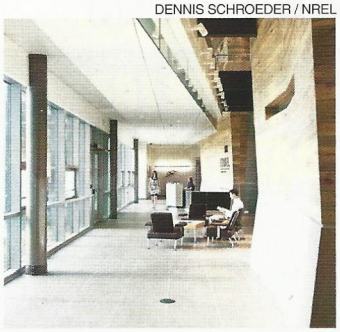
CLOSE-UP: DAYLIGHTING

Harvest Daylighting's Bright Potential With Ongoing Monitoring

by rita tatum, contributing editor

Modern energy conservation procedures in new and retrofit buildings often tap the benefits of daylight to reduce both lighting and HVAC cooling loads significantly. At first, great strides in energy efficiency are achieved and everyone seems delighted. But as time passes, the daylight harvesting system is too often overridden by occupants and even facility managers trying to resolve complaints.

DENNIS SCHROEDER / NREL



The lobby of NREL's Research Support Facility features daylighting. The facility also uses natural ventilation and a rooftop photovoltaic system.

Daylight harvesting systems usually save energy, even when they may not be performing optimally. In fact, a recent study by the Energy Center of Wisconsin found daylight harvesting saved a median of 20 percent in lighting energy savings and another 3 percent when HVAC savings were added for the 20 commercial and public assembly spaces studied.

About the same time, Lawrence Berkeley National Laboratory published a best estimate of 28 percent average lighting energy savings when daylight harvesting is employed.

Initial design estimates often place savings at slightly higher levels than the LBNL and Energy Center of Wisconsin studies found. Over time, space planning and other elements may reconfigure the daylit space, resulting in significant daylight harvesting losses. Therefore, facility managers who regularly monitor their daylight harvesting systems often can increase their savings with minimal effort.

Starting With Commissioning

The first step for maintaining daylight harvesting starts at post-construction commissioning. At this point, functional testing of the entire daylighting system — lighting controls, interior partitions, and glare control devices — is essential. Careful attention to calibration of these controls is crucial, under both sunny and bright cloudy conditions, either on-site or through simulations. This allows the photosensor setpoints to be adjusted for real-world building conditions. An illuminance meter verifies that workplace illuminance is achieved under various exterior lighting conditions.

"All control equipment should be verified as being the right equipment, properly delivered," says Craig DiLouie, education director, Lighting Controls Association. "After installation, the control system should be verified to be properly installed and oriented, particularly the light sensors, and then functionally tested to make sure it works as specified. Finally, the owner should be trained on the control system's proper use and receive a systems manual with all documentation."

50%

After recommissioning, daylighting saved an average of 50 percent of lighting energy use in 20 spaces studied by the Energy Center of Wisconsin. Before commissioning, the average savings was only 20 percent.

Recommissioning's Added Value

The Energy Center of Wisconsin also assessed actual savings compared to ideal savings and found that most (16 spaces) were achieving just half their potential savings. Four others were not saving any energy.

Analyzing the problems showed the primary culprit.

Softer Benefits of Daylighting

Productivity and workplace improvement are difficult to quantify. However, studies on daylighting's connection to student learning done by Heschong Mahone Group found 20 percent improvement in student learning rates when daylighting was a positive element.

In another study, Heschong Mahone Group looked at more than 100 stores in a retail chain. The major difference in design was that more than 60 percent had skylights. When the sales figures were analyzed, stores with skylights had an average of 40 percent higher sales.

Why daylight affects productivity is not completely understood, but there is growing physiologic evidence that daylight decreases melatonin, the body's natural sleep aid. Sunlight suppresses melatonin and increases serotonin, explains Tom Hootman, director of sustainability at RNL. "Serotonin during the day elevates mood," making people feel more alert and energetic.

Other daylighting benefits include providing sensory variability, connection to nature, and full-spectrum light, which can provide a more pleasant and comfortable visual environment, says Craig DiLouie, education director, Lighting Controls Association.

— Rita Tatum

Eight spaces needed major control calibration and five others needed minor control calibration. In three spaces, the zoning was too large; another three spaces applied heavy shading to reduce glare. Two spaces suffered from incorrect relays. High cubicle dividers, improper sensor positioning, and low deadband (disabled daylight harvesting controls) were found in three spaces.

DENNIS SCHROEDER / NREL

At NREL's Research Support Facility, a louver system installed in the windows redirects sunlight deep into the office space to provide a comfortable ambient light. Completed in 2010, the 218,000 square foot office building has achieved an operating lighting power density of less than 0.2 watts per square foot.

In each space, the Energy Center of Wisconsin recommissioned the daylight harvesting system. The retuning often took about two hours. In return, recommissioning saved an average of 50 percent in lighting energy savings that combined with HVAC savings totaled 57 percent. Even where daylight harvesting seems to be working, periodic recommissioning can yield significant energy savings.

Constant commissioning helps maintain daylight harvesting advantages, says Tom Hootman, director of sustainability at RNL. As space use changes, and even when the space appears to be the same, periodic calibration of sensors is essential, says Hootman. "Over time, those sensors may be overridden," he says.

Certainly when major changes are being made to spaces in the building, facility managers need to double-check that daylighting is providing the number of footcandles needed for occupants. One simple way to continuously commission the system is to use a light meter application on a smart phone. "Then, as you walk through an area, you can check light levels in moments," says Hootman.

