



DAYLIGHTING

FACTS & FIGURES

2012



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Energy

Commercial Buildings

- 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.
(2003). Los Alamos National Laboratory Sustainable Design Guide. U.S. Department of Energy. Retrieved from <http://apps1.eere.energy.gov>
- 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. Sustainable Facilities Magazine. Retrieved from www.sustainablefacility.com
- 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.
(2003). Los Alamos National Laboratory Sustainable Design Guide. U.S. Department of Energy. Retrieved from <http://apps1.eere.energy.gov>
- More than a third of the energy used in the United States is consumed in buildings, and 25 to 40 percent 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 percent," said Professor Marilyn Andersen of the Department of Architecture.
Stauffer, N. (2007, May). Daylight Device Lightens Electricity Cost. Massachusetts Institute of Technology News. Retrieved from <http://web.mit.edu>
- Way Station, a training and education center for people with long-term mental illness in Frederick, Md., reported that its daylight facility uses one-third of the energy that is consumed by a comparable conventional building.
(2000, August). Energy User News.
- Approximately 90 percent of all commercial buildings were built prior to 1986, making them most likely to contain outdated lighting systems.
(2000, March). Energy User News.

According to the New Buildings Institute, lighting comprises an average of 37% of a typical commercial building's total energy consumption.

Green Building Market

- According to the U.S. Green Building Council's (USGBC) report, as of December, square footage of LEED-certified existing buildings surpassed LEED-certified new construction by 15 million square feet on a cumulative basis. A major renovation for the recently LEED-certified Empire State Building in New York has its owners forecasting they will slash energy consumption by more than 38 percent, saving \$4.4 million in energy costs annually. Walsh, D. (2012, January). Specialty Construction Doing Well. ED+C Magazine. Retrieved from www.edcmag.com

Buildings are actually the world's biggest energy users, even ahead of transportation and industry, consuming one-third of the electricity in the United States.

- There are already 2.7 million jobs across the clean economy. And buildings are actually the world's biggest energy users, even ahead of transportation and industry, consuming one-third of the electricity in the United States. The clean energy sector is growing at a rate of 8.3 percent. Walsh, D. (2012, January). Specialty Construction Doing Well. ED+C Magazine. Retrieved from www.edcmag.com
- According to projections, the green building market size is expected to reach \$135 billion by 2015. Today, one-third of all new non-residential construction is green, a \$54 billion market opportunity. Walsh, D. (2012, January). Specialty Construction Doing Well. ED+C Magazine. Retrieved from www.edcmag.com

Daylighting Energy

- Daylighting in businesses and commercial buildings can result in substantial savings on electric bills, and not only provides a higher quality of light but also improves productivity and health. (2011, June). Daylighting. U.S. Department of Energy. Retrieved from: <http://www.eere.energy.gov>

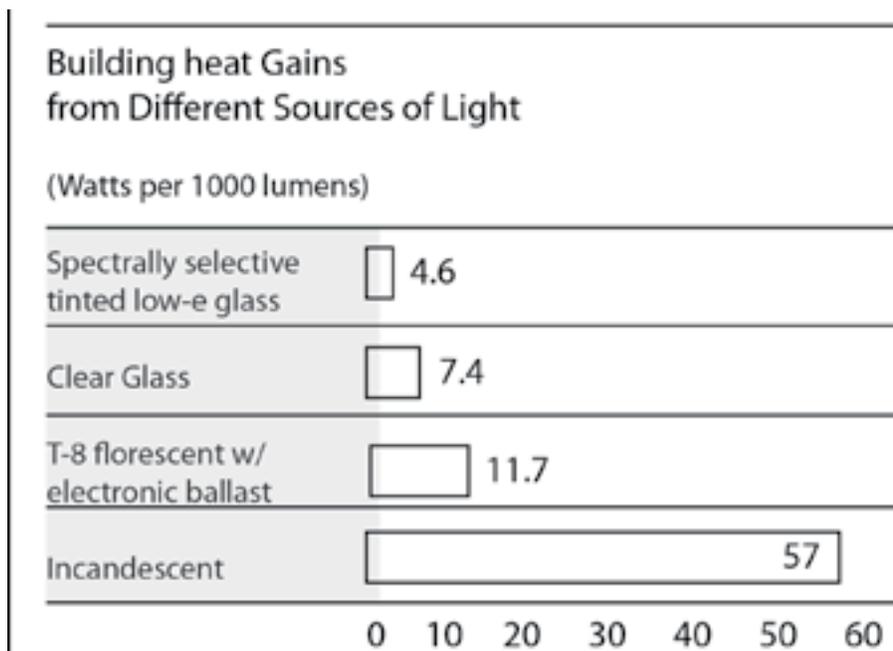
For most buildings incorporating daylighting, the overall energy savings typically range from 15 to 40 percent.

Molinski, M. (2010, May). Everything You Need to Know About Daylighting. Sustainable Facility Magazine. Retrieved from <http://www.sustainablefacility.com>

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

- 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://apps1.eere.energy.gov>



- 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). Daylighting. Whole Building Design Guide. Retrieved from <http://www.wbdg.org/>
- The overall objective of daylighting is to minimize the amount of artificial light and reduce electricity costs, but it can also lower HVAC (heating, ventilation and air-conditioning) costs as well. Electrical lighting in modern buildings produces a lot of heat; whereas if properly directed, natural lighting generates hardly any heat at all.
Molinski, M. (2010, May). Everything You Need to Know About Daylighting. Sustainable Facility Magazine. Retrieved from <http://www.sustainablefacility.com>
- In offices and public areas, lighting typically accounts for 37% of energy consumption, and daylighting helps to reduce both the lighting load and the cooling load. Daylighting saves energy, enhances productivity, and reduces costs associated with electric lighting.
Molinski, M. (2010, May). Everything You Need to Know About Daylighting. Sustainable Facility Magazine. Retrieved from <http://www.sustainablefacility.com>
- The U.S. Department of Energy's (DOE) Federal Energy Management Program reports that daylighting can significantly cut lighting energy use for lighting building interiors, sometimes by up to 75 or 80 percent. The DOE's Renewable Energy Laboratory's Thermal Test Facility in Golden, Colo., was designed to provide natural lighting, allowing it to use 75 percent less energy for lighting than a building without daylighting features. Except for the central service area, the facility is entirely daylit, which has also decreased the energy load imposed on the building's mechanical cooling system. The DOE reports that for many commercial buildings, the total energy costs can be reduced by as much as one-third through the optimal use of daylighting strategies.
Molinski, M. (2010, May). Everything You Need to Know About Daylighting. Sustainable Facility Magazine. Retrieved from <http://www.sustainablefacility.com>

- Daylighting can be a viable, energy-efficient strategy in almost any climate, including traditionally overcast climates such as those found in parts of the Pacific Northwest. The technology can work in all building types as well, including commercial office buildings, most spaces within a school (i.e. classrooms, gymnasiums, media centers, cafeterias, and offices), retail stores, hospitals, libraries, warehouses, and maintenance facilities.
Ander, G. (2011, August). Daylighting. Whole Building Design Guide. Retrieved from <http://www.wbdg.org/>



- According to the Lighting Research Center at Rensselaer Polytechnic Institute in Troy, N.Y., a sample calculation shows that energy costs saved per year can be approximately 25 cents per square foot of daylit floor area. This assumes that there are 260 working days per year, electricity costs 10 cents per kilowatt hour, the daylighting system turns off the lights five hours per day, and the connected lighting load is two watts per square foot.
(2000, August). Energy User News.

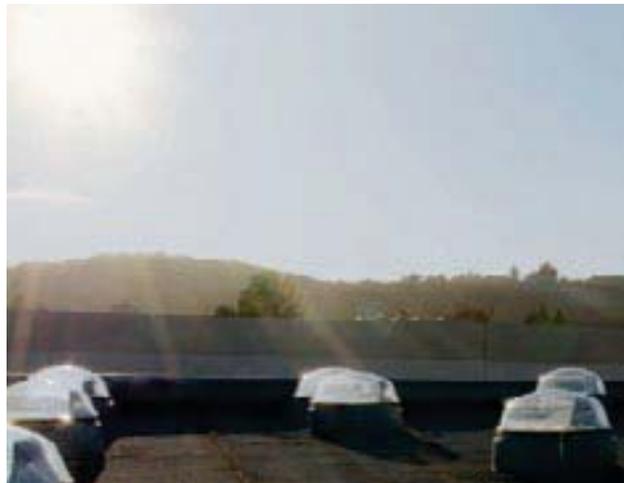
- According to the Wisconsin Daylighting Collaborative, about 86 percent of electricity in traditional buildings goes for light, fans and cooling. A cool daylighting project can cut these costs by more than 50 percent by reducing electric lighting, because daylight produces less heat per unit of illumination than most light sources. The Collaborative also notes that the demand savings are more important than the energy savings since daylighting provides energy usage reduction at the most important time – during peak hours, when energy rates are the highest and daylight availability is the greatest.
(2001, April). Energy User News.

