Schools that Teach

October 8, 2022

Craig Schiller

Executive Director

COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS

CHPS SCHOOLS®

Better buildings. Better students.

Learning Objectives

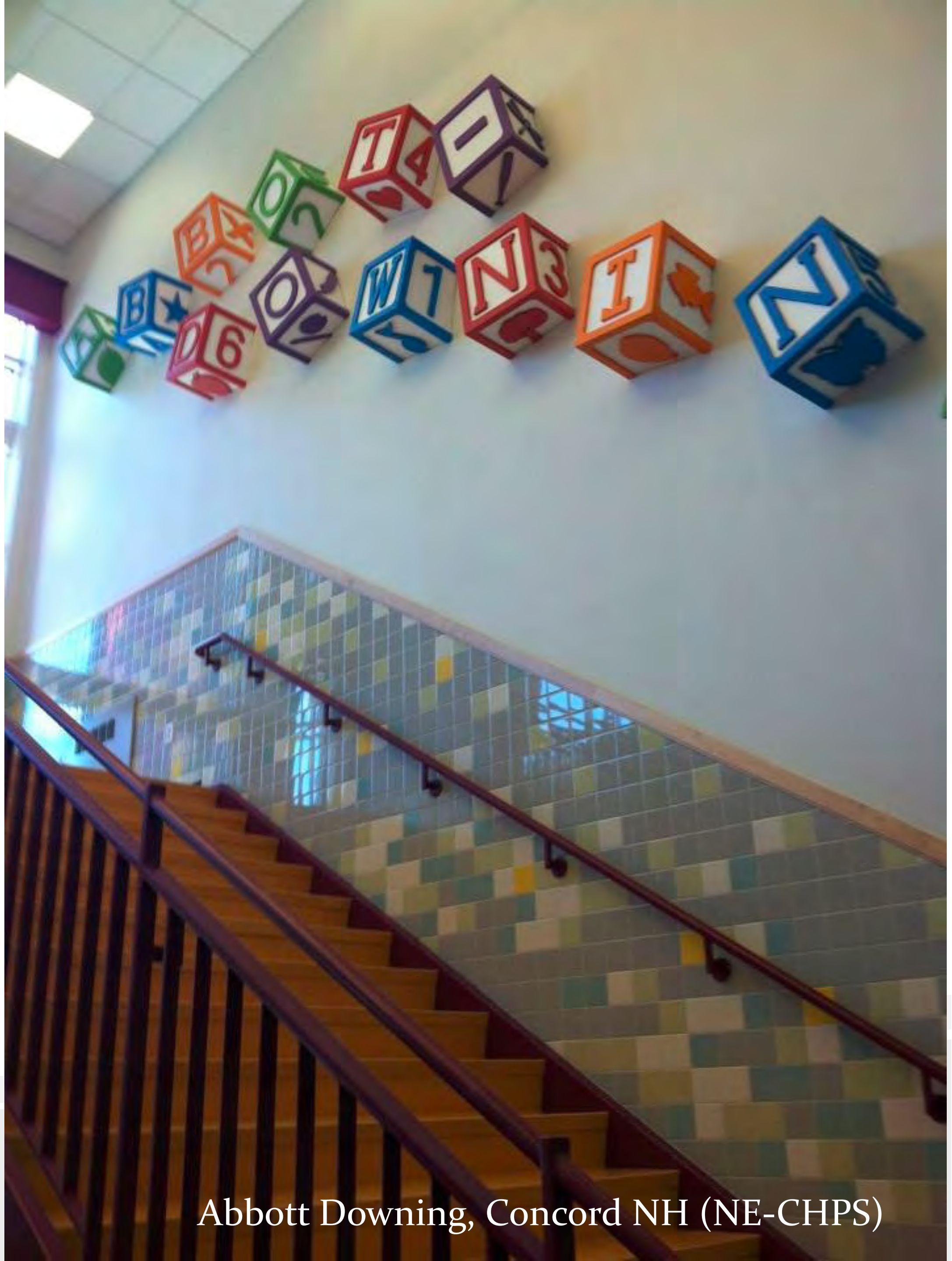
- Understand the necessity of a whole-school approach to integrating sustainability into educational programs, organizational culture, and facility design to create buildings that successfully teach
- Define common design principals and building components which make successful teaching tools and the methods used to connect building features to learning opportunities.
- Explore 'best-case' examples of how school buildings across the country are being used to teach sustainability
- Understand how 'schools that teach' can achieve green building standards such as LEED and CHPS

Saturday Objectives

- 10 minutes of your attention
- Show some picture
- Tell some stories
- Get the ideas flowing
- Provide 1 clear takeaway

Our Mission

CHPS aspires to make every school an ideal place to learn

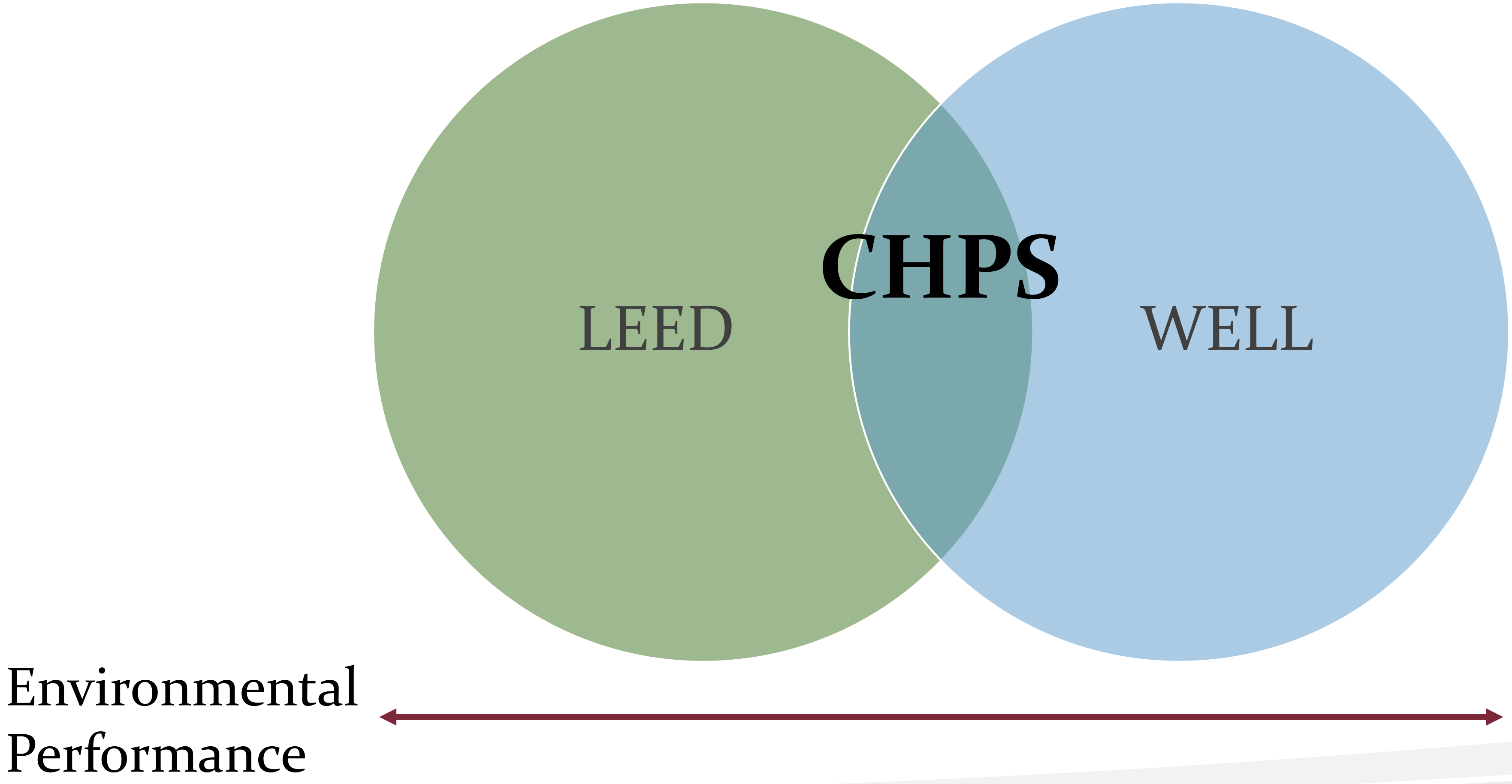


Abbott Downing, Concord NH (NE-CHPS)

CHPS Criteria Overview

- Over **750** CHPS projects nation wide
- State funding for CHPS schools in Massachusetts & Colorado
- Rhode Island requires CHPS
- Washington's WSSP code is based on CHPS
- **3** of the top **20** largest school districts require CHPS
  - Los Angeles Unified School District, Cypress-Fairbanks Independent School District, Fairfax County Public Schools
- **70+** School districts have used CHPS

CHPS is School-Specific



CHPS & LEED

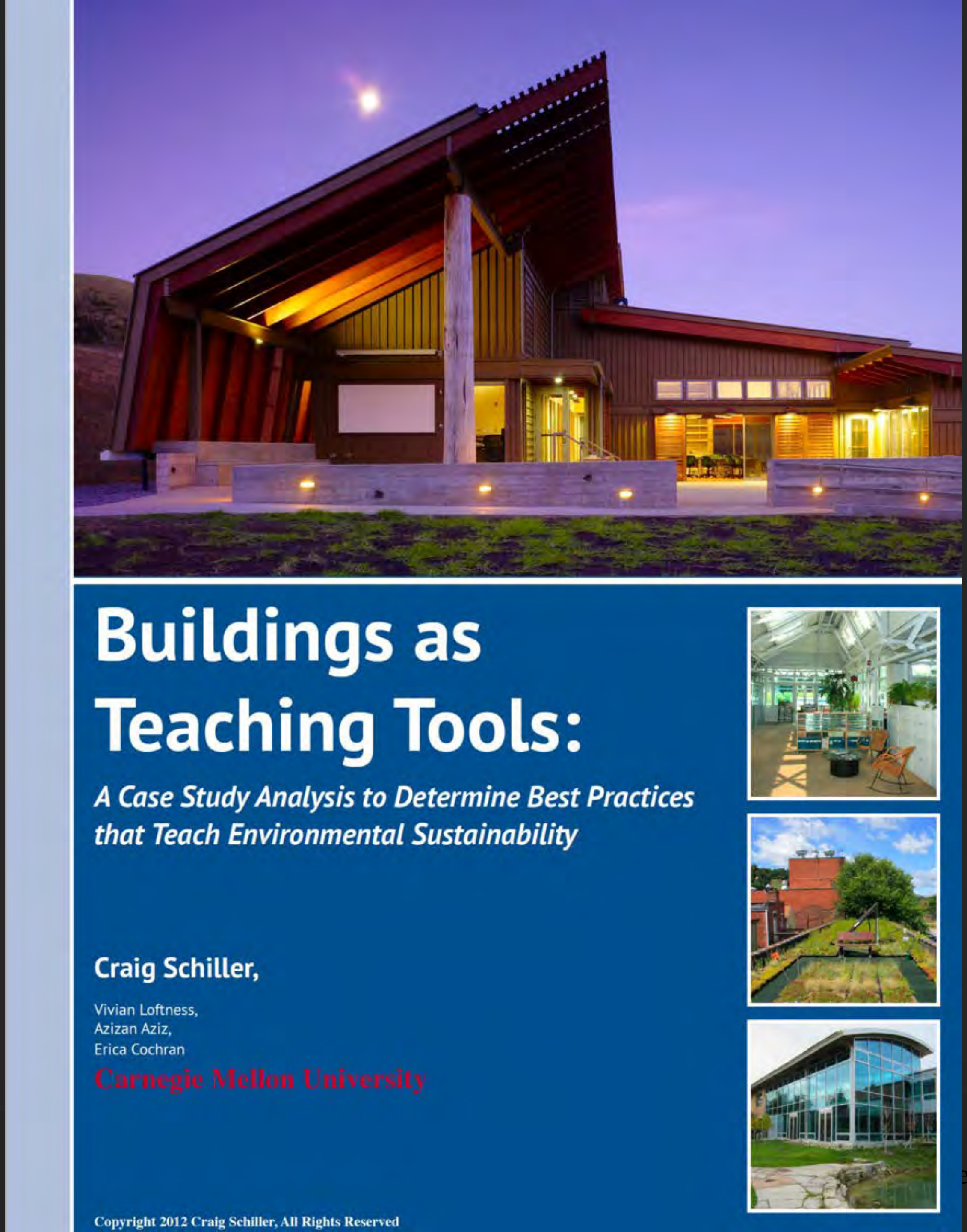
- US-CHPS 2.0
  - II P2.0 Central Education Display
  - II C2.1 School as a Learning Tool
    - Demonstration Areas = 1 point
    - Educational Integration/Environmental Curriculum = 3 Points
  - II Innovation – 1-2 points
- LEED v4
  - Innovation Credit: School as a Teaching Tool = 1 point

