AMERICAN MADE
U.S. DEPARTMENT OF ENERGY

Setting the Stage for Long Term Building Efficiency and Sustainability

SCEP
STATE & COMMUNITY ENERGY PROGRAMS

Fundamental Bldg Science Cohort Groups

Cohort 1	Cohort 2	Cohort 3	Cohort 4
Brevard Public Schools	Jackson County School District	Lansing School District	Paducah Public Schools
Detroit Public Schools Community District	Mascoma Valley Regional School District	Kansas City Kansas Public Schools	Environmental Charter Schools
Canajoharie Central School District	Elkhorn Area School District	Irvington Public School District	Natchez Adams School District
Albemarle County Public Schools	Martin County Schools	Granite School District	East Cleveland City Schools
IDEA Public Schools	San Antonio Independent School District	Nenana City School District	Baltimore City Public Schools
Southwest Vermont Supervisory Union	NEWESD 101	Baltimore City Public Schools	Milwaukee Public Schools
		City Schools of Decatur	Orange County Public Schools

Welcome

Let's get to know each other!	10 mins
Lesson Plan • Introduction • Energy Issues and Building Solutions • The Building is a System: Sustainable Building Performance • Project Preparation	1 hour 20 mins
Discussion	30 mins

Today's Presenters

Shannon Oliver

Energy & Sustainability Manager

Adams 12 5 Star Schools

Reilly Loveland

Associate Director

New Buildings Institute

Icebreaker

Introducing the Mentimeter Marmot!

Instructions:

- Scan the mentimeter code on your phone or enter on your computer browser.
- Respond to the prompts and answers will populate real time.

Introduction

Course Objective

Understand what building science is and how can it be used to optimize building performance to decrease energy use/cost, and alleviate dependency on fossil fuels.

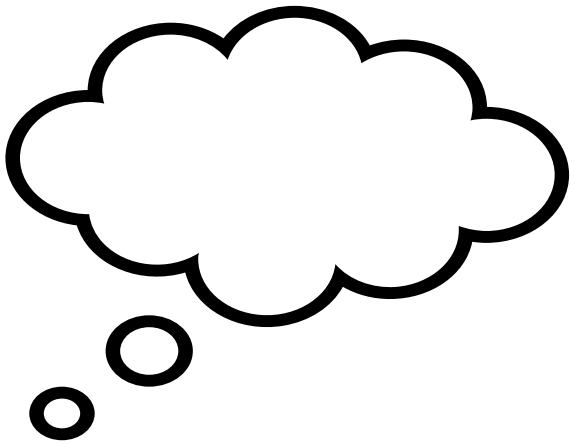
1. Participants will be able to identify major energy using systems common in K-12 school buildings.

2. Participants will understand the impacts of building upgrades, maintenance, and operation on efficiency and occupant health.

3. Participants will understand how to begin the process of project planning and preparation to achieve efficient and healthy school buildings.

What is building science?

- A field of knowledge that explains how a building works as a system of components that interact with each other and the outdoor environment.
- It describes how the physical behavior of the building impacts energy efficiency, durability, comfort, and indoor air quality.
- Important in all building phases!

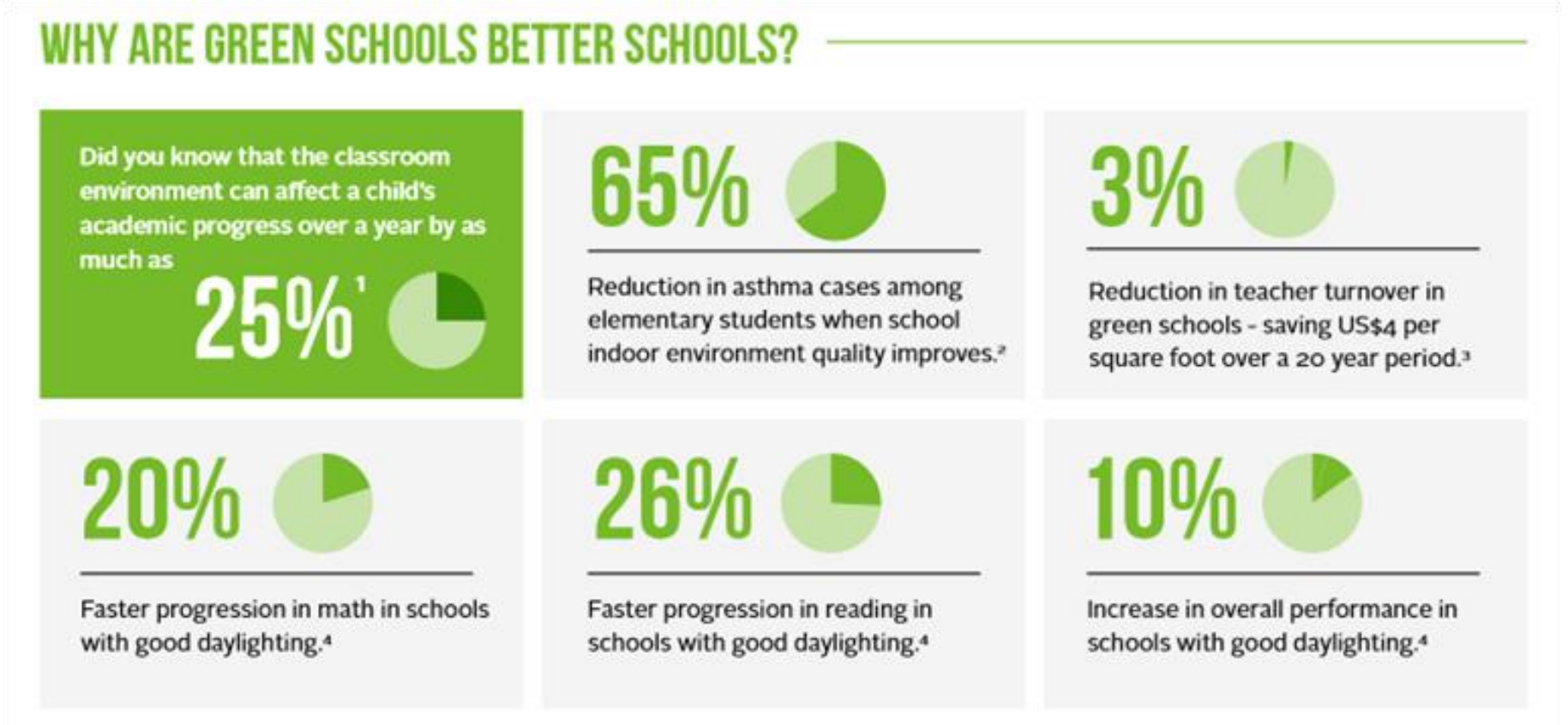


Why building science matters to schools

- Upgrades to school facilities can:
  - ✓Improve air quality
  - ✓Improve comfort and health conditions
  - ✓Support better student learning
  - ✓Provide significant reductions in school energy bills
  - ✓Help to stabilize utility costs for annual budgeting
  - ✓Opportunities for safety and security

Source: https://www.energy.gov/eere/buildings/efficient-and-healthy-schools

Why building science matters to schools



Credit: World GBC

1. Barett, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2012, October 03). A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning.
2. Meng, Y., Babey, S. H., & Wolstein, J. (2012). Asthma-Related School Absenteeism and School Concentration of Low-Income Students in California.
3. Katz, G. (2006). Greening America's Schools: Costs and Benefits.
4. Heschong Mahone Group. (1999). Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance.

