

Solatube International

# Daylighting Facts & Figures

## Building Energy Efficiency

### Daylight and lighting controls provide commercial benefits

Electric lighting comprises almost 25% of the total electricity used in buildings in the United States (US-DOE 2006) and buildings comprise over 75% of the total electricity used nationwide (US-EIA 2008), thus pursuing ways to improve the performance of lighting control systems is a worthwhile endeavor.

Van Den Wymelenberg, K.G. (2013, November). Identification of Discomfort Glare Sources from Vertical Fenestration and Occupant Control Strategies. *Illuminating Engineering Society*. Retrieved from <http://www.ies.org> (white paper courtesy of the author).

### Government cafeteria incorporates daylighting with tubular skylights

National Renewable Energy Laboratory's state-of-the-art cafeteria on the South Table Mountain campus in Golden, Colo., certified to the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) Platinum-level rating, uses about 25% less energy than a cafeteria built to current commercial code. Energy efficiency features include daylighting, accompanied by tubular skylights, to help achieve uniform light distribution across the main dining area space to limit the use of electric lighting.

(2012). Campus Cafeteria Serves As Sustainable Model for Energy-Efficient Food Service. *National Renewable Energy Laboratory*. Retrieved from [http://www.nrel.gov/sustainable\\_nrel/buildings\\_cafe.html](http://www.nrel.gov/sustainable_nrel/buildings_cafe.html)

### Daylighting contributes to 24% energy reduction in Los Angeles schools

The most recent K-12 project that our team has been involved in was the Los Angeles Unified School District's Robert F. Kennedy Community Schools. Incorporating high-efficiency equipment in the design of the central plant, thermal displacement in all classrooms and large occupant areas, and daylight harvesting controls allowed the entire complex to have 24% energy reduction versus the latest California energy codes.

(2012, March). School is in Session. *Consulting-Specifying Engineer*. Retrieved from <http://www.csemag.com/single-article/school-is-in-session/55de8f70a29977d4d9ab021c94d2476e.html>

### Daylighting reduces as much as one-third of total building energy costs

Daylighting is the controlled admission of natural light—direct sunlight and diffuse skylight—into a building to reduce electric lighting and saving energy. By providing a direct link to the dynamic and perpetually evolving patterns of outdoor illumination, daylighting helps create a visually stimulating and productive environment for building occupants, while reducing as much as one-third of total building energy costs.

The benefits of a daylit building extend beyond simple energy savings. For example, by reducing the need for electric consumption for lighting and cooling, the use of daylight reduces greenhouse gases and slows fossil fuel depletion.

Ander, G. (2011, August; updated 2014, October). Daylighting. *Whole Building Design Guide*. Retrieved from <http://www.wbdg.org/resources/daylighting.php>

### **Integration of daylighting strategies can reduce total energy costs by up to 30%**

Daylighting has the potential to provide significant cost savings. For example, using an estimated incremental first cost increase of \$0.50 to \$0.75 per square foot of occupied space for dimmable ballasts, fixtures, and controls, daylighting has been shown to save from \$0.05 to \$0.20 per square foot annually (1997).

Additionally, electric lighting accounts for 35% to 50% of the total electrical energy consumption in commercial buildings. By generating waste heat, lighting also adds to the loads imposed on a building's mechanical cooling equipment. The energy savings from reduced electric lighting through the use of daylighting strategies can directly reduce building cooling energy usage by an additional 10% to 20%. Consequently, for many institutional and commercial buildings, total energy costs can be reduced by as much as one-third through the optimal integration of daylighting strategies.

Ander, G. (2011, August). Daylighting. *Whole Building Design Guide*. Retrieved from <http://www.wbdg.org/resources/daylighting.php>

### **Lighting costs can be reduced by 20 to 80% through daylighting**

More than a third of the energy used in the United States is consumed in buildings, and 25 to 40 % of that is used to run electric lights. In many cases, daylight could be used instead. "Depending on the building and how it's used, a good daylighting strategy can reduce the need for energy-consuming electric lighting by 20 to 80 %," said Professor Marilyne Andersen of the Department of Architecture.

