Office of the Future

Sustainable Design and Workplace Productivity: A Research Review

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Office of the Future: Sustainable Design & Workplace Productivity
Research Review

Sustainable Design and Workplace Productivity: Executive Summary

Sustainability Increases Productivity

Companies spend, in the average year, 60-70 times the dollars per square foot on employee costs (salaries and benefits) as they do on energy. It follows that a 1% increase in employee productivity alone can pay for or exceed a company's energy costs for an entire year.[5]

The Rocky Mountain Institute and US Green Building Council (USGBC) resaearch reviews show that energy-efficient and sustainable building design is associated with a 6-16% increase in employee productivity, as measured by reduced employee absenteeism, reduced turnover and improved quality of work.[6]

Costs for Sustainable Buildings

Green buildings do not cost more; they cost less: compared with conventional construction, LEED-certified buildings' overall construction costs are reported to be 10-15% lower[4]. Long-term costs are further reduced when capital construction costs are integrated with operating costs. Sustainable building costs will decrease as technologies are refined, applications streamlined, and government subsidies and incentives come on line.

The Bottom Line

Investment in energy-efficient, sustainable buildings has a double payoff: decreased operating costs and increased productivity. The research reviewed in this report suggests it is relatively simple to achieve these results: the USGBC reports worker productivity increases up to 15% by implementing smart daylighting;[7] the Massachusetts Technology Collaborative reports productivity boosts of 7% per year when indoor air quality is improved, daylight increased and office temperatures controlled[8]; at Toyota's new, highly sustainable facility in Torrance, California, employee morale increased and absenteeism fell by 14%, so that the cost of green design features was offset by energy savings and worker productivity additions to the bottom line.

Sustainability translates into worker productivity: decreased human resource costs and increased revenues, making sustainable building a significant and compelling marketing feature for building owners and developers.

Introduction

Employers who are motivated to attract and retain the highest-quality workers are increasingly aware that they must pay attention to their workers' physical environment. Although the American work force spends a greater proportion of its time at work than ever before, research suggests that they may not do so happily. A 2002 Steelcase Workplace Survey revealed that, although 79% of the employees surveyed regarded their physical comfort as an important factor in their workplace satisfaction, 53% believed their organizations had minimal information about workers' satisfaction with their physical workspace.[1]

The rapidly accelerating cost of developing and operating office buildings and other workplace environments has not diminished the pace with which new facilities are being built. But it is now clear that development in all market sectors threatens to consume a disproportionate amount of our natural resources, contributing to the problems of global warming and the escalation of air and water pollution. Those concerned with workplace design and development are increasingly responsive to these issues: the 2004 Steelcase Workplace survey showed that 74% of employees surveyed revealed that environmental sustainability is a high priority for both workers and employers.[2]

In the face of these challenges, architects and their clients are seeking to create workplaces that improve employee well-being, reduce costs and increase productivity while at the same time slowing down the depletion of world resources by using sustainable building materials and design. In 2006, building owners registered 5,000 buildings with the US Green Building Council and produced 660 LEED-certified projects. Fifty-four cities and twelve states have mandated the LEED system for state or municipal projects. Many cities have accelerated the building permit process for gold or platinum LEED-certified buildings and are providing incentives for the adoption of the LEED model.

Researchers, initially intent on measuring energy gains and cost savings in sustainable-designed buildings, have discovered that 'green' design features can positively affect worker productivity and well-being, which adds its own contribution to the bottom line. This review of current research sheds light on the standards and practices that designers, architects and their clients should adopt to responsibly create the "office of the future".

Five Case Studies on Lighting and Productivity

At **Lockheed Martin,** a new 600,000 square ft office building was constructed with energy conscious daylighting: 15-foot high window walls with sloped ceilings brought daylight into the space; a central atrium incorporated a glazed roof; light shelves were installed on the south side to project daylight into workspaces; fluorescent fixtures were dimmed with photocells.

– A 15% increase in worker productivity was achieved after daylighting the factory and absenteeism declined by 15%. The reduced absenteeism paid 100% of the extra costs of construction in the first year.

– The daylighting features led to a 75% decrease in lighting costs, and because daylighting reduced the heat-air conditioning load, these costs were also reduced, resulting in $500,000 in annual energy use savings[45].

