Daylight evaluation of buildings – practical examples

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Daylight and sunlight have been used for centuries as the primary source of light in buildings. Daylighting schemes have been designed to allow maximum penetration of daylight into the building and to help avoid undesired heat gain as well as direct or reflected glare. However, with the emergence of new technologies, daylighting in design prioritising has suffered a setback.

Today, increased focus on the energy consumption of buildings and savings by reducing the energy used for electrical lighting – linked with the recognised benefits of daylight to the occupants´ productivity and well-being – have revived the attention on daylighting as a key to successful building design.
But daylighting is not a matter of just using plenty of glass in a building. Windows should be treated as daylight providers and the key to successful design is to increase daylight penetration while avoiding the drawbacks by incorporating intelligent and integrated solar shading systems and accepted controls.

What, then, are the design criteria for successful daylight design? The requirements laid down in the building regulations of European countries are mostly defined by minimum requirements to the ratio between glass or window area and floor area: typically 1:10 or, in some cases, 1:8. In most cases, this value will not guarantee appropriate daylighting of interiors. Successful daylighting design also has to consider aspects as exterior conditions, the effect of overhangs, neighbouring buildings, trees and vegetation etc.

Only few countries define or recommend specific daylight levels defined by such aspects as average daylight factor: according to the British Lighting Guide (CIBSE, 1997), an average daylight factor of 5 % or more will ensure that an interior looks substantially daylit, whereas an average daylight factor below 2 % generally makes a room look dull so that electric lighting will most likely be in frequent use.

Daylight availability defined by daylight factor levels is a recognised and simple method - but are illuminance measurements sufficient? Or should daylight availability be defined by luminance levels that also consider the surfaces of the room? How should daylight quality be defined? And how can daylight quality be ensured in the design process?

As a manufacturer of daylight system solutions (windows, shading, control etc.) we wish to raise the interest in the field by supporting the proper terminology. One example is a recent study conducted by SBI, Hørsholm (Johnsen et al), in collaboration with Laval School of Architecture, Quebec (Dubois et al): Assessment of daylight quality in simple rooms. Impact of three window configurations on daylight conditions. The study presents the results of simulations of daylight conditions in three rooms with three different window configurations by using the Radiance Lighting Simulation System (Ward Larson & Shakespeare, 1998)

The overall objective of the study was to develop a basis for a method that will make it possible to assess the daylight quality in a room with simple geometry and window configuration. The study investigates a number of daylight parameters (10) such as horizontal illuminance and daylight factor, cylindrical illuminance, vertical-to-horizontal illuminance and luminance distribution. One of the significant findings is that a window-to-floor ratio of 10 % (even in a simple room) does not guarantee an adequate spread of illuminance levels (daylight factor) and it does not prevent too large differences in luminance ratios, resulting in risk of a sensation of glare.

Architects today have a general wish – often expressed in a direct mandate from the developer or builder – to give high priority to daylight conditions. When it comes to daylight planning, there may however be some barriers against integrating simulation tools in the daily practice: the programmes available for daylight simulation are often too complicated as they demand great expertise and require many hours just to wait for the renderings.

In the design phase, tools are needed to be able to evaluate such aspects as the spread of illuminance (daylight factor) values and the transition of luminance values (under overcast sky conditions) as well as an evaluation of the need for solar shading over the course of the year/day (under sunny sky conditions). Equally important is the evaluation of the building in use: in this case an evaluation of the luminance values measured with a luminance-meter or by a camera with adequate software.

IMAGE 1: Office building, Kolding (DK). Floor 2, Daylight factor (iso contour lines) on work plane, overcast sky conditions

