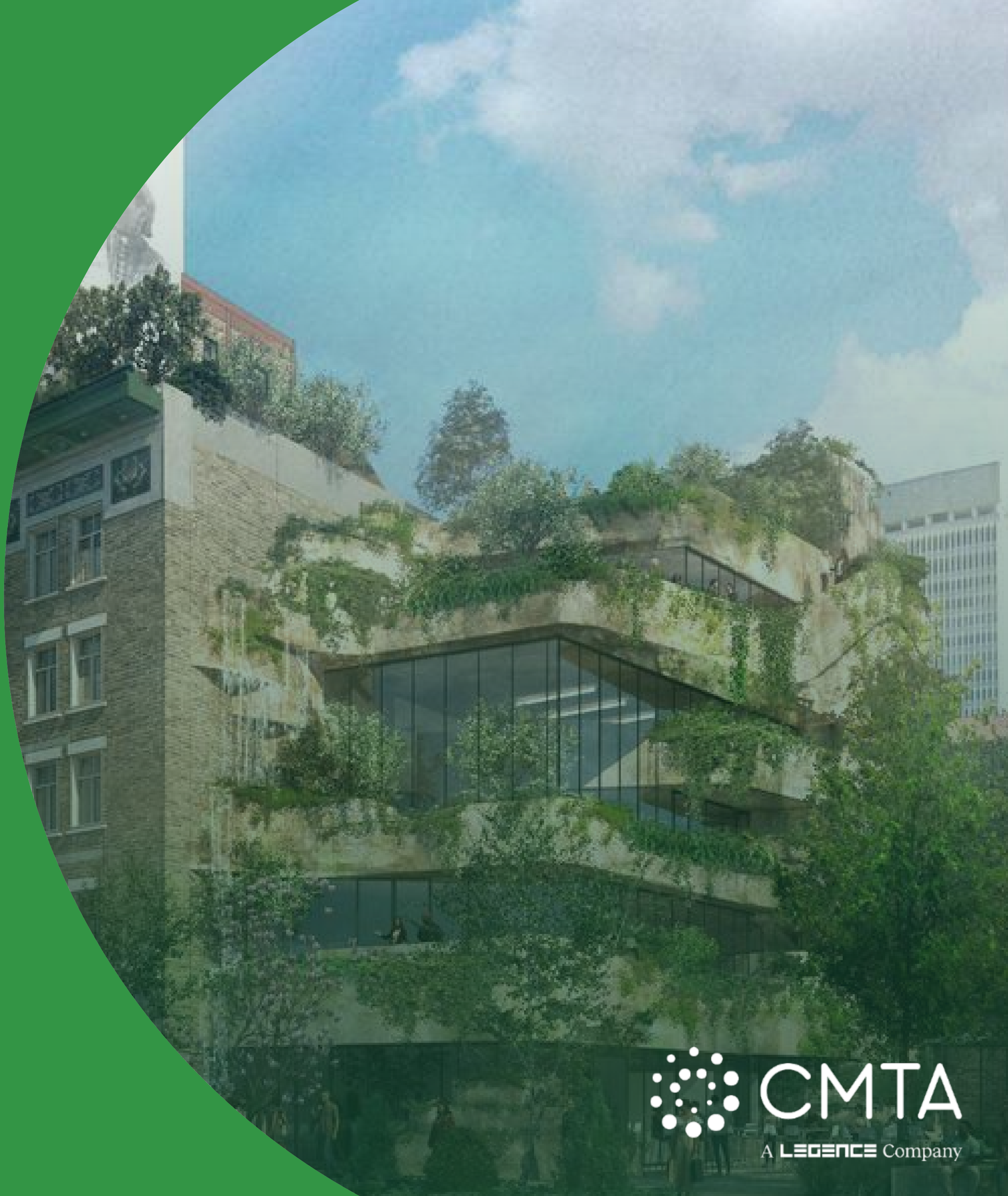
Regenerative Design

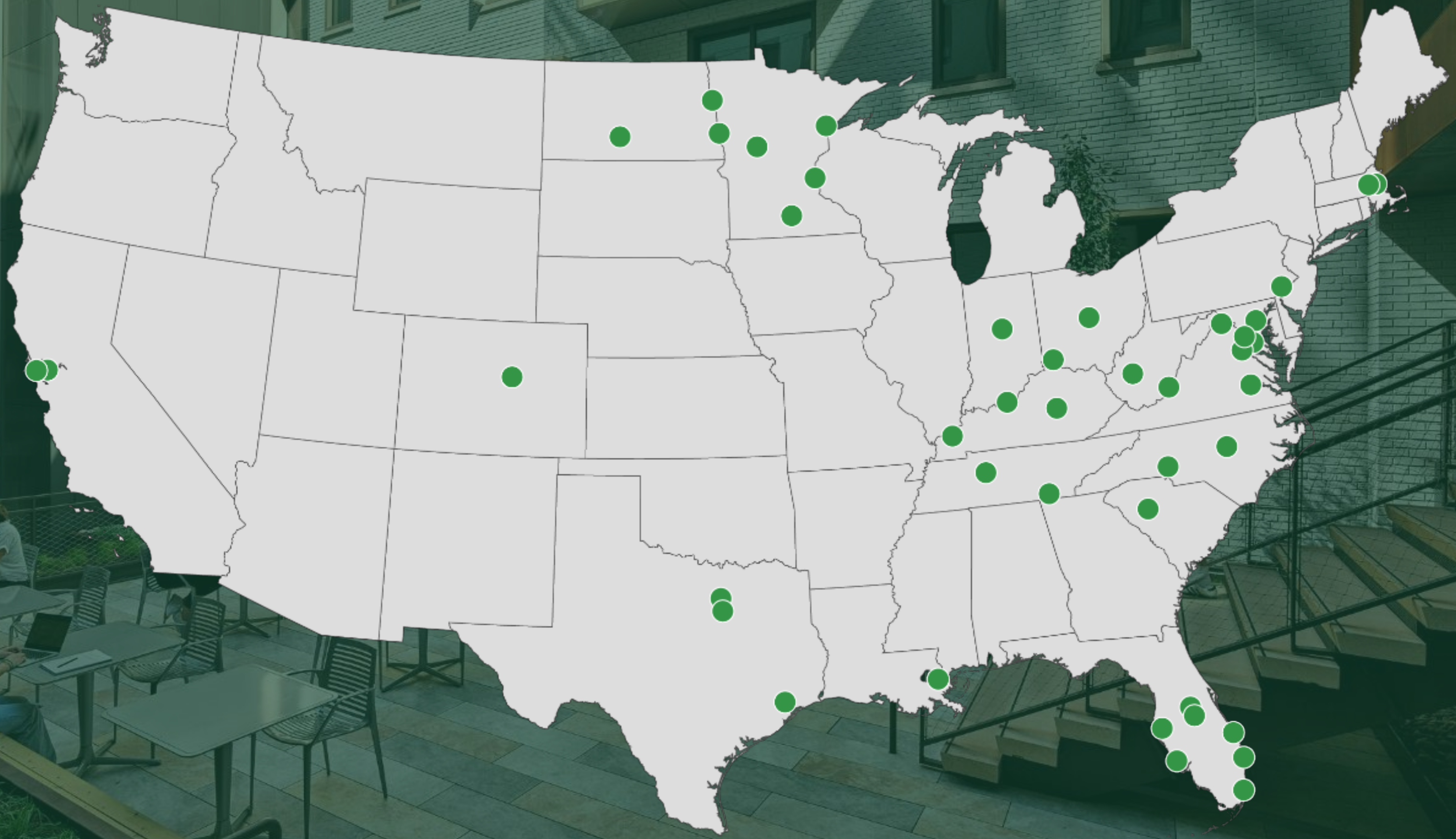
April 22, 2024



About Us

CMTA
BUILDING SCIENCE LEADERSHIP
DECARBONIZATION ZERO ENERGY
ENERGY EFFICIENCY
TRANSPARENCY SUSTAINABILITY INDUSTRY LEADERS
DESIGN BUILD INDOOR AIR QUALITY
GEOTHERMAL
HIGH PERFORMANCE BUILDINGS
INFRASTRUCTURE UPGRADES MEP RESULTS OCCUPANT WELLNESS
ENERGY DASHBOARD
INNOVATION GUARANTEE DATA DRIVEN LEED
AWARD WINNING QUALITY
EXIT

By the Numbers



900

Employees

44

Offices Nationwide

250

Professional Engineers

56

Years of Service

Our Expertise

MEP Engineering

Zero Energy / Carbon Engineering

Renewable Energy & Sustainability

Energy Modeling

Commissioning

Technology / Security Infrastructure Design

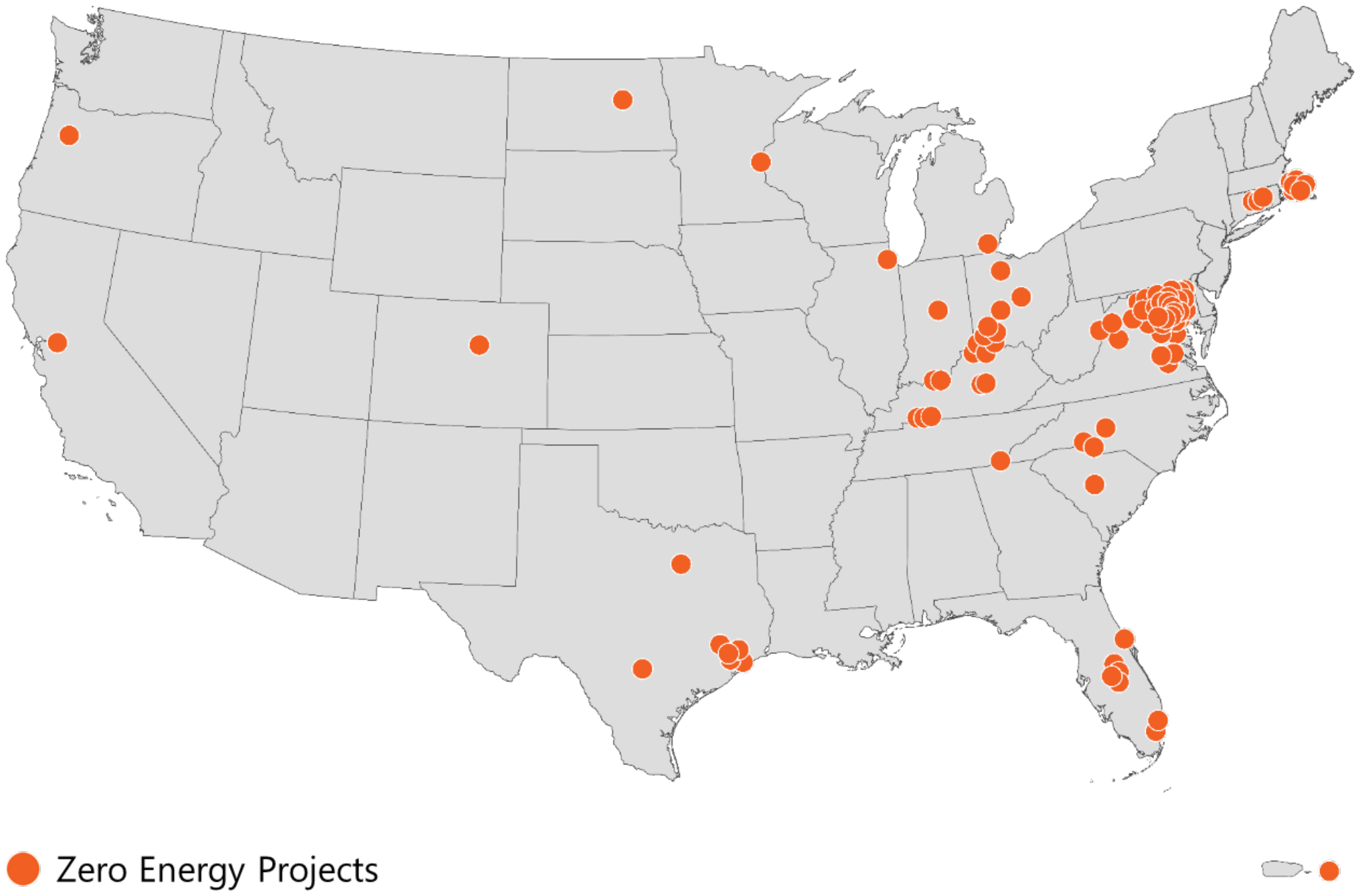
Construction Administration

Performance Contracting

Energy as a Service (EaaS)

