From Daylight Harvesting to Daylight Autonomy

by Brent Protzman

Achieving 'daylight autonomy' requires mitigating glare while maximizing energy savings

Daylighting is a relatively new term for an ancient practice. In the millennia before the introduction of electricity, buildings were designed to take advantage of daylight to illuminate interior spaces. The Egyptians used daylight control to temper the heat of their extreme climate, introducing lattice and screens with different size openings to allow for daylight penetration into a space. In Rome, buildings were designed around courtyards surrounded by living space to maximize available daylight.

Throughout history, architectural design has been intimately linked to daylight. During the European Renaissance, the masters revered light as a practical design tool, but also recognized that light could be used to enhance the experience of a space. Baroque style used indirect light to create mystery and highlight the special qualities of a building.

More recently, as electric lighting sources and technologies have improved, daylight became almost passé; but, evolving building codes, new energy regulations and a renewed emphasis on sustainability encouraged today's architects, building owners and lighting designers to once again embrace daylight as a practical, aesthetic and symbolic element of good building design.

The greatest challenge to using daylight as a primary light source is that it is naturally dynamic. Some changes are predictable—seasonal patterns, sunrise and sunset—but daylight also changes from day-to-day, hour-to-hour and even from one building façade to the next. Weather, clouds, mature landscaping and changes in the built environment all require that buildings take an equally dynamic approach to lighting control.

New solutions minimize the need for electric light by incorporating dynamic fenestration (automated shades, solar-adaptive software and window sensors) into total light management systems.

CODES DRIVE TREND

One of the most powerful motivators to use daylight more effectively is code compliance. As utilities struggle to meet the ever-increasing demand for power, federal and state agencies are stepping in to regulate energy use and mandate compliance by strengthening building codes to support energy savings and sustainable building design. Daylight harvesting strategies are key elements in these codes.

Standards and guidelines developed by the American Society of Heating, Refrigerating and Air-Conditioning (ASHRAE) are now mandated by the Department of Energy. As of October 18, 2013, all state commercial building codes must meet or exceed ASHRAE/IESNA 90.1-2010 standards that include mandatory requirements for daylight harvesting technology. Other building standards, including IECC and Title 24, are following suit by including similar daylighting requirements in their updated recommendations.

Buildings can meet codes with manual shades and standard technology mandated by the 90.1–2010 "Daylight Zone Requirement." Or buildings can exceed codes and realize their full potential with automated shades and wireless technology. By designing the same space with wireless technology and automated shades, the initial cost is slightly higher, but the return on investment is significantly better.

As spaces are designed to more effectively use daylight, they are fundamentally less dependent on electric light. This is the basis for lighting and controls designed around "daylight autonomy."

FACILITATING DAYLIGHT AUTONOMY

Daylight autonomy is achieved when a space maximizes the amount of useful daylight, thereby minimizing the need for electric light. In mathematical terms, daylight autonomy is the percentage of annual work hours during which all or part of the lighting needs can be met through daylighting alone. Designing for daylight autonomy presents several challenges. The final product has to embrace daylight while minimizing or eliminating glare, and maximize energy savings by reducing the use of electric light. This is not an easy task since the amount of daylight outside a building is in constant flux, which also affects the indoor lighting environment.

Maximize energy savings. As energy rates rise, energy savings become more and more important to the bottom line. Ample daylight reduces the need for electric light, but can also cause heat gain, which can raise HVAC costs. Daylight has to be admitted judiciously to balance light and heat.

Reduce glare to increase comfort and productivity. Glare can cause eye strain, headaches and general discomfort. Vast amounts of daylight may eliminate the need for electric light during daytime hours, but create expensive workplace problems like decreased productivity or increased absenteeism. There are several different categories of glare that need to be addressed by lighting design[1]:

- Discomfort glare: glare sensation experienced as a result of viewing a light source or reflection of sufficient luminance to cause discomfort, but the observer is still capable of seeing.
- Disability glare: glare sensation experienced as a result of viewing a light source or reflection of such great luminance as to be visually disabling. The observer cannot see or can see in only such a limited capacity that his/her vision is essentially disabled.

These categories of glare are described in *Architectural Lighting Design* by Gary Steffy[1], and it is key to note that "light source" is not limited to light fixtures and lamps; it also includes the sun, the sky, etc.

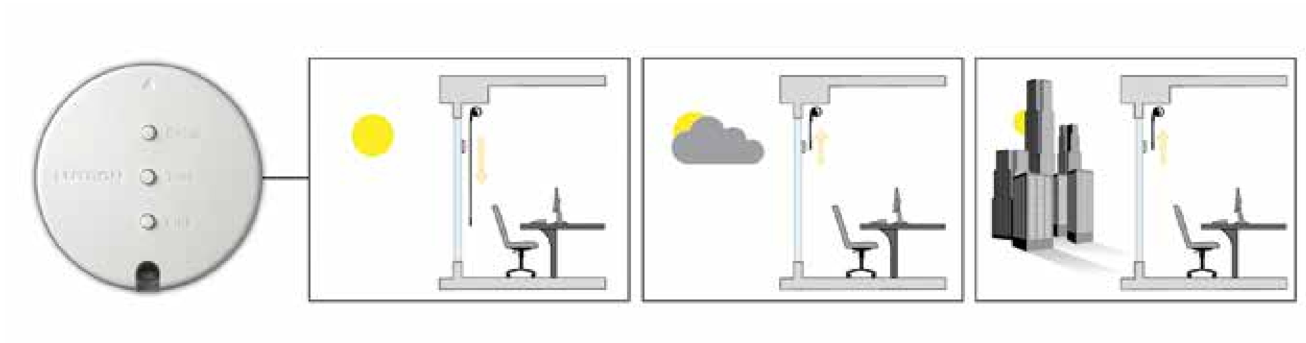
Automated shades maximize the amount of daylight entering a space to minimize or eliminate the need for electric light, increasing daylight autonomy.