Another way to catch when the daylight harvesting system is not performing optimally is to install lighting system submeters. By monitoring the submeters, facility managers will be able to spot telltale energy spikes.

Importance of Controls

Maintaining energy savings in daylight harvesting requires both solid initial design elements and — more importantly — retuning and monitoring to make sure those savings continue.

"Daylighting does not save energy by itself," DiLouie asserts. "For daylighting to save energy, some type of control is needed. This involves use of a light sensor that signals a controller to reduce output and wattage to maintain a light level setpoint."

With such controls in place, a 2012 LBNL study of about 250 facility experiences as presented in papers and case studies estimated daylight harvesting systems could save an estimated average of 28 percent as compared to more conventional lighting systems.

Occupied since June 2010, the National Renewable Energy Laboratory's (NREL) research support facility (RSF) in Golden, Colorado, shows that with work and continued follow up a large net zero energy office building can maintain its positive daylight harvesting.

"We see an operating lighting power density of less than 0.2 watts per square foot," says Jennifer Scheib, lighting engineer for NREL's Commercial Buildings Research Group. The installed lighting power density is about 0.6 watts per square foot.

Scheib concedes that some of the reduction is due to occupancy variations. "But approximately 50 percent of the reduction can be attributed to daylighting," she says. "This means both automatic photosensor control and occupants' choice to leave the lights off in spaces they are occupying because there is sufficient daylight to perform the task at hand."

Designing for Daylight

Tapping daylight successfully begins with good space planning. "If private offices are oriented along the windows, workers have no access to daylight," Hootman notes. One strategy is to use the building's north side or interior space for offices, with the more sun-

lit areas for open plan environments.

It's important to make sure glare control doesn't dampen gains. When exterior shading is not possible, another option that keeps the sun shining in is to divide the window area into a daylight harvesting segment and an exterior view, as was done for the Civic Center in Commerce City, Colo. The top windows benefit from light louvers that redirect sunlight to the ceiling and then back down to the work environment. To control heat gain and glare in some areas, interior shades are used below the daylight window portion.

Heat gain and glare are obvious drawbacks that can occur with daylighting. But there are subtler elements at play as well. Not all occupants want or need 30 footcandles in their spaces, according to Scheib.

"While a space should be daylit to sufficiency," Scheib says, "sufficiency can be pretty low for some people and tasks." For example, she says computer workers "prefer a 10-footcandle environment with a view but not over-daylit."

To address these variations, Scheib recommends offering some spaces that provide an average of 10 footcandles, while others achieve closer to 30 footcandles.

Scheib also recommends giving new occupants to the space training and information about control options, as well as time to adjust to the space, "because sometimes it is simply an adjustment period that is needed."

For example, if workers are moving from a dark working environment with high wall partitions and little or no natural daylight, the transition may take some adjustments. "Even a very low-glare environment can be glary to some occupants and for certain tasks," Scheib notes.

"The control effect should be as transparent as possible," says DiLouie. "For example, if there are workers in an open office performing intensive tasks, continuous dimming would provide a smooth transition between light levels, as opposed to an abrupt change in lighting state with bilevel switching, which would be irritating. Additionally, some daylight harvesting control systems might benefit from a local user override."

Modifications Over Time

Lighting experts and researchers agree that building operators need to be able to make ongoing adjustments to address occupant complaints, changes in space use or furnishings and other modifications to the facility. Even with one year of operation to see how the daylighting system performs, some problems may not surface.

For example, a manufacturing defect on a daylight redirection device might cause intense glare for a few occupants only a few hours annually under certain very specific lighting conditions. This wouldn't be detectable during the building's turnover phase, or possibly even during the warranty period. So identifying the root cause for the prob-

lem becomes essential before occupants attempt to correct it themselves with solutions that do not address the real problem.

"Preparing a solution set that can help improve occupant comfort is an approach we have used in the RSF," explains Scheib. The RSF process begins by assessing the environment to see if the issue can be addressed at the occupant's space rather than at the window.

PNC

PNC has focused on daylighting in its construction planning. In January 2013, PNC opened a net-zero energy 5,000 square foot branch in Fort Lauderdale, Fla. that uses photosensors to control dimmable light fixtures as sunlight increases. A canopy covers the building's southern exposure to reflect the sun during hot periods without preventing daylight from entering the building.

On a larger scale, The Tower at PNC Plaza, now under construction in Pittsburgh, is oriented away from its street grid to achieve 91 percent daylighting inside the building. The 33-story building's tower features narrow floorplates that allow light to penetrate all workspaces. The project also hopes to achieve net-zero-energy status for 40 percent of the year.

"Can the occupants reorient in the modular furniture?" asks Scheib. "Can an adjustable and right-sized glare panel be placed at the workstation so it can be used at the time of perceived glare but then removed if not needed? Can they relocate with another employee who is comfortable in the space?" Using the answers to these questions has allowed RSF to maintain its daylighting control system's intent over the years.

With routine monitoring, recommissioning, and periodic recalibration, many daylight harvesting systems can provide occupant comfort and still maintain their initial energy savings from letting the sun shine in. ■

Rita Tatum, a contributing editor for Building Operating Management, has more than 30 years of experience covering facility design and technology.

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