Inflation Reduction Act

Operational Zero Energy / Zero Carbon



90+
Projects

9.8M SF
Operational Zero Energy

5.7M SF
Operational Zero Carbon

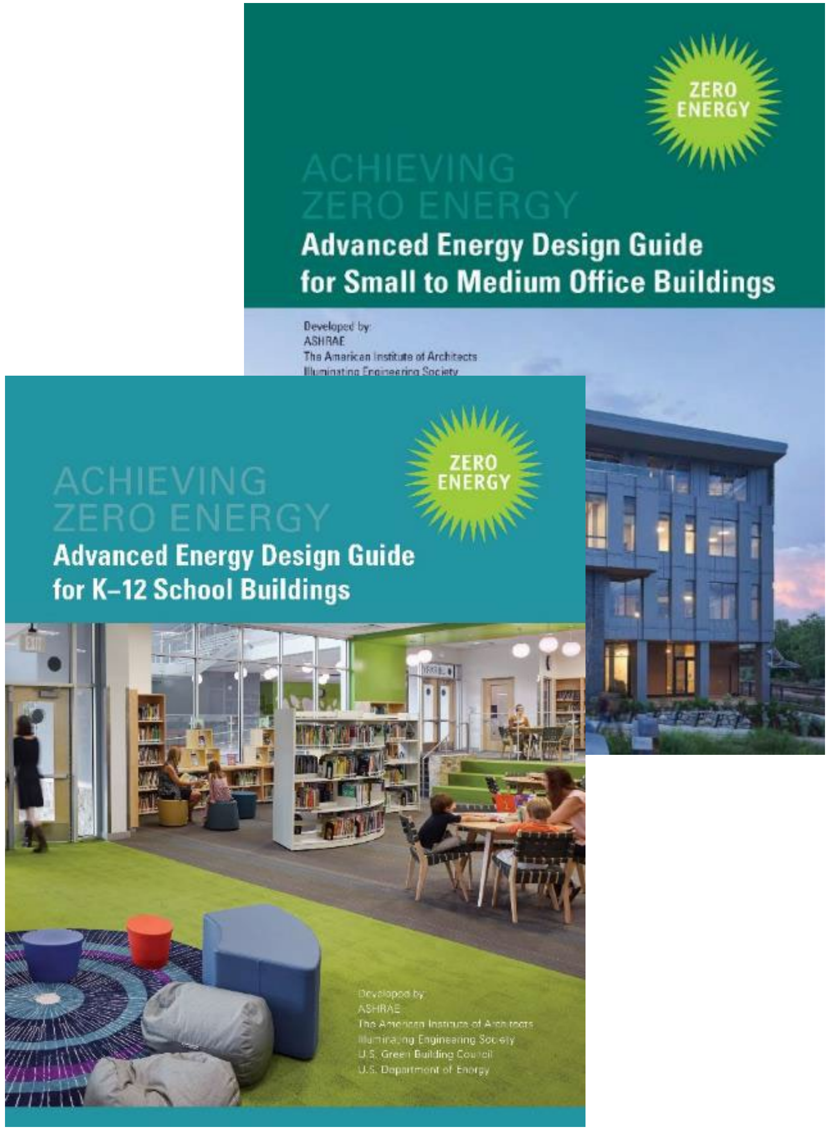
Zero Energy Thought Leadership

Leading ASHRAE Awarded Design Firm

30+ ASHRAE Society International Technology Awards

Co-Authored Multiple Advanced Energy Design Guides for Zero Energy

Schools and Offices



What is Regenerative Design?

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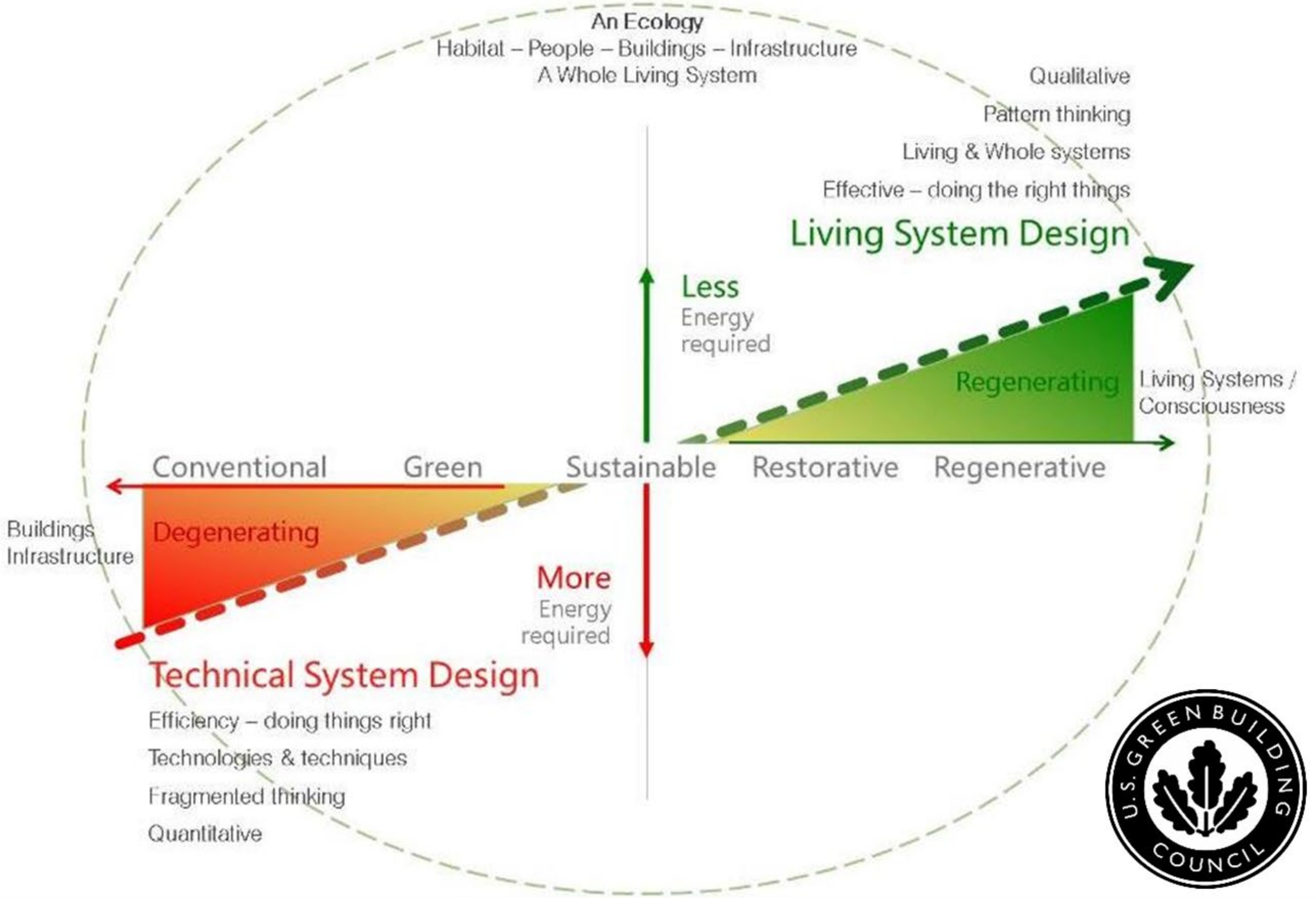

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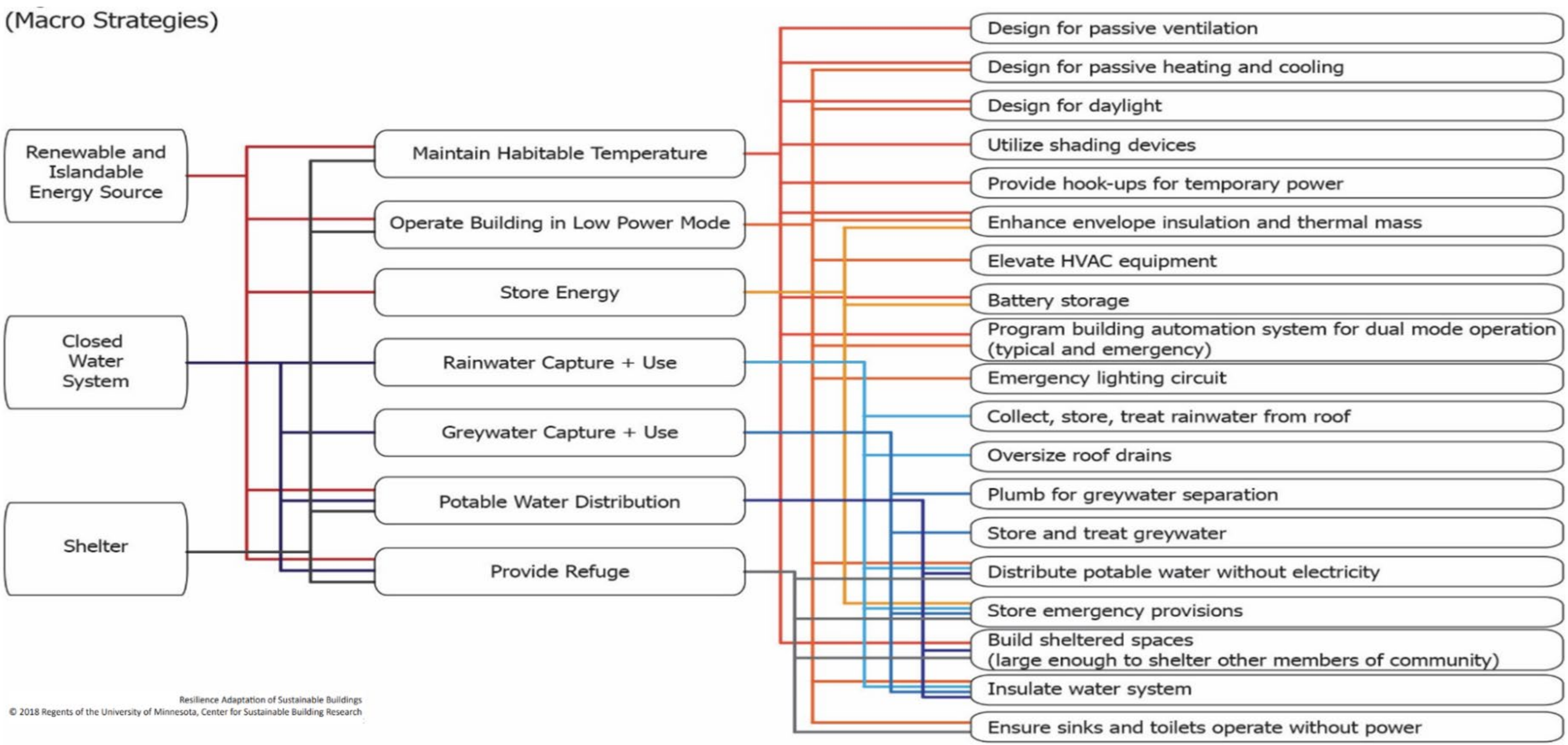


What is Regenerative Design?

Typical Definition:

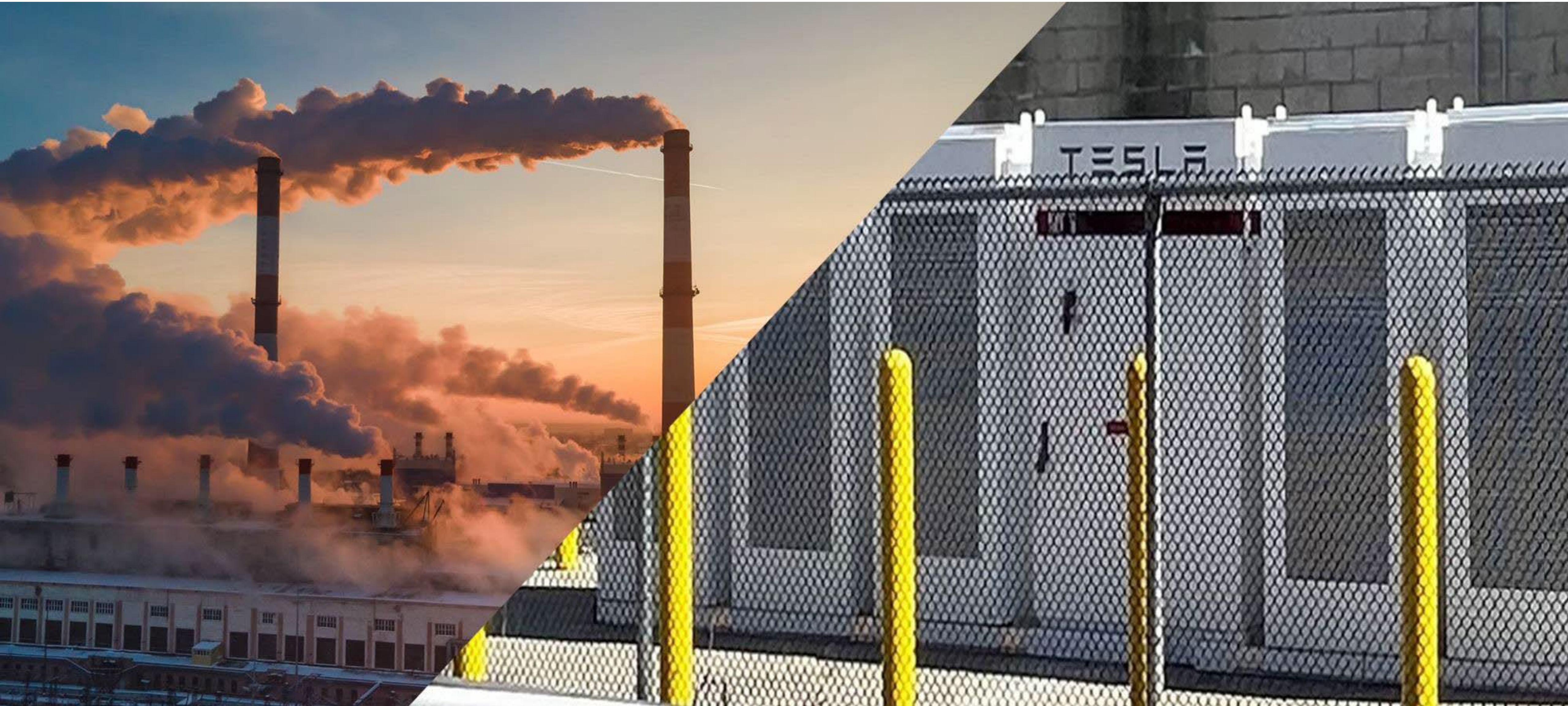
Creating resilient and equitable systems that integrate the needs of society with the integrity of nature.

