Improving Health and Productivity via Sustainable Design

Honors Thesis

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ABSTRACT

Sustainable architecture is growing in popularity and scale across the United States and throughout the world. This architectural paradigm employs sustainable means to create energy efficient buildings that impact the environment in less degrading ways. Sustainable architecture strives to reduce energy consumption, use safer building materials, and construct buildings in locations that respect the environment. Behind the veil of green and eco-friendly efforts, however, lies a far more remarkable source of value. Even though sustainable architecture proudly markets increased energy savings, fewer carbon dioxide emissions, and decreased water use, research suggests that sustainably designed buildings increase human health and productivity of building occupants. The value generated from improved human health and increased occupant productivity may considerably surpass the benefits most commonly associated with sustainable architecture.

Research in schools, offices, and hospitals reveals how sustainable architecture can be used to improve the environments in which individuals work. The health benefits of sustainable architecture include improvements in air quality, moods, and overall well-being. Sustainable architecture emphasizes the use of products that do not emit or contain chemicals that may harm humans or pollute indoor air. By using fewer harmful chemicals during the construction phase of buildings, fewer chemicals are present that could be detrimental to human health. Humans spend most of their time indoors, where the air quality is often worse than outdoors, so providing more comfortable places to work improves how people work and live. Also, sustainable architecture improves how efficiently individuals work and how much they accomplish. Studies suggest that occupant productivity can be increased by incorporating nature into buildings. By using natural aspects of the environment, such as introducing sunlight or plants into buildings, indoor settings

promote greater concentration and accomplishment. Sustainable architecture focuses on designing buildings that allow sunlight into buildings and provide views of nature so that occupants can work in comfortable and inviting areas. Sustainable architecture generates much more value from improved human health and increased productivity as opposed to energy savings and water use reductions.

INTRODUCTION

Sustainable architecture is growing in popularity and scale across the United States and also throughout the world. This branch of architecture employs sustainable means to create energy efficient buildings that impact the environment in less degrading ways. The modern ecological movement has allowed this process to become more widespread in communities. The main priorities of sustainable architecture are to reduce energy consumption, use safer building materials, and construct buildings in locations that respect the environment. By considering what means are used to construct, power, and operate these buildings, human impact on the environmental is reduced. Behind the veil of green and eco-friendly efforts, however, lies an even more remarkable source of value provided by sustainable architecture. An emerging but active field of research has unveiled considerably more benefits to promoting sustainable architecture in the forms of health and productivity. The value generated from improved human health and increased occupant productivity may considerably surpass the benefits most commonly associated with sustainable architecture. Even though sustainable architecture decreases energy costs and improves efficiency, the most significant benefits are generated from increases in improved human health and occupant productivity.

SUSTAINABLE ARCHITECTURE

Sustainable architecture encompasses many different aspects of building design, material use, and building locality to produce benefits to the environment and the occupants within each building. Sustainable architecture is defined by the Environmental Protection Agency (EPA) as "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction." This process has been given various names, including green design, environmental architecture, sustainable development, and a host of other names, but no matter the name of the process, the end goal remains the same. All aspects of sustainable architecture seek to reduce resource use and improve the health of the environment.

Even though some forms of sustainable architecture have existed as long as humans have constructed buildings, sustainable architecture did not gain considerable momentum until the early 1990s. Before the times of electricity, homes had to be well lit by windows that let in natural light. Also, homes did not have central air conditioning systems, so homes had to rely on windows and doorways to ventilate homes. Both examples relied on the natural world to provide services that were later replaced by electricity and heating and cooling systems. With advancements in technology, human behavior favored updated means of constructing, fueling, and maintaining structures that were not always protective of the environment. The modern environmental movement of the 1960s and 1970s helped begin the paradigm shift towards a sustainable future, however. This change of thinking and behavior helped renew the importance of the natural world and humanity's role in it. This movement helped bring awareness to the resources humans were exhausting and the ecosystems that were being destroyed. The paradigm

shift did not reach buildings and structures until the 1990s when architecture and urbanism were viewed as the most influential means of promoting sustainable development (Baweja, 2014). Since Americans spend nearly 90% of their time indoors, buildings and homes needed to be scrutinized to reduce resource use (EPA, 2014). This time period created the foundation for sustainable architecture to grow rapidly in the upcoming decades.

