.8.26.8.2

Tables C.2 – C.5 give the overview of all possible states, with state identifier and the state number assigned to each state, as presented in the flow diagram Figure 2 and for each state:

- the fraction that is extended “by rule”: as specified by the control scenario;
- with in the next column:
 - for manual control the correction due to user behaviour according to 6.8.6;
 - for automated control the correction due to occupant intervention, as specified in 6.8.6;
- The state extension number, referring to the secondary states. In case of venetian blinds the secondary states are:
 1. slats open (0°)
 2. slats half open (45°)
 3. slats closed (80°)

For roller blinds and chromogenic glazings there are no secondary states.

NOTE For internal roller blinds or equivalent or active chromogenic glazing the function is likely to be more focused on visual comfort, so the scenarios are slightly different compared to Tables C2 – C.5.

Table C.2 – Position of each state, for external or integrated roller blinds or chromogenic glazing, residential space

| State number | State identifier ^a | Manual control | | | Automated control | | |
|--------------------------------|-------------------------------|----------------------------|---|------------------------|----------------------------|---|------------------------|
| | | Fraction extended, by rule | Correction for deviating occupants ^b | State extension number | Fraction extended, by rule | Correction for deviating occupants ^c | State extension number |
| Comment: | | -- | -- | No variation | | | No variation |
| Occupied-awake (OCC-AW) | | | | | | | |
| 1 | DA-HE-TX-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 2 | DA-HE-TX-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 3 | DA-NE-TN-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 4 | DA-NE-TN-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 5 | DA-NE-TH-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 6 | DA-NE-TH-RH-GX-LN | 1,00 | -0,40 | 1 | 1,00 | 0,00 | 1 |
| 7 | DA-NE-TH-RH-GX-LL | 1,00 | -0,40 | 1 | 1,00 | -0,20 | 1 |
| 8 | DA-NE-TV-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 9 | DA-NE-TV-RH-GX-LN | 1,00 | -0,40 | 1 | 1,00 | 0,00 | 1 |
| 10 | DA-NE-TV-RH-GX-LL | 1,00 | -0,40 | 1 | 1,00 | -0,20 | 1 |
| 11 | DA-CO-TN-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 12 | DA-CO-TN-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 13 | DA-CO-TH-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 14 | DA-CO-TH-RH-GX-LN | 1,00 | -0,40 | 1 | 1,00 | 0,00 | 1 |
| 15 | DA-CO-TH-RH-GX-LL | 1,00 | -0,40 | 1 | 1,00 | -0,20 | 1 |
| 16 | DA-CO-TV-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |

| | | | | | | | |
|----|-------------------|------|-------|---|------|-------|---|
| 17 | DA-CO-TV-RH-GX-LN | 1,00 | -0,20 | 1 | 1,00 | 0,00 | 1 |
| 18 | DA-CO-TV-RH-GX-LL | 1,00 | -0,20 | 1 | 1,00 | -0,20 | 1 |
| 19 | NI-HE-TX-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 20 | NI-NE-Tx-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 21 | NI-NE-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 22 | NI-CO-Tx-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 23 | NI-CO-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |

Occupied-sleeping (OCC-SL) or Unoccupied (UNOCC):

Manual control: same position as the last occupied hour

Automated control: same as occupied (because no occupancy sensor assumed), but without the occupants correction

^a State identifiers: see 6.8.26.8.2, with:

X = placeholder for any option.

x = placeholder for any but one option

^b The fraction does not need to be physically possible, because it stands for a statistical fraction of non-responding occupants.

^c Until next change of state.

