U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Healthy Buildings Initiative

Nora Wang, Ph.D., Chief Engineer

Pacific Northwest National Laboratory

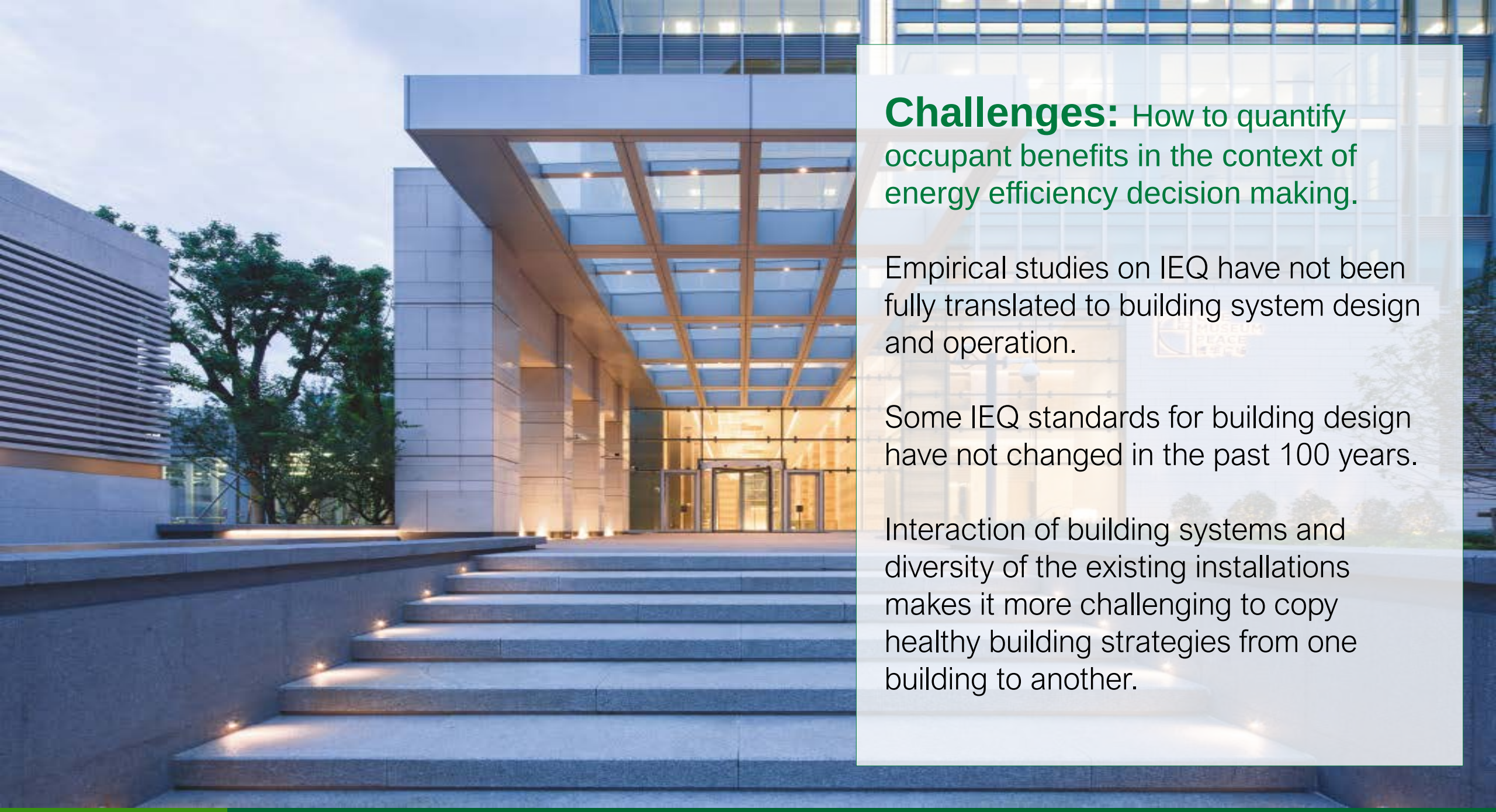
Value Propositions

Non-energy benefits, such as health and productivity improvements, can have large economic benefits—which are currently unaccounted for in energy efficiency project valuation methodologies.

Leveraging buildings to achieve broader energy goals (demand reduction, smart buildings, building-grid integration) requires gaining knowledge and developing measurement of human outcomes, which represent the best interest of building owners, business owners, and building occupants.

3-30-300

On average, companies spend $3 in utilities, $30 in rent, and $300 in payroll per square foot per year.



Challenges: How to quantify occupant benefits in the context of energy efficiency decision making.

Empirical studies on IEQ have not been fully translated to building system design and operation.