– Lockheed attributed winning a $1.5 billion defense contract on the basis of the improved productivity. [6]

Note: the Lockheed Martin features included acoustical panels and chambers to block out ambient noise; the research reports do not attempt to determine whether a proportion of the worker productivity gains can be attributed to reduced noise levels.

Penn Power & Light reported that after completion of building upgrades including the use of more daylight,

– absenteeism dropped by 25%;

– drafting staff sick leave was reduced by 25%;

– productivity increased 13.2%;

– reduction of errors was estimated at $50,000 per year;

– complaints of eyestrain and headaches declined, and employee morale improved;

– energy costs declined 69%; and

– overall operating costs fell 73%

When reduced absenteeism and reduced employee errors were factored in, Penn Power & Light estimated the actual return on investment to exceed 1,000%. The agency concluded that the lighting retrofit paid for itself in 69 days versus the original estimate of 4.1 years. [6, 37, 38]

Wal Mart undertook an experimental "eco store", installing skylights over half of the store and left the other half without daylight.

– The sales from the daylit part of the store were significantly higher than the sales in departments in the artificially-lit side of the store.

– Employees in the half of the building without skylights have persisted in trying to have their departments moved to the daylit side of the store, suggesting that employees recognized that skylighting created a superior work environment.[6]

Toyota found that in their new energy-efficient building in Torrance, CA, which exceeds California Title 24 energy efficiency requirements by 60%, employee morale increased while absenteeism fell by 14%, saving $31,000 per year. Overall energy and worker productivity savings more than offset the added cost of green design features, which include highly efficient air handling units gas fired chillers, thermally insulated double-paned windows, highly efficient insulation and a highly reflective cool roof, resulting in savings estimated at about $400,000 annually. The building also uses 94% less potable water than in a conventional building; this was estimated to achieve a savings of 11 million gallons and $12,000 annually. The California Public Utilities Commission self-generation incentive program paid for 50% of the installed cost of the solar panel system.[39]

The California Energy Commission, in a research partnership with **Heschong Mahone Group**, assessed the impact of skylights in two-thirds of the 108 retail stores operated by a chain retailer. They found that the skylit stores had up to 40% higher sales. Furthermore, in interviews with shoppers, although only 7% were aware of the skylights, 80% said the skylit stores felt cleaner, and 65% said they felt more spacious and more open. The researchers presented possible reasons for these results: the skylights may create a more relaxed atmosphere, create better visibility, make the products more attractive, and/or create higher morale among employees. They also cited the finding from a companion study that daylighting is associated with higher text scores in elementary school students, which further supports the evidence that daylight affects people in a positive way.[40]

How to Define Worker Productivity?

The connection between sustainable building design features and worker productivity has been documented in a significant number of research projects. These studies make it clear that the design of the workplace environment has a well-documented tie to the well-being, productivity and mental health of the employee. Many studies demonstrate that factors such as lighting, acoustics, air quality, and design layout have a strong relationship to both objective and subjective measures of productivity.

Each of these studies uses its own definition of worker productivity and each assess the costs and benefits of sustainable design features in its own way.

– Some workplaces produce measured outputs such as manufactured components, reports completed, forms processed, calls handled or orders taken that serve as measures of worker productivity.

– In controlled laboratory or workplace studies where employees can be tested directly, objective definitions of worker productivity focus on the mental building blocks of attention, vigilance, memory, creativity, mental computation and comprehension. Other studies assess the psychological processes of motivation, persistence and effort.

– In workplace settings where it is not possible to directly measure these underlying psychological factors, researchers use objective data collected by the employer such as absentee rates, use of sick days, employee retention, employee turnover or overall financial success[3].

– Finally, research based on employee surveys often use subjective measures such as employee work satisfaction, employee comfort, and emotional and mental well-being as proximate indicators of employee productivity.

This research review recognizes all of these measures as valid assessments of worker productivity. Particular attention is given to research in which more than one form of measurement is employed.

The Costs of Sustainable Buildings

Although some studies have reported that there can be a 10-15% reduction in the construction costs of LEED-certified buildings when compared with conventional construction costs, others have shown that when there are additional costs for green building features, these costs are typically offset by the energy savings realized in the project. Costs associated with sustainable design features can also be lower when capital construction costs are integrated with long-term operating costs. These cost reductions will only increase as technologies are refined and applications streamlined. To the extent that governments and public agencies provide subsidies and incentives, the costs will decrease even further[4].