- The Florida Energy Conservation Assistance Program reported that 29 Florida businesses that installed daylighting systems reduced daytime electric lighting consumption by an average of 93 percent while still achieving an average of 160 foot candles of light with a color rendering index of 98 in work areas.
(2001, January) Environmental Design & Construction.
- The Utah State Department of Natural Resources office building in Salt Lake City utilizes daylighting as an integral part of an energy-efficient design that reduces lighting load by 51 percent and saves \$50,000 a year over a reference-case building.
(2001, January) Environmental Design & Construction.
- According to BetterBricks Daylighting Lab in Seattle, the majority of commercial space in the United States is either one-story or within 25 feet of an exterior wall. This means that nearly every commercial building is a potential daylighting project. By combining daylighting with efficient fluorescent lighting and dimmers, often 75 percent of lighting energy consumption can be saved.
(2002, September). Environmental Design & Construction.
- Outdoor gear manufacturer Patagonia, based in Reno, Nev., built its distribution facility to include skylights and lighting controls to conserve energy. The company reports that the lighting system in its distribution center is 30 percent more efficient than the standard center in terms of total energy consumption. The catalog company realized a return on investment in just three years.
(2001, November). Catalog Age.
- According to U.S. Department of Energy's Energy Efficiency and Renewable Energy Clearinghouse (EREC), artificial lighting accounts for as much as 40 percent to 50 percent of the energy consumption in many commercial and institutional buildings.
Reference Briefs. EREC's. Retrieved from <http://www.eren.doe.gov>
- According to the U.S. Green Building Council's Sustainable Building Technical Manual, well-designed daylighting can reduce lighting energy use by 50 percent to 80 percent.
(2001, January) Environmental Design & Construction.
- To achieve the greatest capital costs savings and the best performance in a building, the Illuminating Engineering Society (IES) Handbook offers seven fundamental steps, which include harvesting and distributing natural daylight (Step #5).
(2002, February). Buildings.
- NASA's Ames Research Center in Moffett Field, Calif., underwent an energy savings campaign in 2001 that included turning off lights to take advantage of natural light. As a result, energy costs were reduced by \$30,000 to \$65,000 a month.
(2001, September). Government Executive.

A daylighting test at the Federal Office Building in Oakland, Calif., reported up to 86 percent lighting energy savings and a daily cooling load reduction of up to 24 percent, with higher worker satisfaction.

(2001, January) Environmental Design & Construction.

- At Solatube International's headquarters in Vista, Calif., a retrofit to include 21-inch Solatube units has resulted in an 86.1 percent reduction in lighting costs for the daylit portion of the office and 68.2 percent reduction for the warehouse area.
(Internal study report conducted by Architectural Energy Corporation for Solatube International, Inc.)



- A Southern Californian computer company constructed a new facility adjacent to its original facility that was nearly identical to the original except that it incorporated significantly more natural light. After two years, the company recorded a 62 percent reduction in electricity costs in the daylit building, which allowed a four-year payback on the initial extra capital costs. Additionally, absenteeism was reduced by 45 percent in the daylit building (a rate which has held steady for seven years).
(1999, July). Portland Business Journal.
- Lockheed Martin reports that after daylighting its facility in Sunnyvale, Calif., the company reaped annual energy savings of \$500,000 (approximately 75 percent of its electric bill) plus 15 percent higher worker productivity.
(1998, September). Journal of Property Management.
- Florida's Energy Conservation Assistance Program (ECAP) reports that 29 Florida businesses that installed daylighting systems with the organization's help reduced daytime electric lighting consumption by an average of 93 percent while still achieving an average of 160 foot candles of light with a color rendering index of 98 at work surfaces.
(1998, February). Environmental Design & Construction.

- According to the Sustainable Building Industries Council in Washington, D.C., the average middle school that incorporates daylighting will save \$500,000 over the next 10 years. Reicher, D. (2002). Learning by Design. School Board Journal. Retrieved from www.asbj.com/lbd
- Researchers at the Lawrence Berkeley National Laboratory in Berkeley, Calif., reported the successful use of daylighting techniques in the retrofit of the single-story Palm Springs Chamber of Commerce resulted in reduced annual electricity consumption of 47 percent. Additionally, the daylighting retrofit was met with positive feedback from the building's occupants, many who were often able to work with no electrical lighting at all. (2001, January). Environmental Design & Construction.

In the Netherlands, the ING Bank built a new headquarters designed to favor natural lighting. Since opening in 1987, the bank has used 92 percent less energy than an adjacent bank constructed at the same time, saving the bank \$2.9 million a year.

(2000, March). Charleston Gazette.

- According to the California Public Utilities Commission's Energy Design Resources website, an average grocery store could save about \$16,000 a year (or 32 cents per square foot) in operating costs by utilizing skylights. A typical school could save \$7,500 per year (or 23 cents per square foot) and an industrial building could save about 12 cents per square foot. (2002). www.energydesignresources.com
- Pacific Gas & Electric participated in a daylighting control project at a McDonald's restaurant near Pittsburg, Calif. Dimmable ballasts and daylighting controls reduced energy use in the dining and lobby areas by 30 to 45 percent. (1998, July). EPRI Journal.

Productivity

Impact on Performance

- Although energy savings and sustainability may be the reasons companies initially opt for daylighting, it can have a significant, measurable impact on the productivity and satisfaction of employees, students and even clients and retail customers.
Molinski, M. (2010, May). Everything You Need to Know About Daylighting. Sustainable Facility. Retrieved from <http://www.sustainablefacility.com>

Numerous studies also indicate that daylighting can help increase worker productivity and decrease absenteeism in daylit commercial office buildings, boost test scores in daylit classrooms, and accelerate recovery and shorten stays in daylit hospital patient rooms.

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

- A 2001 study by the Lighting Research Center in Troy, N.Y., of the impact of daylight on worker productivity during winter months found that workers in windowed offices spent significantly more time working on their computers than workers in interior, windowless offices.
(2002). California Energy Commission. Retrieved from www.energy.ca.gov
- According to betterbricks.com, a resource promoting sustainability concepts, “The initial costs of improving a facility through better lighting, heating and cooling systems can be offset exponentially by the productivity gains of a more productive workforce. In a typical office, energy costs run \$2 per square foot, while employee salaries and benefits are \$130 per square foot or more. Even slight changes in productivity can have a major impact on the bottom line.”
(2001, September). Journal of Property Management.
- According to the Peter Kiewit Institute of Information Science, Technology and Engineering at the University of Nebraska, poor lighting in the workplace can lead to excessive sick days, worker discontent, high staff turnover rates and poor-quality work. Natural light, however, makes workers feel and work better, prevents eye strain, helps people retain what they have learned and boosts productivity.
(2002, June). Chicago Tribune.
- Research suggests that unvarying electric light can lead to a low-level kind of sensory deprivation that can lead to impairment of organized thinking, depression, confusion, and general irritability. By contrast, variability of light has been shown to have a positive impact on worker performance. A study of shift workers under a daylight-simulating skylight showed improved performance of cognitively challenging tasks by creating a higher sense of mental arousal.
(1999). New School of Social Research in New York analyzing 60 studies and articles on the topic of daylighting and productivity. Parsons School of Design.

- Conditions such as “windowlessness” can be perceived by the body as harmful to its well-being, causing stress. The stressed employee can adopt attitudes and behaviors that can not only adversely affect his or her performance at work, but also that of other workers. (1999). New School of Social Research in New York analyzing 60 studies and articles on the topic of daylighting and productivity. Parsons School of Design.
- The Rocky Mountain Institute lists “high levels of daylight” among the five major contributors to worker productivity. (2002, August). Buildings.
- According to the International Labor Organization (ILO), American productivity grew a mere 22 percent between 1980 and 1996 – vs. at least 30 percent in Europe and 43 percent in Japan. In these tougher economic times, maximizing building productivity is more critical than ever in ensuring the success of facilities and their occupants. Improper lighting levels negatively impacts productivity – too much or too little can leave workers drowsy. The effective use of daylighting can improve people’s moods and energy levels. (2002, May). Buildings.
- Carnegie Mellon University’s Intelligent Workplace design studio found that improved lighting with an extra up-front cost of \$370,000 saved almost \$700,00 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 five percent saves more than \$10 per square foot. (2002). The non-profit Center for Energy & Climate Solutions’ Cool Companies. Retrieved from www.cool-companies.org
- 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 percent, employee productivity increased five percent and energy bills were slashed 50 percent, for a payback time of under one year. (2002). The non-profit Center for Energy & Climate Solutions’ Cool Companies. Retrieved from www.cool-companies.org
- Lockheed Martin reports that after daylighting its facility in Sunnyvale, Calif., the company achieved 15 percent 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. The non-profit Center for Energy & Climate Solutions’ Cool Companies. Retrieved from www.cool-companies.org,

According to the Natural Resources Defense Council, workers who enjoy their environments, whether due to good air, natural materials or daylighting, work harder. Even a one percent increase in productivity can save the equivalent to a year’s utility bill.

