"Whole Building" Performance Metrics for Commercial Buildings

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PERFORMANCE METRICS OVERVIEW

► **"Whole" Building performance metrics** measure the sustainability-related attributes across primary areas of **existing building** operations and costs: energy, water, operations & maintenance, purchasing, waste & recycling, indoor environmental quality, and transportation.

Energy
Water
Operations & Maintenance
Purchasing, Waste & Recycling
Indoor Environmental Quality
Transportation
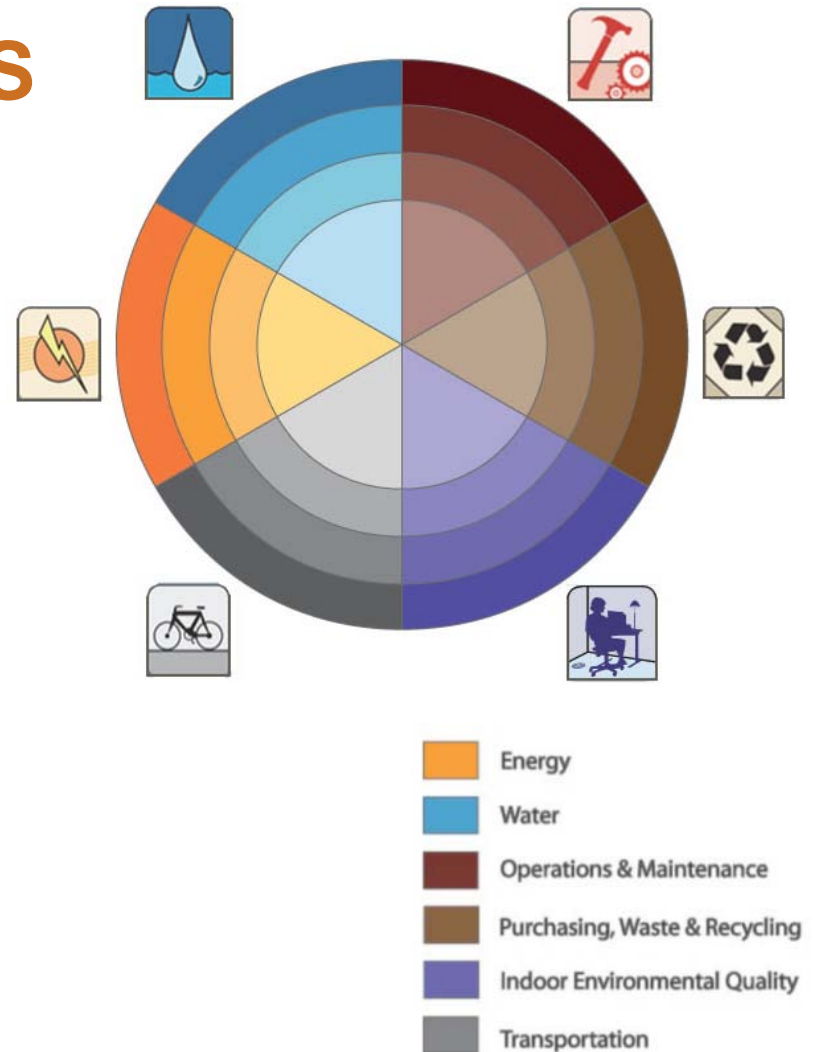
PERFORMANCE METRICS OVERVIEW

► Levels of detail

  ■ Informative

    ● Identifying major strengths and weaknesses about the building

  ■ Investigative

    ● Examining aspects of a building to discover which building systems are impacting performance

  ■ Diagnostic

    ● Identifying specifically how a building system needs to change to improve performance

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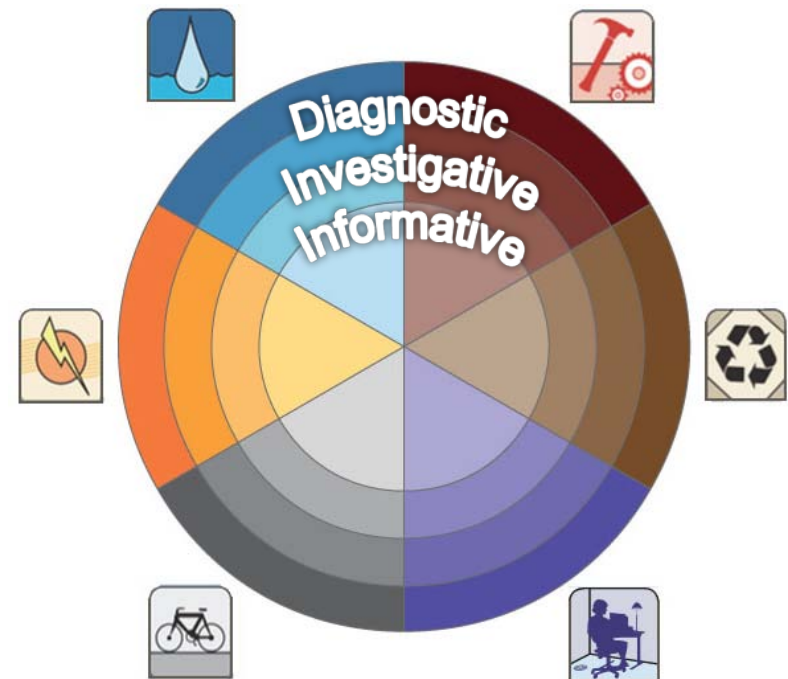
EXAMPLE: WATER METRICS
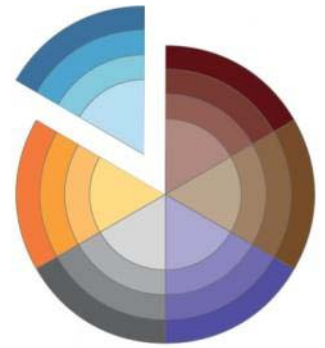
Level 1 → Total Building Water Use | Wastewater Production

