TECHNICAL REPORT

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Energy performance of buildings - External climatic conditions —

Part 2:
Explanation and justification of ISO 52010-1

Performance énergétique des bâtiments — Conditions climatiques extérieures —

Partie 2: Explication et justification de l'ISO 52010-1

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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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

ISO/TR 52010-2 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 parts in the ISO 52010 series can be found on the ISO website.

Introduction

The set of EPB standards, technical reports and supporting tools

In order to facilitate the necessary overall consistency and coherence, in terminology, approach, input/output relations and formats, for the whole set of EPB-standards, the following documents and tools are available:

a) a document with basic principles to be followed in drafting EPB-standards: CEN/TS 16628:2014, *Energy Performance of Buildings - Basic Principles for the set of EPB standards*[1];

b) a document with detailed technical rules to be followed in drafting EPB-standards: CEN/TS 16629:2014, *Energy Performance of Buildings - Detailed Technical Rules for the set of EPB-standards*[2];

The detailed technical rules are the basis for the following tools:

1) a common template for each EPB standard, including specific drafting instructions for the relevant clauses;

2) a common template for each technical report that accompanies an EPB standard or a cluster of EPB standards, including specific drafting instructions for the relevant clauses;

3) a common template for the spreadsheet that accompanies each EPB (calculation) standard, to demonstrate the correctness of the EPB calculation procedures.

Each EPB standard follows the basic principles and the detailed technical rules and relates to the overarching EPB standard, ISO 52000-1[3].

One of the main purposes of the revision of the EPB standards has been to enable that laws and regulations directly refer to the EPB standards and make compliance with them compulsory. This requires that the set of EPB standards consists of a systematic, clear, comprehensive and unambiguous set of energy performance procedures. The number of options provided is kept as low as possible, taking into account national and regional differences in climate, culture and building tradition, policy and legal frameworks (subsidiarity principle). For each option, an informative default option is provided (Annex B).

Rationale behind the EPB technical reports

There is a risk that the purpose and limitations of the EPB standards will be misunderstood, unless the background and context to their contents – and the thinking behind them – is explained in some detail to readers of the standards. Consequently, various types of informative contents are recorded and made available for users to properly understand, apply and nationally or regionally implement the EPB standards.

If this explanation would have been attempted in the standards themselves, the result is likely to be confusing and cumbersome, especially if the standards are implemented or referenced in national or regional building codes.

Therefore each EPB standard is accompanied by an informative technical report, like this one, where all informative content is collected, to ensure a clear separation between normative and informative contents (see CEN/TS 16629[2]):

— to avoid flooding and confusing the actual normative part with informative content,

— to reduce the page count of the actual standard, and

— to facilitate understanding of the set of EPB standards.

This was also one of the main recommendations from the European CENSE project[10] that laid the foundation for the preparation of the set of EPB standards.

This document

This document accompanies ISO 52010-1, which forms part of the set of EPB standards.

The role and the positioning of the accompanied standard in the set of EPB standards is defined in the Introduction to ISO 52010-1.

Brief articles on the subject can be found in [27] and [28].

ISO 52010-1 provides the common standard climatic data to be used as input by all EPB standards. It builds on ISO 15927-1, ISO 15927-2 and ISO 15927-4 and completes a missing link: the calculation of the distribution of solar irradiation and illuminance on a non-horizontal plane based on measured hourly solar radiation data on a horizontal surface; with or without taking into account solar shading.

Typical inputs for ISO 52010-1 are the hourly values for diffuse horizontal and direct beam solar irradiation. However, these quantities are not necessarily directly measured. In many cases, only the global horizontal irradiation is available as measured parameter, and the two components need to be calculated with a model. There are alternative models provided, open for choice at national or regional level.

For ground reflectivity often a constant value of, e.g., 0,2 is used. However, the value depends greatly on the surface conditions, and the influence on the irradiation is not negligible. Therefore, the option of providing hourly values is included. This may be especially of importance for mountain regions or for high latitudes.

For the solar shading calculation, the height and distance of each shading object are given per sector of the horizon (360 degrees). The subdivision into sectors (small or large) is open for national or regional choice. The same solar shading calculation procedure is adopted in ISO 52016-1 [5] for the calculation of the building energy needs and loads. This is especially important because if there are different shading objects in the same sector, it will not be correct to calculate the effects separately in different standards. It is up to national or regional choice to decide about the details of the solar shading calculations.

Accompanying spreadsheet

In line with the common template for all EPB standards, a spreadsheet has been prepared for demonstration and validation. This spreadsheet shows an overview of all input variables, the (step by step) hourly calculation procedures and an overview of all output variables.

