Beyond Energy Efficiency: How Big Data and Strategic Planning can lead to Sustainable Building Construction

Sustainable Indiana County

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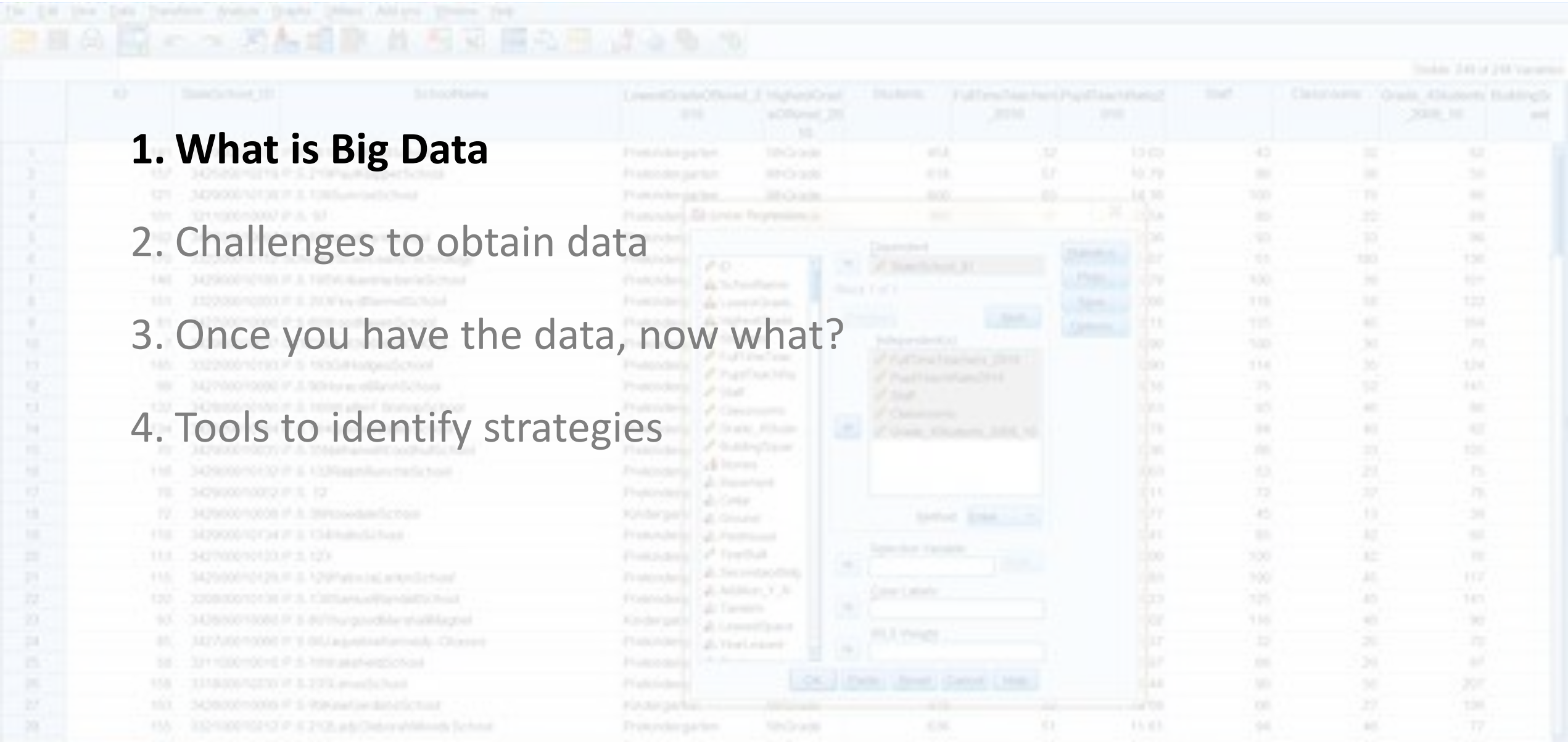
Overview

1. What is Big Data
2. Challenges to obtain data
3. Once you have the data, now what?
4. Tools to identify strategies



1. **What is Big Data**
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Why do we need access to building's energy consumption data?

Utility programs promoting benchmarking can drive similar results:

62%

said that benchmarking their building's performance strongly influenced them to take energy management actions

84%

of those who benchmarked made energy efficiency retrofits or operational improvements to their buildings

Among facility managers who have used ENERGY STAR for benchmarking:

70%

have used ENERGY STAR to guide energy efficiency upgrade plans

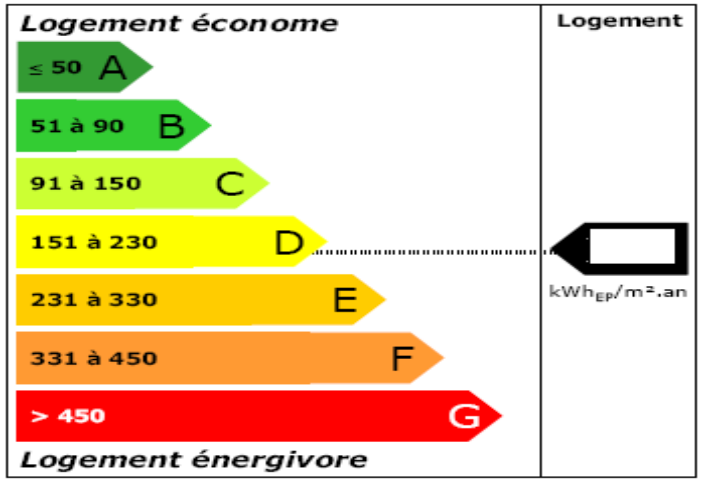
67%

have used ENERGY STAR to justify energy efficiency project

Source: Survey of hundreds of facility managers. Audin, Lindsay. "Finding Your Best Energy Opportunity." Building Operating Management. December, 2011.
California Statewide Benchmarking Process Evaluation, NMR Group, Inc. April, 2012.

What is Benchmarking?

"Benchmarking is the process of **comparing your energy performance to something similar**. "Something similar" might be internal, like performance at the **same time last year**. Or it might be external, like performance compared **to similar facilities elsewhere**."

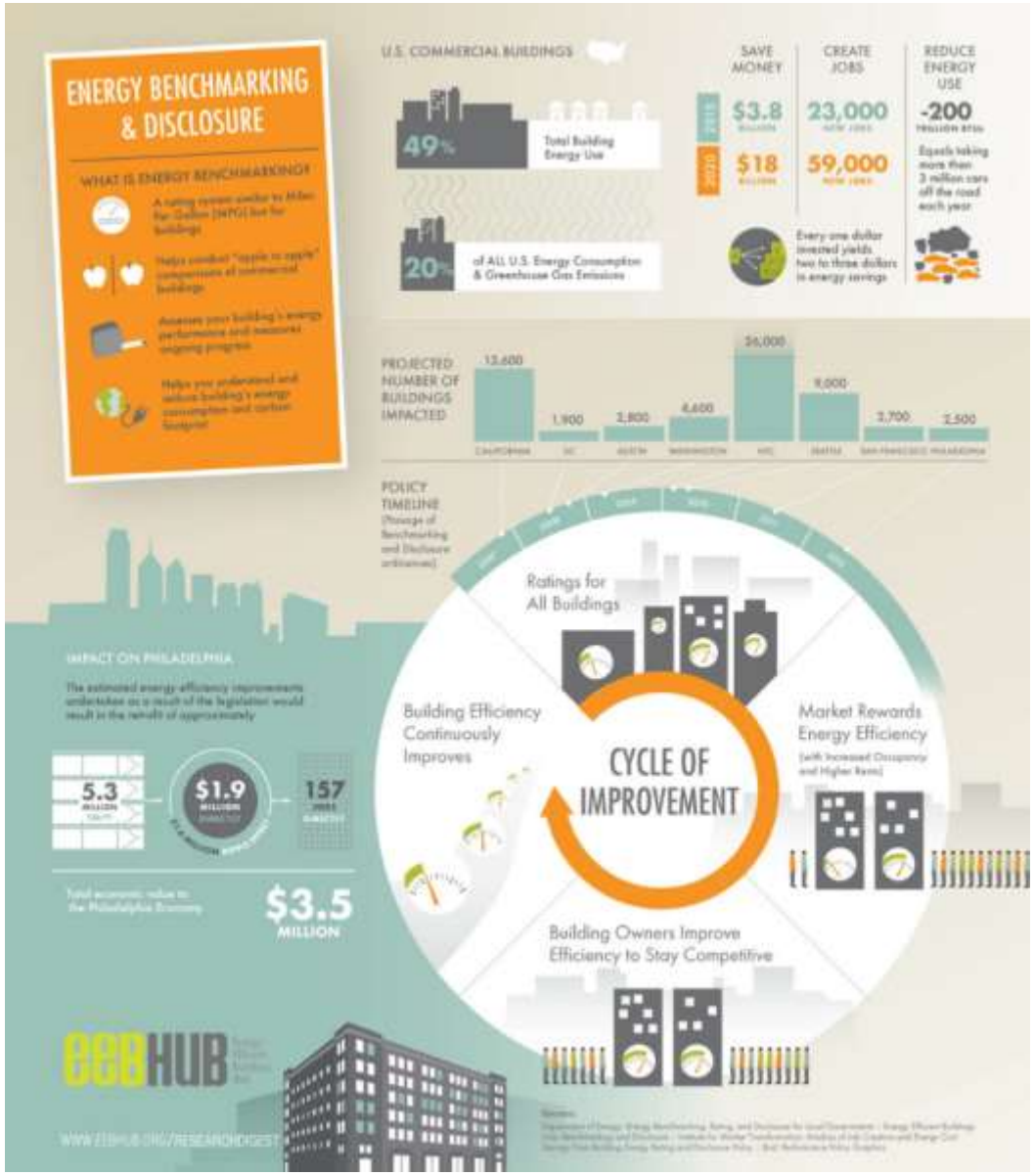


Source: EPA. (n.d.). *Benchmarking energy use*. (U.S. Environmental Protection Agency (EPA)) Retrieved February 2015, from Energy Star: http://www.energystar.gov/buildings/about-us/how-can-we-help-you/benchmark-energy-use
Sustainable Real Estate Solutions. Retrieved February, 2015 from http://srmnetwork.com/solutions

Why do we need building energy data?

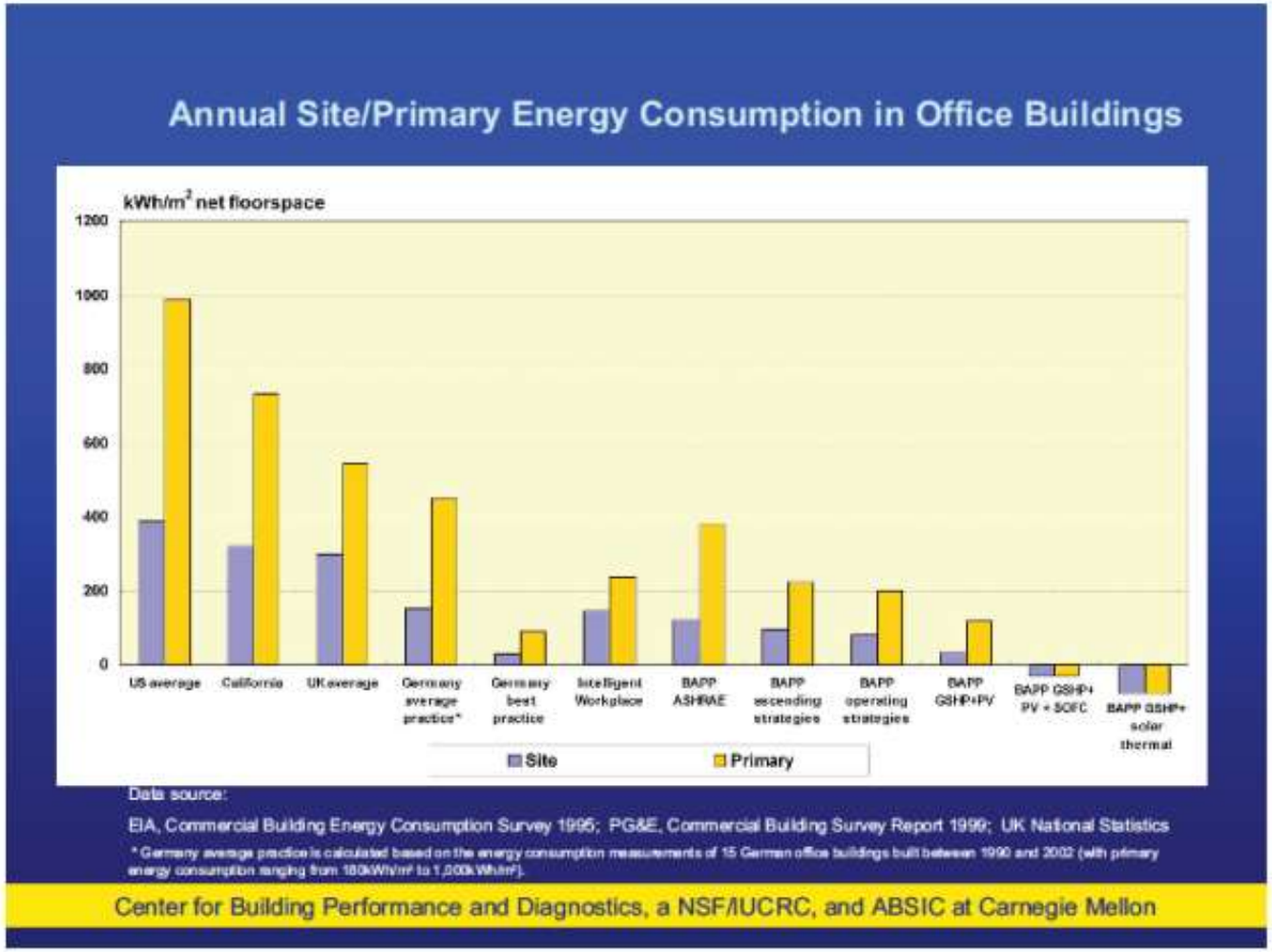
Buildings account for:

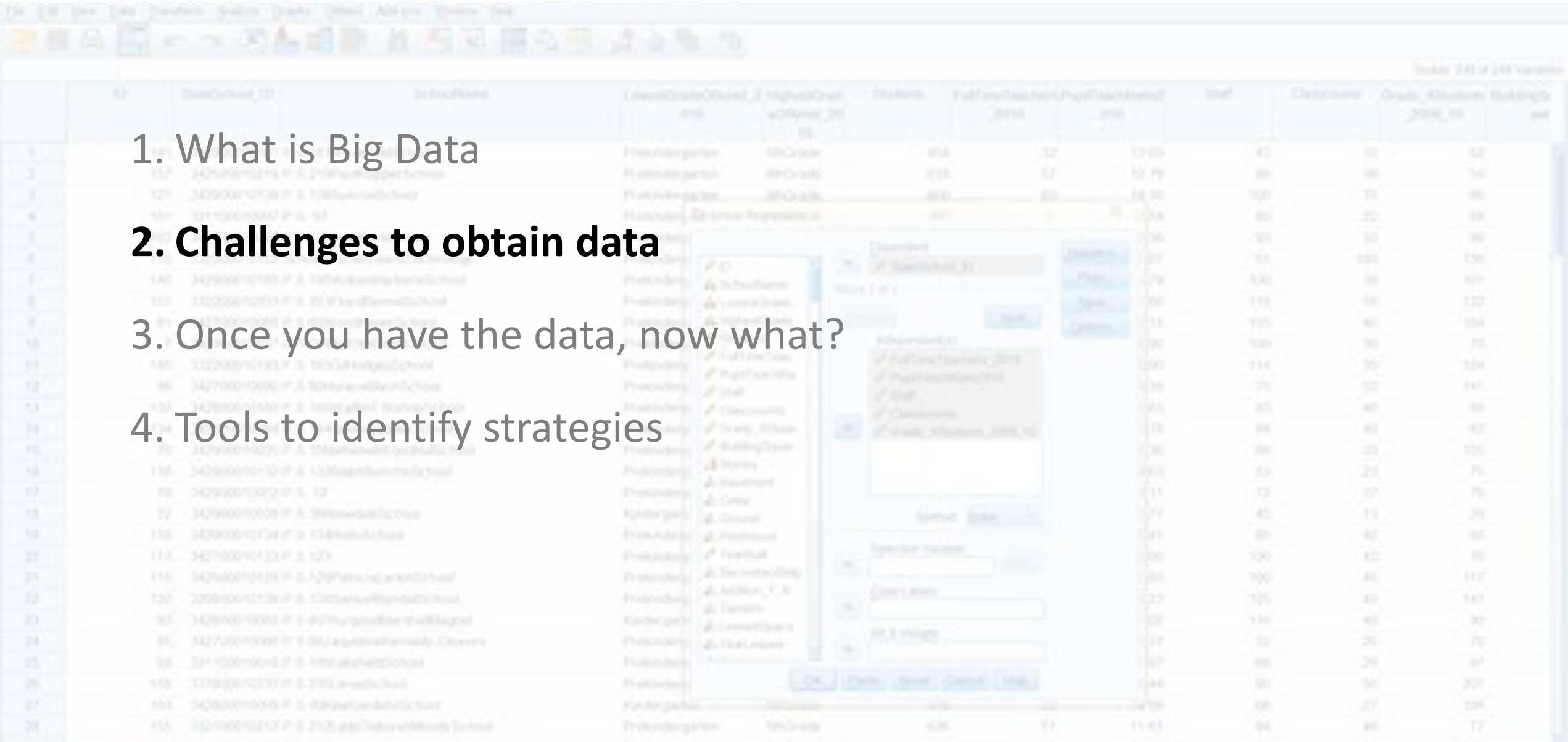
- **~40%** of US Energy
- **~70%** of Electricity
- **~55%** of Natural Gas
- **~52%** of CO_2 Emissions



Source: Helping Buyers and Tenants Understand the Energy Efficiency of Buildings. (n.d.). Retrieved from http://cbei.psu.edu/benchmarking-and-disclosure/

World Office Building Energy Consumption





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2. **Challenges to obtain data**
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Challenges to obtain Data?

