Integrating Health and Energy Efficiency in Federal Buildings

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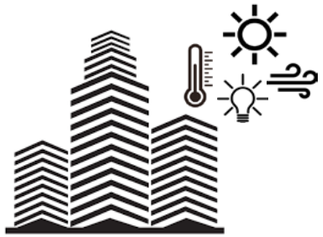
Methodology Overview

1

Primary Metrics
(IEQ monitoring)



2

Potential Improvement
(delta to targets)

ASHRAE IES WELL BUILDING STANDARD

3

Literature Correlation
(to prod./abs.)

4

Secondary Metrics
(identify issues)

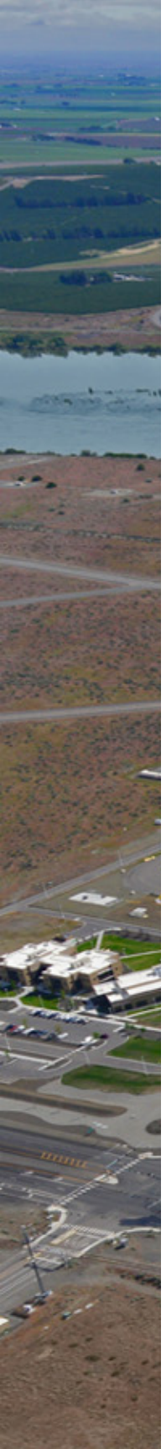
5

Output 1: Cost Benefit Analysis

HR $

6

Output 2: Improvement Recs



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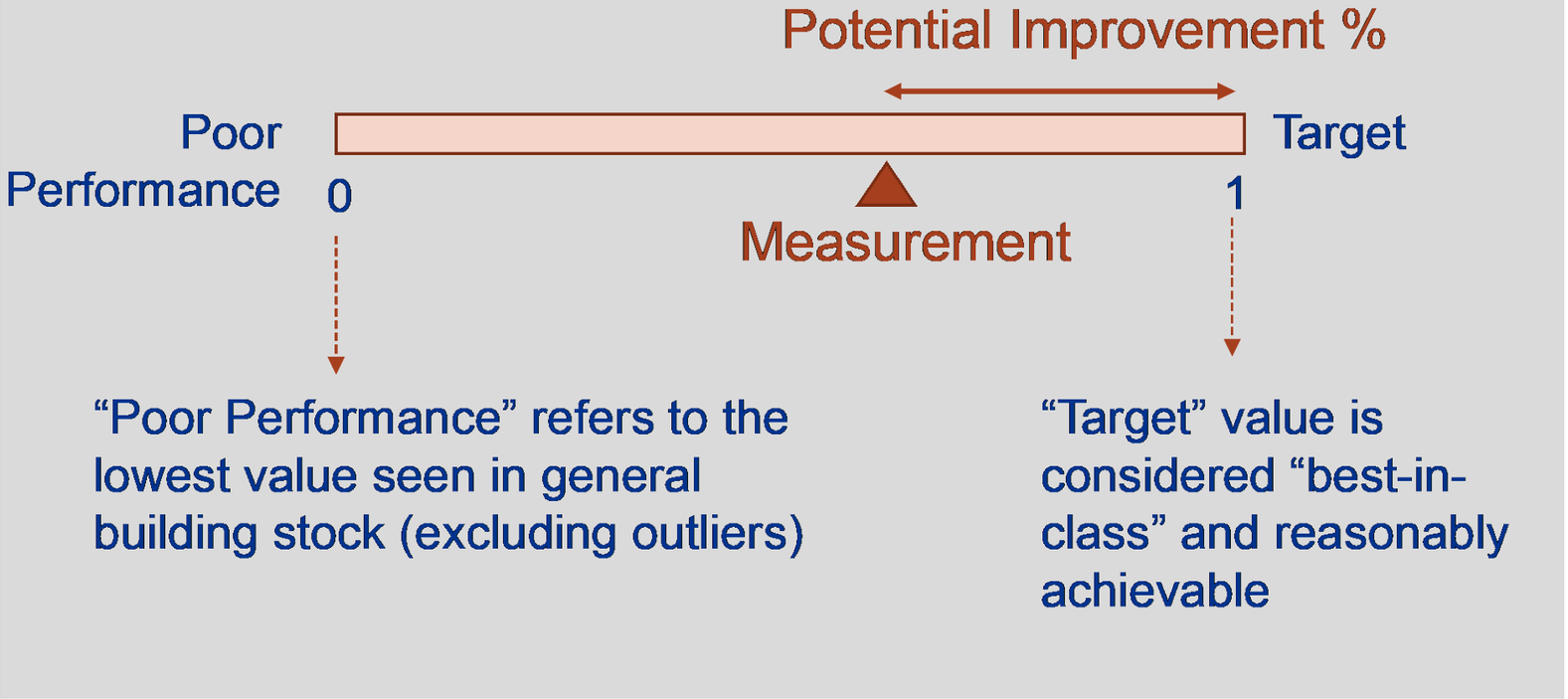
Metrics