(1998, November). Corporate Report Wisconsin.

- If an existing lighting system is at least 10 years old, a lighting upgrade is likely to boost worker productivity by at least 10 percent. Assuming that a new system will improve lighting enough to save 30 seconds per hour, a one percent productivity gain will be realized. For an annual payroll expense of \$1 million, a one percent productivity boost is worth \$10,000. Walsh, D. (2012, January). Specialty Construction Doing Well. ED+C Magazine. Retrieved from (2002). National Lighting Bureau. Retrieved from www.nlb.org

Productivity means big bucks: According to analyst firm IDC, the promise of increased worker productivity justifies the \$1.2 trillion businesses are expected to spend on technology by 2003, spending that's growing nine percent annually.

(2000, August). Smart Business. ZDWire.

- Pennsylvania Power & Light reported that after completing building upgrades to use more daylight, absenteeism rates dropped 25 percent, productivity increased 13.2 percent and energy costs declined 69 percent. The original energy payback was calculated to be a 24 percent annual return on investment. Once the employee productivity and reduced absenteeism were factored in, however, the actual return on investment was approximately 1,000 percent per year. In other terms, it was estimated that the lighting retrofit paid for itself not in the 4.1 years estimated, but in just 69 days. (2000, January). Seattle Times. (2000, July). Architecture Week. (2002). Sustainable Development International Corp. Retrieved from www.smartoffice.com
- Control Data Corp.'s Operations Group in Sunnyvale, Calif., upgraded its lighting systems for \$15,000. Energy usage dropped 65 percent, saving \$7,000 a year. The reduced glare cut the number of input errors, raising productivity by an estimated six percent, saving \$28,000 a year – four times the energy savings and almost twice the cost of the lighting upgrade. (2002). The non-profit Center for Energy & Climate Solutions' Cool Companies Retrieved from www.cool-companies.org

- At Metal Industries Inc., a window and door manufacturer, a lighting upgrade resulted in an increase in productivity of more than five percent, worth \$1.5 million annually. The reject rate was reduced by 20 percent, saving the company on labor, energy and materials, for an overall savings of \$200,000 annually. (2002). National Lighting Bureau. Retrieved from www.nlb.org

- 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 concentration 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. (2002). Retrieved from Betterbricks.com

- At the present time, much of the green building literature focuses on air quality and physical health, thereby ignoring the other dimensions that are equally important. Ironically, many of the prominent features of green buildings are likely to have the greatest impact on cognitive and psycho-social well-being. For instance, contact with nature and sunlight penetration has been found to enhance emotional functioning. Positive emotions, in turn, are associated with creativity and improved cognitive functioning. (2001, January). Environmental Design & Construction.
- According to EREC, daylighting may reduce the loss of worker productivity during power failures. Studies show that if a worker in a daylit office can continue productive work for even one hour during a power loss, the dollar savings are equal to cost of lighting that person's work area for an entire year. (2002, August). Reference Briefs. EREC. Retrieved from <http://www.eren.doe.gov>
- The average annual lighting cost for U.S. commercial buildings is 90 cents per square foot. This is a mere fraction of the estimated \$30 per square foot office worker's costs (based on a \$15/hour employee). The Electric Power Research Institute (EPRI) published a report in which errors due to improperly lit video terminals resulted in estimated costs between \$5 and \$10 per square foot. (2002). Retrieved from www.lightforum.com
- The U.S. Green Building Council's Sustainable Building Technical Manual reports that worker productivity can be increased by up to 15 percent by implementing smart daylighting. Because salaries of building occupants far exceed the construction or operating costs of a building, any sustainable design features that positively impact productivity, however modestly, will pay back the investment over time. (2002, July). Environmental Design & Construction.
- Mail sorters at the main U.S. Post Office in Reno, Nev., became the most productive and error-free in the western U.S. after a retrofit to include natural light. In five months, productivity on the machines under the new lighting shot up almost 10 percent, leveling off to about six percent after one year. Working in a more naturally lit environment resulted in employees who did their jobs better and faster. While combined energy savings and maintenance savings came to about \$50,000 per year, the improvements in employee productivity (\$400,000 to \$500,000) dwarfed the energy savings, resulting in a payback of less than 12 months. (2000, January). Journal of Property Management. Retrieved from www.cool-companies.org
- According to the Rocky Mountain Institute, productivity gains of six to 16 percent, including decreased absenteeism and improved quality of work, have been reported from energy-efficient building design. Since companies spend an average of 70 times as much money (per square foot per year) on employee salaries as on energy, an increase of just one percent in productivity can result in savings that exceed the company's entire energy bill. (2000, January). Journal of Property Management.

Lighting is the number one contributor to office productivity according to a Harris Poll.

(1998, April). Los Angeles Times.

- Productivity of the workers in the new West Bend Mutual building increased 16 percent following a redesign which provided increased access to natural light for the workforce. (In the new building, 92 percent of employees had workstations near the window wall, compared to only 30 percent in the old building. (2002, July). Environmental Design & Construction.
- After the National Audubon Society office in New York changed its space to allow more light, employees were not tired at 5 p.m. when before they reported being tired at 4 p.m. (2000, August). Smart Business. ZDWire.

Daylight is essential to a sense of well-being, and a lack of variation in lighting (e.g. natural, general, accent and task) can result in sensory deprivation: boredom, fatigue, lack of concentration and even reduction of intellectual capacity.

(2000, March). Business First of Columbus.

- According to the authors of a Pacific Gas & Electric study on the effects of natural light on the school performance of children and on retail sales, "If daylighting enhances the performance of children in schools, it is not too large a stretch to suppose that it might also enhance the performance of adults in office buildings. If daylighting motivates buyers at a retail store, it is not too large a stretch to presume that it might also help motivate workers in a factory." (2000, September). Houston Business Journal.
- Ninety percent of business decision makers surveyed by the American Society of Interior Designers, Washington, D.C., in 1998 said they believe that improvements in interior design can enhance worker productivity. (2002). Retrieved from Betterbricks.com
- Mail sorters at the main U.S. Post Office in Reno, Nev., became the most productive and error-free in the western U.S. after a retrofit to include natural light. In five months, productivity on the machines under the new lighting shot up almost 10 percent, leveling off to about six percent after one year. Working in a more naturally lit environment resulted in employees who did their jobs better and faster. While combined energy savings and maintenance savings came to about \$50,000 per year, the improvements in employee productivity (\$400,000 to \$500,000) dwarfed the energy savings, resulting in a payback of less than 12 months. (2000, January). Journal of Property Management. Retrieved from www.cool-companies.org

- A pre- and post-occupancy analysis of the new facility for Herman Miller, a furniture manufacturer in Holland, Mich., found the following:
 - o Workers in the new, extensively daylit, “green” facility had more positive attitudes and work experiences compared to those in the previously occupied building (which was not daylit).
 - o They gave their work environment a 17 percent higher score than their previous building, with increased numbers saying they looked forward to going to work (70 percent in the new building compared to 45 percent in the old building).
 - o Over 20 percent reported an increase sense of being in good spirits while at work.
 - o Workers in the new building reported higher job satisfaction and greater sense of belonging in the new building.
 - o They also reported that the daylit interior made it easier for them to relax and gave them more contact with nature. Approximately 60 percent perceived the new building as healthier.
 - o While it is not uncommon for companies to experience a significant drop in productivity following a move (that can take weeks or months to recover from), Herman Miller actually reported a modest increase in productivity in the nine months following its move. (Even small increases in productivity are viewed as providing a competitive advantage in the marketplace.)
 - o The analysis reported that daytime shift workers revealed much more positive attitudes than those working in the same facility during night shifts, reinforcing the impact of daylight on the workers rather than just the newer facility itself.
 - o Happier employees resulted in late deliveries being cut in half and an increase in product quality.
 - o Electricity costs were reduced by 18 percent on a square foot basis.

(2002, July). Environmental Design & Construction.
(1998, November). Corporate Report Wisconsin.

