Perspective on daylight provision according to the new European standard “Daylight in Buildings” (EN 17037)

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Abstract. The entry into force of the first European standard dealing with daylight is very good news. However, the objectives set by this standard in terms of daylight provision are quite demanding and the consequences on the design of buildings are far from neutral. Based on simulations conducted with the DIAL+ software, the study focuses on the Daylight Provision criterion and looks at the influence of localization (latitude). The work consists of the evaluation of a 2 case-studies and analyses the results obtained for 4 locations in Europe. The aim is to put in perspective, on the one hand, the daylighting performance and, on the other hand, the induced energy consumption in terms of heating, cooling and electric lighting. This gives a better idea of the consequences of this Standard on the overall energy performance and allows to question the objectives set by the standard

1. Introduction

1.1. Daylight provision

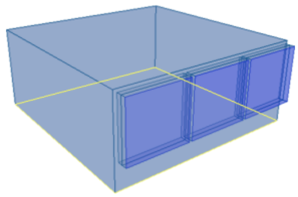
According to EN 17037 [1], the daylight provision corresponds to “*a level of illuminance achieved across a fraction of a reference plane for a fraction of daylit hours within a space*”. Daylight provision can be either estimated with a simplified method, based on daylight factor values (DF) or a detailed method based on illuminance values. In this case, “*hourly (or sub-hourly) internal daylight illuminance values for a typical year are computed using hourly (or sub-hourly) sky and sun conditions derived from climate data appropriate to the site*” /1/. The results presented here are based on the detailed method.

The analysis considers both median and minimum illuminance values in assessed rooms. The minimum value is calculated on 95% of the surface of the room while the median value takes into account the entire room. A given space can get a *Minimum*, *Medium* or *High* ranking for both median and minimum illuminance criteria.

In the Tables presented hereafter, the ranking obtained for median illuminance is called “*Med. Ranking*” and the one obtained for minimum illuminance is called “*Min. Ranking*”.

1.2. Reference case

In order to review all of these criteria, we used as reference case a mono-oriented room which characteristics are described below:



- Room width: 7.00m
- Room depth: 7.00m
- Room height: 3.00m
- Glazing height: 2.00m
- Window sill: 0.90m
- Glazing transmission: 0.80
- Glazing g-value 0.62
- Glazing U-value (U_{glass}): 1.1
- Window to Floor Ratio (WFR): 24%
- Outdoor obstruction angle: 15°
- Shading device: External venetian blinds (reflection coefficient = 0.60)
- Blinds control: Down if incident flux > 200 W/m²
Up if indoor temperature < 22°C

The position of the slats is adjusted according to the height of the sun in order to block direct rays, as described in Figure 1.

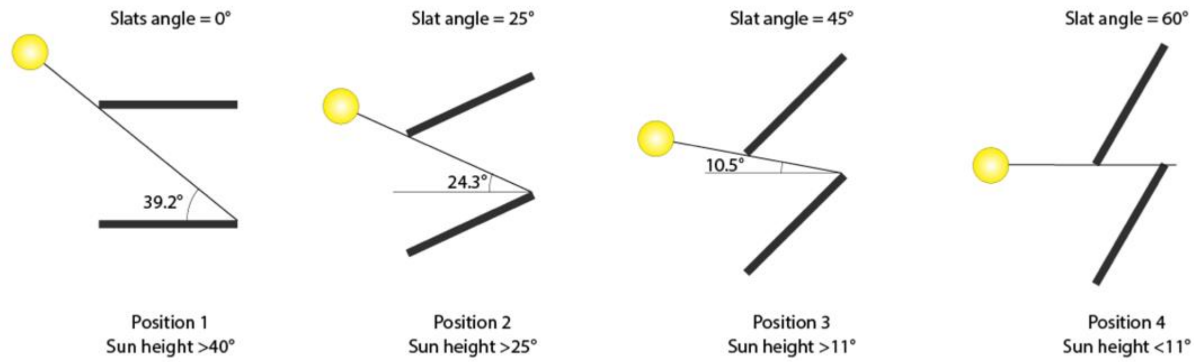


***Figure 1**: Schematic description of the 4 inclinations of the slats according to the sun altitude.*

It is generally accepted in Switzerland that this type of configuration represents a reasonable compromise between energy and economic considerations.

All the simulations are run with DIAL+ software /2/ /3/ using the Radiance three-phase method /4/. Meteonorm data /5/ are processed on a yearly basis between 8AM and 6 PM (hourly step).

2. Influence of the room localization

2.1. Reference case (WFR = 24%)

Table 1 shows the results obtained in Athens (38°N), Lausanne (46.5°N), Berlin (52.5°N) and Oslo (59.9°N) for a south oriented case-study. Since the requirements laid down by the standard are identical regardless of the project location, the ranking is, logically, better for low latitudes.

In this case, the rankings obtained in Athens and Lausanne are rather similar whereas the rankings are lower in Berlin and Oslo. This example shows that, for high latitudes, the standard pushes to choose higher window to floor ratio (WFR).

