EPB standard EN ISO 52010:

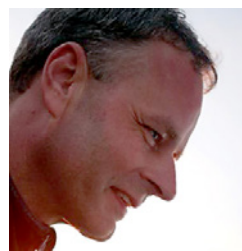## Conversion of climatic data for energy calculations: completion of a missing link

The new standard EN ISO 52010-1 provides the common standard climatic data to be used as input by all EPB standards. It builds on EN ISO 15927 (part 1, 2, and 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.

Keywords: energy performance of buildings, EPB, EPB regulations, climatic data, solar radiation, daylight, Perez model.

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A comprehensive series of European (CEN) and international (CEN & ISO) standards is at an advanced stage of development, following CEN Mandate M/480 [1]. The series, called the "set of EPB standards", aims at the international harmonization of the methodology for the assessment of the overall and partial energy performances of buildings. The first issue of the 2015 REHVA journal focused on the EPB standards. Article [2] contained a broad overview of the subset of EPB standards on the energy use and the thermal performance of buildings and building elements.

This article provides further information on one of this subset, namely the new standard EN ISO 52010-1, which is being developed in ISO/TC 163/SC 2/ WG 15.

EN ISO 52010-1 [3], accompanied by the technical report CEN ISO/TR ISO 52010-2 [4], provides the common standard climatic data to be used for all relevant EPB standards (see also [12]). It gives procedures to calculate the hourly distribution of solar irradiation on a non-horizontal plane based on measured hourly

solar radiation data on a horizontal surface, obtained from EN ISO 15927 (part 1, 2 and 4) [5].

The procedures include assumptions to assess the impact of surrounding obstacles on the irradiation (shading). A simple method for conversion of hourly solar irradiance to illuminance is also provided. The solar irradiance and illuminance on an arbitrary surface are needed as input for energy and daylighting calculations.

The standard also contains procedures for the use of (other) output from EN ISO 15927 (part 1, 2, and 4) as input for the EPB assessment.

The technical report CEN ISO/TR ISO 52010-2 provides background information, explanation (including examples) and justification (including validation cases).

In addition, 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.

Calculation of the distribution of solar irradiation on a non-horizontal plane

The model is named after Mr Perez ([6], [7], [8]). Several improvements were made in the course of time. The calculation procedure described in this standard is based on the "simplified Perez model" proposed in the early 90's. The explanation and justification is given in CEN ISO/TR 52010-2 [4]. 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.

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.

These three areas are (see **Figure 1**):

- Isotropic diffuse (for the sky hemisphere);
- Circumsolar radiation;
- Horizon brightness.

For the purposes of this International Standard the following is added:

- Isotropic ground reflected radiation
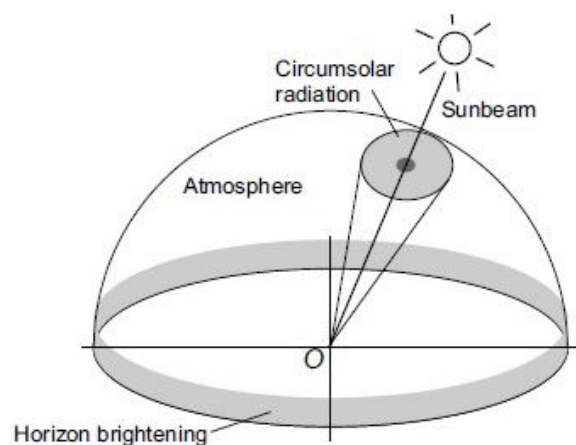
Figure 1. Sky hemisphere areas according to Perez.

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

Calculation of illuminance

For the luminance distribution of the sky and ground the irradiation is converted into illuminance by multiplication with the global luminous efficacy (Lm/W).

Calculation of shading by external objects

Shading by distant objects is taken into account through a shading correction coefficient for the direct radiation. Shading of diffuse radiation and reflection by distant objects is not taken into account, as explained below. Shading by fins and overhangs is calculated in EN ISO 52016-1.

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

In order to avoid that for those objects specific solar reflectivity data have to be 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.

This approach is chosen for simplicity. The effects on the accuracy of the calculated solar radiation has to be determined. An alternative method is to take diffuse shading into account. In order to do this sky view, factors have to be 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.

Other climatic data

The standard also contains procedures for the use of (other) output from EN ISO 15927 (part 1, 2, and 4) [5] as input for the EPB assessment, such as:

- air temperature;
- atmospheric humidity;
- wind speed;
- precipitation;
- solar radiation;
- longwave radiation.