SHADES AND SOFTWARE

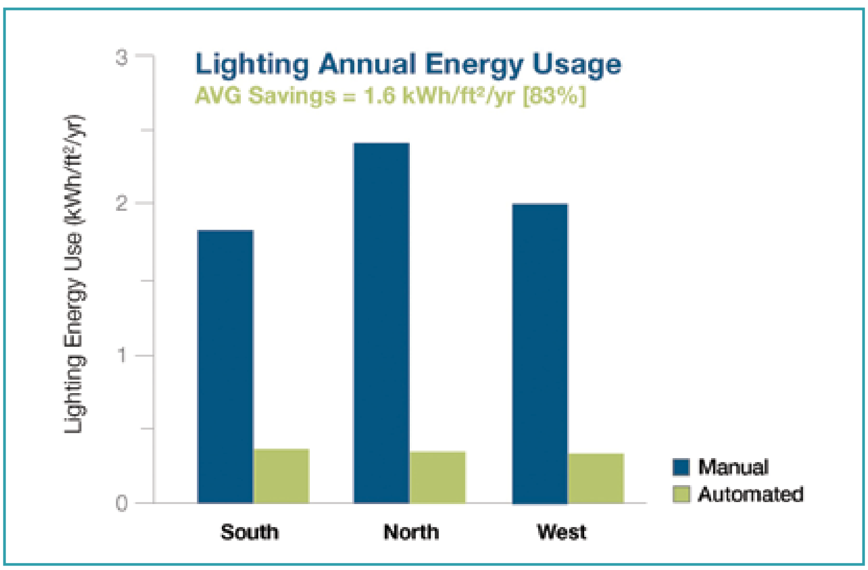
Dynamic fenestration, including automated shade control, is the ideal lighting design strategy for addressing both energy savings and glare management. Theoretically, manual shades could provide some of the same benefits, but in practice manual shades are virtually never adjusted, and often remain closed, significantly increasing the need for electric light, and providing none of the daylight benefits that can be gained from automated shading solutions.

The best solutions combine automated shade control with solar-adaptive software, and cloudy-day/shadow sensors that further enhance automatic shade adjustment by allowing the shading software to evaluate and respond to real-time daylight conditions. By using the same software to control electric light, the electric light can be used only to supplement available daylight, minimizing or eliminating lighting energy use whenever possible.

Automated shading allows the lighting system to respond to environmental factors related to both energy use and glare. As related to energy use, automated shading control works to maintain a consistent light level in all environments and can extend the useful daylight zone (the area inside a space where enough glare-free daylight is available for daylight harvesting) inside the



Solar-adaptive shading, like Lutron Hyperion systems with window sensors, adjusts shades throughout the day based on the position of the sun and environmental conditions.



Automated shades can extend the useful daylight zone to significantly increase lighting energy savings[2].

perimeter of the space. Manual shades can generally achieve a useful daylight zone of 10 ft inside the perimeter windows. Because automated shades respond to real daylight conditions, they can extend the useful daylight zone to 20 ft inside the perimeter, allowing for higher daylight autonomy.

To mitigate glare, it is important to choose a shade manufacturer that offers a broad selection of fabrics, allowing the lighting designer or architect to choose the appropriate transmittance level based on the building's location and orientation.

A recent study conducted by Purdue University and Lutron Electronics analyzed the benefits and energy-saving potential of solar adaptive, automated shading control systems. Results show that perimeter private offices with daylight harvesting strategies in place can further reduce lighting energy usage by 65 percent through the use of automated shades[2].

Forward thinking lighting design will increasingly call upon the well-documented benefits of sunlight to create spaces that are comfortable, energy-efficient, sustainable and code compliant. The Masters of ancient architecture relied on building techniques that simultaneously captured and tamed the sun's potential—automated shading systems bring daylight back into the mainstream of modern design.

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SOURCES

1. Steffy, G. (2008). Architectural Lighting Design. John Wiley & Sons, Inc., New York, NY

2. Lutron Electronics Co., Inc. worked with Purdue University to analyze the benefits and savings potential useful daylight zone up to 10 ft of Lutron's Hyperion automated shading systems. The results showed the impact of how automated shades significantly reduce annual lighting energy usage. Savings are based on energy simulation of a perimeter private office with a lighting power density of 0.9 watts per sq ft, a standard clear double pane glass, and a shade fabric with 5% transmittance and a 76% reflectance. Values shown are the average of three window to wall ratios: 20%, 40%, and 60%. Daylight harvesting system required.