Healthy Building Industry Review Resources

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This industry review investigates existing resources for facility managers, owners, operators, and other decision-makers to make informed decisions relating to energy efficient buildings that also support occupant health and productivity. Healthy building practices have had limited adoption due to lack of awareness and limited research compared to energy efficiency. This review explores some of the most impactful existing resources for healthy buildings and their integration with energy efficiency. The focus is on the commercial and federal sector and healthy building categories that intersect with energy use

Name	Type	Summary	IEQ Elements	Sector	New or Existing Buildings?	Energy Connection	Reference
The Financial Case for High Performance Buildings	Business Case	By applying financial impact calculations to findings from over 60 robust research studies on the effect of HPBs in three key occupant impact areas (Productivity, Retention, and Wellness), this paper arrives at the financial impacts below to help owneroccupants and tenants quantify the benefits of investing in HPB strategies.	Lighting, Indoor Air Quality, Thermal Comfort	Commercial	Existing	No	https://stok.com/wp-content/uploads/2018/10/stok_report_financial-case-for-high-performance-buildings.pdf
Buildings emerge as drivers of health and profits	Business Case	The paper describes and documents a methodology for Buildings emerge as drivers of health and profits assessing the financial performance of health and wellness investments that can be used to analyse property and portfolio decisions (Property Health and Wellness ROI Model [The ROI Model]). The ROI Model is then applied to a hypothetical investment in the WELL Building Standard for a 200,000 sq.ft office building to demonstrate the sensitivity and substantial profit potential of building level investments in health and wellness.	General	Commercial	Existing	No	https://static1.squarespace.com/static/5a00a5ad90bade3bd62dbaa1/t/5aff64bf758d46bedbd90862/1526686912747/Buildings+Emerge+as+Drivers+of+Health+%26+Profits_Corp+RE+Journal_Dec+2017.pdf
Facility innovations toward wellness environment leadership (FITWEL)	Certification System	Voluntary workplace certification program including criteria for location, building access, outdoor spaces, entrances and ground floor, stairwells, indoor environment, workspaces, shared spaces, water supply, cafeterias and prepared food retail, vending machines and snack bars, emergency procedures.	Physical Activity, Food and Water, Indoor Air Quality, Biophilia, Lighting, and more	Commercial; Residential	Both	No	https://www.fitwel.org/
Leadership in energy and environmental design (LEED)	Certification System	Criteria include considerations for site, energy, water, materials, and indoor air quality. Includes all building types and all phases of development. Levels of certification: certified, silver, gold, and platinum. Programs for professionals: Accredited Professional (AP) and Green Associate.	Thermal Comfort, Indoor Air Quality, Lighting, Acoustics, and more	Commercial; Residential	Both	Yes	http://leed.usgbc.org/leed.html
WELL building standard	Certification System	An evidence-based system for "measuring, certifying, and monitoring" the performance of building features "that impact human health and wellbeing, through air, water, nourishment, light, fitness, comfort and mind".	Thermal Comfort, Indoor Air Quality, Lighting, Acoustics, and more	Commercial; Residential	Both	No	https://v2.wellcertified.com/
Living building challenge (LBC)	Certification System	"…building certification program, advocacy tool, and philosophy that defines the most advanced measure of sustainability in the built environment possible today and acts to rapidly diminish the gap between current limits and the end-game positive solutions we seek." Seven performance categories called "Petals:" Place, water, energy, health & happiness, materials, equity, and beauty. Includes all building types and all phases of development.	Biophilia, Indoor Air Quality, and more	Commercial; Residential	Both	Yes	https://living-future.org/lbc/

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BREEAM	Certification System	BREEAM is the world's leading sustainability assessment for the built environment. It recognizes and reflects the value in higher performing assets across the built environment lifecycle, from new construction to in-use and refurbishment.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Commercial	Existing	Yes	https://www.breeam.com/usa/
Green Seal	Certification System	Green Seal® is the nation's premier ecolabel, symbolizing transparency, integrity and proven environmental leadership. We develop life-cycle-based, multi-attribute standards and certify products and services that can prove they meet our strict criteria for human health, reduced environmental impact and excellent performance. Operating as a nonprofit since its founding in 1989, Green Seal has certified thousands of products and services in over 450 categories, and is specified by countless schools, government agencies, businesses and institutions.	Indoor Air Quality	Not specific	Both	No	https://www.greenseal.org/programs/healthy-green-buildings
Green Label Plus	Certification System	As almost all commercial carpet is certified as Green Label Plus, you can be sure that the carpet you select emits the very lowest level of VOCs. The GLP testing program meets or exceeds all regulatory requirements for emissions, including CA 01350, and is accredited by the American National Standards Institute (ANSI) to ISO 17065 specifications.	Indoor Air Quality	Not specific	Both	No	https://carpet-rug.org/testing/green-label-plus/
Healthy Buildings	Consultant	Healthy Buildings® indoor air quality programs build value into our clients' assets, retaining and attracting tenants and employees, improving productivity, reducing liability, and branding them in the marketplace as sustainability leaders. Energy benchmarking, audits and commissioning services ensure our clients' buildings are running with minimum operating costs and maximum NOI. Healthy Buildings has built a formidable reputation as the go-to specialists for technical LEED credits, helping building owners and LEED consultants alike ensure a smooth pathway to LEED certification.	Indoor Air Quality and more	Commercial, Federal	Both	Not Explicit	https://healthybuildings.com/
Mott MacDonald	Consultant	Large, international company. Mott MacDonald has a market-leading position in materials consultancy and in-depth knowledge of the health effects of construction products having worked as the materials consultant on major new construction and fit-out projects globally. We combine this with our expertise in all aspects of building services and environmental engineering to provide an integrated consultancy with well-being at its heart. Does WELL and LEED certification.	Circadian Lighting, Materials, and more	Not specific	Both	Not Explicit	https://www.mottmac.com/
IEE Indoor Environmental Engineering	Consultant	IEE provides consultation and testing services for IEQ parameters in newly constructed buildings and existing building renovations, and design of IAQ management programs, tailored specifically to existing facility operations that facility management staff can use to respond to occupant IAQ concerns and maintain good indoor air quality in their buildings. Includes design and operation and maintenance.	Indoor Air Quality	Not specific	Both	Yes	http://iee-sf.com/healthy-building-services/index.html