The United States began expanding programs that focused on sustainable development through the 1990s and until the turn of the millennium. Notable progress included the Energy Star Program developed by the EPA and Department of Energy in 1992, which focused on allotting homeowners and businesses the resources to efficiently use energy and save money. This program was one of the first to create consistency within green building by placing Energy Star labels on products that met EPA standards for efficiency so that consumers could choose the best products to save money and energy. In the following year, the United States Green Building Council (USGBC) was founded to fundamentally change the design, construction, and operation of buildings. The USGBC further progressed its mission of promoting sustainability in architecture by implementing the Leadership in Energy and Environmental Design (LEED) system in 2000. LEED has become the flagship program for green architecture in the United States and also around the world (USGBC, 2015). LEED awards certifications for buildings that meet specific criteria based on the design, construction, maintenance, and operation phases of buildings. Buildings satisfying more criteria received a higher score and a higher certification level for each building. Certification levels include certified, silver, gold, and platinum. Buildings satisfying over 80 different credits will receive a platinum rating, while buildings only satisfying 40-49 of the prerequisites and credits will only claim a certified ranking. LEED is considered one of the most prestigious certifications in regards to building sustainability (NRDC,

2013). LEED continually improves and advances its criteria to improve architecture around the world.

LEED

LEED categories were formulated to support sustainability through the conservation of energy and resources in buildings. The rating system's categories include location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, regional priorities, and innovation. LEED also incorporates integrative processes to favor activities combining different categories. Categories also vary in regards to the type of building that is being constructed or retrofitted. LEED includes criteria for projects such as new construction, indoor renovations, neighborhood developments, and homes that are tailored to suit each building project and maximize efficiency.

LOCATION AND TRANSPORT

The first category to discuss is the location of each sustainable building and its relationship to transport. This category takes advantage of existing infrastructure near buildings to respect the environment. Credits are awarded for utilizing the surrounding area of a building without wasting any valuable or sensitive space. Credits can be awarded for siting a building within a half-mile of either public or private transportation routes. This allows occupants to have more sustainable options for reaching the workplace. In addition, sensitive sites near buildings can be slightly altered to provide more value to human health and also the environment. Sites such as natural ecosystems, waterways, and wetlands can have sustainable buildings in close proximity only if slight changes are made. To encourage people to experience and appreciate these sensitive sites, walk or bike paths may be added to each area. Also, LEED recommends

expanding biking facilities to encourage more employees to bike to work. With adequate facilities, including reliable storage of bikes and having on-site showers, more occupants will bike to work (Green Buildings Elements, 2014). By focusing on existing services and infrastructure near buildings, this category reduces the number of vehicles entering and exiting the area.

SUSTAINABLE SITES

The next category focuses on creating a smaller footprint on the natural environment. LEED rewards facilities that conduct an initial survey of the site to determine the most beneficial sustainability methods. The assessment includes topography, soils, vegetation, human health effects, and other areas. By considering these factors at the outset, architects can design buildings that coalesce with the natural environment. Next, this category includes points for engaging in pollution prevention tactics during construction. Instead of managing pollution after construction, LEED encourages contractors to include plans to control erosion and waterway sedimentation so less pollution is generated through construction processes. This approach improves the environmental quality surrounding sustainable buildings and also provides a more aesthetic view for occupants to enjoy. In addition, construction teams are encouraged to reduce the amount of light pollution resulting from building construction. The intent of this credit is to reduce how people and biota are affected by the presence of light and light structures. LEED guides buildings to find a balance between providing the proper visibility at nighttime but also not using considerably bright lights that may degrade night sky access. Lastly, this category includes a credit for providing direct access to outdoor space that can be enjoyed by occupants. Outdoor areas can range from gardens to recreation areas to walk paths that are vegetated. These

areas can also be protected or restored habitats for occupants to enjoy (USGBC, 2015). This category ensures that buildings respect and use the natural capital that surrounds buildings.

