



# Health in **LEED**



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# Connecting people with places

Human health is a longstanding value of the green building movement. Green buildings can promote health and well-being in the near term while preserving resources and protecting the environment for human benefit in the long term. By intentionally deploying green building strategies, like those available for use within LEED, the buildings industry can simultaneously promote health and well-being at a variety of population scales.

These strategies can help:

- Create superior environments for building occupants.
- Promote safe and healthy sites for construction workers.
- Reduce toxic exposures throughout the supply chain.
- Advance the health of surrounding communities.
- Mitigate climate change to benefit global populations.

The research within this document aims to narrate the story of green buildings in light of the influence they can have in improving people's lives and helping them live longer, healthier and happier.

We have taken LEED, one of the strongest tools available globally to evaluate green building design, construction and operations and conducted a detailed assessment to understand the impact a LEED certified building has on human health based on critical topics identified by industry leaders. This document builds on previous assessment of health in LEED, with a focus on LEED v4.1, the newest version of the rating systems.

The report delves into the relationship between natural environment and human health; and the role green buildings play.

## Contribution to environmental issues

Buildings are a key contributor to global climate change which is the single biggest health threat facing humanity as pointed out by a 2021 World Health Organization (WHO) release.<sup>1</sup> Cited key factors include:

- Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter.
- Between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress.
- The direct damage costs to health (i.e. excluding costs in health-determining sectors such as agriculture and water and sanitation), is estimated to be between USD 2-4 billion/year by 2030.
- Areas with weak health infrastructure – mostly in developing countries – will be the least able to cope without assistance to prepare and respond.
- Reducing emissions of greenhouse gases through better transport, food and energy-use choices can result in improved health, particularly through reduced air pollution.

Construction, operation and maintenance of buildings uses natural resources, burns fossil fuels for energy usage and generates waste, resulting in environmental pollution that degrades quality of air in communities and cities.

**Buildings are made for people and by people—and throughout their life cycle, they impact people.**

**Buildings are much more than just spaces to live, work and play. They have the power to make people healthier and happier and to help save our planet.**

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<sup>1</sup> <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health> (Accessed on 23 June 2022)

WHO also estimates that around 7 million people die every year from exposure to fine particles in polluted air that penetrate deep into the lungs and cardiovascular system, causing diseases including stroke, heart disease, lung cancer, chronic obstructive pulmonary diseases and respiratory infections, including pneumonia.<sup>2</sup>

Wastewater is generated when people use water in buildings. Globally, around 80% is dumped back into the environment without proper treatment,<sup>3</sup> thus contaminating freshwater resources and soil. Contaminated soil and irrigation from untreated wastewater can result in these toxic contaminants, including heavy metals, entering the food supply chain.

With global building floor area expected to double by 2050,<sup>4</sup> the construction sector is going to have a significant impact on the state of our planet and the public health issues.

### **Impact of environmental quality**

It is estimated that we spend 90% of our time in buildings. The air we breathe, the light we are exposed to, the noise we hear, our thermal perception and the views we see are all components that form what we call the indoor environment.

Through better design and operation strategies, an indoor environment can be created that not only supports occupants' health, but that also enhances mental well-being and improves occupant performance and productivity.

For example, high levels of CO<sub>2</sub> in indoor air may cause drowsiness, restlessness, poor concentration and tiredness; it also has a direct and negative impact on human cognitive abilities.<sup>5</sup> However, if we can avoid CO<sub>2</sub> buildup in spaces through proper ventilation design, we can reduce these impacts, which in turn increases cognitive ability, productivity, and physical and mental wellness.

Another example is light. Employees in workplaces with windows have significantly higher light exposure during work hours and sleep an average of 46 minutes more per night during the workweek, compared to employees in workplaces without windows.<sup>6</sup>

Building design holds great potential in creating communities that support public health. Locating building in well developed areas with existing infrastructure and diverse types of services within walking distance, can encourage greater physical activity. Use of public transit promotes physical fitness and reduces dependence on automobiles resulting in reduced vehicular emissions and improves ambient air quality also. Outdoor open spaces help people to interact with nature, encourage physical activity and community engagement thus improving physical as well as mental health. Providing opportunities for urban farming and access to healthy food stores will encourage healthier eating.