This accompanying calculation spreadsheet (July 2016) provides:

— full year of hourly calculations of solar irradiance (split in components) on plane with any azimuth and tilt angle;

— validated against BESTEST cases;

— hourly calculations of solar shading by multiple shading objects along the skyline. These calculations also cover the calculation procedures for overhangs from ISO 52016-1[5].

This spreadsheet (including possible updated version) is available at www.epb.center.

Energy performance of buildings - External climatic conditions —

Part 2:
Explanation and justification of ISO 52010-1

1 Scope

This document contains information to support the correct understanding and use of ISO 52010-1.

This document does not contain any normative provision.

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/ 52010-1:2010, *Energy performance of buildings — External climatic conditions — Part 1: Conversion of climatic data for energy calculations*

NOTE More information on the use of EPB module numbers, in all EPB standards, for normative references to other EPB standards is given in ISO/TR 52000-2[4].

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 52010-1, apply.

More information on some key EPB terms and definitions is given in ISO/TR 52000-2 [4].

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

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

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

4 Symbols and subscripts

For the purposes of this document, the symbols and subscripts given in ISO 52010-1, apply.

More information on key EPB symbols and subscripts is given in ISO/TR 52000-2[4].

5 Description of the methods

5.1 Output of the method

Beside solar radiation data, ISO 52010-1 also contains data regarding

— air temperature;

— atmospheric humidity;

— wind speed;

— wind direction;

— longwave radiation.

The definitions and data are obtained from the ISO 15927 series regarding hygrothermal performance of buildings ([7],[8]).

The reason for passing these data via this standard is to have one single and consistent source for all EPB standards and to enable any treatment if needed for specific application. The above mentioned climatic data are not processed in this standard.

5.2 General description of the method

5.2.1 Calculation of the distribution of solar irradiance on a non-horizontal plane

It is (Torres 2006[20],) of paramount importance for HVAC (heating, ventilating and air conditioning) and photovoltaic systems designers to have suitable models requiring usually available data in order to calculate the irradiance on the plane where conversion systems are located.

From all the models developed to fulfil this objective, the one of conversion or translation proposed by Perez et al. (1986) has been widely used, as it considers all sky conditions ranging from completely covered to clear sky (Pohlen et al., 1996[17]).

Essentially, the model is composed of three different components:

1) a geometric representation of the sky dome,

2) a parametric representation of the insolation conditions, and

3) a statistic component linking both components mentioned before (Perez et al., 1987[15]).

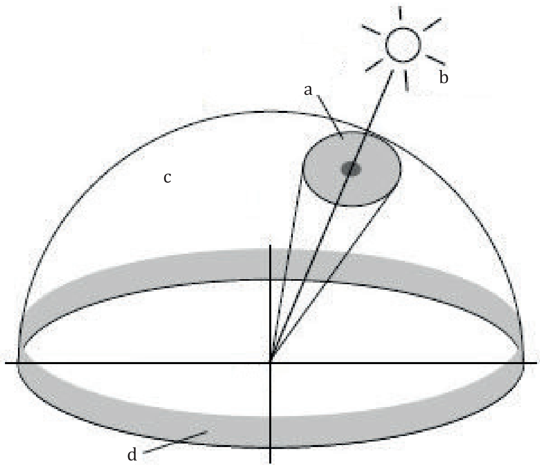
It is a model of anisotropic sky, where the sky dome is geometrically divided into three areas, each of them showing a constant radiance, different from the other two (see Figure 1).

These three areas are:

— isotropic diffuse (for the sky hemisphere);

— circumsolar radiation;

— horizon brightness.



Key

a circumsolar radiation

b sunbeam

c atmosphere

d horizon brightening

Figure 1 — Sky hemisphere areas according to Perez

And to be added to these three:

— Isotropic ground reflected radiation.

This anisotropic diffuse (sky) radiation for the plane uses as input hourly values the diffuse horizontal and direct beam solar radiation. Other inputs to the model include the sun's incident angle to the plane, the plane tilt angle from the horizontal, and the sun's zenith angle.

The model is named after Mr Perez. Several improvements were made in the course of time, see the list of references in the bibliography.

The calculation procedure described in ISO 52010-1 is based on the "simplified Perez model" proposed in the early 90s.

5.2.2 Calculation of solar shading by distant objects

Objects in the environment may block part of the solar irradiation on a plane (e.g., hills, trees, other buildings).

The same or other objects may also reflect solar radiation and consequently lead to a higher irradiation.

NOTE For example, on the northern hemisphere, a highly reflecting surface (e.g., glazed adjacent building) in front of the North facing façade of the assessed building.

