A new draft standard with calculation procedures regarding adaptive building envelope elements: prEN ISO/DIS 52016-3

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A new draft standard in the (EN) ISO 52000 family of standards to assess the overall energy performance of buildings has been published for public enquiry until July 14, 2022: prEN ISO/DIS 52016-3, to provide calculation procedures to assess the energy performance of a building with adaptive building envelope elements.

Keywords: EPB standards, Energy efficiency, Smart buildings, Adaptive facades, EPBD, SRI

Set of CEN and ISO standards to assess the overall energy performance of buildings (EPB)

The set of international standards to assess the overall energy performance of buildings (CEN/ISO EPB standards, published in 2017 [1]) has been developed on the basis of a Mandate (M/480) from the European Commission ([2]) to develop a methodology to support the EPBD ([3], [4]), that is fit for use in the context of national building regulations: to check compliance with minimum energy performance of buildings (EPB) requirements and as information for the energy performance rating on a EPB certificate. The core of the set of EPB standards consists of the **(EN) ISO 52000 family** of standards.

The relevant standards in the set of EPB standards take into account adaptive facades only to a very limited extent and in a highly simplified manner. As a result, the advantages of this type of facade are largely not honoured. This is even more the case for adaptive facades with performance properties that can adapt

to (sub-)hourly changes in outdoor conditions and building use, aiming for less energy use and improved comfort over the seasons.

Creating a level playing field for different techniques is crucial here.

On the other hand, this set of EPB standards provides is ready for the integration of dynamic facade components in the energy performance calculation, because it offers hourly calculation time intervals and it has a modular set up.

Most relevant EPB standard: EN ISO 52016-1

The most relevant EPB standard in this context is EN 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* [5].

EN ISO 52016-1 :2017 provides a (recommended) hourly method to calculate the energy needs for heating and cooling, internal temperatures and sensible and latent heat loads.

> The standard also contains a simple monthly method, using monthly correction coefficients to account for dynamic (hourly) interactions between building, systems, building use and weather conditions. This monthly method has strong limitations, especially when dealing with adaptive facades and other innovative technologies.*

EN ISO 52016-1 contains a normative Annex G that offers already a **framework** for calculation procedures involving adaptive building envelope elements.

Work on a new standard providing fully developed calculation procedures

Instead of only a framework, a new work item was initiated, collaboratively by CEN (TC 89) and ISO (TC 163/SC 2, to develop a new standard, providing fully developed calculation procedures to assess the energy performance of a building with adaptive building envelope elements.

The work was assigned to ISO/TC 163/SC 2/WG 15, with the title:

> EN ISO 52016-3, *Energy performance of buildings - Sensible and latent heat loads and internal temperatures - Part 3: Calculation procedures regarding adaptive building envelope elements* ([6])

The work started in 2019 and is expected to be finished in 2023. The draft version (prEN ISO/DIS 52016-3) has been published for public enquiry until July 14, 2022.

Main challenges

Four main challenges arose during the standardization process:

Challenge 1. To focus on a generic "horizontal" approach

There are many different types of products with adaptive components, with different combinations and functions. The first question was which types should be covered in the standard (at least for the moment) and how these should be categorized, from a 'generic' physics perspective (for the modelling).

Challenge 2. To focus on standardization

In practice, the control scenarios of actively controllable adaptive building envelope elements vary widely in complexity. They also vary with the aim to optimize for a specific building or space category, orientation, composition of the adaptive building envelope element, et cetera. Reference control scenarios, specified for different control types, adaptive building envelope elements and space categories (residential and non-residential) are needed to create a level playing field for comparison of options.

Challenge 3. To clearly describe the link with EN ISO 52016-1

The calculation procedures in EN ISO 52016-3 are a kind of extension to the calculation procedures of Part 1 (EN ISO 52016-1). The challenge is to describe these additional calculation procedures in a clear and unambiguous way without duplicating content of Part 1.