Why:

Project-Based Learning
Inquiry-Based Learning
Multiple Intelligence Theory
Scale Better Results

Why:

Better Knowledge Retention
More Motivated Students
Empowerment = Engagement
Knowledge = Doing More



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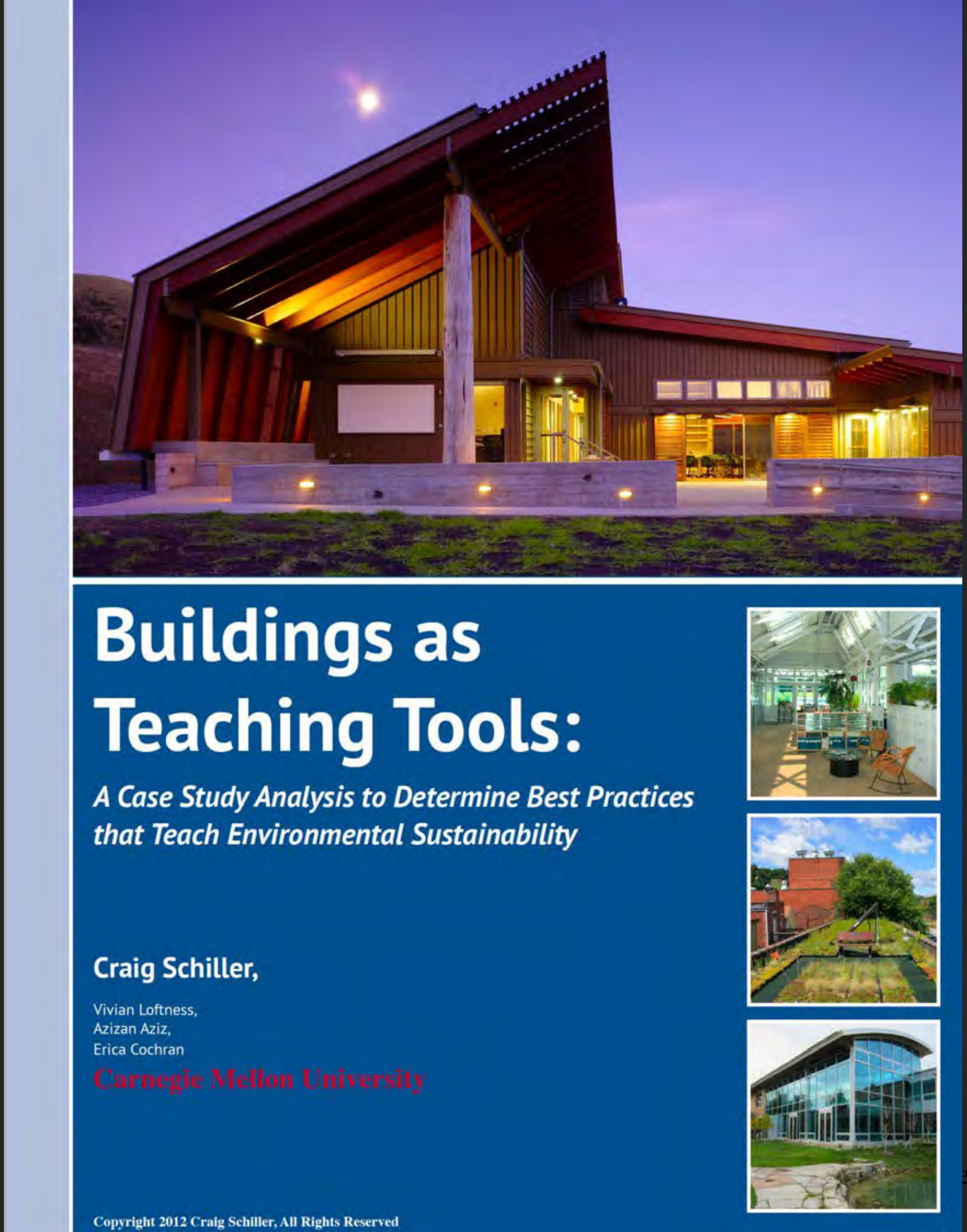

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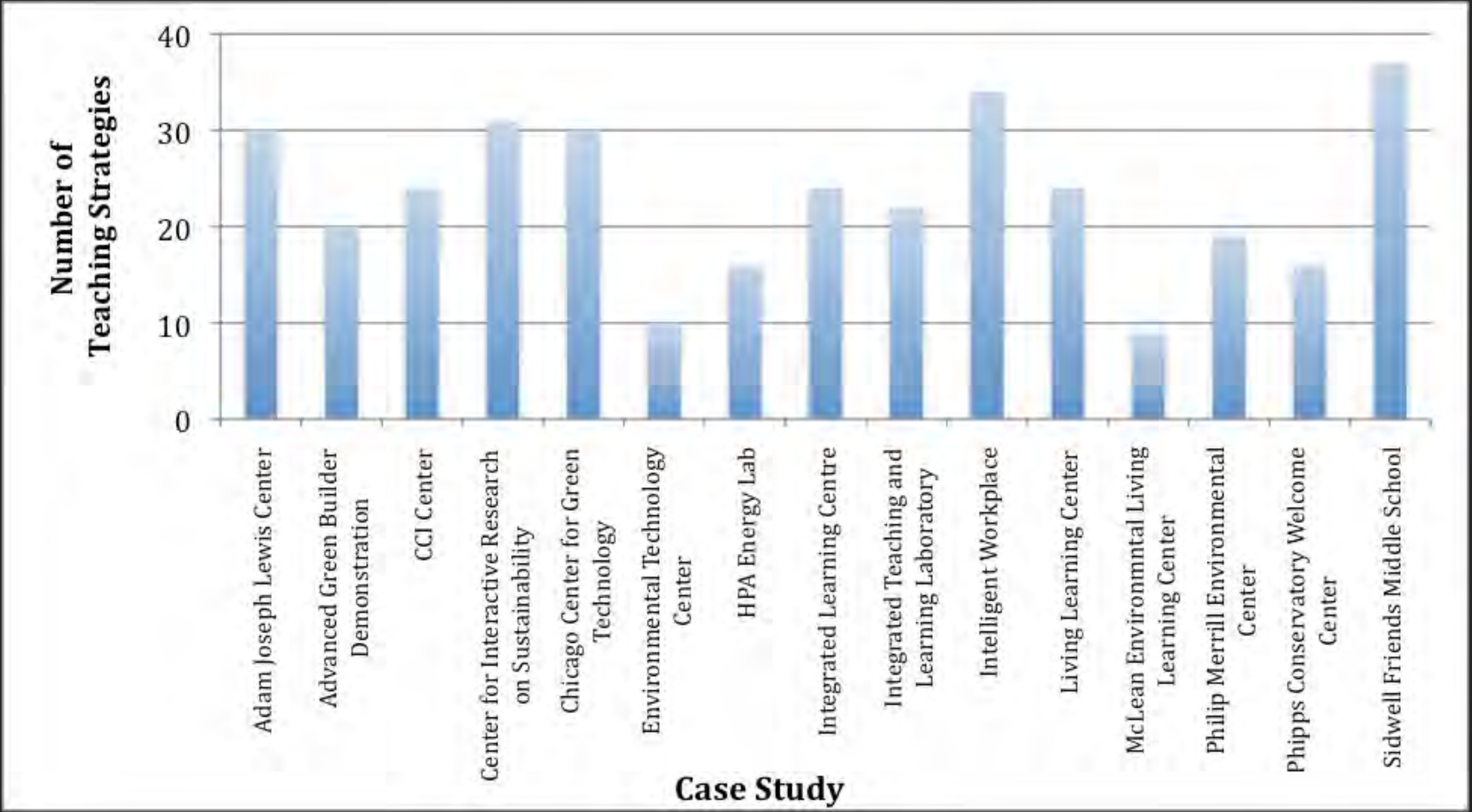
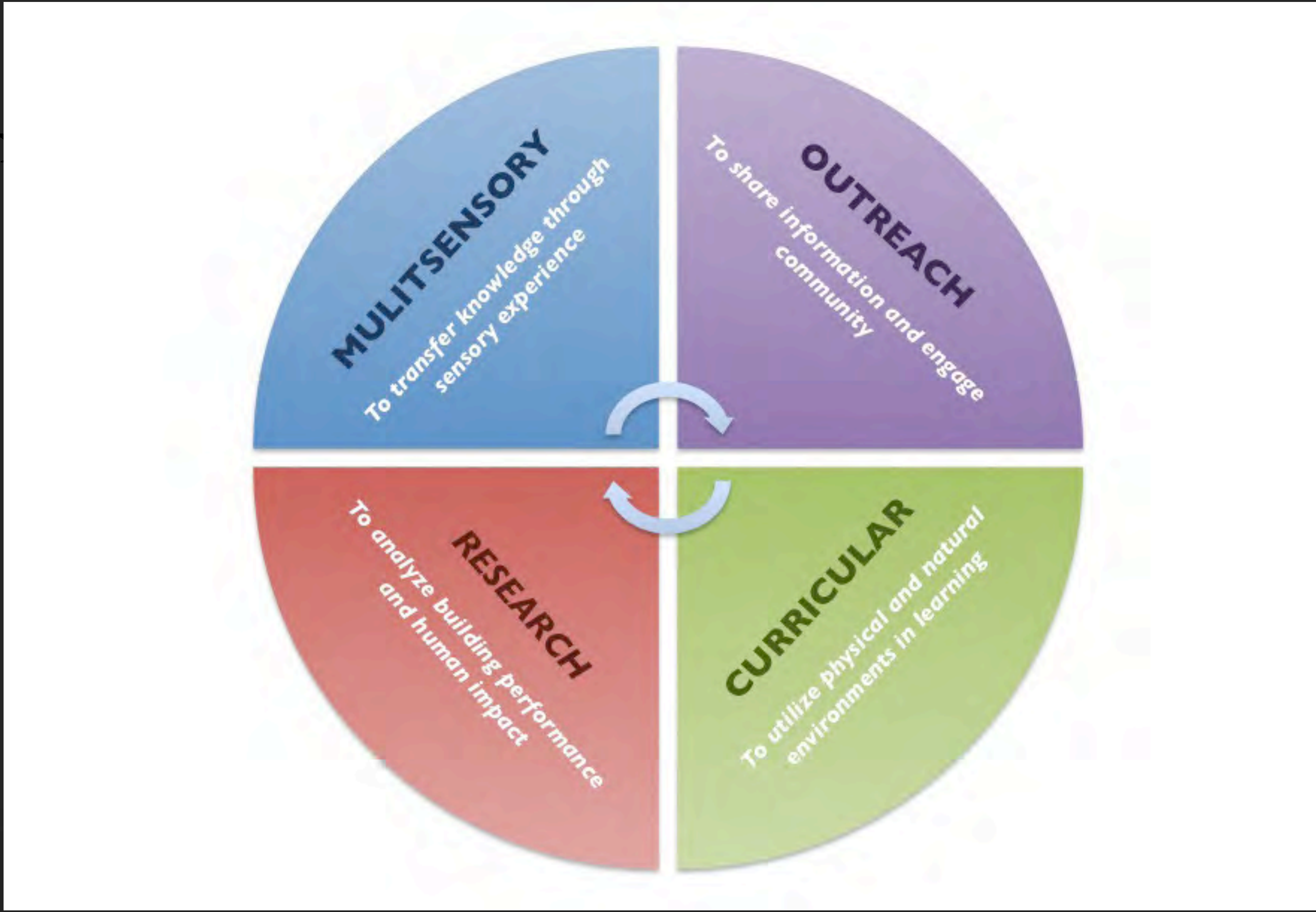

Number of Teaching Strategies
40
30
20
10
0
Adam Joseph Lewis Center
Advanced Green Builder Demonstration
CCI Center
Center for Interactive Research on Sustainability
Chicago Center for Green Technology
Environmental Technology Center
HPA Energy Lab
Integrated Learning Centre
Integrated Teaching and Learning Laboratory
Intelligent Workplace
Living Learning Center
McLean Environmntal Living Learning Center
Philip Merrill Environmental Center
Phipps Conservatory Welcome Center
Sidwell Friends Middle School
Case Study

Fram


MULITSENSORY
To transfer knowledge through sensory experience
OUTREACH
To share information and engage community
RESEARCH
To analyze building performance and human impact
CURRICULAR
To utilize physical and natural environments in learning


SITE
WATER
ENERGY
MATERIALS
I.E.Q
RESEARCH
CURRICULAR
OUTREACH
MULTISENSORY

Storm Water

Chartwell School
Seaside, California

Excess rainwater can be **seen, felt** and **heard** as it flows out of the rainwater collection cistern on a beautiful sculpture.