Some IEQ standards for building design have not changed in the past 100 years.

Interaction of building systems and diversity of the existing installations makes it more challenging to copy healthy building strategies from one building to another.

Objectives

- Integrate occupants' health outcomes with energy efficiency measures.
- Quantify potential financial benefits from productivity gains.
- Develop a toolkit aka "program-in-a-box" (data collection guide, cost-benefit calculator, equipment library) to help facility managers make holistic decisions on building retrofits and operation.

Industry Landscape

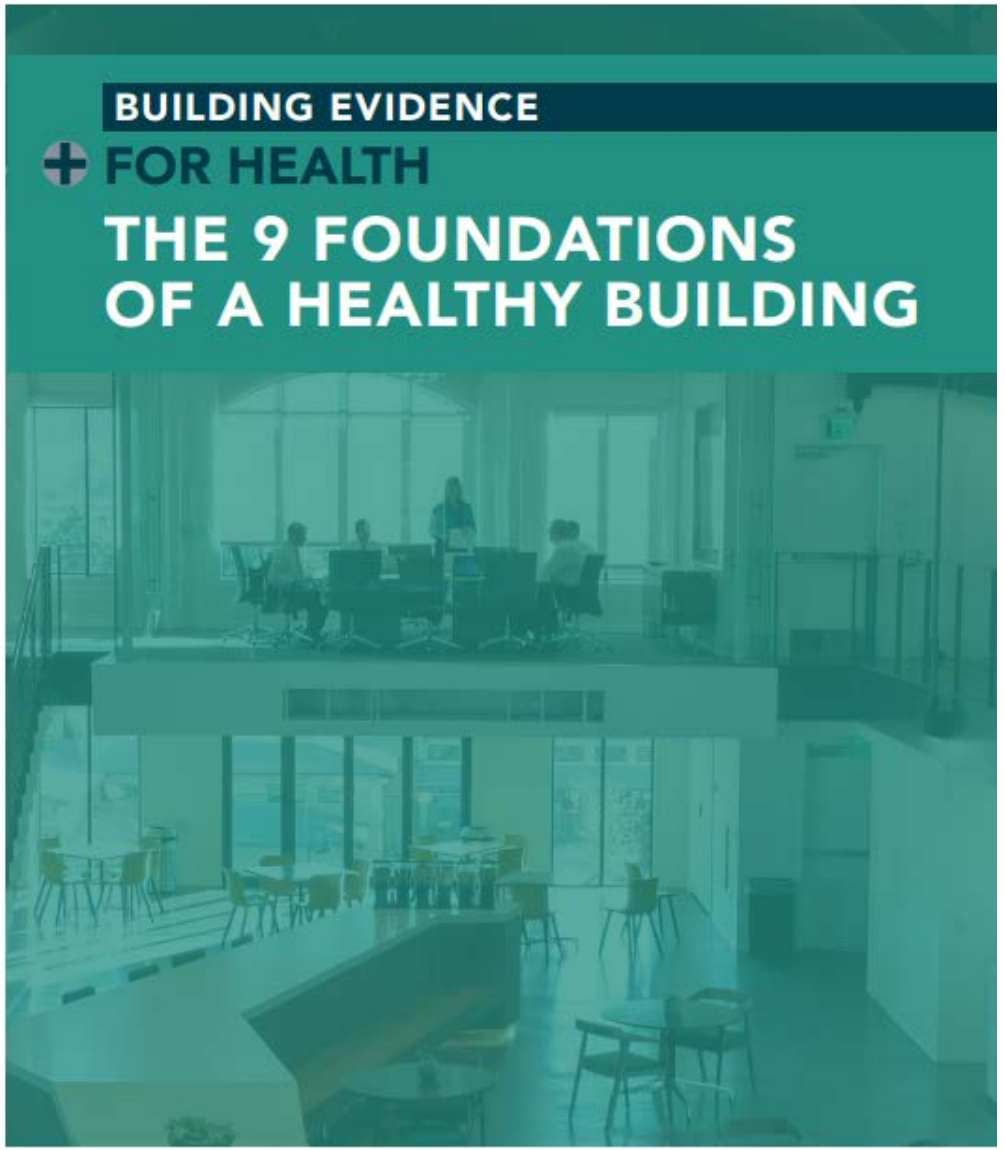
- Guides
- Tools and Services
- Government Programs
- Building Standards and Codes
- Certification Systems
- Academic and Applied Research

Best Practice Guides and Business Cases

Business cases that have financial returns for general healthy building practices.

https://stok.com/financial-case-for-high-performance-buildings/

https://9foundations.forhealth.org/9_Foundations_of_a_Healthy_Building.February_2017.pdf