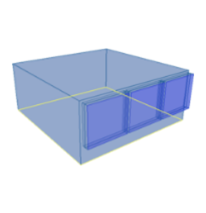
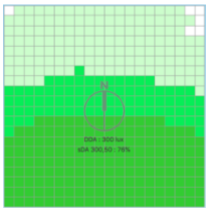
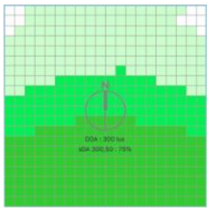
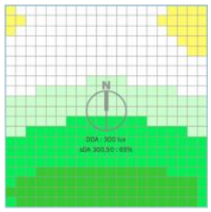
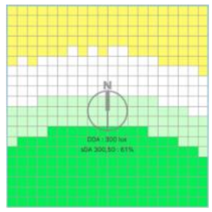
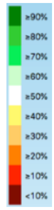
	Athens	Lausanne	Berlin	Oslo	
					
Med. Ranking	High	High	Medium	Medium	
Min. Ranking	Medium	Medium	Minimum	Minimum	

Table 1: *Daylight provision for a south oriented room (WFR = 24%) in Athens, Lausanne, Berlin and Oslo.*

2.2. Variant 1: Fully glazed façade (WFR = 34%)

In order to see how far the performance level in the Nordic countries can be raised, we have modified the reference case by enlarging the windows area.

Table 2 shows the result obtained in the same room with a fully glazed south oriented façade (window height = 2.80m; WFR = 34%, all the other geometric and photometric parameters are identical).

We can see that in this situation, the rankings in Athens and Lausanne reach “High” for both median and minimum illuminances whereas the ranking in Berlin reaches “High” and “Medium” and in Oslo only “Medium”.

This example shows that the standard is very demanding and that it is difficult to exceed the "Medium" level in northern Europe even with a fully glazed façade.

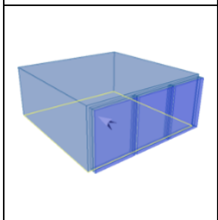
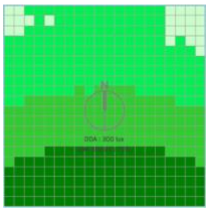
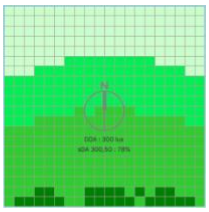
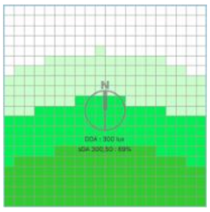
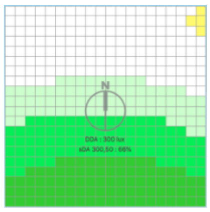
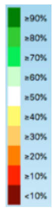
	Athens	Lausanne	Berlin	Oslo	
					
Med. Ranking	High	High	High	Medium	
Min. Ranking	High	High	Medium	Medium	

Table 2*: Daylight provision for a fully glazed south oriented room (WFR = 34%) in Athens, Lausanne, Berlin and Oslo.*

3. Impact on the thermal performance

Encouraging the increase of glass surfaces is not without consequences for the thermal behaviour of the room.

In order to quantify this effect, we ran dynamic thermal simulations with the thermal module of DIAL+ to see the impact of this trend (increased WFR) on both heating and cooling loads (nodal model with a time step of 10').

. The following parameters were used:

- Floor: Concrete slab covered by linoleum,
- Ceiling: Concrete slab covered by acoustic panels,
- Indoors walls: Light walls,
- Outdoor wall: Curtain façade, 20 cm insulation (thermal conductivity 0.04 W/mK)
- Heating / Cooling device: Fan coil units
- Heating set point: 21°C
- Cooling set point: 26°C
- Air flow during room use: 126 m^3/h
- Air flow when room is not used: 15 m^3/h

Figure 2 shows the results obtained with both reference case (WFR = 24%) and fully glazed façade (WFR = 34%) in Athens, Lausanne, Berlin and Oslo.

We can observe that, for the 4 locations, the increase in the glazing ratio results in an increase in energy consumption for both heating and cooling. Unsurprisingly, heating needs are dominant in Oslo and cooling needs are dominant in Athens. In absolute terms, the highest increase in heat demand is 7.5 kWh/m^2 in Oslo and the highest increase in cooling needs is 5.9 kWh/m^2 in Athens.