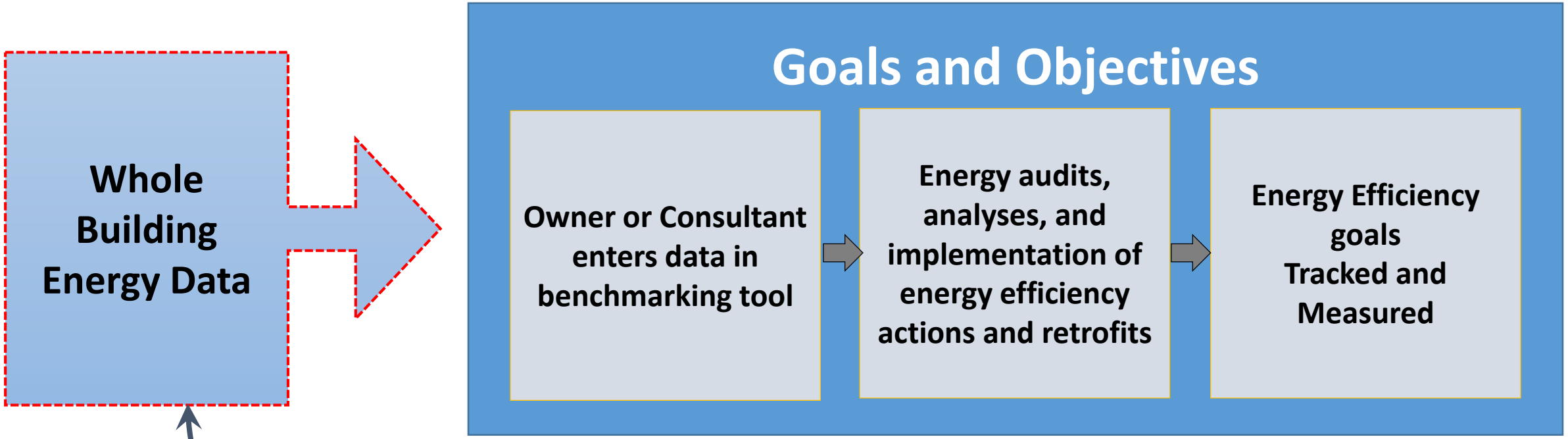
Goals and Objectives

Owner or Consultant enters data in benchmarking tool

Energy audits, analyses, and implementation of energy efficiency actions and retrofits

Energy Efficiency goals Tracked and Measured

How can we address the need for whole building energy data?



Energy Data Accelerator

The Accelerator, among other DOE and Market efforts to enable benchmarking, is designed to **address the upstream barrier of data access**

Energy Data Accelerator

"Partners have committed to put systems in place to provide whole building data to at least **20% of commercial buildings** by the end of 2015."

Accelerators announced in President's Climate Action Plan in June 2013

Enhanced access to whole-building energy consumption data enables and **facilitates benchmarking**

Benchmarking leads to **actionable information** on energy management opportunities, and **increased participation in energy efficiency programs**

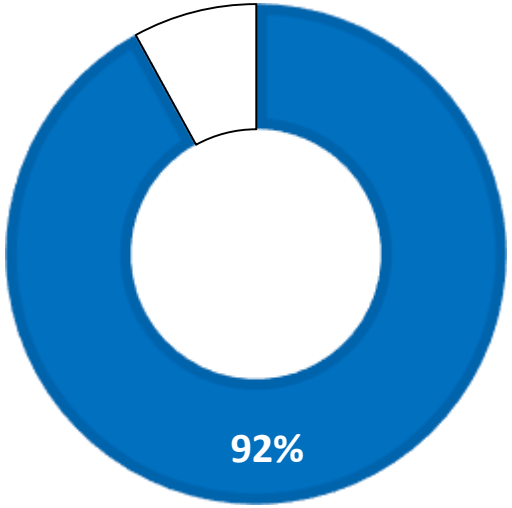
Participation in efficiency programs drives **cost savings** for customers and **energy savings** for program administrators

*NMR Group, Inc. and Optimal Energy, Inc., Statewide Benchmarking Process Evaluation, Volume 1: Report, April 2012

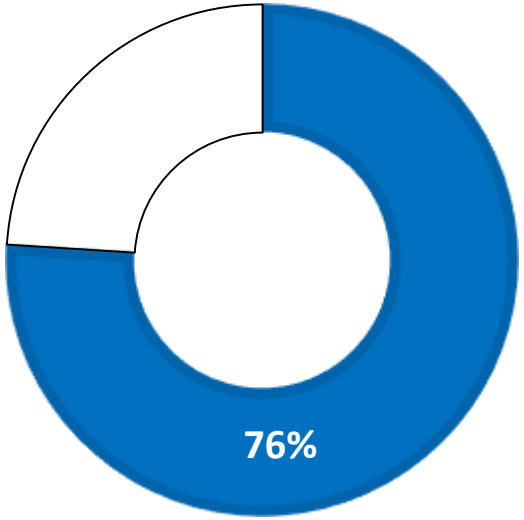
Securing public commitments from 22 city-utility pairs has created a platform for engagement, dialogue and action on whole-building data access across the country…

Best practices are solidifying for 3 main aspects of whole building data access

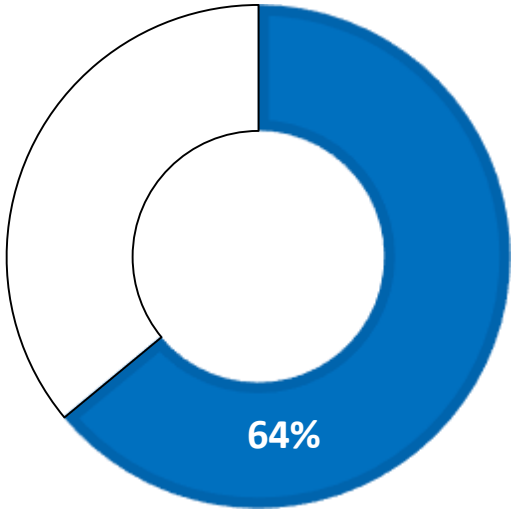
PLANNING TO OR ARE ALREADY **STREAMLINING THE TENANT CONSENT/AUTHORIZATION PROCESS***



PLANNING TO OR ARE NOW PROVIDING ***STREAMLINED TRANSFER OF UTILITY BILL DATA*** *TO BENCHMARKING TOOLS*



PLANNING TO OR INCLUDE THE CAPABILITY TO ASSIST BUILDING OWNERS WITH ***ACCURATELY MAPPING METERS TO BUILDINGS***



* Excluding CA Cities

As of October 2015

"Through the Better Buildings Energy Data Accelerator (EDA), **18 utilities** , serving more than **2.6 mil commercial customers** and working within their communities, are announcing they will provide whole-building energy data access to building owners by 2017"

https://www.whitehouse.gov/the-press-office/2016/01/29/fact-sheet-cities-utilities-and-businesses-commit-unlocking-access

1. What is Big Data
2. Challenges to obtain data
3. **Once you have the data, now what?**
4. Tools to identify strategies

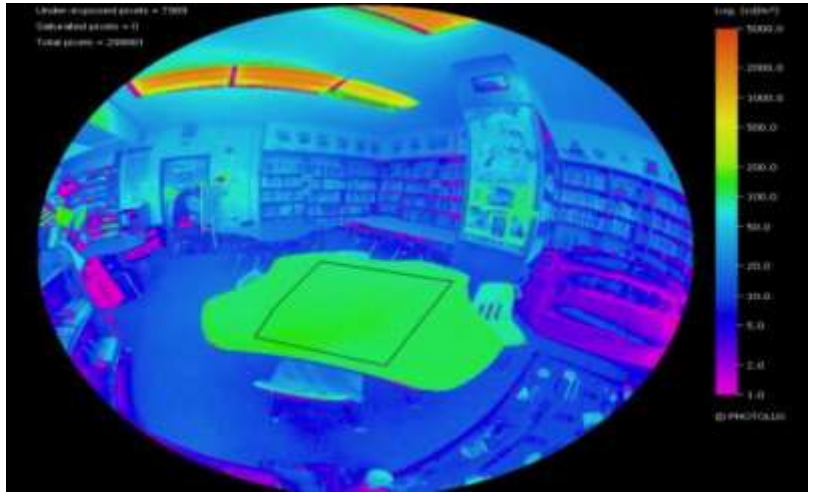
Now What?

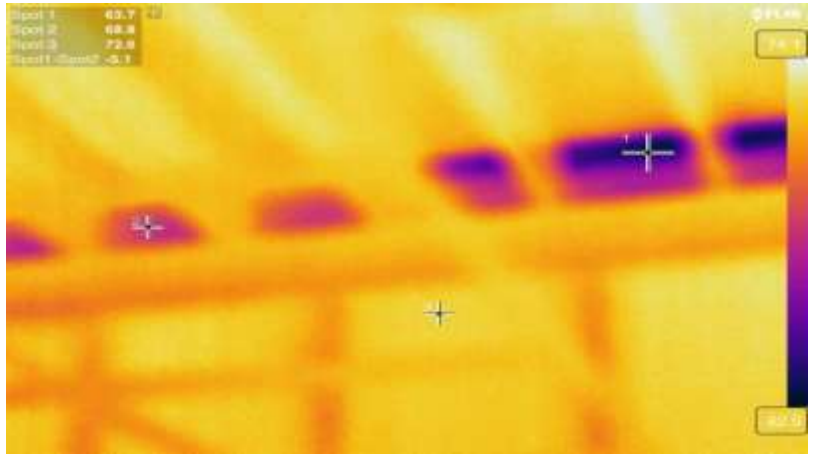
Source: Miller, G. (2014, January 16). 64% of Companies Deploy Big Data — 56% Struggle To Get Value From Their Data: A Contradiction? Retrieved from http://upstreamcommerce.com/blog/2014/01/16/64-companies-deploy-big-data-56-struggle-data-contradiction

Post Occupancy Evaluation :

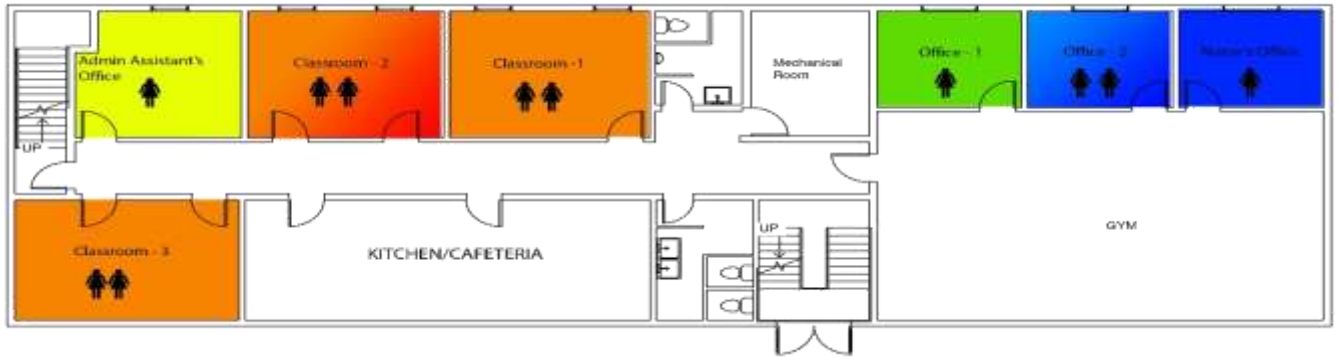
Measurements, Surveys, Interviews, Attribute Records

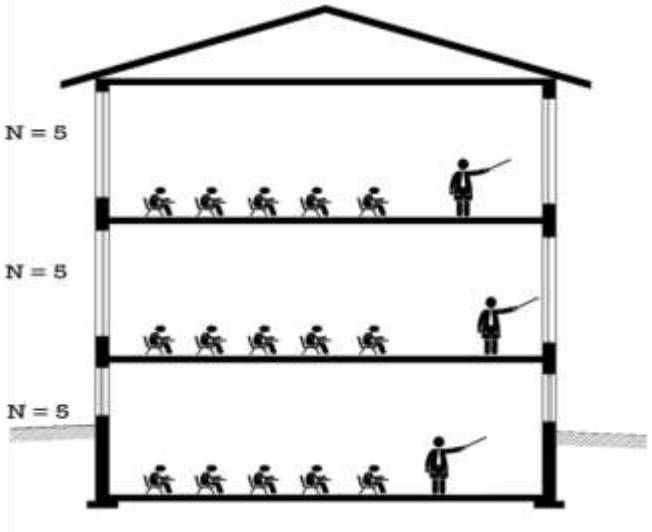
Lighting and Thermal Measurements

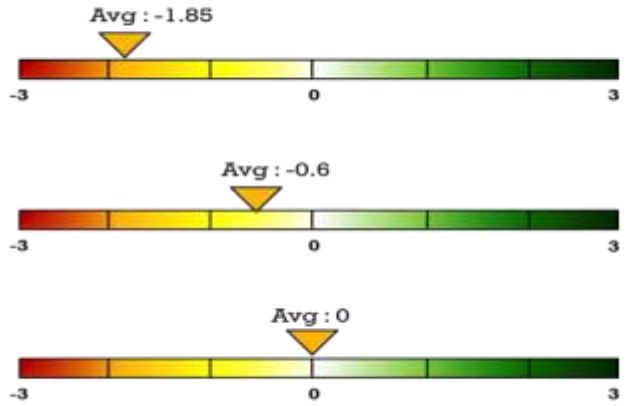




Thermal Satisfaction “Right Now”







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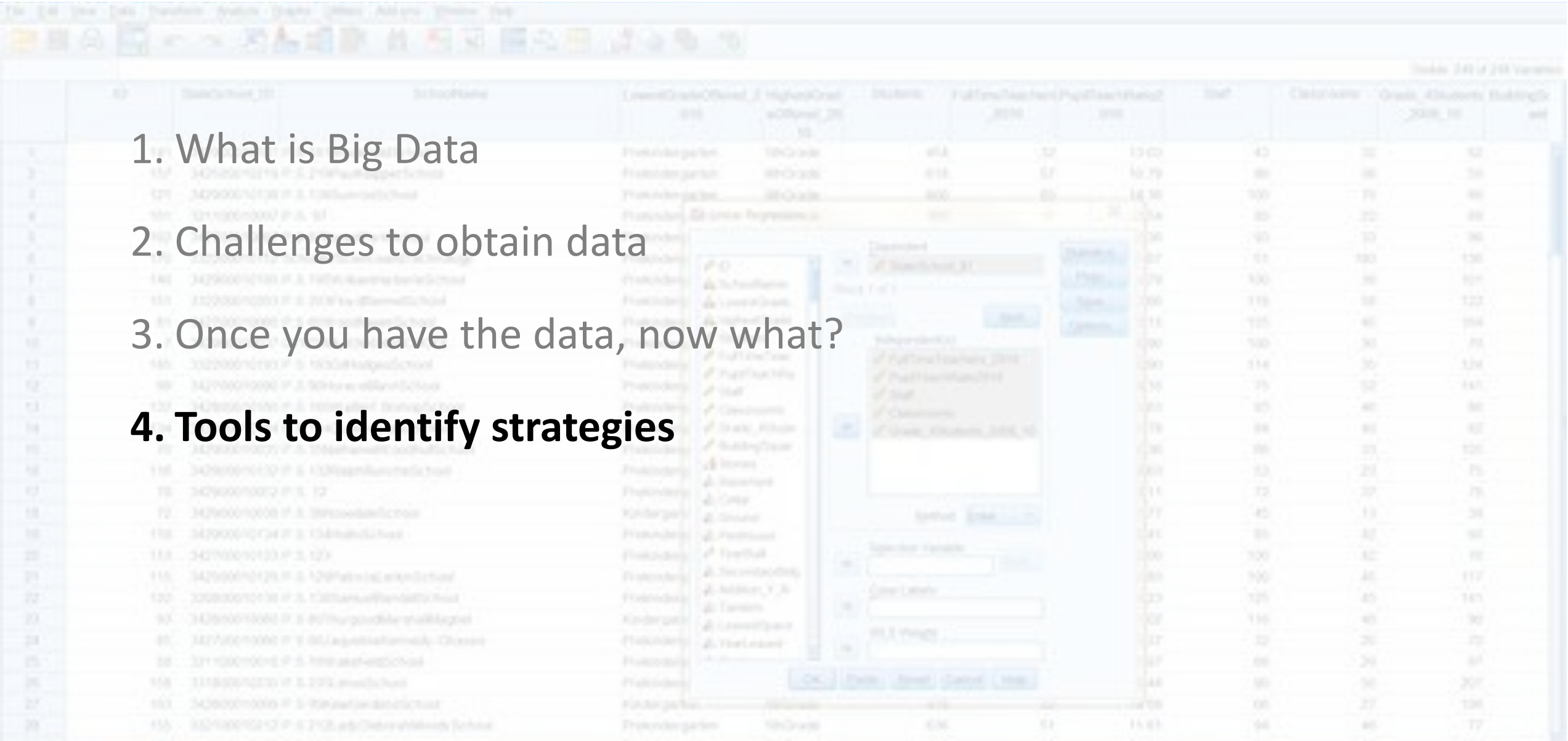
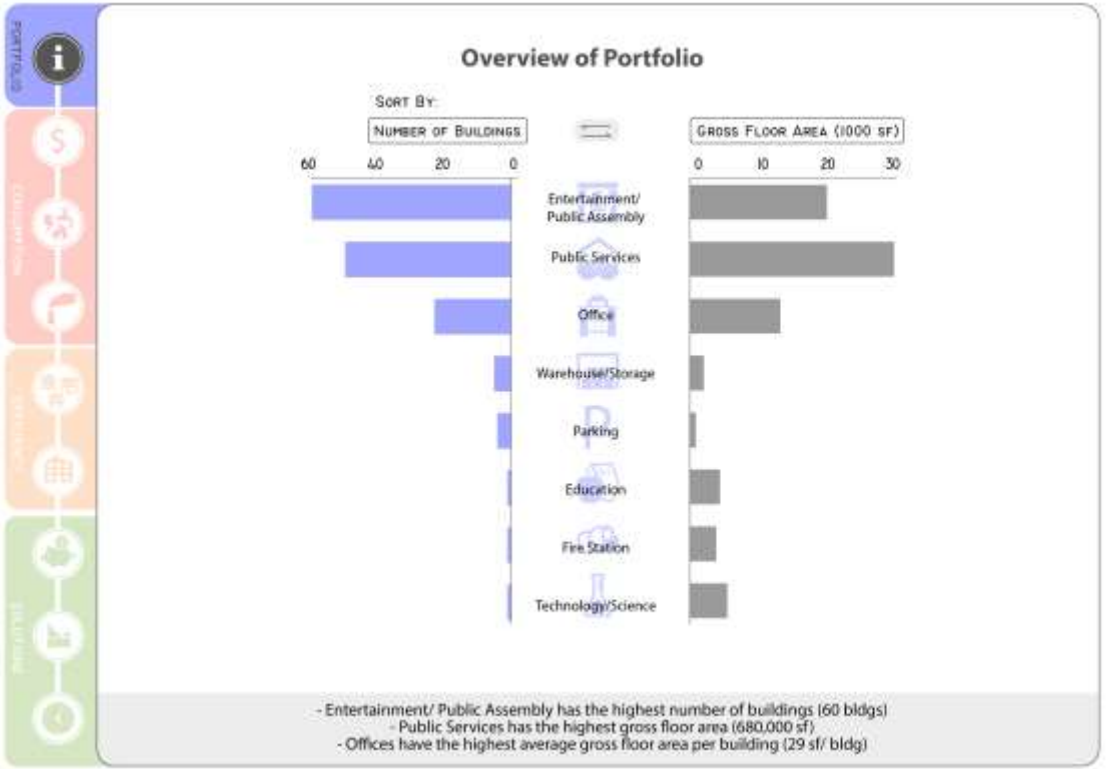