In order to avoid that for those objects, specific solar reflectivity data are gathered. It is, as simplification, assumed that:

a) The direct radiation (including circumsolar irradiation) is partially blocked, if the object is in the path between sun and plane;

b) the diffuse irradiation (including irradiation from ground reflectance) remains unaffected.

This is physically equal to the situation where the radiation reflected (and/or transmitted) by the objects in the environment is equal to the diffuse radiation blocked by these objects.

Examples of the calculation are presented in Clause 10.

An alternative method is to take diffuse shading into account. In order to do this sky view factors are calculated. This can be simplified by dividing the skyline in different segments and calculate the sky view factors for each segment separately assuming an equal skyline height over the segment. This approach is presented as an option in ISO 52016-1[5], with informative calculation procedures provided in ISO/TR 52016-2[6].

6 Calculation method

6.1 Output data

No special limitations on the output are applicable.

6.2 Calculation time intervals

The conversion from measured solar irradiance on horizontal surface to an arbitrary inclined surface is instantaneous. Most measured data are available integrated over a period of an hour. To convert this data special care is taken for the calculation of the solar position used for the conversion. The position is determined in the middle of the measured period. In the determination of the hour angle (ISO 52010-1:2017, 6.4.1.5) this is taken into account.

6.3 Input data

No additional information beyond the accompanied standard.

6.4 Calculation procedure

6.4.1 Calculation of the sun path

See explanation in 6.2 on the sensitivity of the calculation results for the position of the sun. See also ISO 52010-1:2017, Clause 7.

6.4.2 Split between direct and diffuse solar irradiance

A number of models, based on statistical analysis of measured data, have been developed in different climates to enable global solar irradiance to be split into the direct and diffuse parts, if such split is not directly available from measured data.

The European Solar Radiation Atlas (3rd edition) contains a complete description of methods for analysing solar data. The European Solar Radiation Atlas (4th edition of 2000, ESRA 4[20]) contains on a CD-Rom not only a database but also 10 algorithmic chains for deriving modified quantities.

On Method 1 in ISO 52010-1:2017, 6.4.2.1:

The global irradiance, measured on a horizontal plane, is split into the approximate direct and diffuse fractions by calculating the diffuse fraction according to the statistical results in Erbs[19].

6.4.3 Solar reflectivity of the ground

No additional information beyond the accompanied standard.

6.4.4 Calculation of the total solar irradiance at given orientation and tilt angle

See also the general brief explanation given in 5.2.1.

The method in ISO 52010-1 is based on the Perez 1990 method as described in Duffie and Beckman[21].

There are two minor points of discussion.

1) In different literature different values for the values for clearness parameter and brightness coefficient are used (ISO 15010-1:2017, Table 10). The values used in ISO 52010-1 are based on the publication in Duffie and Beckman. The values found in other literature do not differ significantly.

2) In different literature several definitions of the a and b factors (ISO 52010-1:2017, 6.4.2) are given. The values are used to determine the circumsolar component. The definitions used are based on the publication in Duffie and Beckman.

6.4.5 Calculation of shading by external objects

See the general brief explanation given in 5.2.2.

6.4.6 Calculation of illuminance

See the more detailed method described in Clause 9.

7 Quality control

A number of checks can be made to increase confidence in correct implementation of the calculation procedures of the standard. These are presented in ISO 52010-1:2017, Clause 7.

Annex C shows examples of such checks; see in particular Table C.5 and Figure C.2.

8 Compliance check

No additional information beyond the accompanied standard.

9 Directional (spatial) distribution of hourly solar irradiation or illumination (not covered in ISO 52010-1)

9.1 General

The distribution of irradiation on a non-horizontal plane calculated hourly with the method described in the standard can be used to provide a more detailed spatial distribution.

Such detailed spatial distribution can be used for situations where the directional distribution of the solar radiation or luminance is relevant,[24] for instance in case of non-isotropic window elements (e.g., Venetian blinds), (other) daylight elements with Bi-directional Transmission (and Reflection) Distribution Functions (BTDF), for instance for the assessment of task illuminance levels and/or to assess the luminance distribution in a room, discomfort glare or other visual comfort related parameters in a room (with or without additional artificial lighting).

The method used in the standard ISO 52010-1 (based on Perez) yields the following components:

— beam radiation (direct from the sun),

— circumsolar radiation from the immediate vicinity of the sun,

— isotropic diffuse radiation,

— near-horizon radiation,

— ground reflected radiation (assumed to be homogeneously diffuse).

The conversion from radiation to luminance can be done on the basis of the assumption of a constant luminous efficacy (lm/W); see, e.g., ISO 52010-1:2017, 6.4.6.