* See e.g. EPB Center webinar on this subject: https://epb.center/news/news_events/fourth-webinar-epb-standards-hourly-vs-monthly-met/

Note that merging Part 3 into Part 1 is not a good solution, because EN ISO 52016-1 is one of the most widely used EPB standards around the globe and adding the special and novel standardized calculation procedures on adaptive building envelope elements to EN ISO 52016-1 would complicate and could jeopardize the acceptance of Part 1 and the adoption of Part 1 in national and regional building codes. Moreover, the calculation procedures on adaptive building envelope elements require special expertise, so the commenting, approval and also maintenance of the document needs to be done as a separate track.

Challenge 4. To prepare for digitization of standards

Because CEN and ISO are speeding up their initiatives towards a future of **machine readable standards** ([15]), the draft standard has been pro-actively re-edited in such a way that it 'almost only' contains the recipe for a calculation: most of the explanations are moved to an **accompanying technical report**. Such a technical report is in preparation simultaneously with the standard, as required for each EPB standard anyway, to provide justification, explanation and worked examples: CEN ISO/TR 52016-4 ([7]). It is intended to make a rough draft available, just for information, along with the draft standard.

The scope of prEN ISO/DIS 52016-3:2022

prEN ISO/DIS 52016-3 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 EN ISO 52016-1, with additions or modifications of the calculations 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 EN 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 compliance with minimum energy performance criteria.

The document is also applicable to assess the contribution of the adaptive building envelope element to the smartness 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.

This document is applicable to buildings at the design stage, to new buildings after construction and to existing buildings in the use phase.

Links with Energy Performance of Buildings Directive (EPBD)

The EC's proposal for the EPBD revision [8], published in December 2021, clearly shows that the changes compared to the current EPBD will have impact on certain EPB standards.

The proposed EPBD demands that the energy needs and energy use for space heating, space cooling, domestic hot water, ventilation, lighting and other technical building systems are calculated using **hourly or sub-hourly calculation time intervals**, in order to account for varying conditions that significantly affect the operation and performance of the system and the indoor conditions, and in order to optimise health, indoor air quality and comfort levels defined by EU Member States at national or regional level.

Hourly calculation procedures are indeed essential for the assessment of the impact of adaptive building envelope elements on the energy needs for heating and cooling and thermal comfort.

The revised EPBD will also reinforce the **Smart Readiness Indicator** (SRI, see REHVA article [9]).

An adaptive building envelope element can significantly contribute to the smart readiness of a building

and EN ISO 52016-3 is a tool to quantify the impact, as part of the set of EPB standards. Again, assessment of the actual impact requires an (sub-)hourly calculation time interval.

Types of adaptive building envelope elements

As can be read from the scope, three types are distinguished:

Adaptive building envelope elements with dynamic solar shading (blind or shutter), defined as:

A 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.

Examples:

- Internal blind (venetian blind, roller blind, vertical blind, pleated blind, honeycomb blind, …)
- External or integrated blind (vertical roller blind, venetian blind, …)
- Shutters (roller shutter, wing shutter, concertina shutter, …)

Adaptive building envelope elements with chromogenic glazing, defined as:

Glazing with optical and visual properties that can vary (passively or actively) as function of a specific environment condition.

Examples:

- Thermochromic glazing, thermotropic glazing and photochromic glazing (passive)
- Electrochromic glazing, liquid crystal glazing, suspended particle device (active)

Adaptive building envelope elements with actively ventilated cavity, defined as:

A cavity between two layers of glazings or blinds 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.

Examples:

Naturally, hybrid or mechanically ventilated cavity in a double envelope façade or in a window with integrated venetian or roller blinds; with fixed or operated vent openings

Model of the adaptive building envelope element

With respect to the modelling of the adaptive element, two options are distinguished:

Simplified adaptive building envelope element, defined as:

An adaptive building envelope element that is described with the same (simplified) 2 layers (2 nodes) model as used to describe a transparent building element in ISO 52016-1, with thermal, daylight and solar properties that, for a given state, are constant and thus can be pre-calculated for the full year. See illustration in **Figure 1**.