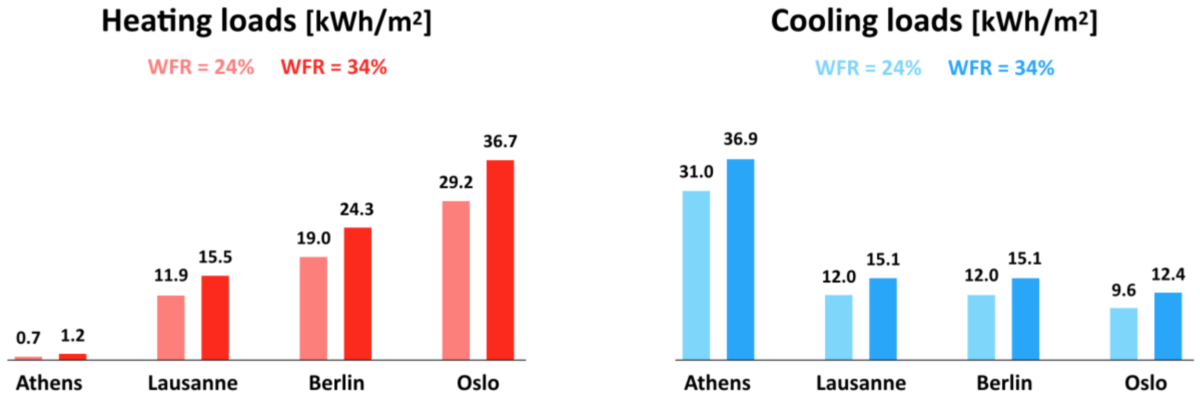


***Figure 2**: Heating and cooling loads as a function of the room location and glazing ratio.*

4. Impact on the electric lighting demand

On the other hand, the increase in glazed area should result in an increase in the coverage of lighting needs. In order to quantify this effect, we ran simulations with the electric lighting module of DIAL+.

We used the following parameters:

- Luminaires: 3 lines of 4 LEDs recessed luminaires
- Luminaire power: 21W
- Luminous efficacy: 109 lm/W (2150 lm per luminaire)
- Specific power: 5.1 W/m^2
- Luminaire control: Manual switch + Automatic shut off (dimming + absence sensor)
- Required illuminance: 500 lux
- Occupation period: 8AM-6PM, 5 days/week

In order to take into account variation in light availability according to the orientation of the façade, we have simulated a south-facing room and a north-oriented room.

Figure 3 below shows that the reduction in energy consumption due to electric lighting is limited and in no case, exceeds 1 kWh/m^2 per year regardless of the localization and the orientation.

This reduction in energy consumption is therefore significantly lower than the increase related to the thermal aspects. The spatial and visual qualities associated with the presence of a 100% glazed facade must therefore be compared with the rise in overall energy consumption.

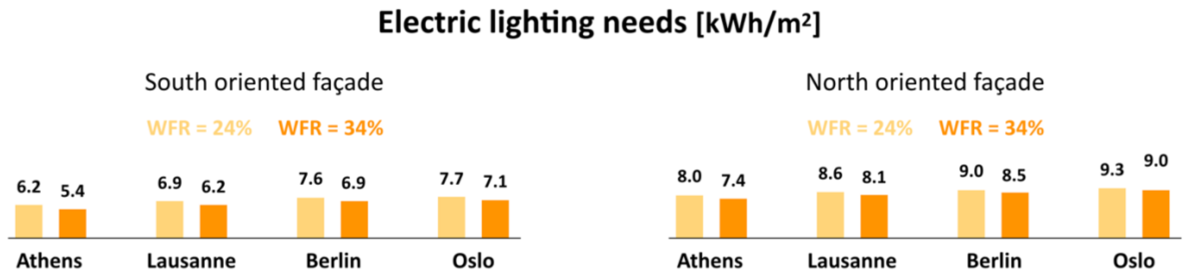


***Figure 3**: Comparison of the electric lighting needs according to the WFR and the room localization.*

5. Conclusion

This work shows that the requirements of EN-17037 could result in an overall increase of the building energy consumption.

In a way, one can understand that the standard seeks to ensure an identical level of service throughout the geographical area to which it applies. However, considering the climatic varieties encountered in the different European territories it is illusory to think that buildings should reach identical performance, whatever their location.

As it stands, the Standard clearly encourages designers to increase glazed surfaces which is not in line with the current context where reducing the building energy consumption is a major objective. Furthermore, with 100% glazed facade, the motorization and automation of solar protections are almost mandatory, which is not neutral in terms of investment cost and, depending on the type of shading device, could prove counterproductive in regards of effective daylight contribution.

We believe that one of the solutions to this problem could lie in the revision of the Daylight Provision ranking levels as they are defined in the current Standard.

In our opinion, the "Minimum" ranking should at least be rated as "Satisfactory" and the "Medium" ranking should be "Very satisfactory". In addition, with regard to the "High" level, we also believe that it could be qualified as "Risky" since it leads to a probable degradation of the overall energy performance.

We are aware that the introduction of an upper bound in the valuation of the Daylight Provision would induce a significant philosophical change. Anyway, we think that the building is a very complex system and that the search for an “optimum” must take into account all the fields of building physics.

We hope that this work will give the reader a better understanding of some consequences of the new Standard and that this may lead to a better arbitration of issues related to the overall building performance**.**

References

[1] European Standard EN 17037 Daylight in Building, Decembre 2018.
[2] https://www.dialplus.ch/, last visited: 09-02-19
[3] Paule B, Boutillier J, Pantet S, Sutter Y, :A lighting simulation tool for the new European daylighting standard, proceedings of the Building Simulation and Optimization 2018, Emmanuel College, University of Cambridge, 11-12 September 2018.
[4] McNeil A, TheThree-Phase Method for Simulating Complex Fenestration with Radiance, LBNL 2014.
[5] https://meteonorm.com/en/ last visited: 09-02-19