Available Tools and Methodologies

1. **Energy Star Portfolio Manager**
2. **Engineering Audits**
   - Preliminary Energy Use Analysis
   - ASHRAE Audit Level 1 – Walk through Analysis
   - ASHRAE Audit Level 2 – Energy Survey and Analysis
   - ASHRAE Audit Level 3 – Detailed Analysis of Capital Intensive Modifications.
3. **Lean Analysis**
4. **Asset Score Tool**

City Scale

CMU Center For Building Performance and Diagnostics: Research & Publications - SEED Platform

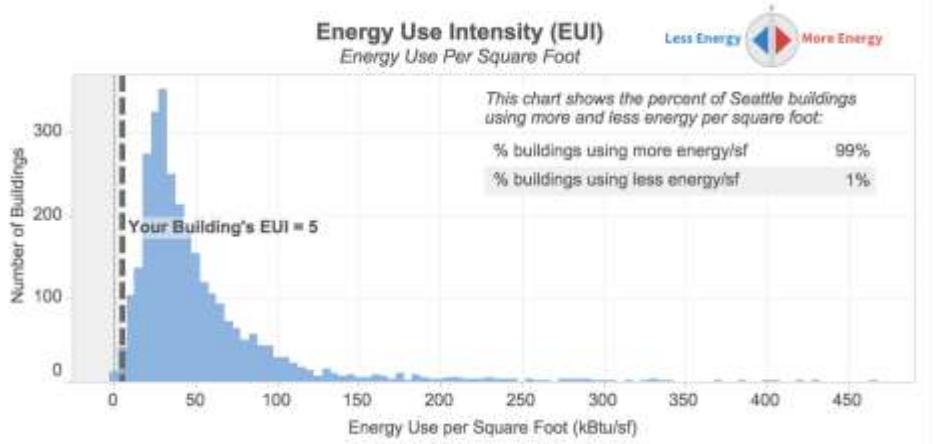


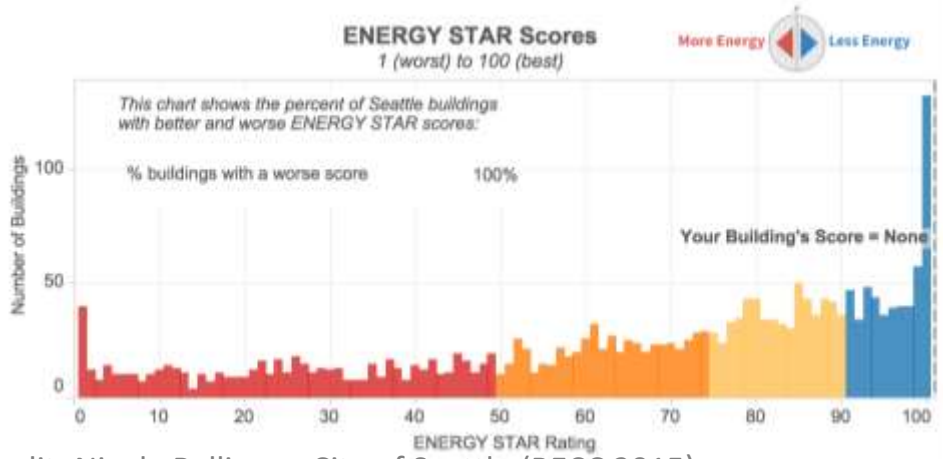
SEED enables users to ***import data from multiple sources*** about the same group of buildings, and ***conduct analysis and reporting*** of the information.

Seattle - Benchmarking and EE Investment

SEATTLE ENERGY BENCHMARKING & REPORTING

ENERGY BENCHMARKING DASHBOARD





PUT THE MONEY YOU SAVE IN ENERGY COSTS BACK INTO YOUR BUILDING.

Reduce your building's EUI by **23.50%** and meet the median for your building type. It can help you **save up to $26,085** each year. That's real money you can put back into your building each year to improve your property, attract new tenants, and continue reducing your energy bills.

GET STARTED

10% IMPROVEMENT
CAN YIELD UP TO
$11,108
In annual energy savings
(EUI of 68)

20% IMPROVEMENT
CAN YIELD UP TO
$22,216
In annual energy savings
(EUI of 61)

YOUR BUILDING'S PATH TO IMPROVEMENT

Investing in the right upgrades will help you improve your building's EUI score and reduce energy-related operating costs. **Rebates and incentives are available now** to help make these upgrades affordable and effective.

1. **GET A FREE ENERGY SAVINGS ASSESSMENT**
from an energy expert to identify energy saving opportunities and qualify you for money-saving rebates to help cover up to 70% of the cost of upgrades.

Seattle City Light
seattle.gov/light/assessment

2. **UPGRADE TO ENERGY EFFICIENT LIGHTING**
in common areas, parking garages and tenant spaces for significant cost savings. Qualifying businesses can save 70% on project costs through rebates.

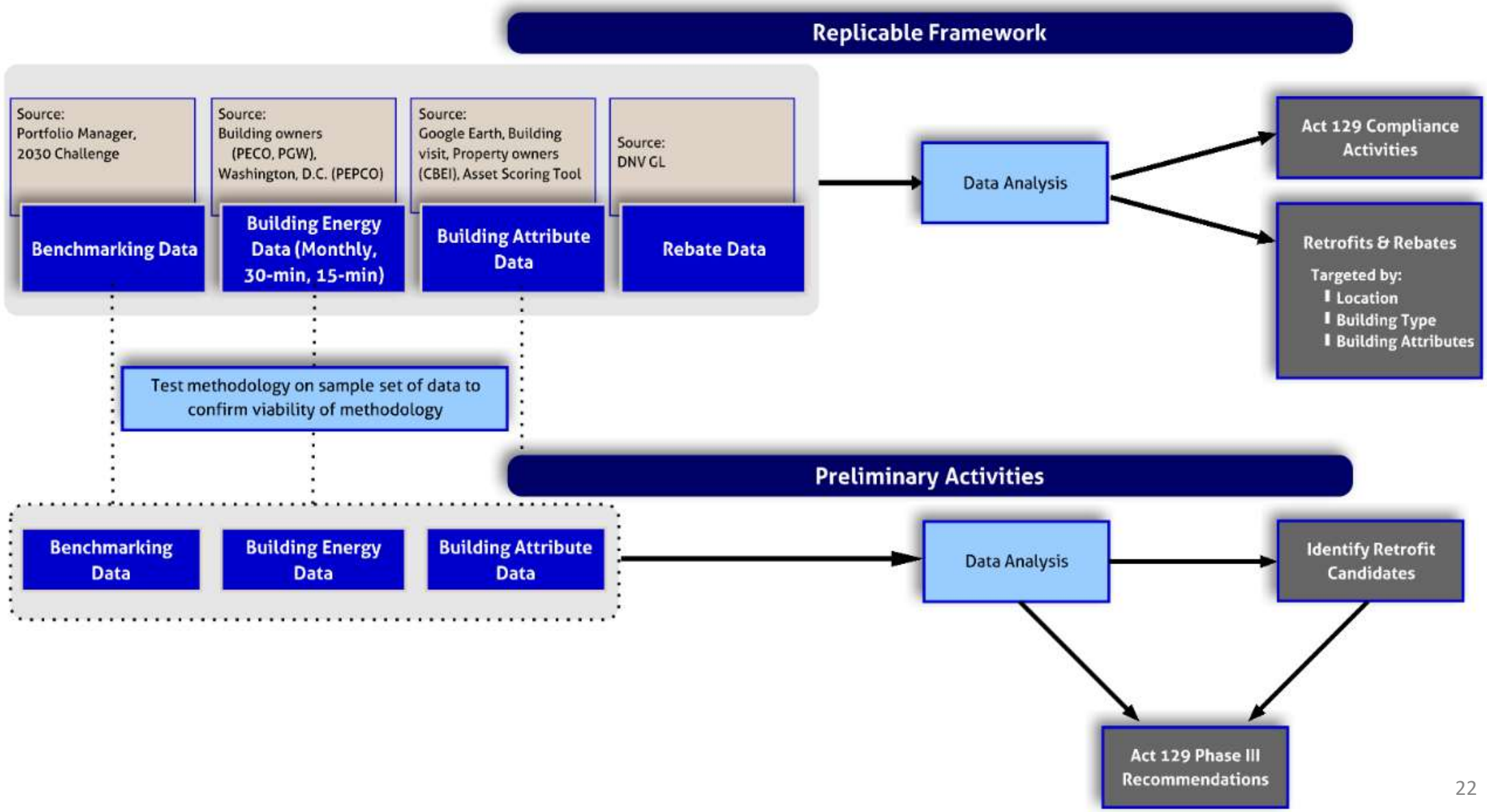
Seattle City Light
seattle.gov/light/theworks

3. **ATTEND A FREE PORTFOLIO MANAGER WORKSHOP**
where you'll learn how to fine-tune your account for accuracy, develop energy use reports, and take steps towards better management of your energy use.

Seattle Office of Sustainability & Environment
seattle.gov/energybenchmarking

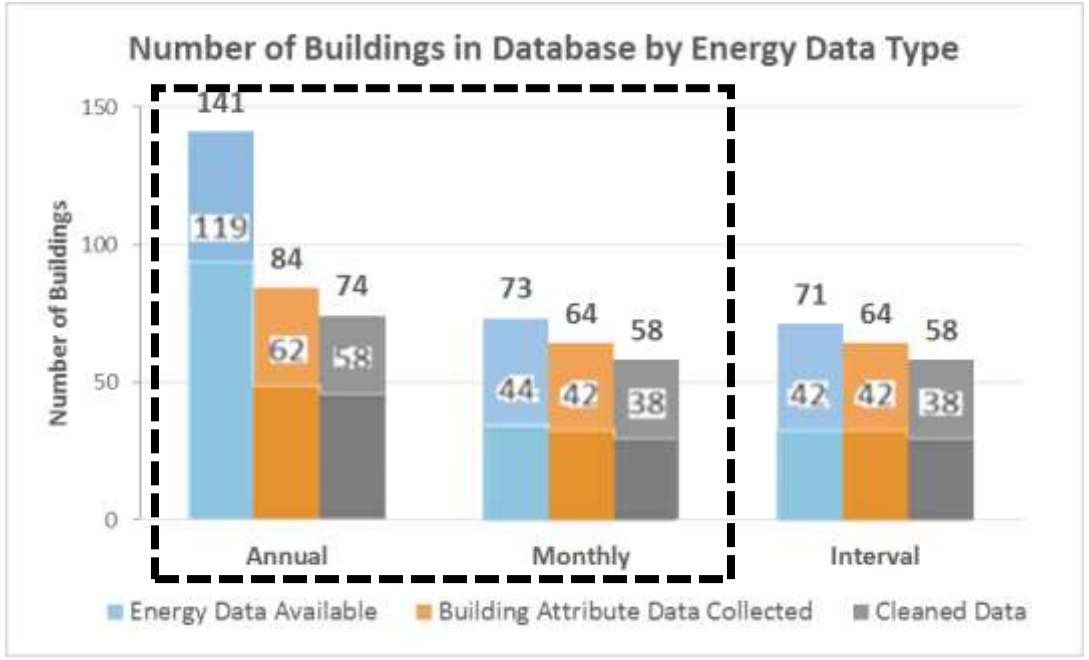
Credit: Nicole Ballinger, City of Seattle (BECC 2015)

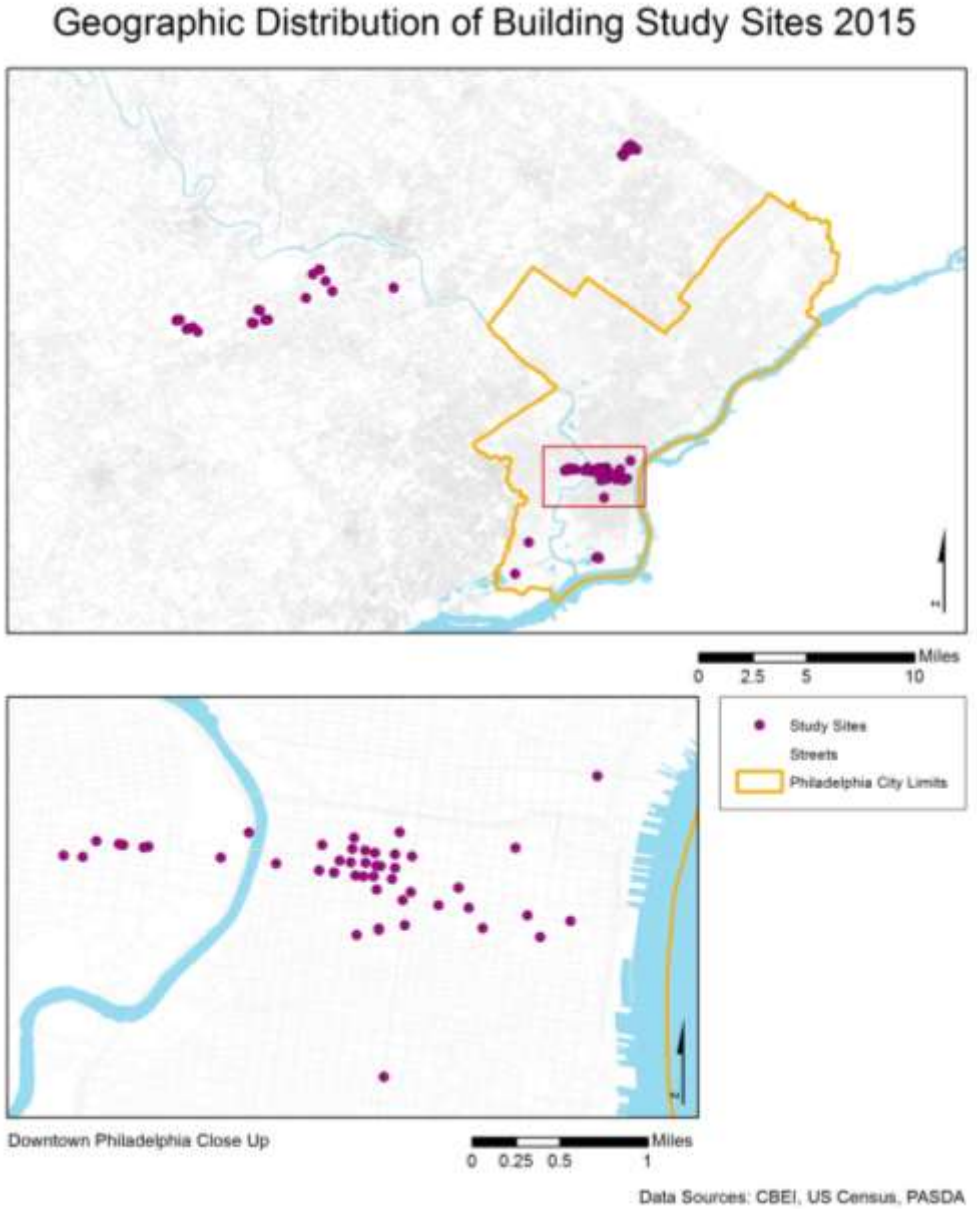
Utilizing Public Data to make Strategic Decisions



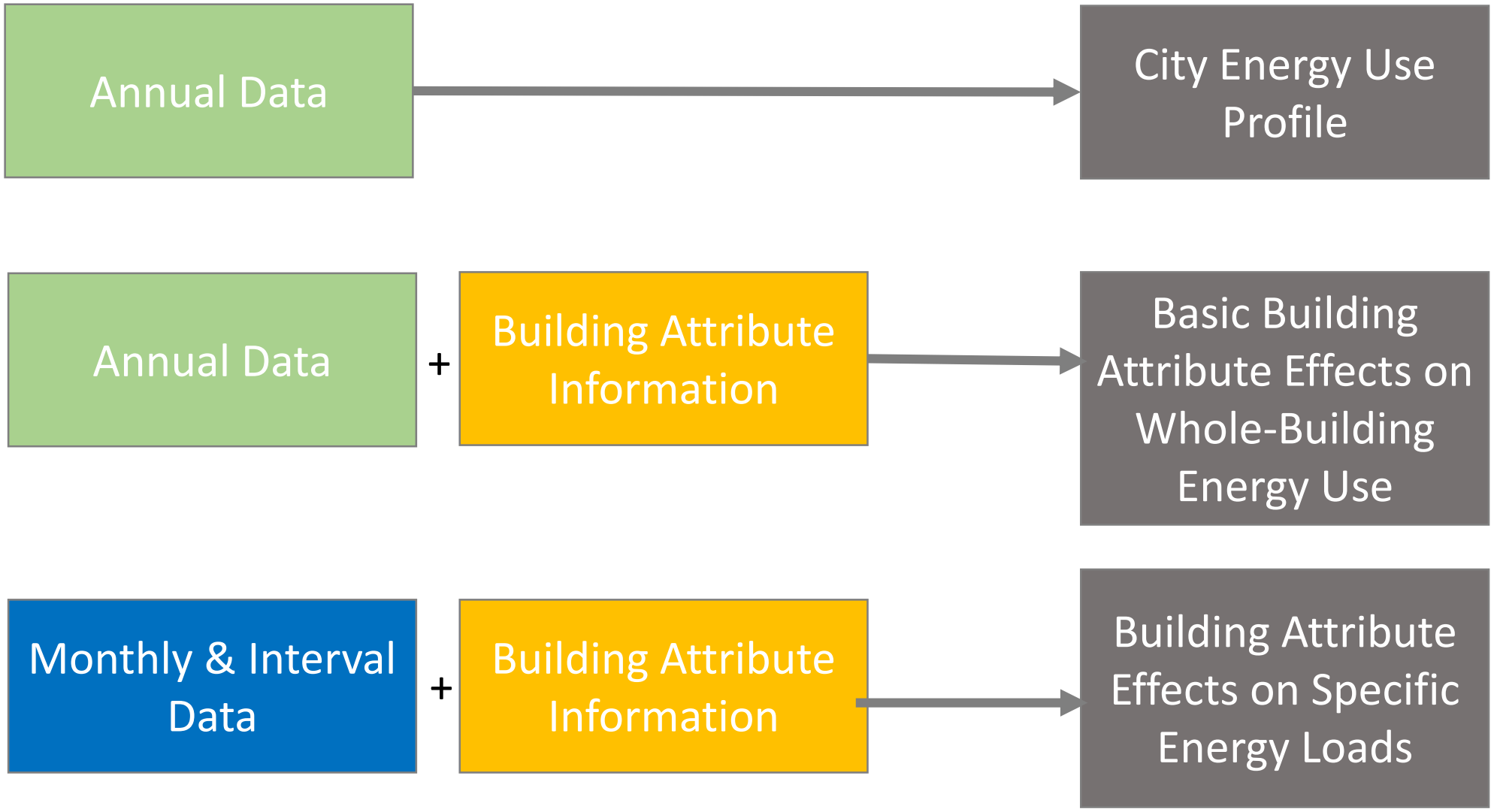
Utilizing Public Data to make Strategic Decisions