Employee Recruitment & Retention

- Quality lighting not only helps increase sales, beautifies the colors in our interiors, it improves our health. Lighting with a higher Color Rendering Index makes us feel better and look healthier. There are countless clinical studies showing that poor-quality lighting (primarily fluorescent) adversely affects our health.
Turner, D. Color & Light: Is Affecting Your Sales, Environment & Health. Munsell Color. Retrieved from www.munsell.com
- Natural light is important to the health and psychological well-being of office workers. The design of office environments must place emphasis on providing each occupant with access to natural light and views to the outside.
(2001). Retrieved from betterbricks.com
- WRQ, a software development company in Seattle, is well aware of the competition it faces when attracting and retaining its high-tech employees. Part of WRQ's strategic human resources plan includes offering recruits a facility with amenities such as ample daylight, good air quality and temperature controls.
(2001). Retrieved from betterbricks.com
- The Container Store, a national storage and organization products retailer, was placed for the third consecutive year on Fortune Magazine's list of the "100 Best Companies to Work For" (ranked as number two in 2002). The retailer's physical work environment, which includes daylighting, has been noted as a contributing factor. "Our store design serves to take away the stress typically associated with the workplace. Happy employees equal better customer service," reported Container Store executives.
(2002, August). Display & Design Ideas.
- Winners of the Business Week/Architectural Record Awards, which recognize projects in which architecture is used to find solutions for businesses, had a common feature – inventive use of daylight. This included offices for The Gap, Inc., in San Bruno, Calif., in which daylighting is used to reinforce the corporation's support of healthy living and a commitment to offering its employees a visually comfortable work environment, which has a positive impact on productivity. The entire complex is designed so that any office area is at most 22 feet from a source of natural light. During the designing of the building, the company did an extensive cost-benefit analysis to measure the amount of savings the daylighting and other "green" features would provide. They were interested in a payback of under 10 years and came out far lower than that.
(1998, October). Architectural Record
(2001, January). Environmental Design & Construction.

Natural light is important to the health and psychological well-being of office workers.

- When conducting a site search for its new call center in Massachusetts, high-tech outsourcer Cerida Corp. specifically looked for buildings with plenty of natural light and interesting design, believing that these features help enable the company to attract and keep bright and creative agents who generate leads and sell and service the business customers better.
(2001, June). Call Center.
- Retaining its innovative workers is crucial for the Pentland Group, which designs and produces sportswear brands such as Speedo. Taking its lead from other creative businesses, the company has changed its working environment to incorporate lots of natural light, among other amenities like a coffee bar and gym.
(2001, July). The Guardian [United Kingdom].
- The “Intelligent Workplace” research project at Carnegie Mellon University seeks to prove that an initial investment in a “smart” facility not only benefits workers but also saves money in the long run. The project maximizes natural light and ventilation. According to the research team, the benefits of the project include reduced energy costs, reductions in medical insurance costs and absenteeism, increased productivity, improved employee retention rates, as well as less easily measured benefits that result from a workforce that likes being at work.
Walsh, D. (2012, January). Specialty Construction Doing Well. ED+C
(1998, September). MIT’s Technology Review.
- According to Business Week, “Today’s small companies seek an environment that communicates an image of success and creativity, that wow’s potential clients, reassures investors, attracts hard-to-find recruits, and helps employees forget how hard they’re working.” One of the “design tips that won’t bust your budget” is allowing more natural light into cubicle work areas.
(2000, November). Business Week.
- In the early 1990s, when military leaders were aiming to attract talent, retain soldiers and improve morale, they turned to green buildings as a partial solution.
(2001, June). Architectural Record.

Retail Sales

Increased Sales

- 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

Heschong, L. (2003, October). Daylight and Retail Sales. California Energy Commission. Retrieved from www.h-m-g.com

- 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).

(Heschong, L. (2003, October). Daylight and Retail Sales. California Energy Commission. Retrieved from www.h-m-g.com

- 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 www.h-m-g.com

- When Federated Logistics (Macy's and Bloomingdales) introduced daylighting into their Los Angeles warehouse their main goal was to reduce energy consumption and increase the quality of light. They found that natural light from TDD also reduced errors in product identification for repairs, warehousing and shipping.

Head, C. Turn Off Those Lights: Daylighting Increases Productivity, Decreases Energy Costs. Facilities Magazine. Retrieved from <http://www.facilitiesmagazine.com>

- A 1999 Pacific Gas & Electric Company (PG&E) daylighting study analyzed a retail chain of 108 stores where two-thirds of the stores were lit with skylights and one-third were not. All other things being equal, the study found that the daylighted stores had 40 percent higher sales than those without.

(1999). Skylighting and Retail Sales. Heschong Mahone Group. Retrieved from www.h-m-g.com

- The Energy Efficiency Best Practice Programme (EEBP) in the United Kingdom reports that reduced energy costs lead directly to increased profits and competitiveness. In many businesses, a 20 percent cut in energy costs represents the same bottom-line benefit as a five percent increase in sales.

(1999). Skylighting and Retail Sales. Heschong Mahone Group. Retrieved from www.h-m-g.com

Even retail stores like Wal-Mart are beginning to see the environmental and monetary benefits of daylighting for both employees and consumers. In a test experiment, stores included skylights over certain departments and found that overall sales per square foot were higher in the departments lit by natural light.

Molinski, M. (2010, May). Everything You Need to Know About Daylighting. Sustainable Facility. Retrieved from <http://www.sustainablefacility.com>

- Larry's Markets, a small grocery store chain in the Pacific Northwest, reports that since upgrading its stores with more energy-efficient lighting and skylights with dimmers, the stores have experienced annual cash savings of \$75,000, with an 18-month payback. They have cut utility costs by 20 percent, which they report is equivalent to a \$20 million increase in gross sales.

(2002). Environmental Protection Agency. Retrieved from www.epa.gov

- Following three years of research and development aimed at reducing energy usage, Stop & Shop, a chain of 320 grocery stores in the Northeast, opened a "low-energy" superstore in Foxboro, Mass., which features extensive use of skylights and dimming controls, resulting in an expected 50 percent reduction in energy usage for lighting. Additionally, it creates a more pleasant atmosphere for customers, encouraging them to stay longer and therefore increase checkout totals. Skylights and daylighting controls have also proven their worth at the Ralphs grocery chain, a division of The Kroger Co., which has witnessed an estimated 30 percent annual energy savings.

(2002, January). Chain Store Age.

(2001, March). Display & Design Ideas.

- Costco, an international chain of membership warehouses, experienced utility rate hikes that doubled and even tripled its energy costs during the 2001 energy crisis in California, where 37 percent of its total U.S. stores were located. As a result, the store stepped up energy conservation methods, including store lighting. While all of its California stores had been harvesting sunlight (the state's greatest natural resource) since they were built, electric lights were dimmed to take better advantage of the skylights. Most stores reduced their overhead lights to one-third during daytime hours, and new stores were built to incorporate even more skylights. Costco reported that all of its energy-saving measures during the crisis helped reduce energy costs from a \$60-\$70 million per year to less than \$15 million.

(2002). Retrieved from www.lightforum.com

- An Ace Hardware store in Martinez, Calif., which installed a skylight system to reduce energy consumption experienced a 65 percent annual saving in electric lighting costs, or 4.9 kilowatts per square foot, while interior light levels were increased.

(2001, July). Building Design & Construction.

- The vice president of store development and real estate for Lund Food Holdings Inc., operator of the Lunds and Byerly's grocery and specialty foods chains in Minnesota, reports "light is power in our stores when it comes to featuring unique items and creating impulse sales." New and remodeled stores for the chain are utilizing more daylighting, because it helps to create a warm and comfortable feeling inside the store. "Whether in a supermarket or apparel boutique, a well-paced lighting design incorporating daylight gets shoppers to slow down and relax. Then they reward you by staying longer and buying more."

(2002, May). Display & Design Ideas.

Daylighting can have a positive effect on customers, sales and the bottom line, according to the Food Marketing Institute's 22nd annual Energy and Technical Services Conference in Cleveland in 2001.

(2001, September). Supermarket News

- After payroll, electricity is a retailer's largest expense. As profit margins shrink, retailers are focusing on improving the bottom line through savings rather than sales volume. Anything retailers can do to save on utility overcharges or to save a kilowatt hour comes back as increased profits. Many retailers and shopping center operators are finding that lighting improvements offer the biggest bang for the buck. Wal-Mart, for example, has been utilizing a daylighting system of skylights and lighting controls in many of its stores since 1995, with an average reduction of 250 kilowatt-hours in utility savings per year. (2002, March). Chain Store Age.

A lighting upgrade at the Thalhimer Brothers department store in Richmond, Va., contributed to an annual sales increase of \$1 million.

- In 2001, the flagship Piggly Wiggly supermarket in Sheboygan, Wis., tested out a new store design for the chain, which focuses on natural light, rich color and a circular floor plan, giving the store a more upscale feel. The store's skylights resulted in an energy savings of 30 percent or \$55,000. Additionally, the chain's executives have found that the skylights give the whole store a clean, bright and natural feel that is soothing to customers and makes them want to linger in the store longer. (2001, December). Display & Design Ideas. (2002, May/June). Food Distributor.