Verdical Group	Consultant	Full service green building consulting firm: LEED, Living Building Challenge, WELL, Commissioning (Cx), Energy Modeling, and Program Management.	Indoor Air Quality and more	Not specific		Not Explicit	https://www.verdicalgroup.com/

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ESD	Consultant	ESD has been a leader in the health and wellness market by infusing well-being concepts into the design, marketing, performance analysis, and operation of built environments. We have experience on multiple projects related to health and wellness projects and have presented widely on the topics. As a participant in the first WELL AP provisional class, we have been at the forefront of the health-and-wellness movement. Our staff includes several WELL AP and Fitwel Ambassadors and continues to be a leader in health and wellness certification systems including WELL building, Fitwel, and RESET. Our team can help distinguish the value behind each certification for maximum return on investment, along with their synergies with other certifications (excluding LEED).	Indoor Air Quality, Thermal Comfort, and more	Not specific	Both	Not Explicit	https://www.esdglobal.com/
Natura Architectural Consulting	Consultant	Our staff includes LEED Accredited professionals with specialty accreditation in LEED Operations & Maintenance.	Indoor Air Quality and more	Not specific	Both	Not Explicit	http://naturaconsultingllc.com/
Healthy Building Science	Consultant	Healthy building/sick building testing and inspection. WELL Buidling Verification and testing.	Indoor Air Quality and more	Not specific	Existing	No	https://healthybuildingscience.com/environmental-services-2/green-building-consulting/
Real Building Consultants	Consultant	Green building consultants, focus on WELL standard.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Not specific	New	Not Explicit	http://realbuildingconsultants.com/
EHSI	Consultant	EHSI's indoor air quality team excels in incorporating a multidisciplinary approach to indoor air quality (IAQ) challenges. Our team exemplifies the integration of knowledge regarding building materials, mechanical systems, contaminant characteristics, chemical and biological sampling methods, and investigative skills. Our consulting services include commercial IAQ assessments, real estate pre-purchase indoor environmental quality (IEQ) assessments, odor investigations, and support for LEED® IEQ credits such as IAQ construction management plans and pre-occupancy testing.	Indoor Air Quality	Not specific	Existing	No	https://www.ehsintl.com/
Noresco	Consultant	NORESCO's consulting services identify and integrate viable design strategies into new and existing buildings, identify synergies between WELL and other rating systems that can be applied to documentation and performance verification phases and identify market value and costs for certification. We will advise and work with the building owner and design team from inception through construction and occupancy and will organize the preparation and online submittal of WELL documentation to obtain WELL Certification.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Commercial, Federal	Both	Yes	https://www.noresco.com/

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Protecting the Health of Vulnerable Populations with In-Home Energy Efficiency: A Survey of Methods for Demonstrating Health Outcomes	Government Program	This study looks at programs across the United States to identify the methods they are using to measure and document their health impacts. For this report, we have compiled evaluations of methods used by 63 programs (appendix A). This group includes energy efficiency or weatherization programs as well as home health or green home programs designed explicitly to improve the health of building occupants. To collect data, we conducted a literature review of studies measuring the health impacts of energy efficiency in buildings across the nation. We identified 25 published studies summarizing health impacts of programs and projects offering a variety of energy efficiency measures.	Thermal Comfort and Indoor Air Quality	Residential; some Commercial	Existing	Yes	Hayes, Sarah and Ronald Denson. 2019. Protecting the Health of Vulnerable Populations with In-Home Energy Efficiency: A Survey of Methods for Demonstrating Health Outcomes. Report H1901, American Council for an Energy-Efficient Economy (ACEEE), Washington, D.C.
Massachusetts Housing Partnership (MHP)	Government Program	Provide lower interest rates and additional financial incentives for owners who invest in increased energy efficiency and healthy building design for their residents. Healthy Housing Financing (HHF) – HHF offers reduced interest rates and reimbursement for the costs of obtaining healthy housing certification from the Fitwel® multifamily certification program.	Indoor Air Quality, Thermal Comfort, and more	Residential	New	No	https://www.mhp.net/rental-financing/green-healthy-financing
Fannie Mae	Government Program	Fannie Mae Multifamily offers Healthy Housing Rewards, a financial incentive to Multifamily Affordable borrowers that invest in health-promoting design elements or resident services for their tenants. Fannie Mae affordable borrowers receive a pricing incentive and reimbursement of the cost of certification for Fitwel or CORES or ERS certification, valued at $750-6,000.	Indoor Air Quality, Thermal Comfort, and more	Residential	New	No	http://www.ncsha.org/wp-content/uploads/2018/11/Promoting-Healthy-Building-Strategies-Rachel-Cluett.pdf
Green Building Incentives Guide	Government Program	Collection of ~50 financial incentive programs in PA and national. For new construction and retrofits of any size.		Various	Both	Yes	https://www.go-gba.org/resources/green-building/green-building-incentives-guide/
EPA: List of Green Building Funding Opportunities.	Government Program	Numerous sources of funding for green building are available at the national, state and local levels for homeowners, industry, government organizations and nonprofits. We are providing the links on this page to help you find a variety of funding sources including grants, tax-credits, loans, or other.		Commercial, Residential, Federal, Non-profit	Both		https://archive.epa.gov/greenbuilding/web/html/funding.html
National Center for Healthy Housing	Government Program	Policy incentives, ranging from tax credits and low-interest loans to tax abatement and exemption programs, can provide a “carrot” alternative to the “stick” of code enforcement. Incentive programs targeted to healthy housing improvements should list eligible repairs and renovations to avoid simply funding aesthetic improvements.		Residential	Existing		https://nchh.org/resources/policy/incentivizing-healthy-housing/
The Bronx Healthy Buildings Program	Government Program	The Bronx Healthy Buildings Program aimed to reduce asthma-related hospital visits and address the social determinants of health through education, organizing, work force development, and building upgrades.	Indoor Air Quality	Residential			https://buildhealthchallenge.org/communities/awardee-bronx-nyc/
Home Rx: The Health Benefits of Home Performance: A Review of the Current Evidence	Guide	The Department of Energy (DOE) and its contractor, the National Renewable Energy Laboratory (NREL), have sponsored this literature review to describe what is currently known about the occupant health benefits resulting from residential energy efficiency or work that is consistent with home performance upgrades.	Indoor Air Quality	Residential	Existing	Yes	Wilson, J., D. Jacobs, A. Reddy, E. Tohn, J. Cohen, E. Jacobsohn. 2016. Home Rx: The Health Benefits of Home Performance. U.S. Department of Energy, Washington D.C.