Level 1 → Total Building Water Use

- Indoor Water
- Outdoor Water
- Process Water
- Water Processing

Wastewater Production

- Stormwater Sewer
- Indoor Wastewater Production
- Indoor Wastewater Production

Level 2 →
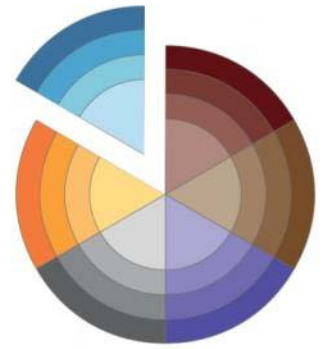- Indoor Potable Water
- Indoor Non-Potable Water
- Outdoor Potable Water
- Outdoor Non-Potable Water
- Non-Potable Water Collection
- On-site Collected Non-Potable Water Treatment

EXAMPLE: WATER METRICS

Level 1 ➡

Level 2 ➡

Total Building Water Use

- Indoor Water
  - Indoor Potable Water
  - Indoor Non-Potable Water
- Outdoor Water
  - Outdoor Potable Water
  - Outdoor Non-Potable Water
- Process Water
- Water Processing
  - Non-Potable Water Collection
  - On-site Collected Non-Potable Water Treatment

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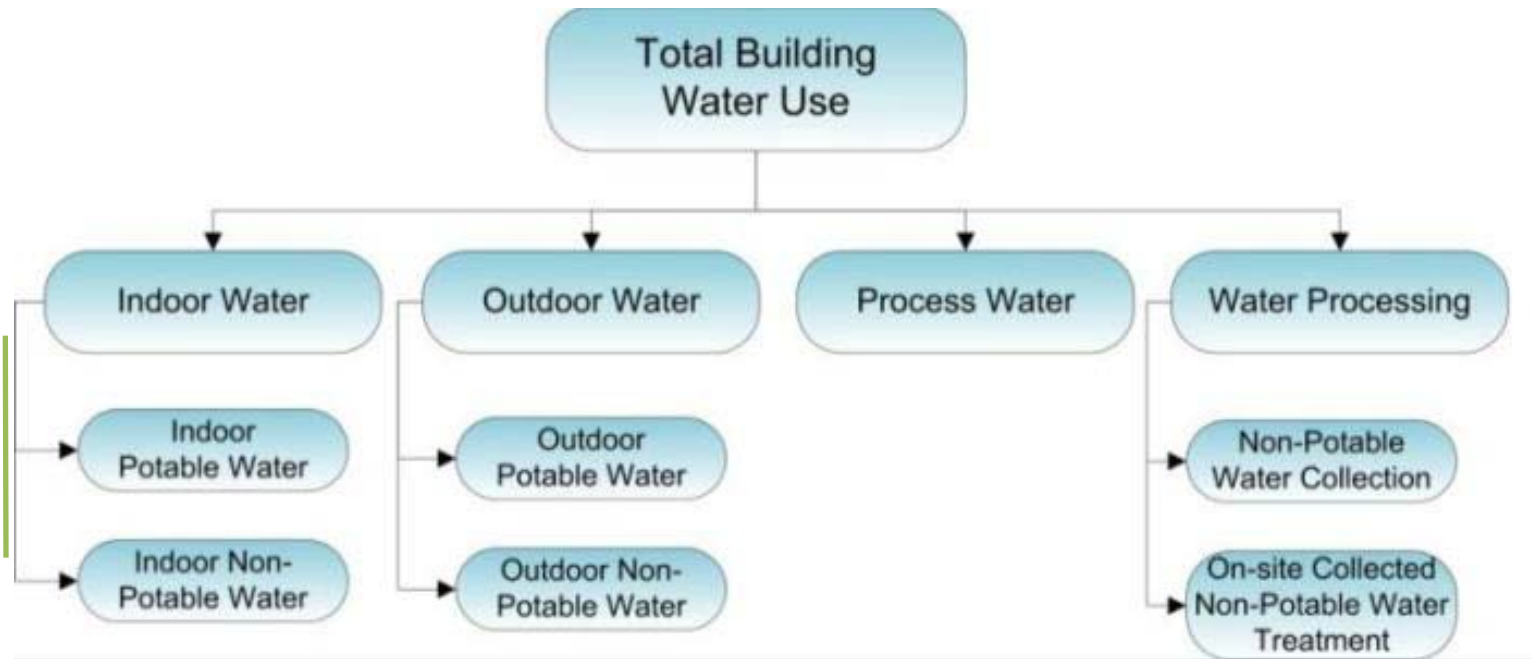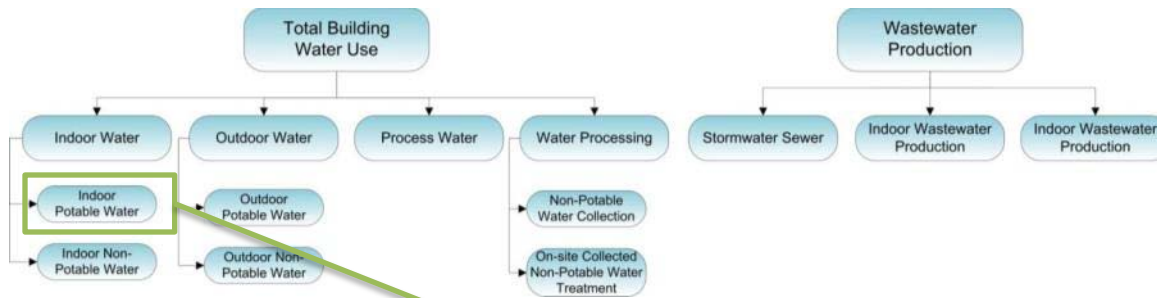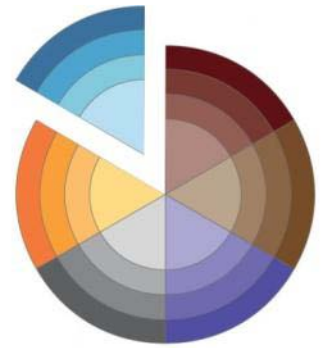
EXAMPLE: WATER METRICS