Stauffer, N. (2007, May). Daylight Device Lightens Electricity Cost. *Massachusetts Institute of Technology News*. Retrieved from <http://newsoffice.mit.edu//2007/techtalk51-26.pdf>

### **Daylighting provides energy savings and soft savings for building occupants**

A good daylighting design can save up to 75% of the energy used for electric lighting in a building. The amount of daylight available, the occupancy pattern, and the control strategy can all affect energy savings. In addition, because significant daylight is often available during utility peak demand hours, a good daylighting design can reduce demand charges. Electric lights also generate significant heat in a building and by turning off or dimming the lights when not needed, 10 to 20% of the energy used to cool a building can be saved. On top of that, so-called soft savings attributable to increases in productivity and health of the building occupants can add to the hard savings, researchers say.

Kozlowski, D. (2006, April). Using Daylighting to Save on Energy Costs. *FacilitiesNet*. Retrieved from <http://www.facilitiesnet.com/energyefficiency/article/Harnessing-Daylight-For-Energy-Savings-Facilities-Management-Energy-Efficiency-Feature--4267#>

### **Annual U.S. lighting expenditures top \$60 billion**

The U.S. spends about one quarter of its entire electricity budget on lighting, equating to approximately \$60 billion annually. According to the New Buildings Institute, lighting comprises an average of 37% of a typical commercial building's total energy consumption.

Mocherniak, T. (2006, May). Lighting Technologies Produce Energy Savings. *Energy & Power Management*. Retrieved from [www.highbeam.com/doc/1G1-146346289.html](http://www.highbeam.com/doc/1G1-146346289.html)

### **Daylight harvesting offers opportunity to reduce energy consumption, costs**

The United States Department of Energy estimates that U.S. commercial businesses use one-quarter of their total energy consumption for lighting. Daylighting and its associated systems, therefore, offer the opportunity to reduce energy consumption and costs.

Commercial buildings in the United States house more than 64 billion feet of lit floor space. Most of these buildings are lit by fluorescent lighting systems. Estimates show between 30% and 50% of the spaces in these buildings have access to daylight either through windows or skylights. The installation of technologies designed to take advantage of available daylight would be an appropriate energy-saving strategy that could potentially turn off millions of light fixtures for some portion of each day.

Leslie, R.P., R. Raghavan, O. Howlett, and C. Eaton. (2005). The Potential of Simplified Concepts for Daylight Harvesting. *Lighting Research and Technology*. Retrieved from <http://www.lrc.rpi.edu/programs/daylighting/pdf/simplifiedConcepts.pdf>

### **Building cooling load reduction among the benefits of daylighting**

- The single largest operating cost of commercial buildings in the U.S. is lighting. Lighting systems represent one-third or more of the total electrical energy costs of a commercial building. They also introduce heat into the space and increase building cooling loads. Because lighting systems significantly impact a building's operating cost and energy performance, evaluate options for the lighting systems before considering strategies for a low-energy HVAC system. Also, take advantage of daylighting opportunities whenever possible.
- Lighting systems constitute 30% to 50% of the total annual electrical energy consumption in U.S. office buildings. In the Federal sector, lighting accounts for 25% of the total electricity consumed annually.
- A building designed to take advantage of daylighting will have electric lighting system controls that turn the electric lights off or dim them when sufficient daylighting is available. The electric lights operate only to maintain set lighting conditions that the daylighting cannot meet. Less waste heat from the electric lighting system is then introduced to the space, which in turn reduces the building's cooling loads.
- The solar heat gains from a good daylighting system can be less than half of the heat gains from the most efficient current electric lighting system technologies, to achieve equal lighting levels in a space.

(2003). Los Alamos National Laboratory Sustainable Design Guide. *U.S. Department of Energy*. Retrieved from <http://www.lanl.gov/orgs/eng/engstandards/esm/architectural/Sustainable.pdf>

## Worker Productivity

### **Green buildings bring green (money) to companies**

Carnegie Mellon University's Intelligent Workplace design studio found that improved lighting with an extra up-front cost of \$370,000 saved almost \$700,000 in energy and operating costs for a typical workplace. However, the resulting gains in productivity were worth as much as \$14 million. Here's why: In a typical building, energy costs average \$1.50 to \$2.50 per square foot, while salaries exceed \$200 per square foot. Cutting energy use in half typically saves \$1 per square foot per year, while boosting productivity just 5% saves more than \$10 per square foot.