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Health and Household-Related Benefits Attributable to the Weatherization Assistance Program	Guide	This report describes and monetizes numerous health and household related benefits attributable to the weatherization of low-income homes by the U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP). The comprehensive non-energy benefit framework presented in this report greatly enhances the household component by recognizing that weatherization can provide many direct and second-order income benefits to households.	Thermal Comfort and Indoor Air Quality	Residential	Existing	Yes	Tonn, B, E. Rose, B. Hawkins, B. Conlon. 2014. Health and Household-Related Benefits Attributable to the Weatherization Assistance Program. ORNL/TM-2014/345, Oak Ridge National Laboratory, Oak Ridge, TN.
Healthy Indoor Environment Protocols for Home Energy Upgrades	Guide	This document provides a comprehensive list of guidance for achieving a healthy building. For contaminants, HVAC equipment, moisture, mold, radon, etc., it lists detailed minimum and expanded actions to remediate any issues. It will take some digging into the links in this document to find the specific tools used.	Indoor Air Quality	Residential	Existing	Yes	Environmental Protection Agency. 2014. Healthy Indoor Environmental Protocols for Home Energy Upgrades. U.S. Environmental Protection Agency. https://www.epa.gov/sites/production/files/2014-12/documents/epa_retrofit_protocols.pdf
Energy-Plus-Health Playbook	Guide	The Playbook provides resources, program design guidance, and case studies to help efficiency PAs develop Efficiency-Plus-Health programs, engage community-based organizations (CBOs) and health partners, and understand health care system changes.	Thermal Comfort and Indoor Air Quality	Residential	Existing	Yes	Capps L., L. Curry and, E. Levin. 2019. Energy-Plus-Health Playbook. Efficiency Vermont. VEIC. https://www.veic.org/documents/default-source/resources/manuals/energy-plus-health-playbook.pdf?Status=Temp&sfvrsn=2
ASHRAE Guideline 42P	Guide	The purpose of this guideline is to recommend measures that exceed minimum requirements for improving indoor air quality in commercial and institutional buildings. These measures are intended to provide enhanced indoor air quality that is acceptable to human occupants and that minimizes adverse health effects. This guideline provides recommendations related to certain sources, and for ventilation and air cleaning-system design, installation, commissioning, and operation and maintenance.	Indoor Air Quality	Commercial	Both		ASHRAE. May 2018. Indoor Air Quality in Commercial and Institutional Buildings. ASHRAE Guideline 42P. Advisory Public Review Draft. ASHRAE, Atlanta GA
The 9 Foundations of a Healthy Building	Guide	The 9 Foundations curated summaries are designed to be a clear and actionable distillation of the core elements of healthy indoor environments. For each, we created a 2-page summary of the underlying science, fully cited back to the primary literature. These summaries are included in the following pages, along with a short guide for how to achieve each foundation. The 9 Foundations apply universally to all building types, including homes, but the supporting text focuses mainly on commercial office environments.		Commercial; Residential	Both		Harvard. 2017. The 9 Foundations of a Healthy Building. Harvard T.H. Chan School of Public Health. https://9foundations.forhealth.org/9_Foundations_of_a_Healthy_Building.February_2017.pdf
The Drive Toward Healthier Buildings 2016: Tactical Intelligence to Transform Building Design and Construction	Guide	The data and analysis in this report are based on an online survey conducted with owners, architects, interior designers and contractors in the first quarter of 2016. 975 responses to the survey were received. The analysis in this report focuses primarily on the 671 responses received from the U.S. respondents. This publication produced by McGraw Hill Construction provides data on elements of a healthier building, benefits and metrics, drivers and obstacles, partnerships and learning opportunities and the survey information.	All	Commercial	Both	Yes	Dodge Data & Analytics. 2016. "The Drive Toward Healthier Buildings 2016: Tactical Intelligence to Transform Building Design and Construction." SmartMarket Report.

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Building Healthy Places Toolkit	Guide	Building Healthy Places Toolkit: Strategies for Enhancing Health in the Built Environment outlines evidence supported opportunities to enhance health through changes in approaches to buildings and projects. Developers, owners, property managers, designers, investors, and others involved in real estate decision making can use the strategies described in this report to create places that contribute to healthier people and communities and that enhance and preserve value by meeting the growing desire for health-promoting places.	Physical Activity, Food and Water, IAQ, Lighting, Acoustics, Nature	Commercial; Residential	New	No	Urban Land Institute (ULI), 2015. Building Healthy Places Toolkit. Washington, D.C. http://americas.uli.org/wp-content/uploads/sites/2/ULI-Documents/Building-Healthy-Places-Toolkit.pdf
Ten Principles for Building Healthy Places	Guide	Ten principles for integrating healthy building into senior management decision making.	Space Organization, Equity, Food, Physical Activity	Commercial; Residential	New	No	http://uli.org/wp-content/uploads/ULI-Documents/10-Principles-for-Building-Healthy-Places.pdf
Building for Wellness	Guide	This publication provides answers directly from developers who have completed projects with wellness intentions. In 13 sets of interviews, developers explain their motivation, their intended wellness and health outcomes, the development process and operations as related to their health intentions, and the key issue in this publication—the metrics of market performance.	Indoor Air Quality, Physical Activity, Daylighting	Residential, Some Commercial	Both	Some	https://uli.org/wp-content/uploads/ULI-Documents/Building-for-Wellness-The-Business-Case.pdf
Building the Business Case: Health, Wellbeing and Productivity in Green Offices	Guide	This document presents practical information on how to design and construct buildings with better IAQ without large financial investments or untested technologies. The guide is full of information on design and construction to control moisture, reduce contaminant entry, and provide effective ventilation	Indoor Air Quality, Thermal Comfort, Lighting, Acoustics, Biophilia, and more	Commercial	Both	Not Explicit	World Green Building Council. 2016. Building the Business Case: Health, Wellbeing and Productivity in Green Offices. https://www.worldgbc.org/sites/default/files/WGBC_BtBC_Dec2016_Digital_Low-MAY24_0.pdf
Designing and Building Healthy Places for Children	Guide	This paper describes how features of the built environment that promote health for children can be incorporated into the design and construction of buildings, communities and global systems.	Indoor Air Quality, Safety	Residential; some Commercial	New	No	Wendel, A.M., Dannenberg, A.L. and Frumkin, H. 2008 "Designing and building healthy places for children." Int. J. Environment and Health, Vol. 2, Nos. 3/4, pp.338–355.
