

Existing Healthy Building Resources Overview

The Federal Energy Management Program (FEMP), in partnership with the General Services Administration, is currently investigating how traditional building energy-efficiency measures can impact health in the federal sector through the Healthy Buildings Initiative (HBI).

Summary

Pacific Northwest National Laboratory (PNNL), in support of the FEMP Healthy Buildings Initiative (HBI), undertook an extensive literature review to determine what information exists about healthy building practices. This overview explores some of the most impactful resources to help building owners and operators understand more about buildings that are both healthy and energy efficient.

This review focuses on healthy building topics (lighting, thermal comfort, and indoor air quality) that intersect with energy-efficiency topics in the commercial and federal sectors. Existing resources are categorized as guides, certification programs, building standards and codes, tools and services, government programs, business cases, and research studies to help decision-makers identify resources most applicable to them.



Photo credit: Xiye. <https://www.dreamstime.com/stock-photography-hotel-lobby-image16747412>

Guides

A number of high-level guides are available that describe healthy building concepts and practices. These guides are useful for familiarizing healthy building newcomers to the field, and these include background research about health and productivity and case studies and feedback from stakeholders. Some examples of well-known and comprehensive guides for the commercial sector are Sustainable Facilities Tool by General Services Administration (GSA), *How to Deliver Healthy Buildings* by the UK Green Building Council¹, and *The 9 Foundations of a Healthy Building* by the Harvard T.H. Chan School of Public Health². These guides outline steps and relevant knowledge to begin putting healthy building improvements into practice.

For the residential sector, two distinguished guides are *Healthy Indoor Environment Protocols for Home Energy Upgrades* by the U.S. Environmental Protection Agency³ (EPA) and the *Energy-Plus-Health*

Playbook by Efficiency Vermont⁴. The EPA guide is for home energy auditors and contractors to assess health and safety while performing home energy upgrades, and the Efficiency Vermont guide is for state and utility energy-efficiency program administrators to incorporate home health evaluations into their home energy assessments.

Certification Programs

Some examples of certification programs that promote occupant health in commercial and multi-family buildings include Facility Innovations Toward Wellness Environmental Leadership (Fitwel), developed by Center of Disease Control and GSA; the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED); the International WELL Building Institute WELL Building Standard; and Living Building Challenge (LBC). LEED and LBC look at energy and other areas of sustainability comprehensively, and Fitwel and WELL primarily focus on health and wellness. The certification

costs for WELL are typically higher than the certification costs for Fitwel because it is more stringent and performance-based system, whereas Fitwel focuses on providing amenities like opportunities for exercise and access to nature. Despite the costs of these certifications, they are useful for prescribing solutions that are backed by industry consensus and research, taking the burden off users needing to identify their own solutions and strategies.

There are numerous certifications for specific healthy products for commercial and residential spaces, including programs for low- and no-VOC paints, stains, and sealers like Green Seal and the Master Painters Institute Green Performance Standard; the California Air Resources Board for formaldehyde-free wood products; the Carpet and Rug Institute's Green Label Plus for eco-friendly carpets; Green Guard for cleaning products; and more.

Building Standards and Codes

Standards and codes typically outline prescriptive minimum requirements and are useful to get a sense of healthy building parameters and design strategies. In the federal sector, the GSA created the Facility Standards for the Public Building Service (PBS-P100), which establishes baseline requirements and three higher voluntary performance levels for the design and construction of all GSA facilities. PBS-100 covers building enclosures (Sections 3.2 and 3.3), HVAC systems (Sections 5.1 and 5.2), lighting and daylighting (Sections 6.2 and 6.3), and other health-related considerations (Sections 3.4-3.7). The Council on

What is a Healthy Building?

The 9 Foundations of a Healthy Building published by the Harvard T.H. Chan School of Public Health describes important actions for achieving nine aspects of healthy buildings. Most of these healthy features directly relate to energy efficiency:

VENTILATION - Meet or exceed outdoor air ventilation rate guidelines to control indoor sources of odors, chemicals, and carbon dioxide; filter out particles; commission and monitor ventilation systems.