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 conversion or other treatment if needed for specific application.
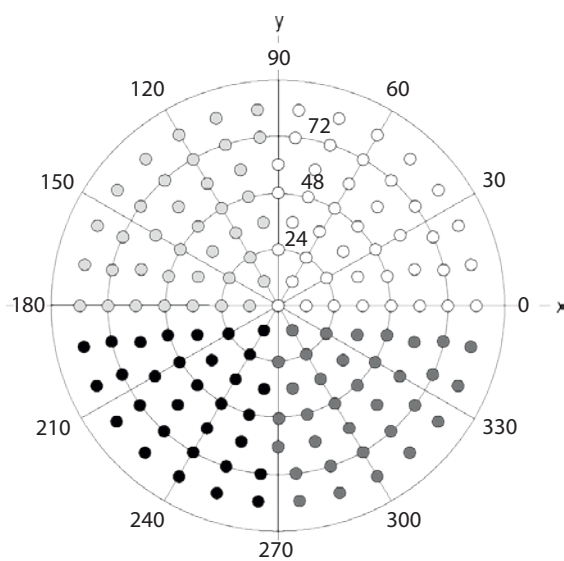
Spatial distribution

In addition, CEN ISO/TR 52010-2 [4] contains an informative calculation procedure for the spatial distribution of solar radiation and luminance as seen from a window or another plane.

It was Tregenza [10] who suggested the distribution of the sky into 145 elements (**Figure 2**). Van Dijk [10] adapted and extended the distribution rules to enable a direct conversion from the components obtained from the Perez model (beam, circumsolar, isotropic diffuse, horizontal diffuse and ground reflected radiation) to 145 elements seen from an arbitrary plane.

Flexibility

Typical inputs for the standard are the hourly values for diffuse horizontal and direct beam solar irradiation. However, these quantities are not necessarily directly

Figure 2. Spatial distribution according to Tregenza.

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 EN ISO 52016-1, 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.

Validation

The calculation procedures have been validated by using relevant cases from the so called BESTEST series. The BESTEST cases are well established since decades (several IEA ECBCS annexes and IEA SHC tasks), widely used worldwide, well described (e.g. ASHRAE 140, [11]) and regularly extended with additional cases. The successive series of test cases are also very powerful as diagnostic tool. Renowned institutes participate in the set-up of the test cases. The calculation results of several renowned software tools are available for comparison. Examples of input data for BESTEST cases are available for several building simulation tools and within different ICT environments. The "drawback" of the BESTEST series is that there is no single reference "true" result and no acceptance criteria.

Relevant BESTEST cases are also chosen for the validation of the hourly calculation procedures of EN ISO 52016-1, as presented in a parallel article.

The relevant BESTEST cases are the calculation of the solar irradiation at vertical planes, using the measured data from the climate file provided for this purpose: DRYCOLD.TMY (Denver, Col., USA).

Figures 3-5 show examples of the validation results.

The results of the comparison show that the hourly method in EN ISO 52016-1 is very fit for purpose. It has to be taken into consideration that not each software program whose results are available for the comparison use nowadays state-of-the-art algorithms

(in that sense these are not reference results). This is because these base cases of the BESTEST series were created and tested many years ago.

Another basic test is the calculation of the hourly diffuse and total irradiation on a horizontal plane. These should match the measured hourly values of
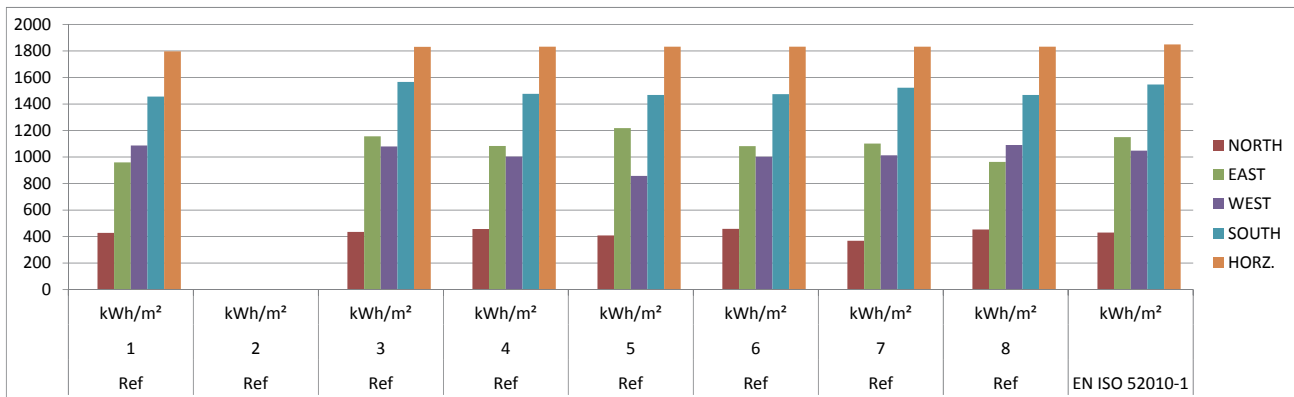
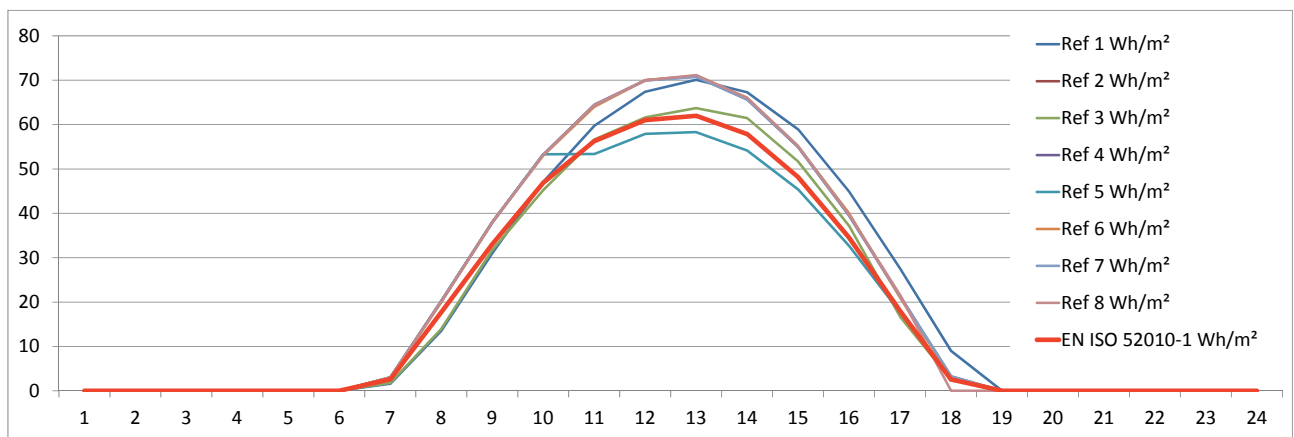**Figure 3.** BESTEST validation result: Annual solar radiation on five different planes.

