Deeper Energy Savings with Automated Shading Integrated with Lighting Controls

What is Automated Shading Integrated with Lighting Controls?

Perimeter shading system operation can be automated with controls that use a sun position algorithm and local radiometric sensor inputs to manage glare. Automated shade controls maximize the utility of natural light while preserving occupant visual comfort. Admitting more natural light enables daylight dimming controls to save lighting energy with an added benefit of savings in cooling energy.

Lighting energy in the daylit zone is significantly reduced via implementation of dimming controls. In this study, Lawrence Berkeley National Lab (LBNL) found annual lighting energy savings up to 30%[i] in the controlled zones, compared to a baseline with the same lighting system (fluorescent or LED) but no daylight dimming and manual venetian blinds for shading. The highest energy savings are possible in cooling-dominated climate zones due to lighting and HVAC interactive effects. Energy savings at the whole-building level will vary based on perimeter-to-core ratios and the type of HVAC system in place.

System Setup

The system is implemented to deliver energy savings to perimeter zones in two ways. First, the automated shades are retracted when conditions permit, to allow as much natural light into the space as possible, which facilitates electric lighting dimming in the daylit zone.[ii] Second, reduced lighting power leads to less cooling energy use. The automated shades did not appear to reduce solar heat gains relative to the manually operated venetian blinds, so measured HVAC savings were associated only with the lower electric lighting energy usage.

For daylight dimming, fixture output varies according to distance from the window; the fixtures nearest the window dim the most due to higher daylight availability. Automated controls are implemented to deploy shades based on sun position and data from local sensors to block direct or reflected solar glare due to daily and seasonally changing sun angles. The shades may also be operated manually in response to occupant preferences in the space.

Performance Validation at FLEXLAB®

Each system was tested in FLEXLAB, a heavily instrumented and metered test facility that supports side-by-side comparisons of baseline and test conditions. Testing was conducted for a total of six months, to cover different façade orientations[iii] varying daylight conditions, and a seasonal range of sun angles. Test data was collected to verify energy performance, and for analysis of task plane light levels and the incidence of glare – both important for quantifying occupant visual comfort.

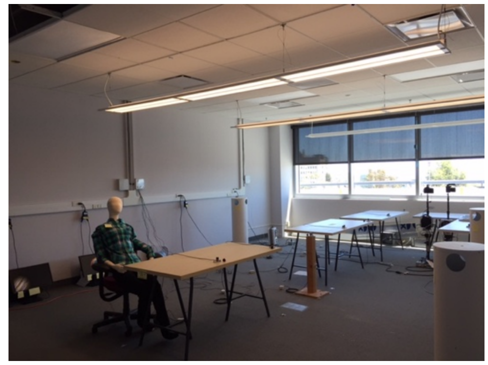

Figure 1. System installed in FLEXLAB® Testbed

Overview: A Systems-based Approach

Most building retrofits are still component-based, typically addressing only one piece of equipment at a time. Case studies demonstrate that to achieve deeper whole building energy savings, integrated systems and strategies are required.[iv] However, a systems-based approach requires a more rigorous design and savings assessment effort, as well as greater resources for installation and commissioning. A main objective of developing these integrated systems packages is to simplify implementation and operation by commercial building owners and operators. These systems may also benefit from access to customer incentives from local utilities.

Cost Effectiveness

Simple payback was calculated with energy savings valued at an average US electricity rate of $0.11/kWh

- Simple payback for the retrofit case, which includes the full project cost of the automated shades and lighting controls, is approximately 27 years.
- For the replace-on-burnout case, where the payback is calculated based on the incremental cost of the specified technology over the cost of a "standard" shading and lighting controls replacement, simple payback is estimated at around 11 years.
- Cost effectiveness will vary based on local utility rates and market labor rates. Cost effectiveness would also be greatly improved with the addition of an LED lamp replacement.

Table 1. Energy Savings Results Compared to Baseline (no daylight dimming or automated shades)

Energy Savings (kWh/sf/yr)	Energy Cost Savings ($/sf/yr) at $0.11/kWh	Lighting Energy Savings (%)
3.49	0.37	85%

Occupant Comfort

Automation of the rollershades is based on known solar position, a local irradiance sensor (indicates clear sky or overcast conditions), and a window-mounted glare sensor. With the automated shades, Daylight Glare Probability is maintained within acceptable levels at almost all times, even during the winter season when sun angles are lowest. The electric lighting dimming controls also maintain illuminance of 500 lux at the workplane at all times.

Identifying Suitable Sites

Automated shading with daylight dimming and HVAC controls is an attractive option for commercial office buildings, but candidate sites should be selected with attention to façade orientation, ceiling height, window size, current glazing specification, and existing lighting system and controls. Generally, buildings with a high ratio of perimeter-to-core floor areas and with high cooling load will save the most energy. A simple assessment calculator is available to estimate energy performance using site-specific inputs.

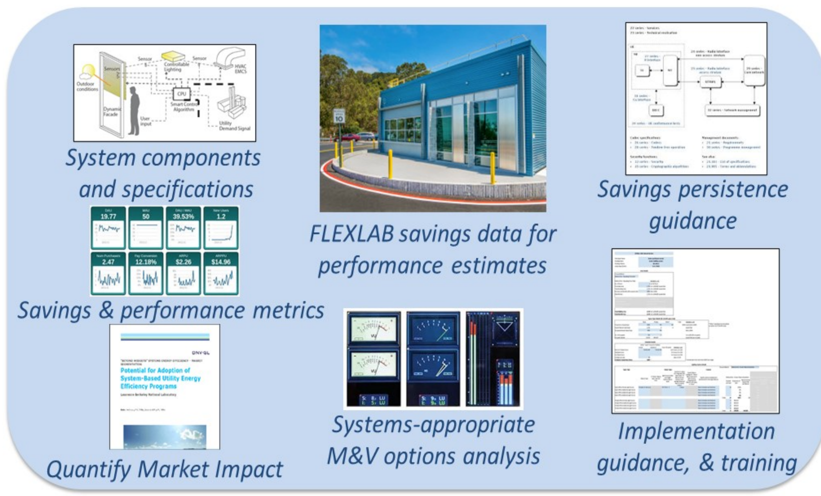

Figure 2. Key Elements of the System Package Development

Integrated Comprehensive Implementation Support

A Systems Package Program Manual (see Figure 2) provides guidance for implementation and is comprised of a systems description, performance specification of the system components, savings and performance metrics, candidate site requirements, a site energy savings assessment calculator, an assessment of market savings potential, energy savings and performance data, and implementation guidelines (including measurement and verification) and training. The Program Manual and the assessment calculator along with other systems packages and papers can be found here.

[i] Measured for a fluorescent lighting system, at 500 lux setpoint at the workplane, for a west-facing office

[ii] Generally assumed to be twice the window head height

[iii] FLEXLAB's rotating test bed was utilized to allow testing at all orientations north through east in a counterclockwise direction

[iv] Regnier, C., Sun, K., Hong, T., and Piette, M. 2017. Quantifying the benefits of a building retrofit using an integrated system approach: A case study. Energy and Buildings, 2017.