Table C.3 – Position of each state, for external or integrated venetian blinds, residential space

| State number | State identifier ^a | Manual control | | | Automated control | | |
|--------------------------------|-------------------------------|----------------------------|---|------------------------|----------------------------|---|------------------------|
| | | Fraction extended, by rule | Correction for deviating occupants ^b | State extension number | Fraction extended, by rule | Correction for deviating occupants ^c | State extension number |
| Comment: | | -- | -- | -- | -- | -- | -- |
| Occupied-awake (OCC-AW) | | | | | | | |
| 1 | DA-HE-TX-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 2 | DA-HE-TX-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 3 | DA-NE-TN-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 4 | DA-NE-TN-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 5 | DA-NE-TH-RL-GX-LX | 1,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 6 | DA-NE-TH-RH-GX-LN | 1,00 | -0,40 | 2 | 1,00 | 0,00 | 2 |
| 7 | DA-NE-TH-RH-GX-LL | 1,00 | -0,40 | 2 | 1,00 | 0,00 | 2 |
| 8 | DA-NE-TV-RL-GX-LX | 1,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 9 | DA-NE-TV-RH-GX-LN | 1,00 | -0,40 | 3 | 1,00 | 0,00 | 3 |
| 10 | DA-NE-TV-RH-GX-LL | 1,00 | -0,40 | 3 | 1,00 | -0,20 | 2 |
| 11 | DA-CO-TN-RX-GN-LX | 1,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 12 | DA-CO-TN-RX-GY-LX | 1,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 13 | DA-CO-TH-RL-GX-LX | 1,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 14 | DA-CO-TH-RH-GX-LN | 1,00 | -0,40 | 2 | 1,00 | 0,00 | 3 |
| 15 | DA-CO-TH-RH-GX-LL | 1,00 | -0,40 | 2 | 1,00 | -0,20 | 2 |
| 16 | DA-CO-TV-RL-GX-LX | 1,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |

| | | | | | | | |
|--|-------------------|------|-------|---|------|-------|---|
| 17 | DA-CO-TV-RH-GX-LN | 1,00 | -0,20 | 3 | 1,00 | 0,00 | 3 |
| 18 | DA-CO-TV-RH-GX-LL | 1,00 | -0,20 | 3 | 1,00 | -0,20 | 2 |
| 19 | NI-HE-TX-RX-GX-LX | 0,00 | 0,10 | 3 | 1,00 | 0,00 | 3 |
| 20 | NI-NE-Tx-RX-GX-LX | 0,00 | 0,10 | 3 | 1,00 | 0,00 | 3 |
| 21 | NI-NE-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,50 | 0,00 | 1 |
| 22 | NI-CO-Tx-RX-GX-LX | 0,00 | 0,10 | 3 | 1,00 | 0,00 | 3 |
| 23 | NI-CO-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| Occupied-sleeping (OCC-SL) or Unoccupied (UNOCC) | | | | | | | |
| Manual control: same position as the last occupied hour | | | | | | | |
| Automated control: same as occupied (because no occupancy sensor assumed), but without the occupants correction | | | | | | | |
| <p>^a State identifiers: see 6.8.26.8.2, with: X = placeholder for any option. x = placeholder for any but one option.</p> <p>^b The fraction does not need to be physically possible, because it stands for a statistical fraction of non-responding occupants.</p> <p>^c Until next change of state.</p> | | | | | | | |

Table C.4 – Position of each state, for external or integrated roller blinds or chromogenic glazing, office space

| State number | State identifier ^a | Manual control | | | Automated control | | |
|--------------------------------|-------------------------------|----------------------------|---|--------------------------------|----------------------------|---|------------------------|
| | | Fraction extended, by rule | Correction for deviating occupants ^b | State extension number for the | Fraction extended, by rule | Correction for deviating occupants ^c | State extension number |
| Comment: | | -- | -- | No variation- | -- | -- | No variation |
| Occupied-awake (OCC-AW) | | | | | | | |
| 1 | DA-HE-TX-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 2 | DA-HE-TX-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 3 | DA-NE-TN-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 4 | DA-NE-TN-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 5 | DA-NE-TH-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 6 | DA-NE-TH-RH-GX-LN | 1,00 | -0,40 | 1 | 1,00 | 0,00 | 1 |
| 7 | DA-NE-TH-RH-GX-LL | 1,00 | -0,40 | 1 | 1,00 | -0,20 | 1 |
| 8 | DA-NE-TV-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 9 | DA-NE-TV-RH-GX-LN | 1,00 | -0,40 | 1 | 1,00 | 0,00 | 1 |
| 10 | DA-NE-TV-RH-GX-LL | 1,00 | -0,40 | 1 | 1,00 | -0,20 | 1 |
| 11 | DA-CO-TN-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 12 | DA-CO-TN-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 13 | DA-CO-TH-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 14 | DA-CO-TH-RH-GX-LN | 1,00 | -0,40 | 1 | 1,00 | 0,00 | 1 |