Dataset includes:
Over 900 buildings with energy data, 96 offices with usable data are used for this study





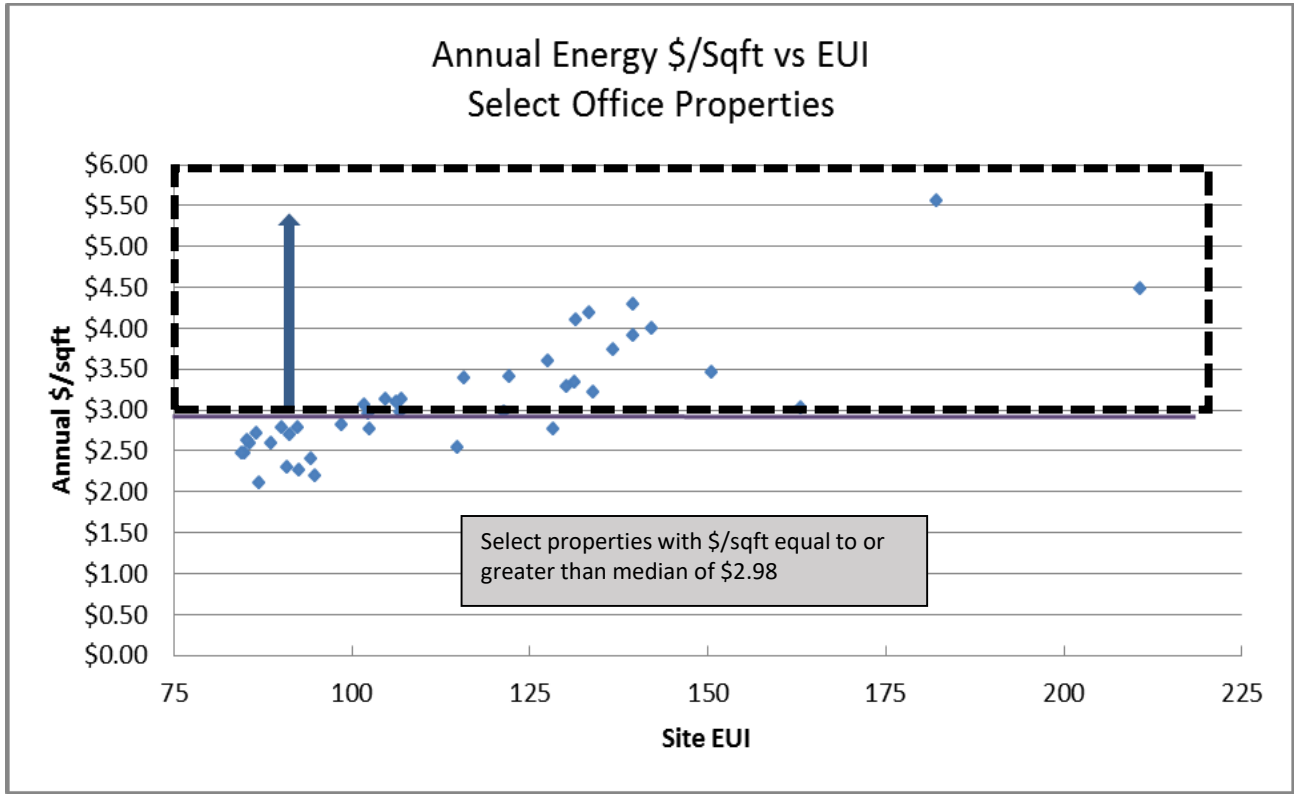
Utilizing Public Data to make Strategic Decisions



Step 1: Using Benchmarking Data to Identify Inefficient Buildings

Using Energy Star score, site EUI and cost/yr as selection parameters, a subset of buildings can be identified as being energy inefficient.

Taking Philadelphia's 2013 cleansed benchmarking data for office properties, inefficient office buildings can be identified from publically disclosed data.



Typical Philadelphia-Area Fuel Costs:

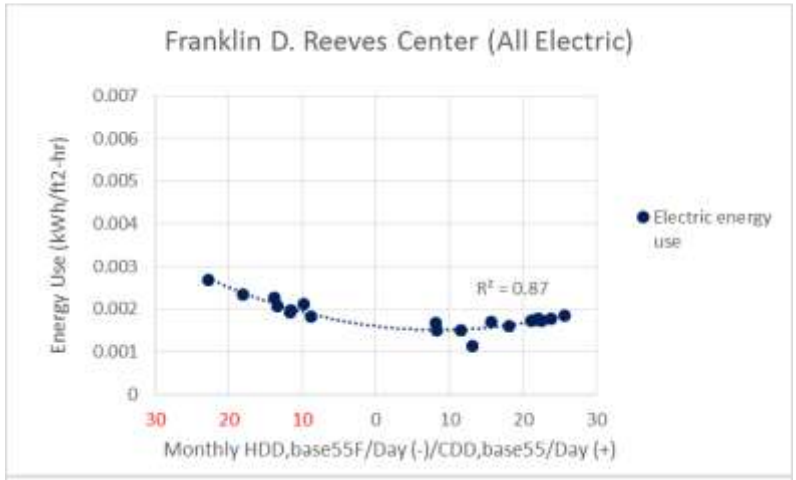
Electric Rates = $0.0293/kBTU = $29.30/million BTU

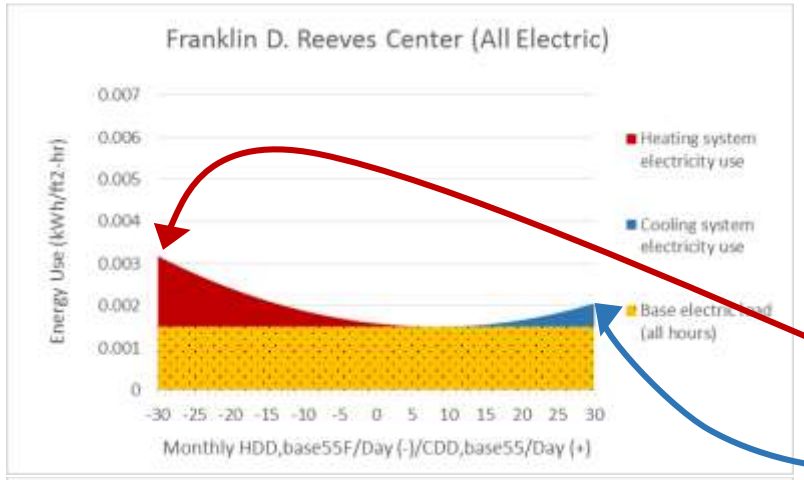
Gas Rates = $0.0136/kBTU = $13.60/ million BTU

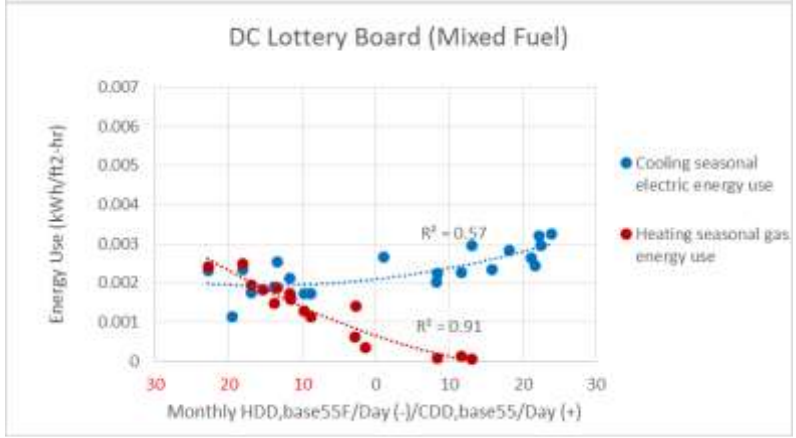
Fuel Oil Rates = $0.0205/kBTU = $20.50/ million BTU

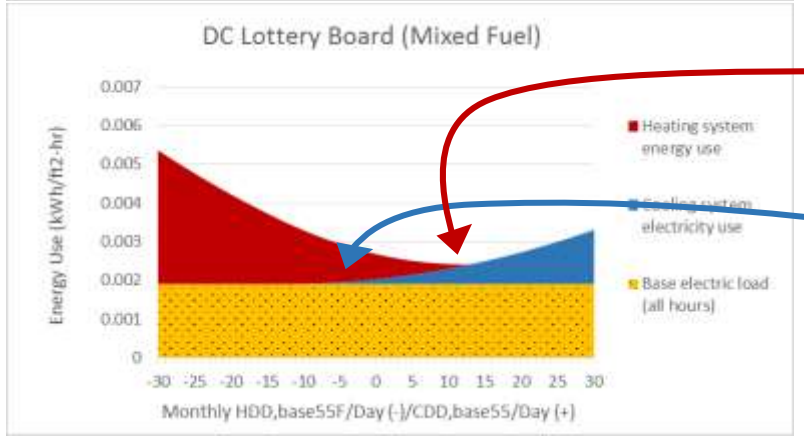
Steam Rates = $0.0340/kBTU = $34.00/ million BTU

Step 2: Using Monthly Whole Building Data for LEAN Analysis





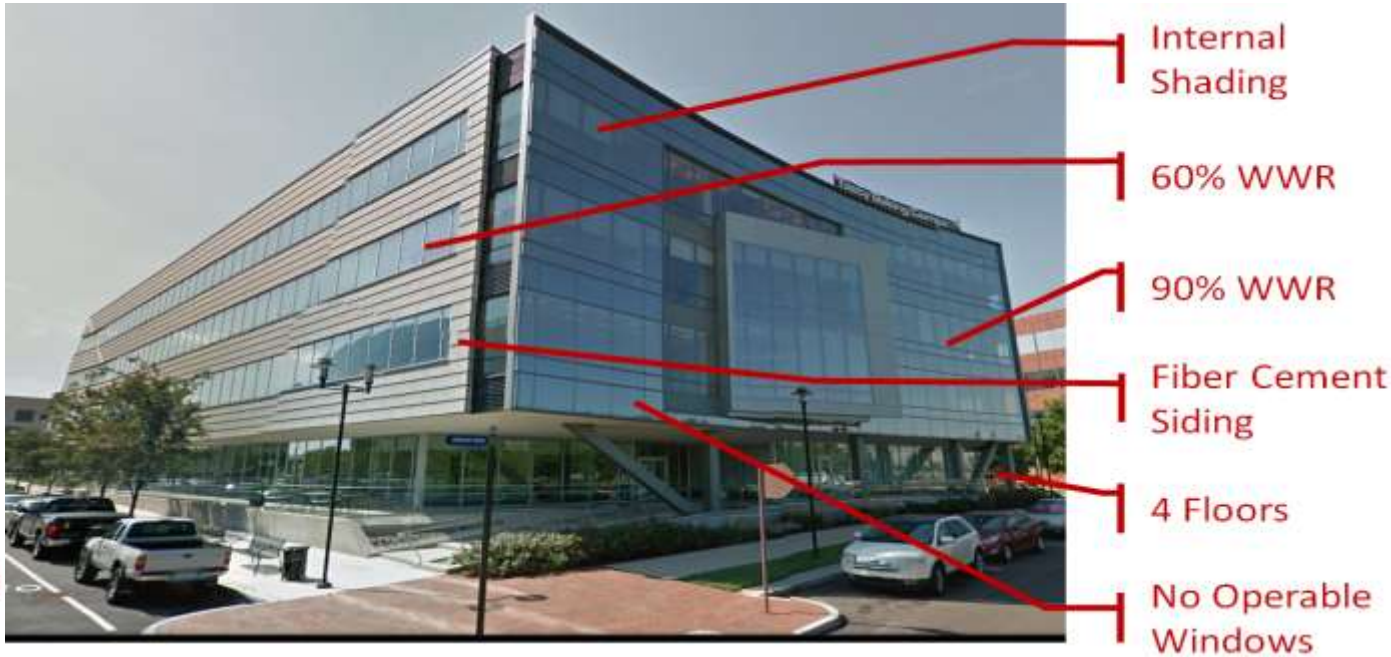




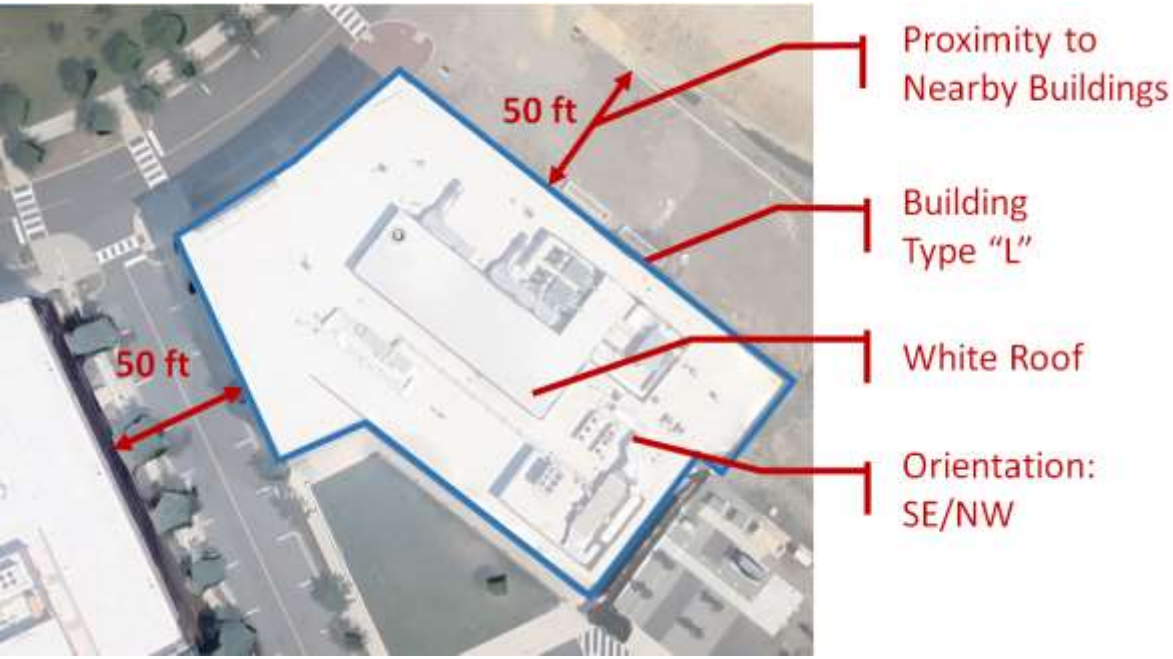
Data Points:

- Base energy use
- Seasonal heating energy
- Seasonal cooling energy
- Peak heating load
- Peak cooling load
- Heating inflection point temperature
- Cooling inflection point temperature

Step 3: Collecting Building Attribute Data



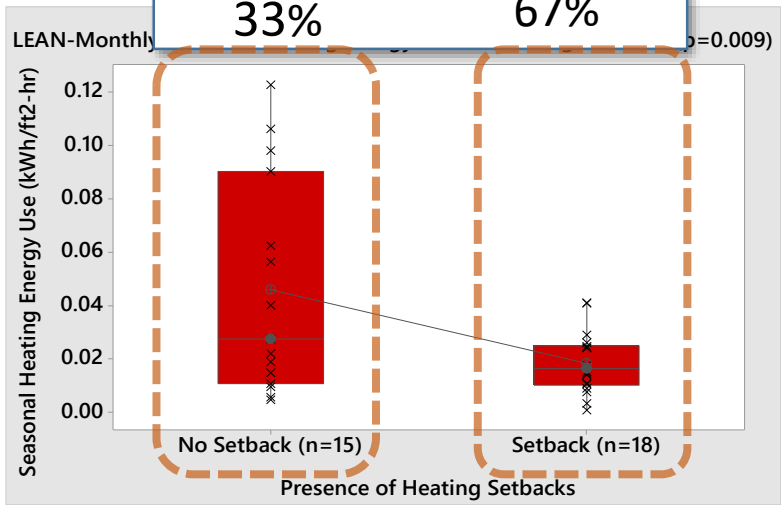
Google Maps Street View Data Collection Example (Google Maps, 2015)

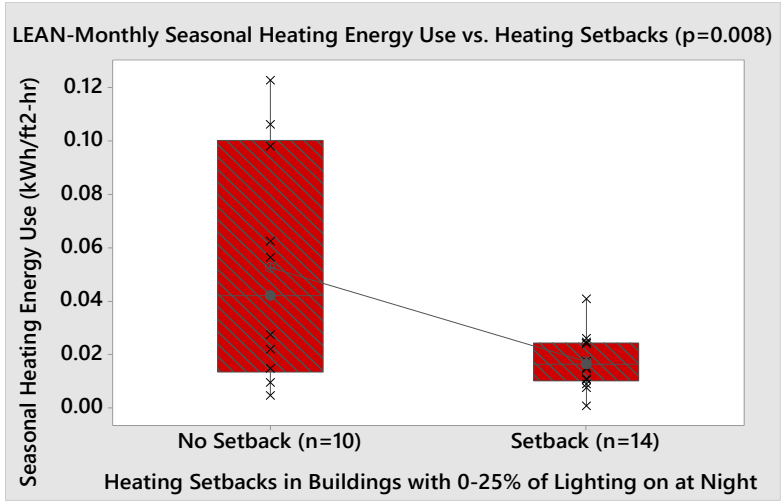


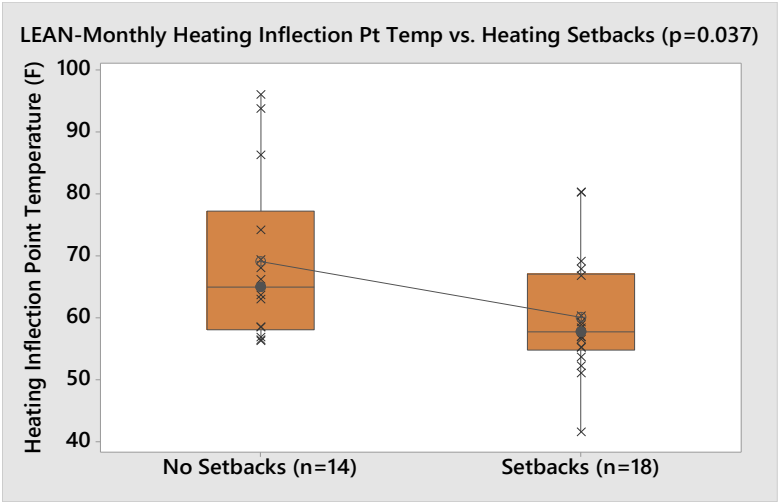
Google Maps Earth View Data Collection Example (Google Maps, 2015)

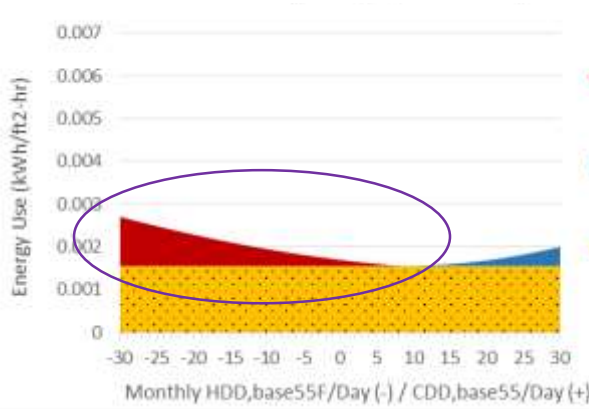
Sub-hypothesis Results: Thermostat Setbacks

Percent Below Median
33% 67%









Hypothesis: Buildings with thermostat setbacks will reduce space conditioning loads in lengthy unoccupied periods, leading to less heating and cooling energy use.