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<sup>2</sup> <https://www.who.int/news-room/detail/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action> (Accessed on 17 April 2019)

<sup>3</sup> <https://unesdoc.unesco.org/ark:/48223/pf0000247553> (Accessed on 18th April 2019)

<sup>4</sup> <https://www.globalabc.org/>

<sup>5</sup> Allen J.G., MacNaughton P, Satish U, Santanam S, Vallarino J, Spengler J.D. (2016). Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments. *Environmental Health Perspectives*, volume 124, number 6. 805-812

<sup>6</sup> Boubekri M, Cheung IN, Reid KJ, Wang CH, Zee PC. Impact of windows and daylight exposure on overall health and sleep quality of office workers: a case-control pilot study. *J Clin Sleep Med*. 2014;10(6):603–611. Published 2014 Jun 15. doi:10.5664/jcsm.3780

## Health strategies in LEED

The LEED impact categories outline the market transformation that the technical requirements then work to achieve and help determine where points should be assigned. These goals serve as the foundation for the rating system and included is the goal to Enhance Individual Human Health and Well-Being. These strategies are designed to:

- Enhance Individual Human Health and Well-Being
- Protect Human Health from Direct Exposure to Negative Health Impacts
- Protect Human Health Globally and Across the Entire Built Environment Life Cycle

This in-depth review of the latest version of the LEED rating system (LEED v4.1 for Building Design and Construction (BD+C), Interior Design and Construction (ID+C) and Operations and Maintenance O+M) explores its influence on human health and well-being. Credits and prerequisites were classified as health credits based on intent and listed strategies or outcomes.

Health impacts are not restricted to building occupants; they also address issues pertaining to the health of the larger population. For example, energy efficiency and use of renewable energy are strategies that lead to reduced fossil fuel usage and thus reduced ambient air pollution. Similarly, reducing storm water runoff and discouraging development close to bodies of water will minimize groundwater pollution and pollution of nearby water sources like rivers, lakes and streams.

Both the direct and indirect impacts of LEED on health were considered for this document. Strategies that have a more direct impact on the health of building occupants have been listed separately as **site user health**. Examples include providing adequate ventilation, use of low-emitting materials indoors, interior lighting and bicycle facilities. Strategies with benefits that reach beyond building occupants have been labeled as **community/global health**.

# Clean Air

Clean air is essential for human health and well-being. Around 91% of the world's population lives in places where air quality levels exceed WHO limits.<sup>7</sup> Poor air quality can be especially harmful to vulnerable groups such as children, elderly people and those with cardiovascular and chronic respiratory diseases. However, the risk of air pollution can be prevented.

Sources of indoor air pollutants include volatile organic compounds (VOCs) emitted from building and furnishing materials, chemicals from cleaning products, tobacco smoke, printers and copiers, kitchen fumes, biological contaminants like molds and mildews, bacteria, house dust mites and outdoor polluted air (in regions with poor ambient air quality).

Various studies show that improved indoor air quality (measured by levels of CO<sub>2</sub> and pollutants like VOCs, CO, PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>2</sub>, and O<sub>3</sub> are associated with reduced respiratory illnesses, asthma, allergies, headaches, and infectious disease transmission.

LEED shares strategies for delivery and maintenance of healthy indoor air and for reducing ambient air pollution.

## Community/Global-level strategies

Reduce vehicle miles traveled

- Encourage walkability
- Encourage bicycle commuting
- Promote alternate low-emission automobiles

Increase energy efficiency

- Reduce energy consumption
- Increase distribution system efficiency and grid reliability

Generate clean energy

- Encourage renewable energy generation and consumption

Address pollutant sources

- Control pollution from construction activities
- Discourage waste incineration
- Monitor and track waste generated and recycled
- Prevent contamination of air in public parks

## Site user-level strategies

Design good ventilation systems

- Improve ventilation design
- Ensure international standards compliance

Use proper materials

- Use nontoxic materials
- Ensure informed decision-making by understanding the content of building materials

Ensure green operations

- Encourage development of smoke-free spaces
- Use nonchemical/ safe cleaning practices
- Ensure system efficiency
- Take appropriate construction measures
- Assess occupant comfort
- Monitor indoor air quality

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<sup>7</sup> <http://www.who.int/airpollution/ambient/en/> (Accessed on 20 April 2019)

# Toxicity

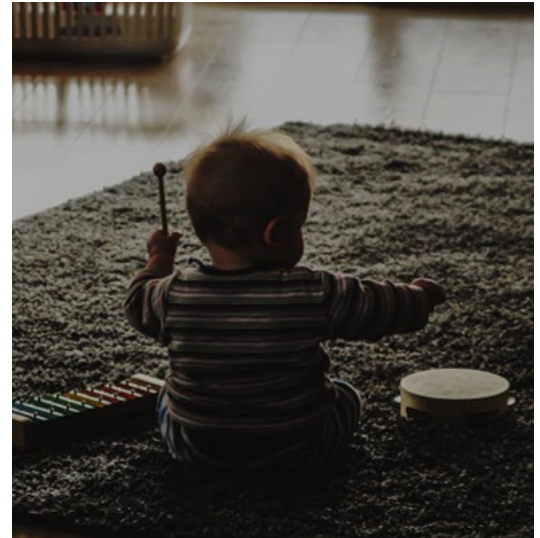
A toxic chemical can be poisonous for humans and the environment, and toxicity is the extent to which a chemical can cause harm. We are exposed to many toxic chemicals present in the air, water, food, dust, furniture, building materials, personal hygiene products, cleaning products, pesticides and tobacco smoke around us.