Minimizing the impacts on carbon, water, nutrients, air, biodiversity, social, ecological and health.

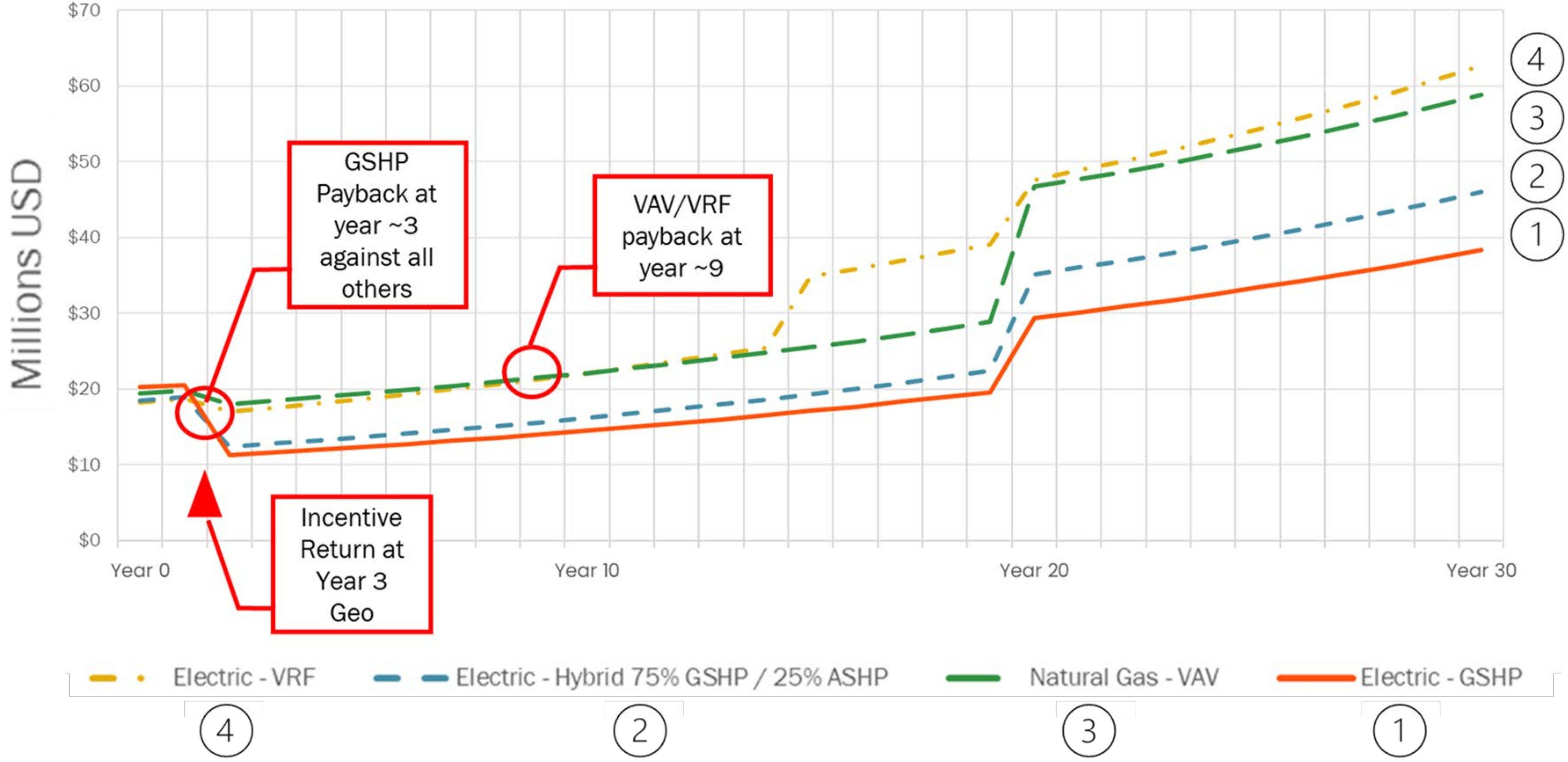
Our Definition *(Engineer's Definition)***:**
Shifting the focus from minimizing negative impact to maximizing positive impact.

What Does that Mean?

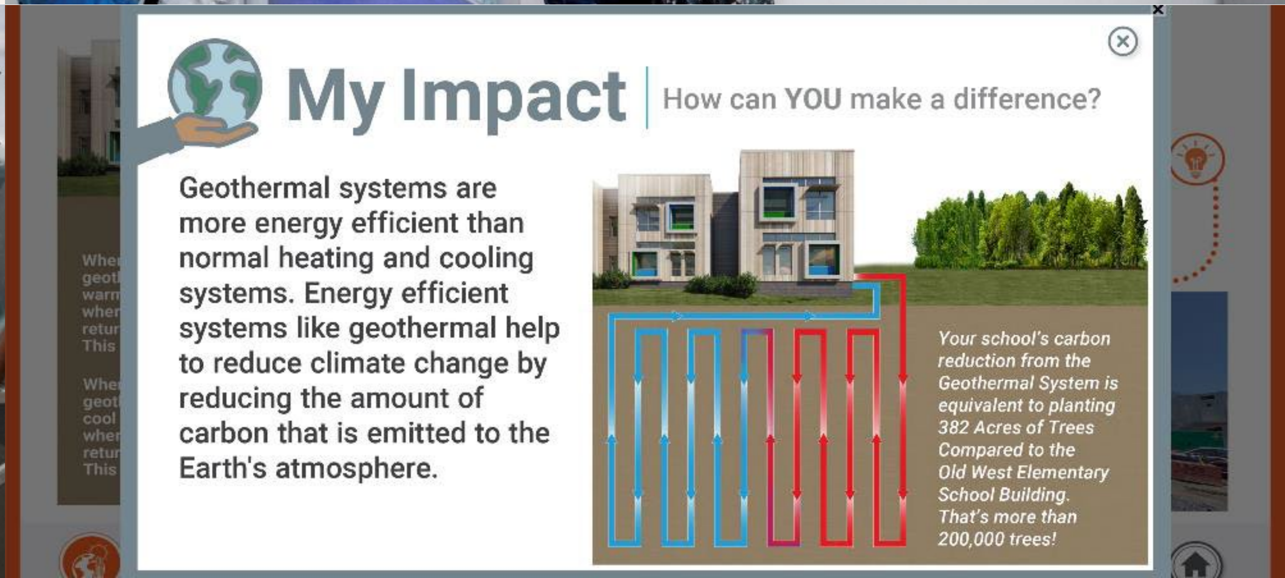
Using the Grid... Better



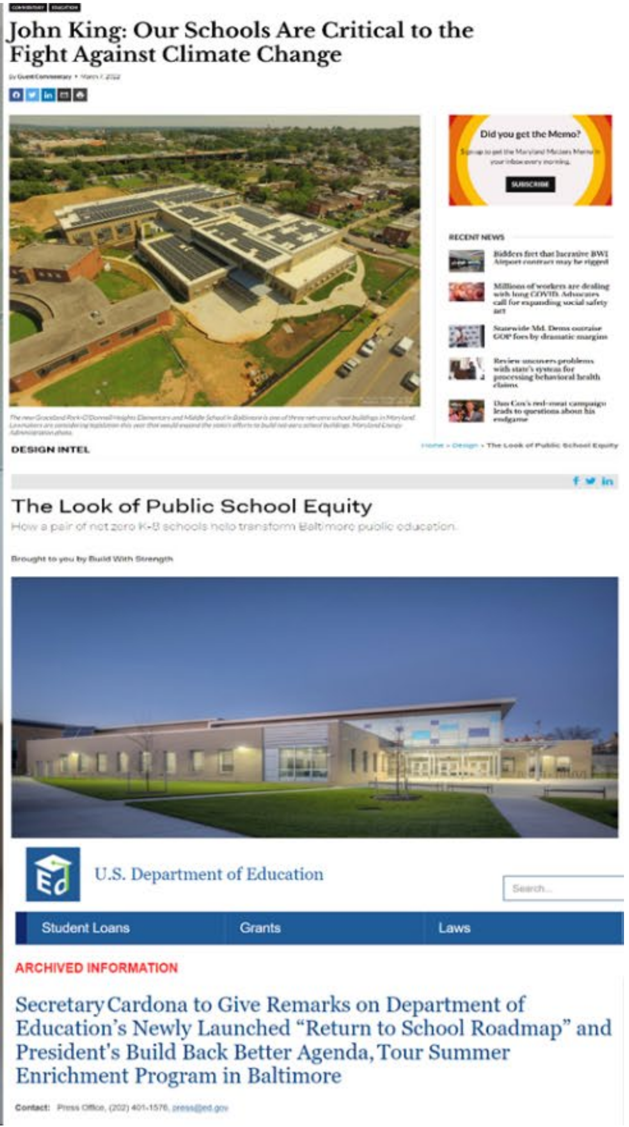
Financial Impact



Building as a Teaching Tool



Community Impact



John King: Our Schools Are Critical to the Fight Against Climate Change

Did you get the Memo?

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Bidders fret that lucrative BWI Airport contract may be rigged

Millions of workers are dealing with long COVID. Advocates call for expanding social safety net

Statewide Md. Dems outraise GOP foes by dramatic margins

Review uncovers problems with state's system for processing behavioral health claims

Dan Cox's red-meat campaign leads to questions about his endgame

DESIGN INTEL

The Look of Public School Equity

How a pair of net zero K-8 schools help transform Baltimore public education.

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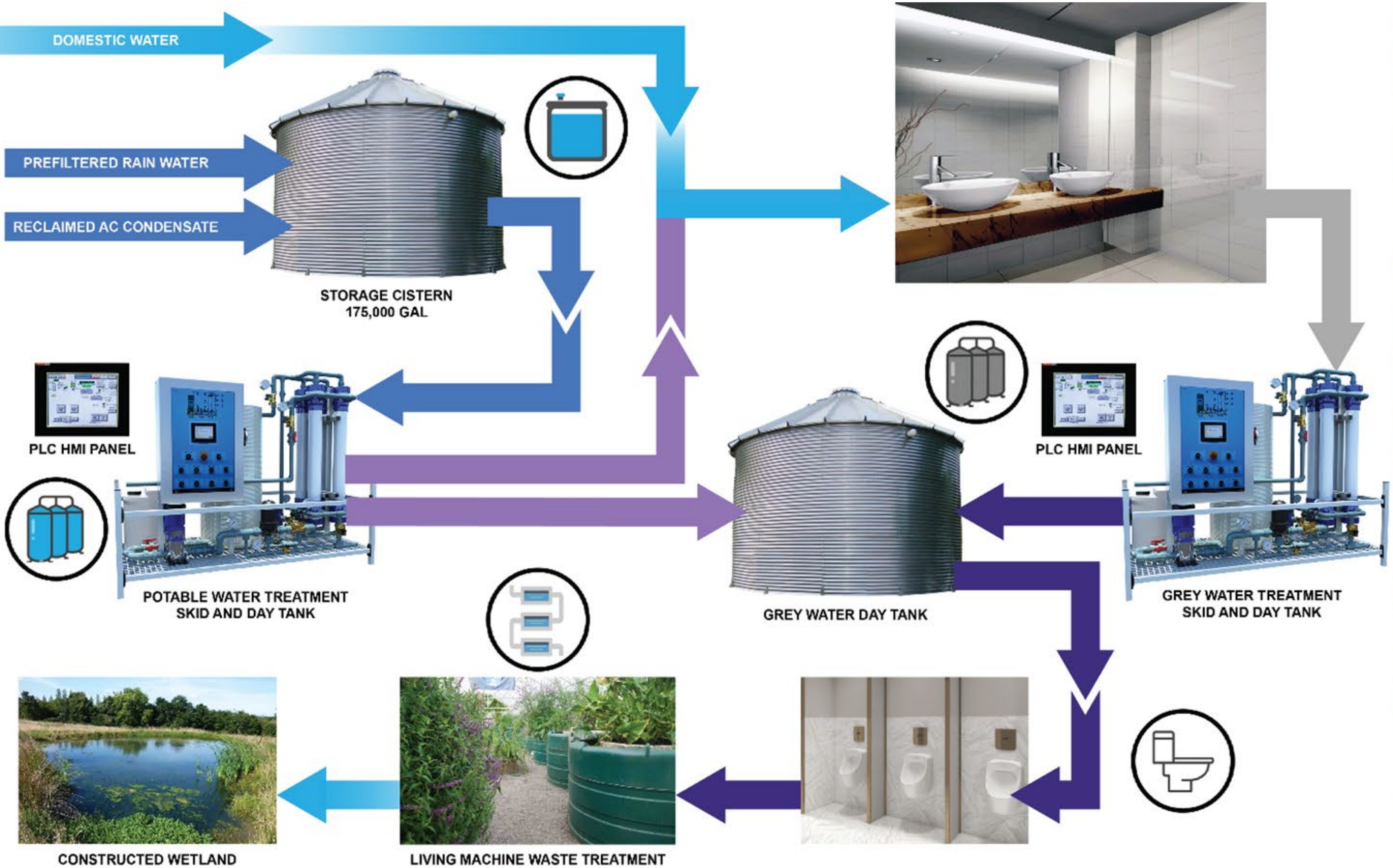
U.S. Department of Education