Image by Michael David Rose

Grey Water

Islandwood: A School in the Woods
Bainbridge Island, Washington

Small artistic accents near each sink and shower drain are **visible cues** to draw a connection between the water people use, and where the water ends up.

Image by DesignShare

Stormwater

Living Learning Center, Washington University in St. Louis
Eureka, Missouri

Visitors can **see** and **hear** rainwater flowing down an elegant rain chain to be stored in a cistern for irrigation use.

Images by Washington University in St. Louis

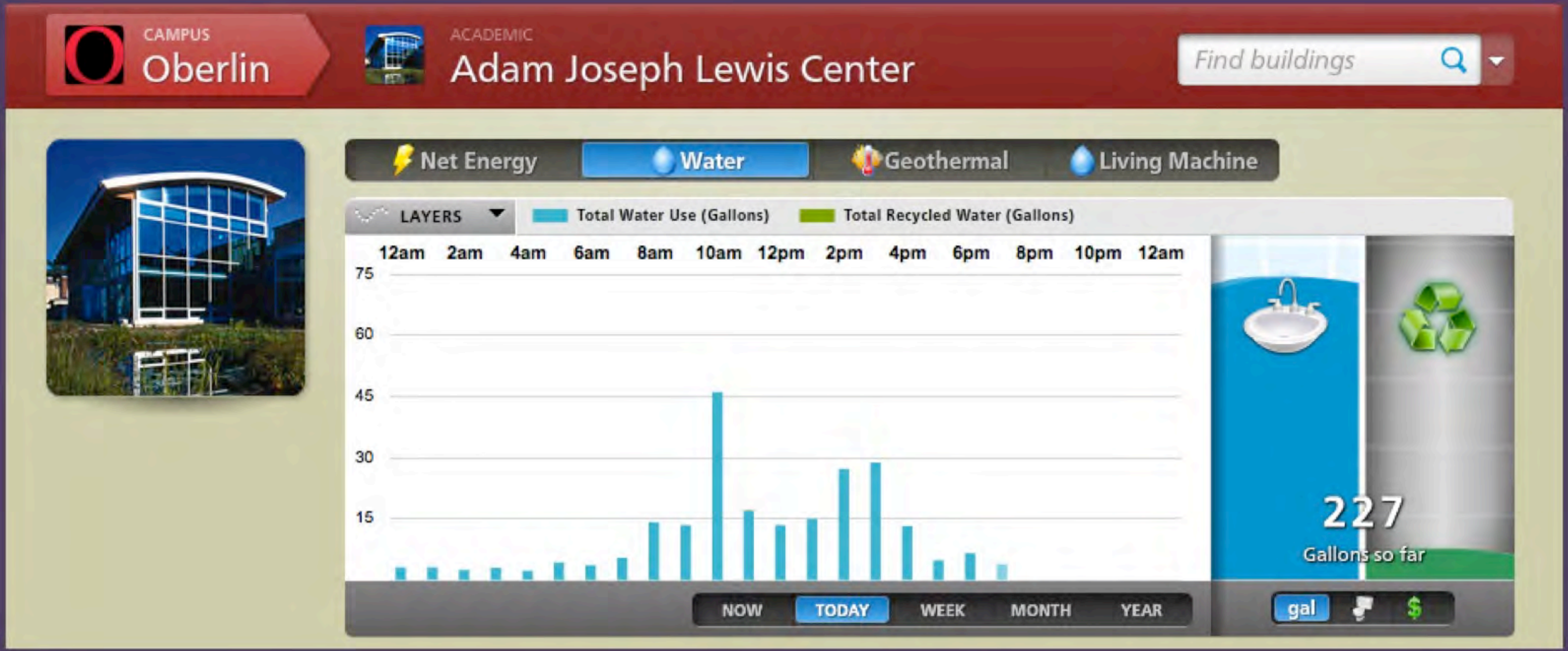
Photo by: Benjamin Benschneider

WATER

Conservation

Adam Joseph Lewis Center, Oberlin College
Oberlin, Ohio

RESEARCH
CURRICULAR
OUTREACH
MULTISENSORY

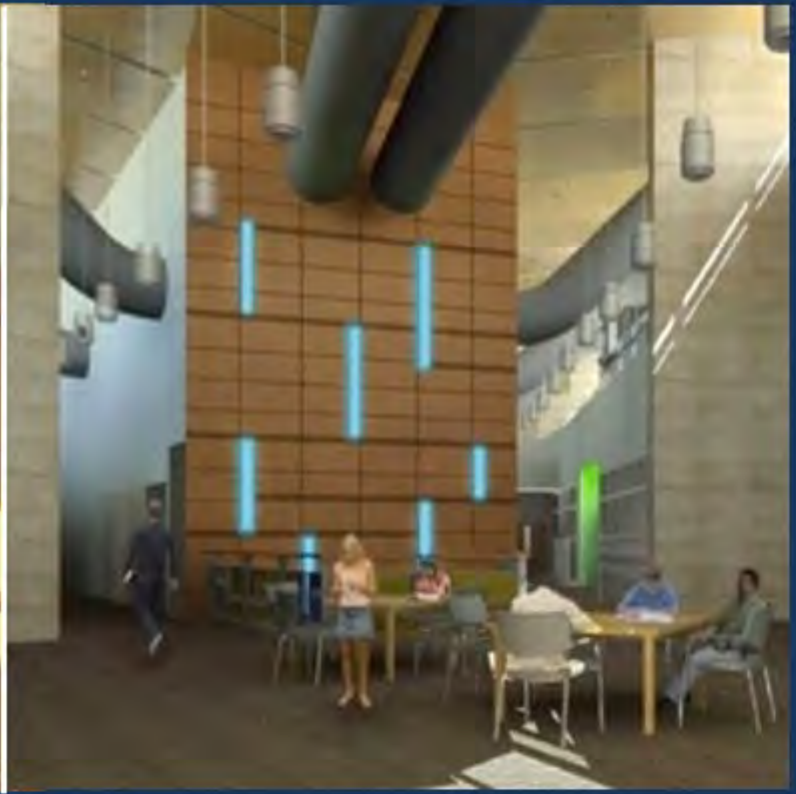


- **Designated website** for the building
- Interactive graph displaying **real-time data** for the building's water use
- Easily accessible **historic data**
- Interpretive gauges to **visualize** water use and cost

Image by Oberlin College

Total Performance

Riverview Elementary School
Snohomish, Washington



Accent lights in each school zone provide **feedback by changing color** depending on the energy consumption of that zone. This allows students to **see** and **compare** the amount of energy being used for different parts of their school.

Image by NAC Architecture

Regional, Renewable and Recycled Materials

Chicago Center for Green Technology, Chicago's Department of Energy
Chicago, Illinois

Multiple green materials are used on the same floor to illustrate the different types of regional, renewable and recycled materials.