Finding: **Buildings with heating setbacks use less overall heating energy (p=0.008).**

Interval Data	Monthly Data	Annual Data
—	✓	—

Overview of Free Department of Energy Tool Asset Score Tool

National, free software tool for assessing the *physical and structural* energy efficiency of commercial and multifamily residential buildings

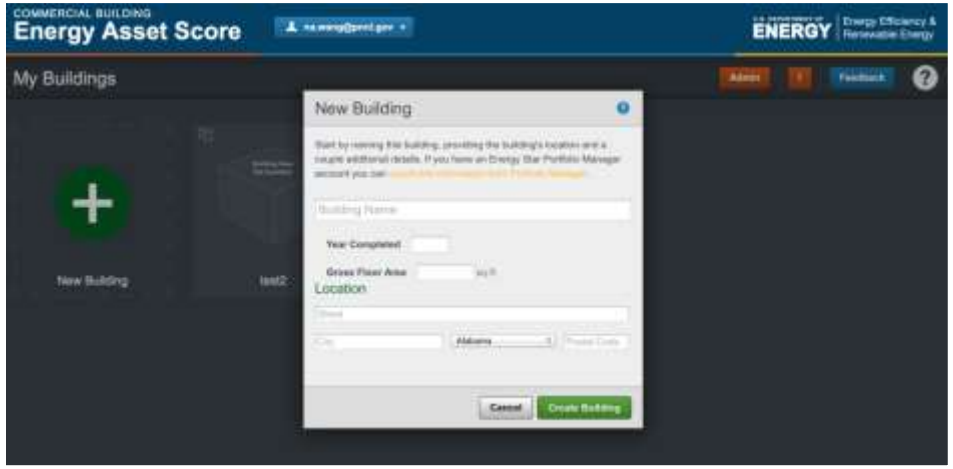
- Envelope (roof, walls, windows)
- Major systems and equipment (mechanical, electrical, service hot water)

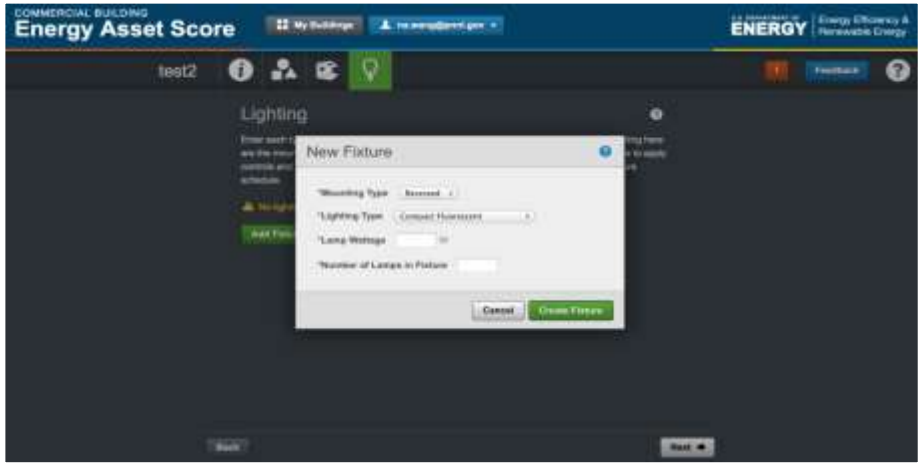
How it Works

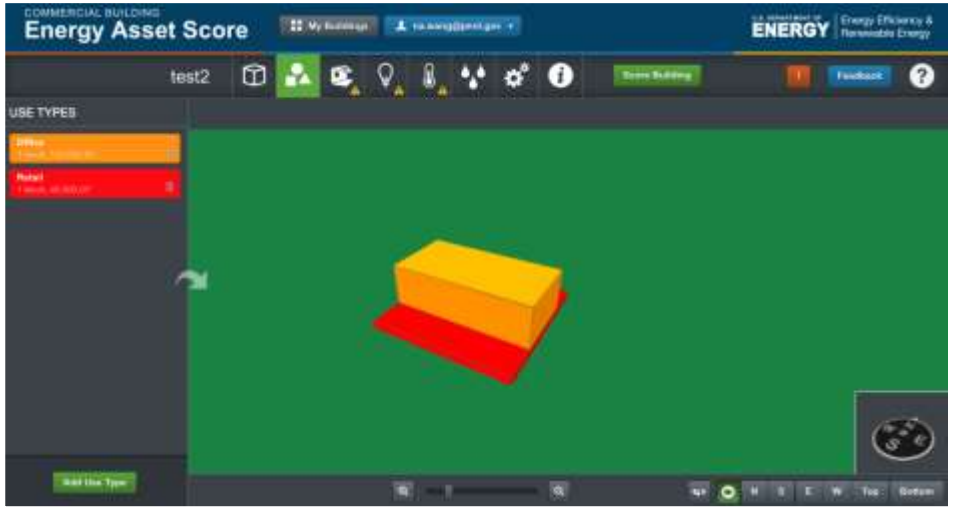
Asset Score runs an *energy simulation* using a powerful building energy modeling engine (EnergyPlus)

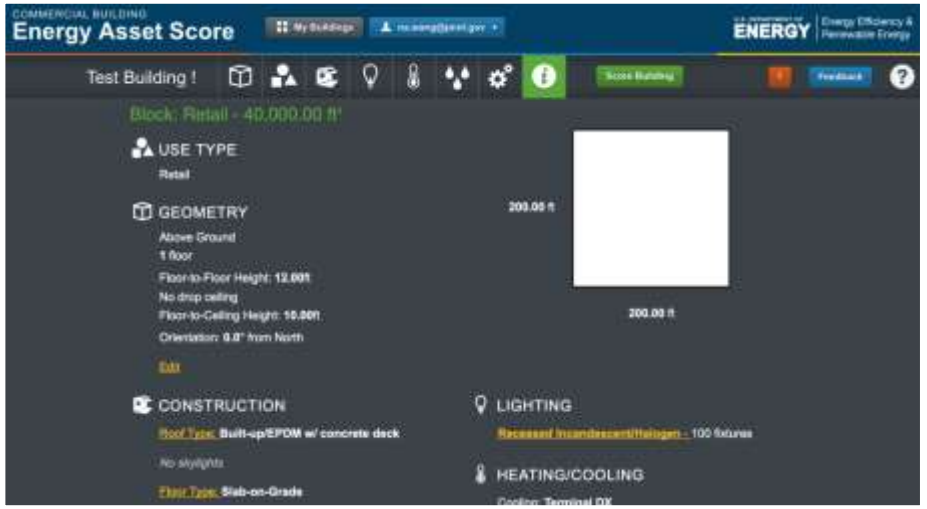
- The simulation normalizes for building operations, occupancy and tenant behavior
- Users (owner, operator, service, provider, etc.) enter building information through an web interface
  - General information: # of floors, footprint dimension, orientation, use type
  - Envelope components: Roof, exterior wall, floor types, insulation levels
  - Fenestration: Skylights, windows, shading
  - Lighting: Fixture types, # of fixtures or % of served floor area, lighting controls
  - Mechanical components: Cooling/heating types, controls, equipment efficiency
  - Service water heating: Fuel type, distribution type, equipment efficiency

How it Works


COMMERCIAL BUILDING
Energy Asset Score
ENERGY
My Buildings
New Building
Location
Cancel
Create Building


COMMERCIAL BUILDING
Energy Asset Score
ENERGY
test2
Lighting
New Fixture
Cancel


COMMERCIAL BUILDING
Energy Asset Score
ENERGY
test2
USE TYPES

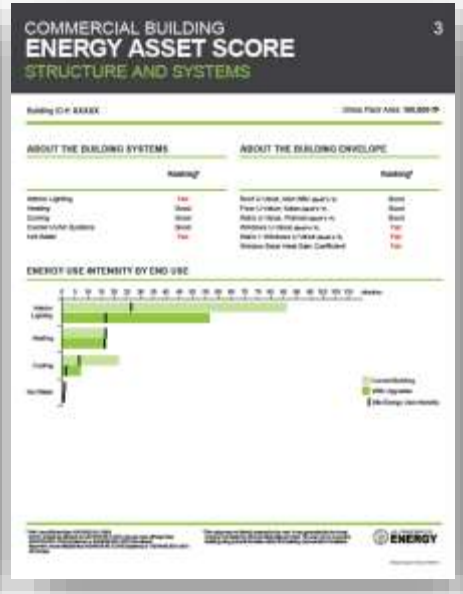

COMMERCIAL BUILDING
Energy Asset Score
ENERGY
Test Building !
USE TYPE
Retail
GEOMETRY
Above Ground
1 floor
CONSTRUCTION
LIGHTING
HEATING/COOLING

Types of Buildings

Asset Score assesses the following *new and existing* building types:

- Multifamily (low/high-rise, 3+ units)
- Office
- Retail
- Assisted living
- City hall
- Community center
- Courthouse
- Educational (including K-12 schools)
- House of Worship
- Library
- Lodging
- Medical office
- Parking garage
- Police station
- Post office
- Senior center
- Warehouse (unrefrigerated)
- Mixed-Use (of the above types)

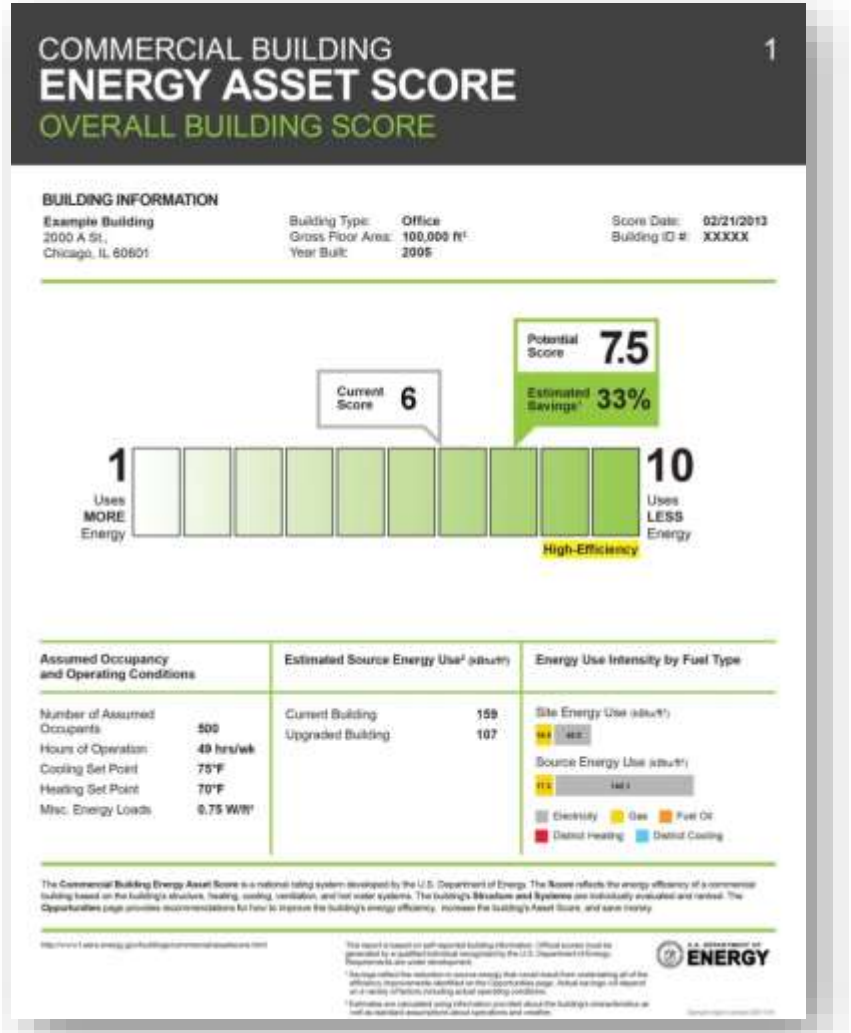
Asset Score Report



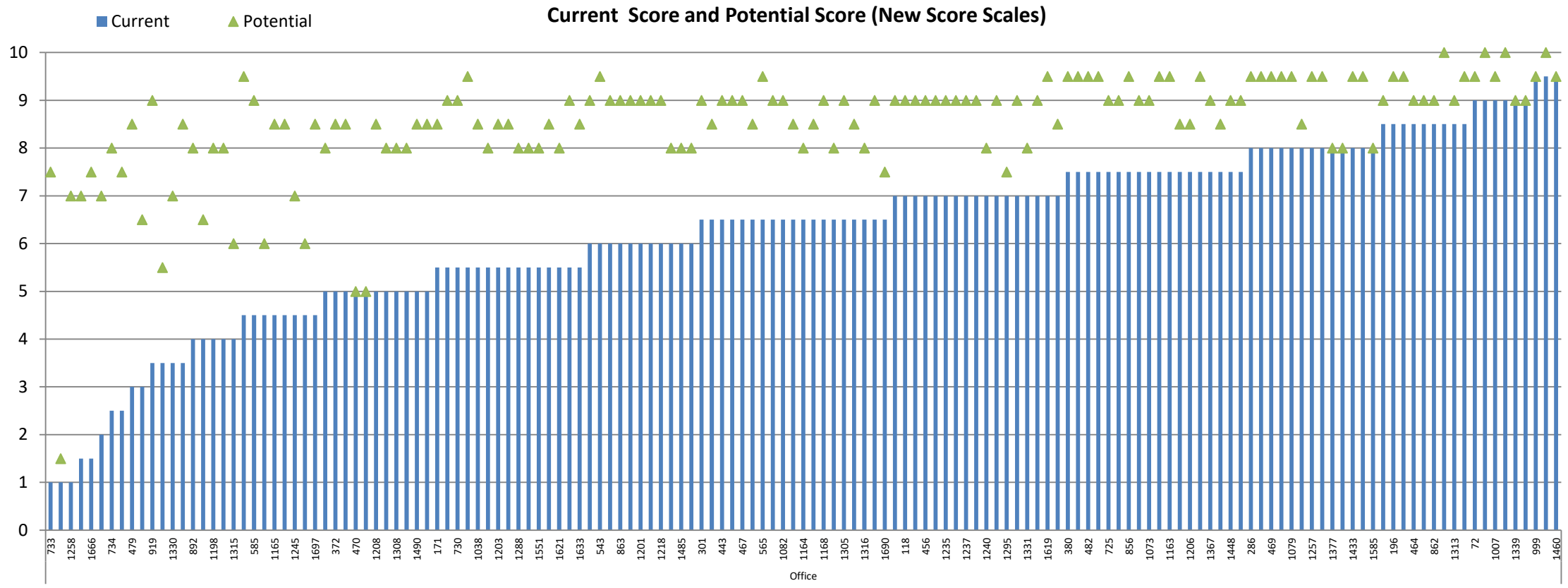
Asset Score Report

10-point scale based on predicted EUI

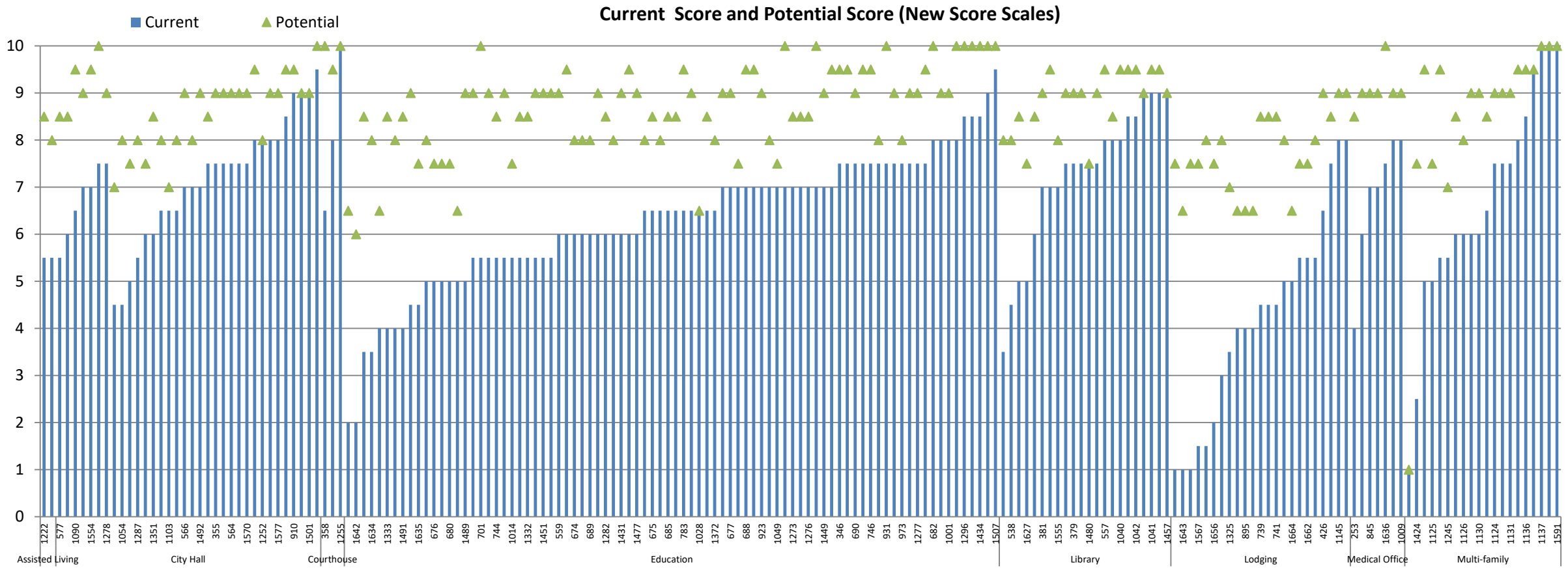
- Recently transitioned from 100-point scale
- Current and Potential Scores
- “10” represents lowest expected energy usage using current EE technologies
- Weather normalized
- Scale moves in half-point increments



