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TECHNOLOGY

Daylight Dialect

Building a common daylight language will dramatically facilitate the necessary dialogue between architect, lighting designer, client, and contractor.

By Kevin Van Den Wymelenberg

On a thickly overcast December day in 2005, a group of “daylighting experts” convened in Portland, Oregon, to review a photocontrols research project presented by the Heschong Mahone Group. The presentation prompted an interesting discussion about what it means for a space to be **daylit**. A lively debate produced little agreement. It is common for experts to disagree; in fact, it is part of being an expert. But is it only the experts that do not agree or is this a more pervasive question among the entire design community?

Agreement over a defined daylighting vocabulary is not a new issue. One of the more recent attempts to work toward a more common vocabulary was a survey conducted by the National Research Council of Canada during the summer of 2005. (The survey results are published in the March 2008 issue of the journal *Building Research & Information*.) The survey of more than 150 architects and engineers worldwide presented five alternate definitions of daylighting. Each definition emphasized one of the following aspects: user comfort, electric lighting energy savings, overall building energy savings, peak energy demand reduction, or general economic benefits. Participating architects prioritized user benefits while engineers prioritized energy savings and economic benefits.

The survey results reinforce what many practitioners already realize: most designers working in the medium of daylight are a bit cloudy when it comes to explaining just what is meant by describing a building or a space as daylit. Or is the correct term “daylighted”? Even on this point there is no consensus.

What can we agree on? First, let us concur that daylight can be present in a space without the space being daylit. Too often, spaces with even a modest daylight feature, say a classroom with a few small windows, are described as daylit. In a daylit space, daylight is more than a feature; it accommodates the visual needs of the occupants allowing them to function in the space. Some experts say a daylit space must have **sufficient daylight** but not cause users to perceive **glare**. Additionally, some would argue that a daylit space must meet a lighting-quality or uniformity threshold. Others are more concerned that electric lighting energy savings are realized and that occupants have not disconnected the daylight sensing lighting controls. In truth, a daylit space is all of this and more.

In an attempt to wrap this set of ideas into a definition, let me posit that a daylit space provides daylight as the primary source of daytime illumination to accommodate the occupants’ visual demands, is experienced as a visually and thermally comfortable place connected to outdoor phenomena, and persistently maximizes electric lighting energy savings while minimizing peak energy demand. By design this definition does not state how much daylight is necessary to accommodate the occupants’ visual demands or what constitutes visual comfort. A definition that is specific enough for a particular space type will be useless for a general application. This is precisely why daylight is so challenging to understand and to successfully design into buildings.

These questions of sufficiency and comfort are not new. For more than 100 years daylighting researchers have wrestled with what constitutes sufficient daylight in a space and how to measure and predict human perceptions of glare. Definitions for daylight sufficiency were borne out of the early twentieth century British law and the principal of Right to Light—an easement provision under the Prescription Act of 1832 that ensures the owner of a building with windows that have received daylight for 20 years or more to prevent the construction of a building or obstruction that would interfere and deprive the existing building with said daylight illumination. In the mid-twentieth century, researchers evolved small source glare metrics for use with daylight but these have never been broadly accepted since they stem from electric light-source testing in laboratory settings with no daylight or view. This early dialogue made promising gains but largely was put on hold during the second half of the twentieth century because of the dominance of electric illumination. What persisted through these years was a sufficiency metric described as **daylight factor**.

Daylight factor (DF) is the most common metric for measuring daylight in a space. The measurement technique evolved over time and the threshold values recommended vary drastically, from 0.1 DF to 10 DF (0.001–0.10 of outdoor illumination) depending on occupancy type, regional lighting expectations, and historical time period. DF is easy to measure, is conceptually clear, can be considered point-by-point or as an average by space, and generally is consistent over time regardless of the amount of illumination outdoors. However, it is limited in use to overcast sky conditions, and therefore has garnered heavy criticism and is no longer considered a viable metric in abundantly sunny climates. Being that DF

emerged from England's predominantly overcast skies, it should be no surprise that it does not work well in Southern California. Furthermore, DF does not give adequate information about visual comfort in a space, consider functions of time or sky condition, or suggest the likelihood for view potential or electric lighting energy savings to be realized, and it virtually ignores the energy impact from heat gain and loss through daylight aperogy tures. Practitioners are beginning to realize that additional metrics are necessary to adequately describe daylight in all its complexity.