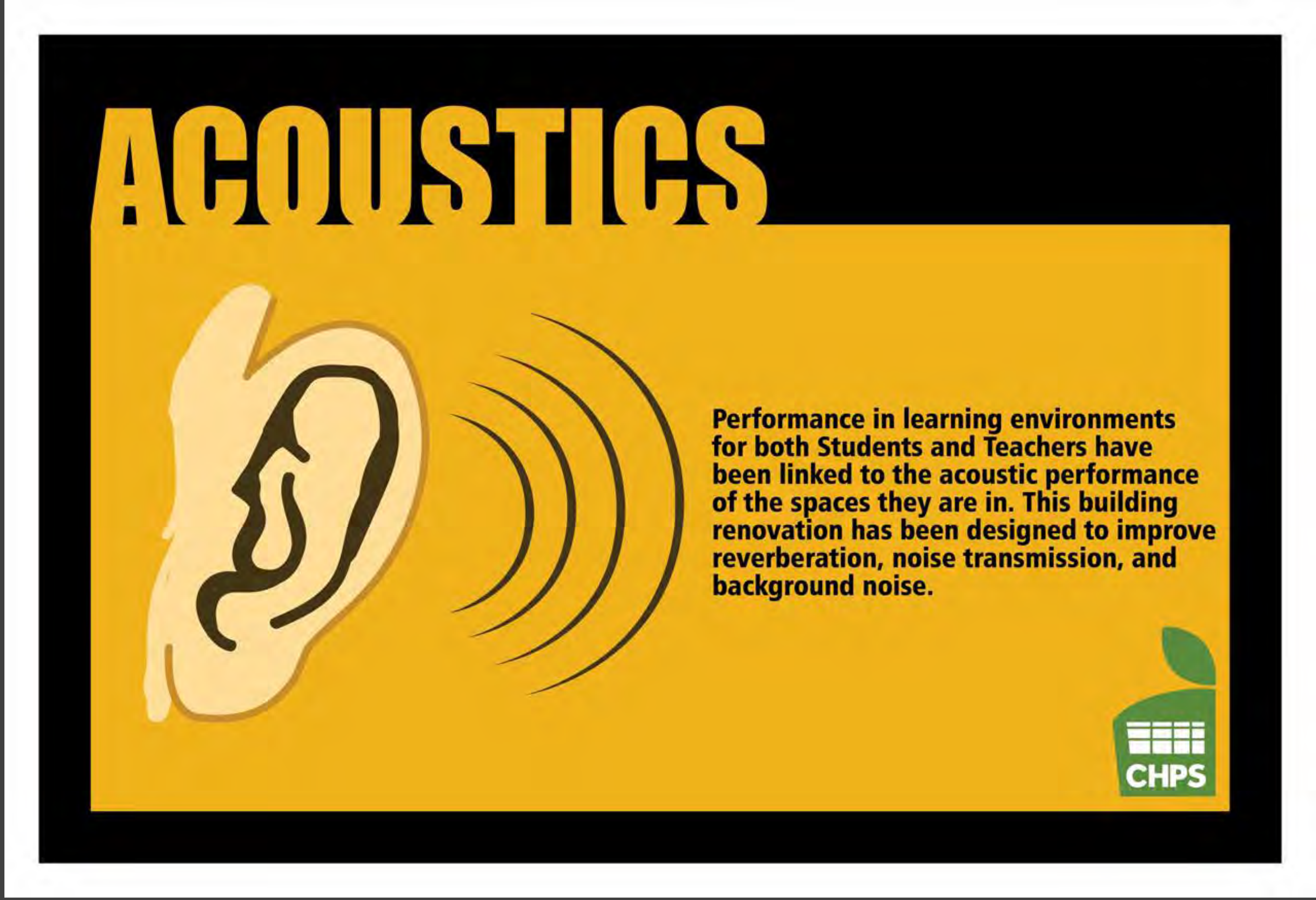
Image by Craig Schiller

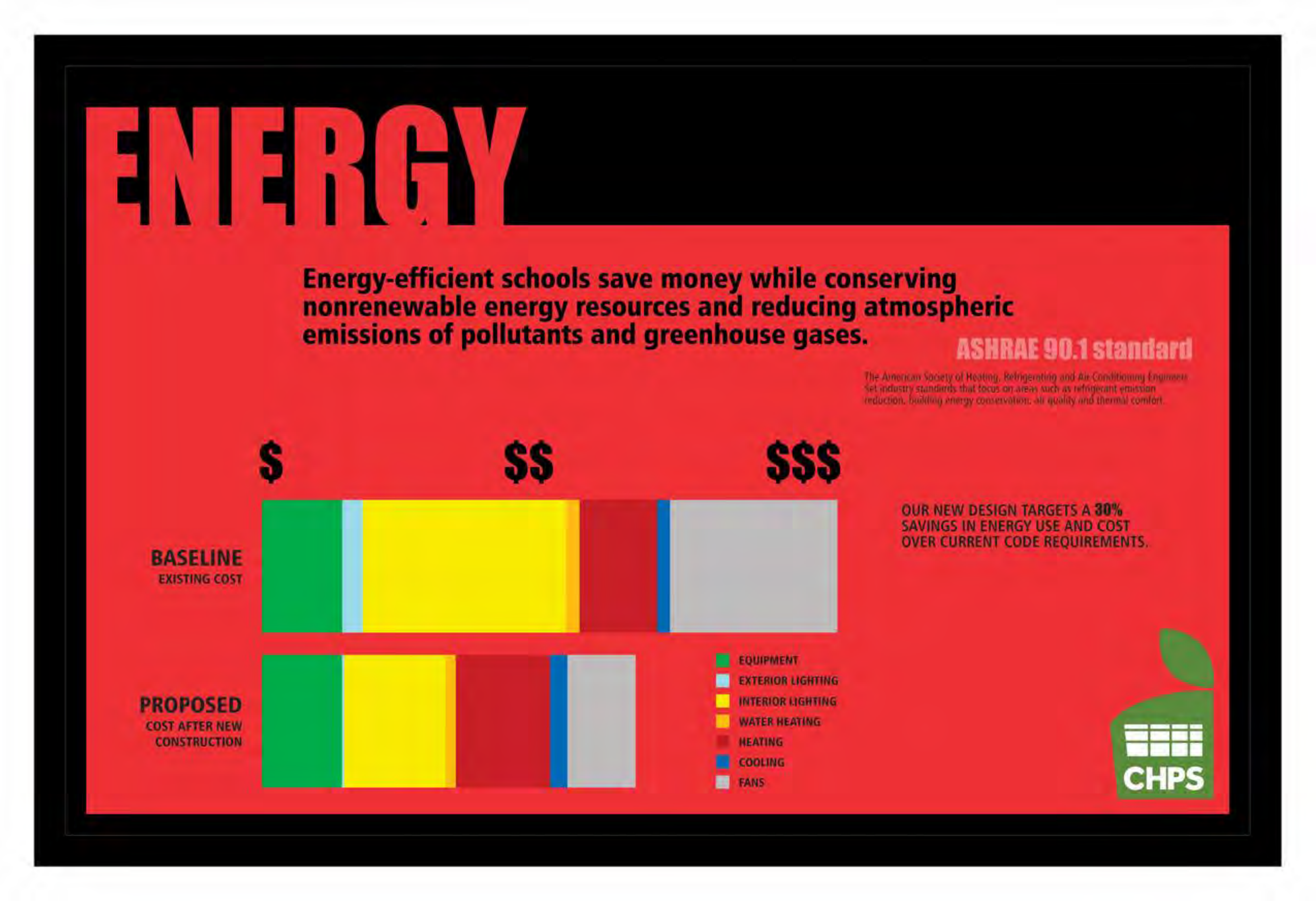
Recycled Content & Recyclability

Riverview Elementary School
Snohomish, Washington

A colorful **interpretive sign** on each bathroom stall shows that the partitions are comprised of recycled plastic bottles.

Image by NAC Architecture


ACOUSTICS
Performance in learning environments for both Students and Teachers have been linked to the acoustic performance of the spaces they are in. This building renovation has been designed to improve reverberation, noise transmission, and background noise.
CHPS



ENERGY
Energy-efficient schools save money while conserving nonrenewable energy resources and reducing atmospheric emissions of pollutants and greenhouse gases.
ASHRAE 90.1 standard
The American Society of Heating, Refrigerating and Air-Conditioning Engineers Set industry standards that focus on areas such as refrigerant emission reduction, building energy conservation, air quality and thermal comfort.
$
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$$$
BASELINE
EXISTING COST
PROPOSED
COST AFTER NEW CONSTRUCTION
EQUIPMENT
EXTERIOR LIGHTING
INTERIOR LIGHTING
WATER HEATING
HEATING
COOLING
FANS
OUR NEW DESIGN TARGETS A 30% SAVINGS IN ENERGY USE AND COST OVER CURRENT CODE REQUIREMENTS.
CHPS

ENERGY

Renewable Energy

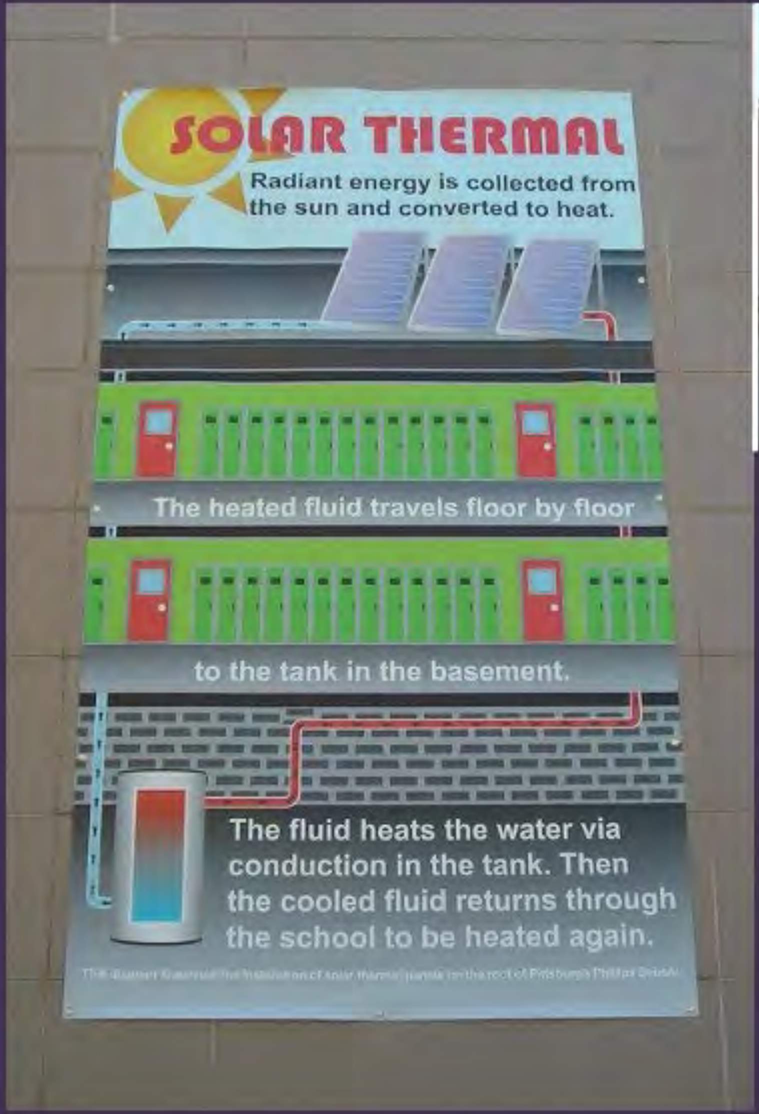
Art Institute of Pittsburgh + Pittsburgh Public Schools
Pittsburgh, Pennsylvania

RESEARCH

CURRICULAR

OUTREACH

MULTISENSORY



Under the advisement of sustainability consultants, students in an Environmental Graphic Design course at at the Art Institute of Pittsburgh collaborated with the Pittsburgh Public School district to **create an educational mural about renewable energy and a school's new solar hot water system.**

Photos by Ann Rosenthal

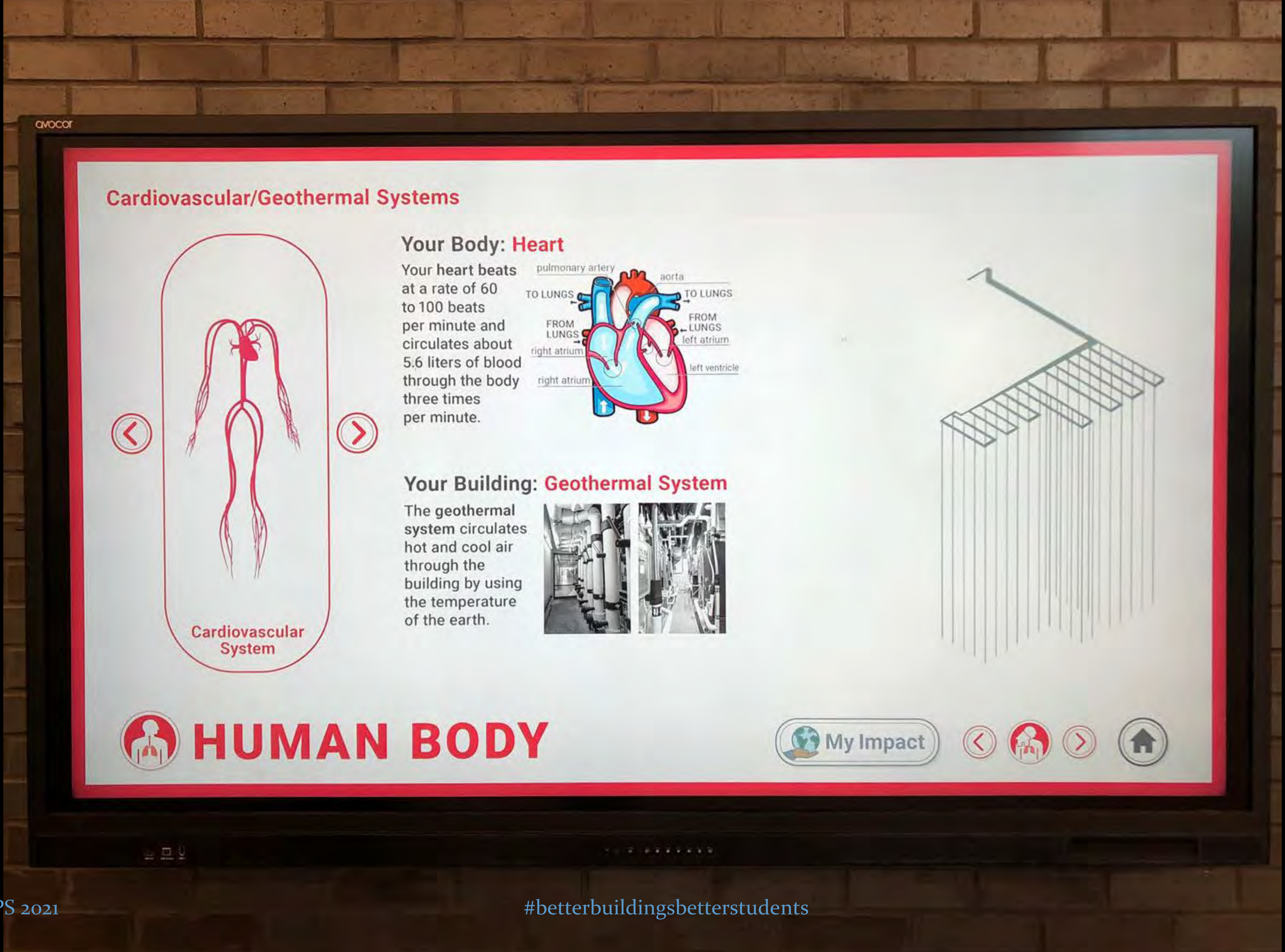
Renewable Energy

Art Institute of Pittsburgh + Pittsburgh Public Schools
Pittsburgh, Pennsylvania

Under the advisement of sustainability consultants, students in an **Environmental Graphic Design course** at at the Art Institute of Pittsburgh **collaborated** with the Pittsburgh Public School district to **create an educational mural about renewable energy** for a school's new solar hot water system.

Photos by Ann Rosenthal


FICTION



Cardiovascular/Geothermal Systems
Cardiovascular System
Your Body: Heart
Your heart beats at a rate of 60 to 100 beats per minute and circulates about 5.6 liters of blood through the body three times per minute.
pulmonary artery
aorta
TO LUNGS
TO LUNGS
FROM LUNGS
FROM LUNGS
left atrium
right atrium
left ventricle
right atrium
Your Building: Geothermal System
The geothermal system circulates hot and cool air through the building by using the temperature of the earth.
HUMAN BODY
My Impact

INDOOR ENVIRONMENTAL QUALITY

EQ 1.0 HVAC DESIGN - VENTILATION AND AIR CONDITIONING
LMEC ventilation systems are designed to operate in continuous mode during occupied hours and maintain the minimum ventilation rates. MERV-13 filters remove fine particles, dust, pollen, mold and bacteria.