(2002). Energy Savings Often Bring Improvements in Productivity and Product Quality *The non-profit Center for Energy & Climate Solutions' Cool Companies*. Retrieved from <http://www.cool-companies.org/profits>

### **Daylight reinforces natural circadian rhythms and other worker benefits**

Higher occupant productivity and satisfaction are likely to result from the better visual quality that is provided by good daylighting design. Daylight provides the truest and most vivid color rendition of all available light sources. There is also evidence that the high concentrate of blue wavelengths in daylight help the eye to see more detail with greatest precision, especially at lower light levels. Mental stimulation is perhaps the biggest benefit of natural light. Daylight reinforces natural circadian rhythms and the production of neural transmitters, such as serotonin. Higher illumination levels have been associated with greater mental acuity and the simple variability of daylight may be key to mental stimulation. Studies show that lab animals learn and remember better when they are kept in a naturally variable and stimulating environment.

Heschong, L. (2002). Productivity and Satisfaction: Daylight Makes the Difference *Northwest Energy Efficiency Alliance*. Retrieved from <http://retired.betterbricks.com/default.aspx?pid=article&articleid=98&typeid=10&topicname=increasedvalue&indextype=>

### **Worker compensation cases drop 2,000% in new daylit facility**

When subsidiary Prince Street Technologies, a subsidiary of Interface Carpet, built a new 160,000- square-foot factory in Cartersville, Georgia, they used extensive natural daylighting. Daylight streams into the factory through 32 skylights - a big help for employees making richly colored carpets. A company official brags theirs is "the only carpet factory with a 60-foot picture window. The workers love it . . . It's made an immense difference in attitude." In the first three years after moving into the new building workers' compensation cases dropped from 20 per year to under one per year for savings worth an estimated of \$100,000 to \$200,000 a year - more than the value of the energy savings.

(2002). Energy Savings Often Bring Improvements in Productivity and Product Quality *The non-profit Center for Energy & Climate Solutions' Cool Companies*. Retrieved from <http://www.cool-companies.org/profits>

### **Energy bills reduced by 50%, absenteeism drops 40-45% in Hewlett-Packard subsidiary**

VeriFone, a subsidiary of Hewlett-Packard in Costa Mesa, Calif., upgraded its 76,000-square-foot building to include a series of roof skylights and other energy-efficient features. On sunny days, workers used only natural daylight and small task lights. Workers no longer complained about end-of-the-day headaches or end-of-the-week sluggishness. As a result, absenteeism dropped 40 to 45%, employee productivity increased 5 % and energy bills were slashed 50%, for a payback time of under one year.

(2002). Energy Savings Often Bring Improvements in Productivity and Product Quality *The non-profit Center for Energy & Climate Solutions' Cool Companies*. Retrieved from <http://www.cool-companies.org/profits>

### **Company increases worker productivity by 15% after adding daylighting to its facility**

Lockheed Martin reports that after daylighting its facility in Sunnyvale, Calif., the company achieved 15% higher worker productivity. Additionally, the company won a \$1.5 billion defense contract based on increased productivity, profits which paid for the entire building. As an added bonus, the company saved \$300,000 to \$400,000 a year on energy bills.

Romm J. and Browning W. (1994, 2002). Greening and the Bottom Line: Increasing Productivity Through Energy- Efficient Design. *Rocky Mountain Institute*. Retrieved from [http://www.columbia.edu/cu/alliance/EDF-2012-documents/Reading\\_Fox\\_3.pdf](http://www.columbia.edu/cu/alliance/EDF-2012-documents/Reading_Fox_3.pdf)

### **Furniture manufacturer employees reaps the benefits of daylighting design**

A pre- and post-occupancy analysis of the new facility for Herman Miller, a furniture manufacturer in Holland, Mich., found the following:

- Sustainable features of the building included extensive daylighting
  
- Occupants experienced the following:
  - Increased sense of well-being, belong and work spirit
  - Increased job satisfaction
  - Increased feeling of looking forward to work and being in good spirits at work
  - Higher satisfaction overall with the building, especially the daylight
  - The daytime workers responded most positively

Herman Miller improves worker satisfaction and productivity. *U.S. Dept. of Energy*. Retrieved from [http://www1.eere.energy.gov/femp/pdfs/buscase\\_section3.pdf](http://www1.eere.energy.gov/femp/pdfs/buscase_section3.pdf)

## Employee Retention and Recruitment

### **Workers with daylight exposure enjoy a better quality of life**

Office workers with more light exposure in the office had longer sleep duration, better sleep quality, more physical activity and better quality of life compared to office workers with less light exposure in the workplace, reports a new study from Northwestern Medicine and the University of Illinois at Urbana-Champaign. The study highlights the importance of exposure to natural light to employee health and the priority architectural designs of office environments should place on natural daylight exposure for workers.

“There is increasing evidence that exposure to light, during the day – particularly in the morning – is beneficial to your health via its effects on mood, alertness and metabolism, said senior study author Phyllis Zee, M.D., a Northwestern neurologist and sleep specialist. “Workers are a group at risk because they are typically indoors often without access to natural or even artificial bright light for the entire day. The study results confirm that light during the natural daylight hours has powerful effects on health.”

(2014). Natural Light in the Office Boosts Health. *Northwest University*. Retrieved from <http://www.northwestern.edu/newscenter/stories/2014/08/natural-light-in-the-office-boosts-health.html>

### **Natural light may decrease afternoon sleepiness**

Brief indoor exposure to natural bright light may decrease afternoon sleepiness. This technique of light could be used in work settings in which napping is not permitted.

Kaida, K.; Takahshi, M.; Haratani, T., Otsuka, Y.; Fukasawa, K.; Nakata, A. (2006). Indoor exposure to natural bright light prevents afternoon sleepiness. *Sleep*. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16676779>

**Sales increase significantly in daylight departments at WalMart**

The WalMart store in City of Industry, California, uses half the energy of a typical new California store, thanks to advanced lighting and efficient, downsized climate control system. In place of ordinary opaque roofing, the store has an 18-kilowatt solar photovoltaic canopy. Annual energy savings are estimated at \$75,000 to \$80,000, which means a three-year payback of the added cost of the equipment. Southern California Edison, the local utility, provided a \$170,000 incentive that shortened payback to less than one year. But rewards are much greater than that: WalMart's decision to use skylights was sparked by the stunning success of its "Eco-Mart" store in Lawrence, Kansas. In a cost-cutting move, the company installed specially- designed skylights over just half the store, leaving the other side without daylighting. Managers using Wal-Mart's famous real-time inventory system quickly found that sales per square foot were significantly higher in the daylight half of the store, and higher than the same departments in other stores.

(2002). Energy Savings Often Bring Improvements in Productivity and Product Quality *The non-profit Center for Energy & Climate Solutions' Cool Companies*. Retrieved from <http://www.cool-companies.org/profits>

**Daylighting delivers 40% increase in sales**

Research indicates that people prefer to work, buy and recreate in spaces illuminated with glare-free daylight. A recent investigation into the relationship between Daylighting and Human Performance indicates that sales are 40% higher in stores with skylights. The study analyzed sales performance data for 108 nearly identical stores of a chain retailer - the exception was the skylights in some of the stores. The Bottom Line: If a typical non-skylit store were averaging sales of \$2 per square foot, then its sales might be expected to increase to somewhere between \$2.61 and \$2.98 with the addition of a skylighting system.

The Benefits of Daylighting. *Northwest Energy Efficiency Alliance*. Retrieved from <http://www.betterbricks.com/design-construction/daylighting-overview>

**Store reports 10 to 15% increase with use of daylighting**

Outpost Natural Foods, a three-store co-op in the Milwaukee area, opened a new store in 2000 that was designed from the ground up to include daylighting as part of an overall "green building" approach. "We saw a big difference in sales per customer," said Pam Mehnert, Outpost's general manager. "That store continues to be our highest sales per shopper of the three we have. And it was that way right from the beginning.