Why building science matters to schools

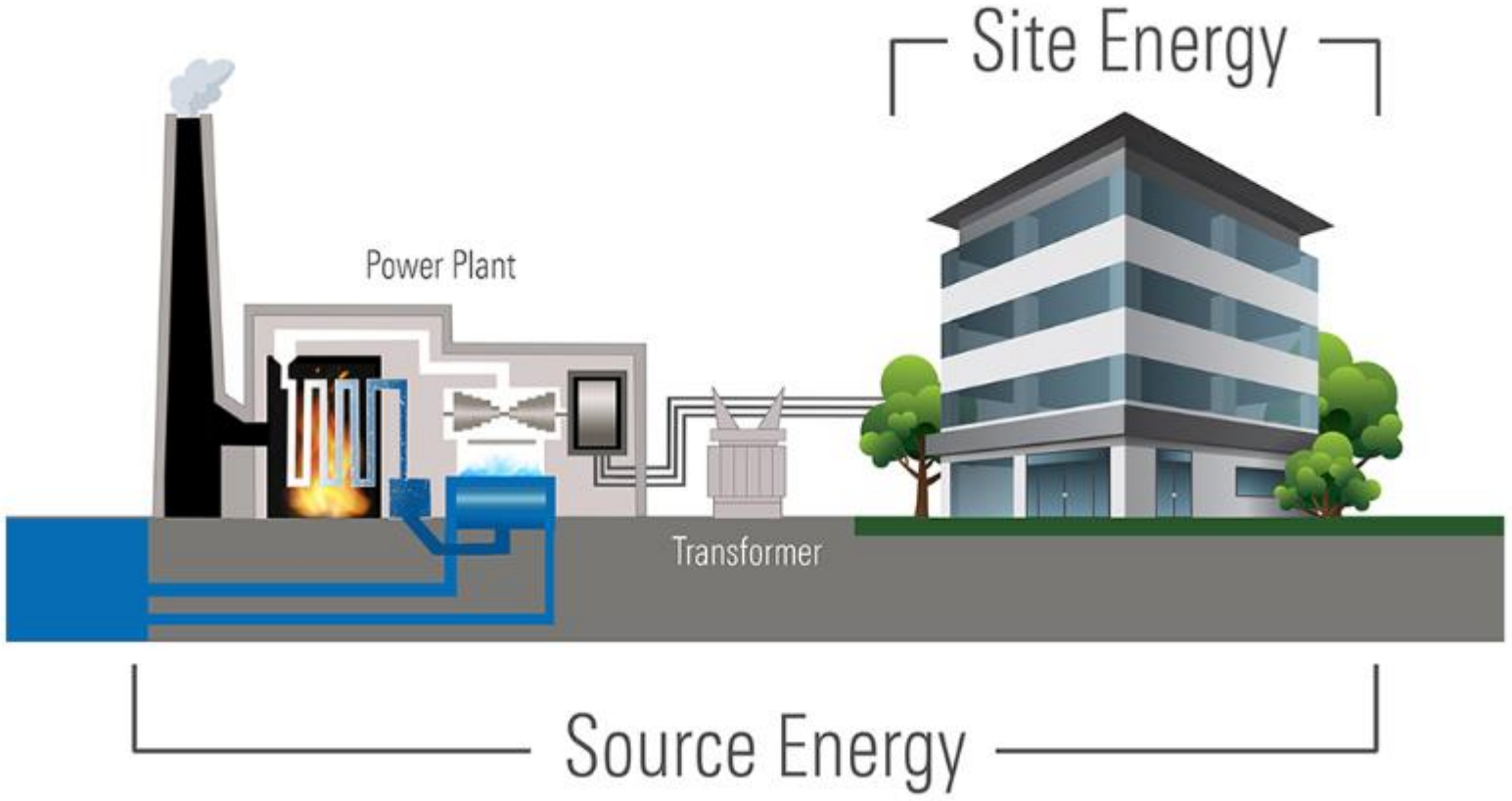
School buildings can be a tool to enhance student learning

Student Performing Energy Audit, Los Angeles USD, CA
Credit: Los Angeles USD

Foundational Concepts

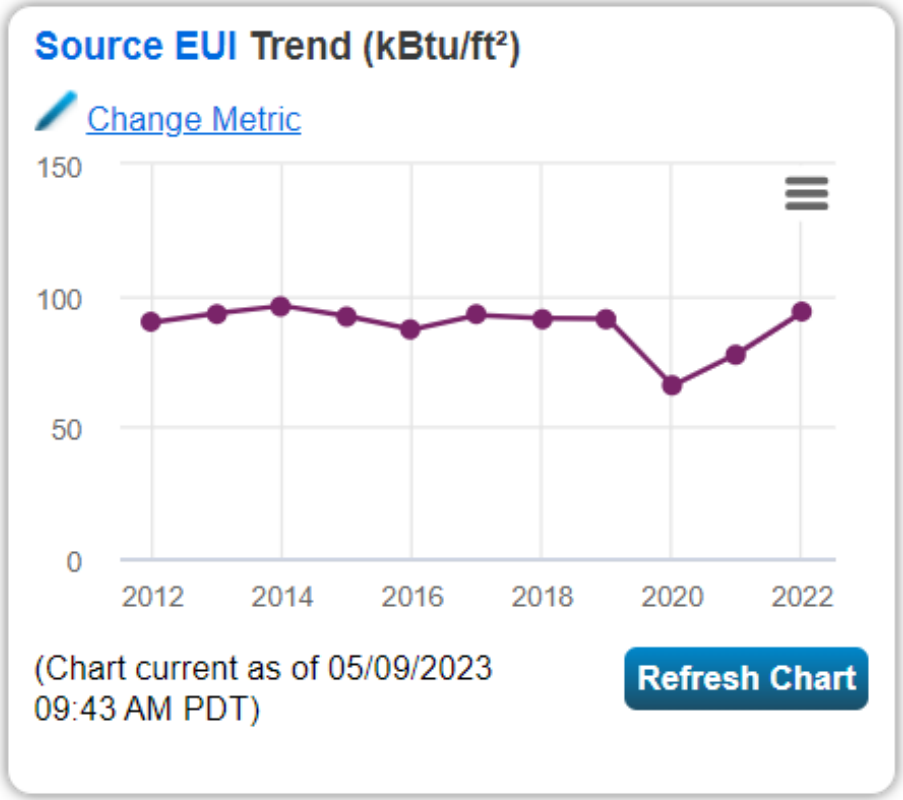
Key Energy Concept: Site vs. Source Energy

- **Source energy:** The total amount of raw fuel required to operate a building
- **Site energy:** The amount of heat and electricity consumed by the building



Source: https://www.energystar.gov/buildings/benchmark/understand_metrics/source_site_difference

Key Energy Concept: Site vs. Source Energy



ENERGY STAR® Portfolio Manager®

Change Metrics
Change Time Periods

Metrics Summary

Metric	Jan 2010 (Other)	Jun 2023 (Energy Current)	Change
ENERGY STAR Score (1-100)	71	80	9.00 (12.70%)
Source EUI (kBtu/ft²)	107.0	89.6	-17.40 (-16.30%)
Site EUI (kBtu/ft²)	47.2	41.0	-6.20 (-13.10%)
Energy Cost ($)	96,589.16	109,153.86	12564.70 (13.00%)
Total (Location-Based) GHG Emissions Intensity (kgCO2e/ft²)	5.5	3.0	-2.50 (-45.50%)
Water Use (All Water Sources) (kgal)	2,191.8	Not Available	N/A
Total Waste (Disposed and Diverted) (Tons)	Not Available	Not Available	N/A

Key Energy Concept: Energy Use Intensity (EUI)

- Total energy consumed in one year, divided by the gross floor area (square footage)
  - Energy is expressed in units of kBtu for easy comparison
  - Usually based on site energy (not source energy)

$$\frac{\text{Annual Energy Use (kBtu/yr)}}{\text{Square Footage (ft}^2\text{)}}$$

EUI is similar to MPG (miles per gallon) … for buildings!