Student Loans | Grants | Laws

ARCHIVED INFORMATION

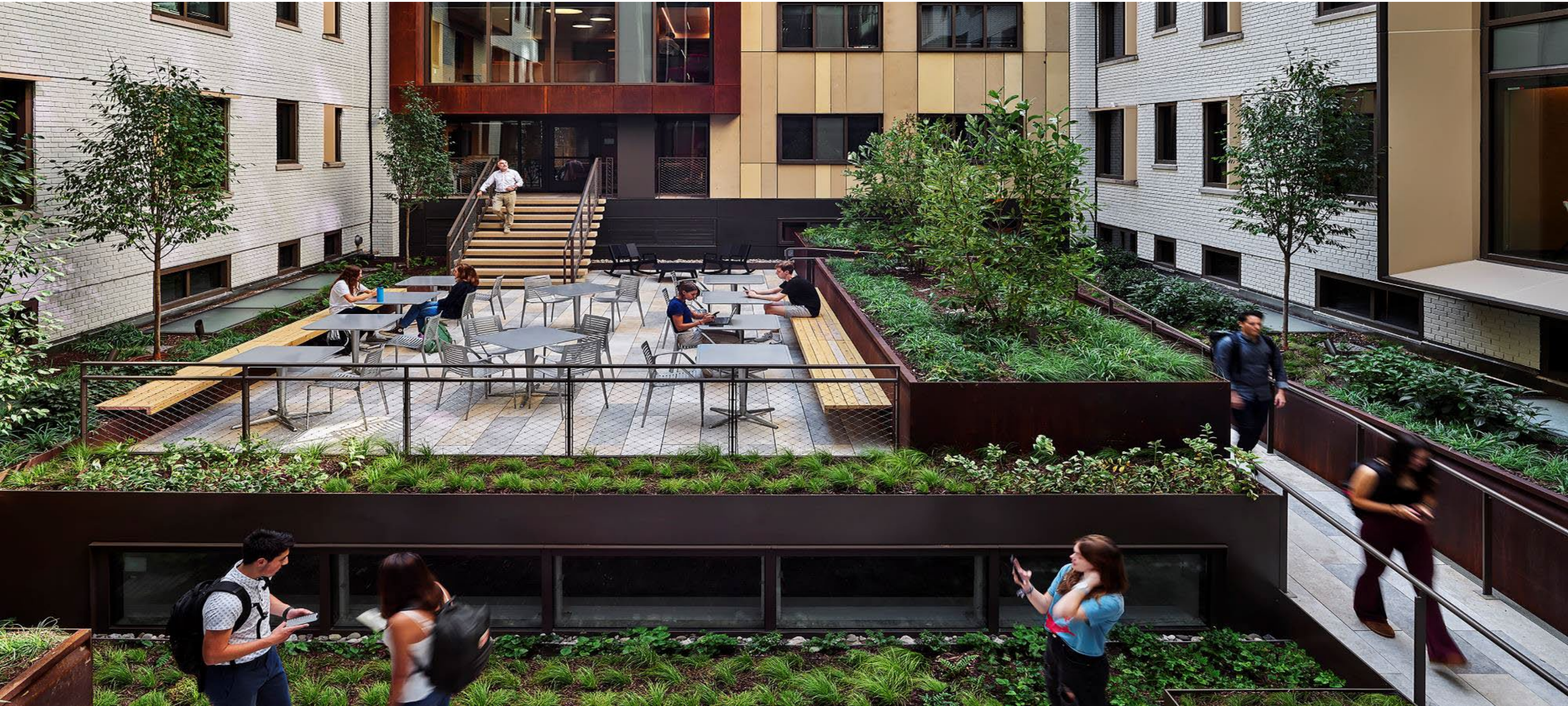
Secretary Cardona to Give Remarks on Department of Education's Newly Launched "Return to School Roadmap" and President's Build Back Better Agenda, Tour Summer Enrichment Program in Baltimore