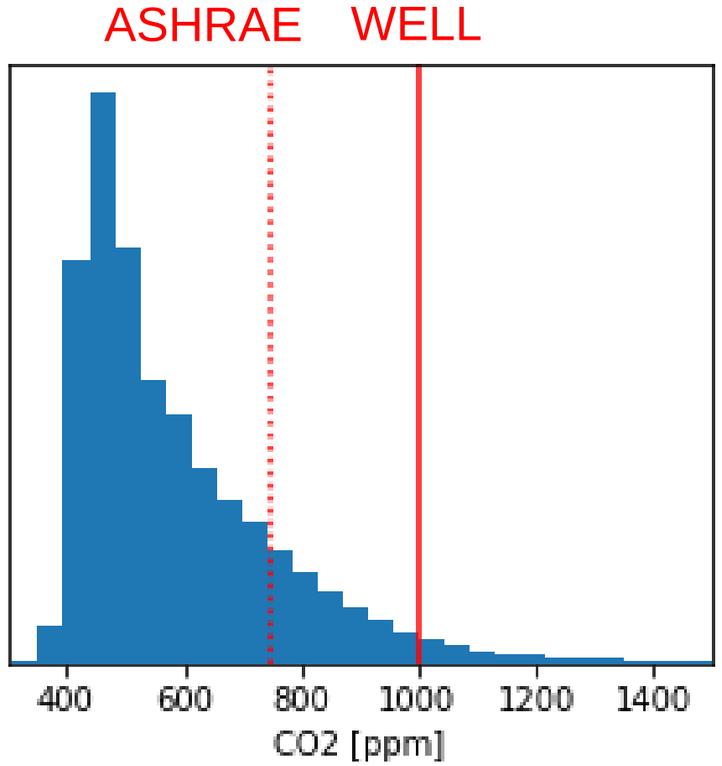
Category	Primary Metrics (1)	Secondary Metrics (4)
Lighting	Horizontal Illuminance	Task Lighting
		Automatic Dimmers
		Occupancy Sensors and Controls
	Circadian Stimulus	Window Proximity
	Glare (screening Qs)	Same as screening data
Indoor Air Quality	Particulate Matter	Air Filters
		Positive Building Pressure
		Outdoor Air Intake Location
	Carbon Dioxide	Outdoor Airflow Supply
		Ventilation Rate
		Zone Diffuser Obstruction
	VOC (screening Qs)	Same as screening data
Thermal Comfort	Predictive Mean Vote	Temperature Setpoint and Controls
		Manual Controls
		Personal Thermal Devices
		Enclosure Heat Loss/Gain

Metric	Screening Data
Glare	Automatic and manual blinds, shades
	Perpendicular desks
	Occupant survey question about effectiveness of blinds, shades and source of glare (electric/daylight)
VOCs	Green cleaning products
	Low-emitting materials and equipment

