Daylight and energy modeling: a developing relationship

By Scott Schuetter, Energy Center of Wisconsin

Daylight modeling is a powerful but under-utilized tool for understanding the design decisions that impact a building’s visual and thermal comfort, as well as its energy performance. Fundamentally, daylight modeling is any technique that can predict the illuminance levels and heat gain in a space due to the direct and diffuse components of sunlight. Daylight modeling may be as straight-forward as using sun path diagrams and daylight factors or as complex as a full computer simulation using radiosity or ray-tracing algorithms. Visit the Daylighting Collaborative for more information about the different types of daylighting analysis.

Historically, computer-based daylighting simulation techniques have evolved concurrently, but separately, from their energy modeling cousins. Today, a multitude of daylighting (AGi32, Ecotect, and others) and energy modeling (DOE-2, EnergyPlus, EnergyPro) sofware exist. Although most energy modeling software has daylight modeling capability, it is normally limited to simpler analyses, sometimes leading to inaccurate energy savings estimates. Currently, no software successfully marries advanced daylighting algorithms and energy modeling into one seamless package. Designers are left to build two separate models of their spaces to accurately understand the illuminance levels and energy performance of their designs.

Two recent papers have explored techniques to integrate these two analyses into one. You’ll find citation and links to the papers, in the resources section of the Daylighting Collaborative.

1. John An and Sam Mason of Atelier Ten developed a methodology to more accurately predict the lighting savings from implementing daylight controls by adjusting the DOE-2.2 lighting schedules with results from a DAYSIM analysis. They compared their methodology to DOE-2.2's daylight modeling methodology for one east facing office and one west facing office/conference room in a campus administration building. Their methodology showed a 21 percent and 32 percent increase, respectively, over lighting energy savings predicted by DOE-2.2's methodology in the same spaces. A glare evaluation was also performed in Evalglare. The analysis showed that glare was not an issue in the spaces.

2. Rob Guglielmetti, Shanti Pless, and Paul Torcellini of the National Renewable Energy Laboratory (NREL) studied the impact that similar tools had on the design of NREL’s Research Support Facility, a net-zero, LEED Platinum building on the lab’s campus. Specifically, they used daylight modeling to analyze the impact that different window head heights, window-to-wall ratios, glazing transmittance, and interior finishes had on daylight
illuminance levels. They also analyzed an innovative system from LightLouver showing
daylight penetration of up to 60 feet from the south-facing clerestories. Additionally they
developed a technique to integrate radiance modeling in SPOT with DOE-2.2 to create a
more robust daylight model within the energy model. This model showed an overall building
EUI of 34 kBTU/ft²/yr. A portion of this low energy usage was attributable to the aggressive
daylight harvesting.

It should be noted that, although energy modeling software’s daylight analyses are more basic,
they are not without merit. For simple spaces, the split-flux method used by DOE-2.2 can
accurately predict the daylight savings from using photosensor control of the electric lighting. To
understand the energy savings of photosensor control, Energy Center of Wisconsin staff
conducted a comparison between DOE-2.2 and SPOT results for a classroom located in Chicago,
IL. The space was 31.5 feet by 23.5 feet with 10 foot ceiling heights. The window-to-wall ratio was
100 percent for the west-facing wall with 70 percent visible transmittance. The space had a
lighting power density of approximately 1.0 W/ft² from two-lamp T8s in a combination of pendent
indirect and lensed troffer fixtures. For the DOE-2.2 model, Energy Center staff incorporated the
space into a 50,000 ft² building served by water-cooled chillers and atmospheric boilers. The
figures illustrates daylit renderings of the classroom space in SPOT.

The DOE-2.2 model predicted electric energy savings of 1.60 kWh / ft² of daylit area. This
compared well to SPOT’s prediction of 1.76 kWh / ft² of daylit area. By no means conclusive, this
analysis at least points to an order-of-magnitude accuracy between a single energy modeling
package’s algorithms and a more sophisticated radiance-based one.

Selection of the right modeling software to use ultimately comes down to the project’s objective
and budget. For projects with aggressive energy savings goals, a combined approach with its
longer analysis time and more accurate results is usually warranted. For projects with shorter
timelines and smaller budgets, it is often preferable to use the simpler techniques.

For more information or questions about daylighting analysis, please contact the Buildings Team
at the Energy Center of Wisconsin.
Be part of the green revolution: dynamic daylighting systems

By Moshe Konstantin, CPI Daylighting, Inc.

Delivery of natural daylight into the building envelope is one of the most important elements of green or sustainable architectural design. Architects often find themselves grappling to find the right daylighting design strategy for their projects. How does an architect design a building to receive all of the desired sunlight while avoiding unwanted solar heat gain and managing daylighting glare?

This often frustrating design dilemma can be addressed by employing dynamic daylighting systems. Dynamic daylighting systems have revolutionized the way green buildings harvest low-angle daylight that is available early and late in the day.

These systems use intelligent solar blades within the glazing panels to gauge the sun’s position and dynamically manage the desired amount of sunlight, solar heat and sun-shading inside the space. Solar blades revolve to provide uniform light transmission and sun-shading performance across the entire space and can be set to deliver direct or diffused sunlight. By angling the sunlight that penetrates the space, they deliver less energy per square foot than direct sunlight.

A sun-tracking sensor also allows optimal position alignment of the solar blades to harvest daylight that would otherwise be lost due to the low incident angle of the sun early and late in the day. Dynamic daylighting systems ensure enormous energy savings, comfort in any space, and give architects the flexibility to design large glazed openings in which they can manage solar transmission and natural light levels within the building envelope.