A lighting simulation tool for the new European daylighting standard

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Abstract

This paper describes how the new version of DIAL+ software will offer building designers the possibility to assess the requirements of the new European Standard *Daylight in Buildings* (EN-17037), CEN (2018) with a unique tool based on an intuitive interface. In this article we also confront the requirements of this new standard with practical challenges met during the building process.

Introduction

The new daylighting European Standard EN-17037 is about to come into effect at the end of 2018. For the first time an international standard proposes a set of criteria allowing to evaluate the main parameters related to natural light. This standard evaluates the four following criteria:

- Daylight provision
- View out
- Exposure to sunlight
- Protection from glare

For each of these criteria, the future Standard defines three levels of performance: Minimum, Medium and High. The Standard specifies that the level of performance can either be evaluated via a simplified approach or a detailed analysis.

This ambitious approach requires multiple analyses, which implies a specific treatment of the data provided by the existing simulation tools. Within the new version of DIAL+ software, we tried to offer a quick and easy way to seize upon this new standard in the first stages of design. This work also allowed us to discuss the potentials and limits of EN-17037.

Daylight Provision

Short description

The daylight provision corresponds to "*a level of illuminance achieved across a fraction of a reference plane for a fraction of daylit hours within a space*" CEN (2018). The evaluation should take into account the local daylight availability, which means that the results should incorporate climatic information.

The requirement is evaluated simultaneously through two indicators: the median and the minimum daylight value. The minimum value is to be met on 95% of the ground surface in order to eliminate edge effects related to the presence of a pillar or any other opaque element that may affect the final results. The median value takes into account the whole room surface.

Table 1 and 2 show the recommended levels for median and minimum values of daylight provision for vertical and inclined openings. For spaces with horizontal daylight openings there is no minimum target illuminance recommendations.

Table 1: Recommendation for the Median value of the daylight provision due to vertical and inclined window. CEN (2018).

Level	Target Illuminance	Fraction of space for target level	DIAL+ Display
High	750 lux	50%	
Medium	500 lux	50%	
Minimum	300 lux	50%	

Table 2: Recommendation for the Minimum value of the daylight provision due to vertical and inclined windows, CEN (2018)

Level	Target Illuminance	Fraction of space for target level	DIAL+ Display
High	500 lux	95%	
Medium	300 lux	95%	
Minimum	100 lux	95%	

This evaluation system requires integrating several results by manipulating time (% of daylight hours) and space (% of reference plane) data. We are therefore proposing a combined representation of the results obtained respectively on the median and minimum levels as shown on Figure 1. In this approach, we considered that the final rank obtained by a given room is determined by the lowest value reached on the two specific levels of analysis (i.e. in the example presented in Figure 1, the global rating is "Medium").

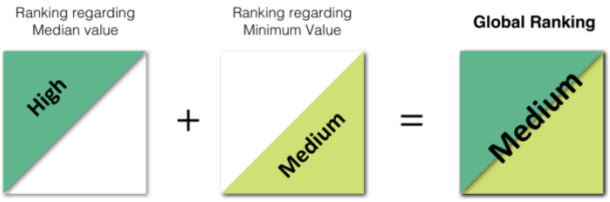

Figure 1: Illustration of the global ranking of Daylight Provision by aggregating the partial rankings reached for Median and Minimum values, CEN (2018).

Description of the case-study

To help the understanding of this Daylight Provision criterion, we present the results obtained for a reference room Which characteristics are described in Table 3 below.

Table 3: Characteristics of the case study

Room Geometry (m)	Depth: 5.50 / Width: 5.50 / Height: 2.80
Room Reflectance (-)	Floor: 0.30, Walls: 0.60, Ceiling: 0.80
Opening geometry (m)	Height: 2.80, Width: 5.50
Glazing characteristics	Frame area: 25% / Visible transmission: 0.8
Venetian blinds	Diffuse reflectance = 0.60
Fabric blinds	Global transmission: 0.10 / Transparency: 3%
Blinds automation	Down if irradiance > 200 W/m² and T_{int} > 22°C
Outdoor masks	Angular height: 10°, Reflectance: 0.25
Ground reflectance (-)	0.25
Location	Paris (Meteonorm data)

Simplified approach

The simplified approach is based on the calculation of daylight factor values on the reference plane (mobile shading devices are not taken into account within this approach). To transform these results into Daylight Provision, a list of CEN capitals cities is available in Annex A of the document, CEN (2018), that indicates the minimum DF value required to exceed 100, 300, 500, or 750 lux on the work plane during more than 50% of the daylight hours (additional cities could be added for each country to take into account more precise role of latitude and climate).