| | | | | | | | |
|----|-------------------|------|-------|---|------|-------|---|
| 15 | DA-CO-TH-RH-GX-LL | 1,00 | -0,40 | 1 | 1,00 | -0,20 | 1 |
| 16 | DA-CO-TV-RL-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 17 | DA-CO-TV-RH-GX-LN | 1,00 | -0,20 | 1 | 1,00 | 0,00 | 1 |
| 18 | DA-CO-TV-RH-GX-LL | 1,00 | -0,20 | 1 | 1,00 | -0,20 | 1 |
| 19 | NI-HE-TX-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 20 | NI-NE-Tx-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 21 | NI-NE-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 22 | NI-CO-Tx-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 23 | NI-CO-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |

Unoccupied (UNOCC):

Manual control: same position as the last occupied hour

Automated control: same as OCC-AW, except: no GY and no DL and no occupants correction

^a State identifiers: see 6.8.26.8.2, with:

X = placeholder for any option.

x = placeholder for any but one option

^b The fraction does not need to be physically possible, because it stands for a statistical fraction of non-responding occupants.

^c Until next change of state.

Table C.5 – Position of each state, for external or integrated venetian blinds, office space

| State number | State identifier ^a | Manual control | | | Automated control | | |
|--------------------------------|-------------------------------|----------------------------|---|------------------------|----------------------------|---|------------------------|
| | | Fraction extended, by rule | Correction for deviating occupants ^b | State extension number | Fraction extended, by rule | Correction for deviating occupants ^c | State extension number |
| Comment: | | -- | -- | -- | -- | -- | -- |
| Occupied-awake (OCC-AW) | | | | | | | |
| 1 | DA-HE-TX-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 2 | DA-HE-TX-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 3 | DA-NE-TN-RX-GN-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 4 | DA-NE-TN-RX-GY-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |
| 5 | DA-NE-TH-RL-GX-LX | 0,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 6 | DA-NE-TH-RH-GX-LN | 1,00 | -0,40 | 2 | 1,00 | 0,00 | 2 |
| 7 | DA-NE-TH-RH-GX-LL | 1,00 | -0,40 | 2 | 1,00 | 0,00 | 2 |
| 8 | DA-NE-TV-RL-GX-LX | 0,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 9 | DA-NE-TV-RH-GX-LN | 1,00 | -0,40 | 3 | 1,00 | 0,00 | 3 |
| 10 | DA-NE-TV-RH-GX-LL | 1,00 | -0,40 | 3 | 1,00 | -0,20 | 2 |
| 11 | DA-CO-TN-RX-GN-LX | 0,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 12 | DA-CO-TN-RX-GY-LX | 0,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 13 | DA-CO-TH-RL-GX-LX | 0,00 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 14 | DA-CO-TH-RH-GX-LN | 1,00 | -0,40 | 2 | 1,00 | 0,00 | 3 |

| | | | | | | | |
|----|-------------------|-------|-------|---|------|-------|---|
| 15 | DA-CO-TH-RH-GX-LL | -0,40 | -0,40 | 2 | 1,00 | -0,20 | 2 |
| 16 | DA-CO-TV-RL-GX-LX | 0,40 | -0,40 | 1 | 0,00 | 0,00 | 1 |
| 17 | DA-CO-TV-RH-GX-LN | -0,40 | -0,20 | 3 | 1,00 | 0,00 | 3 |
| 18 | DA-CO-TV-RH-GX-LL | -0,40 | -0,20 | 3 | 1,00 | -0,20 | 2 |
| 19 | NI-HE-TX-RX-GX-LX | 0,00 | 0,10 | 3 | 1,00 | 0,00 | 3 |
| 20 | NI-NE-Tx-RX-GX-LX | 0,00 | 0,10 | 3 | 1,00 | 0,00 | 3 |
| 21 | NI-NE-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,50 | 0,00 | 1 |
| 22 | NI-CO-Tx-RX-GX-LX | 0,00 | 0,10 | 3 | 1,00 | 0,00 | 3 |
| 23 | NI-CO-TV-RX-GX-LX | 0,00 | 0,10 | 1 | 0,00 | 0,00 | 1 |