Many commonly used building materials contain toxic chemicals, and the exposure to these chemicals can be very high for occupants, particularly those who stay indoors for longer durations.

Examples of toxic substances found in building materials include heavy metals like lead, mercury, cadmium, chromium and copper; VOCs like formaldehyde; and semivolatile organic compounds (SVOCs) like phthalates, perfluorinated compounds (PFCs), and halogenated flame retardants. SVOCs are widely used in the building materials industry due to properties like flexibility, water resistance and ability to prevent flame spread.<sup>8</sup> At certain thresholds, these have been proven to be harmful. Lead and mercury are toxicants that affect multiple body systems and are particularly harmful to young children.<sup>9</sup> Paints, coatings, adhesives, carpets, furniture, furnishings and cleaning supplies can emit VOCs that may cause irritation in eyes, nose or throat, as well as headaches or nausea.

Likewise, toxicity in the external environment is also harmful. Contaminated soil and freshwater resources can result in toxic contaminants, like heavy metals, entering the food supply chain.

LEED addresses toxicity in the indoor as well as outdoor environment and minimizes exposure of humans to harmful toxins.



## Community/Global-level strategies

### Reduce environmental toxicity

- Protect health of vulnerable populations by conducting assessment and remediation of contaminated sites
- Limit soil pollution by minimizing use of chemicals
- Minimize use of CFCs that would result in stratospheric ozone depletion, exposing people to harmful UV radiation

## Site user-level strategies

### Minimize exposure to toxins in indoor environment

- Encourage development of smoke-free spaces
- Minimize use of harmful chemicals in building materials, furniture and furnishings
- Restrict use of hazardous chemicals in cleaning and pest control
- Monitor TVOC and other contaminants
- Enable informed decision-making by disclosing human health impacts of the products

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<sup>8</sup> Fact sheet: Toxic Chemicals in Building Materials. Written and produced by Healthy Building Network. Production funded by the Global Health and Safety Initiative with the support of Health Care Without Harm

<sup>9</sup> <https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health/>  
[https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health](https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health/) (Accessed on 1 May 2019)



# Stress Mitigation and Comfort

Thermal conditions, lighting quality, connection with the outdoor natural environment, acoustic performance, ergonomics, interior layout and overall look of a space determine how comfortable we are, which impacts health and productivity.

For example, the presence of unnecessary noise in an office environment affects concentration<sup>10</sup> and is one of the main causes for dissatisfaction in an office environment.<sup>11</sup> In classrooms, it has a significant impact on the speech perception and listening comprehension of children.<sup>12</sup>

Thermal discomfort also affects mood and productivity. A study in a controlled setting indicated a reduction in performance of 4% at cooler temperatures, and a reduction of 6% at warmer ones.<sup>13</sup>

High-quality, comfortable indoor environments positively impact people's mood and health and improves work performance. Employees who are around more light (especially natural light) during the day are more likely to be healthy and maintain a good mood.<sup>14</sup>

LEED recommends several design and operations strategies for creating and maintaining a comfortable environment in and around the building.

## Community/Global-level strategies

Reduce light pollution

- Enhance visual comfort by improving nighttime visibility through reducing light pollution

Minimize effects on microclimates

- Mitigate urban heat island effect

Increase acoustic comfort

- Design and locate exterior noise sources so that the project noise levels are not exceeded at the project boundary

## Site user-level strategies

Enhance visual comfort

- Ensure lighting efficiency
- Enhance visual comfort by providing a connection with nature outdoors

Enhance thermal comfort

- Conduct assessment to ensure systems are performing efficiently

Boost ergonomics

- Integrate ergonomic principles

Perform a comfort assessment

- Share an occupant satisfaction survey

Increase acoustic comfort

- Create an efficient acoustics design
- Reduce noise emissions and vibrations from construction equipment and other non-road engines

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<sup>10</sup> Banbury SP & Berry DC (2005). Office noise and employee concentration: Identifying causes of disruption and potential improvements, *Ergonomics*, 48:1, 25-37, DOI: 10.1080/00140130412331311390