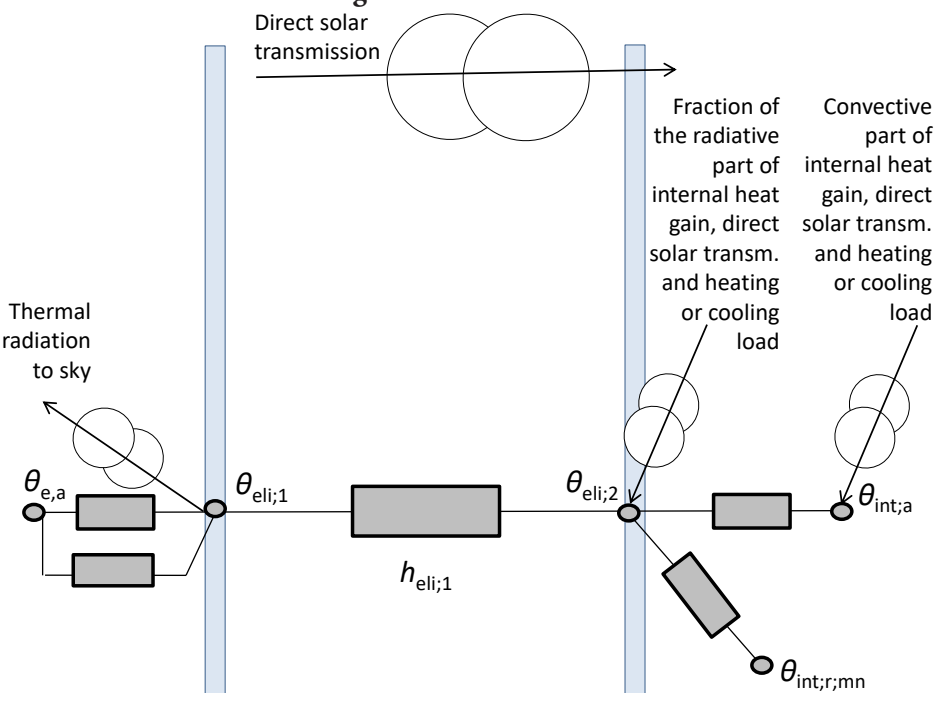


Figure 1. Illustration of the simplified model for transparent building element in EN ISO 52016-1.

The reason for the simplification in EN ISO 52016-1 was 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. For conventional glazing these simplifications are justified. For adaptive building envelope elements such simplification is not always possible or justified, as described in the following paragraph.

Detailed adaptive building envelope element, defined as:

An adaptive building envelope element that is described with a more complex N layers (N nodes) model than a simplified adaptive building envelope element. For a given state, the thermal, daylight and solar properties of the adaptive building envelope element may depend on the conditions. These are calculated at each time interval on the basis of the model and the properties of the individual components. This typically refers to the models as provided in the standards ISO 15099 ([11]) and EN ISO 52022-3 ([12]), but without the spectral and detailed spatial distribution.

Such a more detailed model is also needed if specific layer properties are needed for the control, e.g. the temperature of a glass pane or cavity air.

prEN ISO/DIS 52016-3 describes how to build and connect the more detailed model to the model of the building from EN ISO 52016-1.