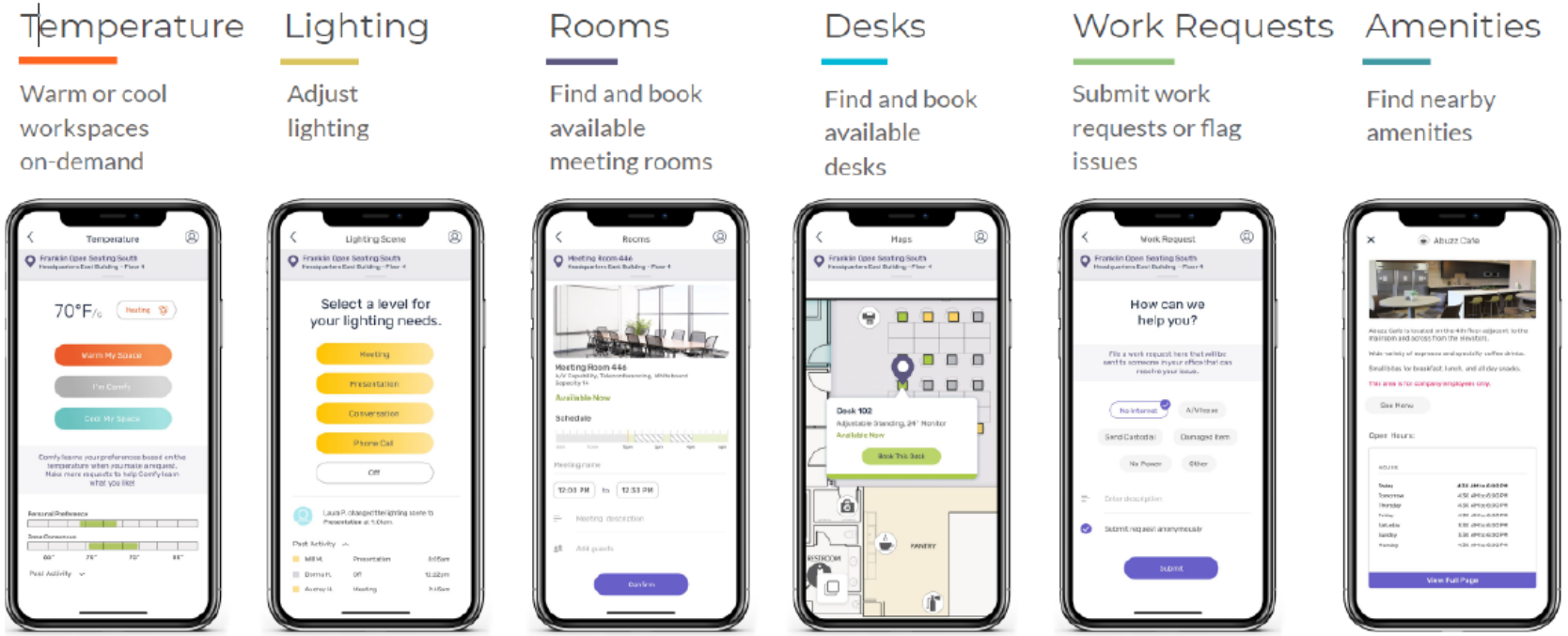
HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH Center for Health and the Global Environment

FOR HEALTH forhealth.org

General, high-level guides that overview the principles of healthy building, for example lighting, thermal comfort, acoustics etc.

Tools and Services

- Design services for new buildings or building renovations.
- Healthy building products and technologies (e.g. apps, sensors, building system equipment, cloud analytics).
- Occupancy surveys to identify operation issues with building systems and controls.



www.comfyapp.com

Government Programs

Upward of 100 existing city, state, and federal green building incentive programs (mostly residential buildings with a focus on low-income public housing).

Fannie Mae

- Fannie Mae financing will reimburse Fitwel certification fees, valued at $750-6,000, for multifamily affordable housing units.
- Intended for borrowers that have incorporated health-promoting design and operational strategies at the property.

mc Pittsburgh, PA

- The City of Pittsburgh, PA offers a sustainable development bonus for commercial LEED-certified buildings including a 20% increase in floor area and height.

Building Standards and Codes

References for HBI Methodology

- ASHRAE, International Code Council (ICC) and Illuminating Engineering Society (IES) release and updates a variety of standards that include IEQ metrics (mostly minimum requirements).
  - For example, ASHRAE Standards 55/62/189, IESNA Lighting Handbook, and International Green Construction Code (IgCC).

- Federal sector has specific standards for federal facilities.
  - Facility Standards for the Public Building Service (PBS-P100) has provisions for occupant controls in temperature, lighting and acoustics and occupant satisfaction requirements.
  - The Guiding Principles for Sustainable Federal Buildings (and DoD Unified Facilities Criteria) emphasize greatly on energy efficiency and includes some health provisions for IAQ, thermal comfort, and lighting.