9.2 Tregenza elements

It was Tregenza[23] who suggested the distribution of the sky into 145 elements, to obtain the spatial distribution of the (solar radiation and) luminance over the hemisphere seen by an object (see Figure 2).

Seen from a horizontal position, the 145 Tregenza elements are:

For the sky hemisphere.

Angles from zenith: 0, 12, 24, 36, 48, 60, 72, 84 degrees

Covering azimuth of: 360, 60, 30, 20, 15, 15, 12, 12 degrees

EXAMPLE 360/360 = 1 point at zenith; 360/12 = 30 points in circle at 84 degrees from zenith (6 degrees above horizon).

And similarly: 145 Tregenza elements for the ground hemisphere.

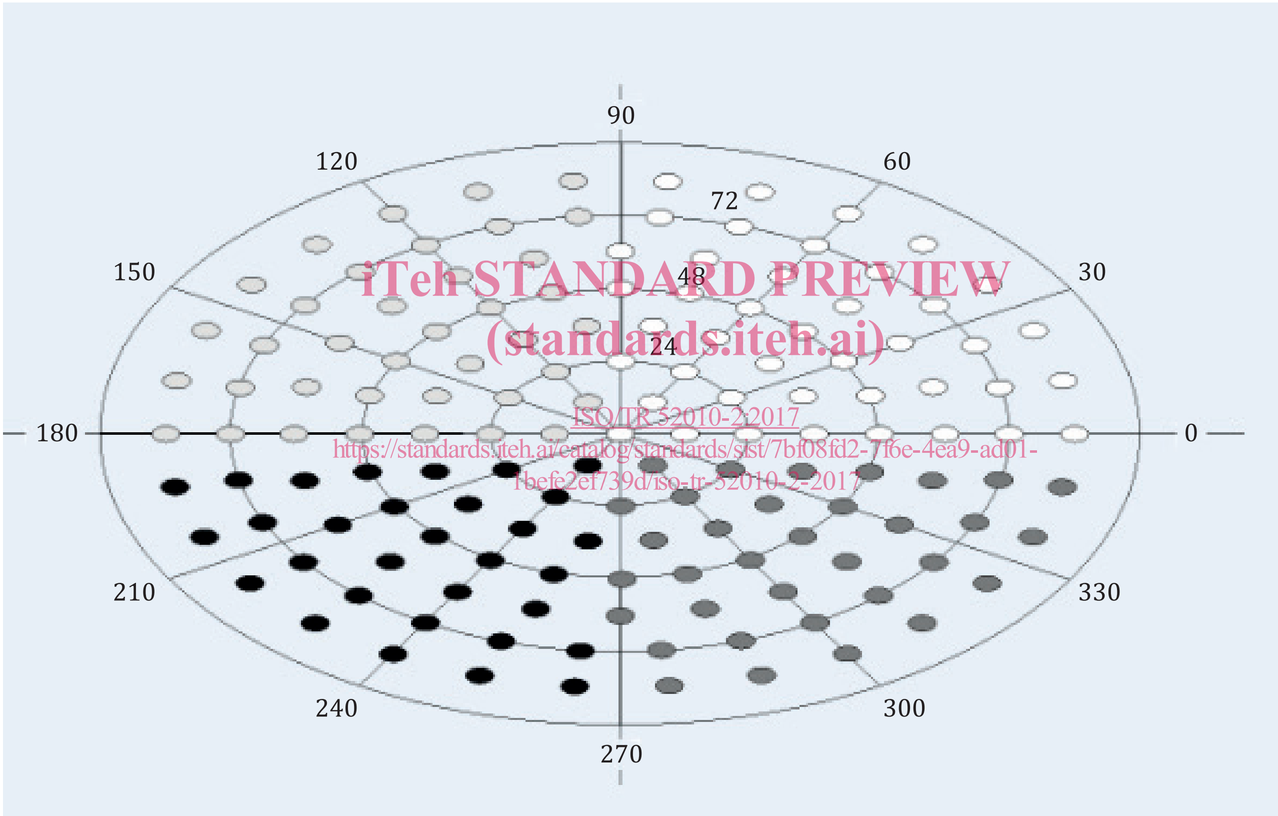


Figure 2 — Spatial distribution according to Tregenza

9.3 Allocation of the radiation in each element

For each Tregenza elements in the sky and ground hemispheres the radiation intensity is determined in the following way:

The **beam** radiation is attributed to the nearest Tregenza element.

The **circumsolar** radiation is attributed to the same Tregenza element as the beam radiation.

NOTE 1 The equation for circumsolar radiation has been slightly adapted compared to Perez, to allow a calculation without pre-knowledge of the orientation and tilt of the plane; see REVIS FD 19[26].