A Healthy, Energy-Efficient and Comfortable Indoor Environment, a Review	Guide	The paper focuses on defining the limits of adaptation on the three aforementioned levels (building design; indoor environmental quality; occupant behavior) to ensure the energy efficiency of the whole system and healthy environments. The adaptation limits are described for measurable physical parameters and the relevant responsible human sensory systems, evaluating thermal comfort, visual comfort, indoor air quality and acoustical quality	Indoor Air Quality, Lighting, Thermal Comfort, and Acoustics	Commercial Residential	Both	Yes	Šujanová P, M Rychtáriková, TS Mayor, and A Hyder. 2019. "A Healthy, Energy-Efficient and Comfortable Indoor Environment, a Review." Energies 12(8). DOI: 10.3390/en12081414
Building Evidence for Health: Green Buildings, Current Science, and Future Challenges	Guide	On the basis of 40 years of research on indoor environmental quality, we present a summary of nine environment elements that are foundational to human health. We posit the role of green buildings as a critical research platform within a novel sustainability framework based on social-environmental capital assets.	Indoor Air Quality, Thermal Comfort, Lighting, Acoustics, Biophilia, and more	Commercial	Both	Not Explicit	Cedenõ-Laurent JG, A Williams, P MacNaughton, X Cao, E Eitland, J Spengler, and J Allen. 2018. "Building Evidence for Health: Green Buildings, Current Science, and Future Challenges." Review, 291-308. Annual Reviews Inc.
Sustainable Facilities Tool	Guide	The General Services Administration is tasked with putting our nation's public servants into efficient, healthy buildings and buying goods and services that provide maximum value to the taxpayer. With each high-performance building, waste and utility costs drop, people breathe better air and we conserve resources for future generations. Helping the Federal Government make sustainable decisions and acheive high-performance is our mission, but we built SFTool to inspire and prepare everyone to take action.	Biophilia, Indoor Air Quality, Thermal Comfort, Lighting, and more	Federal	Both	Yes	https://sftool.gov/

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Building Evidence for Health: Green Buildings, Current Science, and Future Challenges	Guide	On the basis of 40 years of research on indoor environmental quality, we present a summary of nine environment elements that are foundational to human health.	Indoor Air Quality	Not specific	Not specific	No	Cedenõ-Laurent, J.G., Williams, A., MacNaughton, P., Cao, X., Eitland, E., Spengler, J., Allen, J. Building Evidence for Health: Green Buildings, Current Science, and Future Challenges (2018) Annual Review of Public Health, 39, pp. 291-308. DOI: 10.1146/annurev-publhealth-031816-044420
Practical how-to guide: How to Deliver Healthy Buildings	Guide	This how to guide gives an introduction to the concept of healthy buildings, the frameworks and tools available to assess them, and a step by step process to help you deliver a healthy building.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Not specific		No	UK Green Building Council. Practical how-to guide: How to Deliver Healthy Buildings. https://www.ukgbc.org/sites/default/files/How%20to%20deliver%20Healthy%20Buildings.pdf
Prescription for Healthier Building Materials: A Design and Implementation Protocol	Guide	The protocol guides owners, design professionals, contractors, and facilities managers toward best practices for choosing and installing products that are healthier over their full life cycle for humans and the environment. Unlike chemical avoidance list approaches, which have their place, this guide does not declare any bans on specific materials or product content.	Indoor Air Quality	Not specific	Both	No	Yang, Frances and Sara Tepfer. 2018. Prescription for Healthier Building Materials: A Design and Implementation Protocol. http://content.aia.org/sites/default/files/2018-06/2018-06-07-SAI18_Materials_Protocol_Handbook_v04_FINAL.pdf
Signature Sustainability Blog. Health Buildng Materials Research.	Guide	With today's options for building materials, picking the right product can prove difficult, even if you know what you are looking for. This article will examine the changes happening in the building materials industry and provide guidance on selecting products that will meet the goals of your project.	Indoor Air Quality	Not specific	Both	No	https://signaturesustainability.com/healthy-building-materials-research/
Smart Buildings: How IoT Technology Aims to Add Value for Real Estate Companies: The Internet of Things in the CRE Industry	Guide	Guide and literature review of IoT in commercial buildings.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Commercial	Both	Yes	Kejriwal, Surabhi and Saurabh Mahajan. Smart Buildings: How IoT Technology Aims to Add Value for Real Estate Companies: The Internet of Things in the CRE Industry. A Research Report from the Deloitte Centerfor Financial Services. Deloitte University Press
Building Clean. Product Evaluation and Healthy Building Information	Guide	A collection of resources to help evaluate health/safety of products for buildings.	Indoor Air Quality	Not specific	Both	No	https://buildingclean.org/product-evaluation-and-healthy-building-information
Mindful Materials	Guide	The Mindful Materials Library is a multi-stakeholder initiative developed by the building industry for the building industry, providing a common platform to access and clearly communicate transparency and optimization information for building products. It is a free, brand-agnostic product library, which allows project teams and industry professionals to search for a multitude of relevant, qualified products.	Indoor Air Quality	Not specific	Both	No	http://www.mindfulmaterials.com/
Comfy	Product	Monitoring app, sensors and cloud computing.	Indoor Air Quality, Lighting, Thermal Comfort, and more	Not specific	Both		https://www.comfyapp.com/product/
Airthings	Product	Monitoring system with dashboard.	Indoor Air Quality	Not specific	Both	No	https://www.airthings.com/business
Sensware	Product	IEQ monitoring with dynamic controls. Modular architecture enables customization of the IAQ package with only the sensors you need--Include Indoor Environmental Quality sensors (e.g., light, sound, etc.) as needed. Also sells energy management technology.	Indoor Air Quality, Lighting, Thermal Comfort, Acoustics and more	Not specific	Both	Yes	https://www.senseware.co/product-packages/
3M Daylight Redirecting Film	Product	Simple, effective daylighting solution that comfortably brings natural light deeper into buildings. Helps to light the room as deep as 40 feet from the window. Redirects as much as 80% of light up onto the ceiling, providing more natural light, which has been linked to increased productivity and purchasing behavior. Helps to reduce dependence on electric lighting.	Lighting	Commercial	Both	Yes	https://www.3m.com/3M/en_US/company-us/all-3m-products/~/3M-Daylight-Redirecting-Film/?N=5002385+8710647+8710827+8735787+3290229128&rt=rud