- Residential sector standards include:
  - The National Healthy Housing Standard by the National Center for Healthy Housing.
  - Standards developed by the American Public Health Association.

Certification Systems

References for HBI Methodology

- Two prominent certification systems that focus on healthy buildings: WELL Building Standard and Facility Innovations Toward Wellness Environmental Leadership (Fitwel).
  - Fitwel created by GSA and CDC and focuses on amenities, policies, and services for occupants.
  - WELL focuses on building systems, design and operation and has some amenity and policy credits.

- Green building certification systems include provisions for occupant health in addition to sustainability and energy.
  - Of the 126 possible credits in LEED v4.1 BD+C – New Construction, 20 are specifically for occupant comfort, and 12 of those are for IAQ.

LIVING BUILDING CHALLENGE

fitwel℠

Research

- Controlled laboratory studies on occupants under different IEQ conditions.
  - Most studies are focused on IAQ (carbon dioxide and ventilation) and temperature.
- Literature review and analysis.
  - Synthesize conclusions from available literature in a certain area healthy building (e.g., ventilation or productivity).

Foundation of HBI Methodology

- Theoretical frameworks and evaluation methodologies.
  - For example, sustainability index for healthy buildings, a framework for evaluating ventilation rate effectiveness.
- Technology research and development.
  - For example, IoT sensors and machine-learning algorithm for thermal comfort, testing protocol for identifying sources of VOCs.

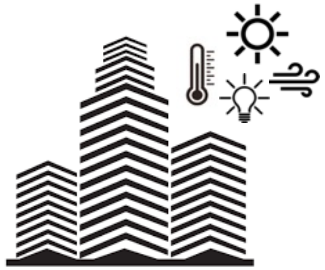
Healthy Buildings Initiative Methodology

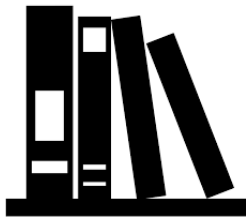
- How healthy is my building?
- How to make my buildings healthier?
- How much financial gains to expect from the improved occupants' health and productivity?

In the context of energy efficiency, our "healthy buildings" study includes thermal comfort, air quality, lighting/daylighting and excludes noise, physical activities, and nutrition.

Overview

1. Baseline Health Performance
2. Identify Potential Improvements
3. Corelate to Human Outcomes
4. Investigate Problems & Solutions
5. Outputs: Cost Benefit Analysis Improvement Recs





Baseline Metrics

8 Primary metrics to baseline building performance. (10-question supplemental occupant survey)

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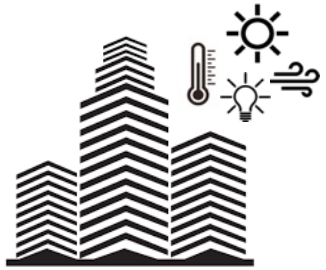
Baseline Health Performance



Category	Baseline Metrics
Lighting / Daylighting	Horizontal Illuminance
	Circadian Stimulus
	Glare
Indoor Air Quality	Particulate Matter
	Carbon Dioxide
	VOC
Thermal Comfort	Predictive Mean Vote
	Humidity

4

Investigate Problems & Solutions

5

Outputs: Cost Benefit Analysis Improvement Recs

Improvement Potentials

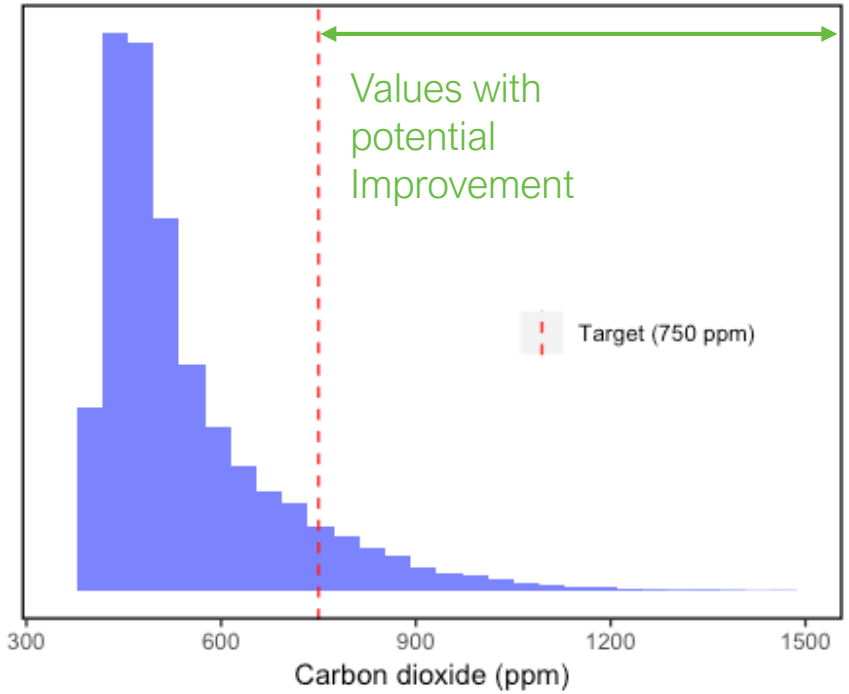
Baseline measurements are compared with target values to calculate improvement potentials.