WATER EFFICIENCY

The Water Efficiency Category encompasses the many different ways water is used collectively in each facility. This category first places emphasis on reducing water use both inside and outside. LEED rewards buildings that reduce the overall use of water. For outdoor water use, LEED suggests limiting the use of nonvegetated surfaces, such as concrete or asphalt. These surfaces do not retain the water that passes over them, so implementing more areas with soil to capture rain water would prevent runoff around buildings. In the indoor context, LEED awards points for installing fixtures and appliances that include WaterSense and Energy Star labels. WaterSense products are high performance and can save water and energy through efficiency (WaterSense, 2015). Products that are labeled by this partnership with the EPA includes toilets, faucets, and showerheads. By installing these new and efficiency fixtures, buildings can reduce their total water consumption by 20%. To further reduce water consumption, LEED suggests continually tracking aggregate water use (USGBC, 2015). Further water savings can be realized by continually tracking, evaluating, and implementing changes to improve how water is managed by using water meters. All of these steps are useful to properly preserve water on the planet.

ENERGY AND ATMOSPHERE

To address issues associated with energy use and atmospheric impact, LEED created the Energy and Atmosphere category to encourage methods that reduce energy use, promote energy efficiency, and utilize renewable energy sources. For a building to receive points from LEED,

each building must meet the requirements for the minimum level of efficiency. All new structures must improve efficiency by at least 5%, and major renovations must achieve a 3% improvement. This requirement must be met before any other credits can be awarded for this category. This approach by LEED ensures that new buildings and renovations can in fact achieve energy efficiency marks before acquiring LEED certification. Next, LEED takes steps to prevent ozone depletion in the atmosphere. LEED prohibits using chlorofluorocarbons (CFCs) in heating, ventilation, air-condition, and refrigeration systems. For buildings that still have CFCs in these systems, a phase-out must be conducted and completed. The reduction of CFCs at the source helps certified buildings generate a smaller impact on the atmosphere. LEED also awards points for increasing the percent of renewable energy that is generated by a building. This approach allows buildings to reduce fossil fuel use and also reduce energy costs. To supplement renewable energy sources, LEED also suggests using green power and carbon mitigation to reduce emissions. For buildings lacking the space or infrastructure to fuel the entire buildings, contracts can be formed with other entities to supply energy, where 50% to 100% is generated by a renewable energy source (USGBC, 2015). Overall, this category exists to optimize how energy is used and how buildings can impact the atmosphere in less degrading ways.

MATERIALS AND RESOURCES

For this category, LEED improves the life-cycle of the materials used in the building process to ultimately improve the efficiency of resource use. During construction, a management plan of construction waste must be completed. This plan must show how materials can be reduced, reused, or recycled before disposal is considered. This helps improve how waste is handled and reduces the amount of waste that reaches a landfill or is incinerated. Also, LEED encourages the use of materials that provide life-cycle information. The information found on

these products helps construction teams choose products that are sustainably generated or have fewer harmful components. By verifying this information, buildings are constructed with materials that are better for the environment than traditionally used materials. Additionally, LEED awards points for reducing the impact of construction as a whole. Methods can include reusing historical buildings, renovating existing buildings, or reusing or salvaging materials from other sites. These methods required less materials and reduce the amount of raw materials required in the construction process. Upon completion, LEED certified buildings must have areas reserved for the collection and storage of recyclable materials. A visual example of recycling helps occupants of buildings use and dispose of materials more carefully (USGBC, 2015). This category seeks to reduce the amount of waste and pollution generated by carefully monitoring the life-cycle of materials and also implementing reduction, recycling, and reusing techniques.

INDOOR ENVIRONMENTAL QUALITY

The Indoor Environmental Quality category places emphasis on improving the air quality and comfort of interior environments. For this category any building wishing to reach certification must first prohibit smoking indoors and also outside of the structure. Occupants of buildings who smoke are only allowed to smoke in selected areas that are at least twenty-five feet from the building. This requirement is also bolstered by prohibiting the use of tobacco during the construction and preoccupancy stage. By limiting smoking to certain areas, the amount of secondhand smoke entering doorways and air intakes is considerably reduced. Next, to improve indoor environmental quality, LEED-certified buildings are built and furnished with products that are less degrading to the environment. Before products are able to be placed into buildings each must pass tests to determine volatile organic compound (VOC) emission levels. Materials are divided into several categories, including paints, adhesives, flooring, ceilings,