Potential Improvement

2 Illustrative of concept only:

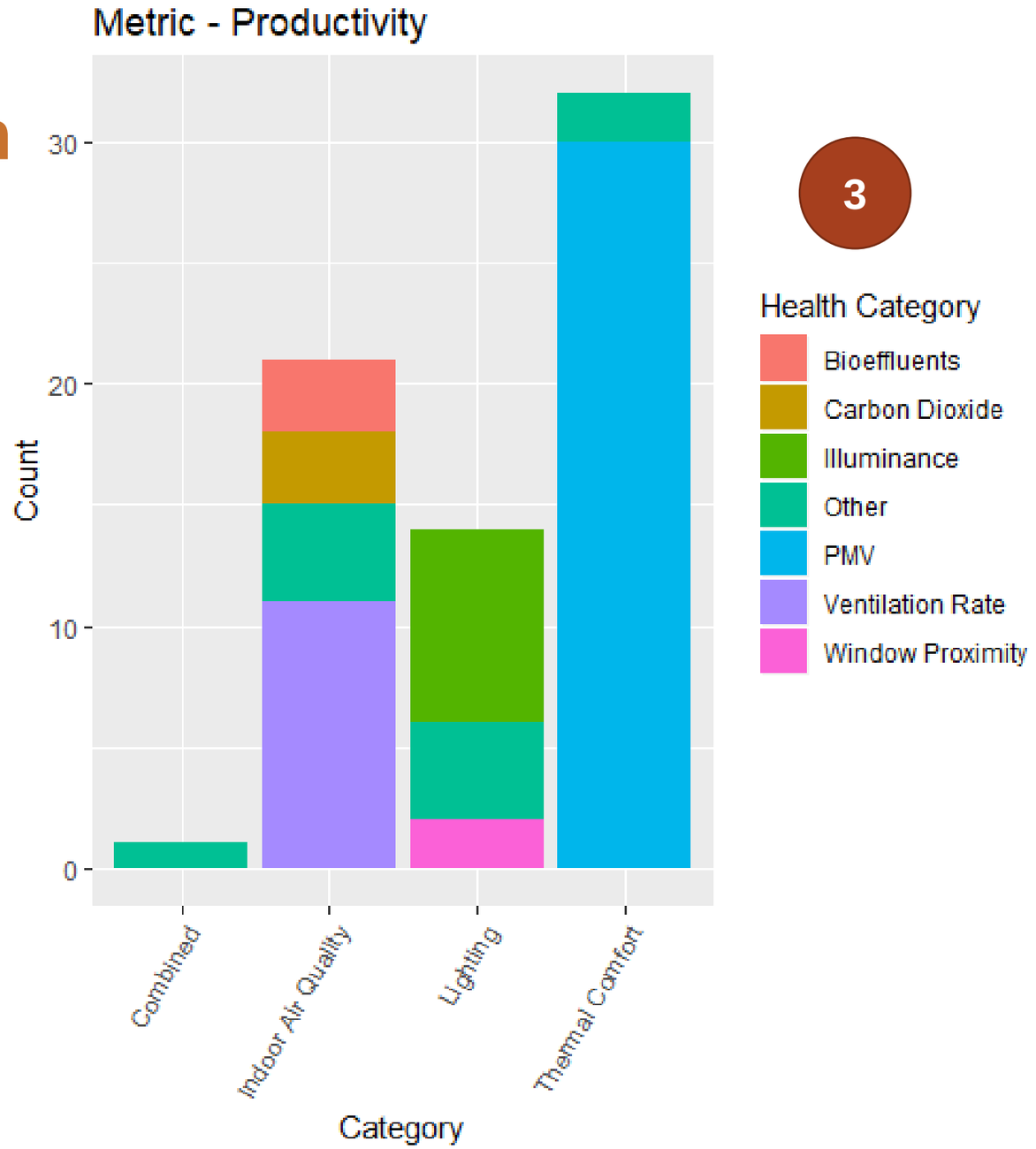




Example CO_2 data
(pilot building: office)