1 Baseline Health Performance

2 Identify Potential Improvements

WELL BUILDING STANDARD

IES ASHRAE



5 its: Benefit Analysis vement Recs

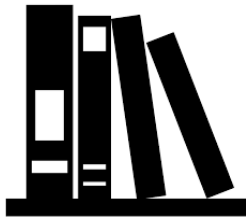
Human Outcomes

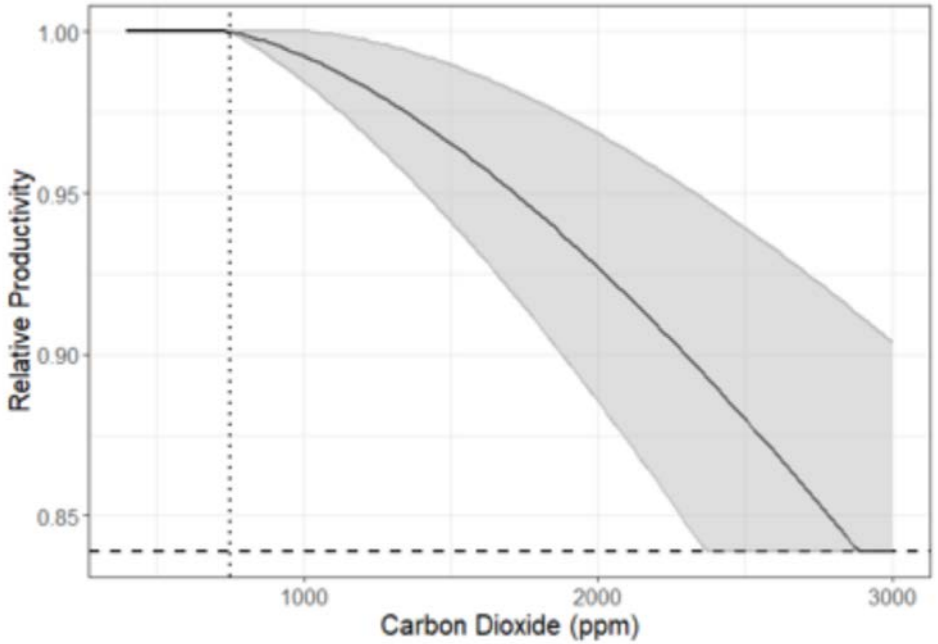
Correlations were developed for lighting (horizontal illuminance), thermal comfort (PMV), and IAQ (ventilation rate, CO_2), Humidity, and Circadian Stimulus based on published empirical studies.