Key Energy Concept: Energy Use Intensity (EUI)

ENERGY STAR® PortfolioManager® U.S. Energy Use Intensity by Property Type

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft²)	Site EUI (kBtu/ft²)	Reference Data Source - Peer Group Comparison
Education	Adult Education		110.4	52.4	CBECS - Education
	College/University		180.6	84.3	CBECS - College/University
	K-12 School*		104.4	48.5	CBECS - Elementary/Middle & High School
	Pre-school/Daycare		131.5	64.8	CBECS - Preschool
	Vocational School		110.4	52.4	CBECS - Education
	Other - Education				

https://portfoliomanager.energystar.gov/pdf/reference/US%20National%20Median%20Table.pdf

Net zero target: 16-26 kBtu/SF-year

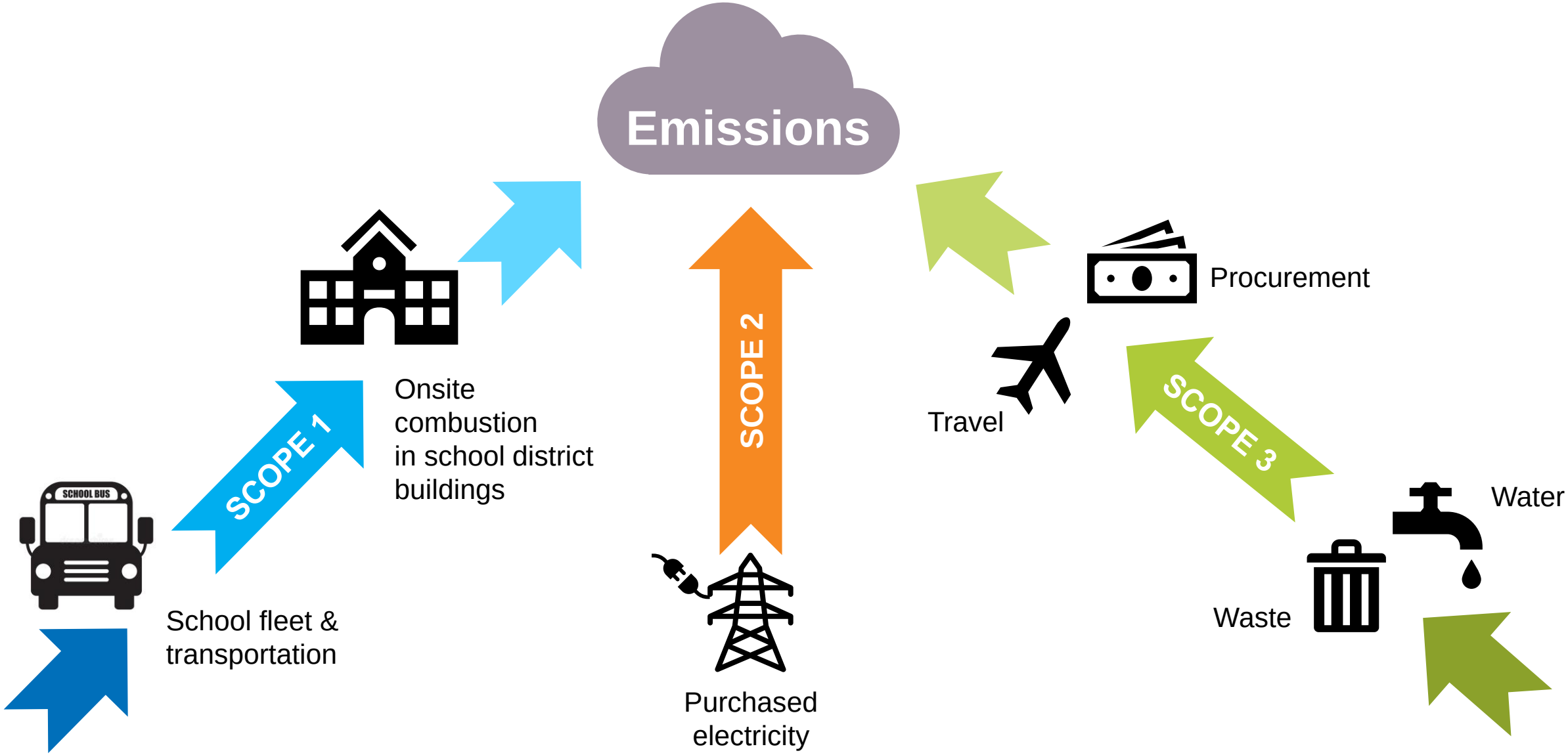
Key Energy Concept: Greenhouse Gas (GHG) Emissions

- Measured in units of CO_2e
- May also be referred to as “carbon”
- Total emissions = direct (used at building + transportation) + indirect (energy purchased from a utility)
- Different fuel sources = different emissions per unit of energy
- Different grids have different fuel mixes (and carbon intensity)
- Not all hours of the grid are equal

Schools in the United States produce emissions equivalent to **18 coal-fired power plants** each year.

Source: *Why K-12 Should Feature in America’s National Climate Strategy*

Scopes of Emissions in Schools



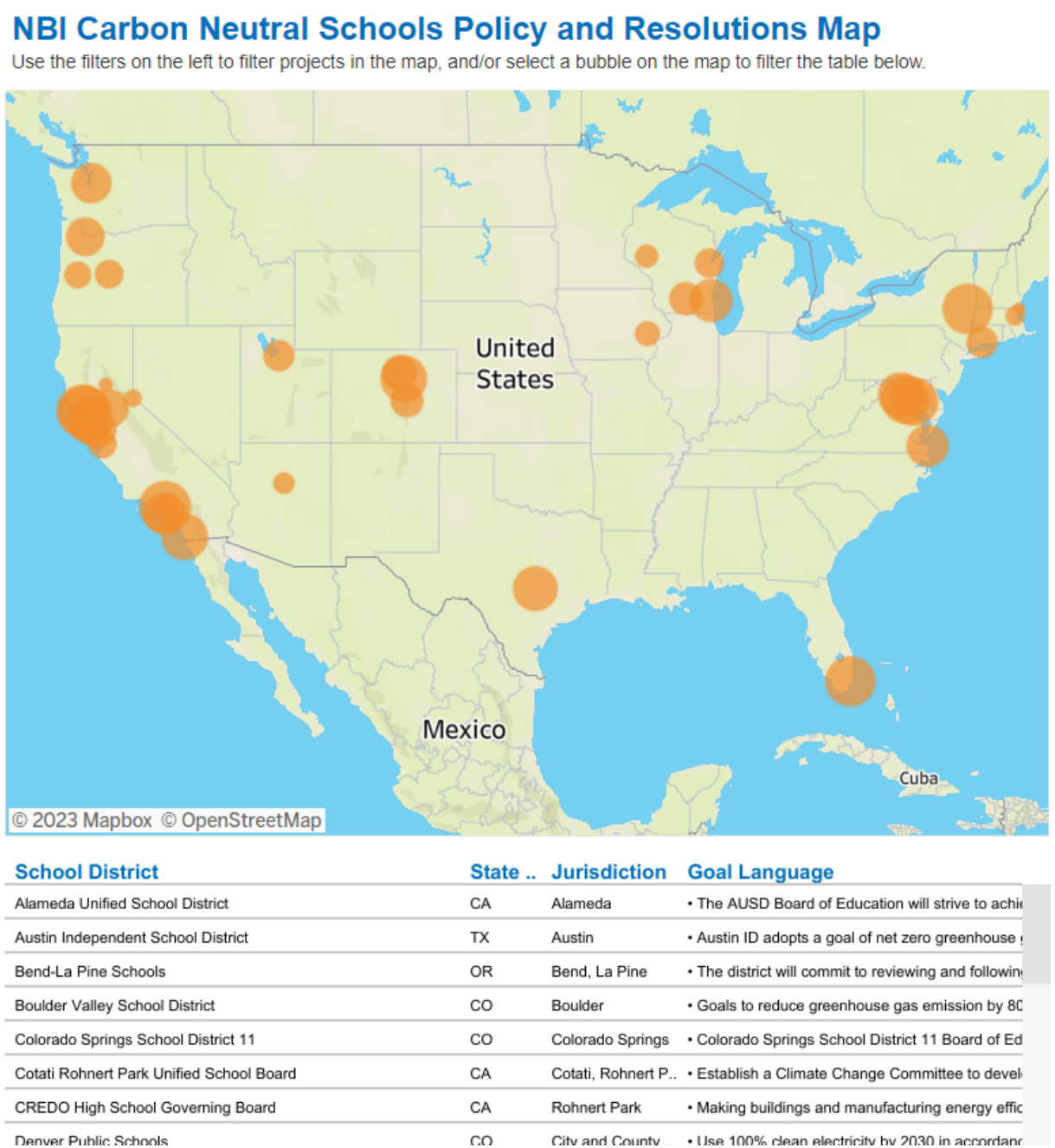
Key Energy Concept: Carbon Neutral Buildings