Unoccupied (UNOCC):

Manual control: same position as the last occupied hour

Automated control: same as OCC-AW, except: no GY and no DL and no occupants correction

^a State identifiers: see 6.8.26.8.2, with:

X = placeholder for any option.

x = placeholder for any but one option

^b The fraction does not need to be physically possible, because it stands for a statistical fraction of non-responding occupants.

^c Until next change of state.

Bibliography

- [1] ISO 9050, *Glass in building – Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*
- [2] EN 12216:2018, *Shutters, external blinds, internal blinds - Terminology, glossary and definitions*
- [3] ISO 13789, *Thermal performance of buildings — Transmission and ventilation heat transfer coefficients — Calculation method*
- [4] ISO 10077-1, *Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: General*
- [5] EN 15193-1 *Energy performance of buildings - Energy requirements for lighting - Part 1: Specifications, Module M9*
- [6] ISO 15099, *Thermal performance of windows, doors and shading devices – Detailed calculations*
- [7] EN 16798-1, *Energy performance of buildings – Ventilation for buildings – Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (Module M1-6)*⁴
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- [9] ISO 16817:2017, *Building environment design — Indoor environment — Design process for the visual environment*
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- [11] ISO 52010-1, *Energy performance of buildings - External climatic conditions - Part 1: Conversion of climatic data for energy calculations*
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- [14] ISO 52120-1, *Energy performance of buildings – Part 1: Impact of Building Automation, Controls and Building Management*
- [15] EN 410, *Glass in building — Determination of luminous and solar characteristics of glazing*

⁴ Currently under review

- [15] CEN/TS 16628:2014, *Energy performance of buildings — Basic principles for the set of EPB standards*⁵
- [16] CEN/TS 16629:2014, *Energy performance of buildings — Detailed technical rules for the set of EPB standards*⁶
- [17] ISO/TR 52000-2, *Energy performance of buildings — Overarching EPB assessment – Part 2: Explanation and justification of ISO 52000-1*
- [18] ISO/TR 52016-2, *Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 2: Explanation and justification of ISO 52016-1 and ISO 52017-1*
- [19] ISO/TR 52016-4⁷, *Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 4: Explanation and justification of ISO 52016-3*

⁵ Currently under review

⁶ Currently under review

⁷ Under preparation. Stage at the time of publication: ISO/WD TR 52016-4.

European foreword

This document (EN ISO 52016-3:2023) has been prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, the secretariat of which is held by SN, in collaboration with Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, the secretariat of which is held by SIS.

This document is part of the set of standards on the energy performance of buildings (the set of EPB standards). The original set of EPB standards has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/480, see reference [EF1] below), and supports essential requirements of EU Directive 2010/31/EC on the energy performance of buildings (EPBD, [EF2]). This document fills in a missing gap in the original set.

In case this standard is used in the context of national or regional legal requirements, mandatory choices may be given at national or regional level for such specific applications, in particular for the application within the context of EU Directives transposed into national legal requirements.

Further target groups are users of the voluntary common European Union certification scheme for the energy performance of non-residential buildings (EPBD art.11.9) and any other regional (e.g. Pan European) parties wanting to motivate their assumptions by classifying the building energy performance for a dedicated building stock.

This International Standard cancels and replaces no other international standard.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

References:

[EF1] Mandate M/480, Mandate to CEN, CENELEC and ETSI for the elaboration and adoption of standards for a methodology calculating the integrated energy performance of buildings and promoting the energy efficiency of buildings, in accordance with the terms set in the recast of the Directive on the energy performance of buildings (2010/31/EU) of 14th December 2010

[EF2] EPBD, Recast of the Directive on the energy performance of buildings (2010/31/EU) of 14th December 2010 (but revised in 2018)