<sup>11</sup> Kim J. and de Dear R. (2012) Nonlinear relationships between individual IEQ factors and overall workspace satisfaction. *Building and Environment* 49:1, pp 33-40

<sup>12</sup> Klatte M, Lachmann T, Meis M. Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. *Noise Health* 2010;12:270-82

<sup>13</sup> Health, Well-being and Productivity in Offices: The next chapter for green buildings. World Green Building Council Report. Available online at: <https://www.worldgbc.org/news-media/health-wellbeing-and-productivity-offices-next-chapter-green-building>

<sup>14</sup> Boubekri M, Cheung IN, Reid KJ, Wang CH, Zee PC. Impact of windows and daylight exposure on overall health and sleep quality of office workers: a case-control pilot study. *J Clin Sleep Med* 2014;10(6):603-611

# Social Connection

Social well-being is influenced by many aspects, including the feeling of social acceptance and belonging, being able to engage with the community and contributing to society. At a community level, social well-being can be achieved by a combination of social equity and empowerment of all members of a community, especially those who are disadvantaged—sensitivity to the needs of all stakeholders and creation of an inclusive environment that embraces everyone. The state of social well-being is an integral component of health and is as significant as physical and mental well-being for achieving overall good health.

Though it may not be very apparent, the life cycle of a building project provides several opportunities for influencing the social well-being of everyone who is associated with or impacted by a project, whether it is the people who are working on the project, the occupants of the building or the members of the community where the project is located.

Inclusive design processes such as involving those who live or work in the community and assessing a project's impact on the health of occupants and the community will enable the project teams to discover how the project could address community health needs and address any existing health inequities. Similarly, creating inclusive spaces that facilitate social interaction can augment the feeling of social well-being among building occupants.

## Community/Global-level strategies

Promote community health

- Encourage development on sites with development constraints

Address community needs

- Provide recreational spaces
- Share facilities within the community
- Promote social equity by addressing disparities within communities

## Site user-level strategies

Ensure stakeholder participation

- Ensure stakeholder participation in design process
- Prioritize inclusive design
- Regularly assess occupant satisfaction

Increase social equity

- Promote equity for people involved in the ownership, design and construction of the project



# Mental Health

The WHO defines mental health as “a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community.”<sup>15</sup>

The quality of places or surroundings where people spend most of their time can positively or negatively impact mental health.

High-quality, comfortable indoor environments have a positive impact on the psychological state of people and improve productivity. Design strategies like biophilic design, maximizing daylight and providing connection with outdoor natural elements give building occupants opportunities to interact with the natural world, which has been found to reduce stress, enhance creativity and improve overall well-being.

One study found that workers in office environments with access to natural elements such as greenery and sunlight reported a 15% higher level of well-being.<sup>16</sup> Additionally, studies have shown that patients in rooms with higher daylight levels tend to recover faster than those in rooms with lower daylight levels.<sup>17</sup>

## Community/Global-level strategies

Improve quality of public spaces

- Prevent obstruction of sunlight in public parks

## Site user-level strategies

Create a connection with nature

- Provide a connection to natural outdoor environment
- Reduce stress and enhance well-being of patients and staff on health care campuses by providing access to outdoor places of respite
- Provide and incorporate elements of nature in the indoor environment.
- Reinforce circadian rhythm

Inclusion

- Prioritize the experience and participation of building users by considering the full range of characteristics of human diversity in the context of place

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<sup>15</sup> World health organization. (2013). Investing in mental health: Evidence for action. Switzerland: WHO Publications. Retrieved from

[http://apps.who.int/iris/bitstream/10665/87232/1/9789241564618\\_eng.pdf?ua=1](http://apps.who.int/iris/bitstream/10665/87232/1/9789241564618_eng.pdf?ua=1)

<sup>16</sup> Human Spaces: The Global Impact of Biophilic Design in the Workplace. Published in 2015. Available at: <https://greenplantsforgreenbuildings.org/wp-content/uploads/2015/08/Human-Spaces-Report-Biophilic-Global-Impact-Biophilic-Design.pdf>

<sup>17</sup> Choi J H. and Beltran L.(2004) Study of the Relationship between Patients' Recovery and Indoor Daylight Environment of Patient Rooms in Healthcare Facilities. College of Architecture, Texas A&M University, 2004.

# Water Quality

Clean water is a fundamental element of human health. With high population growth and unrestrained human activities, deteriorating water quality has become a global cause of concern. Pollutants from sources like industrial effluents, agricultural runoff containing pesticides and fertilizer residues, untreated sewage, and water runoff from construction sites contaminate surface and ground water sources, deteriorating the freshwater quality and negatively impacting aquatic ecosystems.