Figure 4. BESTEST validation result: Hourly irradiation on vertical West plane, cloudy day.
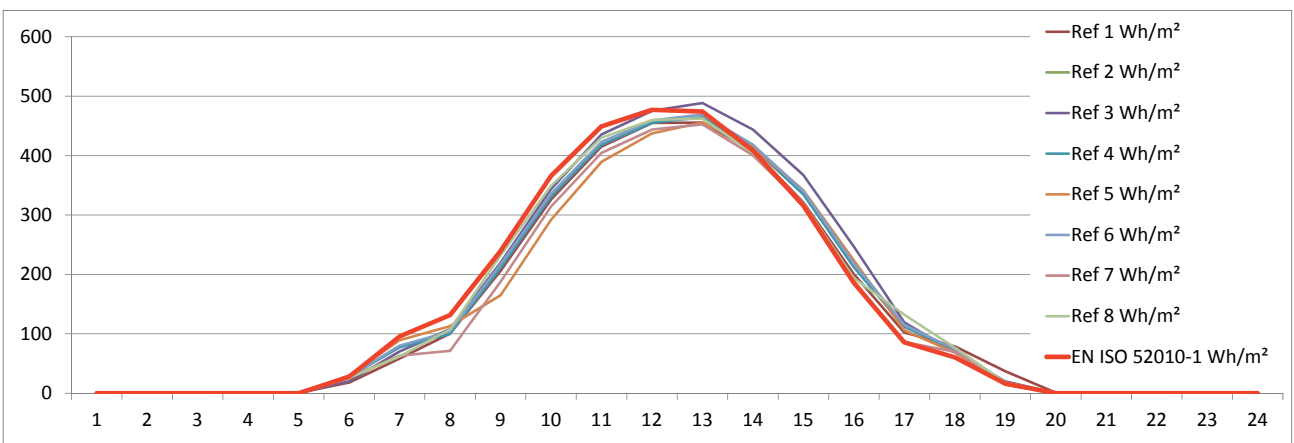

Figure 5. BESTEST validation result: Hourly irradiation on vertical South plane, clear day.

the same properties that are used, together with the measured beam radiation normal to the sun, as the source for the calculation of irradiation on tilted and

vertical planes. This test gave also satisfying results [4]. Note that a perfect match should not be expected, because of the use of several empirical correlation coefficients (Perez model). Plus: at very low sun position (e.g. a few degrees above horizon), the conversion of solar direct normal beam irradiance to irradiance at horizontal plane (multiplication by the sinus of solar altitude) is extremely sensitive for the correct calculation (and correct measurement) of the solar time. A few minutes' difference can already have a significant effect. Also the apparent size of the sun disc may play a role. This may even result in small negative values of the diffuse irradiance. The effects when the time series is applied on a building or system component is normally negligible.

Conclusion

The new EN ISO 52010-1 completes the (until now) missing link in the conversion of climatic data for energy calculations. The procedures have been validated. Choices are possible at national or regional level to accommodate the specific national or regional situation. ■

References

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[3] EN ISO 52010-1, Energy performance of buildings — External climatic conditions — Part 1: Conversion of climatic data for energy calculations (in preparation; submission of FDIS to final ballot expected in 2016).

[4] CEN ISO/TR 52010-2, Energy performance of buildings — External climatic conditions — Part 2: Explanation and justification of ISO 52010-1 (in preparation; submission to Committee Approval expected in 2016).

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