"People are taking more time and spending more money. Our sales per customer at the State Street store is around \$30; in our other stores, it's 10% to 15% less."

Ellis, G. (2007, June 25). Let the Sun Shine In. *Supermarket News*. Retrieved from <http://supermarketnews.com/retail-amp-financial/let-sun-shine>

**Daylighting positively impacts retail sales up to 40%**

An independent study conducted for the California Energy Commission by Lisa Heschong of Heschong Mahone Group found:

- Although further research will be required to uncover the mechanisms of daylight's importance, this study reinforces the finding that daylight does truly increase retail sales. We have presented evidence from a second retail sector that daylight can increase retail sales on average for the chain by up to 6%, or for individual stores by up to 40%, depending on the daylight design, parking lot size, and other store variables

- There is a second possible effect of the spectrum of daylight, due to its greater richness in the blue end of the spectrum. One current theory suggests that people perceive a space to be more brightly lit, and that the resulting size of their pupil is smaller, under so-called “scotopic” sources of light, those rich in the blue end of the spectrum. The smaller pupil size is likely to increase the depth of field of the viewer, allowing a shopper to see greater detail over a wider range of focal distances.
- Daylight has the greatest range of spectral wavelengths of any of our light sources, and is the source our eye has naturally adapted to through millenniums of evolution. With a continuous spectrum of light, all colors will be more vivid and have a more naturally rendered appearance under daylight. Any store which sells products distinguished by color, or where color is a key selection criteria, is likely to benefit from improved color rendition.
- During the California power crisis of 2001, when almost all retailers in the state were operating their stores at half lighting power, the stores in this chain with daylight were found to benefit the most, with an average 5.5% increase in sales relative to the other non-daylit stores within the chain (even while all stores in this chain increased their sales compared to the previous period).
- The value of the energy savings from the daylighting is far overshadowed by the value of the predicted increase in sales due to daylighting. By the most conservative estimate, the profit from increased sales associated with daylight is worth at least 19 times more than the energy savings, and more likely, may be worth 45-100 times more than the energy savings.

Heschong, L. (2003, October). Daylight and Retail Sales. *California Energy Commission*. Retrieved from [http://newbuildings.org/sites/default/files/A-5\\_Daylgt\\_Retail\\_2.3.7.pdf](http://newbuildings.org/sites/default/files/A-5_Daylgt_Retail_2.3.7.pdf)

## Health & Safety

### **Patients with access to sunlight require 20% less pain medication**

A 2004 University of Pittsburgh study showed that patients with access to sunlight required 20% less pain medication, leading to lower medical costs.

Katz, A. (2011, July). Healthy and green with LEED For healthcare. *FacilitiesNet*. Retrieved from <http://www.facilitiesnet.com/green/article/Healthy-And-Green-With-LEED-For-Healthcare-Facilities-Management-BOM-Feature--12542>

### **Blood pressure in nurses reduced, moods improved with access to daylight, resulting in improved patient care**

For the health and happiness of nurses – and for the best care of hospital patients – new Cornell research suggests exposure to natural light may be the best medicine. In a forthcoming Cornell study published in the journal *Health Environments Research and Design*, Rana Zadeh, assistant professor of design and environmental analysis, discovered nurses who had access to natural light enjoyed significantly lower blood pressure, communicated more often with their colleagues, laughed more and served their patients in better moods than nurses who settled for large doses of artificial light.

Maximizing access to natural daylight and providing quality lighting design in nursing areas may be an opportunity to improve safety through environmental design and enable staff to manage sleepiness, work in a better mood and stay alert, according to Zadeh.