- A lighting overhaul at the 500,000-square-foot Colonial Park Plaza in Harrisburg, Pa., reduced system operation and maintenance costs by 66 percent. As a result of the lighting upgrades, the mall's appearance was brightened and more people started shopping there. Over a two-year period, traffic counts increased by one-third after the lighting period was implemented. Over the same period, data showed that merchants' sales increased 38 percent and profits increased 19 percent. Given the mall's new appearance and traffic flow, more retailers opened stores there, cutting the center's vacancy rate 32 percent. The center's resale value was also substantially enhanced by the lighting upgrade. When factoring in this increase, along with merchant profits, increased owner rental income, and lower operation and maintenance costs, the investment in new lighting paid for itself in less than six days. (2002). National Lighting Bureau. Retrieved from www.nlb.org

- A lighting upgrade at the Thalhimer Brothers department store in Richmond, Va., contributed to an annual sales increase of \$1 million. Virtually overnight, with no other changes besides the lighting upgrade, sales shot up eight percent. When the profit portion of the sales increase is considered along with the energy savings of \$20,000 per year, the payback period was less than 12 months. (2002). National Lighting Bureau. Retrieved from www.nlb.org

- A 1995 Wall Street Journal article reported Wal-Mart's experience with daylighting its store in Lawrence, Kan. Sales were significantly higher in the side of the store that utilized skylights than the same products displayed at other Wal-Mart stores. To test the correlation, products were swapped from the artificially lit to the daylit sections and those located under the skylights again had significantly higher sales while those shifted to the artificial lights returned to their national sales average. (1999, July). Portland Business Journal.

- Larry's Markets, a small grocery store chain in the Pacific Northwest, reports that since upgrading its stores with more energy-efficient lighting and skylights with dimmers, the stores have experienced annual cash savings of \$75,000, with an 18-month payback. They have cut utility costs by 20 percent, which they report is equivalent to a \$20 million increase in gross sales.

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(2002). Retrieved from www.lightforum.com

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(2002, May). Display & Design Ideas.

Retail Daylighting

- 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.

Heschong, L. (2003, October). Daylight and Retail Sales. California Energy Commission. Retrieved from www.h-m-g.com

In the daylit store retail areas seem cleaner, absenteeism is reduced, productivity increases, test scores improve and sales volume increase. Energy costs go down.

Head, C. Turn Off Those Lights: Daylighting Increases Productivity, Decreases Energy Costs. Facilities Magazine. Retrieved from <http://www.facilitiesmagazine.com> Magazine. Retrieved from www.edcmag.com

- 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.

Heschong, L. (2003, October). Daylight and Retail Sales. California Energy Commission. Retrieved from www.h-m-g.com Magazine. Retrieved from www.edcmag.com

- In the daylit store, the colors of the merchandise appear brighter and truer. The store feels better. Grocery stores can take advantage of TDD, using natural light to display produce. These devices allow the spectrum that shows produce beautifully and eliminate the spectrum that advances spoilage. Stores that are starting to upgrade lighting find that sales increase in those locations where TDD have been incorporated.

Walsh, D. (2012, January). Specialty Construction Doing Well. ED+C Magazine. Retrieved from www.edcmag.com

- Researchers with North Carolina State University’s Department of Textiles report that inconsistencies in store lighting affect how colors in items such as clothing appear to shoppers, causing colors to look different in the store than when the customer gets home. This leads to unhappy customers and, consequently, a negative impact on sales. The best way to inspect the true color of an item is to view it under natural light. (2001, December). Raleigh News & Observer.
 - Research by the Henley Centre suggests 73% of purchasing decisions are now made in-store. Consequently, catching the shopper’s eye and conveying information effectively are critical to successful sales. Research conducted by the secretariat of the Seoul International Color Expo 2004 documented the following relationships between color and marketing: 92.6 percent said that they put most importance on visual factors when purchasing products. Only 5.6 percent said that the physical feel via the sense of touch was most important. Hearing and smell each drew 0.9 percent.
- Morton, J. (2010). Color and Design/Why Color Matters. Color Matters. Retrieved from www.colormatters.com

- In relation to the PG&E study, the link between high consumer activity and skylighting occurs despite the fact that many of the customers interviewed state that they were unaware of the presence of skylights. Rather, the customers responded that they frequent the skylit stores because of non-specific positive environmental feelings, such as that the stores feel cleaner, more spacious, more open or brighter. The authors of the study offer several hypotheses concerning why the skylights encourage these sentiments, including:
 - o Customer Loyalty – Although they are unaware of the skylights, customers may routinely travel a little farther to shop at a skylit store because it seems cleaner or brighter
 - o More Relaxed Customers – The skylights may impact customers in a manner similar to piped-in music, which has been found so effective at relaxing customers and encouraging them to spend more time shopping in the store
 - o Better Visibility – It may be easier for customers to find products and/or discriminate between alternatives with daylight illumination
 - o More Attractive Products – It is possible that visual quality provided by daylighting, with high color rendition and three-dimensional modeling, may make products more appealing
 - o Employee Morale – It could be that employees working under natural light have higher morale and provide better service as a result

(2000, September). Houston Business Journal.

- According to a daylighting feature in Environmental Design & Construction, some retailers will not release information on their daylighting practices because of the “competitive advantages” they provide.
(1998, February). Environmental Design & Construction .

Health & Safety

Physical Health Benefits

•Physical Benefits of Sun Exposure

- o 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.
- o Lower cholesterol: One of the ways you can help lower your cholesterol naturally is to enjoy some sensible sun exposure.
- o Lower resting pulse rate of the heart: Studies suggest that sunlight can help lower your pulse rate, improving cardiovascular health.
- o 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.
- o 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.
- o Better liver function: The nutrients that come as a result of sun exposure can help enhance your liver's function.
- o Improve digestion: If you are interested in improving your digestion, you can increase your sun exposure to a moderate amount.
- o 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.
- o 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.

(2010, July). Feeling Sunny? 25 Health Benefits of Sensible Sun Exposure. E-Health News Blog. Retrieved from <http://onlineradiologytechnicianschools.com>

- According to the Center for Health Systems and Design at Texas A&M University, providing patients with daylight and windows aids in the healing process. (1998, October). Health Care Strategic Management.

- Patients exposed to natural light and views of the outdoors are thought to recover faster, experience less anxiety and require less pain medication. Mortality rates are also believed to be lower in intensive care units with higher levels of natural light. The Joint Commission for the Accreditation of Healthcare Organizations is contemplating issuing new guidelines for hospital accreditation that would provide standards for exposure to natural light and window views.
(2000, September). Houston Business Journal
- Environmental psychologists at Canada's University of Victoria report office lighting as one of the most frequent complaints of office workers surveyed.
(2000, March). Charleston Gazette.



A study by the U.S. Department of Energy found that employees who sit near windows have 20 percent fewer symptoms common to workers in "sick buildings." The conclusion: Give people light and spend less on healthcare.

(2000, August). Smart Business. ZDWire.

- The Centre for the Analysis and Dissemination of Demonstrated Energy Technologies in the Netherlands reports that a hospital in Canada found that cardiac patients who were in wards receiving direct sunlight were in the hospital for shorter periods, by as much as 11 percent.
(2000). CADDET Energy Efficiency Newsletter.
- The Environmental Protection Agency estimates that building-related illnesses account for \$60 billion of annual productivity lost nationwide. A wider study valued that loss as high as \$400 billion.
(2000, January). Journal of Property Management.

Vitamin D

- People whose sun exposure is limited are at risk of becoming deficient in vitamin D. If you live in a country with cold climate conditions, you may lack this vitamin. People who are housebound (for any reason) can also have low vitamin D levels because their sun exposure is limited.

The most common signs include:

- o Fatigue
- o Weakness
- o Pain in muscles
- o Soft bones
- o Easy fracturing
- o Rickets in children
- o Osteomalacia in adults

Vitamin D deficiency can increase the risk of:

- o Multiple sclerosis
- o Osteoporosis
- o High blood pressure in people who are predisposed to hypertension;
- o Problems in patients who suffer from diabetes
- o Certain types of cancer

- Vitamin D Deficiency Symptoms. Vitamin D Deficiency Site. Retrieved from <http://www.vitamindeficiencysite.com/>
- Ten to 15 minutes of sunshine three times weekly is enough to produce the body's requirement of vitamin D. The sun needs to shine on the skin of your face, arms, back, or legs (without sunscreen). Because exposure to sunlight is a risk for skin cancer, you should use sunscreen after a few minutes in the sun.
Evert, A. (2011, February). Vitamin D. Medline Plus. Retrieved from <http://www.nlm.nih.gov>
- Vitamin D3 is found in animal-derived products, like eggs, meat, fish oil and dairy products. The quantities found in these foods are not considered good enough to satisfy our daily needs. Sunlight remains the best natural source of vitamin D. Eating foods that contain this vitamin will certainly be helpful, but you won't be able to get enough vitamin D if you don't spend time in the sun.
How Much Vitamin D Does your Body Need. Vitamin D Deficiency Site. Retrieved from <http://www.vitamindeficiencysite.com/>
- Vitamin D strengthens the immune system. It will help the body protect itself from various infections (bacteria, viruses and fungi). Vitamin D deficiency can significantly decrease the body's ability to fight infections.
Facts About Vitamin D. Vitamin D Deficiency Site. Retrieved from <http://www.vitamindeficiencysite.com/>
- If you have dark skin, you may be at risk of getting vitamin D deficiency. Melanin acts as sun block, so if your skin is darker, you will need to spend more time in the sun, compared to people who have white skin.
Vitamin D Deficiency Symptoms. Vitamin D Deficiency Site. Retrieved from <http://www.vitamindeficiencysite.com/>

Sleep

- Getting enough sunlight during the day can help you sleep better at night. If you are exposed to natural light during the day, it will increase your melatonin output at night. Melatonin is a natural hormone made by our bodies. It enhances sleep and slows down the aging process.