walls, and furniture, and each category must not exceed VOC thresholds. Indoor and outdoor materials both have several different requirements and thresholds for the amount of VOC content in materials that can be accepted. By reducing the amount of VOCs in products at the purchasing and installation phase, the indoor environment will be much healthier. Furthermore, this category encourages lighting rooms and areas in ways that can be adjusted to meet occupant needs. This is useful for light fixtures, window blinds, and natural light that are present throughout LEED buildings. A positive and productive work environment is created by giving individuals the opportunity to choose the lighting that is best suited for their needs or current task. Next, this category also places an emphasis on providing aesthetically pleasing views for occupants. These views can include unobstructed views of animals, plants, or the sky in settings that are changing often. The use of natural, nonstatic views allows occupants to appreciate the natural environment while still remaining in the confines of his or her workspace (USGBC, 2015). This LEED category serves to continually improve the indoor environment by making all spaces inviting and comfortable for occupants of LEED buildings.

INNOVATION

LEED also places a specific emphasis on innovation to ensure that buildings are designed in ways that continue to improve human performance and protect the environment. In the Innovation category, project teams are given the opportunity to create their own category to augment the green design process. Teams can address problems that may be specific to their needs but not yet required or recommended by LEED. To do this, designers must give the intent, requirements, and strategies of their proposed category so that it can be tested and replicated in the future. If this is not a feasible route for teams, LEED also provides credits for testing out pilot programs that have been created but not yet tested for effectiveness. Designers and constructors

of buildings can use either or both of these strategies to further improve the eco-friendliness and sustainability of their buildings (USGBC, 2015). The emphasis on continuous improvement by designers and LEED itself allows for new methods and strategies to be implemented and improved upon continually.

REGIONAL PRIORITIES

The final category for LEED certification is the Regional Priorities category. This category attempts to solve problems that are distinctive of certain areas of the country and the world. Volunteers from different USGBC and LEED chapters identify the problems that one or several areas face and then prioritize LEED requirements to solve those regional-specific problems. Credits are formulated to either eliminate environmental concerns or accentuate environmental assets that are found in select regions (USGBC, 2015). This approach allows teams and LEED officials to determine what LEED is lacking in certain areas and articulate new methods to improve the environmental situation in those areas.

RESEARCH

While LEED has made consistent progress in finding ways to improve human and environmental health through green design, additional research has been undertaken to further unlock the potential benefits of sustainable architecture. Most research in this field has only focused on the financial and environmental effects of green design. The available literature only discloses a portion of the benefits associated with this topic. Research concerning productivity and human health benefits is growing, but more in-depth research is required before green architecture becomes the norm in building construction today. As sustainable development

becomes more ubiquitous, more research must be performed to fully expose and increase the awareness of the benefits of sustainable architecture on the health and productivity of occupants.

One study sought to determine how green architecture can improve work environments. Howard Frumkin and Christine Coussens from the Institute of Medicine compiled a report that discussed how the current architecture of buildings makes workers sick. Sick building syndrome is the name given to the broad spectrum of symptoms experienced inside buildings, particularly those with poor ventilation (The Environmental Illness Resource, 2015). Symptoms include headache, nausea, wheezing, fatigue, fever, and a host of other ailments, but determining the exact cause of sick building syndrome is difficult. Since the quality of the indoor air is a combination of the materials within the building and also the outdoor air that is ventilated indoors, sick building syndrome cannot be traced to one chemical specifically (Institute of Medicine, 2007). Sick building syndrome greatly concerns individuals who have respiratory problems, such as asthma. Symptoms observed in these individuals pose a greater danger than healthier individuals, but all individuals indoors can still be affected by sick building syndrome. To combat this issue, Frumkin and Coussens generated a guide to promote better indoor air quality. The four steps that were vital to improve air quality of buildings are source control, ventilation control, building commissioning, and maintenance. Source control focuses on eliminating the origin of pollutants from the start or reducing the amount of contaminants that enter buildings. With fewer pollutants indoors, fewer individuals will have the symptoms associated with sick building syndrome. Next, ventilation control requires having the proper methods to ventilate pollutants and eliminate their presence indoors. Buildings should have updated systems that ventilate all areas of the building efficiently in order to dissipate the pollutants that exist in buildings. Third, the authors recommend that ventilation performance