(2014). Daylight is the best medicine, for nurses. *Cornell University*. Retrieved from <http://mediarelations.cornell.edu/2014/08/04/daylight-is-the-best-medicine-for-nurses>

### **Daylight provides physical and mental benefits**

Physical Benefits of Sun Exposure:

- Boost the immune system: Vitamin D is essential to the immune system, and can help boost your immune system so that you can fight off disease more effectively.
- Lower cholesterol: One of the ways you can help lower your cholesterol naturally is to enjoy some sensible sun exposure.
- Lower resting pulse rate of the heart: Studies suggest that sunlight can help lower your pulse rate, improving cardiovascular health.
- Add resistance power to skin: While too much sun can be damaging to the skin, moderate exposure can actually be helpful to the skin. It can actually help your skin build up resistance to eczema, acne and psoriasis.
- Increase metabolism: Sensible sun exposure can help boost your metabolism, increasing the rate at which you burn calories. This can be a great thing, helping you lose weight and stay in shape.
- Better liver function: The nutrients that come as a result of sun exposure can help enhance your liver's function.
- Improve digestion: If you are interested in improving your digestion, you can increase your sun exposure to a moderate amount.

- Enhanced kidney function: Sun exposure, thanks to Vitamin D, offers help when it comes to kidney function. Kidneys remove waste from the body, so getting proper sun exposure can help decrease the toxicity in your bloodstream.
- Stronger skeleton: As the Vitamin D produced from sun exposure is absorbed, it can help strengthen bones in the skeleton. You'll have less brittle bones, and a better posture.

#### Mental Health Benefits of Sun Exposure:

- Reduce stress: You can reduce your stress level with the help of proper exposure to sunlight. Taking some time to enjoy the sun can help you sleep better as you decrease your stress level.
- Reduce anxiety: If you are feeling anxious, sensible sun exposure on a regular basis can help soothe you. Sunlight is one of the natural remedies to anxiety.
- Fight depression: There is evidence that sunlight is a natural way to improve your mood. If you suffer from depression, adding a little moderate sun exposure might help you combat the symptoms.
- Fight Seasonal Affective Disorder (SAD): If you suffer from SAD during the winter, you can combat the feelings with the help of natural light. Look for ways to introduce more sunlight into your environment, with the help of open windows.

(2010, July). Feeling Sunny? 25 Health Benefits of Sensible Sun Exposure. *E-Health News Blog*. Retrieved from <http://onlineradiologytechnicianschools.com/2010/feeling-sunny-25-health-benefits-of-sensible-sun-exposure>

#### Healing in hospital settings aided by daylighting

A patient room providing good outdoor views and daylighting can increase patient well-being: a psychological state resulting in reduced stress and anxiety, lower blood pressure, improved post-operative recovery, reduced need for pain medication and shorter hospital stays.

Brown, G.Z.; Kline, J.; Livingston, G.; McDonald, B.; Smith, C.; Wilkerson, M.; Brickman, J.; Staccek, D. (2005). Daylighting Patient Rooms in Northwest Hospitals. *Energy Studies in Buildings Laboratory, Department of Architecture, University of Oregon and Zimmer Gunsul Frasca Architects LLP*. Retrieved from [http://www.betterbricks.com/graphics/assets/documents/Daylighting\\_Patient\\_Rooms\\_brochure\\_final.pdf](http://www.betterbricks.com/graphics/assets/documents/Daylighting_Patient_Rooms_brochure_final.pdf)

#### Daylighting delivers health benefits, including stress reduction

Daylighting the interior space of buildings is an important consideration for architectural design. Studies have shown that increased daylighting improves worker productivity, provides for faster patient recovery, and improves students' grades. Additional benefits of daylighting include keeping our biological clocks in order and relieving stress. These benefits have long been recognized in Europe, where minimum amounts of daylighting and an opportunity to enjoy an exterior view are regulated.

(2005, January). The Facts About Windows & Daylighting. *National Fenestration Rating Council*. Retrieved from [https://c.ymcdn.com/sites/nfrccommunity.site-ym.com/resource/resmgr/fact\\_sheets/windows\\_and\\_daylighting.pdf](https://c.ymcdn.com/sites/nfrccommunity.site-ym.com/resource/resmgr/fact_sheets/windows_and_daylighting.pdf)

## Education/Student Performance

### **Daylight improves test scores in three school systems by up to 26%**

A study of three school systems in Washington, Colorado and California found that students in rooms with the most diffuse and glare-free daylight improved their performance on standardized tests by up to 26%. The study analyzed test score results for over 21,000 students.