- **Net zero energy ≠ carbon neutral**
- A carbon neutral building is a well-ventilated, highly energy efficient building that does not contribute emissions of carbon and other greenhouse gases that contribute to climate change. A building is considered carbon neutral operations if it:
  - Maximizes energy efficiency while providing healthy indoor environments
  - Is all-electric and has no onsite fuel combustion
  - Offsets all the electricity used with 100% renewable energy sources

Source: *https://newbuildings.org/wp-content/uploads/2022/06/NBI_Key-Messages-About-Carbon-Neutral-Schools_June2022.pdf*

Interactive map of climate school district & building commitments

- https://newbuildings.org/resource/interactive-map-of-carbon-neutral-school-districts/



Key Energy Concept: Major building elements

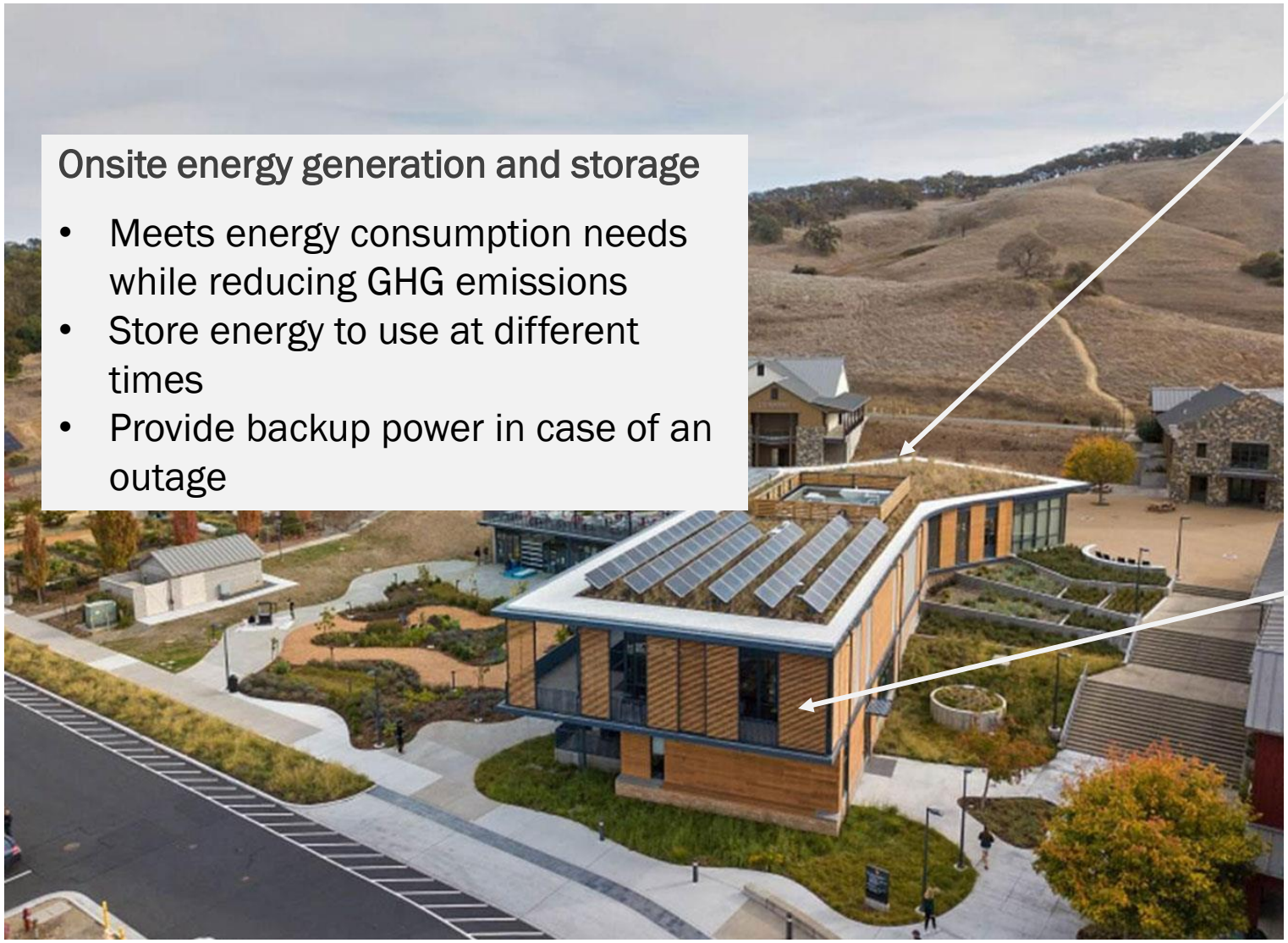
Building systems

- HVAC
- Water heating
- Lighting
- Kitchen equipment
- Electrical systems
- Plug and process loads
- Controls

Building Envelope

- Roofs and walls
- Foundation
- Windows and doors

Key Energy Concept: Major building elements



Onsite energy generation and storage

- Meets energy consumption needs while reducing GHG emissions
- Store energy to use at different times
- Provide backup power in case of an outage