1 Baseline Health Performance

2 Identify Potential Improvements

3 Corelate to Human Outcomes

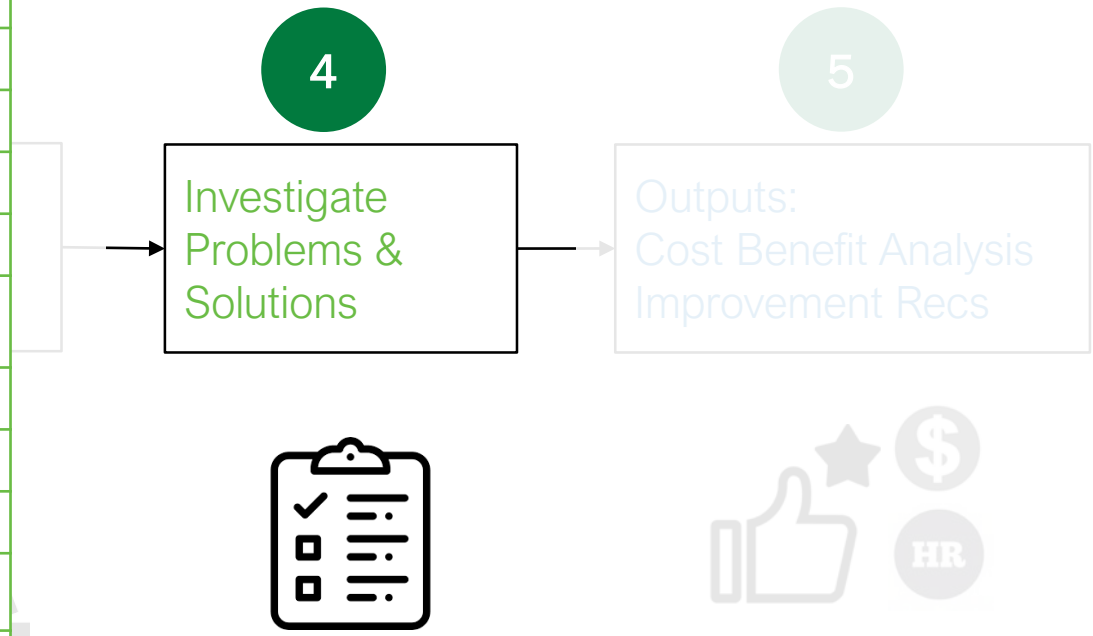




Diagnosis

Baseline Metric	Diagnosis Metrics
Horizontal Illuminance	Task Lighting
Glare	Architectural Shading
	Window Treatment and Shading
	Desk Configuration
Particulate Matter (PM)	Air Filters MERV
	Positive Building Pressure
	Outdoor Air Intake Location
	Combustion-based Equipment
PM / CO_2	Testing and balancing
CO_2	Air Distribution Effectiveness
CO_2	Air Distribution/Ventilation System
CO_2 / VOC	Outdoor Airflow Supply
VOC	Low-emitting Materials and Products
Predictive Mean Vote	Personal Thermal Devices
	Enclosure Heat Loss/Gain

A decision tree to deep dive into the area where primary metric is way below the target value and identify improvements.



Economic Analysis

Example output from a pilot building:

Building Size: 26,190 sq.ft.
No. of Occupants: 92
Improvement Cost: $149,000
Energy Cost Savings: $44,000 (10-yr NPV)
Personnel Gains: $2,163,000 (10-yr NPV)

Benefit / Cost Ratio

Energy: 0.3

Energy + Health: 14.8

5

Outputs:
Cost Benefit Analysis
Improvement Recs

Recommendations

Example recommendations from a pilot building:

	Issues	Recommendations
Thermal Comfort	Mostly too cool in open offices. Survey shows some complaints of too warm in afternoons, especially spring and summer. Lack of thermal control in open offices.	Increase temperature setpoint in open space; provide supplemental heating (heated chairs); and add automated shading to windows to reduce solar heat gain.
Indoor Air Quality	No health-related issue. The building is likely over ventilated.	Reduce outdoor airflow by 40% with continuing CO_2 monitoring to ensure no negative impact on occupants.
Electric lighting	The occupant survey reveals that the occupancy sensors are not functioning properly. Some space is underlit.	Recommission occupancy lighting sensors and install daylighting sensors. Add task lighting to underlit workstations.
Circadian Rhythm	Survey complaints about daylight access; window proximity is good but could be better.	Lower partition walls and provide color-tuning task lighting to workstations without windows.

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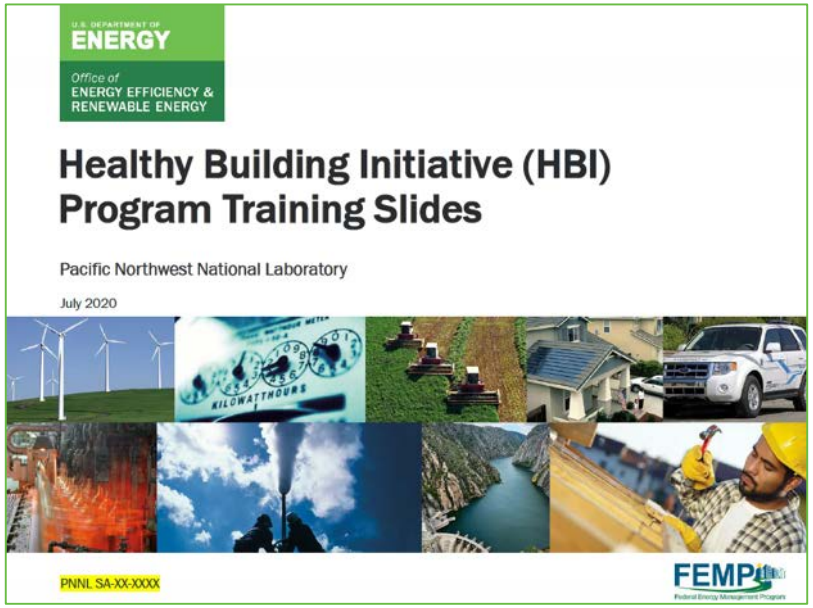
Outputs:
Cost Benefit Analysis
Improvement Recs