Surface water run-off from construction sites can contain silt and eroded soil, along with pollutants like paints, solvents, diesel and oil, cement, and other construction debris. This contaminated water may reach the nearby surface water sources and may infiltrate the groundwater, affecting its quality.

This is a growing focus area for LEED that has been highlighted for future versions of the rating system. LEED v4.1 recommends project teams adopt strategies that minimize contamination of natural water resources during the building construction and operation phase and that prevent exposure of building occupants to contaminated water.



## Community/Global-level strategies

- Discourage development close to bodies of water
- Reduce stormwater runoff
- Prevent water contamination from leaching of pesticides
- Minimize contamination of natural water resources through better management and filtration of rainwater and through reduced stormwater runoff from site
- Restore bodies of water

## Site user-level strategies

- Replicate natural hydrology of site
- Prevent water contamination from leaching of hazardous chemicals from water fixtures
- Conduct periodic hazard screening

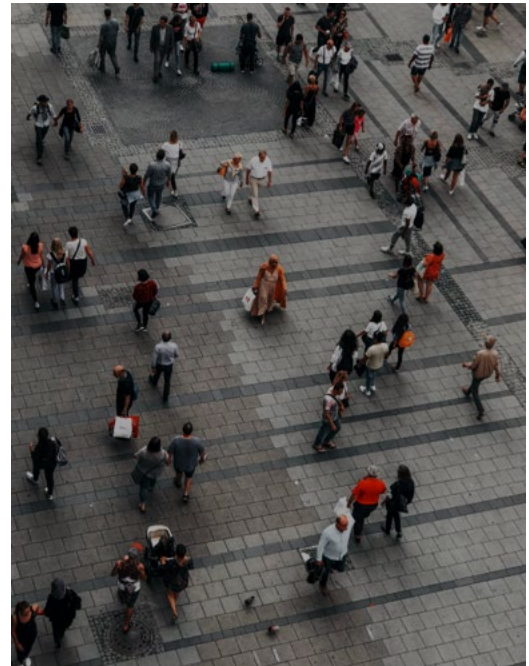
# Physical Activity

The human body is designed for regular movement; however, sedentary lifestyles with very little physical activity are becoming more prevalent. According to the WHO, insufficient physical activity is a key risk factor for non-communicable diseases (NCDs) such as cardiovascular diseases, cancer and diabetes.<sup>18</sup>

The manner in which buildings (and spaces around buildings) are planned and designed can encourage active living and inculcate healthy habits among people.

Selecting a site in a well-developed area with existing infrastructure and basic amenities within walking distance encourages people to walk and ride a bicycle instead of using motor vehicles. Sites with a variety of public transit options available also reduce reliance on motor vehicles. Use of public transport provides opportunity for increased physical activity during the entire trip.

Provision of safe, pedestrian-friendly outdoor open spaces and bicycle facilities are also ways to inspire building occupants to increase their physical activity levels.



## Community/Global-level strategies

Contribute to a more pedestrian-friendly community

- Reducing motor vehicle usage
- Reducing impacts of excessive heat
- Increasing community green space

## Site user-level strategies

- Encouraging alternate methods of transportation
- New or converted spaces designated for physical activity
- Access to exterior open spaces
- Proximity to quality public transit
- Encouraging physical activity
  - Walkable commutes or monitoring transportation choices
  - Interior design

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<sup>18</sup> <https://www.who.int/news-room/fact-sheets/detail/physical-activity> (Accessed 6 June 2019)

# Food



LEED addresses the subject of food or nutrition at a broader level. It encourages community-based food production to improve nutrition through better access to fresh produce. LEED encourages urban food production practices and rewards project teams for creating exterior open space dedicated for growing food.

In addition to providing access to fresh produce, urban farming has several other benefits. It encourages interaction with the environment and promotes community involvement, recreation and physical activity. It increases awareness about growing food and allows people to be more connected with the food they eat.

## Community/Global-level strategies

### Protect farmlands

- Protect and preserve prime farmland, unique farmland, or farmland of statewide or local importance by avoiding development on it

## Site user-level strategies

### Promote urban farming

- Encourage food cultivation in open spaces
- Increase community involvement in and education about food production

LEED has evolved from a rating system primarily focused on commercial buildings and offices to a suite of strategies applicable to nearly all places and spaces—hospitals, homes, schools, data centers, and even cities and communities. As LEED evolves, it is constantly pushing the industry to create buildings that are healthier while minimizing harm done to the environment.

## Examples of the evolution of health in LEED