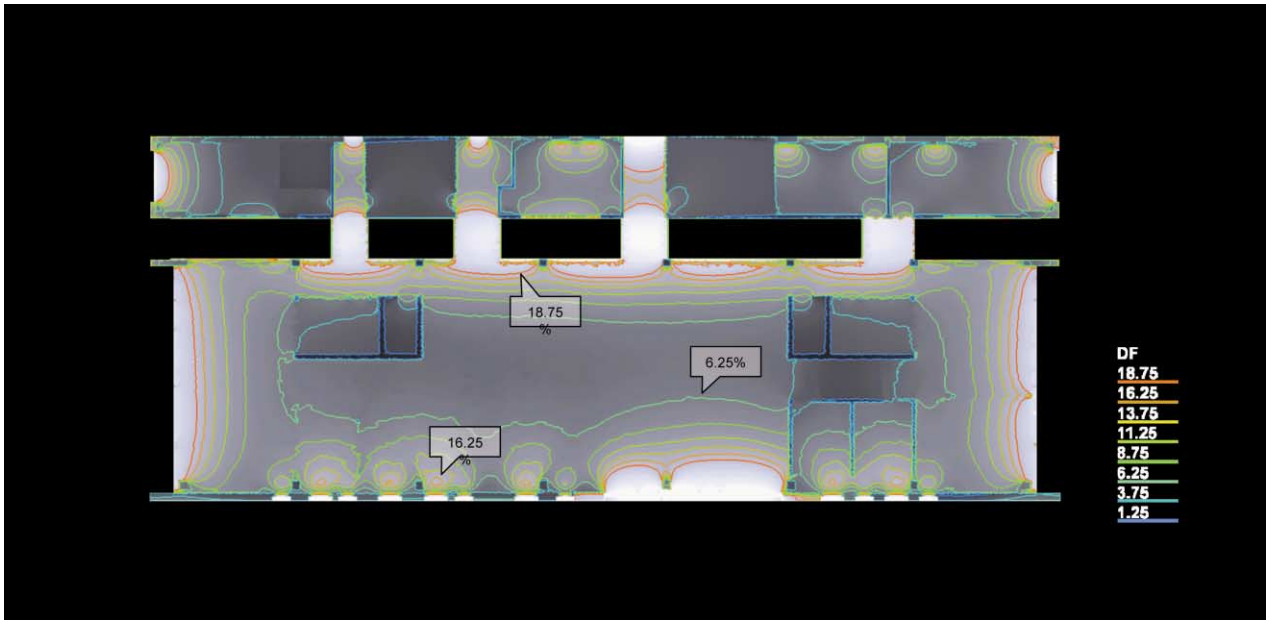
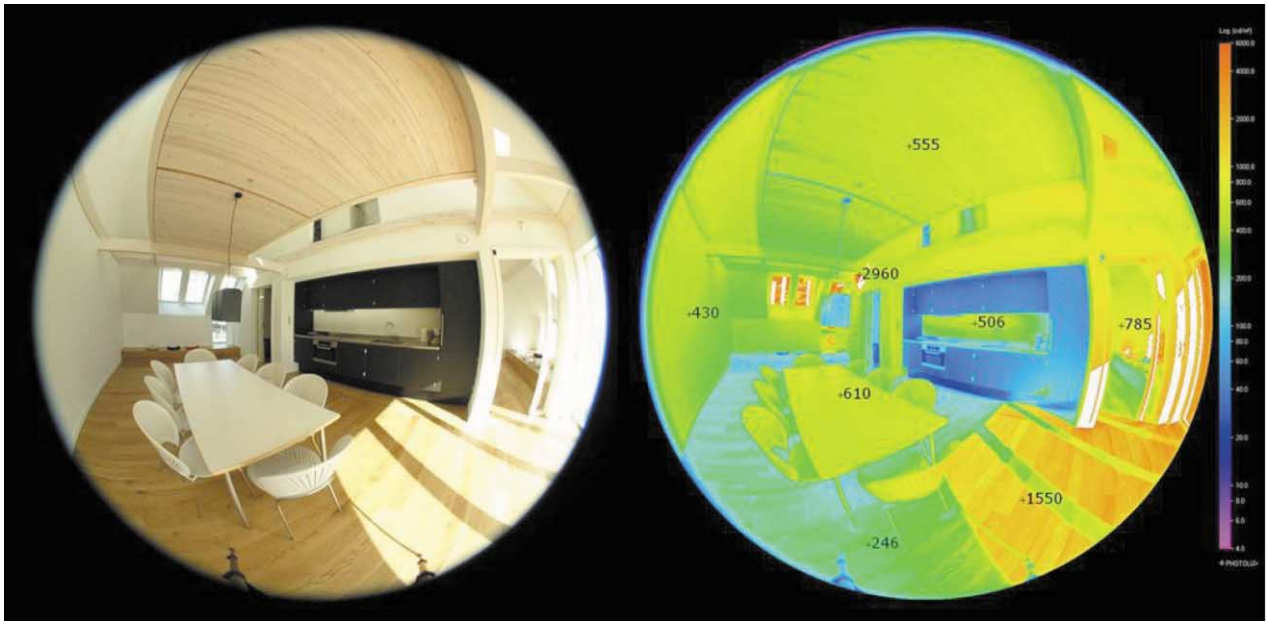


IMAGE 2: SOLTAG, energy housing. Luminance output in false colour. Intermediate sky conditions



As a provider of daylight solutions, we feel an obligation to support the development of user-friendly tools for building professionals. In 2005 we launched a simple visualisation tool as a test prototype of the VELUX Daylight Visualizer. Based on the prototype, we are currently developing a second version targeted at preevaluation of building and room designs. The tool will integrate a simple (user-friendly) modeller for defining the room boundaries and window configurations and the output will in addition to luminance and illuminance visualisations (daylight factor on work plane) also include animation of the light course in the room over a day and a year.

References

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CIBSE (1999). Daylighting and window design. Lighting Guide LG10:1999. The Chartered Institution of Building Services Engineers. London, UK.

Kjeld Johnsen, Marie-Claude Dubois, Karl Grau (2006) Assessment of daylight quality in simple rooms. Impact of three window configurations on daylight conditions, Phase 2 (SBI-2006-08) Downloadable on http://www.en.sbi.dk/publications

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Radiance Lighting Simulation System (Ward Larson & Shakespeare, 1998)

Photolux (2.1) Luminance Mapping System (ENTPE, 2002)

VELUX Daylight Visualizer 1.15 by Luxion (Henrik Wann Jensen, San Diego University, California, 2005); Downloadable on http://www.thedaylightsite.com