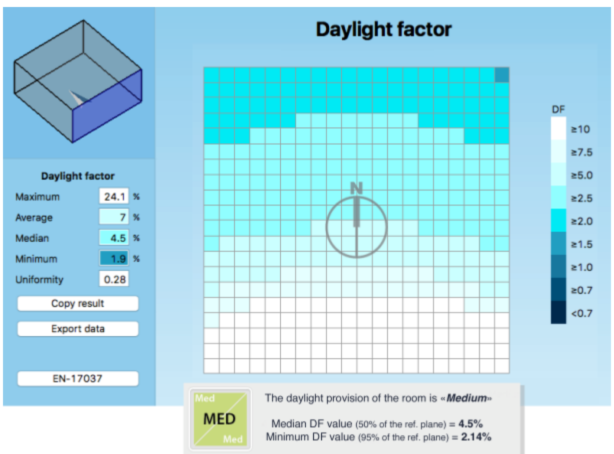

Figure 2: Display of the Daylight Provision calculated with the simplified approach.

DIAL+ daylight factor calculations are made using Radiance software, Regents (2017), with CIE overcast sky conditions. Figure 2 shows the result obtained for the reference room.

Dynamic approach

A second method consists in calculating indoor illuminances on the reference plane, on an hourly base. DIAL+ dynamic simulations are run with the Radiance three-phase method, McNeil (2014). Hourly calculations consider both diffuse and direct components according to the climatic data of the building location. If the actual space is expected to contain moveable shading device then the dynamic modelling of these is included in the simulation. Figure 3 shows the result obtained for the reference room (without shading device).

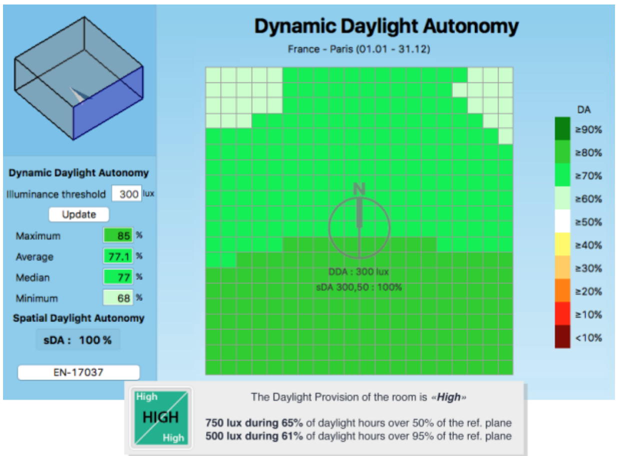

Figure 3: Display of the Daylight Provision calculated with the dynamic approach (Daylight Autonomy).

Discussion about the Daylight Provision criterion

In the multiple analyses that we did, we noticed that in some cases the dynamis methodology yields to better results than the static one (in this example presented in Figures 2 and 3, "Medium" Daylight Provision for the static approach and "High" Daylight Provision for the dynamic approach). In other cases it is the other way round. We believe that the user of this Standard must be aware of this.

In addition, the user should keep in mind that for dynamic simulations, the results take into account the movements of the blinds according to the presence of the sun. Table 4 shows that, the evaluation of Daylight Provision can thus vary depending on the window orientation and the type of shading device.

Additionnaly, with regard to day-to day practice, the "High" level of Daylight Provision seems to be hard to reach in many situations and we think that the "Minimum" perfomance level corresponds to a good daylight objective"

As an example, if we modify the room reflection coefficients (respectively: $\rho_{Ceiling}$: 0.6 vs 0.8; ρ_{Walls}: 0.4 vs 0.6; ρ_{Floor}: 0.1 vs 0.3), which corresponds to many realistic situations, and if we place the room in a medium density urban situation (angular height of the outdoor mask = 22° vs 10°), the daylight provision of the room does not reach the minimum value with the simplified approach (see figure 4 below). In this case, the dynamic approach applied with clear venetian blinds would have led to a "Medium" rating.

Table 4: Variation of the daylight provision of a given room according to the orientation, the shading device and the simulation approach.