specifications should be tested before being installed to ensure that the technology performs well enough to reduce indoor air quality issues. If ventilation systems are tested before being used, buildings will be able to remove indoor air contaminants as promised by performance standards or be improved to meet standards before being fully installed and utilized in buildings. Lastly, buildings must be properly maintained to sustain the proper level of ventilation through the life of the building. Regular cleaning and maintenance repairs will extend the life of ventilation systems and maintain the needed level of efficiency to reduce sick building syndrome symptoms (Institute of Medicine, 2007). This approach given by Frumkin and Coussens should be applied to all new buildings projects and especially those that are promoting green building design. The steps given will allow proper ventilation in buildings and improve the health and comfort of building occupants.

Another study focused on improvements in occupant productivity and comfort. Annika Feige and a host of other researchers from Switzerland composed a report detailing the impact of sustainable development on people's output and well-being. To achieve the purpose of the report, the researchers observed over 1,500 employees in 18 offices. First, the report defines comfort and productivity. The researchers defined comfort as the lack of unfavorable conditions (Feige, et al., 2013). Since determining what each person finds to be comfortable can be difficult, researchers settled on determining what most people find unpleasant in the workplace. Next, the report defines productivity as output divided by input and also as company turnover divided by the number of employees (Feige, et al., 2013). Outputs can include services and value provided by workers, and inputs can include money, energy and the work environment. Company turnover can also be included in productivity because if employees miss work or lay-offs occur, the organization will not be as productive as one with full attendance. By assessing

productivity and comfort in green design offices and non-green design offices, the report attempts to determine the benefits of sustainable architecture.

The results of the study showed that employing sustainable design methods improves productivity and comfort of building occupants. In the several of the offices, changes in temperature, air quality, and lighting were used to see how productivity and comfort reacted. By keeping the indoor temperature below 75˚ F, the study found that performance and productivity was increased, while temperatures above 75˚ F decreased productivity. Improved air quality also resulted in higher comfort and productivity. By removing old carpet and other VOC-containing materials, improved air quality amplified performance and also reduced the dissatisfaction rate of the work environment. Lastly, buildings that provided adjustable windows and increased natural light to occupants to provided more comfortable workplaces. By giving occupants the opportunity to change lighting conditions to their own preference, more occupants were able to achieve more while being more comfortable. Overall, all of these changes helped reduce the effects of Sick Building Syndrome and provide a more comfortable and engaging workplace for the occupants. Furthermore, the study found that buildings that were certified versus those that were not certified also made a difference. The study observed some of the offices before and after being award a green building certification and found that productivity increased by 5% and the number of sick days decreased by 3% (Feige, et al., 2013). By providing more comfortable and engaging areas for occupants to complete their work, occupants are able to work more productively and also remain at work.

LEED encourages providing natural light in buildings, and research has shown that the presence of natural light increases worker productivity. One study revealed research on the effects of using natural lighting in offices, schools, and businesses. For offices, providing

numerous sources of natural light leads to better overall health, reduced absenteeism, and improved productivity (Edwards and Torcellini, 2002). Office workers reported that being near windows or skylights generated positive effects on their well-being. Research has shown enough evidence of benefits to occupants that several countries of Europe have crafted laws to ensure that workers spend a majority of their time near windows. Additional benefits of natural lighting include fewer headaches experienced in workers. These individuals can concentrate better on their work when exposed to natural light sources. Natural daylight improving the health and productivity of occupants shows why buildings should not depend on artificial lights that are common today.