Building systems

- Defines the magnitude of total energy consumption and GHG emissions

Building Envelope

- Passively impacts building system energy consumption

Major building elements: common retrofits

Building systems

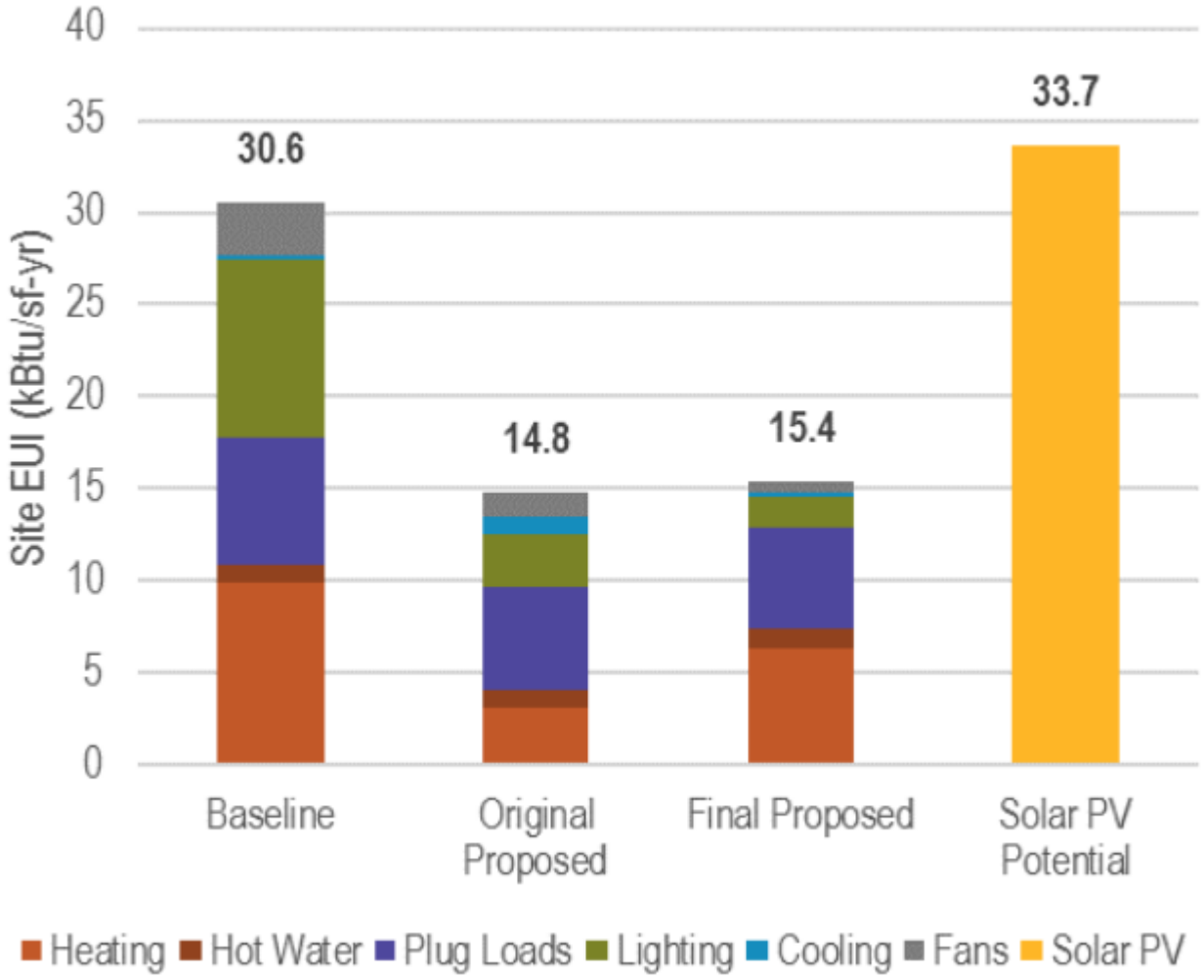
- HVAC
- Water heating
- Lighting
- Kitchen equipment
- Electrical systems
- Plug and process loads (appliance replacement)
- Controls

Building Envelope

- Roofs and walls
- Foundation
- Windows and doors

Major building elements: common retrofits

- The best retrofit options will depend on your site
- HVAC and lighting upgrades often are “biggest bang for your buck”
- Appliance upgrades (kitchen, plug loads) can be lower cost and still add up



Source: Integral Group, Inc for CA Prop 39

Health, Safety, and Comfort in School Buildings

Common building issues

Health	• Mold • Moisture intrusion • Indoor environmental/air quality (IEQ/IAQ)
Safety	• Aging infrastructure *(windows you can't lock!)* • Toxic building materials • Lighting *(security camera visibility)*
Comfort	• Poor temperature balancing • Poor ventilation • Accessibility • Lighting

Healthy buildings

The 9 aspects of healthy buildings:

- ❑ Ventilation
- ❑ Air Quality
- ❑ Water Quality
- ❑ Thermal Health
- ❑ Dust and Pests
- ❑ Lighting and Views
- ❑ Noise
- ❑ Moisture
- ❑ Safety & Security

Source: https://www.energy.gov/femp/articles/existing-healthy-building-resources-overview

Healthy buildings

- **Indoor Air Quality (IAQ)** - focused on air quality

  vs.

- **Indoor Environmental Quality (IEQ)** – holistic assessment

- IAQ/IEQ impacts:
  - Short- and long-term health effects
  - Absenteeism
  - Test scores
  - Productivity
  - Staff wellness and retention

Nearly 1 in 13 children has asthma, the leading cause of school absenteeism due to chronic illness.

Source: https://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools

Healthy buildings

JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HYGIENE
2022, VOL. 19, NO. 8, 478–488
https://doi.org/10.1080/15459624.2022.2089675

Taylor & Francis
Taylor & Francis Group

Check for updates

Relationships between social climate and indoor environmental quality and frequently reported health symptoms among teachers and staff in a suburban school district

er Schill[c], Matthew Klimm[c], Jennifer E. Cross[d,e], Shannon Oliver[f], and

nity Health, University of Illinois at Urbana-Champaign, Champaign, Illinois; [b]Department of ciences, Colorado State University, Fort Collins, Colorado; [c]Institute for the Built Environment, olorado; [d]Institute for Research in the Social Sciences, Colorado State University, Fort Collins, rado State University, Fort Collins, Colorado; [f]Manager, Energy and Sustainability, ent of Epidemiology, Colorado School of Public Health, Aurora, Colorado

Environmental Science and Pollution Research (2020) 27:16624–16639
https://doi.org/10.1007/s11356-020-08092-w

RESEARCH ARTICLE

Check for updates

Identifying and evaluating school environmental health indicators

Shao Lin [1,2] · Yi Lu [1] · Ziqiang Lin [1] · Xiaobo Xue Romeiko [1] · Tia Marks [1] · Wangjian Zhang [1] · Haider A. Khwaja [1,3] · Guanghui Dong [4] · George Thurston [5]

International Journal of
Environmental Research and Public Health

MDPI

Article

Indoor Air Quality Prior to and Following School Building Renovation in a Mid-Atlantic School District

Sandra E. Zaeh [1,2], Kirsten Koehler [3], Michelle N. Eakin [2], Christopher Wohn [4], Ike Diibor [4], Thomas Eckmann [2], Tianshi David Wu [5,6], Dorothy Clemons-Erby [3], Christine E. Gummerson [7], Timothy Green [3], Megan Wood [3], Ehsan Majd [8], Marc L. Stein [9,10], Ana Rule [3], Meghan F. Davis [3,11] and Meredith C. McCormack [2,*]

ELSEVIER

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.com/locate/ijheh

Check for updates

School environmental conditions and links to academic performance and absenteeism in urban, mid-Atlantic public schools

J.D. Berman[a,*,1], M.C. McCormack[b], K.A. Koehler[c], F. Connolly[d], D. Clemons-Erby[c], M.F. Davis[c], C. Gummerson[b], P.J. Leaf[e], T.D. Jones[f], F.C. Curriero[a]

Healthy buildings: energy efficiency can help

The 9 aspects of healthy buildings:

- ❑ Ventilation
- ❑ Air Quality
- ❑ Water Quality
- ❑ Thermal Health
- ❑ Dust and Pests
- ❑ Lighting and Views
- ❑ Noise
- ❑ Moisture
- ❑ Safety & Security

Source: https://www.energy.gov/femp/articles/existing-healthy-building-resources-overview