EQ 3.0 OUTDOOR MOISTURE MANAGEMENT
LMEC provides weather-resistant construction with the use of covered building entries, recesses, flashing and maintained landscape irrigation systems.

EQ 4.1 DUCTED RETURNS
All mechanical systems at LMEC are provided with ducted return air. This reduces the amount of the dust, dirt, fungi and microbial growth in the air.

EQ 5.0 CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT
Long term indoor air quality within LMEC buildings was protected during construction by implementing the following measures.

*All ductwork, equipment and materials were protected from moisture during construction.
*Materials damaged during the course of construction were immediately replaced.
*MERV 8 filtration was provided prior to occupancy.
*Mechanical systems were tested, adjusted and balanced.
*Temporary return air filters were installed during construction
*No CFCs or halons were allowed during construction

EQ 7.0 LOW EMITTING MATERIALS
Indoor air pollutants have been minimized at LMEC by selecting paints, coatings, flooring systems, composite wood products, adhesives and sealants that are low or no VOC.

*All adhesives and sealants inside the buildings comply with the South Coast Air Quality Management District Rule 1168.
*All paints and coating inside the buildings comply with SCAQMD Rule 1113.
*All composite wood products indicate no-added formaldehyde based resins.

EQ 9.0 THERMAL CONTROL ASHRAE 55
LMEC indoor design temperatures and humidity for general comfort have been designed in accordance with ASHRAE 55.

EQ 10.1 INDIVIDUAL CONTROLLABILITY
Each LMEC classroom has independent control over their environment with the use of individual thermostats, temperature sensors and operable windows.

EQ 11.0 DAYLIGHT & GLARE PROTECTION
Spaces at LMEC have been designed to optimize daylight while preventing glare with the use of roller shades and overhangs.

EQ 13.1 ELECTRIC LIGHTING PERFORMANCE
LMEC lighting fixtures are equipped with high performance LEDs with a color rendering index (CRI) of 80 or greater.

EQ 14.0 ACOUSTICAL PERFORMANCE
LMEC classrooms and learning spaces have been designed to meet the CHPS criteria for the following qualities:
*Reverberation Time
*Performance criteria for background noise
*Noise isolation
*Indoor to indoor attenuation of airborne sound
* Structure-borne impact sound isolation
*Classroom audio distribution systems

EQ 17.1 MERCURY REDUCTION
All LMEC light fixtures are LED. There are no mercury containing lamps on campus.

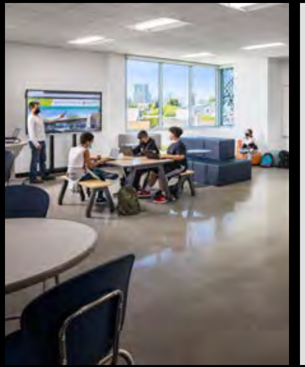
MATERIALS & WASTE MANAGEMENT

MW 1.0 STORAGE & COLLECTION OF RECYCLABLES
LMEC provides easily accessible recycling to students and teachers.

MW 2.0 CONSTRUCTION SITE WASTE MANAGEMENT
During the demolition of the old campus and construction of LMEC, 78 - 100% of construction waste was diverted from the landfill and recycled.

MW 3.1 RECYCLED CONTENT
LMEC building finishes and equipment including carpet, ceiling tiles, tackable wall panels, toilet partitions, resilient flooring, play equipment and storefront windows were all specified to contain recycled content.

MW 5.1 CERTIFIED WOOD
A minimum of 50% of the wood based materials at LMEC are certified by the Forest Stewardship Council. FSC certified products ensure that the wood has been grown and harvested using ecologically sustainable and renewable methods.

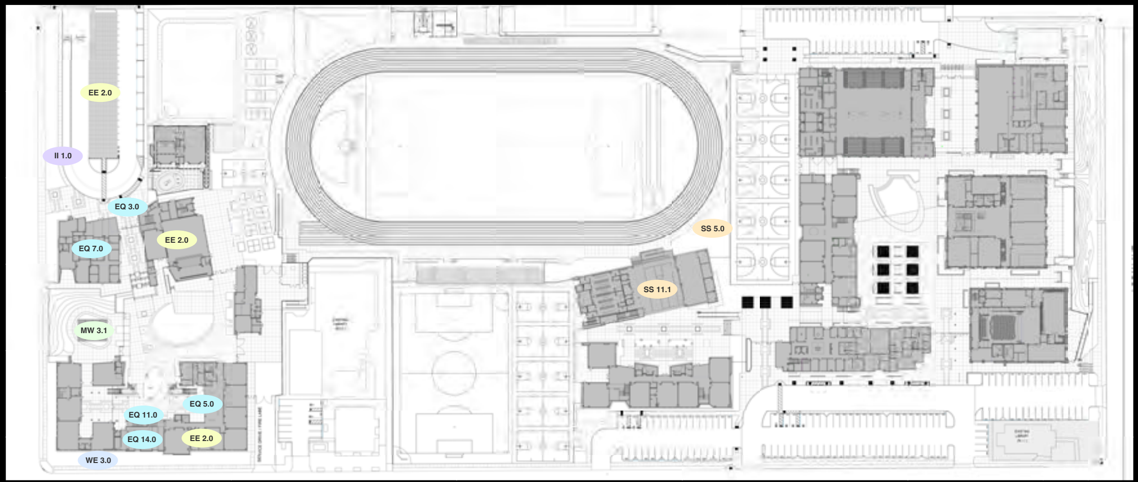


OPERATIONS & METRICS

OM 1.0 FACILITY STAFF & OCCUPANT TRAINING
Teachers, administrators and support staff have been provided with training on operations of lighting, heating and cooling systems in classrooms, offices and auditoriums.

OM 3.0 PERFORMANCE BENCHMARKING
An energy model was created for LMEC during the design phases. SD Unified School District uses this model as a benchmark to track and compare utility data annually. The District tracks and logs detailed energy use.

OM 9.0 ANTI-IDLING MEASURES
Vehicle Idling is not permitted at SD Unified School District campus'. Anti-Idling Signage has been installed at LMEC parking lots.



INTEGRATION AND INNOVATION

II 1.0 INTEGRATED DESIGN
LMEC is an example of integrated design. All building systems and components have been designed with consideration of each other. Integrated design brings together the various disciplines involved in designing a building to develop and review all recommendations as a whole. It recognizes that each discipline's recommendations have an impact on other aspects of the building.

High performance goals were defined early during design. While the project design progressed, decisions to maximize system integration and building efficiencies were made.

II 2.1 DISTRICT LEVEL COMMITMENT
San Diego Unified School District is a member of Collaborative for High Performance Schools (CHPS) and committed to achieving high performance schools. Board resolution to adopt CHPS criteria was passed in 2003.

II 5.0 EDUCATIONAL DISPLAY
Digital display of all CHPS high performance features to educate the community in the Admin Lobby.

LOGAN MEMORIAL EDUCATIONAL CAMPUS

DLRGROUP | BakerNowicki

San Diego Unified SCHOOL DISTRICT

CHPS COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS

WATER

WE 1.0 INDOOR POTABLE WATER:
LMEC reduces water consumption by utilizing low flow faucets, toilets, urinals, shower heads and other plumbing fixtures.

WE 3.0 IRRIGATION AND EXTERIOR WATER BUDGET:
A water budget was utilized to determine appropriate plant and irrigation types for LMEC's new landscape.

Soil moisture meters control and shut off operation of irrigation systems.

SITE

SS 2.1 ENVIRONMENTALLY SENSITIVE LAND
As a whole site modernization of an existing campus, LMEC reduces environmental impacts by utilizing established infrastructure and preserving the open space of the surrounding area.

SS 4.0 CONSTRUCTION SITE RUNOFF CONTROL AND SEDIMENTATION
During construction, LMEC utilized a site specific Storm Water Pollution and Prevention Plan to prevent site and off-site discharge of sediments and particulate matter.

SS 5.0 GRADING AND PAVING
At various locations in and around LMEC, cobble swales have been utilized in the new landscape. These swales and surrounding vegetation allow the site to absorb and slow water run-off to city storm drains during rain events.

SS 7.1 LOCATED NEAR PUBLIC TRANSPORTATION
LMEC has three city MTS bus stops located along bus route #3 on Ocean View Blvd directly adjacent the school. Locating the site close to public transportation and creating safe walking and bike access all reduces automobile related pollution.

SS 11.1 REDUCE HEAT ISLAND - LANDSCAPE / SITES
All LMEC rooftops are cool roofs made of white PVC. Cool roofs can significantly reduce school cooling loads and urban heat island effects by reflecting the sun's energy, instead of absorbing, retaining and radiating it into the occupied spaces below.

SS 12.0, 12.1 REDUCE LIGHT POLLUTION
All non-emergency outdoor lighting at LMEC is automatically controlled to turn off after hours with manual override capability. Avoidance of unnecessary lighting reduces energy use and minimizes adverse effects on the nighttime environment.

ENERGY

EE 1.0 ENERGY PERFORMANCE
Each building individually exceeds Title 24 requirements by 15%.

EE 1.1 SUPERIOR ENERGY PERFORMANCE
LMEC exceeds Title 24 requirements by 66%.

EE 2.0 SOLAR READY
LMEC balances occupant's energy needs with energy production across the campus' 2,028 photovoltaic modules. PV panels are installed on 7 buildings and one car port along Ocean Ave.

EE 3.0 COMMISSIONING
All LMEC building systems have undergone Commissioning to verify that building elements and systems are designed, installed, and calibrated to operate as intended, and provide for the ongoing accountability and optimization of building energy performance over time.

EE 3.1 ADDITIONAL COMMISSIONING QUALIFICATIONS
Commissioning was integrated into the planning of the buildings, early in design and performed by an experienced engineer licensed in the state of California.

EE 4.0 ENVIRONMENTALLY PREFERABLE REFRIGERANTS
No CFCs refrigerants are used in LMEC heating, ventilation, cooling and refrigeration systems.

EE 5.0, 5.1 ENERGY MANAGEMENT SYSTEM
Energy Management Systems (EMS), lighting control and HVAC control are provided to allow for optimization of building energy performance, while allowing for local control within a preset range.

EE 9.0 ENERGY CONSERVATION MODE
The EMS is programed to maximize building energy efficiency.


Overall Performance and Highlights
Honors and Certifications
Rocky Mountain Institute Innovation Center


Welcome to RMI's Innovation Center
Daylighting
Innovative Thermal Comfort
Cooling & Air Quality
On-Site Renewable Energy

Welcome to RMI's Innovation Center

Designed first as a comfortable workplace, it is also a "living lab" that shows the process and performance behind one of the nation's most-efficient buildings.

Why? If we're going to protect the Earth's climate, we need to start by slashing the energy needed to power our buildings—which currently use nearly three-fourths of America's electricity—and then power those buildings with cleaner sources of energy. The Innovation Center shows how.

This building achieves net-zero energy, generating more energy than it needs, allowing it to also power six electric vehicles. As of 2015, fewer than 200 commercial buildings in the U.S. had earned this distinction. In fact, the Innovation Center is one of the top 20 most energy-efficient buildings in the country and uses 74% less energy than the average building in this climate.

The building's modest additional upfront cost to achieve net-zero energy (10.8%) will pay for itself through energy savings in less than four years. This level of performance is achieved thanks to integrative, passive design. A committed team used "integrated project delivery"—a contract model that promotes collaboration, shared goals, and an innovative risk/reward system to make it all possible.

Passive Design

The Innovation Center achieves net-zero energy through whole-system design. We started by considering what occupants need from the building—a comfortable, pleasing, and productive space. Then we designed the best way to fulfill that need most efficiently, while emitting far less carbon.

Passive Design Features

1. Aggressively insulate from the elements
2. Capture solar heat gain in winter
3. Shade from solar gain in summer
4. Provide natural ventilation
5. Reduce temperature swings using thermal mass
6. Use daylight as the primary light source
7. Seal all gaps for airtightness
8. Maximize electricity generation from rooftop solar PV
9. Maximize views of surrounding nature

Daylighting

Daylighting is an important passive design feature that helps achieve net-zero energy by replacing most of our electric lighting needs.

The Innovation Center's window-to-wall ratio, roof design, and southern orientation allow the building to be entirely daylit, reducing the need for energy-intensive internal lighting. Daylighting also increases productivity and reduces stress. Lights are automatically adjusted according to how much natural light is present.