Level 3

Level 4

EXAMPLE: WATER METRICS
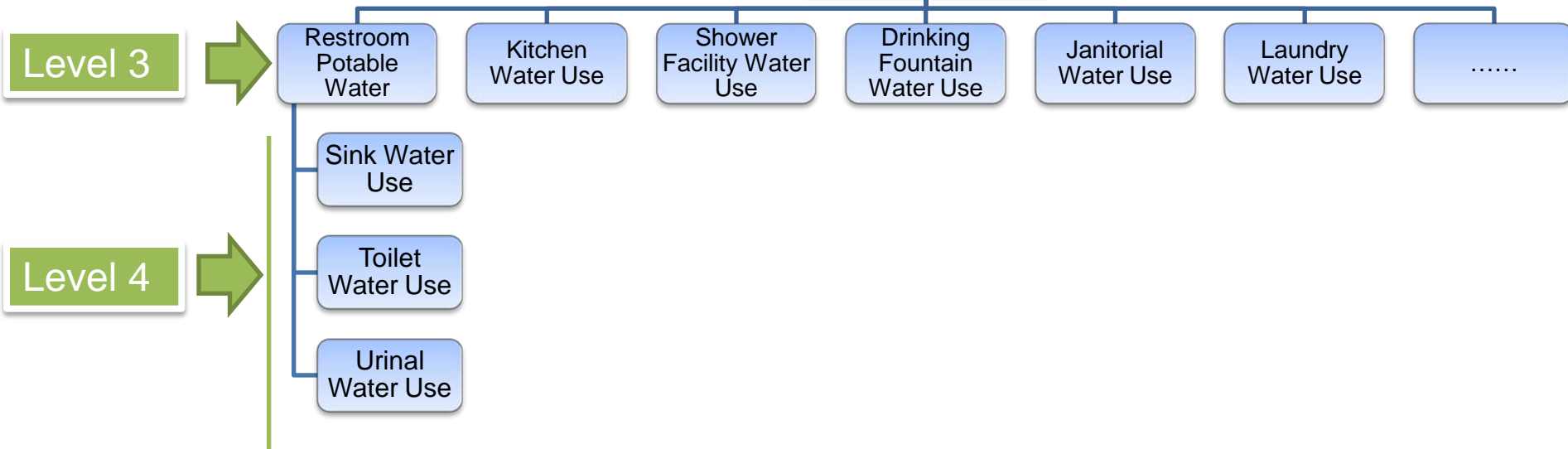
Level 1	Level 2	Level 3	Level 4	Reporting Units (IP)	Reporting Units (SI)	Typical Data Source
Total Building Water Use				gal/ft^2	L/m^2, m^3/m^2	Utility Bill
Total Building Water Cost				cost/ft^2	cost/m^2	Utility Bill
	Indoor Potable Water Use			gal/ft^2, gal/occupant	L/m^2, m^3/m^2, L/occupant, m^3/occupant	Meter, Utility Bill
	Indoor Potable Water Cost			cost/ft^2, cost/occupant	cost/m^2, cost/occupant	Utility Bill, Calculation
		Restroom Potable Water Use		gal/ft^2, gal/occupant	L/m^2, m^3/m^2, L/occupant, m^3/occupant	Meter
			Sink Water Use	gal/ft^2, gal/occupant	L/m^2, m^3/m^2, L/occupant, m^3/occupant	Meter

PERFORMANCE METRICS PUBLIC SECTOR

► Green portfolio compared to industry & internal standards
► Matched pairs analysis
► Pre- and post-occupancy analysis

Seattle CT
Auburn FB
Eugene CT
Bonneville Power
  Administration

Sweetgrass Port
Ogden FB
Lakewood FB
Denver FB
Denver CT
National Renewable
  Energy Laboratory

Sault Ste. Marie Port
Cleveland CT
Youngstown FB and CT
Argonne National
  Laboratory
DOE Fernald Site

Suitland FB
Rockville FB
Washington Naval Yard
Norfolk (2)
Brookhaven National
  Laboratory

San Francisco FB
Lawrence Berkeley
  National Laboratory
Fresno CT and FB
Santa Ana FB
Port Hueneme
Camp Pendleton
Las Vegas CT
Lawrence Livermore
  National Laboratory
Nevada Test Site