	SOUTH Orientation			
Calculation method	Static (DF)	Dynamic (sDA)	Dynamic (sDA)	Dynamic (sDA)
Shading Device	No	No	Venetian blinds*	Fabric blinds*
Daylight Provision	Med MED Med	High HIGH High	High HIGH High	Med MIN Min
	NORTH Orientation			
Calculation method	Static (DF)	Dynamic (sDA)	Dynamic (sDA)	Dynamic (sDA)
Shading Device	No	No	Venetian blinds*	Fabric blinds*
Daylight Provision	Med MED Med	High HIGH High	High HIGH High	Med MED Med

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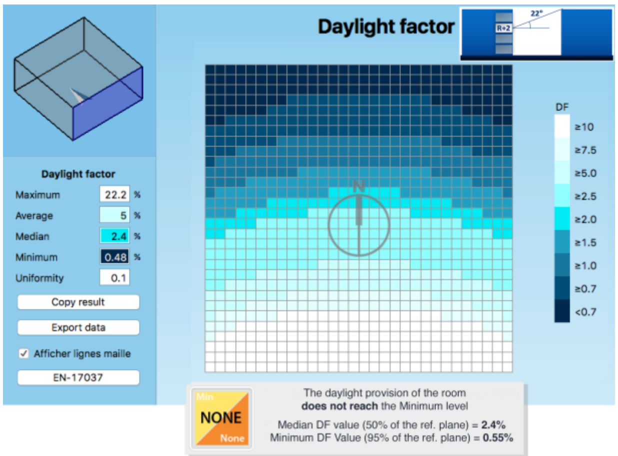

Figure 4: Display of the Daylight Provision for a fully glazed room with lowered reflection coefficients located in a moderately dense urban area.

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View Out

Short description

View covers three specific topics, namely the horizontal sight angle, the outside distance of the view and the number of layers seen from at least 75% of the utilized area. The term "layer" refers to the different components of the external landscape, namely the sky, the city or landscape, and the ground. The utilized space is "*the space which occupants will tend to use for a significant period*" CEN (2018).

Table 5 summarizes the conditions required to meet the Minimum, Medium and High levels. The evaluation is done in three distinct steps.

Table 5: Rating of View-Out, CEN (2018).

	Minimum	Medium	High
Width of view window(s), horizontal sight angle	>14°	>28°	>54°
Outside distance of the view	>6m	>20m	>50m
Number of layers to be seen from at least 75 % of utilized area	At least landscape layer is included	Minimum two layers are included	All layers are included

Horizontal sight angle

We interpreted the norm by calculating the horizontal view over 360°, which allows to express the maximum potential of view. For each point of the selected area, the program performs a horizontal angular sweep to determine if the view through the openings is possible. This calculation takes into account the walls thickness.

Figure 5 and 6 illustrate two typical situations for a given room fitted with 1 or 2 windows. In the latter case, the horizontal sight angle is a combination of the potential view through both apertures.

This approach gives a quick overview of the room potential and may help the designer to determine the distribution of the work places.

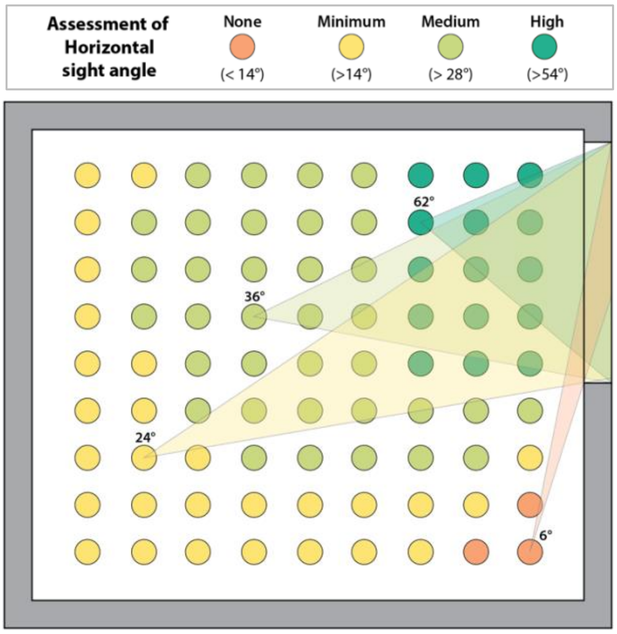

Figure 5: Example of the horizontal sight angle for a room fitted with one windows (10x10 grid).