In addition to providing daylight and views, these windows also help maintain a comfortable temperature. In particular, the windows on the south have been optimized to let in more light and heat than the windows on the north, which insulate more effectively.

Along the south façade, three-foot-deep interior light shelves redirect daylight and minimize glare, reducing interior lighting needs. The high, curved ceilings help distribute the light more evenly from south to north.

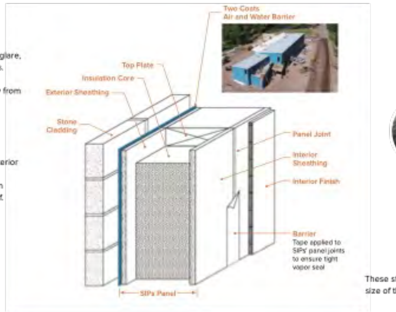
Heat gain is controlled and maintained with automated exterior sunshades. Manually operated interior blinds are installed both above and below the light shelf.

Airtightness

Airtightness is a crucial passive design feature for improving energy efficiency because airtight buildings require significantly less heating and cooling.

The Innovation Center is one of the most airtight office buildings measured in the U.S. It has an effective air leakage area equivalent to the size of a basketball, which makes the office 97% more airtight than a conventional commercial building. Advanced materials combined with carefully constructed wall and roof details avoid leakage, making the building's remarkable airtightness possible.

The building's quad-pane windows combine two panes of glass with two film layers. The gaps are filled with krypton gas, which insulates twice as well as air. The frames have large thermal breaks. Special attention was paid to sealing the construction details between the windows and the wall assembly of structural insulating panels (SIPs).



Innovative Thermal Comfort

The building redefines how occupants experience and control their individual comfort. Integrative design eliminated mechanical cooling and reduced the heating system to a small, distributed electric-resistance system.

The only mechanical systems are for ventilation and localized backup heating—through passive design, the mechanical heating load is reduced to the equivalent energy used in one mid-sized home in this climate zone.

Most buildings rely on blowing hot or cold air using large central HVAC (heating, ventilation, and air conditioning) systems to maintain a set temperature, which often wastes energy and is not that tuned to how comfortable a person feels. In contrast, the Innovation Center addresses all six factors that determine individual comfort, requiring dramatically less energy.

These strategies reduced the size of the mechanical room by reducing the size of the heating system and eliminating any cooling system.

Thermal Mass

Thermal mass—materials that can absorb and later release a large amount of heat—allows the building to store the sun's heat over time without overheating during the day.

Thermal mass is critical to both passive heating and cooling because it stabilizes interior temperature despite significant daily and seasonal outdoor temperature swings, saving energy.

Thermal mass also allows the building to absorb excess heat generated from internal sources such as computers, lights, and people. In fact, because this building is so efficient in its use of heat sources, the thermal mass, which is designed to keep occupants comfortable by helping to regulate interior temperatures, partially relies on the heat those occupants generate!

As in many conventional buildings, the concrete floors throughout the Innovation Center serve as thermal mass. What you can't see is that the Innovation Center has added, unique thermal mass in the form of phase-change material hidden in the light shelves and walls.

This phase-change material is a vegetable-based wax. During warm afternoons, it absorbs excess heat by turning into a liquid. During summer nights, it releases the stored heat into the cool air and solidifies.

Cooling & Air Quality

Many of the same design elements that keep the Innovation Center warm in the winter also keep it cool in summer: passive design elements and advanced materials. With more than triple the code-required levels of insulation, the building's interior is shielded from hot summer temperatures.

Opening low-south and high-north windows with automated controls creates cooling air currents. During particularly hot days, an automated night flush brings in Colorado's cool night air to cool the mass.

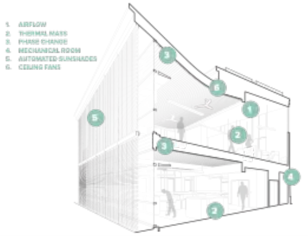
Concrete floors serve as thermal mass that reduces interior temperature swings by storing excess heat that is absorbed throughout the day and releasing it at night.

Phase-change materials behind the drywall and in the light shelves are a more active form of thermal mass, changing states between liquid and solid as temperatures change. When interior temperatures exceed 77 degrees, this material melts and absorbs thermal energy without increasing temperature.

Air-to-air heat exchangers maintain indoor air quality and temperature by passively transferring 93% of warmth or coolth from the outgoing air to the incoming air. These devices are controlled by carbon dioxide levels measured in the air to provide the appropriate amount of ventilation air.

Exterior automated sunshades on the south wall accept heat gain in the winter and block the sun's heat in the summer.

Large, energy-efficient ceiling fans along with personal and wall fans keep occupants cooler through the convective heat transfer induced by moving air.



On-Site Renewable Energy

A rooftop solar photovoltaic (PV) system produces on-site renewable energy. Thanks to the Innovation Center's integrated, energy-efficient design, the PV system provides more than 100% of the building's energy needs right here on the roof.

This 83 kW solar PV system covers the roof and generates enough clean electricity to power the entire building plus six electric vehicles. The panels are an industry-leading 21.5% efficient in converting the sun's energy to electricity.

A 30 kW/45 kWh lithium-ion battery storage system—located in the mechanical room—reduces the building's peak energy demand, stores renewable energy to power the building during cloudy days or nighttime, and reduces RMI's demands for grid-provided fossil fuel-based electricity.

That's enough battery capacity to charge:

4,300 Smartphones

1,100 Tablets

700 Laptops

> DIG DEEPER Innovation Center overview at rmi.org/innovationcenter

Location
Rocky Mountain Institute
Innovation Center
22830 Two Rivers Road
Basalt, CO 81621

Size: 15,610 sf

About Rocky Mountain Institute
Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. In 2014, RMI merged with Carbon War Room (CWR), whose business-led market interventions advance a low-carbon economy. The combined organization has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing.

RMI.org


Photo by Pat Sudmeier

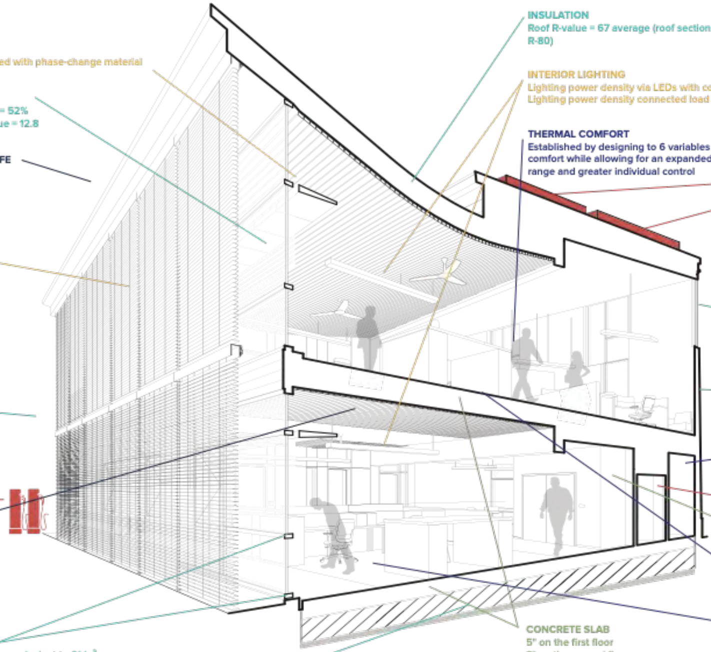
Overall Performance and Highlights

- **17.2** Expected energy use intensity (EUI) thanks to passive integrative design
- **74%** more efficient than the average office building in this climate (according to Energy Star)
- **1 of only 200** Net-zero commercial buildings in the U.S. as of 2016
- **Net+** Produces more renewable energy than it uses in a year plus enough to power 6 electric vehicles
- **#1 Zone 7** The most energy-efficient building in the coldest climate zone in North America. Top 20 most efficient buildings in the country as of 2016
- **6 factors** defined our breakthrough thermal comfort strategy
- **100 year life** Designed for a 100-year life
- **IPD** Used integrated project delivery (IPD)

Honors and Certifications

LEED Platinum (NC v2009)
Passive House Institute Certified
PHIUS+ Source Net Zero project
Exceeds Architecture 2030 Challenge goals
Anticipating ILFI Net Zero Energy Building Certification
Anticipating Living Building Challenge Petal Recognition
Anticipating Energy Star target score of 100

Innovation Center by the Numbers



EXTERIOR SUNSHADES
6 positions to track the sun angle automatically to control solar heat gain

TOTAL OVERALL WINDOW AVERAGES
Quad-pane, 2 glass, 2 suspended films, krypton gas filled
Total window-to-wall ratio = 26%
Average full frame R-value = 6.5, including thermal break sashes
Average center of glass R-value = 12 (U-value = 0.0833)
2 electrochromic windows that can manually change transmissivity

EAST WINDOWS
Window-to-wall ratio = 23%
Center of glass R-value = 13.2

WEST WINDOWS
Window-to-wall ratio = 13%
Center of glass R-value = 13.2

ELECTRIC VEHICLES
4 EV charging stations
Future capacity for 2 additional bidirectional EV charging stations

CROSS LAMINATED TIMBER (CLT)
6"–12" increase in floor-to-ceiling height due to CLTs utilizing beetle kill wood

LIGHT SHELVES
3 feet deep, embedded with phase-change material

SOUTH WINDOWS
Window-to-wall ratio = 52%
Center of glass R-value = 12.8

100-YEAR DESIGN LIFE

AIRTIGHTNESS
Effective leakage area equivalent to 61 in^2
0.36 air changes per hour at 50 pascals
97% less air leakage than a typical commercial building

INSULATION
Below slab R-value = 20

INSULATION
Roof R-value = 67 average (roof sections vary from R-40 to R-80)

INTERIOR LIGHTING
Lighting power density via LEDs with controls = 0.27 W/sf
Lighting power density connected load = 0.49 W/sf

THERMAL COMFORT
Established by designing to 6 variables that influence thermal comfort while allowing for an expanded set-point temperature range and greater individual control

CONCRETE SLAB
5" on the first floor
3" on the second floor
The IC cools the floors (to 55–65°F) based on predictive weather forecasts for the following day

- Innovative Thermal Comfort Heating system
- On-Site Renewable Energy
- Passive Design
- Lighting
- Thermal Mass
- Other Innovations

PV SYSTEM
83 kW system (248 panels at 21.5% efficiency) on a 10° sloped roof (92% of maximum production, making the building a net-exporter of clean energy)
8 inverters with future capabilities to island

MONITORING
122 meters installed throughout the building monitor all loads
hundreds of air quality, temperature, daylighting, and system operation sensors

NORTH WINDOWS
Window-to-wall ratio = 18%
Center of glass R-value = 13.3

INSULATION
Wall R-value = 50

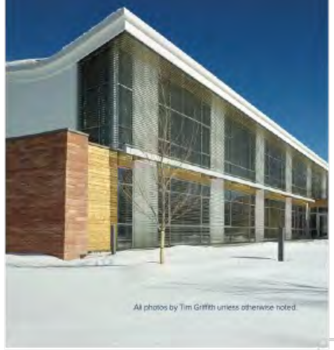
VENTILATION SYSTEM
Dedicated outdoor air system with air-to-air heat exchanger
93% efficient, CO_2 controlled, $\frac{1}{4}$ the size of a typical system

BATTERY SYSTEM
30 kW/45 kWh lithium ion

PHASE-CHANGE MATERIAL
In some walls, with a phase change temperature of 77°F
Embedded in all the light shelves, with a phase change temperature of 80°F

HEATING SYSTEM
**Energy usage is based on modeled energy performance*
Distributed 33 kW electric resistance heating system
Estimated peak heating demand of 22,409 kWh

Rocky Mountain Institute Innovation Center


All photos by Tim Griffith unless otherwise noted.