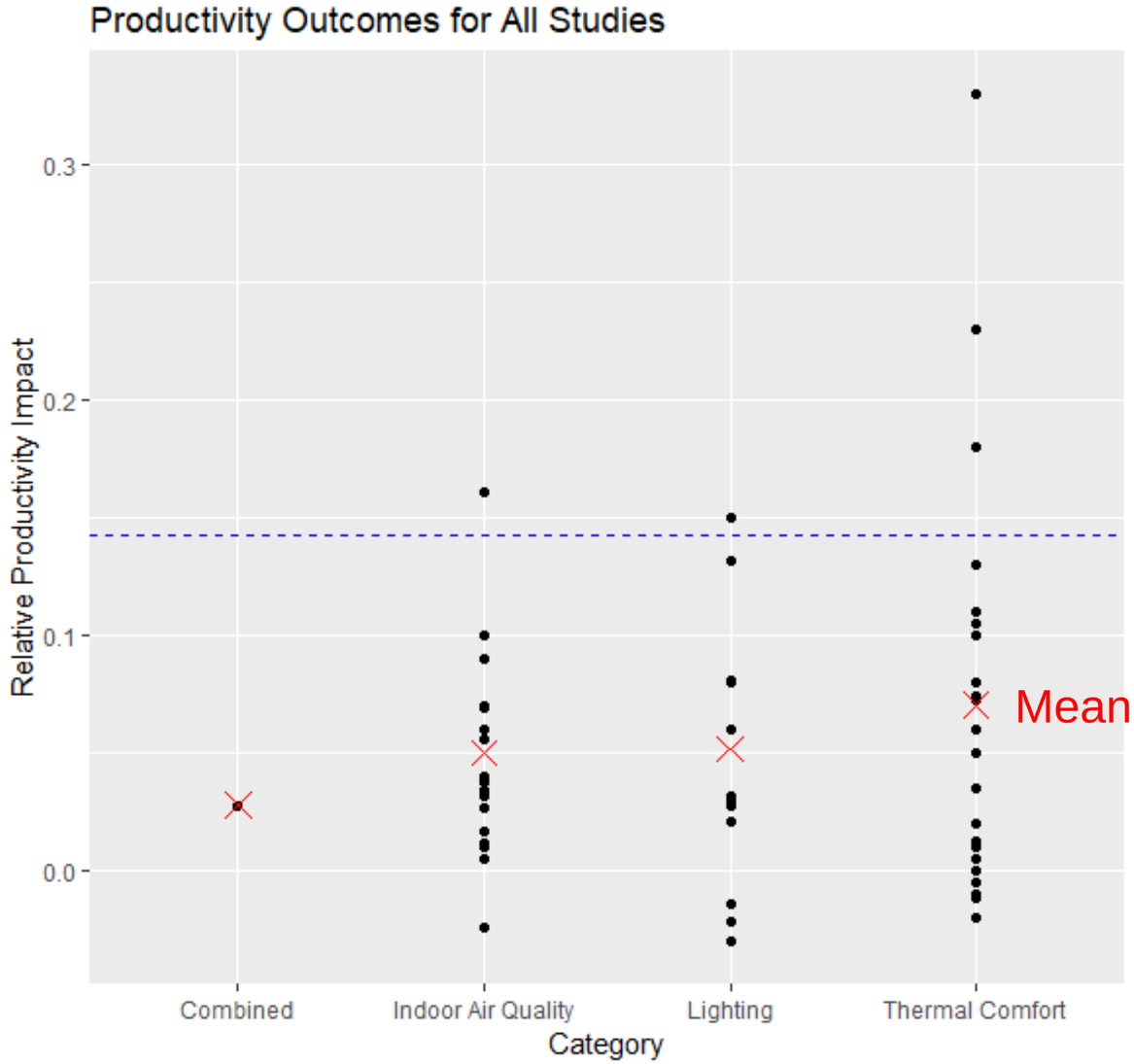
Literature Correlation

- 29 academic studies correlating lighting, thermal comfort, and IAQ to productivity, 68 data points (multiple testing conditions or populations in some studies)
- Productivity was measured in time to complete office tasks or office task output (typing speed, call handling time, typing output, etc.).