Students and teachers also realize benefits when schools harness natural light and provide areas of study with windows. Overall, students and teachers both have better attendance and perform at higher levels in classrooms lit by natural sources. Daylighting schools creates a less stressful environment where all individuals can maximize performance. In addition, students achieve more when learning and testing in rooms with windows. According to a North Carolina study, students testing in daylit areas attained higher scores in math and reading than traditionally lit buildings. Furthermore, research has also revealed that windowless rooms have considerable negative effects on students. Students in classrooms lacking windows tend to be less attentive and more unpleasant which leads to poor performance and increased stress for teachers. Lastly, daylighting also allows students to experience fewer cavities and eye problems when in the presence of natural light. The vitamin D provided by the sun decreases the amount of tooth decay that child suffer from. By receiving more vitamin D, students get fewer cavities and have a lower level of tooth decay. Natural light also reduces the presence of eye problems. Traditional lights flicker and buzz which causes students to strain their eyes. Natural light

provides a higher quality of light that traditional lights can, so replacing artificial lighting with sunlight improves how students focus and learn (Edwards and Torcellini, 2002). Strong evidence exists to show that providing natural light in schools promotes improved performance, reduced stress, and better learning for students.

Natural lighting has also been shown to increase productivity and overall well-being in retail stores. The effects of providing natural light through skylights has led stores to apply sustainable architecture for more reasons than energy savings alone. The presence of natural light in stores creates a more inviting and attractive environment for customers to shop. The most common way to incorporate natural light in retail stores is by installing skylights throughout the store. Skylights allow stores to feel more open, brighter, and cleaner, according to a study by the Heschong Group in California. The study surveyed shoppers in over one hundred stores to compare the contrasting experience of stores with skylights and those without natural light. Stores with skylights were able to attract more customers and improve how customers shopped (Edwards and Torcellini, 2002). Furthermore, many retailers recognized an increase in sales by utilizing skylights. Wal-Mart began piloting means to increase sustainability in the early 2000s to reduce energy costs. One store in Lawrence, Kansas tested a daylighting system to determine how much money could be saved by replacing artificial lights with skylights. Wal-Mart installed the new skylights in half of the store and used standard light fixtures in the other half. The store realized considerable costs savings, but the skylights unexpectedly created an even bigger impact. The daylit areas of the store generated higher sales and employees were more comfortable and productive in these areas. Employees working in the naturally lit areas noticed that products under the skylights sold more quickly than similar products in the artificially lit areas. To ensure that the natural light was the root cause of the sales increase, the store switched

the products and examined the results. Once again, the products in the areas lit by the skylights sold in higher quantity than the other similar products. After discovering this impact, Wal-Mart began emphasizing daylighting systems in stores around the world. Today, out of over 11,000 stores worldwide, over 3,000 supercenters are naturally lit to improve the shopping experience for customers, improve sales, and improve the productivity of workers (Bristolite, 2013). Natural lighting has the ability to positively improve retail environments for customers and even employees.

Further studies concerning worker productivity in sustainably designed buildings were conducted by Brian Edwards and Emanuele Naboni. In their book "Green Buildings Pay," the authors discuss the benefits of a well-designed structure for occupants and the companies they work for. First, the researchers suggest that architecture should focus more on worker productivity as opposed to energy cost savings. Edwards and Naboni state that improvements in production are greater than cost savings (Edwards and Naboni, 2013). Both authors found that even a small increase in productivity could cover the energy required to power buildings. The cost of labor and resources that employees use greatly outweighs the cost of energy per person, so the authors believe more emphasis should be placed on improving how occupants work. Poor work environments lead to absenteeism and illnesses that cost companies more money than energy costs. If a building is designed well enough that it requires little energy but the work environment does not promote the best work out of occupants, the energy cost savings would not be worth the investment in green design. Next, well-designed workplaces improve the quality of work completed by occupants. When workers are immersed in healthy and comfortable areas to work, they are able to think more attentively and creatively, which leads to new products and new ideas. Businesses should focus on providing the proper environment for employees to work

and collaborate in. Also, employing sustainable methods and design is beneficial to companies as a whole. When a company declares a commitment to sustainability, the company's image becomes more favorable to potential customers and future employees (Edwards and Naboni, 2013). An improved image could lead to an increase in sales, workforce morale, and also recruit better talent. Companies that are passionate about protecting the resources of today's world can perform a higher levels by having a healthier and more motivated workforce.