Omaha FB (2)
Davenport CT
Manhattan FB
Cape Girardeau CT

Pantex Plant

Knoxville FB
Greeneville CT
Oak Ridge National
  Laboratory
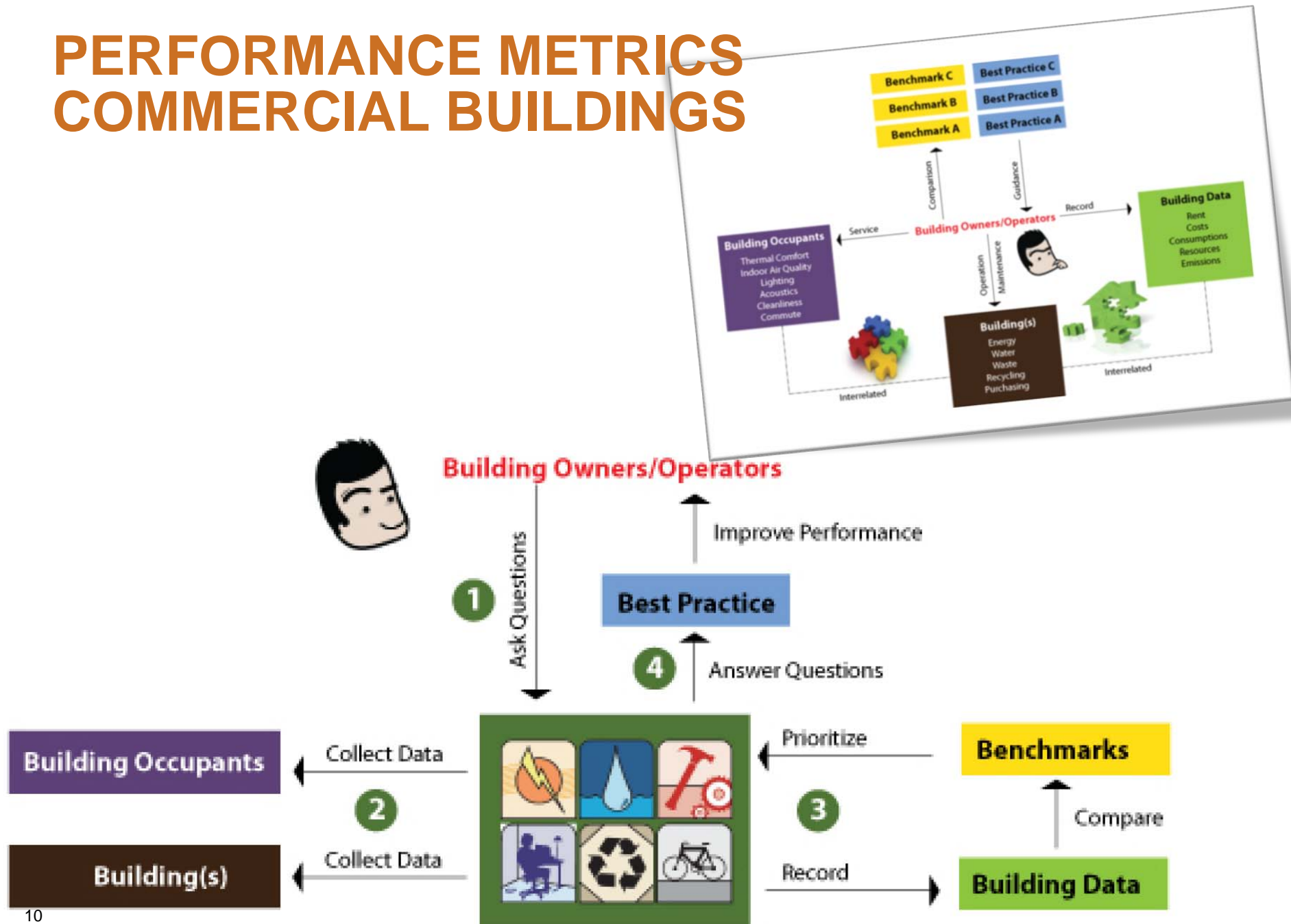Jacksonville FB
Fort Bragg
Fort Campbell