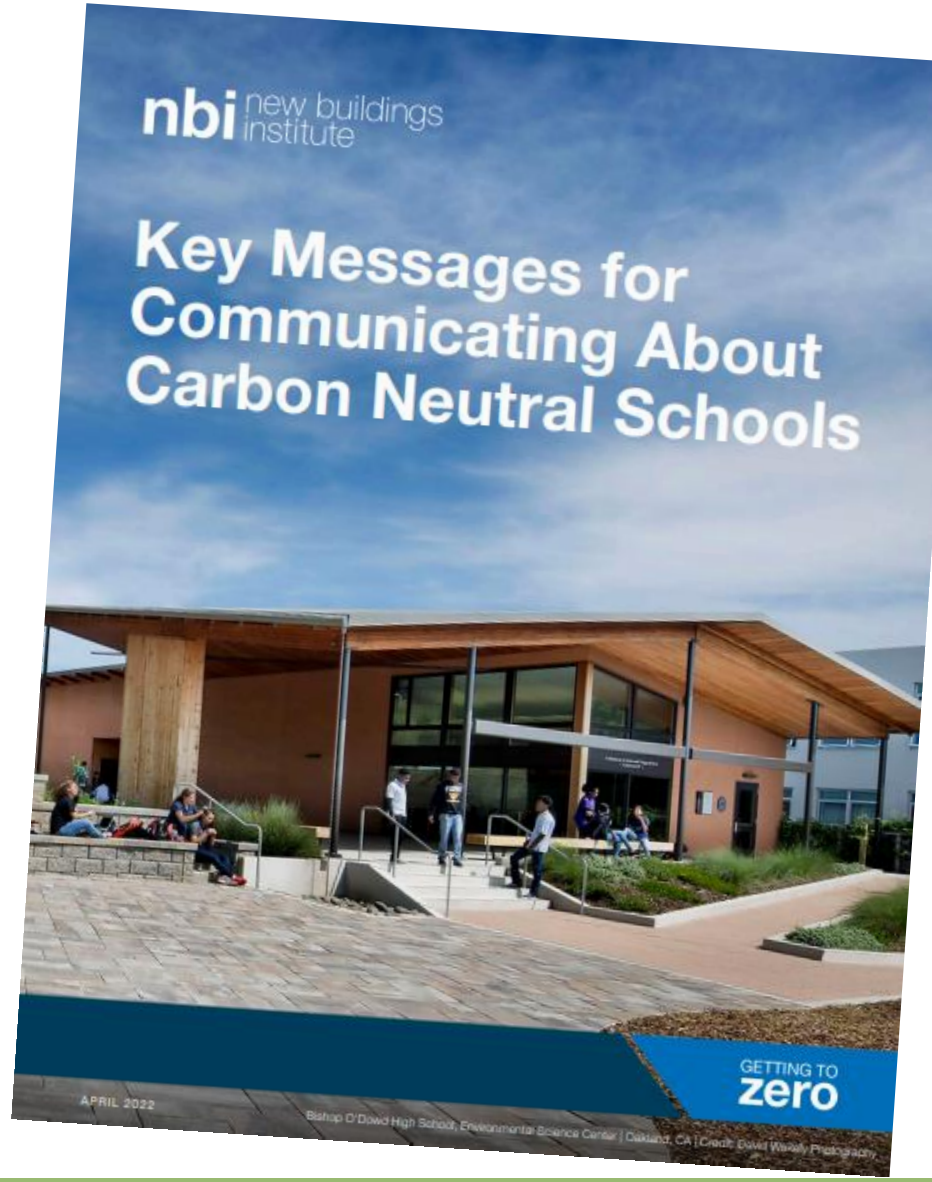
Energy efficiency

- Goal: Use less resources (energy) to operate, without compromising comfort or reliability
- Can be achieved through a variety of measures impacting the building envelope, systems, and equipment.

Benefits	Challenges
☺ Cost savings	☹ Inadequate funding
☺ Community benefits	☹ Competing priorities
☺ Environmental benefits	☹ Overburdened staff
☺ Resilience	
☺ Health benefits	

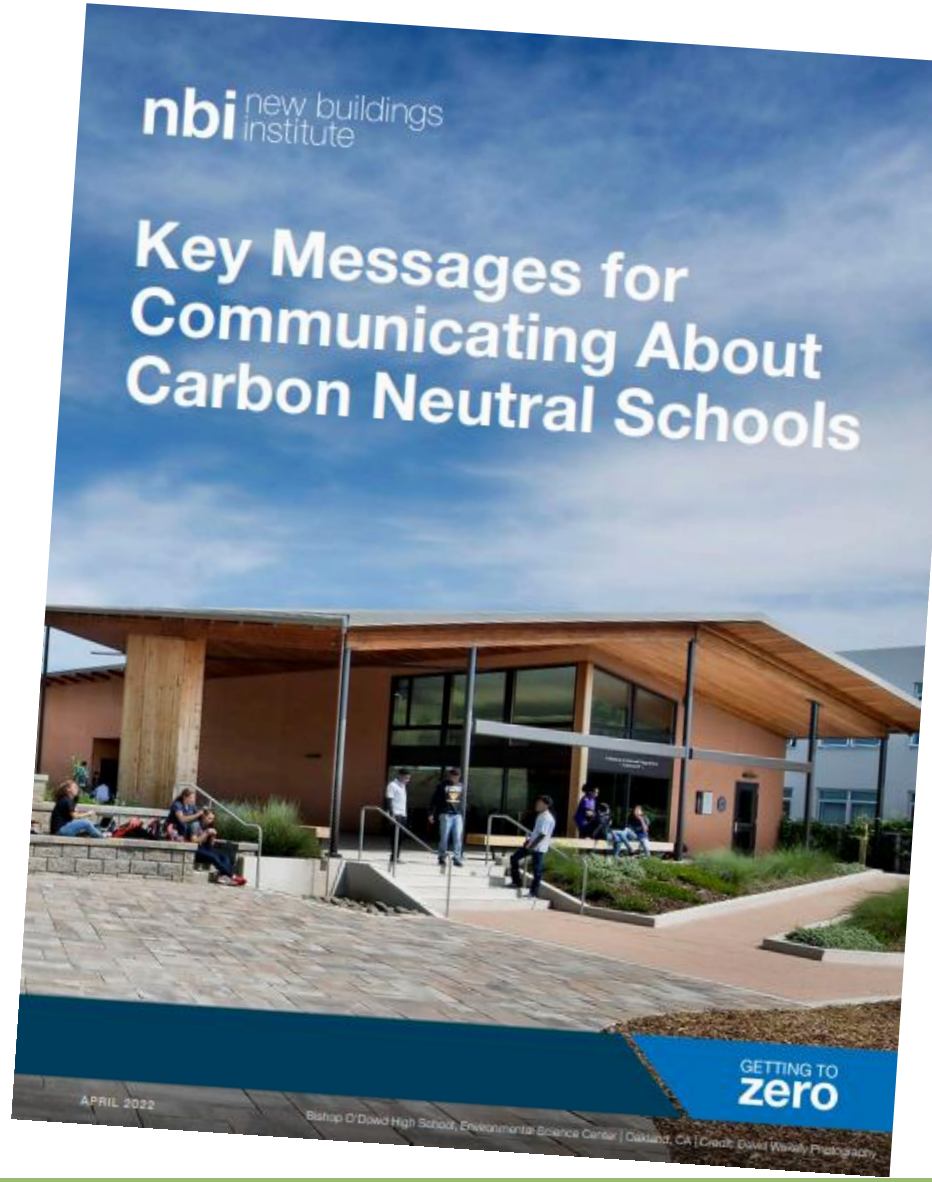
Energy efficiency: opportunity

Schools and educational facilities are the **third largest sector of commercial building energy usage** in the United States.