Sustainable architecture will also play a significant role in improving the health of patients, visitors, and workers in hospitals. Robin Guenther states that humans cannot rely entirely on medicine to improve the health and well-being of people. Guenther recognizes that traditional architecture relies on a set of assumptions and norms that disregard creating structures that promote better living conditions (Guenther, 2009). Architecture today needs to include ways to make hospitals and other healthcare facilities healthier. Guenther exposes the need for architects to work with healthcare professionals and commit to improving the quality of patients' lives while still respecting the environment. Ways that buildings can be constructed to improve the health of occupants are improving air quality and designing for wellness (Guenther and Vittori, 2008). To improve air quality in hospitals, several approaches can be initiated. First, in the design and construction phases, limiting the number of harmful chemicals inputs improves air quality from the beginning and requires no further engineering or personal protective equipment at later stages. The use of materials that emit less harmful chemicals is vital to improving air quality for all those who enter hospitals. Second, to reduce the impacts on worker safety, green chemicals are being introduced into hospitals to achieve the same level of cleanliness but without the harmful chemicals or side-effects (Guenther and Vittori, 2008). Nurses and other workers in hospitals are the individuals directly exposed to harmful cleaners

and must be protected as well. Furthermore, hospitals can be designed for wellness to improve the health of all those who work at and visit hospitals. One example of this is by designing hospitals in ways that reduce moisture and mold. Buildings can prevent moisture buildup by installing vapor barriers in walls and roofs (Prowler, 2010). This is especially important for patients who have allergies and could be sensitive to mold. Without moisture buildup indoors, mold will not be able to develop as easily. Also, another route of designing for wellness is including views and nature areas for patients and visitors to enjoy. The psychological benefits of being surrounded by nature include feeling healthier and happier, which can improve how patients and workers feel when inside hospitals. Hospital rooms should have windows that allow patients to view some aspect of nature to enhance the healing process. Also including a natural area for patients to walk through can boost healing (Guenther, 2009). A connection to the outdoors should be supplied by hospitals so patients can breathe fresh air and receive the benefits of sunlight. If changes such as these become prominent in hospitals today, patient recovery time will decrease and visitors will experience better conditions.

LEED BENEFITS TO HUMAN HEALTH AND PRODUCTIVITY

While green architecture creates an energy-efficient structure that is beneficial to the environment, these buildings also improve the health of occupants. Humans spend approximately 90% of their time indoors where the air quality is often worse than the outdoor air (Westervelt, 2012). The lower quality of air indoors can be attributed to the materials found within buildings and also poor ventilation within buildings. LEED seeks to improve the air quality of buildings by reducing the amount of products and materials that emit harmful gases, such as VOCs, indoors where workers are exposed in confined spaces. When LEED requirements are satisfied, the indoor air pollutants are reduced at the source, which improves the air that occupants breathe in

at work. This is particularly important for individuals who have respiratory issues such as asthma. These people are more sensitive to harmful contaminants in the air and are more likely to require medical attention when contaminants reach a harmful level. LEED makes indoor air quality a priority when buildings are being constructed and also when they are ready for use to improve the health of occupants.

Another human health benefit of LEED is the use of infrastructure near certified buildings. LEED encourages constructing buildings near multiple forms of public transportation. Sustainably designed buildings are placed in locations so that the most individuals can utilize public transportation without requiring much extra effort or difficulty. When buildings are placed next to several bus routes, fewer people will drive to work because of the added convenience. The Location and Transport category of LEED also encourages buildings to provide bicycle access for occupants. In addition to providing access for bicycles, buildings should provide locker rooms and showers for the individuals who wish to bike to work. This initiative allows more people to bike to work because the individuals will be able to take showers and change into work attire upon arrival. Before this, workers were not motivated to bike to work because of the hassle created by getting their work clothes dirty or not having an adequate space to change. While on the outside, sustainable design may seek to reduce the number of vehicles traveling in and out of facilities, LEED guidelines encourage occupants to bike or walk to work, which improves human health.

LEED also encourages buildings to incorporate nature directly into buildings or provide direct access to nature for occupants to improve the quality of indoor environments. Green design respects sensitive areas of nature by preserving their beauty and also providing access for humans to enjoy them. LEED encourages buildings to incorporate the use of plants or gardens

indoors to improve air quality and also provide beautiful aesthetics for occupants to enjoy. Despite the lack of a category dedicated to indoor plant life, buildings can still include plants indoors to bolster the air quality benefits provided by plants. Buildings seeking to receive a credit for including plant life can create a specific use for plants under LEED's Innovation Category (Green Plants for Green Buildings, 2015). LEED awards points, however, for providing areas for occupants to immerse themselves in natural environments. Sustainably designed buildings providing a direct connection to nature benefits occupants by improving their well-being. Occupants can enjoy nature without having to change locations and can enjoy the health benefits of fresh air and sunlight without much hassle. Buildings that make efforts to incorporate nearby gardens, forests, or wetlands without disturbing them improve human health and well-being.