PORTFOLIO ANALYSIS
Example

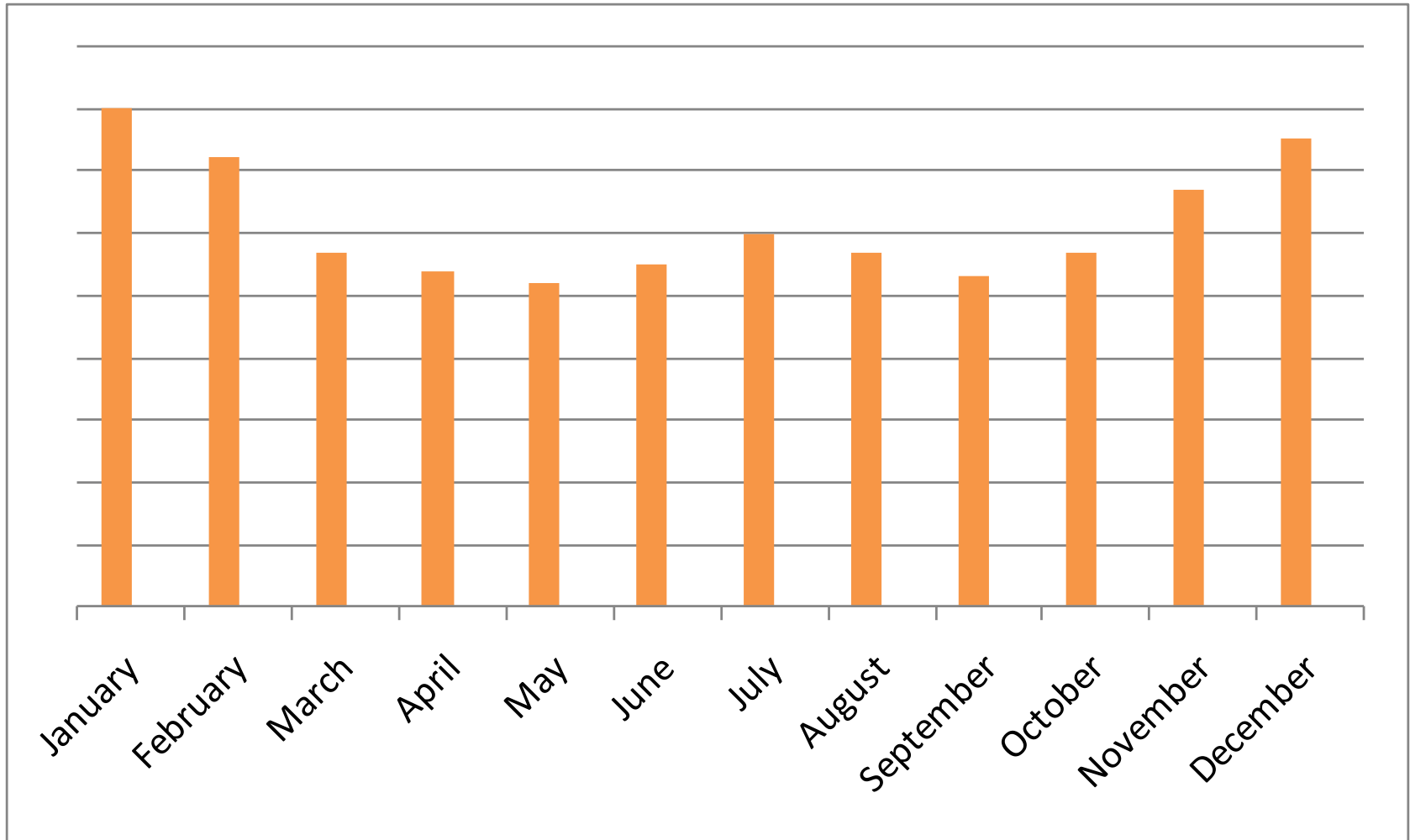# PERFORMANCE METRICS COMMERCIAL BUILDINGS

ENERGY PERFORMANCE
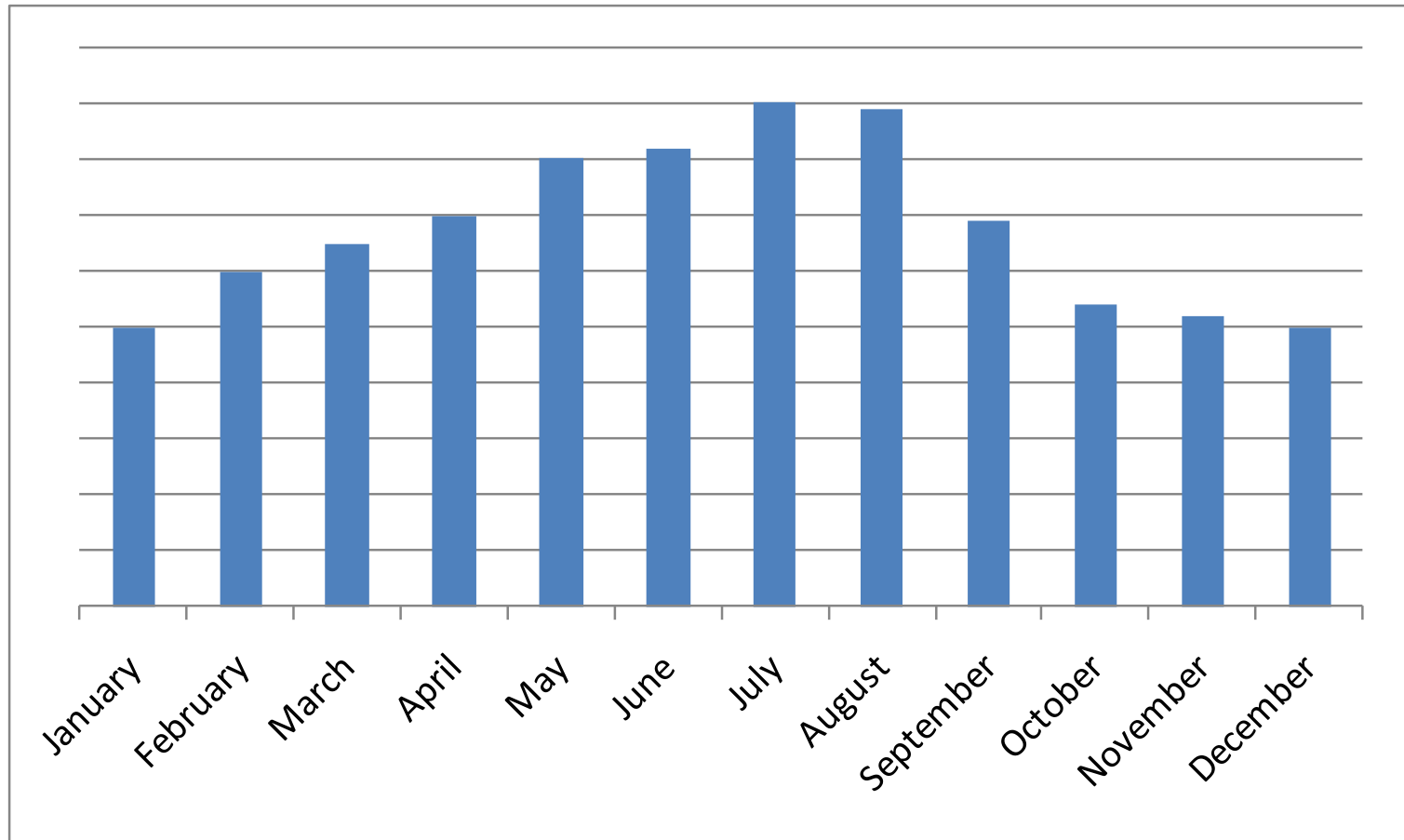## Example

EUI = 70 & Energy Star Score = 82

WATER PERFORMANCE