The different routes for the simplified and the detailed model are illustrated in **Figure 2**:

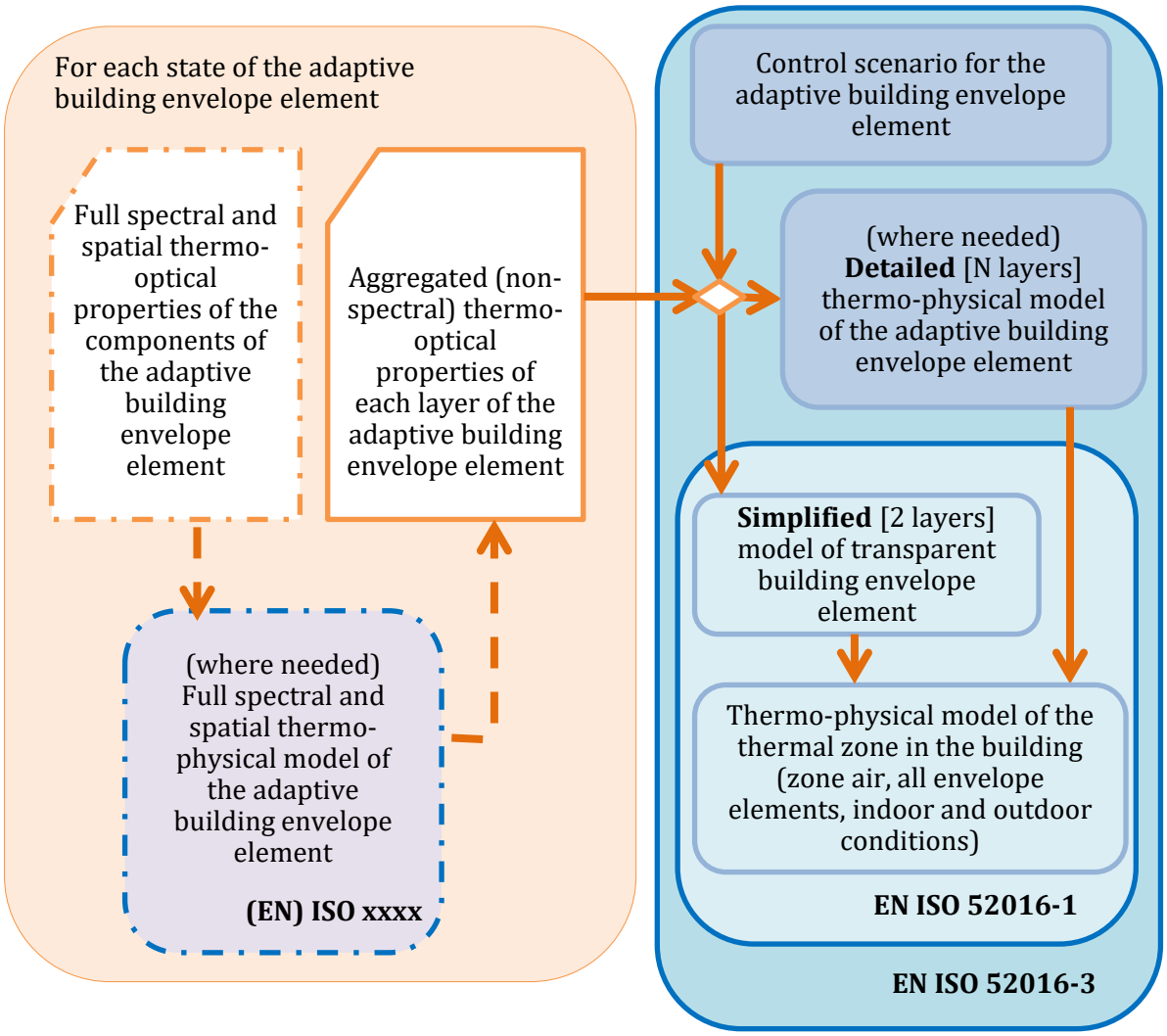


Figure 2. Illustration of the adaptive building envelope element linked to the calculation of heating and cooling load and internal temperatures according to EN ISO 52016-1.

Selection of control types

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

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 foreseen for EN ISO 52016-3.

Output of the calculation

The output of the calculation is the output of the hourly calculation methodology of EN ISO 52016-1. Additional output consists of key performance indicators to show the difference between the performance, in terms of building (zone) energy needs and thermal comfort, with the adaptive building envelope element versus a reference or other building envelope element.