Companies spend, in the average year, 60-70 times the dollars per square foot on employee costs (salaries and benefits) as they do on energy. It follows that a 1% increase in employee productivity alone can pay for or exceed a company's energy costs for an entire year.[5]

The Rocky Mountain Institute review of current research shows that the use of energy-efficient and sustainable building design is associated with a 6-16% increase in employee productivity. These studies measured productivity in terms of reduced employee absenteeism, reduced turnover and improved quality of work.[6] The US Green Building Council showed that companies can realize an increase in employee productivity as much as 16% if its workers are just 2% more productive, or if 2% fewer leave within their first year.[7]

Tracing the Links Between Sustainable Design and Productivity

The connection between sustainable design and productivity is mediated through human psychology and physiology. A multidisciplinary approach to the impact of design shows not only how the already-documented productivity gains have been achieved but how we should design to increase those gains in the future. Because employee benefits and salaries cost an average of $130 per square foot while energy costs average about $2 per square foot, even small changes in productivity can have a significant impact on the bottom line and can more than pay for sustainable design features. Current research tells us that sustainable design can reduce both employee-related and energy-related costs, creating a win-win-win: the employer, the employee and the planet all stand to benefit.

Lighting and Productivity

Our species evolved to respond to the natural patterns of light and shade created by sunlight, cloud formations, dappled shade under trees and sunlight reflected by water. Daylight reinforces our wired-in circadian rhythms. Our brains respond to the natural variability in light levels by producing neural transmitters like serotonin, which control mood. A lack of exposure to natural light patterns disrupts bodily rhythms like appetite and sleep cycles. Deprivation of natural light is associated with depression; light therapy is used effectively to relieve certain forms of depression such as Seasonal Affective Disorder.

How does this translate into improved on-the-job performance? The variability of natural light promotes mental stimulation and has been shown to have a positive impact on worker performance.[11,12] In contrast, unvarying electric light can lead to a low-level sensory deprivation that impairs organized thinking and increases depression, confusion, and irritability. Research results show that increased light levels have a significant impact on tests of memory and recall and that higher illumination levels support greater mental acuity. These kinds of results make it clear why the US Green Building Council emphasizes the productivity benefits of daylighting.[12,13]

In scores of other studies, energy-efficient lighting design and the use of daylighting are linked to improved employee satisfaction with the workplace and significant increases in worker productivity. Good artificial lighting and adequate daylight have been found to reduce absenteeism by as much as 15% and to increase productivity by between 2.8% and 20% [14,15]. It appears that natural light's contribution to preventing eye strain, improving mood and helping people

retain information are factors in boosting productivity.[12,16] In contrast, poor lighting in the workplace leads to excessive sick days, discontent, turnover and poor quality work.[14,17]

– At **Compaq**, increased daylight in the building was associated with a 55% increase in worker productivity and a savings of approximately $1 million a year in reduced energy costs.[6]

– A 2003 study by the **California Energy Commission** found that exposure to daylight was consistently linked to higher levels of concentration, better short term memory and increased school performance.[18,19]

– At **VeriFone**, a subsidiary of Hewlett Packard, skylights and other energy-efficient features were installed in their Costa Mesa, CA complex of offices, warehouse and light manufacturing facilities. On sunny days, workers used the natural daylight and small task lights. Complaints about headaches and sluggishness dropped and absenteeism decreased 45-50%. The company reported energy bills reduced by 50%. But even more important, employee productivity increased 5%, reducing the payback time from the initially estimated 7-1/2 years to one year, a 100% return-on-investment.[6,20]

Lessons Learned:

The links between lighting and productivity have a widespread impact. A 1997 ASID study determined that 68% of employees complain about the light in their offices. A 1991 Steelcase survey found that 44% of office workers and 64% of computer users considered eyestrain due to glare to be the leading health hazard in the office.[21]

Control, Satisfaction and Productivity

Research from the fields of psychoneuroimmunology makes it clear that personal control over the environment boosts immune function. When we do not have control over annoying or distracting environmental features such as glare, noise or uncomfortable temperatures, our bodies experience a brain-based vigilance which distracts us from work-related tasks. The power of personal efficacy is so strong that an individual's immune function is improved even when they are only led to believe that they have control over an unpleasant stimulus, psychology research studies show.

There are a number of ways in which control works to support employee productivity.