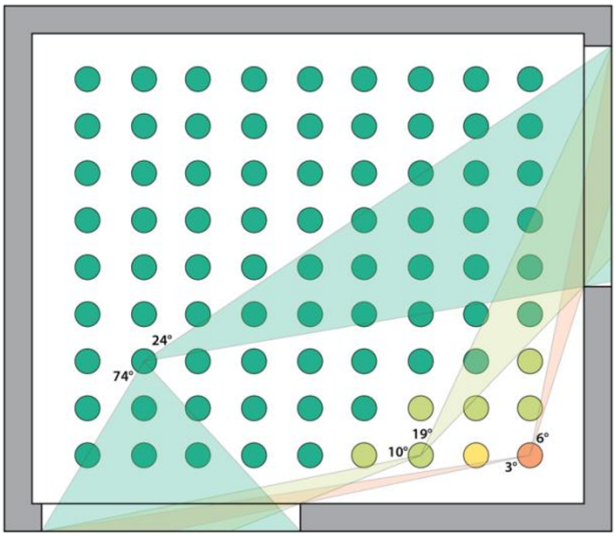

Figure 6: Example of the horizontal sight angle appraisal for a room fitted with two windows (10x10grid).

Discussion about the View Out criterion

Among the three criteria proposed by the standard (cf. Table 5), the first one (Horizontal Sight Angle) seems to us the only one on which the designer has a potential leeway. For this reason, we decided in this new version of DIAL+, to limit the analysis of the view-out only to this criterion. Future developments are expected to refine the analysis by including the criteria dealing with the outside distance of the view and the layers of landscape seen from the utilized area.

Exposure to Sunlight

Short description

This standard proposes minimum of hours during which a room should receive solar radiation on a selected day between the 1st of February and the 21st March. It refers to spaces, such as "*habitable rooms in a dwelling, in patient rooms in hospitals and play rooms in nurseries, or any room where sunlight is considered to be of value*" *CEN (2018).*

The reference point is located in the centre of the window width and at the inner surface of the aperture. The exposure to sunlight takes into account the close masks (walls thickness, overhangs, fins, etc.) as well as the influence of the far horizon. Table 5 shows the levels of recommendation for exposure to sunlight

Table 5: Recommendation for exposure to sunlight, CEN (2018).

	Minimum	Medium	High
Sunlight Exposure	1.5 hours	3.0 hours	4.0 hours

For the evaluation of this criterion, we used the functionalities already present in the existing evaluation modules of DIAL+, which generates either temporal maps of the Sunshine Exposure (Figure 7) or stereographic diagrams including the outdoor environment (Figure 8). This representation is more intuitive and can help to communicate with the client. These outputs are generated separately for each window of a given room.

Discussion about the Sunlight Exposure criterion

The criterion on Sunlight Exposure is quite demanding and may not be achieved in many circumstances. Here again, the influence of the existing environment takes precedence over the will of the designer.

Figure 9 hereafter shows that a given room located on two consecutive facades of the same building (namely here South and West) will be assessed in a radically different way.

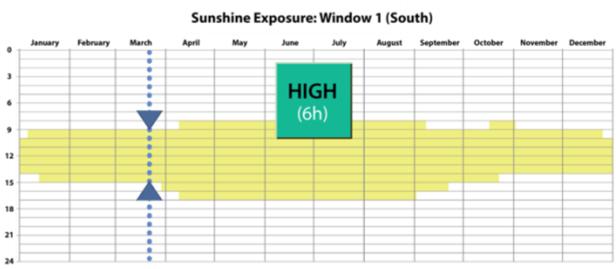

Figure 7: Representation of the Sunshine Exposure with a temporal map (south oriented façade located in Lausanne-CH).

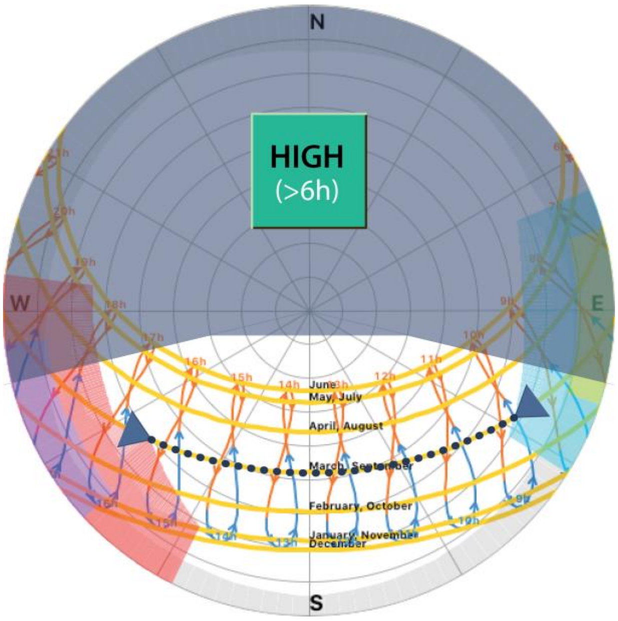

Figure 8: Representation of the sunshine exposure with a stereographic diagram (South oriented façade located in Lausanne-CH).