Water + Eco System Impact

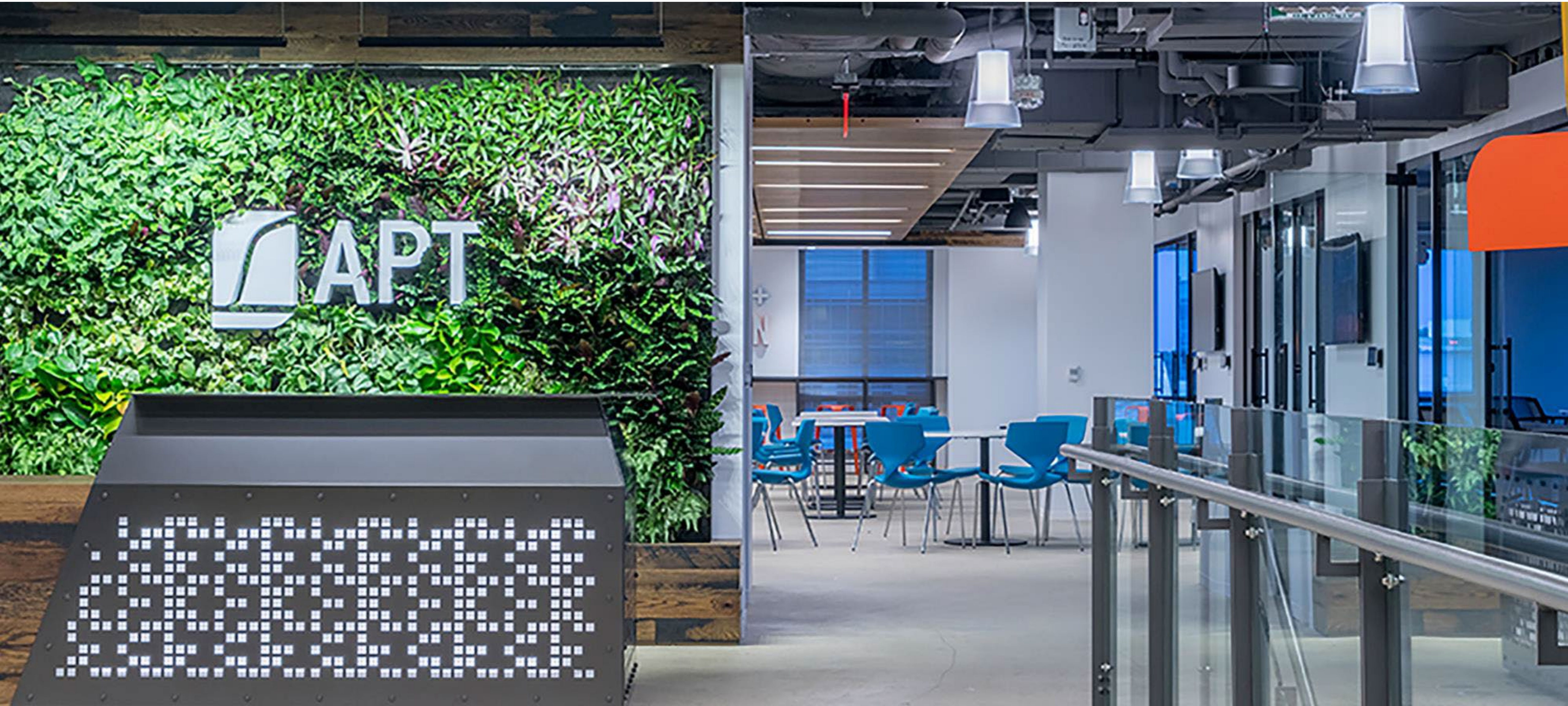


Re-Purposed Buildings

Biophilic Design

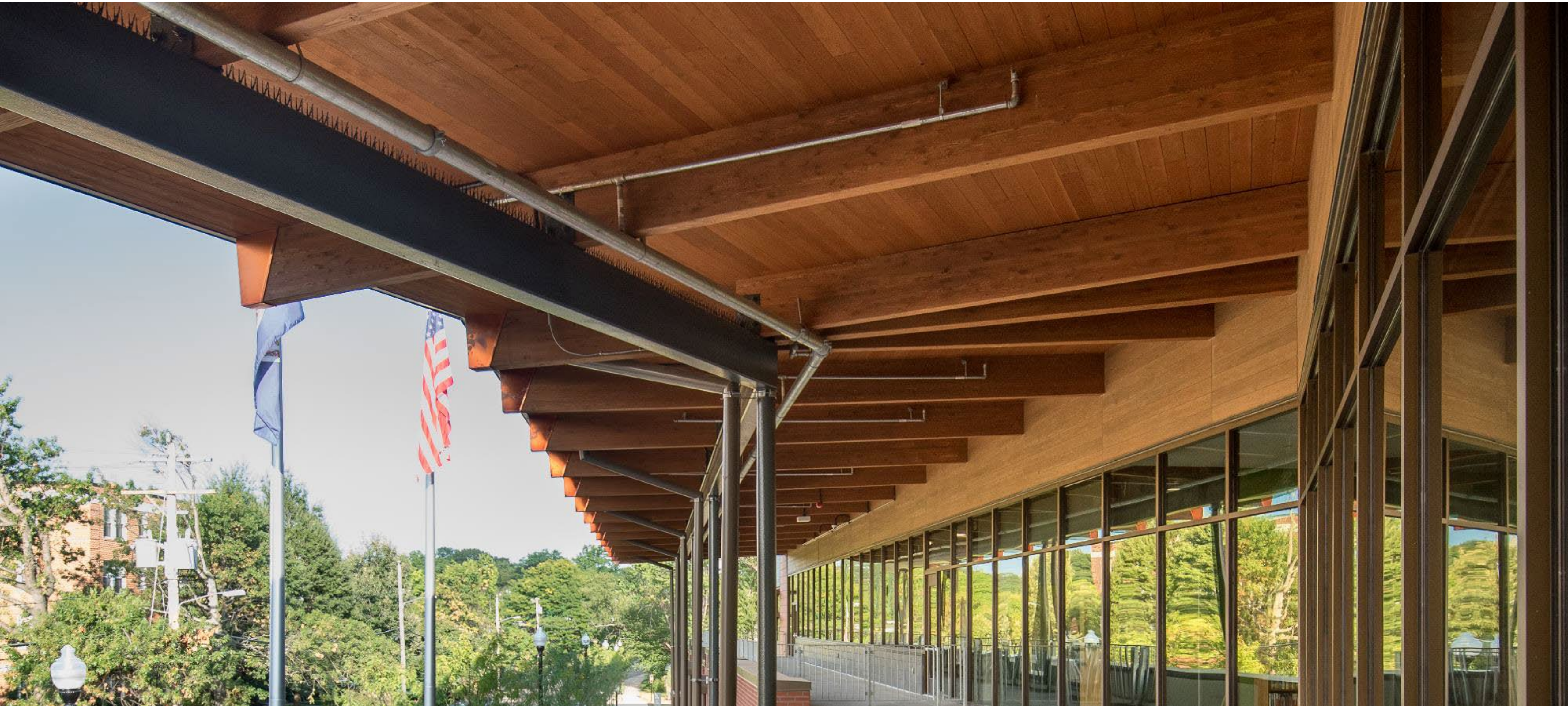


Living Walls + Biofiltration

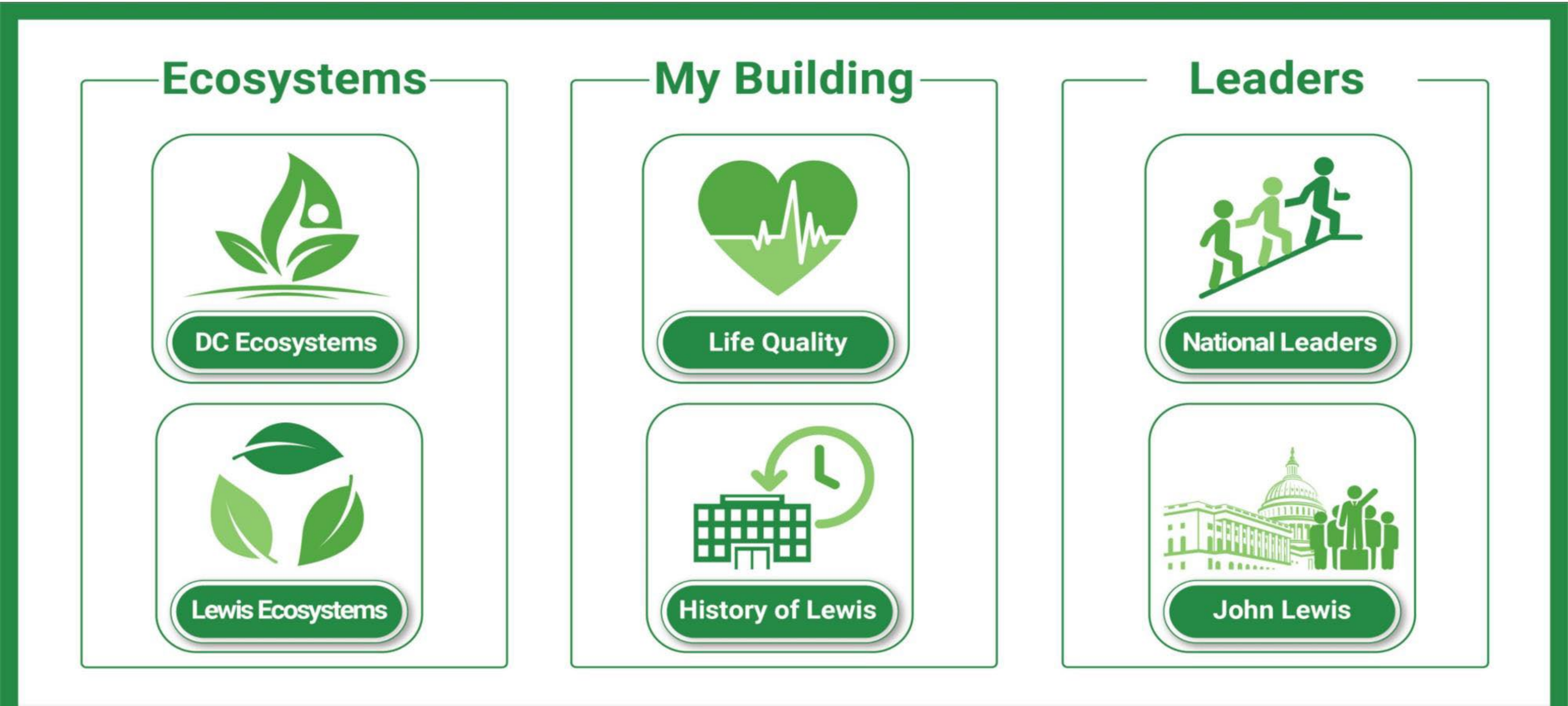


Indoor Air Quality

Sustainable Materials



Social & Environmental Justice



Positive Environments

Performance… Plus More


Designing for
~~Net Zero~~
PERFORMANCE

Our New Reality

Budgets are tighter

Energy & construction costs are on the rise

Communities are looking for good stewardship of taxpayer dollars

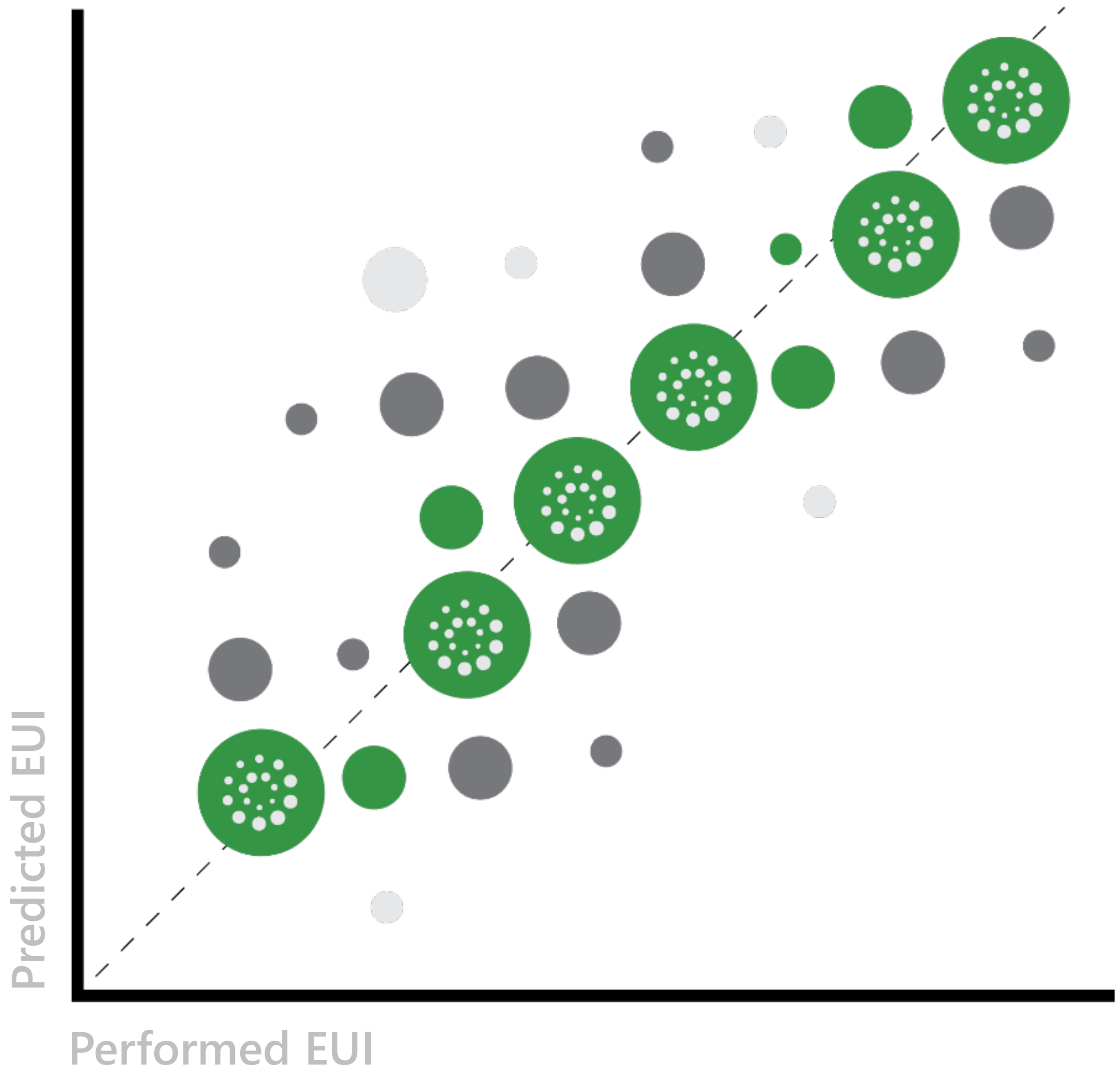
Clients are looking for lower cost of ownership, ease of maintenance, and lower utility costs

https://www.xcelenergy.com/staticfiles/xe/Marketing/Managing-Energy-Costs-Schools.pdf

We are
Data Driven

"You cannot manage what you do not measure."