Over the past decade a fundamental revaluation of the role of architecture in culture, improved expectations about building performance, and the increased demand for reducing energy use because of concerns about global climate change have resulted in a resurgence of building design for the inclusion of daylight. Daylighting researchers and practitioners alike are scrambling to keep pace with the ever-increasing demands for daylight design and analysis. New climatically and temporally sensitive metrics, categorized as dynamic daylight metrics, have been developed to provide a pathway forward. The most significant of these are **daylight autonomy**, **useful daylight illuminance**, and **daylight saturation percentage**. These metrics use site-specific weather files to calculate daylight performance over an entire space grid, typically using digital simulation tools. These metrics create new possibilities for design analysis, but their use is limited in field investigations because of their complexity.

Dynamic metrics will be a major component of future daylight design and analysis. By 2010, the Illuminating Engineering Society's (IES) Daylight Metrics subcommittee hopes to define a suite of metrics that experts can agree on and designers can understand and make use of in guiding the design process. Whatever metrics do evolve, it only makes sense that the corresponding thresholds related to daylight sufficiency, visual comfort, and other major aspects consider occupant needs and space types. It appears as though daylight metrics will become more complex. The challenge will be to keep these metrics relevant to practitioners.

Because of the complexity of daylight, design teams need to carefully analyze their daylighting design to build spaces with the potential of being daylit. Contractors and building users need to be educated about the intent of these designs for the built spaces to actually function as daylit spaces. Assuming the efforts of the IES Daylight Metrics subcommittee are successful, it will have taken more than 100 years to arrive at a consensus about what constitutes a daylit space. Let us hope it takes less time to decide what constitutes a **daylit building**.

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Daylighting Glossary

1: **Daylight** is the natural light of day.

2: A **daylit** space provides daylight as the primary source of daytime illumination to accommodate the occupants' visual demands, is experienced as a visually and thermally comfortable place connected to outdoor phenomena, and persistently maximizes electric lighting energy savings while minimizing peak energy demand.

3: **Sufficient daylight** describes an amount of daylight that meets the minimum spatial lighting requirements as defined by consideration of occupancy type and schedule typically measured on a horizontal work plane.

4: **Glare** is a human sensation usually described as either discomfort glare or disability glare. As defined by the Commission Internationale de L'Èclairage (CIE) in 1957, disability glare is: "Glare which impairs the vision of objects without necessarily causing discomfort." Discomfort glare is: "Glare which causes discomfort without necessarily impairing the vision of objects."

5: **Daylight factor** (DF) is a ratio that represents the amount of illumination indoors relative to outdoors at the same time. It typically is calculated by dividing a value of horizontal work plane illumination by the horizontal illumination available as measured horizontally on the roof of the building being tested. DF was developed at the beginning of the 20th century independently by A.P. Trotter and Percy J. Waldram, and was formalized by Waldram and his son in 1923 in a paper entitled, "The Natural and Artificial Lighting of Buildings," which appeared in the *Journal of the Royal Institute of British Architects, Vol. XXXII, No. 13*, pp. 405–426 and 441–446.

6: **Daylight autonomy** is represented as a percentage of annual daytime hours that various grid points in a space are above a specified illumination threshold. It originally was proposed by the Association Suisse des Electriciens in 1989 and was improved by Christoph Reinhart from 2001 to 2004. It is a major innovation because it considers location-specific weather information on an annual basis. It also can directly relate to electric lighting energy savings if the threshold set is based on electric lighting criteria.

7: **Useful daylight illuminance** is a modification of daylight autonomy conceived by architectural researcher John Mardaljevic in 2005. This metric bins hourly time values based on three illumination ranges, 0–100 lux, 100–2000 lux, and over 2000 lux.

8: **Daylight saturation percentage** is a modification of useful daylight illuminance that modifies the lower limit to 40 footcandles and increases the upper limit to 400 footcandles. It goes further to penalize grid point annual hour values above 400 footcandles by forcing them to be subtracted from the grid point annual hour values above 40 footcandles and below 400 footcandles. The Lighting and Daylighting Committee for the Collaborative for High Performance Schools program (CHPS) developed it in 2006.

9: **Daylit building** is a building with daylit spaces that represent a certain percentage of regularly occupied spaces with critical visual tasks.