Employing sustainable architecture in hospitals will be vital in reducing human health complications in the future. Since the symptoms associated with sick building syndrome are prevalent in current architecture today, architects and design teams must be able to design for wellness in the future in hospitals and other healthcare facilities. LEED encouraging teams to reduce the amount of harmful chemicals inputs in construction and also limiting the amount of harmful chemicals during the operation of buildings will be vital to protect the health of patients, visitors, and workers. Source reduction has been proven to be the most effective method in creating better indoor environments for individuals to live and work. Next, LEED designing buildings to reduce the presence of moisture and mold prevents further complications that those in hospitals may experience. Since many individuals at hospitals suffer from asthma or other sensitive respiratory conditions, eliminating the presence of mold will allow patients to heal faster than normal. Lastly, designing recovery rooms with windows that provide views of nature can improve the healing process. Patients who have access to dynamic views of nature have been

shown to experience better moods and remain optimistic despite their current ailments. Healthcare facilities must provide some form of access to nature for patients to enjoy and enhance the healing process. Designing for wellness in these structures will allow for better healing, shorter stays, and improved health.

In regards to occupant productivity, sustainably designed buildings improve work environments to maximize attentiveness and achievement. Between providing natural lighting and improving air quality, LEED allows occupants to focus on their work and generate new ideas in comfortable environments. By allowing natural light to illuminate areas, LEED-certified buildings provide an improved setting for individuals to maximize their performance. Natural lighting increases attentiveness by reducing the distractions commonly associated with artificial lights, such as blinking and buzzing. These distractions prevent occupants from being fully focused on their work and leads to a higher rate of headaches and stress. LEED helps replace the poor quality of traditionally light with natural sunlight that reduces stress and improves the well-being of individuals. Workers favor buildings that are well-daylight through windows and skylights over those that are traditionally lit. LEED further enhances the benefits of natural light by encouraging structures to provide adjustable lighting conditions. Windows and lighting arrangements that can be adjusted by individuals to their exact preference increases work performance and eliminates distractions. By encouraging the presence of natural light and LEED continually improving to find more innovative ways to incorporate sunlight into indoor environments, sustainable architecture will create more comfortable and engaging areas that lead to higher achievement.

The quality of air that is present in LEED-certified buildings not only improves the health of occupants but also increases productivity. By providing work areas with fewer indoor

contaminants such as VOCs and mold, occupants in sustainably designed buildings experience less of the symptoms associated with sick building syndrome. LEED eliminates the ailments commonly experienced in poorly ventilated buildings and replaces them with fresher air that promotes better attendance. LEED-certified buildings create healthier work environments that do not create further illnesses or contribute to existing illnesses that workers have. By providing a healthier work environment, employees miss less work. As absenteeism decreases, the productivity costs associated with missed work decrease as well. LEED helps create structures that keep employees at work and increase productivity.

CONCLUSION

Based on the current research available, green buildings are worthy of serious consideration and investment.s Sustainably designed buildings provide vast benefits that are not limited to energy savings and eco-friendliness. The importance of providing areas for humans to work productively and healthfully should not be ignored when designing the buildings of the future. Since the costs associated with labor immensely outweigh the costs of energy, organizations should focus on improving health and productivity instead of only developing strategies to reduce energy costs. As sustainable architecture is examined further, researchers will be able to create more quantifiable methods to reveal the multitude of benefits that green buildings provide. When the benefits correlated with LEED and green design are effectively revealed and publicized, sustainable architecture will become the norm in new construction and community development. More organizations will choose to make sustainably designed buildings a priority as sustainable architecture continues to innovate and become more aware of the benefits to occupants. With the guidance of LEED, the list of benefits of sustainable

architecture will continue to grow and building occupants in the United States and the world will experience improved health and increased productivity.

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