CALRIGHT Instruments	Product	An example of a distribution of IAQ test measurement equipment and sensors.	Indoor Air Quality and Thermal Comfort	Commercial	Both	No	https://www.calright.com/application/indoor-air-quality-commercial-institutional-buildings/
CMC Corporate Solutions	Product	This company will come monitor and analyze your IAQ with 24/7 service.	Indoor Air Quality	Not specific	Existing	No	https://www.callcmc.com/services/indoor-air-quality

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Building Performance Equipment, Inc.	Product	Building Performance Equipment, Inc.'s energy recovery ventilators (ERVs) are able to precondition fresh outdoor air to room temperature for your building, school, office, or home while substantially reducing your energy bill, improving indoor air quality, and reducing the emissions that feed global warming. In other words, the units efficiently recover energy from stale air leaving the building and use it to warm room temperature in colder months and cool it during the warmer months.	Indoor Air Quality and Thermal Comfort	Commercial, Residential	Both	Yes	http://bpequip.com/products/
Nortek Air Solutions	Product	Humidity control and dedicated outdoor air systems.	Indoor Air Quality and Thermal Comfort		Both	Yes	http://www.nortekair.com
Acuity Brands	Product	Smart home lighting technologies including sensors, controls, and IoT.	Lighting	Residential mostly	Both	Yes	https://www.acuitybrands.com
Enlighted	Product	Enlighted is an Internet of Things (IoT) solutions company that delivers technology platform for smart buildings with sensor technology and scalable network to real-time data collection. Enlighted's lighting control systems are reducing energy costs by 85% or more in over 210 million sq ft of building space.	Lighting	Commercial	Both	Yes	https://www.enlightedinc.com/
Legrand Wattstopper	Product	Offers energy efficient and human centric lighting solutions. Wattstopper Human Centric Lighting (HCL) is a dimming and tunable white lighting system combining digital lighting control with tunable white technology, intending to reduce the complexity of design, installation, and operation of advanced LED lighting systems.	Lighting	Commercial	Both	Yes	https://www.legrand.us/wattstopper.aspx
Eaton	Product	Three connected lighting systems: Trellix, HALO Home, and WaveLinx. Enhance workspaces with personalized temperature, lighting, and more based on the occupant	Lighting and Thermal Comfort	Commercial, Residential	Both	Yes	http://www.cooperindustries.com/content/public/en/lighting/connected_systems.html
Daintree Enterprise	Product	Daintree Enterprise offers the open wireless controls solution which delivers energy savings and operational efficiency improvements. Daintree helps smart buildings run more efficiently and with increased productivity while also providing a platform for the Internet of Things. The Daintree Enterprise provides full-featured commercial lighting control for both fluorescent and LED lighting products, as well as programmable thermostat automation and plug-load control and control of many other sensors and devices from fans to water heaters, air compressors, refrigeration and more.	Lighting and Thermal Comfort	Commercial	Both	Yes	https://products.currentbyge.com/controls-and-sensors/daintree-enterprise-wireless-controls
Hubbell	Product	Sells lighting fixtures, sensors, mobile app, and control technologies.	Lighting	Commercial	Both		https://www.hubbell.com/hubbelllightingci/en
Honeywell	Product	Sells building automation technology and cloud analytic software, sensors, VFDs, economizers and more for energy efficiency and comfort.	Lighting, Ventilation, and Thermal Comfort	Commercial	New	Yes	https://buildingcontrols.honeywell.com/
75F	Product	75F offers a vertically-integrated smart building solution that includes wireless sensors, equipment controllers and cloud-based software delivering predictive, proactive building automation right out-of-the-box.	Thermal Comfort and Indoor Air Quality	Commercial	New	Yes	https://www.75f.io/

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Outcome-Based Ventilation: A Framework for Assessing Performance, Health, and Energy Impacts to Inform Office Building Ventilation Decisions	Research	This article presents an outcome-based ventilation (OBV) framework, which combines competing ventilation impacts into a monetized loss function ($/occ/h) used to inform ventilation rate decisions. The OBV framework, developed for U.S. offices, considers six outcomes of increasing ventilation: profitable outcomes realized from improvements in occupant work performance and sick leave absenteeism; health outcomes from occupant exposure to outdoor fine particles and ozone; and energy outcomes from electricity and natural gas usage.	Indoor Air Quality	Commercial	Existing	Yes	Rackes A, T Ben-David, and MS Waring. 2018. "Outcome-Based Ventilation: A Framework for Assessing Performance, Health, and Energy Impacts to Inform Office Building Ventilation Decisions." Indoor Air 28(4):585-603. DOI: 10.1111/ina.12466
Itcm: Toward Learning-Based Thermal Comfort Modeling Via Pervasive Sensing for Smart Buildings	Research	In this paper, we propose a learning-based solution for thermal comfort modeling via the emerging machine learning techniques and Internet of Things-based pervasive sensing technologies.	Thermal Comfort	Commercial	Existing	Yes	Hu W, Y Wen, K Guan, G Jin, and KJ Tseng. 2018. "Itcm: Toward Learning-Based Thermal Comfort Modeling Via Pervasive Sensing for Smart Buildings." IEEE Internet of Things Journal 5(5):4164-4177. DOI: 10.1109/jiot.2018.2861831
Healthy Buildings: IEQ Objectivation by Real Time Monitoring	Research	This paper describes an easy to use professional IEQ measuring/monitoring/logging system, putting together indoor and outdoor measurements and presenting on a dashboard real time results at a glance.	Indoor Air Quality	Commercial; Residential	Existing	No	Van Cappellen L, JD Carrilho, MG Da Silva, J Van Putten, and B Smid. 2017. Healthy Buildings: Ieq Objectivation by Real Time Monitoring. In Healthy Buildings Europe 2017, Lublin; Poland, International Society of Indoor Air Quality and Climate,
A Review of Air Filtration Technologies for Sustainable and Healthy Building Ventilation	Research	This paper presents a comprehensive review on the synergistic effect of different air purification technologies, air filtration theory, materials and standards. It evaluated different air filtration technologies by considering factors such as air quality improvement, filtering performance, energy and economic behaviour, thermal comfort and acoustic impact.	Indoor Air Quality	Commercial; Residential	Both	Yes	Liu G, M Xiao, X Zhang, C Gal, X Chen, L Liu, S Pan, J Wu, L Tang, and D Clements-Croome. 2017. "A Review of Air Filtration Technologies for Sustainable and Healthy Building Ventilation." Sustainable Cities and Society 32:375-396. DOI: 10.1016/j.scs.2017.04.011