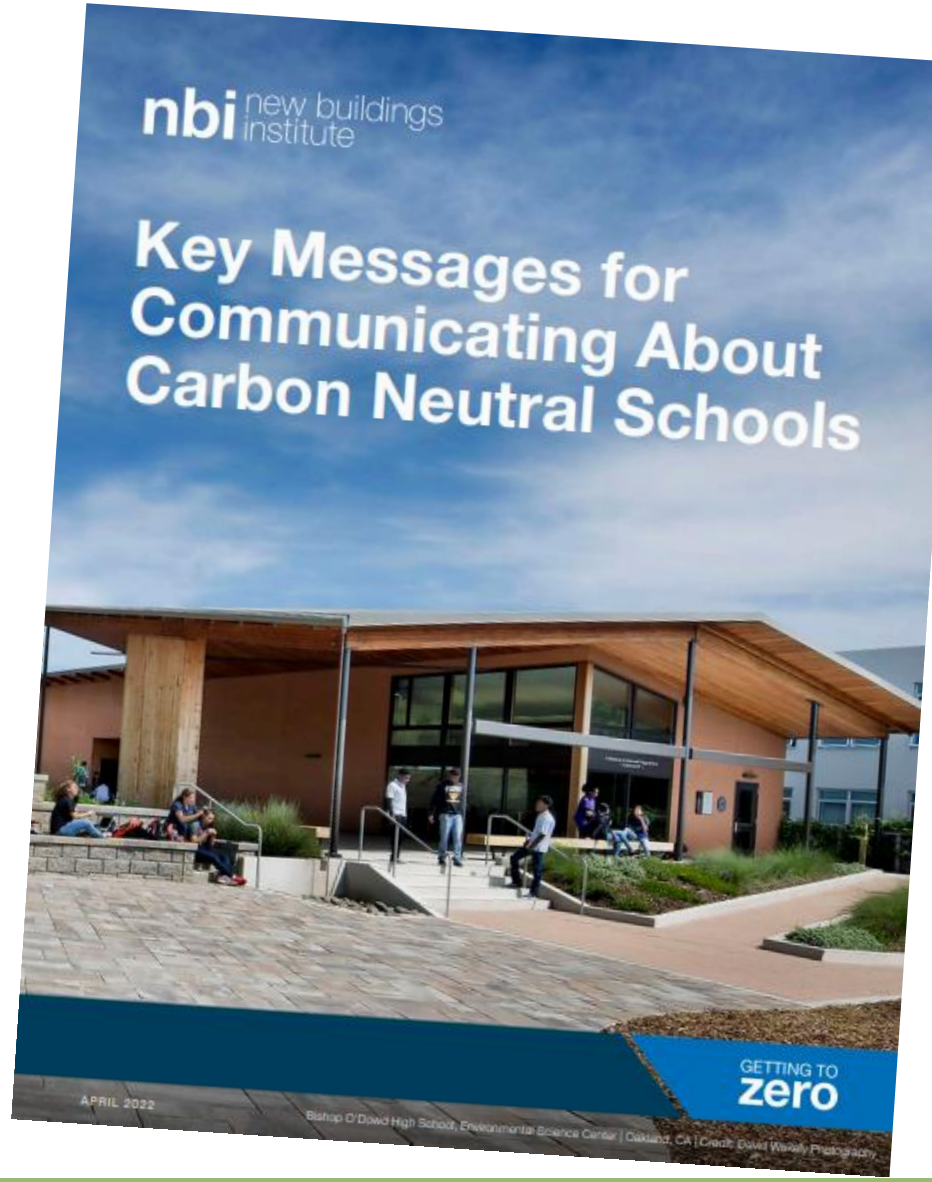
Energy efficiency: opportunity

School building energy consumption costs K-12 school districts in the United States **more than $12.5 billion per year**.



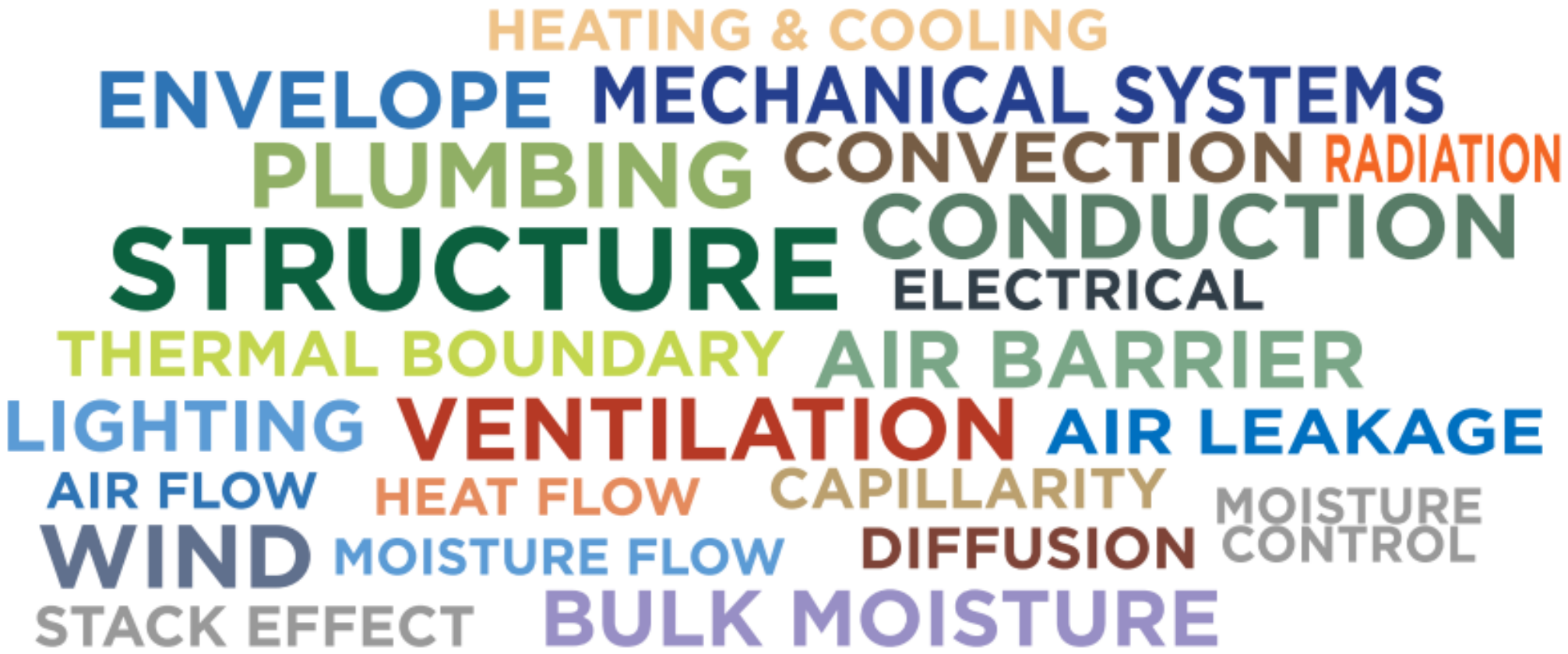
Energy efficiency: opportunity

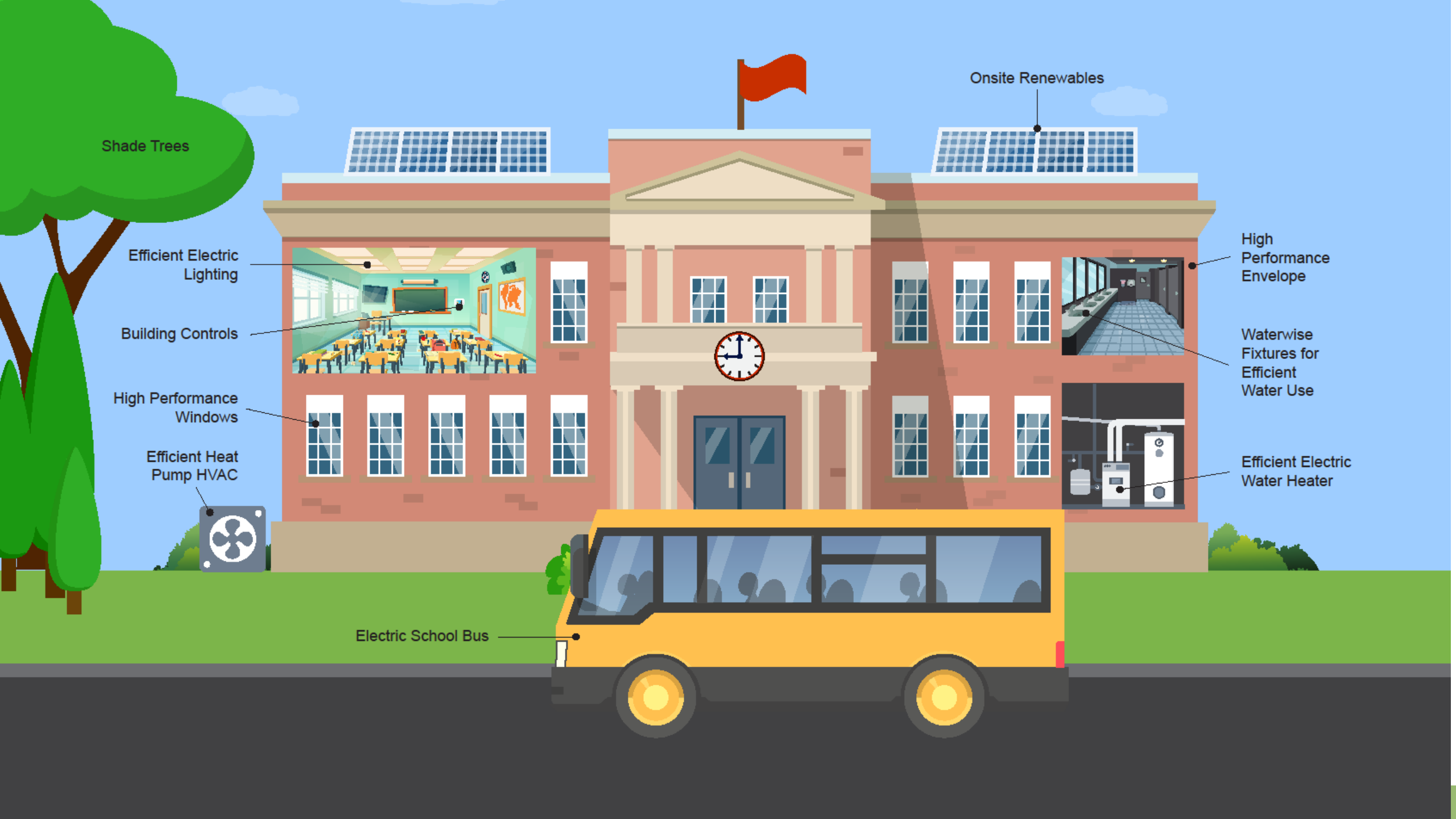
If **only 16%** of high school students in high- and middle-income countries received climate change education, we could see a nearly **19 gigaton reduction of carbon dioxide by 2050**