Literature Correlation

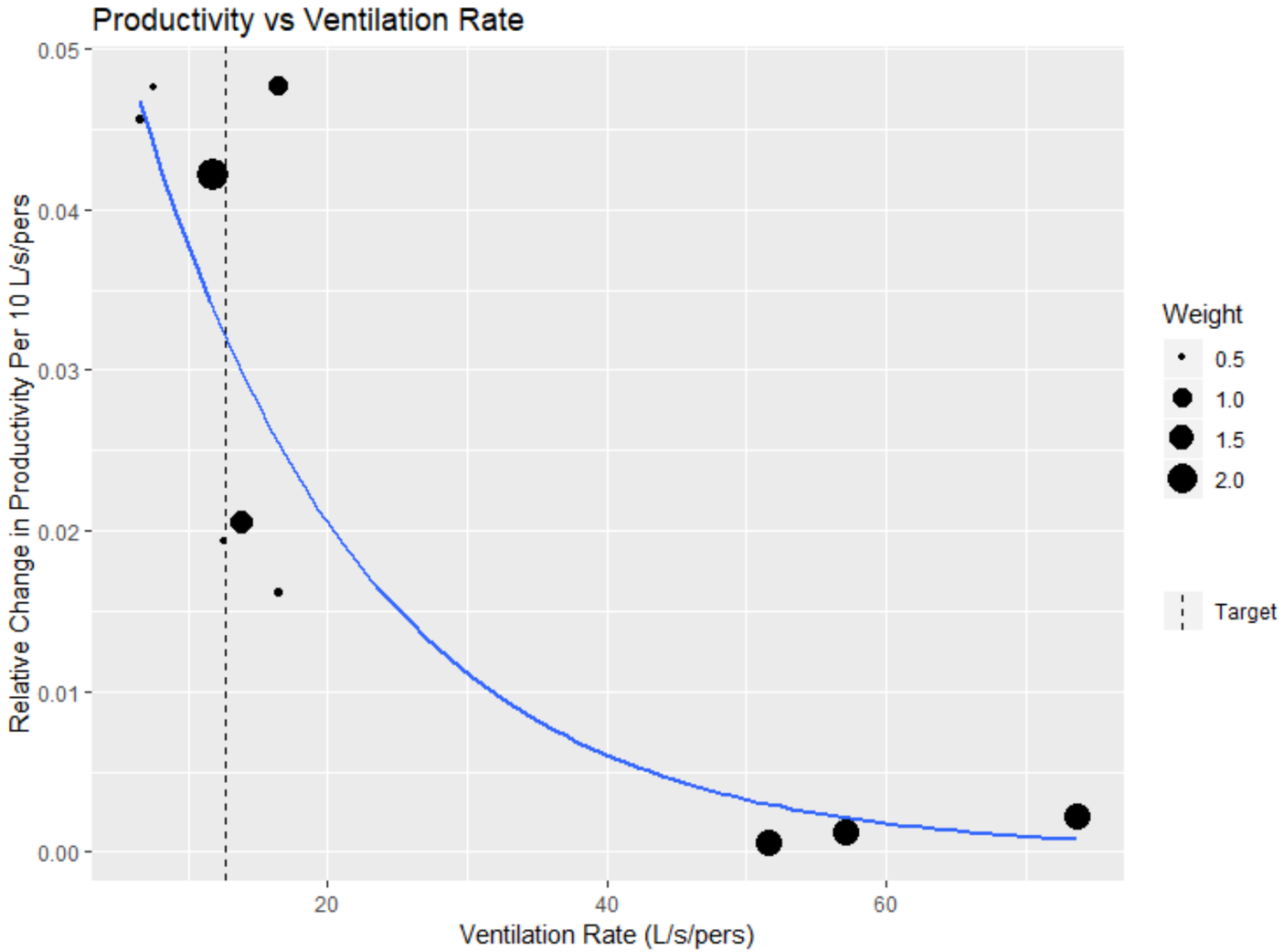
3



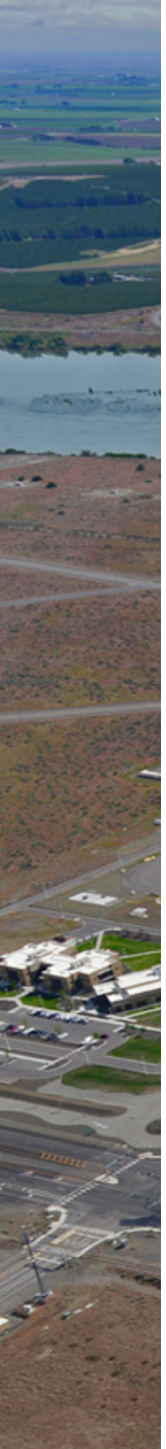
How to compare/combine measures/metrics across categories?