– First, control allows employees to customize their environments in ways that are more supportive of the individual's attention, memory, comprehension, ability to concentrate, and motivation, all building blocks of productivity.

– Second, employees' ability to control light, noise and temperature conditions is a significant factor in their satisfaction, which can translate into improved productivity.

– Third, personal control over environmental factors directly affects mood, increasing worker satisfaction.[22]

Researchers have found that job satisfaction accounts for 63% of the variance in commitment to the organization.[23] Commitment is important because employee turnover costs range from 1.2 to 2 times an individual's annual salary. Furthermore, it is estimated that new employees do not reach maximum efficiency and performance until they have been on the job 12 to 14 months.[24,25] By providing employees with control over light and air temperature, retention of employees alone may well pay for energy-efficient design features that contribute to employee satisfaction.

Control over Light. Consistent with our understanding that light is a critical factor in the workplace and that the ability to control our physical environment is a crucial element in health and well-being, researchers have found that control over lighting appears to be an important influence on employees' attitude toward their surroundings, and by extension, on their productivity. A 2003 study showed that workers who were more satisfied with their lighting were also happier, more comfortable and more satisfied with their immediate environment and with the work environment as a whole.[28] Dr. David Wyon of Denmark's National Institute of Occupational Health estimates that providing individual control over lighting and/or temperature can improve performance between 2.7% and 8.6%.[23] He has also shown that workers who are satisfied with their environment are up to 15% more productive than those who are not[35]. Other researchers have found that workplace characteristics account for as much as 31% of the variance in work satisfaction and that on average, the workplace makes a 5% contribution to individual performance and an 11% contribution to team performance.[26,27]

– The **Light Right Consortium** found that workers who had a light-dimming control for overhead light fixtures showed more sustained motivation and improved levels of attention, persistence and vigilance, all measures of motivation. In another example of the links between sustainability and productivity, this study found that employees who have light-dimming controls chose light levels that were lower than the standards, suggesting that individual dimming controls may also make an additional contribution to energy savings.[29]

Lessons Learned:

Architects, building owners and tenants should try to place the majority of staff workstations so that they have direct or indirect access to natural light. For new construction, light shelves that project natural light into the interior of the building should be considered. Employees should have a variety of lighting options they can control, including task lighting, and, where possible, overhead lighting.

Acoustic Factors in Productivity

The acoustic environment is a control issue that must be addressed in the early stages of design because solutions to noise problems are mainly systemic interventions. Recent research makes it clear that noise is the number-one impediment to workplace productivity.[29,30]

Noise distractions undercut an employee's sense of control over the environment. Noise affects short-term memory and causes employee stress by impairing focus and concentration. A 2006 ASID study found that 70% of office workers felt they would be more productive if their offices were less noisy, and those surveyed reported that the lack of auditory privacy affects their job satisfaction and performance.[32]

In employee surveys about noise, overheard conversation is named as the chief complaint. The widespread adoption of the open office plan has lead to greater challenges in the area of privacy and sound control because human speech is intelligible up to 50 feet away. There are many design-based factors that affect acoustics in the workplace, including the ceiling system, lighting fixtures, office furniture partitions, cubicle fabric, acoustical insulation and partition height, as well as floor covering.[33] The manufacturers for all these design elements have begun to produce sustainable versions of their products.[34]

Sound-masking. A 2002 study conducted by Herman Miller assessed the effect of two types of sound-masking systems on the productivity of 136 employees. Researchers found that a sound-masking system increased employee productivity, with a 51% improvement in reports of sound distraction, 48% improvement in employee's ability to focus on tasks, and nearly a 10% improvement in employee short-term memory and accuracy. Employees reported up to a 27% decrease in stress reduction and increases of 125-175% in satisfaction with the work environment. The researchers noted that the "ideal sound-masking solution makes speech beyond a 12 to 16 foot radius unintelligible so a person can concentrate on his or her work, collaborate with colleagues, and be more productive." [35]

Lessons Learned:

Noise, and particularly human speech, is considered to be the primary problem in workplace productivity and worker satisfaction with the work environment. The capacity to concentrate, short-term memory and accuracy are all affected by noise distractions. The widespread use of open plan work environments has forced employers to address acoustical issues as serious impediments to overall employee well being and productivity. Sound masking systems, appropriate finish materials and more sensitive office design can be used to address the problem of noise distraction.