Score Distributions - Office



Score Distributions - Other



Asset Score Report

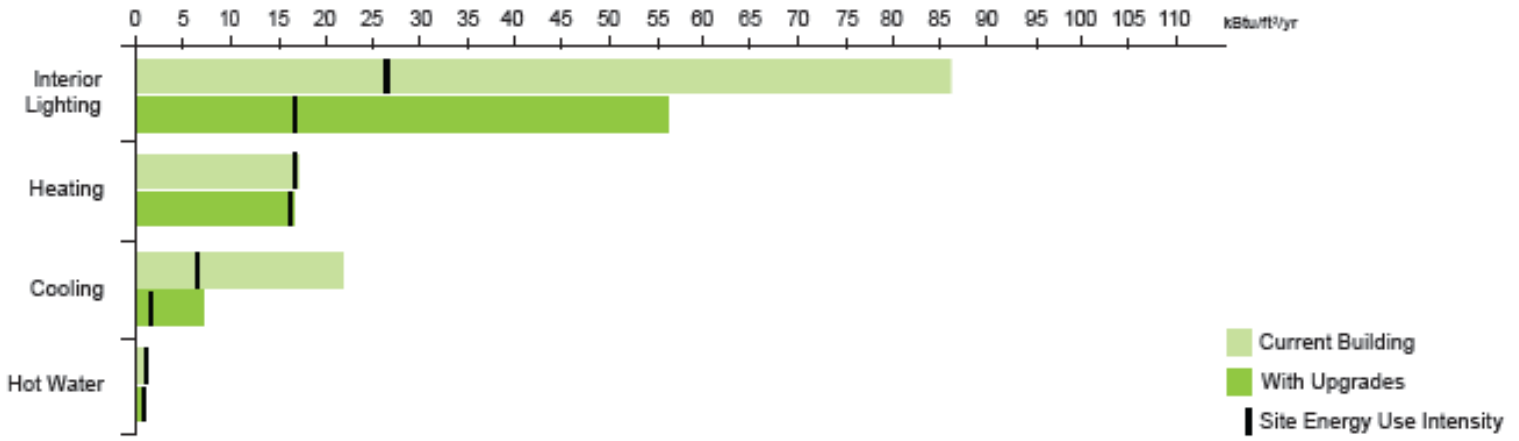
ABOUT THE BUILDING SYSTEMS

	Ranking[8]
Interior Lighting	Fair
Heating	Good
Cooling	Good
Overall HVAC Systems	Good
Hot Water	Fair

ABOUT THE BUILDING ENVELOPE

	Ranking[8]
Roof U-Value, Non-Attic (Btu/ft² h °F)	Good
Floor U-Value, Mass (Btu/ft² h °F)	Good
Walls U-Value, Framed (Btu/ft² h °F)	Good
Windows U-Value (Btu/ft² h °F)	Fair
Walls + Windows U-Value (Btu/ft² h °F)	Fair
Window Solar Heat Gain Coefficient	Fair

ENERGY USE INTENSITY BY END USE



Asset Score Report

COST EFFECTIVE UPGRADE OPPORTUNITIES

	Energy Savings[4]	Cost[5]
Building Envelope		
• Add roof insulation in Office *Learn More*	Medium	$$
• Upgrade windows in Office with high performance double pane windows *Learn More*	Medium	$$
Interior Lighting		
• Upgrade Fluorescent T8 lighting system in Office to compact fluorescent lighting system *Learn More*	High	$
HVAC Systems		
• Upgrade cooling system in Office with high efficiency electric DX cooling system *Learn More*	High	$$$
• Add supply air temperature reset to HVAC system in Office *Learn More*	Low	$
Hot Water Systems		
• Upgrade service hot water system in Office with electric heat pump water heater *Learn More*	Medium	$$

Value

Use the Asset Score to:

- Guide energy-related investment decisions
- Strengthen EE service offerings to clients and enhance business development (service providers)
- Communicate EE capital investments and enhanced asset value (REITS, building owners)
- Provide building energy transparency to taxpayers (governments)

Metro 21 Project

Through Partnership with its home metro, Carnegie Mellon's Metro21 initiative seeks to research, develop and deploy 21st century solutions to the challenges facing metro areas.

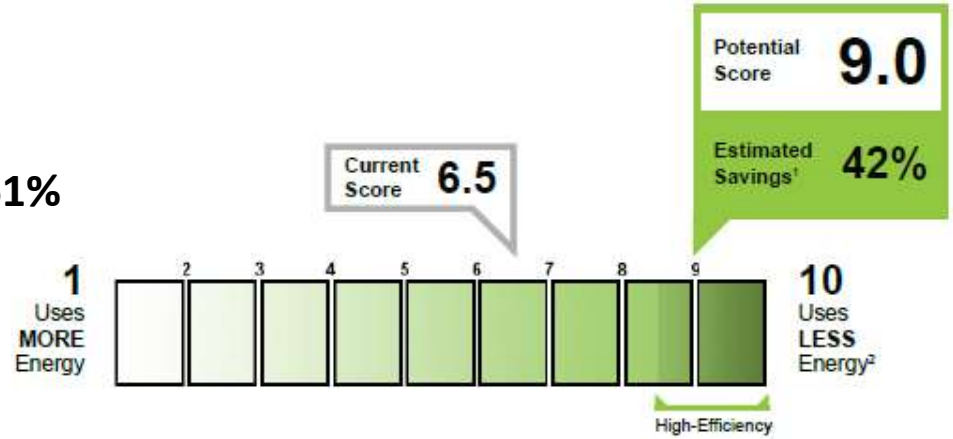
The following are the Pittsburgh Public Buildings:

1. Police Station Zone 1
2. Ammon Community Recreation Center
3. Municipal Court Building
4. Civic Building
5. Brookline Recreation Center
6. Hazzlett Theater and Senior Center
7. City County Building

Ammon Community Recreation Center

Source: http://soulofamerica.com/

Current Score: **6.5**
Potential Score: **9.0**
Estimated Savings: **42%**
Estimated Lighting Savings: **61%**



Building Information

Building Address: 2217 Bedford Avenue Pittsburgh, PA 15219

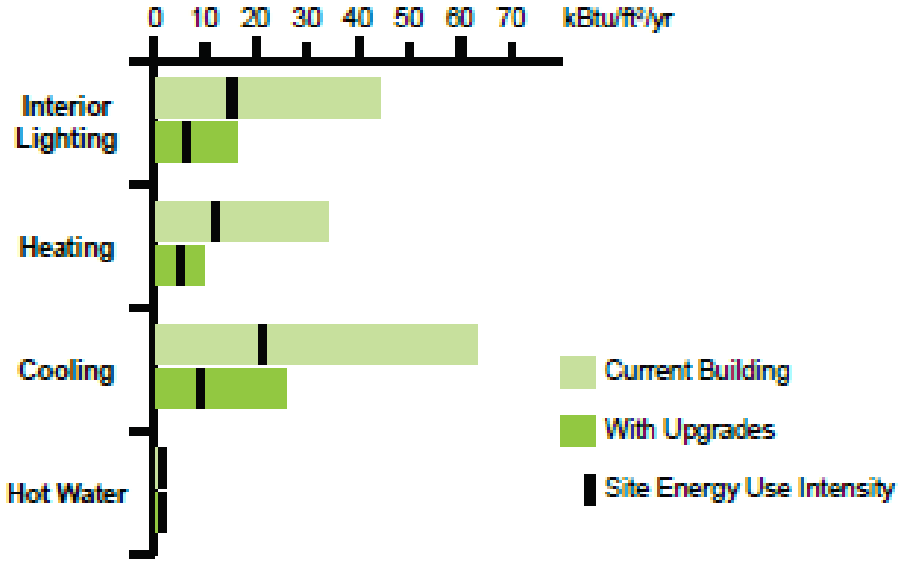
Building Type: Community Center

Gross Floor Area: 26,701 sq.ft.

Year Built: 1940

Source EUI:
Current Building- 213 kBtu/ft^2
Potential Building- 124 kBtu/ft^2

Source Energy Use Intensity by End Use



Ammon Community Recreation Center

Upgrade Opportunities Identified	Energy Savings	Cost
Building Envelope		
1. Add wall insulation	High	$$-$$$
2. Add floor insulation	Medium	$$
3. Add roof insulation	Medium	$-$$
4. Install high performance triple pane windows	Low	$$-$$$
Interior Lighting		
1. Upgrade T-12 fluorescent lighting in basements, first and second floors with LED Lighting ✔	**Low**	**$$**
2. Upgrade T-12 fluorescent lighting in Ground floor with LED lighting. ✔	**Low**	**$**
3. Upgrade incandescent lighting in the sub-basement with compact fluorescent lighting ✔	**Low**	**$**
4. Add daylighting controls ✔	**Low**	**$$**
HVAC Systems		
1. Lower VAV box minimum flow set-points	**High**	**$$**
2. Add air-side economizer	Medium	$$
3. Implement demand controlled ventilation	Medium	$$
4. Implement fan-static pressure reset	Medium	$
5. Implement supply air temperature reset	Medium	$
Hot Water Systems		
1. Add low flow faucets	Low	$$

About Building Systems

	Ranking[5]
Interior Lighting	Good
Heating	N/A
Cooling	Fair
Overall HVAC Systems	Fair

About the Building Envelope

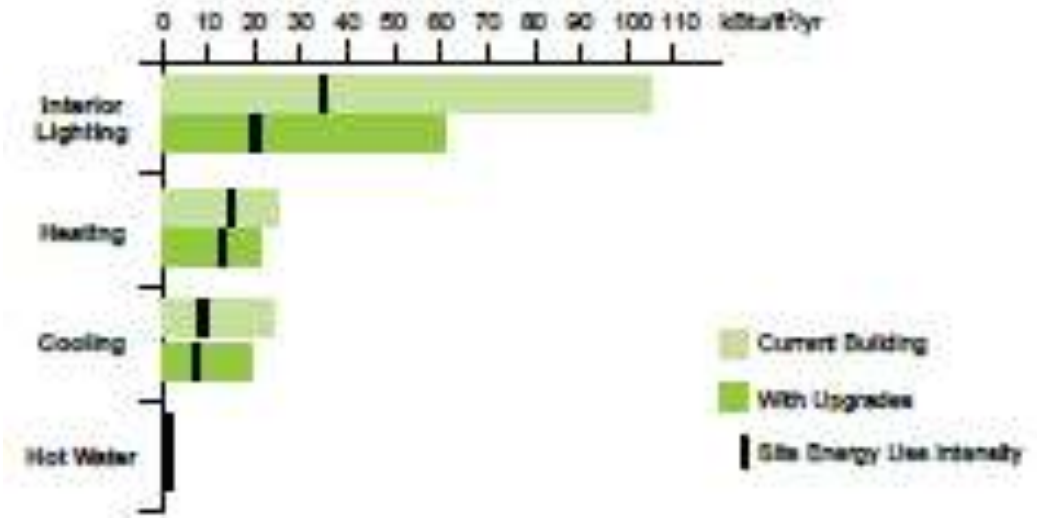
	Ranking[5]
Roof U-Value, Non-Attic (Btu/ft² h °F)	Fair
Walls U-Value, Framed (Btu/ft² h °F)	Fair
Windows U-Value (Btu/ft² h °F)	Good
Walls + Windows U-Value (Btu/ft² h °F)	Good
Window Solar Heat Gain Coefficient	Fair

Brookline Recreation Center

Source: www.brooklineconnection.com

Current Score: **6.5**
Potential Score: 8**.0**
Estimated Savings: **24%**
Estimated Lighting Savings: **43%**

Source Energy Use Intensity by End Use



Building Information

Building Address: 1400 Brookline Blvd
Pittsburgh, PA 15226

Building Type: Community Center

Gross Floor Area: 13,416 sq. ft.

Year Built: 1880

Source EUI:
Current Building- 226 kBtu/ft^2
Potential Building- 172 kBtu/ft^2

Brookline Recreation Center

Upgrade Opportunities Identified	Energy Savings	Cost
Building Envelope		
1. Add roof insulation	High	$-$$
2. Install high performance triple pane windows	High	$$-$$$
Interior Lighting		
1. Upgrade T-8 fluorescent lighting in ground, lower building with LED Lighting ✔	**Low**	**$$**
2. Upgrade T-12 fluorescent lighting in Ground floor with LED lighting. ✔	**Low**	**$$**
3. Upgrade incandescent lighting in lower building with fluorescent lighting. ✔	**Low**	**$**
4. Add daylighting controls in lower building ✔	**Low**	**$$**
HVAC System		
1. Upgrade cooling system in ground floor with high efficiency electric chiller.	Low	$$$

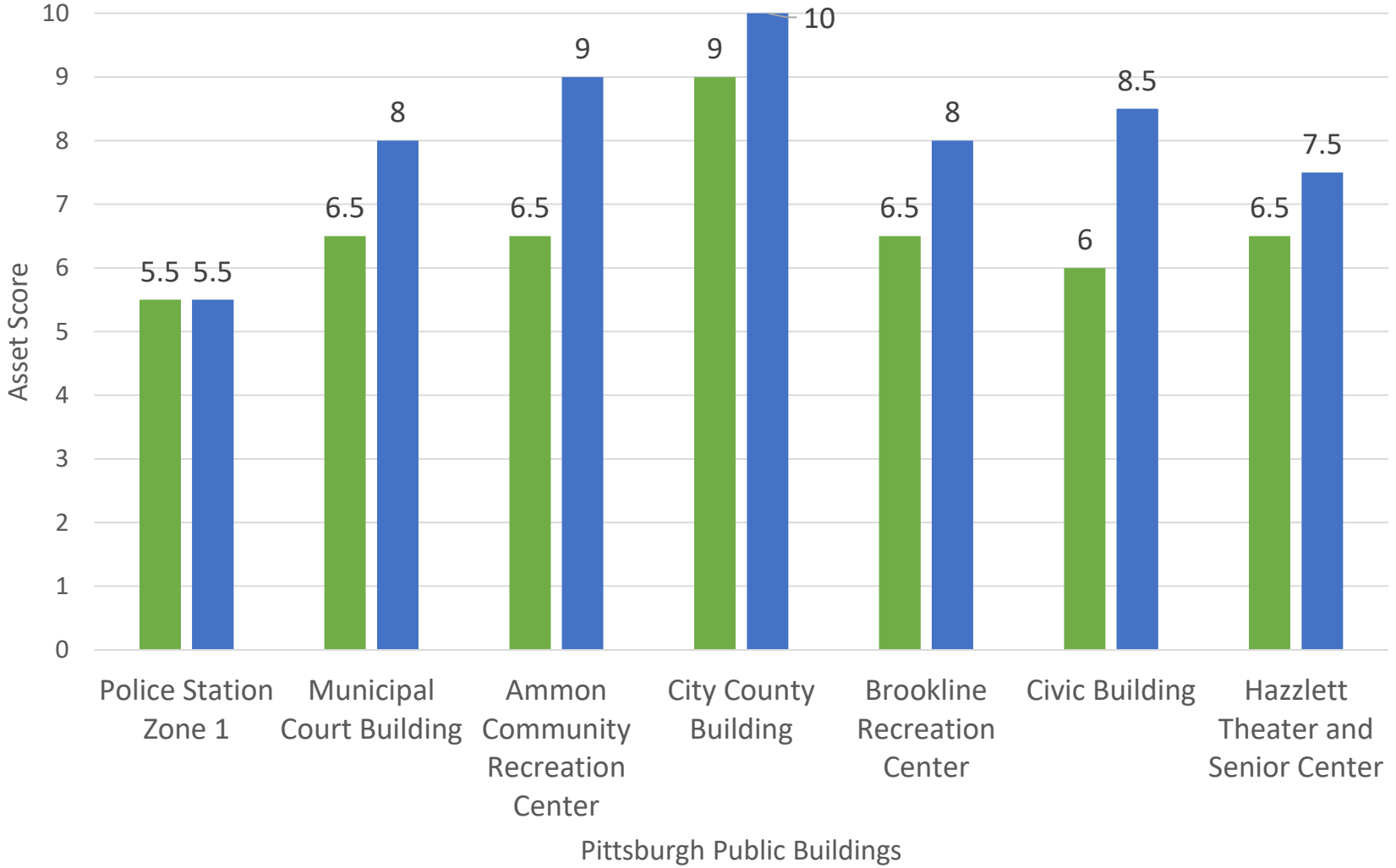
About Building Systems

	Ranking[6]
Interior Lighting	Fair
Heating	Fair
Cooling	Superior
Overall HVAC Systems	Superior