Pulsetest: A New Method to Locate Sources of Indoor Volatile Organic Compounds and Particulate Matter	Research	Identifying the different indoor sources of pollution is a challenging topic. The aim of this study was to develop a 5-phase protocol, named "PulseTest", to enable the identification of sources of VOCs and PM in one office room.	Indoor Air Quality	Commercial; Residential	Existing	No	Castagnoli E, D Taiarol, R Mikkola, J Salo, J Kurnistksi, and H Salonen. 2017. Pulsetest: A New Method to Locate Sources of Indoor Volatile Organic Compounds and Particulate Matter. In Healthy Buildings Europe 2017, Lublin; Poland, International Society of Indoor Air Quality and Climate,
Alternative Ventilation Strategies in U.S. Offices: Saving Energy While Enhancing Work Performance, Reducing Absenteeism, and Considering Outdoor Pollutant Exposure Tradeoff	Research	This work explores those impacts for eight ventilation strategies, relative to a baseline constant mechanical ventilation rate (VR) of 9.4 L/s/occ, in two representative offices.	Indoor Air Quality	Commercial	Existing	Yes	Ben-David T, A Rackes, and MS Waring. 2017. "Alternative Ventilation Strategies in U.S. Offices: Saving Energy While Enhancing Work Performance, Reducing Absenteeism, and Considering Outdoor Pollutant Exposure Tradeoffs." Building and Environment 116:140-157. DOI: 10.1016/j.buildenv.2017.02.004
A Computing Model for Lifecycle Health Performance Evaluations of Sustainable Healthy Buildings	Research	The purpose of this study is to propose a computing model for lifecycle health performance evaluation (LHPE model) of sustainable healthy buildings. The LHPE model consists of a lifecycle health performance tree (LHT) model, a process model and an information model. The LHPE model is intended to be used as a tool to draw out the comprehensive health performance of buildings with ease and quickness, when the evaluation indicators of the factors are completed in the near future.	Indoor Air Quality, Thermal Comfort, Lighting, and Acoustics	Commercial; Residential	Existing	No	Lee G, Y Na, JT Kim, and S Kim. 2013. "A Computing Model for Lifecycle Health Performance Evaluations of Sustainable Healthy Buildings." Indoor and Built Environment 22(1):7-20. DOI: 10.1177/1420326x12469553
Towards Sustainability Index for Healthy Buildings - Via Intrinsic Thermodynamics, Green Accounting and Harmony	Research	Presented is a review of the multi-criteria sustainability analysis methods (intrinsic thermodynamic based on energy, exergy, sustainability index, analytic hierarchy process, etc.). It has been shown that crucial sensitivity of all methods is related to the selected sets of energy criteria (economical, social and environmental) and to the mathematical algorithms for the determination of the weighted factor and sub-indicators agglomeration.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Commercial Residential	Existing		Kim JT, and MS Todorovic. 2013. "Towards Sustainability Index for Healthy Buildings - Via Intrinsic Thermodynamics, Green Accounting and Harmony." Energy and Buildings 62:627-637. DOI: 10.1016/j.enbuild.2013.03.009

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Optimizing ventilation: Theoretical study on increasing rates in offices to maximize occupant productivity with constrained additional energy use	Research	This optimization methodology was simulated in three locations for an average- and high-performance small office building, considering users with varying levels of confidence in ventilation-productivity relationships. Among all simulated cases, lost productive hours due to lower ventilation at constant rates were halved when using the optimized higher annual rates. Offline optimization results were used to develop heuristic rules to predict a ventilation rate for any single day based on weather forecast that would adhere to a building- and climate-specific Pareto optimization, opening avenues for future control strategies that use this framework in real buildings.	Indoor Air Quality	Not specific	Existing	Yes	Ben-David, T., Rackes, A., Lo, L.J., Wen, J., Waring, M.S. Optimizing ventilation: Theoretical study on increasing rates in offices to maximize occupant productivity with constrained additional energy use (2019) Building and Environment, 166, art. no. 106314, DOI: 10.1016/j.buildenv.2019.106314
An examination of factors affecting healthy building: An empirical study in east China	Research	Based on comprehensive literature review, the connotation of healthy building was defined and 30 impact factors that affect healthy buildings were identified by bibliometric analysis and expert interview. A questionnaire survey was conducted to identify the importance of these key factors. Sixteen factors were identified as key impact factors (KIFs) with the importance index above 80. A framework integrating all these impact factors of a healthy building during its life cycle was developed, which provides a thorough picture of the impact factors and their classifications.	Indoor Air Quality, Lighting, and more	Not specific	Not specific	No	Mao, P., Qi, J., Tan, Y., Li, J. An examination of factors affecting healthy building: An empirical study in east China (2017) Journal of Cleaner Production, 162, pp. 1266-1274. DOI: 10.1016/j.jclepro.2017.06.165
Move beyond green building: A focus on healthy, comfortable, sustainable and aesthetical architecture	Research	Regarding the healthy effect of built environment, a conceptual model of healthy building and a framework to research the association between built environment and health is presented and discussed.					Xie, H., Clements-Croome, D., Wang, Q. Move beyond green building: A focus on healthy, comfortable, sustainable and aesthetical architecture (2017) Intelligent Buildings International, 9 (2), pp. 88-96. DOI: 10.1080/17508975.2016.1139536
A real-time, composite healthy building measurement architecture drawing upon occupant smartphone-collected data	Research	In this paper we present a framework and architecture for such a system to measure the state of a healthy building continuously over time.					Steele, R., Clarke, A. A real-time, composite healthy building measurement architecture drawing upon occupant smartphone-collected data (2012) 10th International Conference on Healthy Buildings 2012, 3, pp. 2125-2130