Example

Water use 50% below industry baseline

MAINTENANCE, OCCUPANT SATISFACTION, and ENERGY METRICS Example

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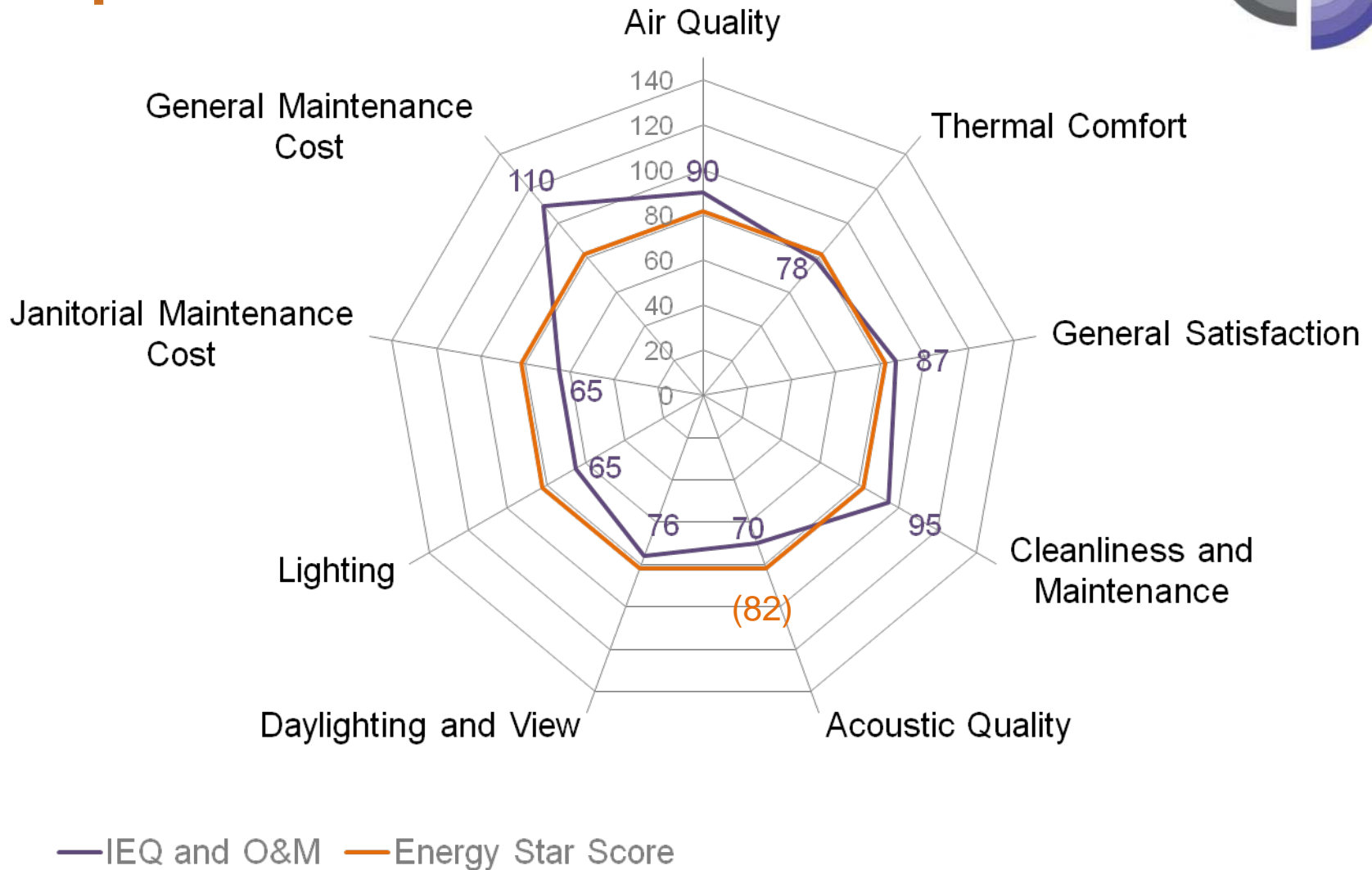
OCCUPANT SATISFACTION METRIC
Example