Literature Correlation

3



Is there a correlation between ventilation rate and productivity?



Personnel Costs 5

Equation 1. Estimated absenteeism savings

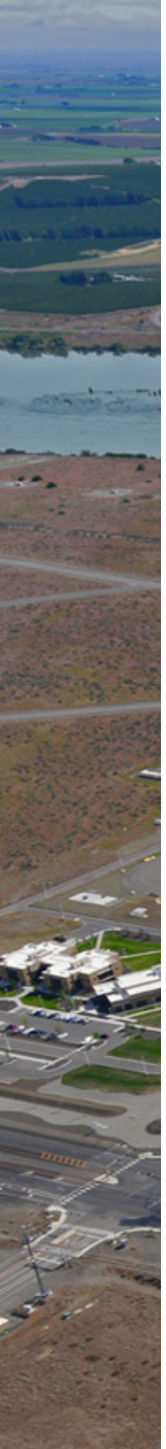
$$S_{abs} = (N_e * C_e) * A_r * A * T_b * (1 + P)$$

Equation 2. Estimated productivity savings

$$S_{prod} = (N_e * C_e) * T_b * P$$

Variable	Default Value	Symbol	Notes
Number of Employees		N_e	Required
Average Annual Cost of Employee	$122,895[1]	C_e	Salary + benefits
Average Percent of Work Time in Building	80%	T_b	From occupant survey or other source
Absentee Rate	2.0%[2]	A_r	
Productivity Improvement		P	From Step 3
Absenteeism Improvement		A	From Step 3

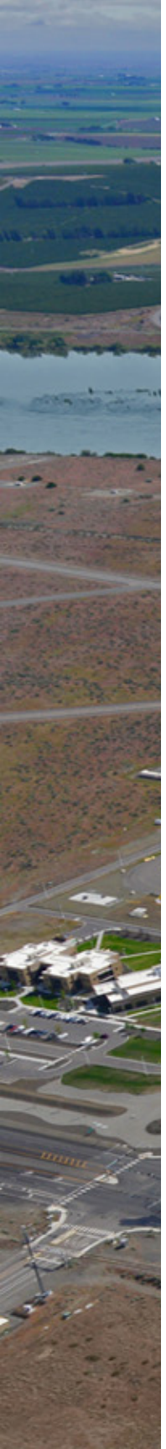
[1] https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey
[2] https://www.bls.gov/cps/cpsaat47.htm



Improvement Recommendations 6

(Example from pilot buildings)

- **Thermal comfort:**
  - **Issue:** Building is cold.
  - **Recommend:** Increase the building temperature setpoint and provide heated chairs as needed.
- **Lighting:**
  - **Issue**: Lack of daylight access; occupancy sensors are not functioning properly.
  - **Recommend:** Provide color-tuning task lighting to workstations without windows. Recommissioning of lighting sensors.
- **Indoor Air Quality**:
  - No Issue identified. Low CO_2
  - **Recommend:** Potential to reduce outdoor airflow and ventilation rate.



Cost-Benefit Analysis

5

(Example from pilot buildings)

	Health (20-yr NPV)	Energy (20-yr NPV)	Retrofit Cost	Cost-Benefit NPV	Benefit / Cost Ratio
Overall	$2,544,000	$16,000	-$50,000	$2,436,000	49.2
IAQ	$0	$2,000	$0	$2,000	N/A
Thermal Comfort	$1,187,000	$14,000	-$24,000	$1,141,000	47.0
Lighting	$1,343,000	$0	-$25,000	$1,278,000	50.6

Default discount rate: 3%

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Thank you