Studies That Directly Measure Employee Productivity & Sustainability

Much of the recent research on sustainable design focuses on the improvement in air quality and physical health but does not directly address the human factors related to employee cognitive function and psychosocial well-being that are enhanced by contact with nature and sunlight penetration. The literature in psychology showing that positive emotions are associated with creativity and improved cognitive functioning is certainly relevant to investigations of worker productivity.[7]

A study of over 2,000 office workers in six US geographic regions and eight different industry groups showed that 20% rated their current physical workplace as being "fair to poor" and 33% believe their office design does not promote interaction, collaboration or teamwork among colleagues, factors that most employers seek to support. Chief complaints included lack of space, too few quiet areas, uncomfortable workstations, poor layout, and an unhealthy work environment.[41]

The four studies outlined below describe pioneering projects that clearly show the direct connection between sustainability and employee productivity.

– A 1986 retrofit of the **Reno Post Office** was originally intended to reduce energy use. The Post Office compared the effects of improved lighting and a lowered ceiling in one area of the building with an unrenovated portion of the plant. In the first 5 months, productivity in the retrofitted area increased 8%, leveling off to 6% after a year. In addition, sorting errors dropped to 0.1% in this quieter and better-lit area of the facility.

The projected energy savings for the building was approximately $22,400 a year, with additional savings on ceiling maintenance of $30,000 a year. The combined savings of $52,000 represented a 6-year payback period for the renovations. More important were the productivity gains, estimated to be worth $400-500,000 a year. These gains effectively paid for the entire renovation in less than one year.[6]

– At **Herman Miller**, a pre/post-occupancy study revealed that workers who moved into a new daylit, green facility rated their new work environment as 17% more positive; 20% of the workers reported an increased sense of well being while at work, and there was a 25% increase in the number of workers who said they looked forward to going to work. Workers reported higher job satisfaction and a greater sense of belonging to the organization after moving to the new building, and 60% perceived the new building as healthier. Workers said the daylit interior made it easier for them to relax and gave them more contact with nature.

Herman Miller realized an annual energy savings of more than $35,000. But more important, although it is not atypical for a company to report a drop in productivity following a move, Herman Miller reported an increase in productivity in the nine months following its move, with worker effectiveness rising from 98.54% to 99.53% and work quality rising from 98.7% to 99.23%.[7,42]

– A study conducted at **West Bend Mutual Insurance** headquarters is one of the most carefully documented instances of increased productivity directly attributable to sustainable design. The new headquarters incorporated a wide range of sustainable design features, including an energy-efficient lighting system, improved windows, shell insulation, a raised floor system, and an efficient HVAC system. Ninety-two percent of the workstations were located on the perimeter next to the windows. A main feature of this study was the introduction of 370 "environmentally responsive workstations" (ERW) equipped with individual controls over temperature, air flow, lighting and white noise.

Compared with their previous building, West Bend reported a 40% reduction in energy costs (annual savings of $126,000) and a 16% productivity increase of which approximately 4-6% was attributed to the ERW's. Complaints about thermal comfort dropped from 40 per day to 2 per week, representing a documented cost savings of at least $5,000 every week. Researchers concluded that the ERW was responsible for an increase in productivity of approximately 2.8%. With the company's annual payroll estimated to be approximately $13 million, this 2.8% gain in productivity translated into a financial benefit of $364,000-$500,000 per year.[6,58]

– In the Netherlands, when **ING (International Netherlands Group)** bank developed a building that integrated art, natural materials, sunlight, energy conservation, low noise and water, absenteeism dropped 15% compared with their previous building. Similarly, at the Netherlands' **NMB Bank Headquarters** an annual energy savings of about $2.4 million resulting from daylighting and energy conservation systems was accompanied by a reduction in staff absentee rates. [6,44]

Research Review Conclusions:

Sustainable, energy-saving "green design" building elements not only yield reduced energy costs, but contribute even more significantly to the bottom line through increased work output, improved employee attendance and reduced employee turnover.

These impacts derive from employees' responses to natural daylighting and improved light conditions, including increased mental acuity and memory; from their opportunities to control light, air temperature and other environmental factors at their workstations; and from improved mood and levels of satisfaction.

Noise control and acoustics, also significant factors in employee satisfaction and productivity, are not generally included in sustainable design frameworks but should be addressed by employers seeking productivity gains.

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