Overall Performance and Highlights

- **17.2** Expected energy use intensity (EUI) thanks to passive integrative design
- **74%** more efficient than the average office building in this climate (according to Energy Star)
- **1 of only 200** Net-zero commercial buildings in the U.S. as of 2016
- **Net+** Produces more renewable energy than it uses in a year plus enough to power 6 electric vehicles
- **#1 Zone 7** The most energy-efficient building in the coldest climate zone in North America. Top 20 most efficient buildings in the country as of 2016
- **6 factors** defined our breakthrough thermal comfort strategy
- **100 year life** Designed for a 100-year life
- **IPD** Used integrated project delivery (IPD)

Honors and Certifications

LEED Platinum (NC v2009)

Passive House Institute Certified

PHIUS+ Source Net Zero project

Exceeds Architecture 2030 Challenge goals

Anticipating ILFI Net Zero Energy Building Certification

Anticipating Living Building Challenge Petal Recognition

Anticipating Energy Star target score of 100

Innovation Center by the Numbers

LIGHT SHELVES
3 feet deep, embedded with phase-change material

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Center of glass R-value = 12.8

100-YEAR DESIGN LIFE

EXTERIOR SUNSHADES
6 positions to track the sun angle automatically to control solar heat gain

TOTAL OVERALL WINDOW AVERAGES
Quad-pane, 2 glass, 2 suspended films, krypton gas filled
Total window-to-wall ratio = 26%
Average full frame R-value = 6.5, including thermal break sashes
Average center of glass R-value = 12 (U-value = 0.0833)
2 electrochromic windows that can manually change transmissivity

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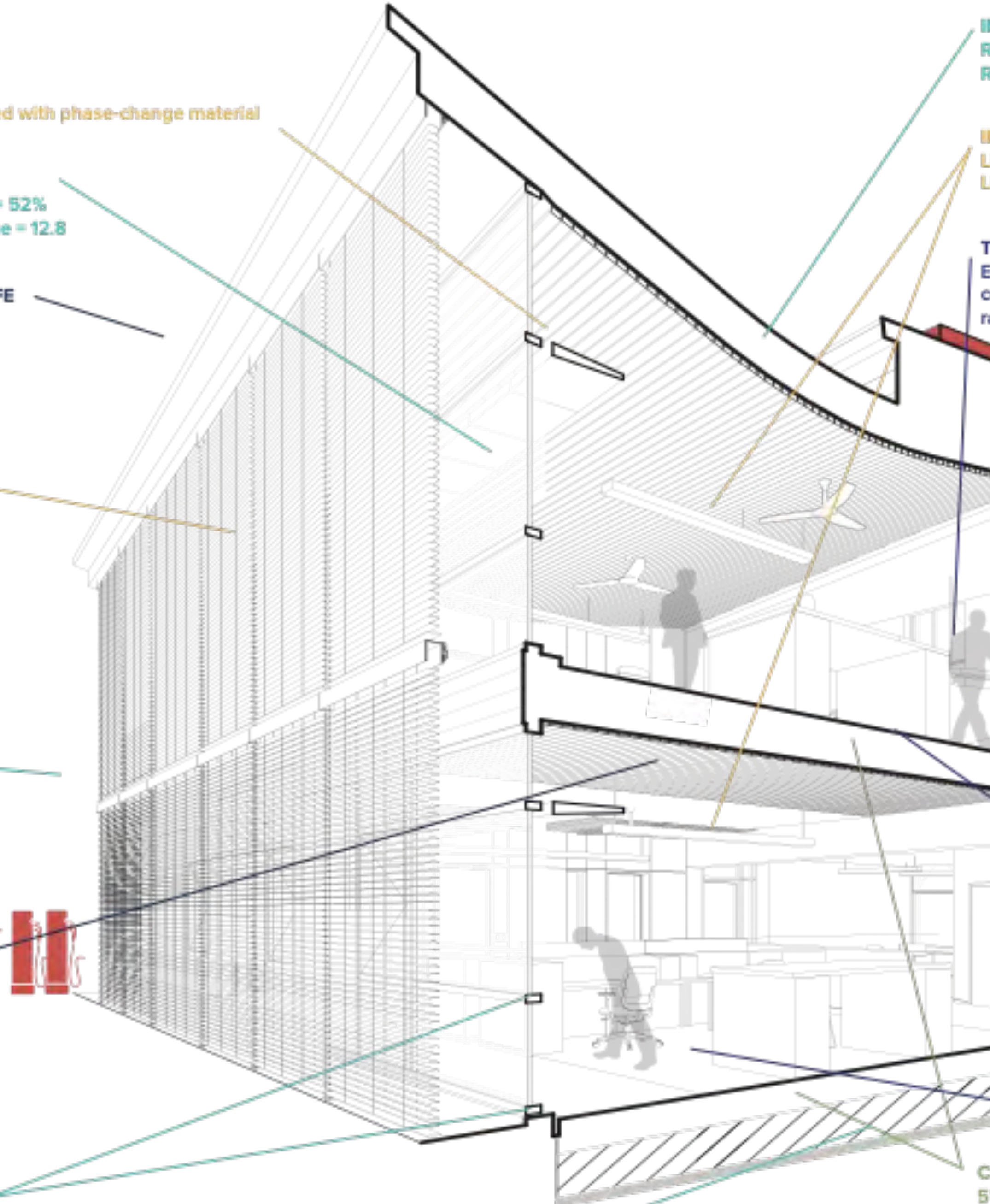

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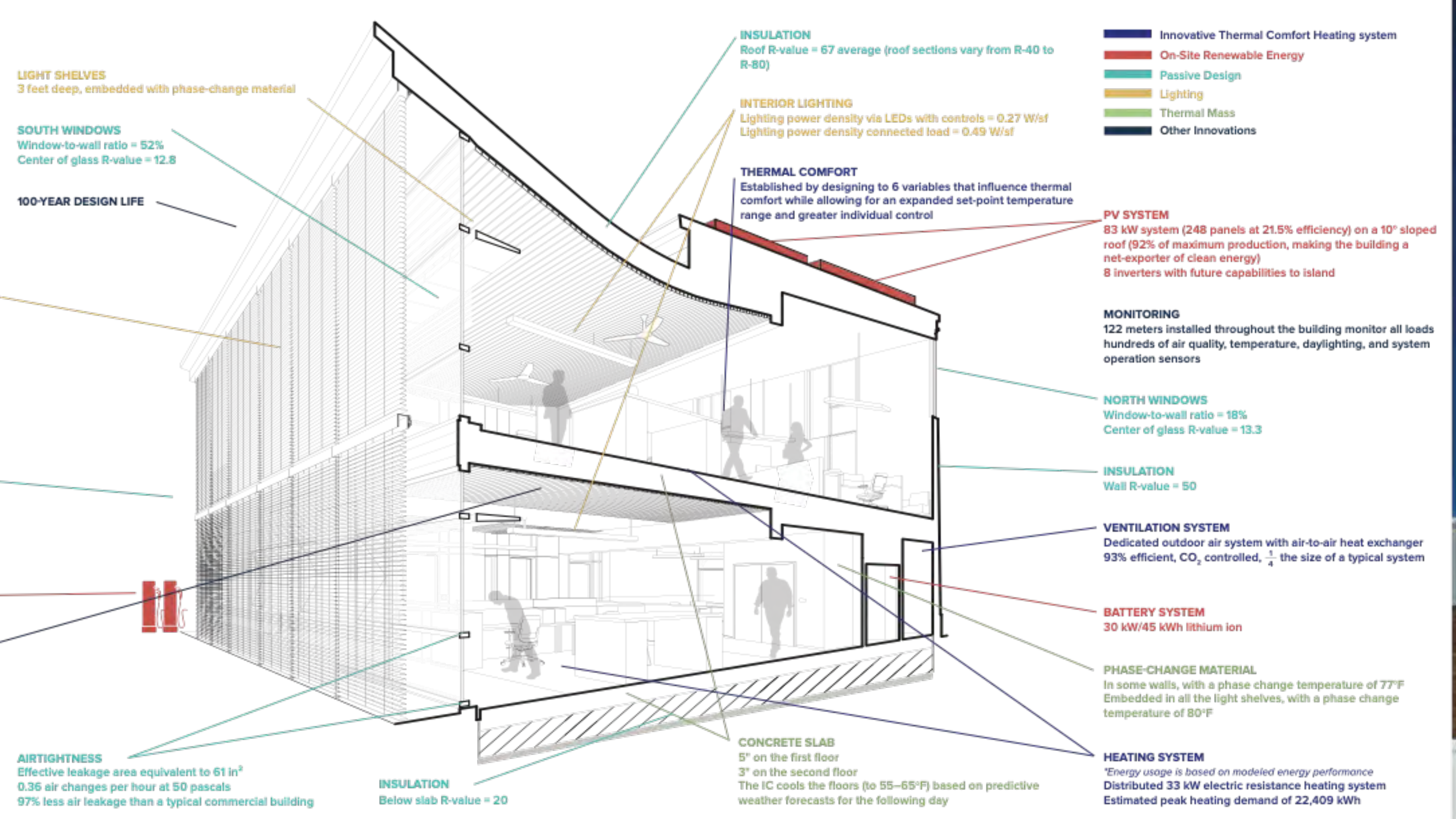

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On-Site Renewable Energy
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SITE

Agriculture

The Phipps Conservatory Welcome Center, The Phipps Conservatory and Botanical Garden
Pittsburgh, Pennsylvania

The Phipps Conservatory **hosts a farmers market** on its grounds to provide a place for communities members to purchase locally and sustainably grown produce.

Images by Craig Schiller

SITE

Agriculture

McLean Environmental Living and Learning Center, Northland College
Ashland, Wisconsin

Students **learn how** to grow organic food and **maintain a community garden** which is located on the grounds of the McLean Environmental Living and Learning Center.

Images by Northland College

Photo Credit: Austin ISD


Academy

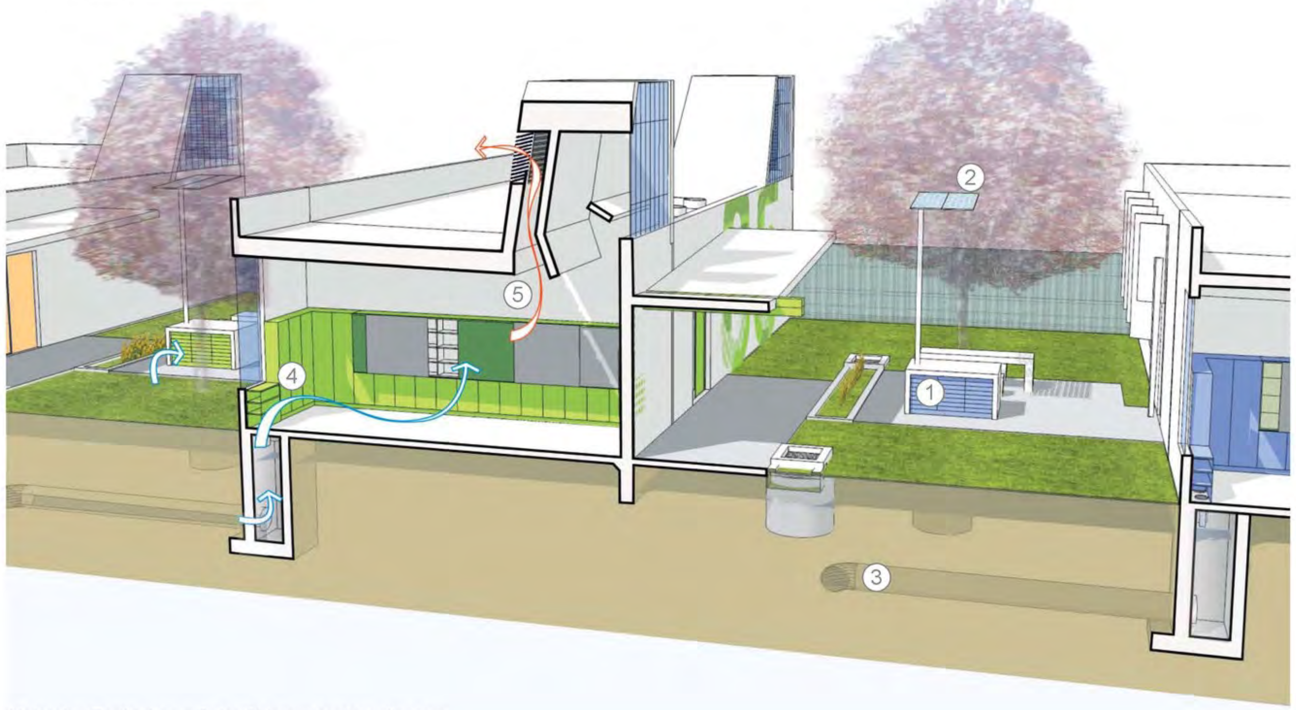
Black Water

Adam Joseph Lewis Center, Oberlin College
Oberlin, Ohio

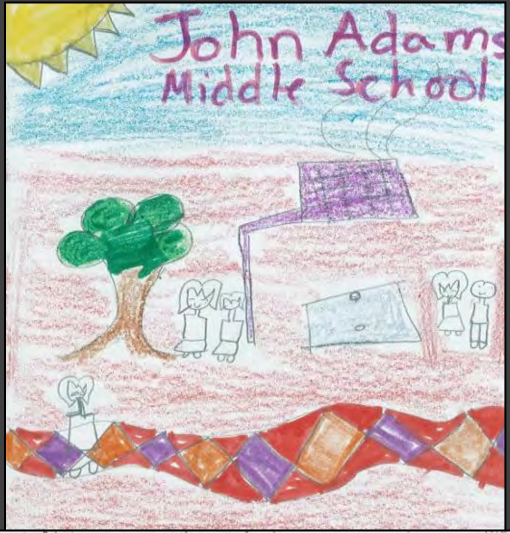
Student interns monitor the Adam Joseph Lewis Center's 'Living Machine', by testing and documenting water quality, and caring for the plants.