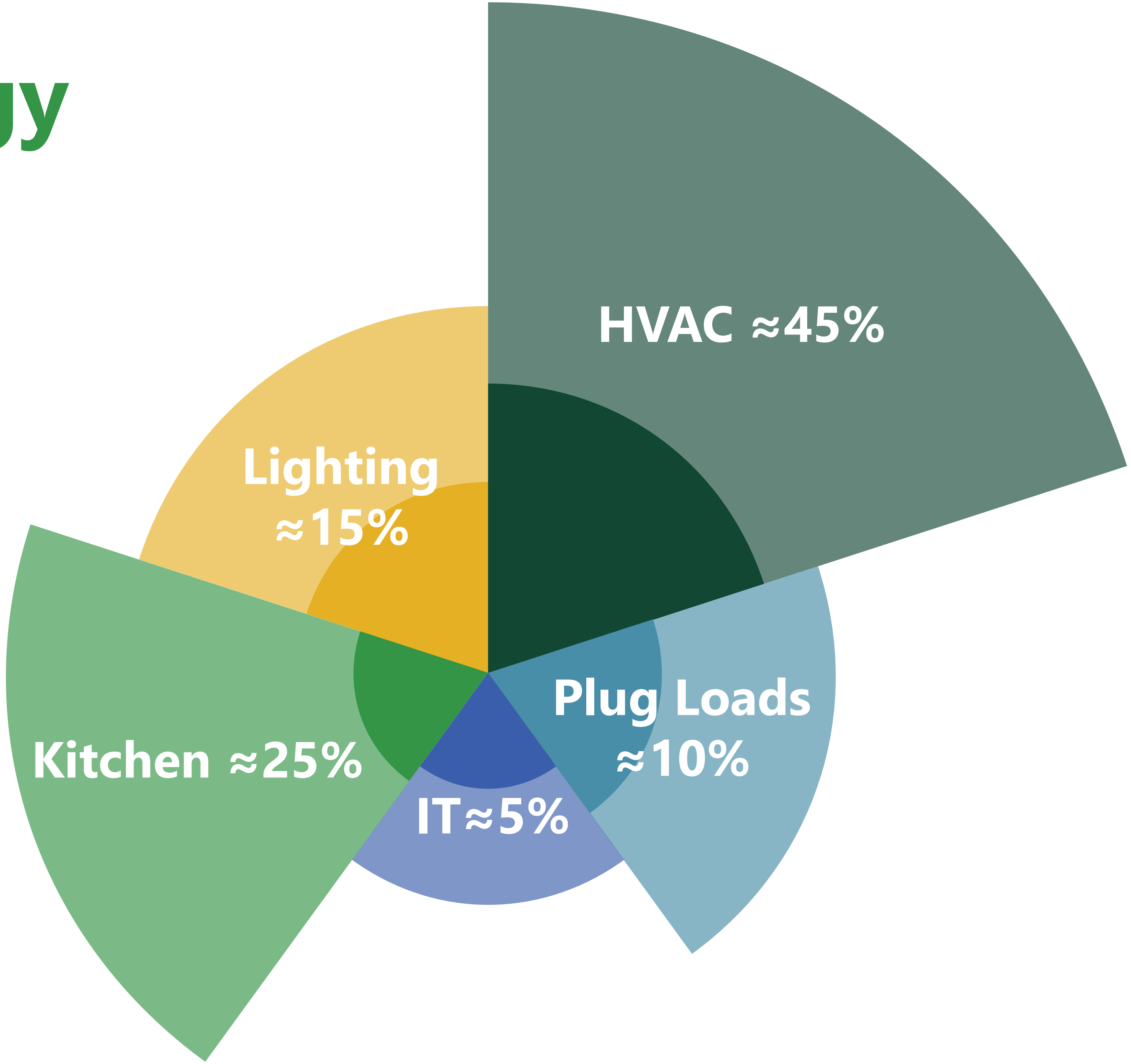
— W. Edwards Deming



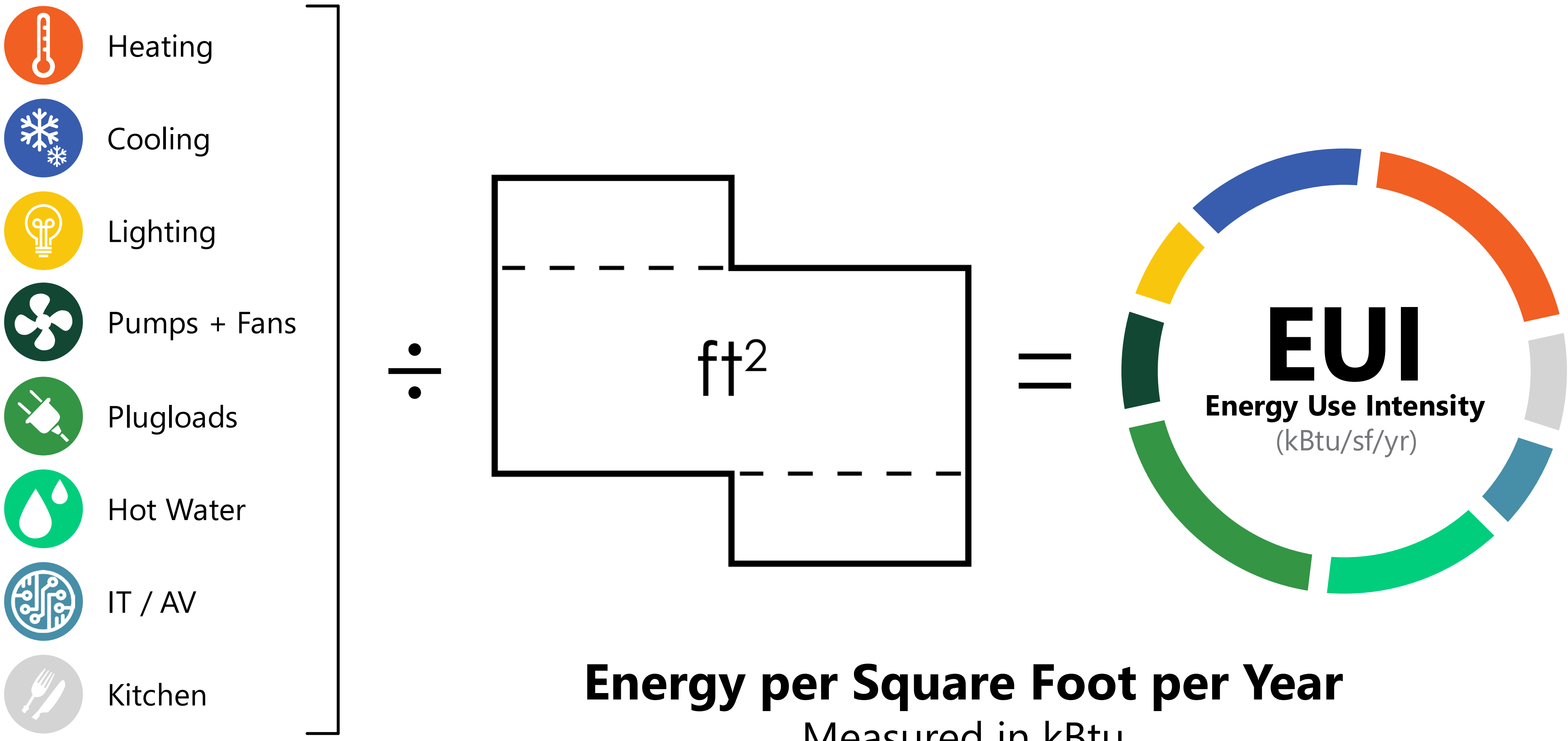
Follow the Energy

Drastic Consumption Reduction

HVAC (~45%)
– Massing/Orientation
– Envelope/Shading
– Systems
– Controls
Kitchen (~25%)
– Cooking
– HVAC + Lighting
– Sanitation
– Refrigeration
Lighting (~15%)
Plug Loads (~10%)
IT (~5%)



What is EUI?



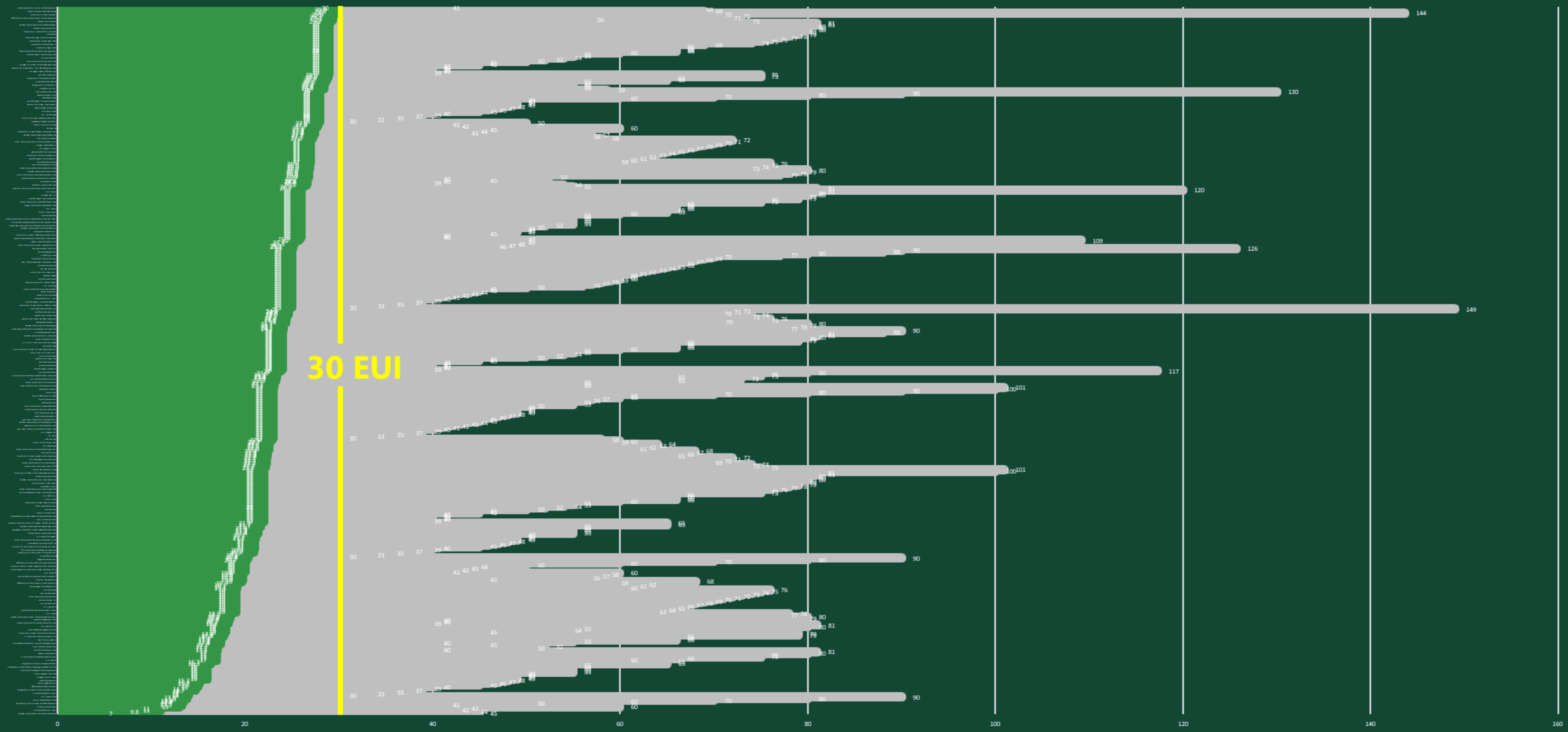
Energy per Square Foot per Year

Measured in kBtu

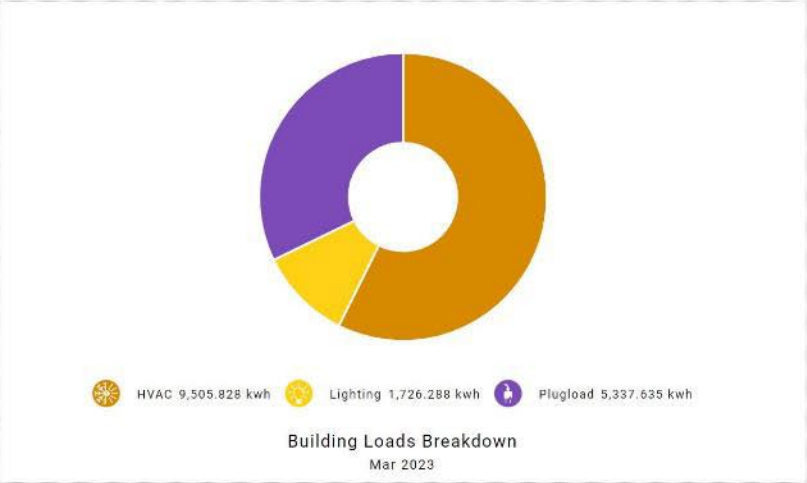
CMTA Deep Energy Retrofit Success

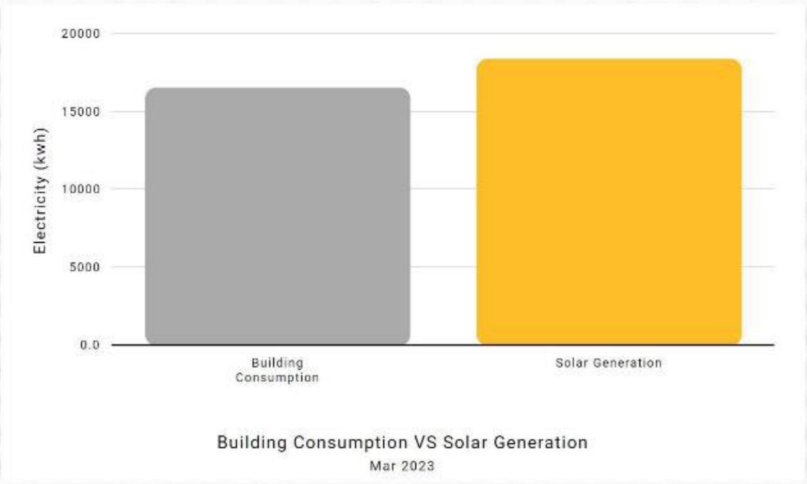
Facility Baseline & Post-Project Energy Use Reduction

Post-Renovation   Pre-Renovation



Performance + More





What does this data mean?

This chart compares the amount of energy the building is consuming to the amount of energy the solar array is generating. The difference between the two amounts is the "net" energy. The net can be positive (which means the building is consuming energy from the utility company - these values are shown in red) or negative (which means that the building is generating more energy than it's consuming - these values are shown in green)