A Lifecycle Health Performance Tree for Sustainable Healthy Buildings	Research	Llifecycle health performance tree (LHT) for sustainable healthy buildings has been developed by this study. Unlike the existing method, which measures the indoor air quality, light and noise factors of a completed space, LHT provides an overall evaluation of the health performance of a space during planning. This is a theoretical framework on how to normalize and weigh health indicators and verify with measurements.	Indoor Air Quality, Lighting, and more	Not specific	Existing	No	Lee, D., Lee, S., Kim, J.T., Kim, S. A lifecycle health performance tree for sustainable healthy buildings (2012) Indoor and Built Environment, 21 (1), pp. 16-27
Corporate policy and decision-making tool development for creating healthy building standards	Research	"This paper addresses the process taken by the non-profit, Kaiser Permanente, the largest healthcare provider in the United States, to develop guidelines for decision-making in the selection and standardization of healthy building technologies and materials. "					Stensland, J., Bernheim, A., Lent, T. Corporate policy and decision-making tool development for creating healthy building standards (2006) HB 2006 - Healthy Buildings: Creating a Healthy Indoor Environment for People, Proceedings, 5, pp. 305-310.
Indoor Air Quality Monitoring for Enhanced Healthy Buildings	Research	The authors present several new open-source and cost-effective systems that had been developed for monitoring environmental parameters, always with the aim of improving indoor air quality for enhanced healthy buildings. Several solutions for IAQ supervision, which support open-source technologies for data processing, collection, and transmission that offers mobile computing architectures for real-time data accessibility, was presented.	Indoor Air Quality	Not specific	Existing	No	Marques, G and R Pitarma. Indoor Air Quality Monitoring for Enhanced Healthy Buildings. (2019). In: Indoor Environmental Quality, eds MA Mujeebu. London: IntechOpen DOI: 10.5772/intechopen.81478

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Interactions Among Health Risk Factors and Decision-Making Process in the Design of Built Environments	Research	The chapter concludes with the tool developed for decision-making processes (Sect. 4.4) supported by the short-term and long-term benefits of holistic design (Sect. 4.5).	Indoor Air Quality, Thermal Comfort, and more	Not specific	New	No	Dovjak M., Kukec A. (2019) Interactions Among Health Risk Factors and Decision-Making Process in the Design of Built Environments. In: Creating Healthy and Sustainable Buildings. Springer, Cham
Smart solutions for adaptive workplaces	Research	Specialty studies have been focusing for several years on developing architectural and technological solutions to enhance productivity, but the present study aims to interweave design and electrical engineering for wellbeing and environmental purposes. Firstly, connection to natural elements based on Biophilic attributes, is seen as restorative and offering balanced response to an increasingly denser built-environment. Secondly, the support of technical systems for indoor climate optimization aim to replicate outdoor environments while allowing local occupant control over individual comfort necessities.	Biophilia	Not specific	Both	No	Mohora, I., Anghel, A.A., Frigura-Ilias, F.M. Smart solutions for adaptive workplaces. Architectural and technological applications. (2019) Proceedings - 2019 IEEE International Conference on Environment and Electrical Engineering and 2019 IEEE Industrial and Commercial Power Systems Europe, EEEIC/I and CPS Europe 2019, art. no. 8783874, DOI: 10.1109/EEEIC.2019.8783874
Sick building syndrome: are we doing enough?	Research	This study provides a review about SBS symptoms. Several negative effects of SBS are identified and potential solutions are advocated. Finally, the study stresses the role of built environment and concludes that ongoing research towards tackling SBS and developing healthy indoor environments should not be limited to a single formula as any health-related building design approach is dependent on several interacting factors.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Not specific	Existing	No	Ghaffarianhoseini, A., AlWaer, H., Omrany, H., Ghaffarianhoseini, A., Alalouch, C., Clements-Croome, D., Tookey, J. Sick building syndrome: are we doing enough? (2018) Architectural Science Review, 61 (3), pp. 99-121
Green building incentives: A review	Research	The review findings signify the importance of the government in relation to green building incentives. Financial incentives include direct grants, tax incentives, rebates and discounted development application fees. Non-financial incentives include Floor-to-Area density (FAR), technical assistance, expedited permitting, business planning assistance, marketing assistance, regulatory relief, guarantee programmes, and dedicated green management teams in building and planning departments.			Both		Olubunmi, O.A., Xia, P.B., Skitmore, M. 2019. Green building incentives: A review (2016) Renewable and Sustainable Energy Reviews, 59, pp. 1611-1621. DOI: 10.1016/j.rser.2016.01.028
Barriers to "green operation" of commercial office buildings: Perspectives of Australian facilities managers	Research	This study categorically identifies and tabulates the barriers that stand in the way of improving the green operational performance of office buildings.		Commercial	Existing	Yes	Rock, S., Hosseini, M.R., Nikmehr, B., Martek, I., Abrishami, S., Durdyev, S. Barriers to "green operation" of commercial office buildings: Perspectives of Australian facilities managers (2019) Facilities, 37 (13-14), pp. 1048-1065. DOI: 10.1108/F-08-2018-0101
Incentives for green retrofits: An evolutionary game analysis on Public-Private-Partnership reconstruction of buildings	Research	This paper reveals the game strategy change of encouraging green retrofits and implementing green retrofits in government groups and investment groups through an evolutionary game analysis. t can be found that the final evolutionary game results will take on two forms: first, the government groups encourage green retrofits, and the investment groups implement green retrofits; second, the government groups do not encourage green retrofits, and the investment groups do not implement green retrofits, respectively.		Not specific	Existing	Yes	Yang, X., Zhang, J., Shen, G.Q., Yan, Y. Incentives for green retrofits: An evolutionary game analysis on Public-Private-Partnership reconstruction of buildings (2019) Journal of Cleaner Production, 232, pp. 1076-1092. DOI: 10.1016/j.jclepro.2019.06.014
World Green building Trends	Research	The latest in a series of studies, the findings show great consistency in the benefits dreived from green with previous studies in 2012 nd 2015, but they also demonstrate the incresing influence of social factors like creating a sense of community, encouraging sustainable business practices and especially improving occupant health and well-being.	Indoor Air Quality, Thermal Comfort, Lighting, and more	Commercial mostly	Both	Yes	Dodge Data & Analytics. World Green building Trends 2018. SmartMarket Report. 2018.