Benefits of Sunlight. Natural Health Restored. Retrieved from www.natural-health-restored.com

- Lack of short-wavelength light in the morning has been shown to delay the circadian clock in controlled laboratory conditions. The results presented here are the first to show, outside laboratory conditions, that removal of short-wavelength light in the morning hours can delay DLMO (dim light melatonin onset) in 8th-grade students.

MG, F. (2010). Lack of short-wavelength light during the school day delays dim light melatonin onset (DLMO) in middle school students. National Center for Biotechnology Information. Retrieved from <http://www.ncbi.nlm.nih.gov>



“As teenagers spend more time indoors, they miss out on essential morning light needed to stimulate the body’s 24-hour biological system, which regulates the sleep/wake cycle,” reports Mariana Figueiro, Ph.D., Assistant Professor and Program Director at Rensselaer Polytechnic Institute’s Lighting Research Center (LRC) and lead researcher on the new study.

Cimo, M. (2010, February). Lack of Morning Light Keeping Teenagers Up at Night. Lighting Research Center. Retrieved from <http://www.lrc.rpi.edu>

- Light therapy specialists at Columbia University report that normal room light rarely exceeds 500 to 600 lux (compared with 800 lux outdoors at the first glimmer of dawn), but we need at least 1,000 lux to start reaping the biological benefits of light. (2000, January). USA Today

Mental Health Benefits

- Mental Health Benefits of Sun Exposure

- o 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.

- o 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.

- o 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.

- o 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>

- A 2008 study by McGraw-Hill Construction found that green building reduces asthma and the air contaminants that lead to 2 million patients annually acquiring infections during hospital stays. A 2004 University of Pittsburgh study showed that patients with access to sunlight required 20 percent less pain medication, leading to lower medical costs.

Katz, A. (2009, July). LEED for Healthcare: Human Health and the Built Environment. Sustainable Facilities Magazine. Retrieved from www.sustainablefacility.com

- Working by electric lighting is not generally believed to produce poorer work output. However, that work output is achieved at the cost of greater stress. As long as the sunlight is controlled in the work environment, it has shown to have a positive psychological impact of increasing relaxation and thereby allowing the execution of tasks that require deep concentration.

(1999). New School of Social Research in New. Parsons School of Design.

- In a study of windowed vs. windowless intensive care units in hospitals, it was discovered that disorientation, hallucinations, loss of memory and delusions were significantly less common in the windowed (yet viewless) ICU. The implication was that daylight alone provided critical information, perhaps about time and weather patterns, to the patients, which in turn led to stress reduction.

(1999). New School of Social Research in New. Parsons School of Design.

- There is evidence that among intensive care units that do have natural light, mortality rates tend to be lower in those that are sunnier, according to an article in Smithsonian Magazine on the correlation between healthcare environments and patient care.

(1999, July). Smithsonian Magazine.

- According to an early 1990s survey, almost 20 percent of the general public said they experienced symptoms of SAD. Studies have shown that the level of light found in daylight buildings can be effective in fighting the disorder.
(2002, May). Display & Design Ideas.
- The lack of light has been documented to cause Seasonal Affective Disorder (winter depression or the winter blues), maladjustment of our body clock (circadian rhythms) and consistent periods of reduced productivity and enthusiasm. The National Commission on Sleep Disorders Research estimates that, in the United States alone, businesses lose more than \$150 billion a year in productivity as a result of employee fatigue. One solution is providing a well-lit workspace, with as much natural light as possible.
(1999, October). Management Review
- The lack of daylight can disrupt one's chronobiology (internal body clock). Moderate disruption of chronobiology can lead to "jet lag," while more serious disruption can lead to the serious performance and short- and long-term health problems evidenced by shift workers. An example of this is Seasonal Affective Disorder (SAD), characterized by recurrent, annual clinical depression, accompanied by oversleeping, overeating, decreased work productivity and social withdrawal.
(1999). New School of Social Research in New. Parsons School of Design.

Safety

- When Prince Street Technologies, a subsidiary of Interface Carpets, built a new 160,000-square-foot factory in Cartersville, Ga., it used extensive natural daylighting (including 32 skylights), which created an "enormous difference in attitude," according to corporate management. Additionally, the better lighting conditions were linked with improved worker safety. In the first three years after moving into the new facility, workers compensation cases dropped from 20 per year to under one per year, for savings worth an estimated \$100,000 to \$200,000 a year – more than the value of the energy savings.
(2002). The non-profit Center for Energy & Climate Solutions' Cool Company.
Retrieved from www.cool-companies.org
- Following a major lighting upgrade at the Colonial Park Plaza in Harrisburg, Pa., there was a decrease in the number of accidents involving senior citizens. The mall had previously been subject to many slip-and-fall accidents, exposing the center to claims, litigation and bad publicity. After the new lighting was installed, the accidents diminished. Insurance premiums paid by the center's management were lower because the insurer's underwriters agreed that lower risks merited lower premiums.
(2002). National Lighting Bureau. Retrieved from www.nlb.org
- At Metal Industries Inc. of Elizabethville, Pa., a new lighting system resulted in a 15 percent reduction on its accident rate. The improved safety record saved the company \$3,000 per year by lowering the costs of accident clean-up and related paperwork, and another \$3,000 annually in lower insurance premiums. More important to the company was the reduced rate of absenteeism attributable to accident-related injuries, which it valued at \$225,000 per year. When factoring in all of these elements, the National Lighting Bureau estimated the payback period as just 37 hours.
(2002). National Lighting Bureau. Retrieved from www.nlb.org

Education

Student Performance

- Overall, the most important benefit [of natural light], though, is increased performance. With the pressures on students, teachers, facilitators and staff, performance is critical. Natural light and the resulting views to the exterior have significant benefits to those using the space. Rettich, K and Hoyle, T. (2011, October). Maximizing your Lighting System. Sustainable Facilities Magazine. Retrieved from www.sustainablefacility.com
- The right balance of natural light and direct/indirect artificial light can create quality spaces that enhance performance. It improves our attention, our physical health, our ability to process critical problems, and calms our demeanor in ways that allows us to work, learn and interact with others. Rettich, K and Hoyle, T. (2011, October). Maximizing your Lighting System. Sustainable Facilities Magazine. Retrieved from www.sustainablefacility.com
- Lighting systems also have a major impact on the health and effectiveness of the building users. Daylight harvesting can provide a lower operational cost versus standard lighting systems while providing the best possible environment for effective teaching, learning and performance. Rettich, K and Hoyle, T. (2011, October). Maximizing your Lighting System. Sustainable Facilities Magazine. Retrieved from www.sustainablefacility.com
- 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.leed.us>
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Daylighting in schools has even improved student grades and attendance.

(2011, June). Daylighting. U.S. Department of Energy. Retrieved from: <http://www.eere.energy.gov>

- Physical characteristics of classrooms are just as likely to affect student learning as many other factors commonly given much more public policy attention. Variables describing the physical conditions of classrooms, most notably the window characteristics, were as significant and of equal or greater magnitude as teacher characteristics, number of computers, or attendance rates in predicting student performance. Heschong, L. (2003). Windows in Classrooms. Heschong Mahone Group, Inc. Retrieved from <http://www.h-m-g.com>

- Natural light contributes to increased concentration among occupants and positively affects their emotional well-being and overall mood. Studies reveal that students in rooms lit by an increased amount of daylight consistently progress 20 percent faster in math and 26 percent faster in reading.

Carduff, D. (2010, May). Untangling Daylighting and Mesh. ED+C Magazine. Retrieved from <http://www.edcmag.com>

- 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. McGraw-Hill Construction. Retrieved from <http://colorado.construction.com>



- A recent study conducted by the Heschong Mahone Group for Pacific Gas & Electric Company tested 21,000 students in three states and found that those in classrooms with the most daylighting progressed 20 percent faster on math tests and 26 percent faster on reading tests in one year than those with the least.