The Benefits of Daylighting. *Northwest Energy Efficiency Alliance*. Retrieved from <http://www.betterbricks.com/design-construction/daylighting-overview>

### **Math and reading improve with daylight**

Classroom lighting plays a particularly critical role in studies. Appropriate lighting improves test scores, reduces off-task behavior and plays a significant role in students' achievement. A study by Alberta Education titled "A Study into the Effects of Light on Children of Elementary School Age," have proven that students with the most classroom daylight progressed faster in one year on math tests and reading tests than those students who learned in environments that received the least amount of natural light.

Spector, M. (2012, May 1). Acoustics and Daylighting. *School Planning & Management*. Retrieved from <http://webspm.com/articles/2012/05/01/acoustics-and-daylighting.aspx>

### **Daylight in schools necessary to stimulating circadian system**

Having enough light in the classroom to read and study does not guarantee that there is sufficient light to stimulate our biological clocks. This is because the human visual system, which is much more sensitive to short-wavelength (blue) light and needs more light to be activated than the visual system. Most schools typically do not provide adequate electric light or daylight to fully stimulate the circadian system. However, if designers provide sufficient daylight, which contains ample, short-wavelength (blue) light, in classrooms, school buildings will be able to provide more circadian stimulation and therefore, better support for circadian entrainment.

In many schools, the desks near the window or under skylights or roof monitors provide the best area for circadian light stimulation.

Leslie, R. (2010). Patterns to Daylight Schools for People and Sustainability. *Lighting Research Center*. Retrieved from [http://www.lrc.rpi.edu/programs/daylighting/pdf/DaylightingPatternBook\\_Final.pdf](http://www.lrc.rpi.edu/programs/daylighting/pdf/DaylightingPatternBook_Final.pdf)

### **Boulder school reports 21% improvement in student learning rates through daylighting**

Several studies have shown that natural daylighting in schools increases student performance. One study, completed for the California Energy Commission, found that among 12 models considered, there was on average a 21% improvement in student learning rates from those in classrooms with the least amount of daylight compared to those with the most.

(2009, June). Boulder School Installs Daylighting Device. *The Daily Journal, McGraw-Hill Construction*. Retrieved from [http://colorado.construction.com/ddj/archive/2009/090518\\_ddj4.asp](http://colorado.construction.com/ddj/archive/2009/090518_ddj4.asp)

### **Daylighting contributes to environmental, fiscal and health benefits for schools**

Better indoor air quality, lower levels of chemical emissions, generous provision of natural daylighting, better humidity control--these and other features of green schools offer not only environmental and fiscal benefits, but health benefits as well. These health benefits,

in turn, manifest in lower student and staff absenteeism, lower staff turnover, lower health care costs, and improved school and job performance.

Frumkin, H. (2006). Safe and Healthy School Environments. *National Center for Environmental Health and Agency for Toxic Substances and Disease Registry*. Retrieved from [http://www.cdc.gov/healthyplaces/publications/designing\\_and\\_building\\_healthy\\_places\\_for\\_children.pdf](http://www.cdc.gov/healthyplaces/publications/designing_and_building_healthy_places_for_children.pdf)

### **Building executives report myriad benefits to green school design**

In fall 2005 Turner Construction released a survey of 665 executives at organizations involved in the building sector. Of those involved with green schools, over 70% reported that green schools reduced student absenteeism and improved student performance.

Katz, G. (2006, October). Greening America's Schools. *The U.S. Green Building Council*. Retrieved from <http://www.usgbc.org/Docs/Archive/General/Docs2908.pdf>