The calculation procedures, step-by-step

The calculation procedure consists of the following steps:

Step 1: Identify the type of adaptive building envelope element.

Step 2:

- If the adaptive building envelope element is "simplified": gather the input data of the adaptive building envelope element
- 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

Step 3: Connect the model of the adaptive building envelope element to the model of the thermal zone in EN ISO 52016-1

Step 4: Select the control scenario.

Table 1. *Control types.*

Level	Name	Description
0	Environmentally activated control	Also known as passive control: activated by a specific environment condition.
1	Manual operation with manual control	Manual operation requiring an effort or a force. EXAMPLE 1: By crank or cord
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 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).
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.

Select the control type:
Four control types are distinguished, each with a different level of complexity, in line with the four classes in EN ISO 52120-1 ([10]).

Example 1:
Environmentally activated or actively controllable (manual, motorized, automated)

For an environmentally activated adaptive building envelope element: model the control scenario: the adaptive properties as function of the environmental conditions (can be discrete or continuous). See example in **Figure 3.**

For an **actively controllable adaptive building envelope element**: model the control scenario, which involves 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.

b) Select the applicable sensors to detect the conditions or events and gather the associated extra input data.

Example 2:
Solar irradiance or illuminance meter; clock + location + algorithm to identify sun position.

c) Selection of methods to identify the conditions or events.

Example 3:
For daytime versus night time: measured solar irradiance, calculated sun path or pre--calculated table with sunrise and sunset.

d) Apply the basic reference control scheme: qualitative description of the conditions and events that lead to a state change of the adaptive building envelope element.

Example 4:
Roller blinds fully extended when high solar irradiance.

e) And specify the criteria (values) for the conditions and events as function of control type, space category and other factors.

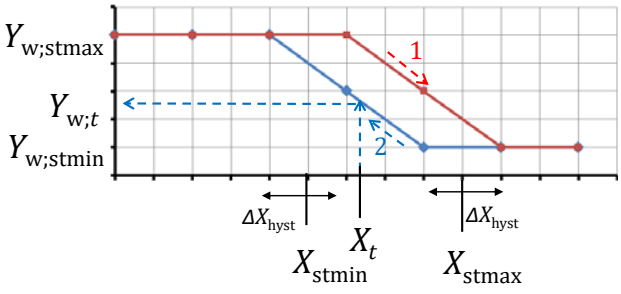
Example 5:
Illuminance > 75000 resp. < 37500 lux for retracting resp. extending roller blinds in case of automated control if cooling mode.

Step 5: Perform the hourly calculation according to EN ISO 52016-1 with the additions and adaptations from Step 1 through Step 4.

Step 6: Post-processing of the output of the calculation: monthly values, summer and winter thermal comfort indicator, etc.

Spreadsheet for evaluation of the calculation procedures of EN ISO 52016-3

According to the common quality procedures for each EPB standard for each EPB standard a spreadsheet has to be developed in parallel, to check the calculation procedures. These spreadsheets are publicly available at the EPB Center website ([13]). For EN ISO 52016-3 the situation is different, because the calculation is an 'addendum' to the calculation according to EN ISO 52016-1. Therefore, the spreadsheet is a sheet that will be embedded in the spreadsheet on EN ISO 52016-1 ([14]). A first version with this extra feature in operation will be made publicly available in summer 2022 at the EPB Center website. ■



Key:

Y: property of the adaptive building envelope element, *e.g. total solar energy transmission (g-value)*

X: environmental parameter, e.g. glazing temperature

1: increasing X-values

2: decreasing X-values

Figure 3. Example of different states of environmentally activated thermochromic glazing.

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[11] ISO 15099:2003, *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.*

[12] EN ISO 52022-3:2017, *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.*

[13] Spreadsheets on EPB standards publicly available at the EPB Center website https://epb.center/support/documents/?title=&group=3.

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