CMTA Sphere

Performance + More

Strategies for Success

Decision Making Process

Building Orientation & Massing

Maximize daylighting and control solar heat gain

Building Envelope

Tight envelope for low infiltration, reduced heating and cooling loads

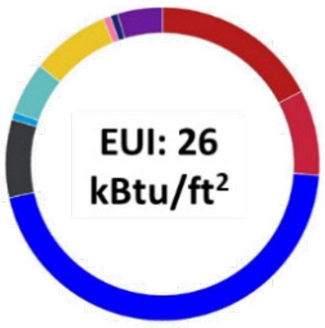
High Performance MEP Systems

Fully electrified, heat pumps, improved IEQ

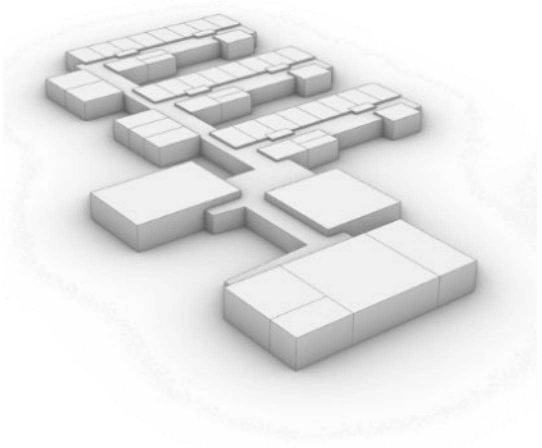
On Site Renewables

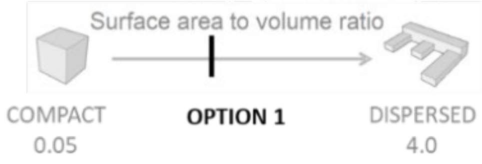
Reduce EUI first and maximize roof area

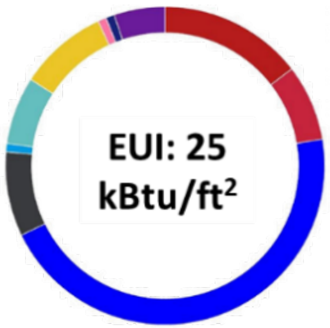
Orientation + Massing



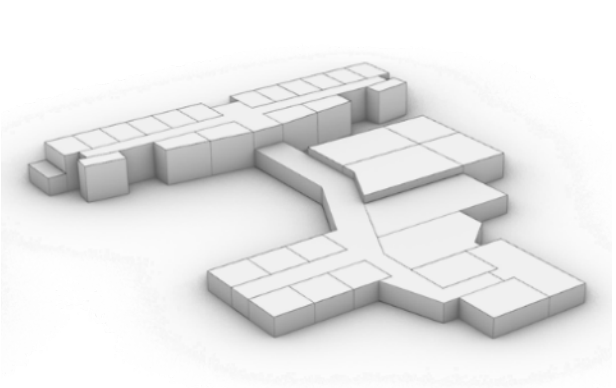
Base Case

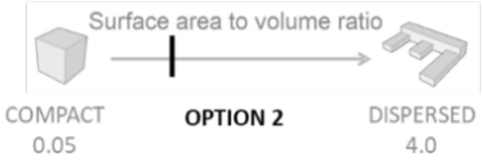


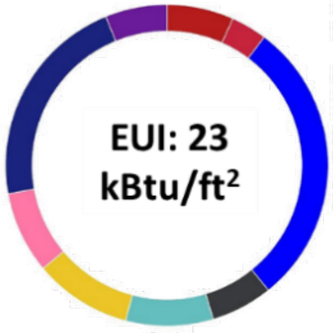




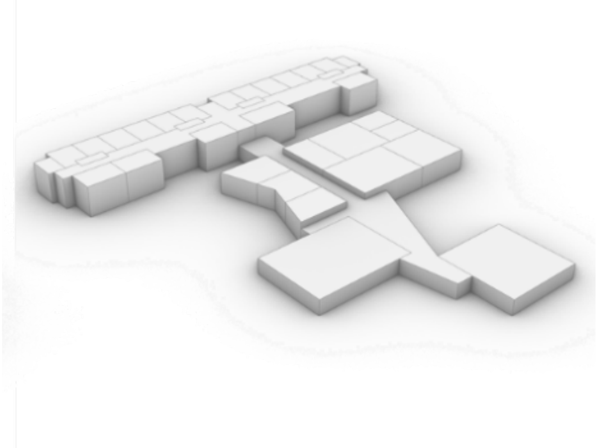
-1 EUI

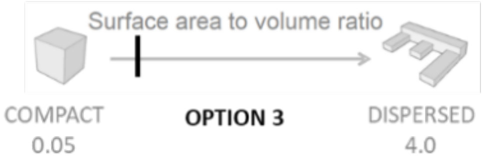






-3 EUI

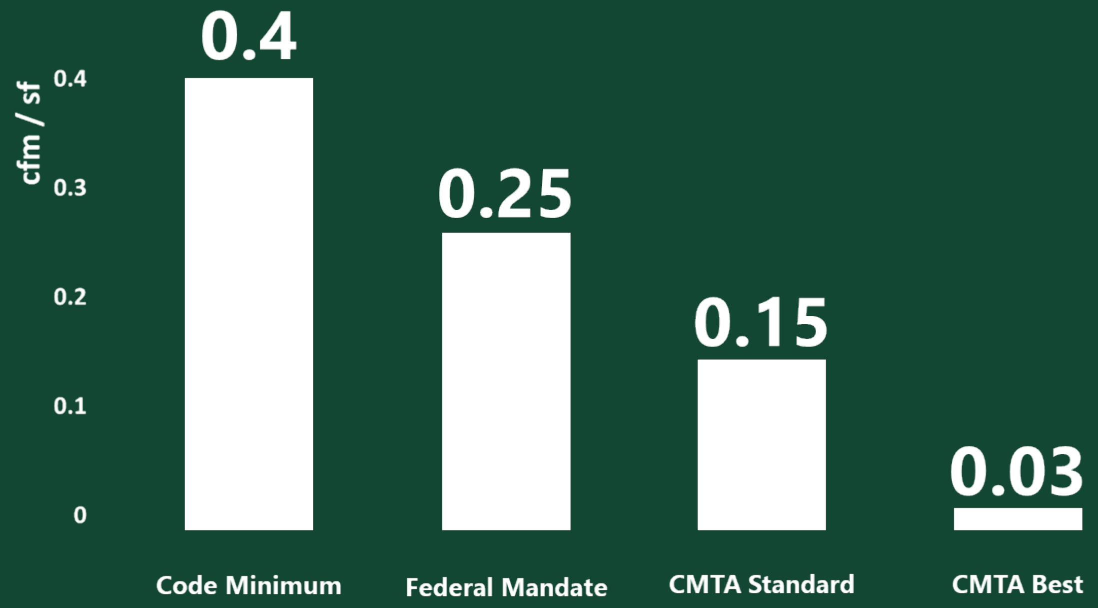




Tight Envelope Verification

Testing Standards
- ASTM E779
- ASTM E1827

Air Infiltration
- Code Minimum
- Federal Mandates
- Industry Standard



Electrification

Feasibility

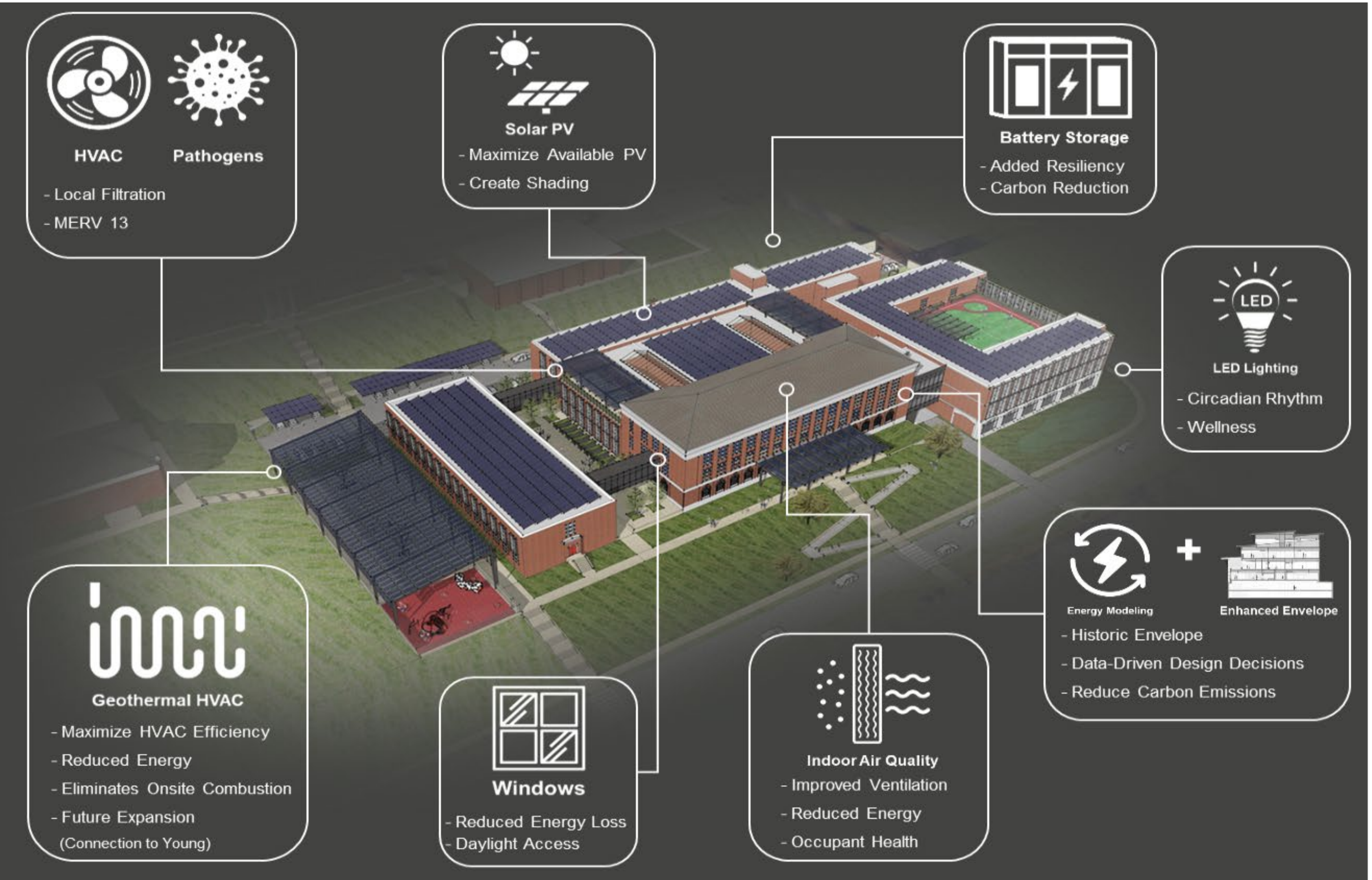
- System Selection
- Electrical Infrastructure
- Cost & Feasibility

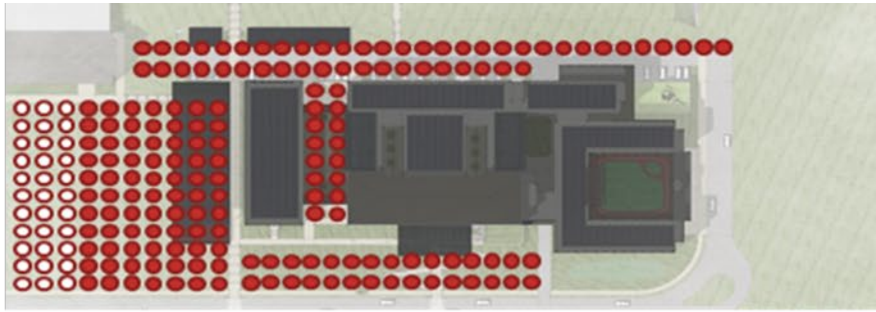
Any Building can be Zero Energy…

…If You can Afford the Solar Array

Achieving Decarbonization

Active + Passive Strategies



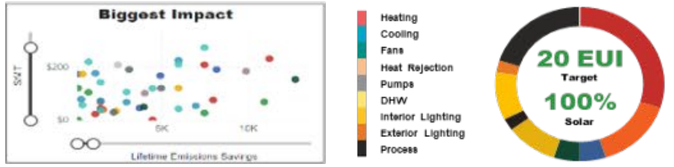


Geothermal Wellfield Analysis

● 166 Wells Available + Future Expansion Green Space

Photovoltaic Sizing Analysis

- 354 kW - 11 EUI Offset
- 225 kW - 6 EUI Offset
- 200 kW - 5.5 EUI Offset



Circadian Rhythm

Design Strategies

- Orientation
- Daylight
- Lighting Design
- Windows
- Room Colors
- Exterior Shading
- Glare Control
- Tuning Materials

Indoor Air Quality

Cognitive Performance Impact

A Section 508–conformant HTML version of this article is available at http://dx.doi.org/10.1289/ehp.1510037.

Research

Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments

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[1]Exposure, Epidemiology, and Risk Program, Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA; [2]Psychiatry and Behavioral Sciences, SUNY-Upstate Medical School, Syracuse, New York, USA; [3]Industrial Assessment Center, Center of Excellence, Syracuse University, Syracuse, New York, USA

BACKGROUND: The indoor built environment plays a critical role in our overall well-being because of both the amount of time we spend indoors (~90%) and the ability of buildings to positively or negatively influence our health. The advent of sustainable design or green building strategies reinvigorated questions regarding the specific factors in buildings that lead to optimized conditions for health and productivity.

OBJECTIVE: We simulated indoor environmental quality (IEQ) conditions in "Green" and "Conventional" buildings and evaluated the impacts on an objective measure of human performance: higher-order cognitive function.

METHODS: Twenty-four participants spent 6 full work days (0900–1700 hours) in an environmentally controlled office space, blinded to test conditions. On different days, they were exposed to IEQ conditions representative of Conventional [high concentrations of volatile organic compounds (VOCs)] and Green (low concentrations of VOCs) office buildings in the United States. Additional conditions simulated a Green building with a high outdoor air ventilation rate (labeled Green+) and artificially elevated carbon dioxide (CO_2) levels independent of ventilation.

RESULTS: On average, cognitive scores were 61% higher on the Green building day and 101% higher on the two Green+ building days than on the Conventional building day ($p < 0.0001$). VOCs and CO_2 were independently associated with cognitive scores.

CONCLUSIONS: Cognitive function scores were significantly better under Green+ building conditions than in the Conventional building conditions for all nine functional domains. These findings have wide-ranging implications because this study was designed to reflect conditions that are commonly encountered every day in many indoor environments.

CITATION: Allen JG, MacNaughton P, Satish U, Santanam S, Vallarino J, Spengler JD. 2016. Associations of cognitive function scores with carbon dioxide, ventilation, and volatile organic compound exposures in office workers: a controlled exposure study of green and conventional office environments. Environ Health Perspect 124:805–812; http://dx.doi.org/10.1289/ehp.1510037

Introduction

The increasing cost of energy in the 1970s led to a change in building practices throughout the United States as buildings were increasingly constructed to be airtight and energy efficient. These changes are reflected in decreasing air exchange rates in homes and office buildings. For homes, beginning in this time period, typical air exchange rates began decreasing from approximately 1 air change per hour (ACH) to approximately 0.5 ACH [Chan et al. 2003; Hodgson et al. 2000; American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 2013b].

Homes built since 2000 are designed to be even more energy efficient and therefore can be even tighter [0.1–0.2 ACH (Allen et al. 2012; ASHRAE 2013b)]. The > 100-year story of ventilation in buildings is complicated and was neatly summarized recently by Persily (2015). Persily describes the original ASHRAE 62 standard, issued in 1973, and the many subsequent iterations (e.g., ASHRAE 62.1 applies to commercial buildings), demonstrating the evolving nature of our understanding regarding the relationship between ventilation rate and acceptable indoor air quality. Similarly to the history of home ventilation, commercial ventilation requirements were lowered in the early 1980s, largely as an energy-conservation measure (Persily 2015).