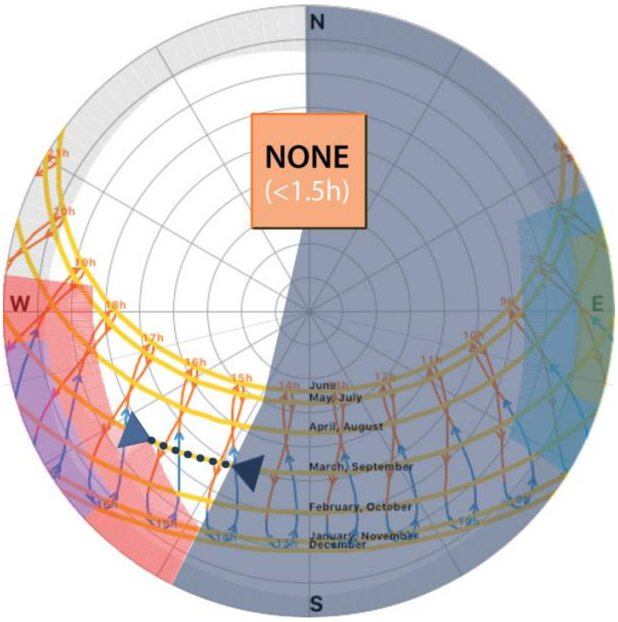

Figure 9: Representation of the sunshine exposure with a stereographic diagram (West oriented façade located in Lausanne-CH).

Another point of discussion about this criterion concerns the consideration of window frames. In its preliminary version, the standard shows a fish-eye picture on which are superimposed the solar trajectories CEN (2018), p. 40. In this photo, the window frames are visible and seem to be taken into account to determine the sunshine exposure of the room. It should be noted that in the design phase, it is highly unlikely that this level of definition can be achieved. For this reason, our approach does not take these elements into account.

Protection from Sunglare

Short description

The norm proposes to include the protection from sun glare into the range of the analyzed criteria. A simplified method consists in verifying that shading devices provide adequate glare protection. A detailed method based on the DGP, Wienold and Christoffersen, (2006) calculation is also mentioned.

We propose, in this first version, to rely on the simplified method insofar as our tool is focused on the early design phase and we believe that it is essential to be able to give a quick response to the user (the implementation of DGP analysis is still under exploration an might be available in a further version of DIAL+).

As a result, when launching the evaluation, the software issues an alarm in the following cases:

- If there is no mobile device.
- If a fabric blind has been selected with either a direct transmission coefficient above 3% or a global transmission (diffuse) above 10%.

In addition, when a permanent protection has been described (fixed lamellas) without any mobile device, the user is prompted to check the sunshine exposure. If the result is not null, then he is informed that the protection from glare is not assured.

Discussion about the Protection from Sunglare criterion.

Glare is a key issue that requires significant computing time to study it accurately (on an hourly basis). Simplified methods such as DGPs "*only delivers reliable data if the façade shows neither a direct transmission component nor a peak reflection or scattering in the observer's direction",* Wienold (2009). It is therefore interesting, for a tool intended for the design phase, that the standard has provided for a qualitative approach related to the shading device type.

Conclusion

The publication of this new standard dedicated entirely to natural lighting is good news for the building sector. Until today, electric lighting was the only subject treated in a complete way on the normative plan. The approach proposed by the standard EN-17037 is ambitious because it addresses all the important issues of daylighting. This paper shows that the implementation of these new requirements in decision tools is possible, even though not all criteria can be approached with the same level of detail.

For our part, we believe that to integrate the daylighting subject in the very first stages of design process and to have a chance to do some optimization work, it is vital to focus on resolution methods that provide results quickly. This is the reason that led us to select, depending on the case, the simplified or detailed approach according to the different analysis criteria.

Regarding the levels of requirement of this standard, we think they are very demanding. In practice, it is feared that only premises located in a very open environment (top floors) are likely to be well ranked. In addition, we are concerned that this standard may favor buildings with fully glazed façades, which is counterproductive if we aim for an overall performance objective, especially with respect to cooling needs.

Acknowledgements

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