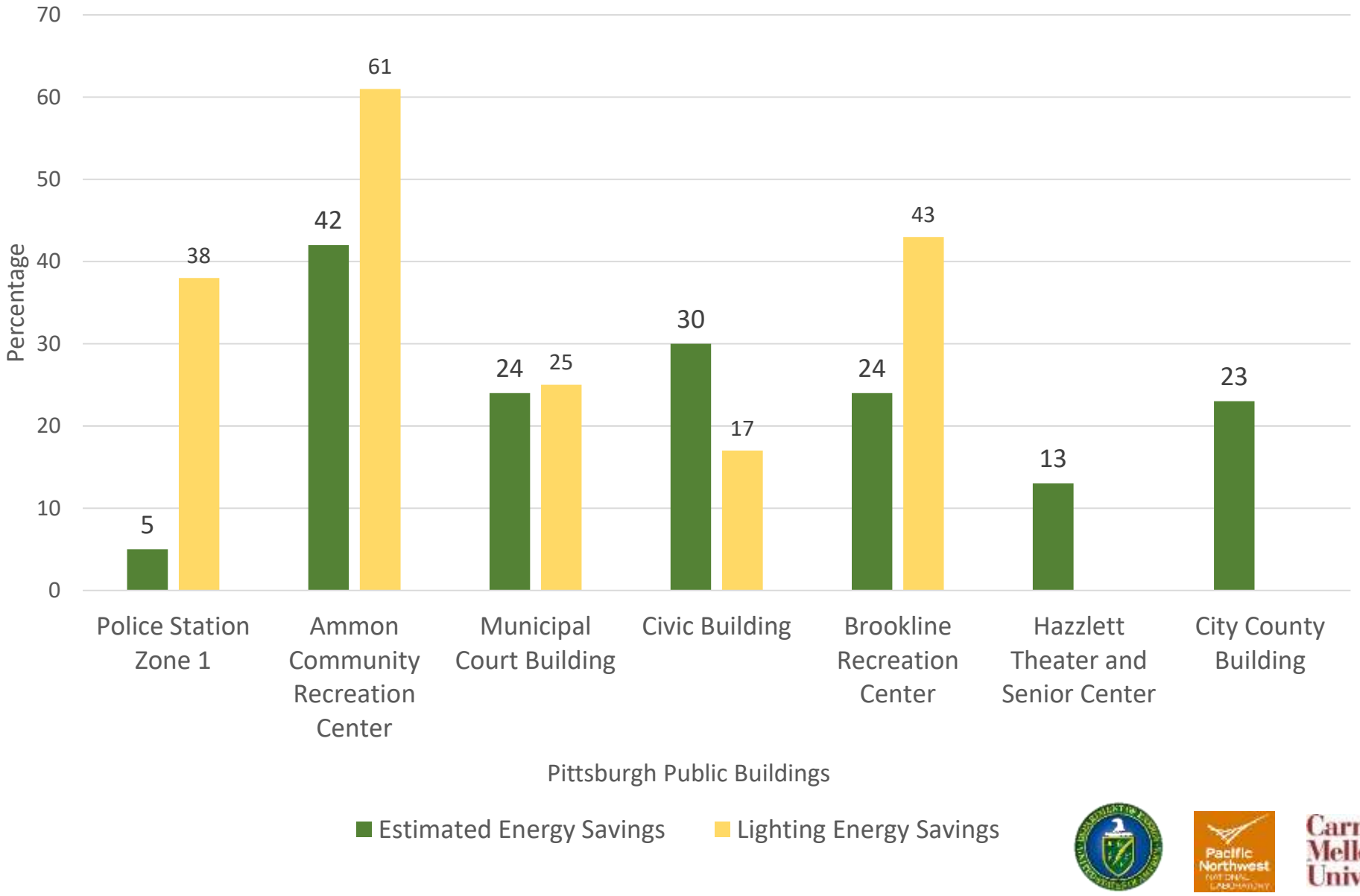
About the Building Envelope

	Ranking[6]
Roof U-Value, Non-Attic ($Btu/ft^2\ h\ °F$)	Fair
Walls U-Value, Framed ($Btu/ft^2\ h\ °F$)	Good
Windows U-Value ($Btu/ft^2\ h\ °F$)	Good
Walls + Windows U-Value ($Btu/ft^2\ h\ °F$)	Good
Window Solar Heat Gain Coefficient	Good

Asset Scores for Priority Buildings



Estimated Energy Savings



Pacific Northwest National Laboratory

Carnegie Mellon University

Metro21 Carnegie Mellon University

Thank you

1. What is Big Data

2. Challenges to obtain data

3. Once you have the data, now what?

4. How can data influence socially responsible design?













Why Schools? Conditions in Urban Schools

Low Investments

- $127 billion in backlogged maintenance.
- 50% cut in school construction 2012.
- $6 Billion annually spent on energy, more than textbooks and computers combined.

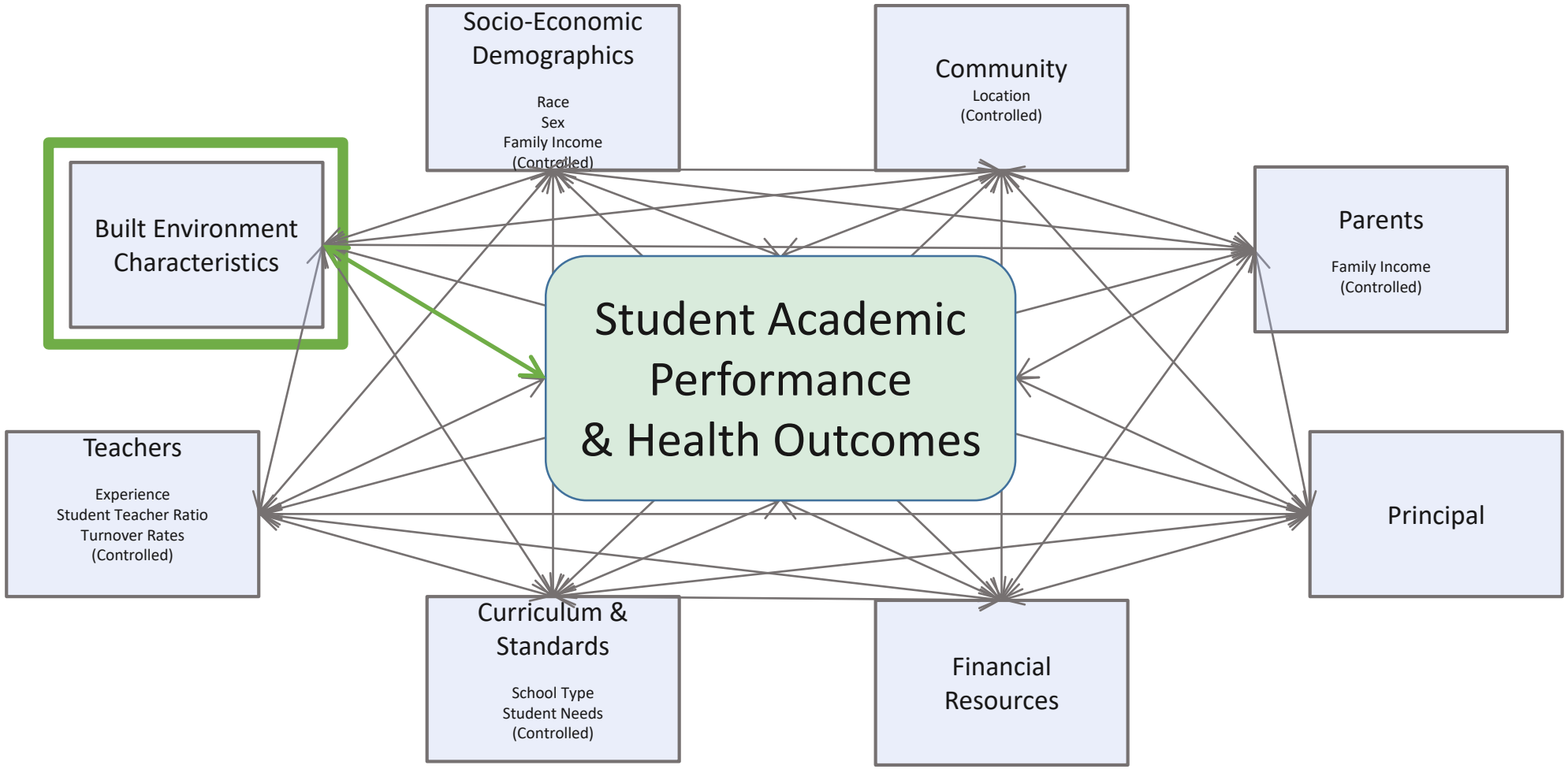
Poor Conditions

- Leaky roofs, flooding, mold, and mildew.
- Indoor and outdoor toxins.
- Windowless classrooms

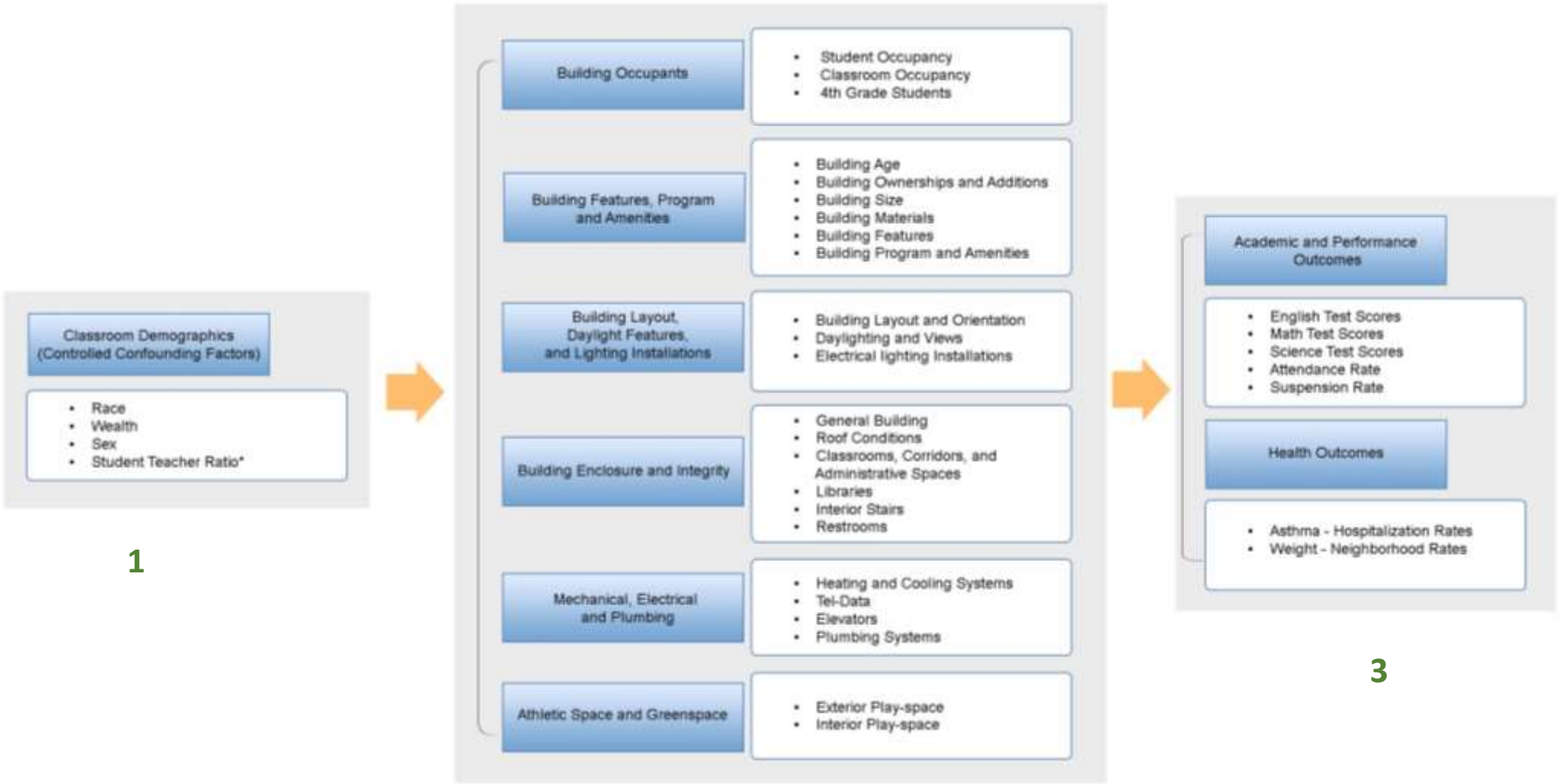
Critical Outcomes

- 1200 hours a year spent in spaces 4 times the density of offices.
- 40% of electricity for poor lighting.
- 14 million missed school days from asthma.
- Teacher turnover rates as high as 50% in urban schools.
- U.S. Public School students no longer proficient in Math, English, Science, and Social Studies.

Academic Performance & Health Web



Can Data Help Identify Problems and Solutions?



Statistical Database:

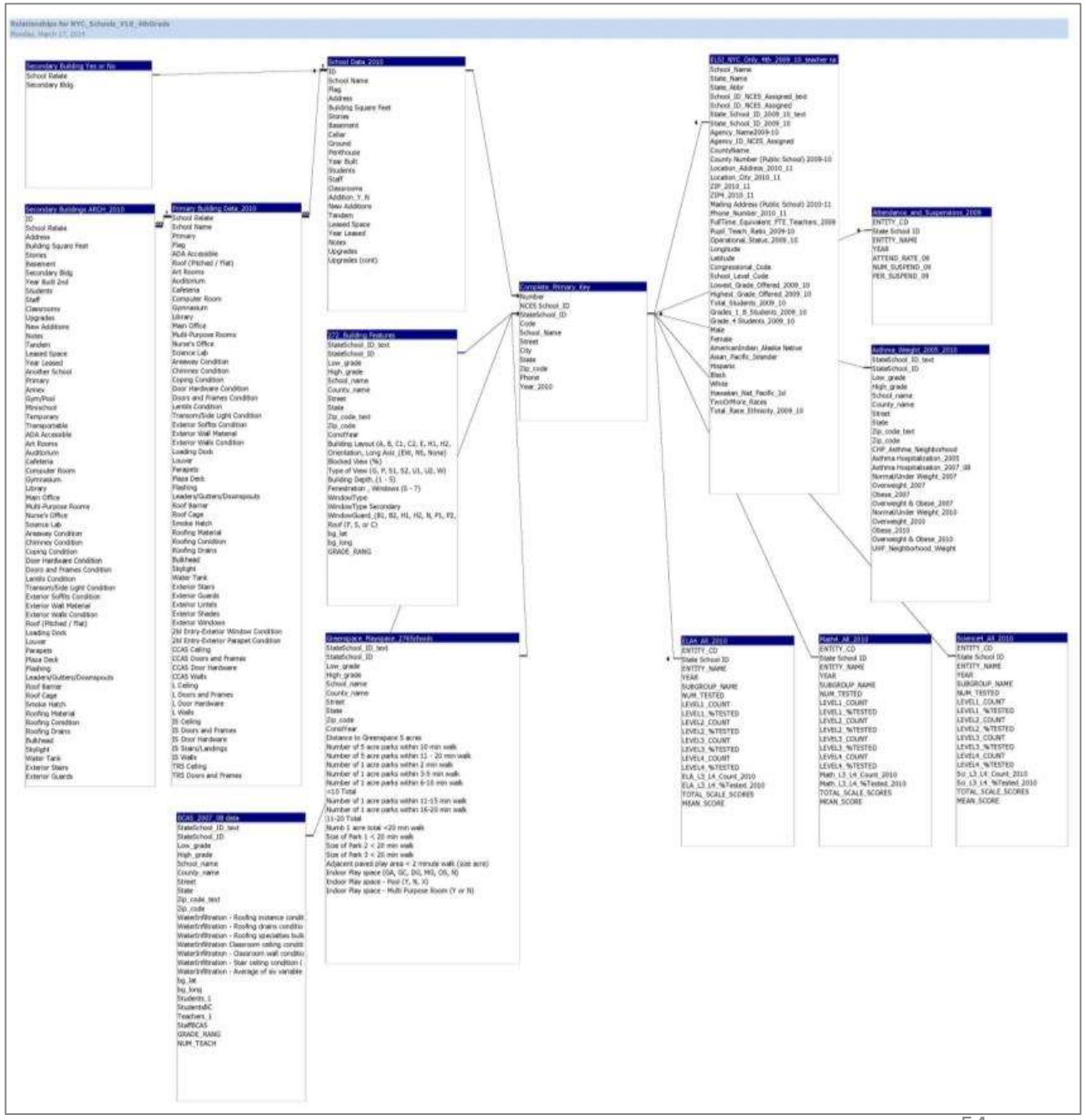
125 urban school with similar demographics.

175 school and neighborhood physical conditions and amenities.

- Building occupants and density
- Building features and conditions
- MEP system conditions and availability
- IEQ systems and conditions
- Athletic space and greenspace

12 measurable performance and health outcomes.

Each school contains 1,200-2,500 entries; approximately over 8 million entries



Existing Building Conditions: Building Layout

Building Type: Bar

Building Type: 2 Bars

Building Type Box

Building Type C1

Building Type C2

Building Type Donut

Building Type E

Building Type H

Building Type L

Building Type O2

Building Type T

Building Type X2

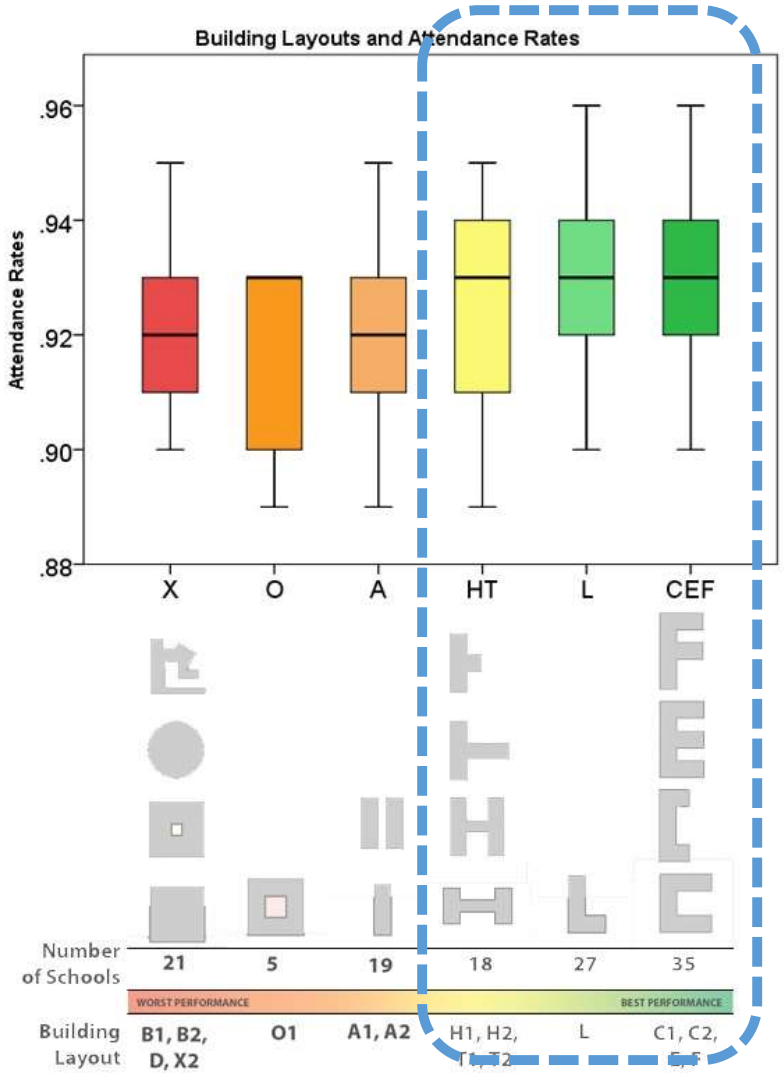
Key Factors Affected by Building Layout

Building Type Donut

Building Type T

1. Daylighting
2. Views
3. Natural ventilation
4. Visual oversight to enhance security
5. Learning clusters
6. Acoustical separation

Building Layout and Student Outcomes



Does the shape of the elementary school building influence student outcomes?

Finger plan elementary school buildings tend to have higher attendance rates.

Finger plan Shapes C E and F have the highest attendance rates compared to all other building shapes (p=.036), and have a 1.8% higher attendance rate compare to shape O.