Thermal Comfort

28% Percentile

Very Satisfied

Very Dissatisfied

-0.44
Mean Response

31%
Satisfied
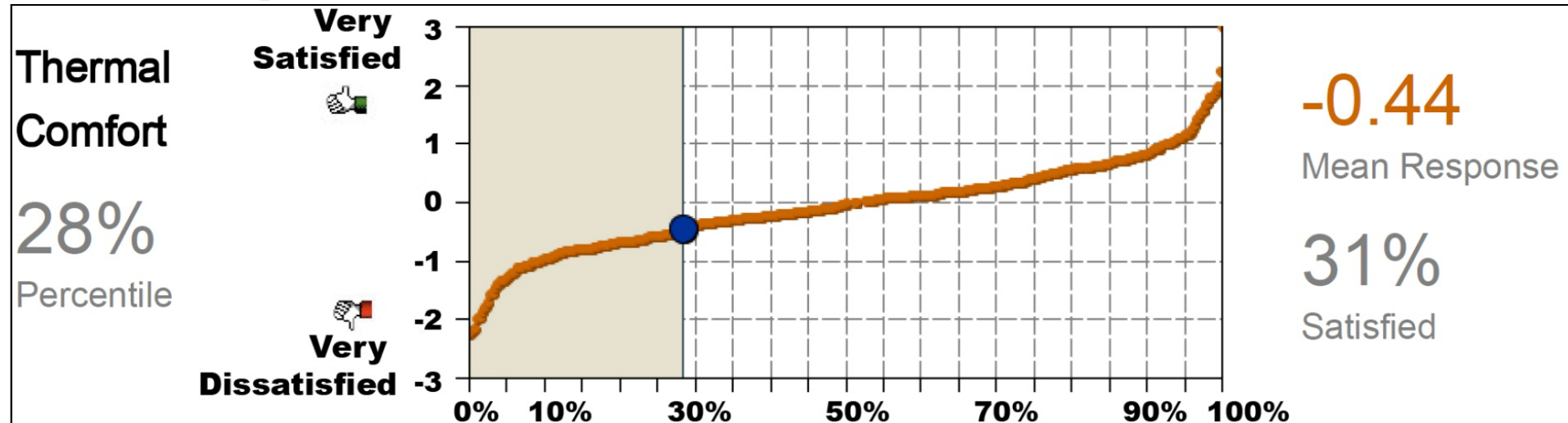
How satisfied are you with the temperature in your workspace?

Mean -0.44

-3	-2	-1	0	1	2	3
13%	20%	16%	20%	16%	11%	4%

49% Very Dissatisfied   20% Neutral   31% Very Satisfied
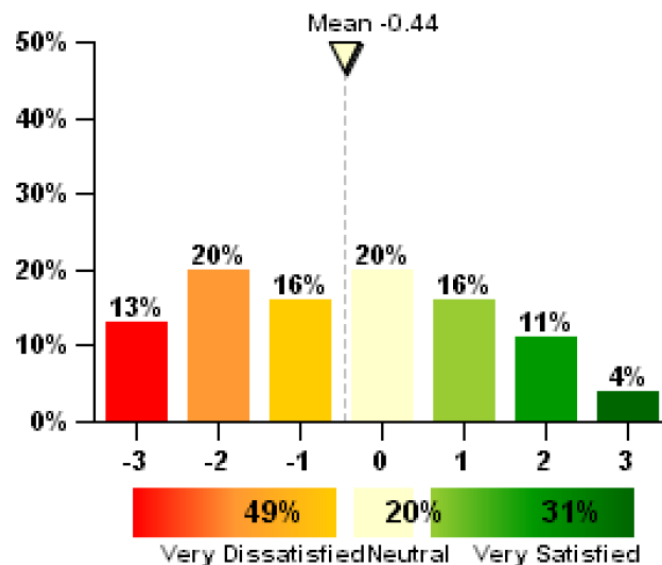
PILOT STUDY

▶ Pilot test goals
  - Clarify metrics so that they meet the needs of the commercial building sector
  - Identify metrics that are difficult to collect
  - Identify metrics that commercial building owners are willing to share with the building industry

▶ Volunteer's responsibilities
  - Collect building data
    - Building square footage, number of occupants, etc.
    - Utility bills
    - Employee survey re: the building & commute
  - Share the performance observations with DOE
  - Share lessons learned from data collection and analysis

▶ Technical assistance provided by PNNL and NREL
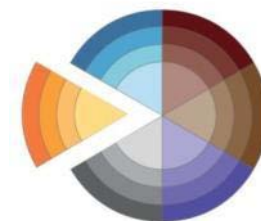
USER'S GUIDE

HOW TO USE PERFORMANCE METRICS?

Step 1: Start with your questions from HERE:

Step 2: Find the metrics that you need to measure

Energy costs tend to be the largest costs associated with a building. Energy metrics cover many facets in a building. Both energy and greenhouse gas (GHG) emissions offsets are included in the metrics. Start from the Questions column and locate the metrics that will help answer your questions.

Questions	No.	Metrics	Description	Data Collection	Reporting Units	Baseline Comparison
Is my building using more or less total energy than similar buildings?	E1	Total Building Energy Use	Total of all energy consumed at the building site	1. Collect and store monthly building utility data;	kBtu/ft^2, total & itemized by fuel type	Energy Portfolio Manager
Can I reduce indoor energy use?	E2	Indoor Energy Use	Energy consumed for HVAC, indoor lighting, facade lighting, DHW, plug loads, people movers, and other building energy uses	2. . Calculate annual building utility use and cost and then convert data to kBtu, if the utility data is not in kBtu unit; (1kW=3.412 kBtu, 1 therm=100 kBtu)	kBtu/ft^2, total & itemized by fuel type	
Can I reduce outdoor energy use?	E3	Outdoor Energy Use*	Energy consumed for parking lot lights, walkway lighting, detached sign lighting, snow melting, landscaping, and other outdoor uses		kBtu/ft^2, total & itemized by fuel type	
Is my energy bill higher or lower than similar buildings?	E4	Total Building Energy Cost		3. Collection Building normalization factors, including gross floor area (or rentable floor area) and site area;	cost/ft^2, total & itemized by fuel type	Energy Portfolio Manager
Can I increase net rent income by reducing indoor and/or outdoor energy cost?	E5	Indoor Energy Cost			cost/site area	
	E6	Outdoor Energy Cost*			cost/site area	
Can costs be reduced if the peak demand is at a different time?	E7	Building Peak Demand*	Amount of power consumption necessary to supply electricity to a facility at the maximum use, usually measured over a specific short period of time.	4. Calculate and record utility data using the corresponding reporting units.	kW, kW/ft^2	
	E8	Building Peak Demand Cost*		(Refer to Master Spreadsheet for an example)	cost/ft^2	
Is purchasing energy credits a proper way to improve my building performance?	E9	Owner Generated Energy Production*	Total of all energy produced at the building and either used at the building or sold for use elsewhere		kWh/site area	
	E10	Purchased Offsets and Cost*	Financial instrucment used to reduce greenhouse gas emissions		MTCO$_2$e/site area cost/site area	
Will purchasing GHG credits a proper way to improve my building performance?	E11	Energy Offsets and Cost*	Credits issued to offset the enviornmental costs of energy needs by funding renewable energy sources elsewhere on the grid		MTCO$_2$e/site area cost/site area	
	E12	GHG Offsets and Cost*	Credits issued to offse the environmental costs of emissions by funding activities that offset emissions, such as reforestation and land fill		MTCO$_2$e/site area cost/site area	