AIR QUALITY - Ensure low/no volatile organic compound (VOC) finishes and furnishings, lead, and polychlorinated biphenyls (PCBs); asbestos abatement; indoor humidity at 30–60%.

WATER QUALITY - Test to meet the U.S. National Drinking Water Standards at point-of-use.

THERMAL HEALTH - Meet minimum thermal comfort standards for temperature and humidity and keep thermal conditions consistent throughout the day. Commission and maintain HVAC systems.

DUST AND PESTS - Seal pest entry points and prevent moisture buildup.

LIGHTING AND VIEWS - Provide daylighting and/or high intensity blue-enriched lighting (480nm). Provide direct lines of sight to exterior windows from all workstations.

NOISE - Protect against outdoor noises. Control indoor sources of noise such as mechanical equipment, office equipment, and machinery.

MOISTURE - Conduct regular inspections of roofing, plumbing, ceilings, and HVAC equipment. Identify and remediate the underlying sources of moisture issues.

SAFETY AND SECURITY - Meet fire safety and carbon monoxide monitoring standards. Provide adequate lighting in common areas, stairwells, emergency egress points, parking lots, and building entryways.

Environmental Quality (CEQ) published Guiding Principles for Sustainable Federal Facilities, to which 22 federal agencies have voluntarily committed. FEMP released a convenient guide on their website for navigating the contents of the Guiding Principles⁵. Section 4 of the CEQ Guiding Principles outlines the required indoor environmental quality provisions for new and retrofitted buildings.

ASHRAE has released and updates hundreds of standards and guidelines related to commercial and residential

buildings and building systems that governments can reference in their building codes. Many of these standards contain provisions concerning occupant health, for example, ASHRAE 55 (minimum requirements for thermal comfort), ASHRAE 62.1 (minimum requirements for indoor air quality), and ASHRAE 189.1 (high-performance targets for thermal comfort, indoor air quality, and energy efficiency). The International Code Council publishes the International Green Construction Code in partnership



Photo credit: Pacific Northwest National Laboratory

with ASHRAE and other organizations to provide prescriptive design strategies for both energy and indoor environmental quality topics.

Tools and Services

Tools and services both provide customized results for users. Tools are user-operable, and services are conducted by a third-party. An example is the Thermal Comfort Tool by the Center for the Built Environment (CBE), which takes temperature, humidity, and other parameters and determines if these meet the ASHRAE 55 comfort zone requirements.

Occupancy surveys are a subjective method to evaluate the occupant experience; they are also useful for identifying operational issues. The GSA Tenant Satisfaction Survey is administered on a yearly basis to all GSA-operated federal buildings. CBE has developed an Occupant Survey Toolkit, a paid analytical service to help building owners prioritize the steps needed to improve occupant satisfaction and workplace

productivity; it has been implemented in more than 1,000 buildings across the world.

Dozens of consultant companies provide recommendations and implementation of upgrades based on audits of energy usage, air leakage in the building envelope and ducts, HVAC performance, and indoor air quality. Many of these companies will facilitate WELL, LEED, or other certifications. In addition, there are dozens of companies that sell products to assist with healthy building. These products include indoor environmental quality sensors, monitoring and analytical apps and software, control technologies for building automation systems, and modern HVAC and lighting equipment and fixtures.

Government Programs

Government programs can be at the local, state, or federal level and can include tax breaks, low-interest loans, grants, rebates, and other financial incentives. Low-income residential weatherization programs that were

designed for energy efficiency also improve thermal comfort with added insulation and ventilation, which can result in better indoor air quality and moisture management.

Local government programs can offer incentives to commercial building owners for constructing green buildings that primarily improve energy efficiency but also improve health. For example, the City of Pittsburgh has a Sustainable Development Bonuses program that offers building owners the option to increase floor area and building height up to 20% over the zoning limit if the building is LEED certified.

Business Case

Business case reports focus on the financial return of health in commercial buildings. *The Financial Case for High Performance Buildings* by Stok⁶ compiles existing research to find a general return on investment and found a \$115/ft² 10-year net present value of general healthy building retrofits in a typical office building. Another report titled *Buildings Emerge as Drivers of Health and Profits* by Scott Muldavin et al⁷ found a \$27.8/ft² 5-year net present value for obtaining a WELL healthy building certification.