(1999). Daylighting in Schools. Heschong Mahone Group. Retrieved from www.h-m-g.com

- A survey by an Atlanta-based research firm of more than 1,000 public school teachers across the country found that 92 percent believed that classroom design had a strong impact on students' learning and achievement. Approximately 89 percent believed classroom design was important for teacher retention and 79 percent believed it was important for student attendance. Lighting was one of the top four design features teachers believed to impact the learning environment of the classrooms.

(2001, September). Boston Globe

- A study by photobiologist Dr. John Nash Ott, Ph.D., reported that "hyperactive children with confirmed learning disabilities calmed down completely and rapidly overcame their learning and reading problems while in the full spectrum lighting environment." (Full spectrum lighting most closely mimics and produces the effects of natural daylight.)

(2002, February). School Planning and Management.

- The North Carolina school (above) also witnessed reduced absenteeism among students, with 98 percent attendance (about three percentage points higher than the rest of the county).

(2010, July). Feeling Sunny? 25 Health Benefits of Sensible Sun Exposure. E-Health News Blog. Retrieved from <http://onlineradiologytechnicianschools.com>

- Most Danish schools have excellent daylit classrooms, less for the students than for an awareness of how important it is to maintain the most productive and healthful workplaces for its teachers.
(2002, September). Environmental Design & Construction
- After a year of detailed observation of 90 eight-year-old students in Sweden, researchers found significant correlations between daylight levels, hormone levels and student behavior. The results indicated that work in classrooms without daylight upset the basic hormonal pattern. This, in turn, influenced the child's ability to concentrate or cooperate and also eventually had an impact on annual body growth and sick leave.
(2002). Collaborative for High Performance School. Retrieved from www.chps.net
- The book collections in daylit libraries are used up to 50 percent more than in traditional library designs, according to the Daylighting Collaborative/Energy Center of Wisconsin.
(2002). The Daylighting Collaborative website. Retrieved from www.daylighting.org



- “The Parents’ Eight-Step Plan to Exam Success,” a Canadian program designed to help parents provide the optimum environmental study conditions at home, includes plenty of natural light.
(2001, May). The Evening Mail.

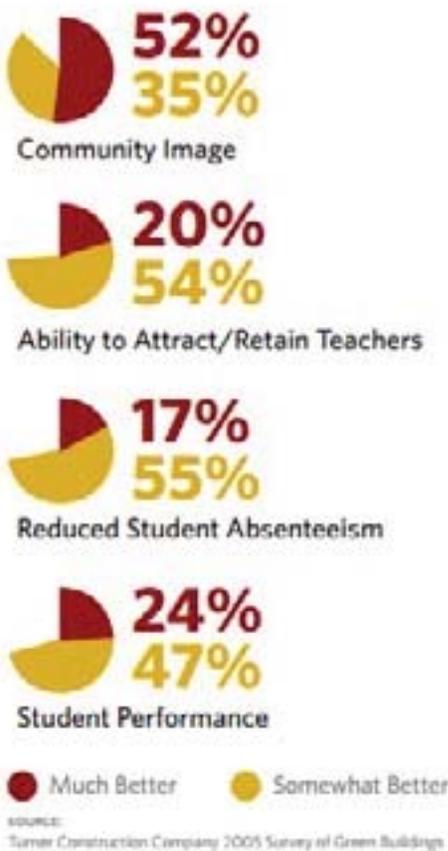
Energy Savings

- 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/ft²) - 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.leed.us>

FIGURE E Benefits of Green K-12 Facilities

Executive Views on Green School Performance Compared with Conventional Schools



- Green schools provide a range of additional benefits... including reduced teacher sick days, reduced operations and maintenance costs, reduced insured and uninsured risks, improved power quality and reliability, increased state competitiveness, reduced social inequity and educational enrichment.

Kats, G. (2006, October). Greening America's Schools Costs and Benefits. ED+C Magazine. Retrieved from <http://www.edcmag.com>

- The most recent K-12 project that our team has been involved in was the Los Angeles Unified School Districts 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>

- If the state [California] encouraged their [daylight] use in new schools statewide, the savings could accumulate to about \$5 to \$7 million dollars per year and 3,330 to 4800 megawatt-hours of energy after ten years of new construction.

Heschong, L. (2003). Windows in Classrooms. Heschong Mahone Group, Inc. Retrieved from <http://www.h-m-g.com>

- The Chapel Hill-Carrboro City School District in Chapel Hill, North Carolina, the Smith Middle School exemplifies good daylighting practice. Good daylighting design incorporated at a buildings inception yields positive results in energy savings (64 percent reduction in lighting energy), comfort (teachers and students favor daylighting in the classrooms) and a reasonable return on the added investment (4.2 years).
(2004). Daylight Dividends Case Study. Rensselaer Polytechnic Institute. Retrieved from <http://www.lrc.rpi.edu>

- A series of schools built in Johnston County, N.C., replaced artificial lights with natural light, which resulted in between 22 percent and 64 percent energy savings as compared to typical neighboring schools. Since their construction, the schools have saved Johnson County Schools in excess of \$500,000 in energy bills. Additionally, students who attended the schools out-performed students in comparable non-daylit schools by five to 14 percent. The daylighting measures cost less than one percent of the construction budget and achieved a payback in less than three years.
(1998, February). Environmental Design & Construction.
(2002). Energy-Smart Building Choices: How School Administrators & Board Members Are Improving Learning and Saving Money. U.S. Department of Energy's Office of Building Technology, State and Community Program.

Greening school design provides an extraordinarily cost-effective way to enhance student learning.

TABLE 2

Financial Benefits of Green Schools (\$/ft ²)	
Energy	\$9
Emissions	\$1
Water and Wastewater	\$1
Increased Earnings	\$49
Asthma Reduction	\$3
Cold and Flu Reduction	\$5
Teacher Retention	\$4
Employment Impact	\$2
Total	\$74
Cost of Greening	(\$3)
Net Financial Benefits	\$71

- East Clayton Elementary School in North Carolina not only utilized daylighting strategies to dramatically reduce energy costs, but also was singled out by the State of North Carolina as a "School of Distinction" for exceeding its academic improvement goals by 10 percent.
(2002). Energy-Smart Building Choices: How School Administrators & Board Members Are Improving Learning and Saving Money. U.S. Department of Energy's Office of Building Technology, State and Community Program.

- An energy-efficient school district with approximately 4,000 students can save as much as \$100,000 per year in energy costs. Over a 10-year period, the savings can reach \$1 million. Spending less on operating costs enables school districts to redirect dollars to more critical educational needs, such as hiring additional teachers, purchasing new computers and instructional materials, or paying for necessary capital improvements.
(2002). Energy-Smart Building Choices: How School Administrators & Board Members Are Improving Learning and Saving Money. U.S. Department of Energy's Office of Building Technology, State and Community Program.

- Roy Lee Walker Elementary School in McKinney, Texas, was constructed to incorporate extensive use of daylighting in every classroom. In addition to creating a bright, cheerful environment for students and teachers, the school was able to save the district \$40,000 to \$50,000 per year in energy costs. When school district zones were re-drawn, so many parents wanted their children to attend the daylit school that the school committed to build two more.
(2000). Daylighting in Schools: Improving Student Performance and Health at a Price Schools Can Afford. National Renewable Energy Laboratory.
(2001, March). School Planning & Management

- A Pittsburgh-area elementary school reported that after skylights were installed, attendance records rose from the state average of 93.5 percent to 95 percent, which earned the school an additional \$4,000 from the state that year. (2000, February). Pittsburgh Post-Gazette.
- Utility expenditures are a major item in every school district budget. In fact, the cost of utilities exceeds that of books and supplies and comes in second only to salaries. The annual cost of energy in schools is estimated at \$110 per student. Through better building design and the use of energy-efficient and renewable energy technologies, schools can save as much as \$50 per student per year. (2002, March). School Planning and Management. (2001, November). School Planning and Management.
- According to a survey conducted in 2001 by the California Association of School Business Officials (CASBO), 97 percent of the 154 districts reported increased energy costs, and 85 percent reported that these unbudgeted expenditures threatened moneys allocated for student instruction. However, according to the U.S. Department of Energy, integrating energy efficiency and renewable measures can save school districts 20 to 30 percent in energy costs in renovation projects, or 30 to 40 percent in new school projects. This savings could instead be used to meet the needs of students, through books, better equipment and better paid teachers. (2002, April). Engineering News Record. (2001, November). School Planning and Management.
- According to a report by the National Center for Education Statistics, 72 percent of the cost of energy in education buildings goes towards electricity, with the majority (56 percent) going toward lighting. America's K-12 schools will spend \$6 billion on annual energy costs, a cost that is second only to salaries and exceeds that of computers, supplies and books. Making a significant cut in electricity costs through daylighting can amount to substantial savings for other school expenses. (2000, November). School Planning & Management.
- As the cost of artificially lighting an average school can amount to approximately one-third of the overall energy usage, daylighting represents a sound investment in both reduced energy costs and improved student performance. (2002, August). School Planning & Management.