Images by Craig Schiller


1301
CASEY MIDDLE SCHOOL
Boulder Valley School District



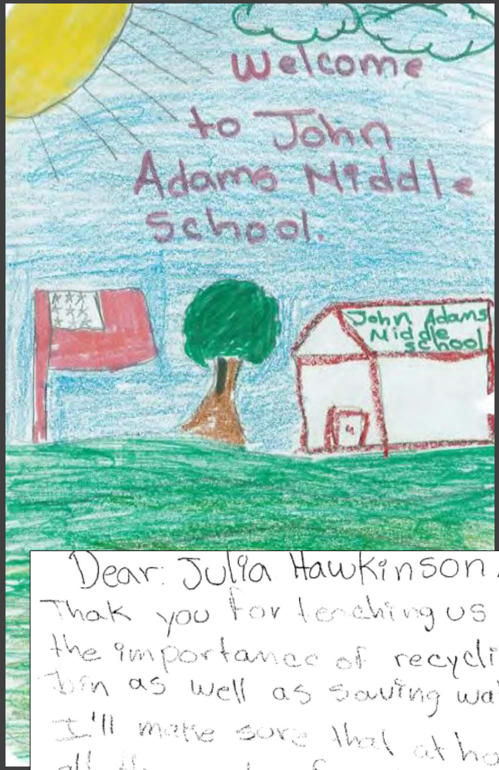
Air Intake, Earthtubes + Solar Chimney system diagram



Dear Ms. Julia Hawkinson:

I learned that every little thing that we can do to safe our planet makes the differnce in our live. Thank you for encouraging me and all my class to be careful and sensitives with our earth

Riza Henderson
8th grader

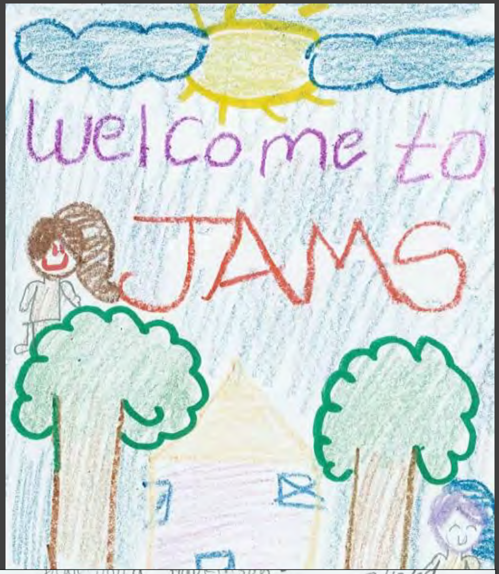


Dear: Julia Hawkinson..

Thak you for teching us the importance of recycling bin as well as saving water. I'll make sure that at home all the water faucets are turn of all the way so I dont waste water.

william gutierrez.
6th grader.

10/3/09



Dear Julia Hawkinson: 3/12/09

What I learn is tha every little thing that we cando to safe our planet makes a big difference in our live's. Because went we recycle we are helping and we are safeng our planet. And not leting the diry staff go into to ocean. Because if it goes in the ocean that fish can died. Thak the teacher because they teach us new thing's ever day we learn new thing at School. I am Yanira Curiel I am I six grade. thank you for coming to Jams.

Yanira Curiel Hernandez
6th

John adams middle school.

ENERGY

Conservation - Enclosure

Integrated Learning Centre (Beamish-Munro Hall), Queen's University
Kingston, Ontario

RESEARCH
CURRICULAR
OUTREACH
MULTISENSORY

Multiple window types with different efficiencies (such as a solar heat gain coefficient ranging from 0.13 – 0.51) are monitored and **analyzed for their performance** on heat and light transfer.

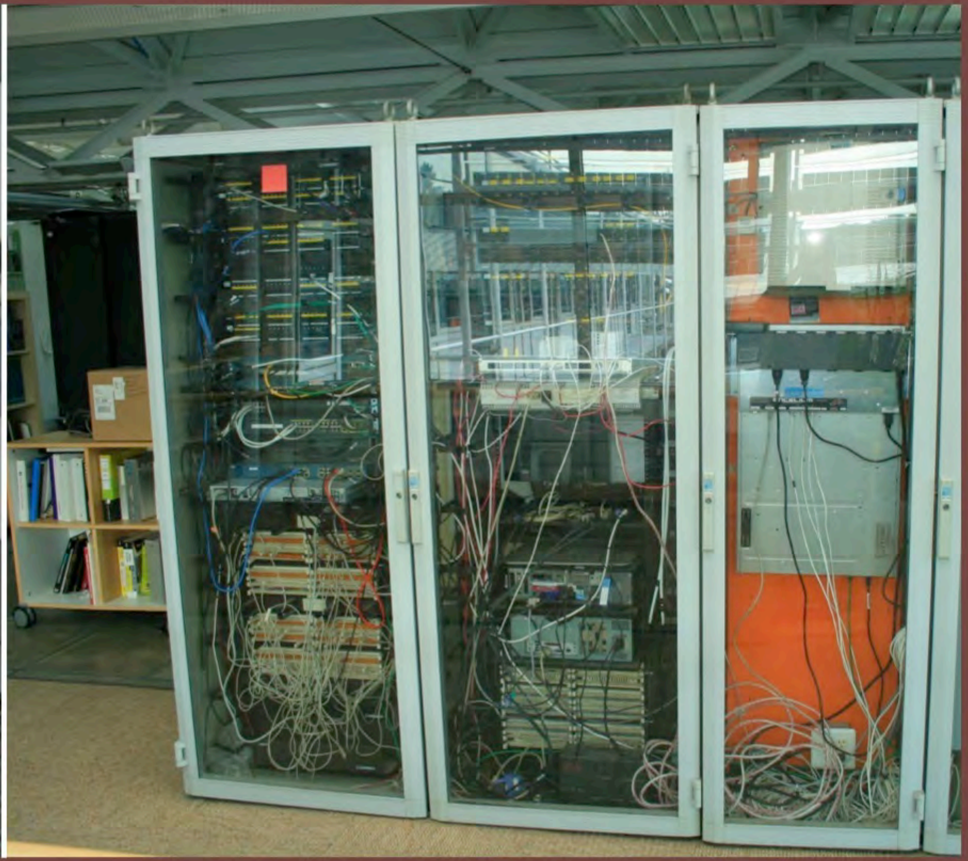
Images Bergman + Hamann Architects. Information from from Renee, Stephen, David S. Lay, and James D. Mccowan. "Using the Technology of University Buildings in Engineering Education." *International Journal of Engineering Education* 24, no. 3 (2008):

WHOLE BUILDING

Site + Water + Energy + Materials + I.E.Q

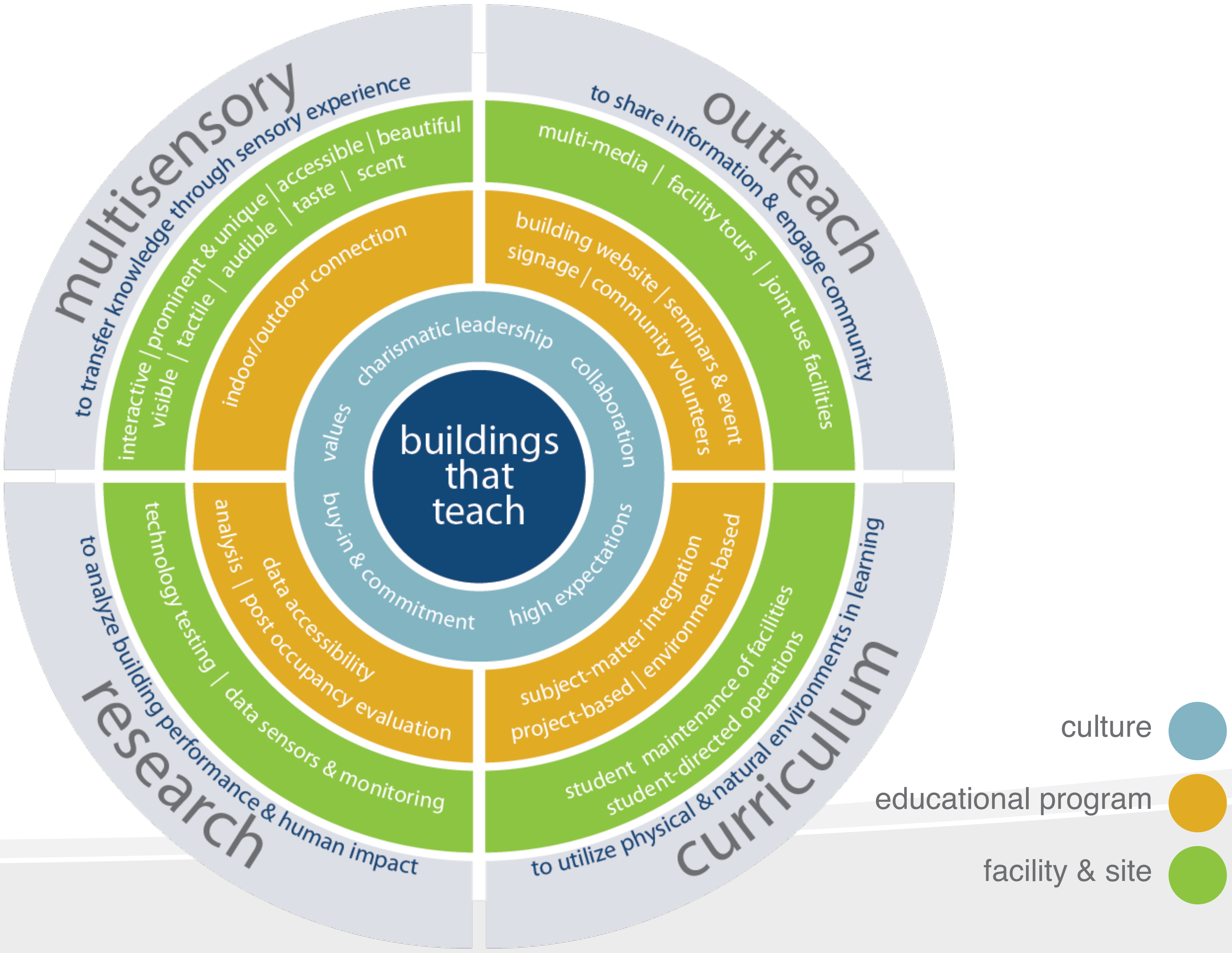
Intelligent Workplace, Carnegie Mellon University
Pittsburgh, Pennsylvania

RESEARCH
CURRICULAR
OUTREACH
MULTISENSORY



Hundred of sensors collect a variety of building data including **air quality, light levels, and electrical use**. These sensors send the information wirelessly to the Intelligent Workplace's **designated data server**.

Images by Craig Schiller


buildings that teach
multisensory
to transfer knowledge through sensory experience
interactive | prominent & unique | accessible | beautiful
visible | tactile | audible | taste | scent
indoor/outdoor connection
outreach
to share information & engage community
multi-media | facility tours | joint use facilities
building website | seminars & event
signage | community volunteers
research
to analyze building performance & human impact
technology testing | data sensors & monitoring
analysis | post occupancy evaluation
data accessibility
curriculum
to utilize physical & natural environments in learning
student maintenance of facilities
student-directed operations
subject-matter integration
project-based | environment-based
charismatic leadership
collaboration
values
buy-in & commitment
high expectations
culture
educational program
facility & site

I want to hear your examples:

Craig Schiller
cschiller@chps.net