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National Healthy Housing Standard	Standard	The Standard provides health-based provisions to fill gaps where no property maintenance policy exists and also a complement to the International Property Maintenance Code and other policies already in use by local and state governments and federal agencies for the upkeep of existing homes.	Lighting, Indoor Air Quality, Thermal Comfort, and more	Residential	Existing	No	American Public Health Association (APHA). 2014, undated June 2018. National Healthy Housing Standard. National Center for Healthy Housing. https://nchh.org/resource-library/national-healthy-housing-standard.pdf
Guiding Principles for Sustainable Federal Buildings (FEMP)	Standard	The 2006 Guiding Principles addressed reducing energy and water use, conserving resources, minimizing waste, protecting indoor air quality, and requiring the use of integrated teams during the design, construction, and operation of new Federal facilities.	Indoor Air Quality	Federal	Both	Yes	https://www4.eere.energy.gov/femp/requirements/guidelines_filtering
Facility Standards for the Public Building Service (PBS-P100)	Standard	The PBS-P100, "Facilities Standards for the Public Buildings Service," is GSA's mandatory facilities standard. It applies to design and construction of new federal facilities, major repairs and alterations of existing buildings, and lease construction facilities that GSA intends to own or has the option to own.	Thermal Comfort, Indoor Air Quality, Lighting, Acoustics, and more	Federal	Both	Yes	https://www.gsa.gov/cdnstatic/2017_Facilities_Standards_%28P100%29%C2%A0.pdf
ASHRAE Standard 55	Standard	ANSI/ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy is an American National Standard published by ASHRAE that establishes the ranges of indoor environmental conditions to achieve acceptable thermal comfort for occupants of buildings. It was first published in 1966, and since 2004 has been updated every three to six years. The most recent version of the standard was published in 2017.	Thermal Comfort	Commercial; Residential	New	No	https://ashrae.iwrapper.com/ViewOnline/Standard_55-2017
ASHRAE Standard 62	Standard	ANSI/ASHRAE Standards 62.1 and 62.2 are the recognized standards for ventilation system design and acceptable indoor air quality (IAQ). Expanded and revised for 2019, both standards specify minimum ventilation rates and other measures in order to minimize adverse health effects for occupants.	Indoor Air Quality	Commercial (62.1); Residential (62.2)	New	No	https://ashrae.iwrapper.com/ViewOnline/Standard_62.1-2019
ASHRAE Standard 189.1	Standard	A model code that contains minimum requirements for increasing the environmental and health performance of buildings' sites and structures. Generally, it applies to the design and construction of all types of buildings except single-family homes, multifamily homes with three or fewer stories, and modular and mobile homes.	Thermal Comfort, Indoor Air Quality, and more	Commercial; Industrial; Residential	New	Yes	https://ashrae.iwrapper.com/ViewOnline/Standard_189.1-2017
Unified Facilities Criteria (UFC)	Standard	UFC documents provide planning, design, construction, sustainment, restoration, and modernization criteria, and apply to the Military Departments, the Defense Agencies, and the DoD Field Activities. UFC 1-200-02 High Performance And Sustainable Building Requirements provides minimum requirements and guidance to achieve high performance and sustainable facilities that comply with the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, EO 13693, and the implementation requirements found in “Guiding Principles for Sustainable Federal Buildings and Associated Instructions”. Where the provisions of ASHRAE 189.1 meet the intent of the HPSB Guiding Principles, the provisions of ASHRAE 189.1 are referenced as a means of compliance or provided as an alternative compliance pathway.	Indoor Air Quality, Thermal Comfort, and more	Federal	Existing	Yes	https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

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GSA Tenant Satisfaction Survey	Tool	Each year, employees in federally owned and leased buildings provide feedback on their physical space via the Tenant Satisfaction Survey (TSS). GSA administers the survey on behalf of all federal landholding agencies. The strategies taken in response to the TSS results vary by agency. For example, at GSA, Facility Managers use TSS data to help identify areas needing improvement and prioritize projects to address feedback.	Indoor Air Quality, Thermal Comfort, and Lighting	Federal	Existing	No	https://www.gsa.gov/real-estate/gsa-federal-tenant-satisfaction-survey
CBE Occupant Survey Toolkit	Tool	The Center for the Built Environment (CBE) has developed a cost-effective, web-based survey that takes approximately ten minutes to complete. The survey is intuitive and streamlined, preserves the confidentiality of respondents, and controls access in order to maintain data integrity.	Indoor Air Quality, Thermal Comfort, and Lighting	Commercial; Residential	Existing	No	https://cbe.berkeley.edu/resources/occupant-survey/