Student Health

- 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.

Leslie, R. (2010). Patterns to Daylight Schools for People and Sustainability. Lighting Research Center. Retrieved from www.irc.rpi.edu

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

Katz, G. (2006, October). Greening America's Schools. The U.S. Green Building Council. Retrieved from <http://www.leed.us>

- 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.

- A study of 90 school children in Sweden shows that lack of daylight can disrupt their chronobiology (internal body clocks) and result in significant psychological and physiological impairment. The study followed the health and behavior of children in classrooms with and without windows for an entire academic year, measuring the children's production of cortisol (a stress hormone governed by the body's biological clock). It concluded that work in classrooms without daylight may upset the basic hormone pattern and may in turn influence children's ability to concentrate and cooperate and also eventually impact annual body growth and sick leave.

(1999). New School of Social Research in New. Parsons School of Design.

(2000). Daylighting in Schools: Improving Student Performance and Health at a Price Schools Can Afford. National Renewable Energy Laboratory Report.

- A study reported in the International Journal of Biosocial Research on the effect of color and lighting on disciplinary incidents in elementary schools found that in some classrooms the use of natural light significantly reduced reported incidents of aggressive, disruptive and destructive behavior.

(2001, April). Journal of Counseling & Development.

Property Value

Marketability

- “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) Selling or staying put, ‘daylighting’ improvements pay off for homeowners. Holland Sentinel. Retrieved from www.hollandsentinel.com
- In addition to being better places to work, daylighted high performance buildings offer an increased return on an owner’s investment through the building’s increased overall asset value at no additional construction cost. Although the design of these buildings shouldn’t cost more than a standard project, it may require some re-proportioning of the budget lines. For instance, the reduction of lighting, cooling and heating loads, which correspond to a good daylighting design, should release money from the HVAC equipment budget, which often accounts for 30 percent of the total construction cost of a commercial building. Over the life of a building, the decreased HVAC costs, lower operating costs and significant productivity gains can enhance the building’s income and increase the overall asset value of the property.
(2002, September). Environmental Design & Construction.
- Energy-efficient building design can significantly increase the value of a property. Because these buildings cost less to operate and maintain, energy savings can go directly to the bottom line – the income of the property. Capitalizing this increased income can add \$5 to \$6 per square foot to the value of the building.
(2001, June). Environmental Design & Construction.
- Quality daylighting systems offer improved comfort, reduced operating costs and a stronger connection to the outdoors, making them more marketable to tenants and valuable to building owners. Daylit properties are likely to rent faster and for higher rates. Additionally, when the owner is ready to sell the building, the investment in energy efficiency should bring added resale value.
(2000, December). Energy User News
- An executive order by former President Clinton in 1999 mandated that all new federal buildings be designed using green principals and technologies. According to the NCSBCS, this means that a building owner who is leasing space can’t even market a building that isn’t green to a state of federal agency. (“Green” is defined as environmentally responsible, decreasing operating costs, increasing occupant productivity and decreasing health complaints.)
(2011, June). Daylighting. U.S. Department of Energy. Retrieved from: <http://www.eere.energy.gov>
- By improving energy efficiency, the real estate investment and management firm Scribcor significantly increased the asset value of a bank office building for sale in suburban Chicago. An energy-efficient lighting retrofit was one of the largest and most cost-effective improvements made, which helped reduce the buildings energy costs by 40 percent. The increase in the building’s net operating income may have increased the building’s value by as much as \$1.3 million.
(1999, June). Environmental Design & Construction.

Tenant Satisfaction

- According to the Rocky Mountain Institute, a great example of energy-efficient design in 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. (1998, February). Environmental Design & Construction. (2002, February). Buildings.
- In 2002, the Building Owners and Managers Association (BOMA) International, along with a group of sponsors including the New Building Institute, conducted a survey on workplace performance and tenant satisfaction. Building owners/managers reported that tenant demand for "green" concepts, including better lighting and energy-efficiency, were a growing trend. Tenants surveyed revealed that quality of lighting and access to natural light have a high impact on how satisfied they were with their space. Over 50 percent of tenants reported that they were not satisfied with the energy efficiency of their space. The survey concluded that while environmental factors, including access to natural light, had the highest impact on tenant satisfaction, these factors were also the ones that fell into the "need to improve" category. Property owners and managers who help address their tenants concerns over lighting and other environmental factors are able to be more competitive today and more profitable in the long term. (2002). Retrieved from Betterbricks.com

According to the Electric Power Research Institute, daylit buildings can result in 10 to 20 percent higher rental income than those that use only artificial lights.

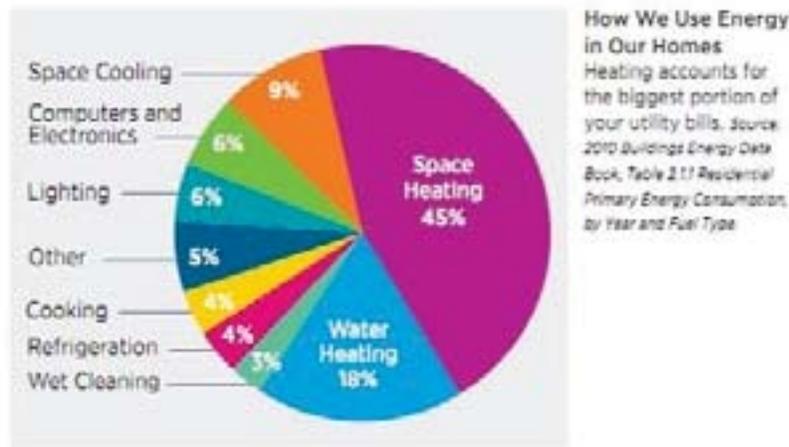
(1998, July). EPRI Journal.

- The Lighting Research Center in Troy, N.Y., conducted a study of occupant reactions to the newly completed daylit office building for the Sacramento Municipal Utility District (SMUD). The found that the office workers on the top floors were the most satisfied with the visual conditions of any building that they had ever studied – 96 percent of workers surveyed reported that they found the lighting comfortable, with none of the common problems associated with office lighting. (The building made extensive use of skylights and windows to provide daylighting even into the deep interior of the building.) (2002). Retrieved from Betterbricks.com
- Green projects typically sell or lease faster and retain tenants better because they combine superior amenity and comfort with lower operating costs and more competitive terms. The resulting gains in occupancies, rents and residuals all enhance financial returns. (2000, January). Journal of Property Management.
- According to the Rocky Mountain Institute, U.S. businesses are recognizing the relationship between natural light and increased productivity. As a result, they are beginning to demand these advantages when leasing office space. (2000, July). South China Morning Post.

- According to a survey conducted by the Building Owners and Managers Association and the Urban Land Institute in 1999 entitled "What Do Tenants Want," one of the top responses was more natural light.
(1999, July). San Antonio Business Journal.
- According to the Housing and Building Technology Division of the National Conference of States on Building Codes and Standards (NCSBCS), daylighting is one of the technologies that has the greatest impact on occupant comfort, health and productivity. Because people are willing to spend more for a comfortable building, owners can charge a premium.
(2000, January). Journal of Property Management.

Home

- Heating and cooling your home uses more energy and costs more money than any other system in your home—typically making up about 54% of your utility bill. (2011, December). Energy Savers. U.S Department of Energy. Retrieved from <http://www.energysavers.gov>



- An average household dedicates about 6% of its energy budget to lighting. Switching to energy-efficient lighting is one of the fastest ways to cut your energy bills. (2011, December). Energy Savers. U.S Department of Energy. Retrieved from <http://www.energysavers.gov>
- One of the major benefits of sunlight in your home is that it is an effective germ killer. You can clean and freshen up your blankets, quilts, and other items by hanging them out in the sunshine. Benefits of Sunlight. Natural Health Restored. Retrieved from www.natural-health-restored.com
- [Picking Paint Colors with Natural Light]
 - o Northern Light is usually cold, and direct sunlight in your room only occurs in the middle of summer. Use warm colors such as red, yellow or orange in your décor to compensate for the coolness of the light. Blues or greens will make the room appear even colder.
 - o Southern Light is warm and sunny. You can use darker colors in a room with a southern exposure. Blues and greens in this room can create a summery feel all year long.
 - o Eastern Light gives a room sunny mornings but muted middays. The afternoon offers no direct light. Use a mix of warms and cools to balance out the daylight.
 - o Western Light features afternoon and evening sun. Use neutrals in this room. Using warm colors will overpower the room in the afternoon.

Harris, P. (2008, May). Natural Light in Room Design. Budget Decorating. Retrieved from <http://budgetdecorating.about.com>