### **Green school design provides financial benefits 20 times that of the cost**

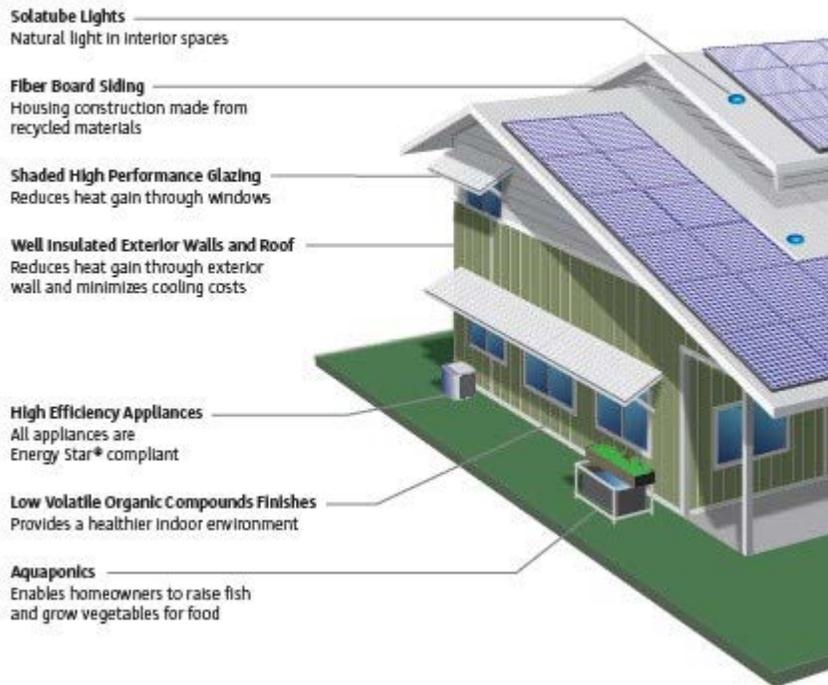
This national review of 30 green schools demonstrates that green schools cost less than 2% more than conventional schools - or about \$3 per square foot (\$3/ ft<sup>2</sup>) - but provide financial benefits that are 20 times as large. Greening school design provides an extraordinarily cost-effective way to enhance student learning, reduce health and operational costs and, ultimately, increase school quality and competitiveness.

Katz, G. (2006, October). Greening America's Schools. *The U.S. Green Building Council*. Retrieved from <http://www.usgbc.org/Docs/Archive/General/Docs2908.pdf>

### Hawaii home development incorporates daylighting to reduce energy consumption by 40%

Kaupuni Village—the first net-zero energy affordable housing community in Hawaii has achieved the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED®) Platinum designation. Each home was designed to have at least 40% lower energy consumption than the baseline, which is minimally 2006 International Energy Conservation Code (IECC) compliant. Energy efficiency was achieved through a variety of measures, including: High efficiency lighting and daylighting with good solar control.

#### Net-Zero Energy By Design: A Kaupuni Village Home



(Photo courtesy of NREL)

(2012, May). Kaupuni Village: A closer look at the first net-zero energy affordable housing community in Hawaii. U.S. Dept. of Energy, National Renewable Energy Laboratory. Retrieved from <http://www.nrel.gov/docs/fy12osti/53401.pdf>

### Daylighting allows developer to attract premium tenants at premium rents

According to the Rocky Mountain Institute, a great example of energy-efficient design is the Conde Nast building in New York City’s Times Square. By improving ventilation rates and daylighting, the building uses half the normal amount of energy yet came in at market median costs, making it a win-win for the developer, which was able to recruit premium tenants quickly at premium rents.

Monroe, L. (2002, February). Problem-solver - Amory Lovins Questions Design and Resource Efficiency. Buildings. Retrieved from <http://www.buildings.com/article-details/articleid/659/title/problem-solver-amory-lovins-questions-design-and-resource-efficiency.aspx>

### **Return on investment a plus for homes with daylight**

“Daylighting” improvements that boost your home’s brightness and energy efficiency offer substantial return on investment for both home sellers and those who will be staying in their homes for the foreseeable future.

(2012, February) Selling or staying put, ‘daylighting’ improvements pay off for homeowners. *Orlando Real Estate News*. Retrieved from <http://orlandohomeinspectionnews.com/selling-or-staying-put-daylighting-improvements-pay-off-for-homeowners/#more-2234>

### **Lighting responsible for 14% of all residential electricity consumption**

Residential lighting consumption was about 186 billion kWh or about 14% of all residential electricity consumption.

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