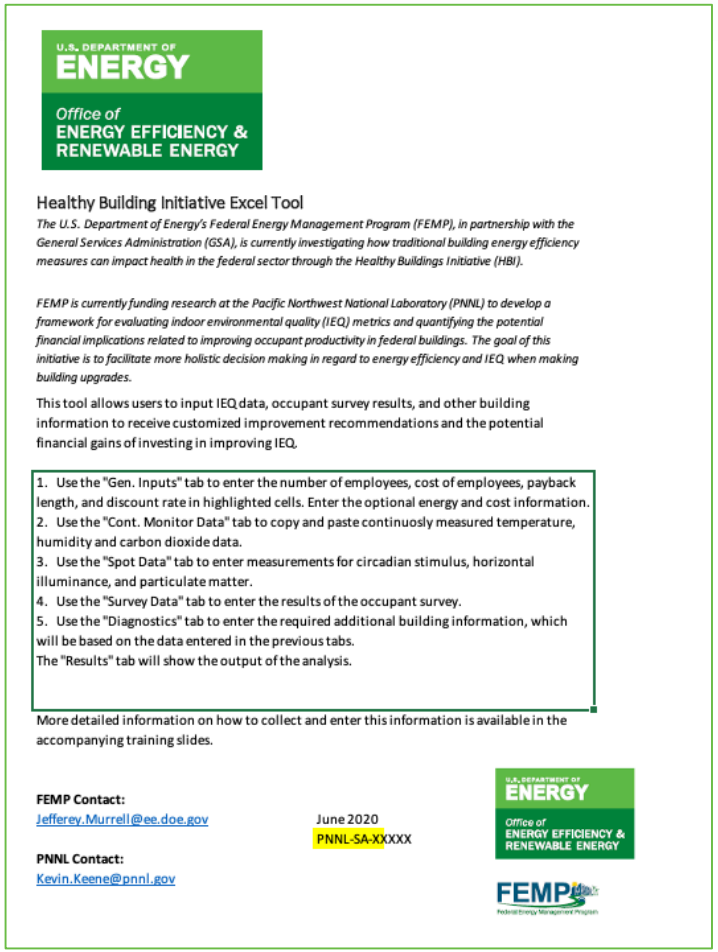
HBI "Program in a Box"

Equipment Library

HBI Training Materials



HBI Calculator (Excel)



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Healthy Building Initiative Excel Tool

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

FEMP is currently funding research at the Pacific Northwest National Laboratory (PNNL) to develop a framework for evaluating indoor environmental quality (IEQ) metrics and quantifying the potential financial implications related to improving occupant productivity in federal buildings. The goal of this initiative is to facilitate more holistic decision making in regard to energy efficiency and IEQ when making building upgrades.

This tool allows users to input IEQ data, occupant survey results, and other building information to receive customized improvement recommendations and the potential financial gains of investing in improving IEQ.

1. Use the "Gen. Inputs" tab to enter the number of employees, cost of employees, payback length, and discount rate in highlighted cells. Enter the optional energy and cost information.
2. Use the "Cont. Monitor Data" tab to copy and paste continuosly measured temperature, humidity and carbon dioxide data.
3. Use the "Spot Data" tab to enter measurements for circadian stimulus, horizontal illuminance, and particulate matter.
4. Use the "Survey Data" tab to enter the results of the occupant survey.
5. Use the "Diagnostics" tab to enter the required additional building information, which will be based on the data entered in the previous tabs.

The "Results" tab will show the output of the analysis.

More detailed information on how to collect and enter this information is available in the accompanying training slides.

FEMP Contact:
Jefferey.Murrell@ee.doe.gov

PNNL Contact:
Kevin.Keene@pnnl.gov

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FEMP

Multi-family Energy Efficiency Measures with Health Impacts

- Sleep Quality
  - Noise reduction from high-performance windows
  - Circadian regulation from daylighting and circadian-rhythm LED lighting
- Indoor Air Quality
  - Efficient exhaust or ventilation system with particle filtration to remove indoor pollutants and reduce unit-to-unit contamination when opening windows is not feasible
- Thermal Comfort
  - Increased envelope insulation and reduced infiltration to reduce health risks associated with heat stress
  - Energy-efficient heating and cooling equipment makes it more affordable to maintain comfort environment. (Thermal comfort affects sleep quality too.)

Resources

- FEMP Healthy Buildings Initiative website: Coming Soon!