HOW TO USE PERFORMANCE METRICS?
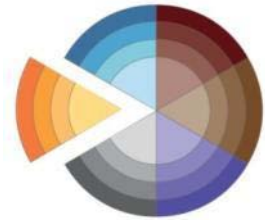
Sample Data Collection Master Spreadsheet: Energy Metrics

Energy Metrics	Fuel Type	Collecting Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total	Converting Factor	Normalization Factor	Reporting Units	Year 1 Value for comparing analysis
Total Building Energy Use	Electricity	kWh	22,000	23,000	15,000	9,000	18,500	23,000	33,000	35,500	19,000	12,500	18,500	25,000	254,000	1 kWh =3.412 kBtu	10,000 (GSF or RSF)	kBtu/ft²	132
	Natural Gas	Therm	500	800	300	80	0	0	0	0	0	150	350	480	2,660				
	Fuel (by type)	gallon	50	60	60	100	126	253	264	237	186	86	44	68	1,534				
Indoor Energy Use	Electricity	kWh	17,600	18,400	12,000	7,200	14,800	18,400	26,400	28,400	15,200	10,000	14,800	20,000	203,200	1 Therm =100 kBtu	100,000 (Site Area)	kBtu/ft²	96
	Natural Gas	Therm	500	800	300	80	0	0	0	0	0	150	350	480	2,660				
Outdoor Energy Use*	Electricity	kWh	4,400	4,600	3,000	1,800	3,700	4,600	6,600	7,100	3,800	2,500	3,700	5,000	50,800			kWh/site area	4
	Fuel (by type)	gallon	50	60	60	100	126	253	264	237	186	86	44	68	1,534				
Total Building Energy Cost	Electricity	$	$1,760	$1,840	$1,200	$720	$1,480	$1,840	$2,640	$2,840	$1,520	$1,000	$1,480	$2,000	$20,320	1 gallon diesel = 138.69 kBtu		cost/ft²	$2.77
	Natural Gas	$	$525	$840	$315	$84	$0	$0	$0	$0	$0	$158	$368	$504	$2,793				
	Fuel (by type)	$	$150	$180	$180	$300	$378	$759	$792	$711	$558	$258	$132	$204	$4,602				
Indoor Energy Cost	Electricity	$	$1,408	$1,472	$960	$576	$1,184	$1,472	$2,112	$2,272	$1,216	$800	$1,184	$1,600	$16,256	1 gallon diesel = 138.69 kBtu		cost/ft²	$1.90
	Natural Gas	$	$525	$840	$315	$84	$0	$0	$0	$0	$0	$158	$368	$504	$2,793				
Outdoor Energy Cost*	Electricity	$	$352	$368	$240	$144	$296	$368	$528	$568	$304	$200	$296	$400	$4,064			cost/site area	$0.09
	Fule (by ype)	$	$150	$180	$180	$300	$378	$759	$792	$711	$558	$258	$132	$204	$4,602				
Building Peak Demand*	Electricity	kW	0	0	0	0	10	12	22	12	5	0	0	0	61			kW/ft²	0.01
Peak Demand Cost*		$	$0	$0	$0	$0	$200	$240	$440	$240	$100	$0	$0	$0	$1,220			cost/ft²	$0.12
Owner Generated Energy Production*	Electricity	kWh	8,000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	96,000			kWh/site area	0.96
		$	$9,600	$9,600	$9,600	$9,600	$9,600	$9,600	$9,600	$9,600	$9,600	$9,600	$9,600	$9,600	$115,200			$/site area	$1.15
Purchased Offsets and Cost*	CO₂ equivalent	Metric ton	200	0	0	350	0	0	180	0	0	400	0	0	1,130			MTCO₂e/site	0.01
		$	$1,000	$0	$0	$1,750	$0	$0	$900	$0	$0	$2,000	$0	$0	$5,650			cost/site area	$0.06
Energy Offsets and Cost*	CO₂ equivalent	Metric ton	0	0	0	200	0	0	0	0	0	200	0	0	400			MTCO₂e/site	0.00
		$	$0	$0	$0	$800	$0	$0	$0	$0	$0	$800	$0	$0	$1,600			cost/site area	$0.02
GHG Offsets and Cost*	CO₂ equivalent	Metric ton	200	0	0	150	0	0	180	0	0	200	0	0	730			MTCO₂e/site	0.01
		$	$1,000	$0	$0	$950	$0	$0	$900	$0	$0	$1,200	$0	$0	$4,050			cost/site area	$0.04

(Year 2 columns: Jan ... Dec, Annual Total — blank)

1. Collect and store monthly building utility data over multiple years if applicable.

2. Calculate annual building utility use and cost and convert energy use to kBtu.

3. Collect corresponding normalization factors.

4. Calculate in the reporting units and prepare data for comparison.

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