With such design changes comes the potential for negative consequences to indoor environmental quality (IEQ) because decreased ventilation can lead to increased concentration of indoor pollutants. Building-related illnesses and sick building syndrome (SBS) were first reported in the 1980s as ventilation rates decreased (Riesenberg and Arehart-Treichel 1986), with significant annual costs and productivity losses due to health symptoms attributable to the indoor environment (Fisk and Rosenfeld 1997). A few factors of the indoor and work environments have been found to be associated with occupant health. These factors include environmental measures, such as humidity; building factors, such as ventilation rate; workspace factors, such as the presence of chemical-emitting materials; and personal factors, such as job stress, allergies, and sex (Mendell 1993; Wargocki et al. 2000; Bornehag et al. 2005; Hedge 2009; Hedge and Gaygen 2010; Nishihara et al. 2014).

The IEQ problems that arose from conventional buildings with a tight envelope contributed to the advent of sustainable design or "green" building rating systems [e.g., U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED®)]. These rating systems aim to reduce the environmental footprint of buildings and to improve occupant health by providing design credits to new and existing buildings for adopting green design, operation, and maintenance. Different levels of ratings for the building are then awarded based on the number of acquired credits (e.g., silver, gold, platinum) (USGBC 2014). Many design credits are aimed at energy efficiency and environmental performance but also include guidelines for improving ventilation and filtration, using low-emitting materials, controlling indoor chemical and pollutant sources, improving thermal and lighting conditions, and offering daylight views to building occupants (USGBC 2014). Compared with conventional buildings, environmental measurements in green buildings show lower concentrations of several key pollutants including particles, nitrogen dioxide, volatile

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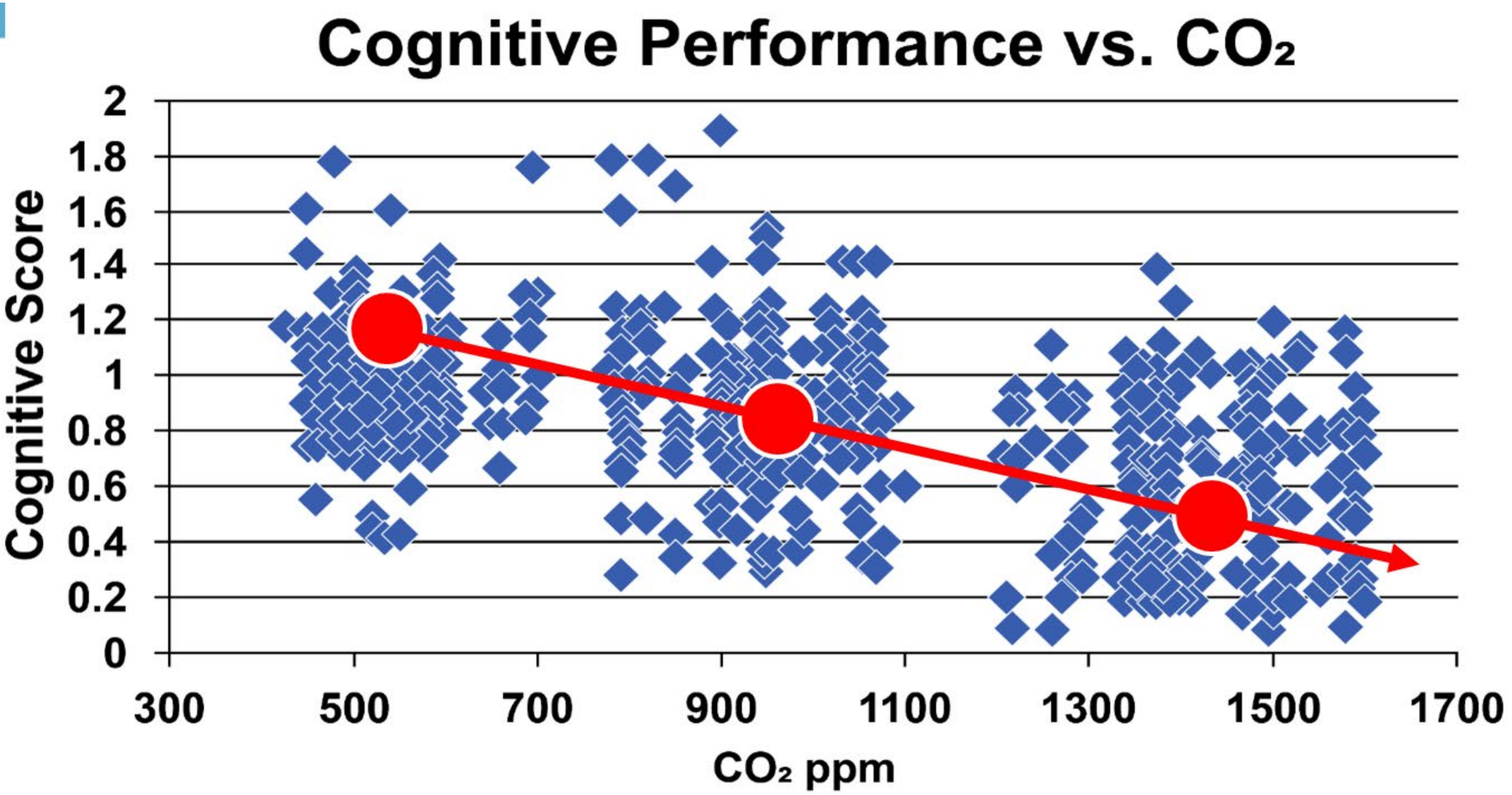
We thank the study participants for volunteering and the reviewers of this manuscript for their insights that helped improve the manuscript.

This research was supported by a gift from United Technologies to the Center for Health and the Global Environment at the Harvard T.H. Chan School of Public Health. J.G.A.'s time was primarily supported by faculty startup funds, J.D.S.'s time was primarily funded by his endowed chair, and P.M.'s time was supported by National Institute of Environmental Health Sciences (NIEHS) environmental epidemiology training grant 5T32ES007069-35. United Technologies Research Center provided limited input during the study design phase (support for adding a control day and adding a third CO_2 test level).

United Technologies was not involved in the data collection, data analysis, data interpretation, data presentation, or drafting of the manuscript.

The authors declare they have no actual or potential competing financial interests.

Received: 4 April 2015; Accepted: 12 October 2015; Advance Publication: 26 October 2015; Final Publication: 1 June 2016.



Concluded cognitive performance decreases as CO_2 increases

HARVARD T.H. CHAN
SCHOOL OF PUBLIC HEALTH

Indoor Air Quality

Design Strategies

- Ventilation
- Filtration
- Economizer
- Material Selections
- Pressurization
- Tight Envelope
- Viral Controls
- New ASHRAE Standards

Thermal Comfort

Design Strategies

- Setpoint Controls
  - Summer: 73-79 Degrees
  - Winter: 68-75 Degrees
- Dehumidification
  - Design humidity range between 30-58%
- Optimize Air Movement
- Fans
- Resiliency
  - Grid Issues / Weather Issues
- Operating Costs
  - Too Hot / Too Cold

Acoustics

Design Strategies

- HVAC Design
- Equipment Placement
- Dampening Surfaces
- Space Adjacencies
- Enhanced Audio Devices

High-Performance Buildings

Circadian Rhythm – Triple Bottom Line Success

Social

Optimize Circadian Rhythm – Student Success

TOOLBOX

Daylight Modeling	Orientation	Window Sizing	Color Selections	Ceiling Heights	Exterior Shading

Economic

- **Reduced Energy Cost**
- **Reduced HVAC System First Cost**
- **Option to Eliminate Blinds**
- **Better Reflectivity & Buy Less Fixtures**

Environmental

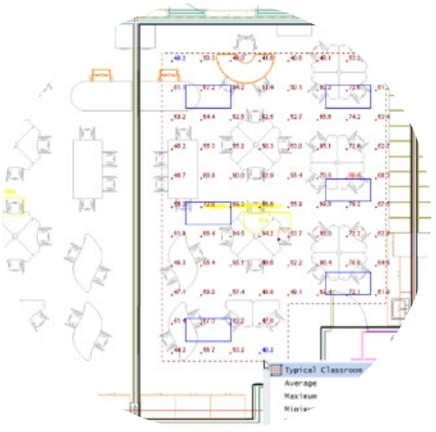
- **Reduced Energy Consumption**
- **Reduced Production of Materials**
- **Reduced Refrigerants Used**

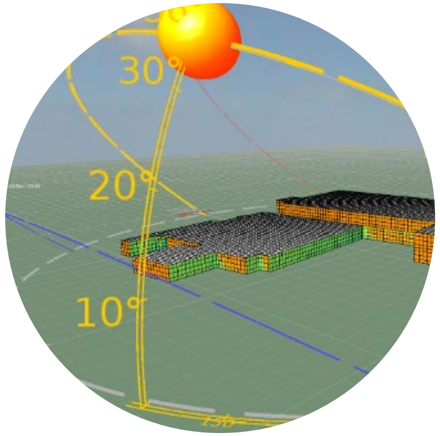
High-Performance Buildings

Circadian Rhythm – Design Strategies for Quality Access to Light


Daylight


Daylight Modeling


Lighting Design



Building Orientation


Window Shading


Light Shelves


External Shading


Room Colors


Ceilings


Exterior Shading

High-Performance Buildings

Indoor Air Quality – Triple Bottom Line Success

Social

Optimize Indoor Air Quality and Pandemic Resilience – Student Success

TOOLBOX	Filtration	Air Changes	Ventilation	Material Selection	Tight Building Envelope	Positive Pressure

Economic

Tight Envelope Reduces Energy Costs & HVAC System First Costs

Shift Cost Saving to Increased Ventilation, Enhanced Filtration & Material Selection

Environmental

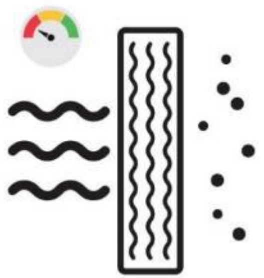
Reduced Energy Consumption

Reduced Production of Materials

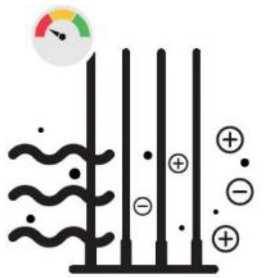
Reduced Refrigerants Used

High-Performance Buildings

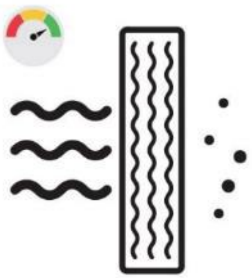
Indoor Air Quality – Design Strategies for Optimal Filtration & Ventilation



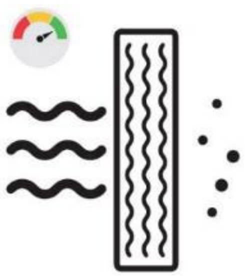
MERV 8



Bipolar Ionization

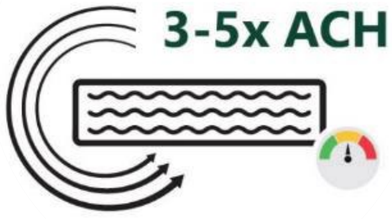


MERV 13

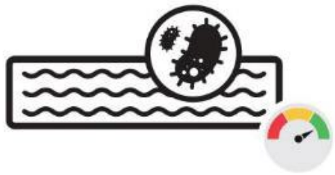


ENVERID

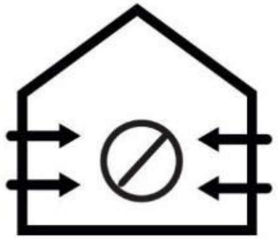
Code Minimum



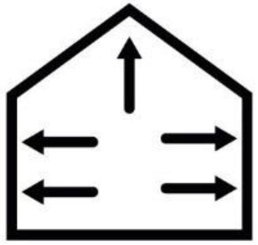
Air Change Rates



Pandemic Resiliency



Eliminate Infiltration



Positive Pressure

1000 ppm CO_2 Max

Case Studies

Brockton Behavioral Health

Boston Medical Center, MA

700kW
Photovoltaic Array

500kWh
Battery Storage

791 $MTCO_2e$
Avoided Per Year

16.67 Miles
of Geothermal

Zero Carbon Targeted

Corporate Headquarters

Pepper Construction

214kW
Photovoltaic Array

Zero Carbon Certified

122 $MTCO_2e$
Avoided Per Year

2.4 Miles
of Geothermal

WELL Gold Targeted | LEED Platinum Targeted

Foundation Headquarters

Galveston Bay Foundation

77.33kW
Photovoltaic Array

Zero Energy Targeted

Microgrid
Battery Backup

Geothermal HVAC

Living Building Challenge Targeted

John Lewis Elementary

District of Columbia Public Schools

650kW
Photovoltaic Array

Zero Carbon Certified

1,500 $MTCO_2e$
Avoided Per Year

15.15 Miles
of Geothermal

WELL Platinum Certified (1st U.S. School) | LEED Platinum Certified

Christina Lee Brown Envirome Institute

University of Louisville

Water Reclamation

Historical Building
Adaptive Reuse

Geothermal
4 Wells vs. 40 (Typical)

Biophilic & Biomimicry Design

WELL Gold Targeted | LEED Platinum Targeted

Thank You!

CMTA

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