- PNNL Healthy Buildings Initiative website:
https://www.pnnl.gov/projects/healthy-buildings

- Energy and Health Nexus white paper:
https://www.pnnl.gov/sites/default/files/media/file/EED_0831_BROCH_HealthyBuildings_v4.pdf

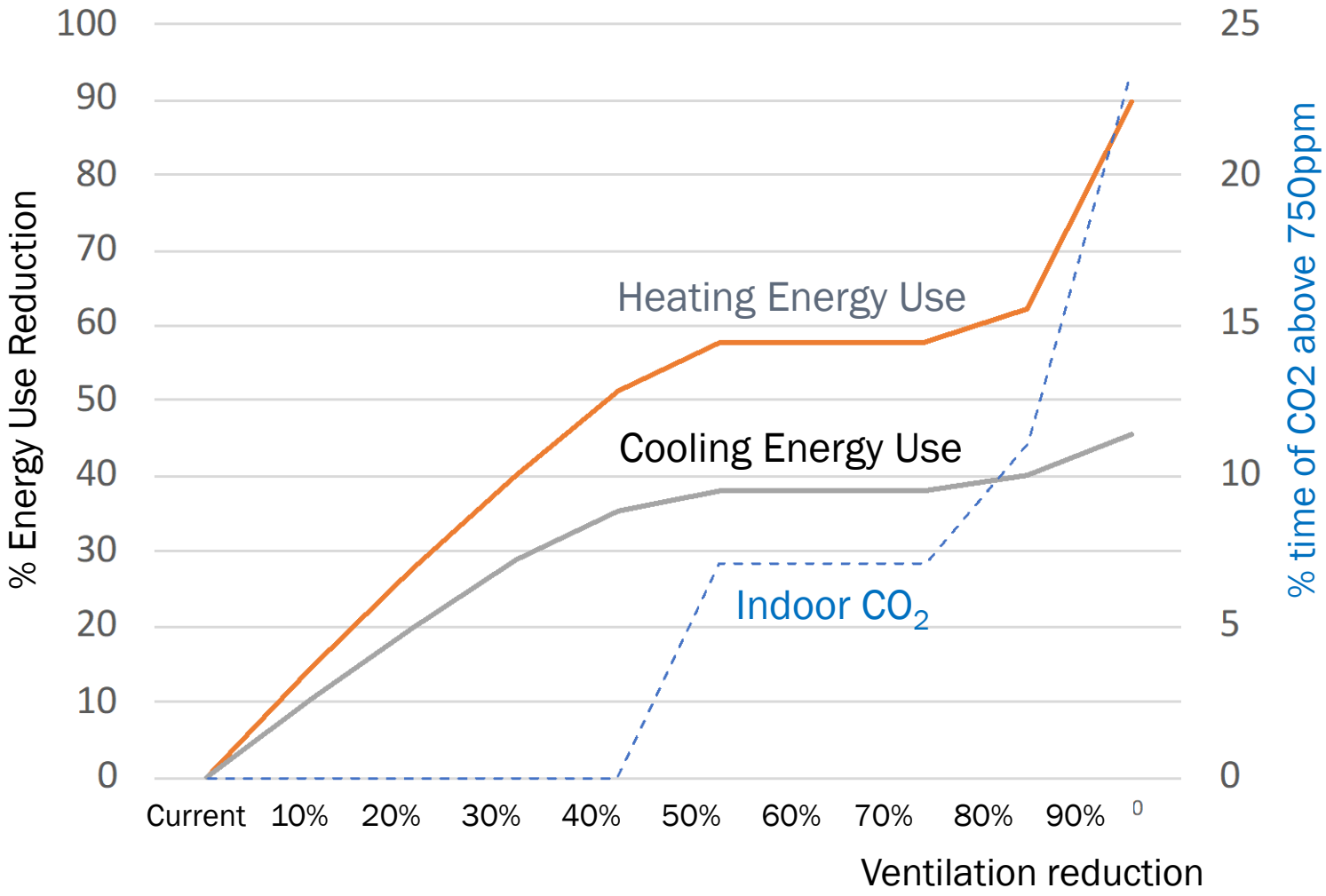
- Case Studies
https://www.pnnl.gov/healthy-buildings/news-and-publications

What are the barriers to utilize non-energy benefits to engage customers or to push for more aggressive energy goals?

What challenges and opportunities come with the pandemic?

What can we do to move the needle?

Ventilation, CO_2, Energy Use (Pilot Building)



How to define productivity

- Productivity, sometimes referred to as work performance, presenteeism, or profitability, among other terms, has been defined and measured in various ways.
- In an office setting, one way to define productivity is the “efficient completion of tasks and the effective generation and deployment of knowledge and ideas.”
- Studies included in our correlation models are related to speed, including time to complete simulated office tasks, cognitive tests, typing tasks, and customer calls.

http://www.bco.org.uk/Research/Publications/Defining_and_Measuring_Productivity_in_Offices.aspx
https://www.emerald.com/insight/content/doi/10.1108/17410400510571437/full/html