Other studies, such as *Building the Business Case: Health, Wellbeing and Productivity in Green Offices* by the World Green Building Council⁸ and *Building for Wellness: The Business Case* by the Urban Land Institute⁹ provide qualitative and quantitative evidence from a variety of sources.



Photo credit: LED Inspirations. <https://flic.kr/p/v3NeNa>

Academic Literature and Research

Numerous studies examine occupant outcomes (improvements in productivity, turnover, absenteeism, cognitive abilities, satisfaction, stress, etc.) due to controlled modifications to indoor environmental quality. From a compilation of 63 studies that quantified productivity due to improvements in indoor

environmental quality, we found these resulted in a 5.7% average improvement in productivity and from 14 studies we found an average 37% reduction in absenteeism. Other academic studies we reviewed serve a variety of objectives, such as synthesizing and reviewing other publications; creating theoretical frameworks or evaluation methodologies; and researching

emerging technologies, including internet of things, control solutions, machine-learning, high-performance equipment, and other occupant health solutions.

Conclusion

While many guides, reports, articles, certifications, and programs cover aspects of energy-efficient and healthy buildings, more can be done to facilitate the adoption of healthy building practices. A gap we have identified is the lack of confident models for applying the large amounts of existing data to specific projects to determine occupant outcomes in health and productivity due to indoor environmental improvements. The purpose of HBI is to establish a starting point for creating a low-cost, high-fidelity, customized tool for modeling occupant health outcomes that are integrated with energy-efficiency measures and goals. ■

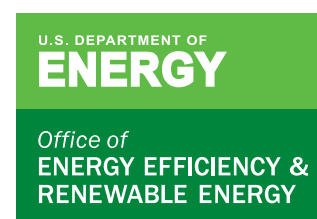
FEMP Contact:

Jefferey.Murrell@ee.doe.gov

PNNL Contact:

Nora.Wang@pnnl.gov

- 1 "Practical how-to guide: How to deliver healthy buildings" by UK Green Building Council. <https://www.ukgbc.org/sites/default/files/How%20to%20deliver%20Healthy%20Buildings.pdf>
- 2 "The 9 Foundations of a Healthy Building" by Harvard T.H. Chan School of Public Health. https://forhealth.org/9_Foundations_of_a_Healthy_Building.February_2017.pdf
- 3 "Healthy Indoor Environment Protocols for Home Energy Upgrades." by Environmental Protection Agency. https://www.epa.gov/sites/production/files/2014-12/documents/epa_retrofit_protocols.pdf
- 4 "Energy-Plus-Health Playbook" by Vermont Energy Investment Corporation. <https://www.veic.org/Media/default/documents/resources/manuals/energy-plus-health-playbook.pdf>
- 5 "Guiding Principles for Sustainable Federal Buildings." by Federal Energy Management Program. https://www4.eere.energy.gov/femp/requirements/guidelines_filtering?
- 6 "The Financial Case for High Performance Buildings" by Stock, LLC. https://stok.com/wp-content/uploads/2018/10/stok_report_financial-case-for-high-performance-buildings.pdf
- 7 "Buildings emerge as drivers of health and profits" by Muldavin S, C Miers, and K McMackin. https://static1.squarespace.com/static/5a00a5ad90bade3bd62dbaa1/t/5aff64bf758d46bedbd90862/1526686912747/Buildings+Emerge+as+Drivers+of+Health+%26+Profits_Corp+RE+Journal_Dec+2017.pdf
- 8 "Building the Business Case: Health, Wellbeing and Productivity in Green Offices" by World Green Building Council. https://www.worldgbc.org/sites/default/files/WGBC_BtBC_Dec2016_Digital_Low-MAY24_0.pdf
- 9 "Building for Wellness: The Business Case" by Urban Land Institute. <https://uli.org/wp-content/uploads/ULI-Documents/Building-for-Wellness-The-Business-Case.pdf>



For more information, visit:
energy.gov/eere/femp

PNNL-SA-152051 • MARCH 2020