(Potentially supervision is easier with a single direction view corridor)

Building Features, Program and Amenities: Building Depth

5 Basic Building Depths ranging in width of less than 40ft to more than 100ft

≤ 39’ deep.
Thin building; typically single loaded corridors with one row of classrooms connected by a corridor along an exterior wall.
(n = 0)

40’ – 59’ deep.
Thin building; typically single or double loaded corridor. (n = 64)

60’ – 79’ deep.
Medium width building; typically double loaded corridors. Classrooms located along the building perimeter with a corridor in the middle. (n = 42)

80’ – 99’ deep.
Wide building. Double loaded corridor with wider corridors, some rooms possibly without access to a perimeter wall. (n = 9)

≥ 100’ deep.
Wide building. Rooms and spaces located in the building core have limited to no access to daylighting. (n = 10)

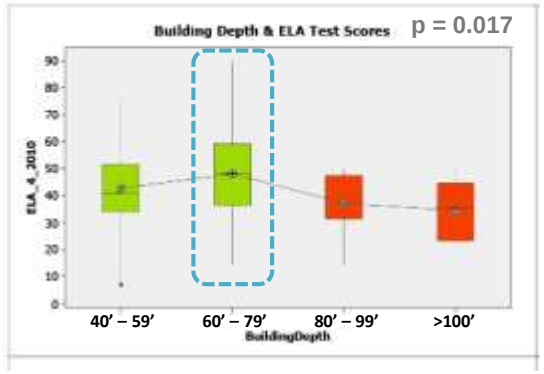
Six Key Factors Affected by Building Layout:

- Daylighting
- Views
- Natural Ventilation
- Visual Oversight to Enhance Security
- Learning Clusters
- Acoustical Separation

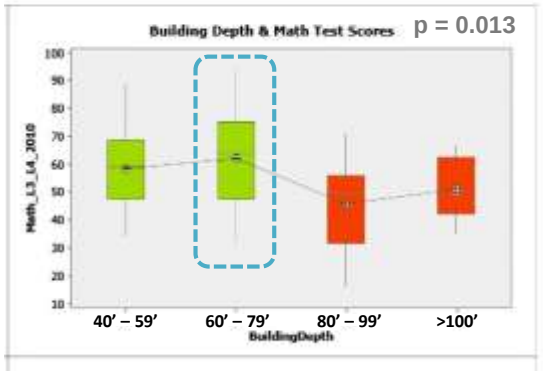
Building Factors

Building Features, Program, and Amenities: Building Depth

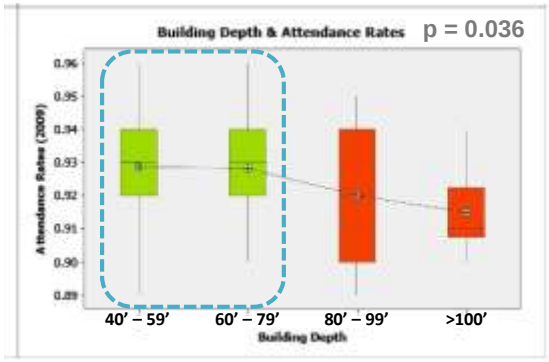
✓ Higher English Test Scores



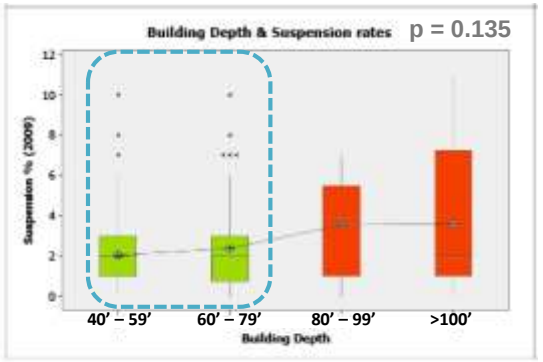
✓ Higher Math Test Scores



✓ Higher Attendance Rates



✓ Potentially Lower Suspension Rates



Does the depth measured from the thinnest portion of the building influence student performance and behavioral outcomes?

Elementary school buildings that are less than or equal to 79' deep have:

- **17-28% higher percentages of students scoring at the minimum ELA and Math competency levels (p=.017 and p=.013)**
- **1.5% higher attendance rates (p=.036)**

(Potentially triple layered corridors increase distractions, reduce supervision, decrease the potential for natural ventilation, and have less access to daylight and views)

Manage Window Wall Ratio:

Window to wall ratio impacts outcomes.



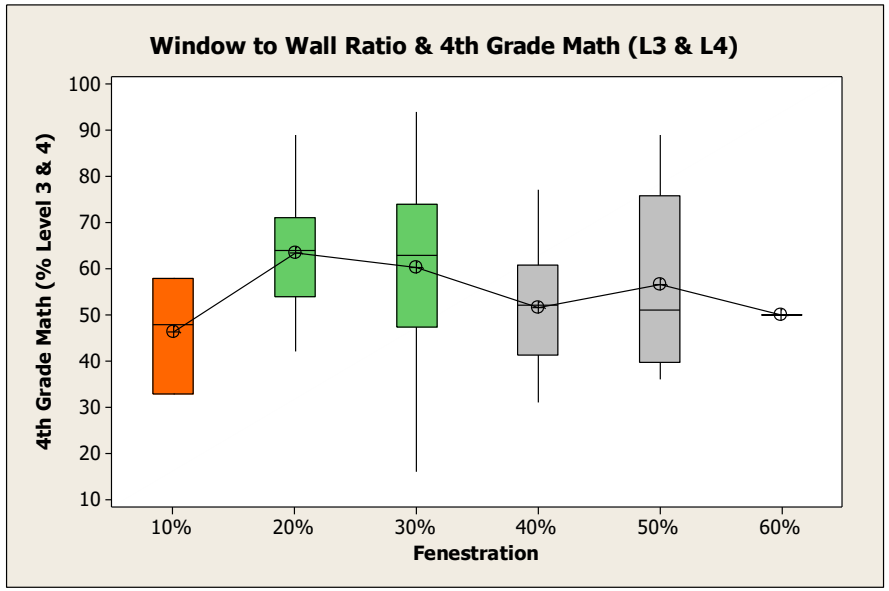


10% **20%** **30%** **40%** **50%**

Requires high performance shading devices

Key Factors Affected by WWR:

- ✓ Daylighting
- ✓ Views
- ✓ Natural Ventilation
- ✓ Thermal Comfort
- ✓ Noise
- ✓ Pollution



Maintain Facility Condition:

Facility condition impacts outcomes.

Inoperable window

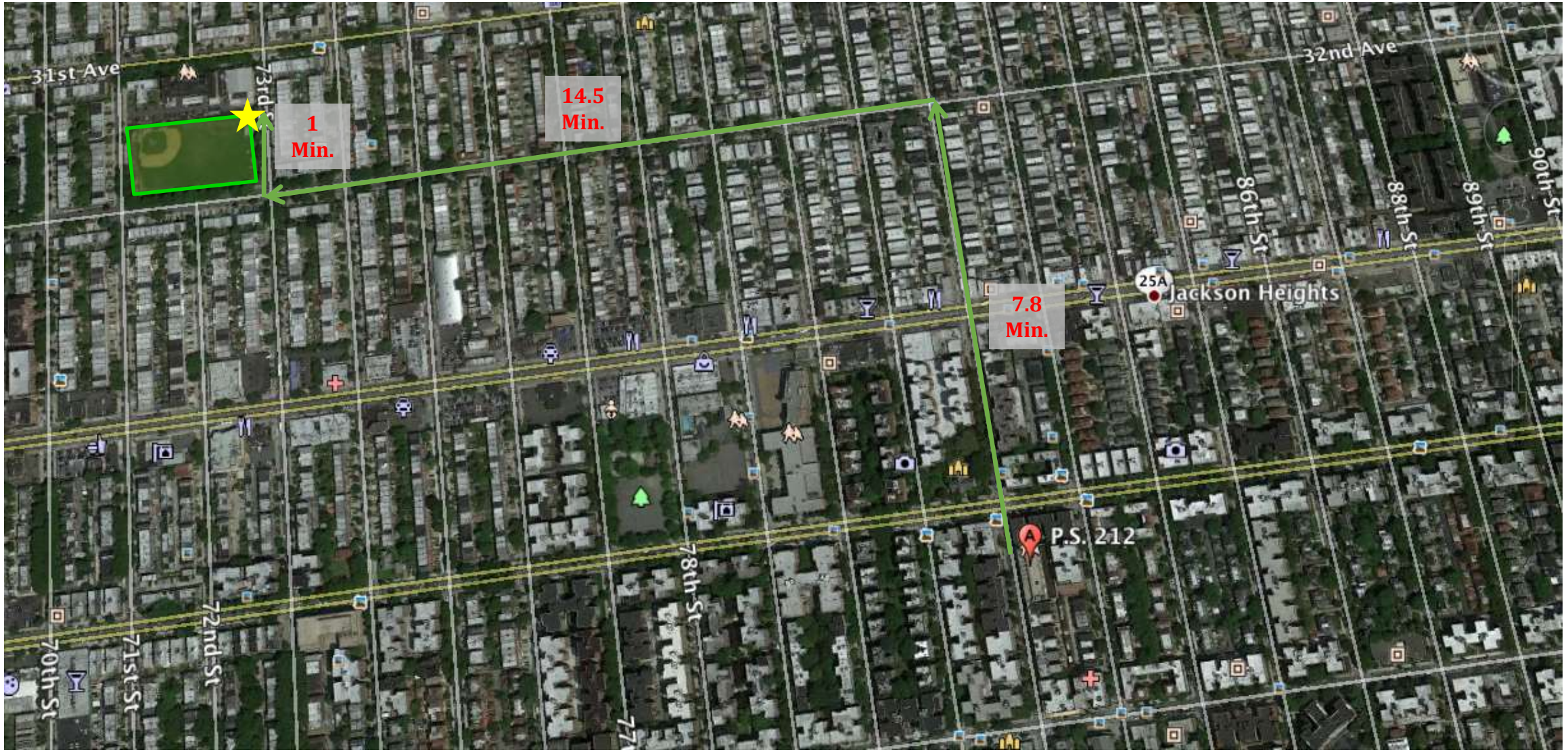
Polluted potable water source

Key Factors Affected by Facility Condition:

- Thermal comfort; 'poor' or lack of pneumatic controls & ELA test scores (p=.014)
- Thermal comfort; thermostats in the classroom & increased teacher satisfaction.
- Thermal comfort; 'fair to poor' and 'poor' unit heaters/cabinet heaters & attendance rates (p=.031)
- Water management; 'poor' roof conditions & Math test scores (p=.040)

Green Space?

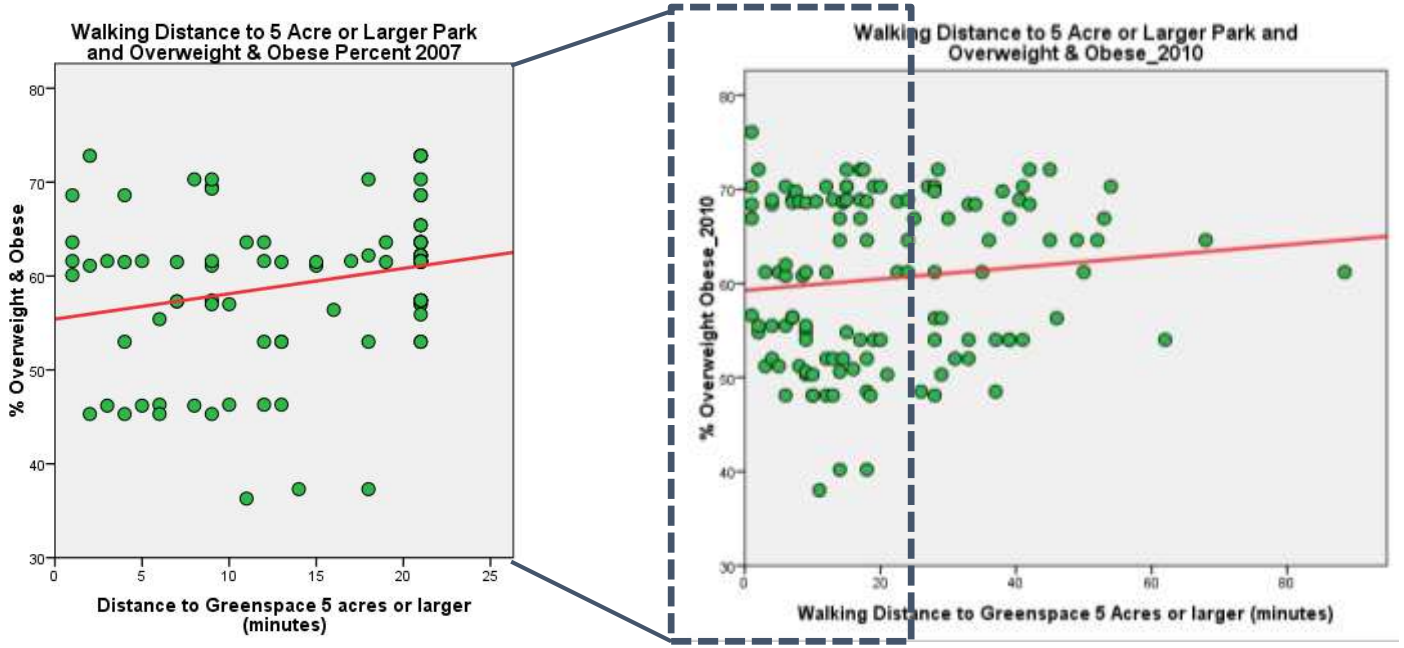
Neighborhood and Community Factors
Outdoor Athletic and Green Space



Connection with Nature

Walking Distance to Five Acre Parks

Is the walking distance to a 5 acre or greater greenspace correlated with neighborhood weight percentages?



Elementary schools greater than a 20 minute walk to the nearest 5 acre or larger park had 3% higher average percentages of communities who are overweight & obese (p=.024).

Elementary schools with greater quantities of 1 acre or larger greenspaces had 5-10% lower neighborhood percentages who are overweight (p=.002), but may possibly have higher suspension rates (p=.016).

Elementary schools with greater quantities of 5 acre or larger greenspaces had 8-9% lower neighborhood percentages who are overweight (p=.039).

Leveraging Data And Technology For Healthy, Equitable, Sustainable Communities

- **Investment in a Data Ecosystem that Advances the Goals of the Social Sector**
  Considering the environment from data to decision maker to improve outcomes
- **Advance Equity and Social Justice**
  Using data as a tool to reveal disparities and inform action and progress
- **Build a Data-Informed Culture**
  Considering what a data-informed culture means internally for organizations and externally for their partners and the field.

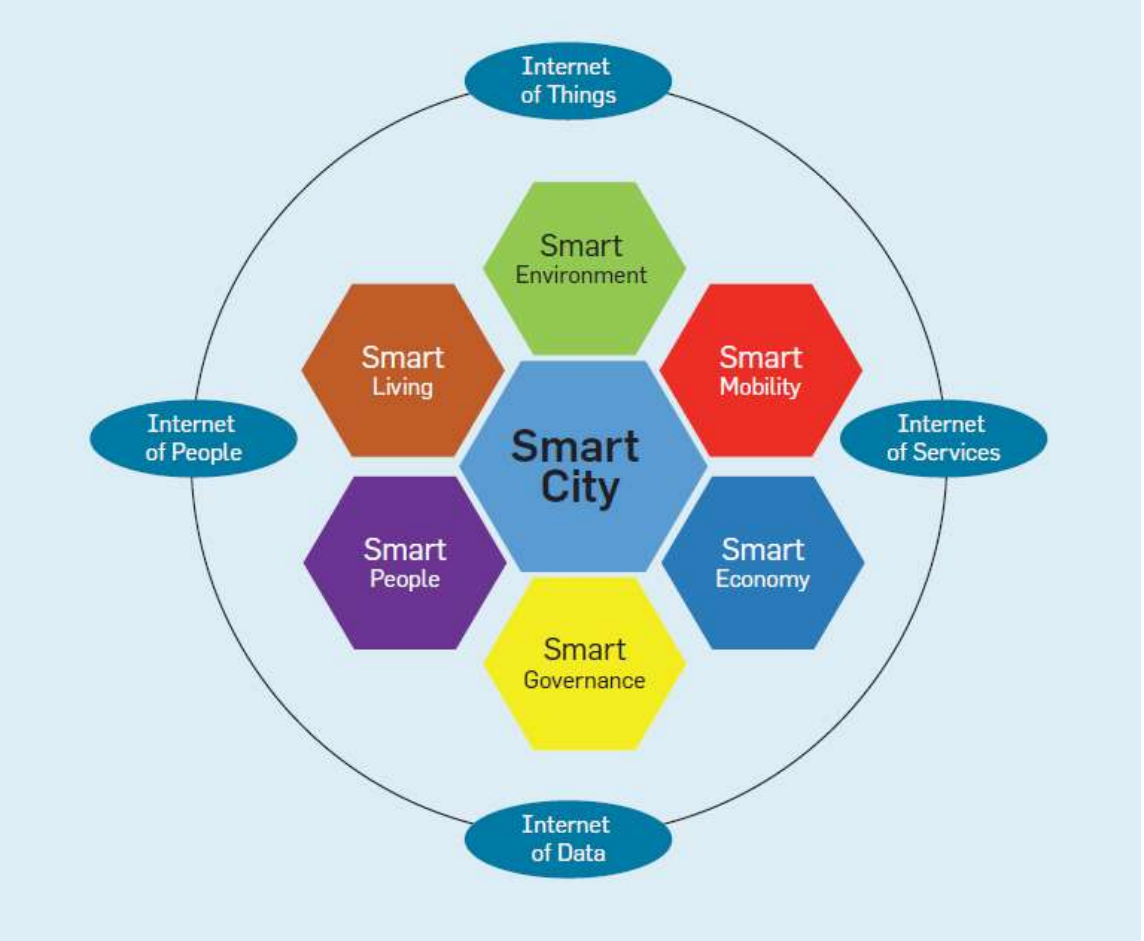
Source: Narain, A. (2017, August 1). Why data revolution is crucial for the success of SDGs. Retrieved from https://www.geospatialworld.net/article/data-revolution-for-sustainable-world/

Role of Big Data Analytics in a Sustainable Smart City

In smart cities, various municipals and state agencies generate heterogeneous data with minimal or no coordination.

Next Steps?

- Overcome challenges like data analytics, query answering, and data visualization, to build smart cities.
- Develop novel and sophisticated techniques to efficiently process the Big Data generated from the sensors deployed in the existing cities.
- Form a common platform for scholars, researchers, scientists, engineers, and administrators to develop and design new ideas and concepts.
- Involve stakeholders in the process to improve the field of smart cities based on Big Data analytics and Internet of Things.



Source: Khatoun, R., & Zeadally, S. (n.d.). Smart Cities: Concepts, Architectures, Research Opportunities. Retrieved from https://cacm.acm.org/magazines/2016/8/205032-smart-cities/abstract