УДК 005:658.26

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DAYLIGHTING AND ENERGY SAVINGS

It is common knowledge that lighting contributes to more than 30% of the total energy consumption of a building. Nowadays lighting systems in so-called smart buildings are optimized to ensure the minimum energy consumption. Such lighting systems are composed of energy efficient luminaires and daylight control, offering additional savings due to the natural light entering the building.

Natural light is one of the key ways of saving energy. Daylighting minimizes the amount of artificial light and reduces electricity and heating, ventilation, and air conditioning costs. Electrical lighting produces a lot of heat, whereas natural lighting generates hardly any heat if it is properly controlled. Making use of natural light can save up to 75 percent of the energy used for lighting buildings and reduce cooling costs. In the past few years, lighting has become a focus for energy saving ideas. However, not enough effort has gone into maximization of the use of natural light either in building design or legislation. Good daylighting solutions demand an integrated building design approach [1]. Daylighting design should be holistic: developing solutions that are part of the main concept, while meeting visual, thermal and energy needs.

A good daylighting design can save energy-a lot of energy in fact. By implementing continuously dimmable lighting controls, electric lighting energy can be offset by using daylight when available. And, since electric lights act as mini heaters in a building, lighting controls also reduce the cooling load. Without lighting controls, the building energy increases as window area increases because the solar heat gain and U-factor of fenestration is generally higher than an opaque wall. However, with lighting controls, the building energy starts to reduce as window area increases because of the electric lighting and heating, ventilation, and air conditioning costs energy savings. At a certain window area, when daylight has saturated the space and the lights are turned off completely, the building energy reaches a minimum. Increasing the window area further cannot save any more electrical energy and so the building energy starts to increase as the effective solar heat gain and U-factor of the envelope increases. The US Department of Energy (DOE) has estimated that if the entire nation's building stock were outfitted with dimmable lighting controls together with highly efficient fenestration with dynamic solar control, a lot of energy could be saved annually [1].

To achieve these kinds of energy savings, a good daylighting design with windows positioned appropriately on the envelope to maximize the depth of daylight admission while minimizing solar gains and glare, is needed. With a good daylighting design, dimmable lighting controls and high-performance fenestration, the minimum of the typical curve can be moved to higher window areas. Indeed, with careful designs, the window to wall ratio can exceed 50 percent and even higher window areas can still result in energy efficient designs.

With daylight comes free heat, which can save energy during the cooler seasons. Some products used mainly for providing natural light can also significantly reduce the amount of heat lost when substituted for more traditional products. This daylighting fact sheet addresses key differences between fenestration products installed primarily vertically (windows, doors, curtain walls and storefronts), and those installed primarily overhead (skylights, roof windows and tubular daylighting devices) and their relation to daylighting and energy savings. The common set of terms used by daylighting professionals for these two fenestration categories is side-lighting and top lighting respectively. Generally, all fenestration products can be sources of quality daylight and passive solar energy; however, additional factors need to be considered when comparisons and/or choices between side lighting and top-lighting products are being made. The basis for the difference is quite simple; side-lighting products face the horizon and top-lighting products face the sky. Side-lighting from windows and doors provides daylight and solar energy along the perimeter of a building. Good daylighting design should consider these side -lighting characteristics: • Most daylight is provided through ambient lighting from the sky. The amount of daylight available will vary throughout the day depending on the direction the fenestration is facing. External obstructions are likely to reduce the available daylight. • Orientation (north, east, south, west) with respect to the sun's path is a critical factor. • The need for shading to avoid excessive glare is essential when the sun is low in the sky. Top-lighting can provide daylight and solar energy throughout the interior of a low-rise building, on the top floor of a building or in an atrium. It should complement side-lighting in any good daylighting design, where conditions permit: • Daylight is available throughout the day from both ambient lighting from the sky and direct exposure to the sun, and is more consistent. • Modern transparent and/or translucent glazing can be utilized to avoid glare, aid in capturing sunlight at low angles and diffuse light to wider areas of floor space. • Shading accessories can be used on many product options to manage light levels when desired or necessary. • Even on a cloudy day, top-lighting can provide three times more daylight than side-lighting according to calculations.

Effective daylighting design results in a system that includes side-lighting and/or top-lighting, electric lighting controls (automated if possible) and a building explicitly designed to optimize the usefulness of daylight. In applications where daylighting is the primary goal, factors which impact the efficient application of side-lighting and/ or top-lighting include: *Building Purpose*. Non-residential – In a retail building, for example, daylighting is typically focused on the public retail areas and not on the lesser-used areas for storage and offices. Top-lighting can provide daylighting into any interior floor space area, a critical advantage for large floor plans, whereas traditional side-lighting is limited to the perimeter of the building spaces. Residential – Daylighting is most beneficial in common areas. Top-lighting is particularly useful further from the perimeter of the building. *Building Siting/ Orientation.* Optimizing exposure to the sun's path is critical to any daylighting system. Top-lighting has the advantage of obtaining the most exposure for longer periods of the day. Multi-story vs. Single-Story Side-lighting is easily provided on all floors of a multi-story building. However, through proper building design and/or use of integral light wells or tubular daylight devices, top-lighting potential still exists for lower floors in multi-story buildings. *Typical Climactic and Daylight Conditions.* Even in moderate climates with typically cloudy weather trends, top-lighting still provides exceptional daylighting potential all day long. *Interior Climate Control System*. Appropriately designed heating, ventilation, and air conditioning systems are critical in any energy conservation effort. Non-residential – Automated lighting controls are critical in multi-user environments such as offices and retail spaces to ensure lighting energy is not used when daylighting is sufficient. For top-lighting, light well design and/or tubular products can be very useful in directing/reflecting light into larger areas of floor space. The overriding goal of any daylighting design is how well it uses the available light. However, uncontrolled daylight may result in excessive heat gain and potential discomfort. It is important to ensure that the fenestration is appropriately sized and located and that the correct glazing and accessories are selected. We have to use the fenestration area wisely to help insure the energy benefits balance the costs.

Literature

1. D. Arasteh, S. Selkowitz, J. Apte, M. LaFrance, "Zero Energy Windows", Proceedings of the 2006 ACEEE Summer Study on Energy Efficiency in Buildings, August 13-18, 2006. LBNL report number 60049**.**