Sustainable Building Performance

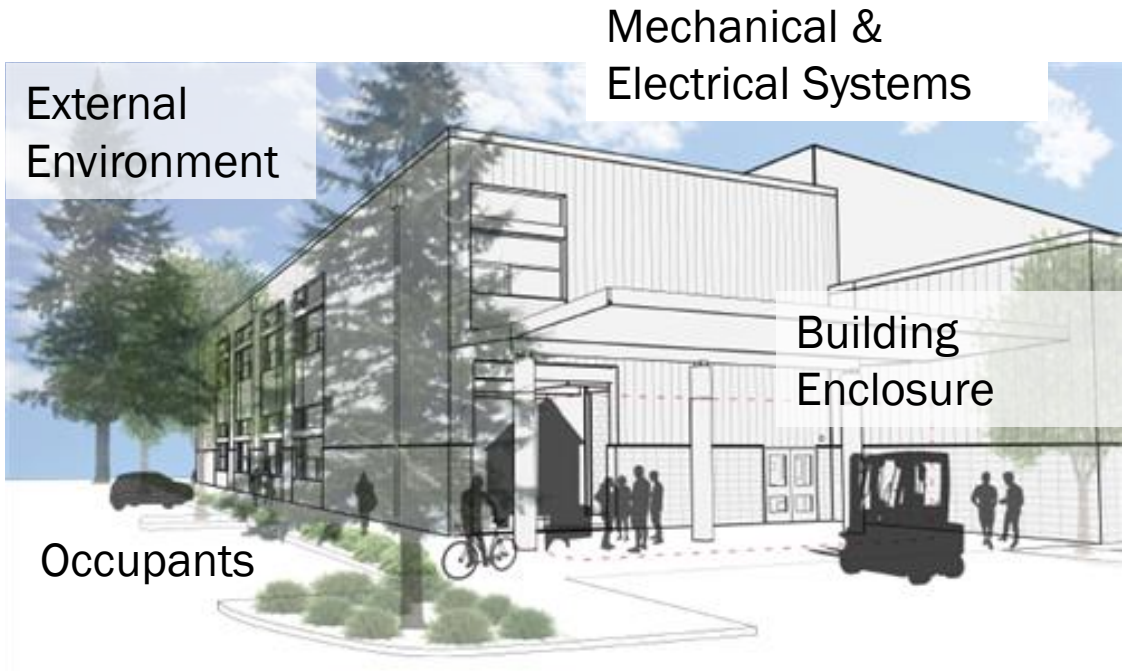
The building is a system




Shade Trees
Onsite Renewables
Efficient Electric Lighting
Building Controls
High Performance Windows
Efficient Heat Pump HVAC
High Performance Envelope
Waterwise Fixtures for Efficient Water Use
Efficient Electric Water Heater
Electric School Bus

The building is a system

- Everything is connected! When planning one system upgrade, consider the impact on the building overall to ensure improved performance
  - Consider both first cost and ongoing equipment costs
- Occupancy in schools matters, and it goes beyond normal school hours



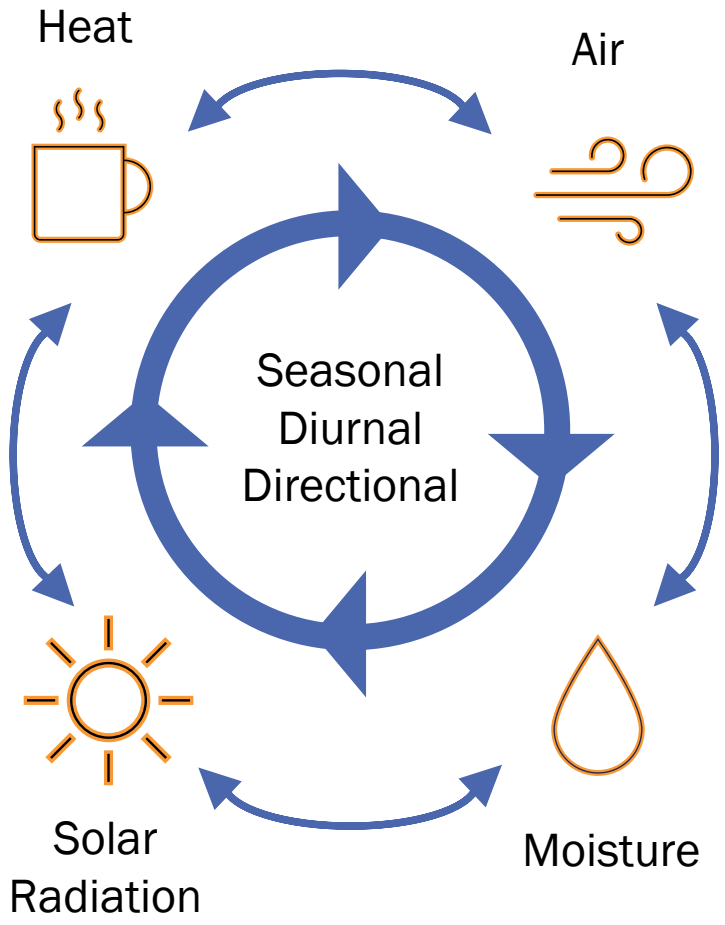
https://www.pps.net/Page/14926

The building is a system

- Rule of thumb: elements will follow the path of least resistance to create equilibrium

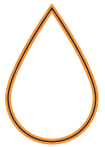
Winter example
(Cold outside, warm inside):

- Heat and warm moist air escape
- Heating system must make up for lost heat
- Humidification required for lost moisture

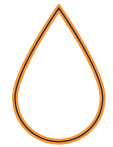


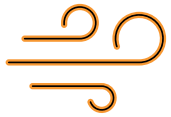
Source: https://www.wbdg.org/resources/building-science-concepts

Climate specific design



Water	Vapor
• Rain • Capillary action (flowing up from ground)	• Condensation • Diffusion • Transported via air leaks

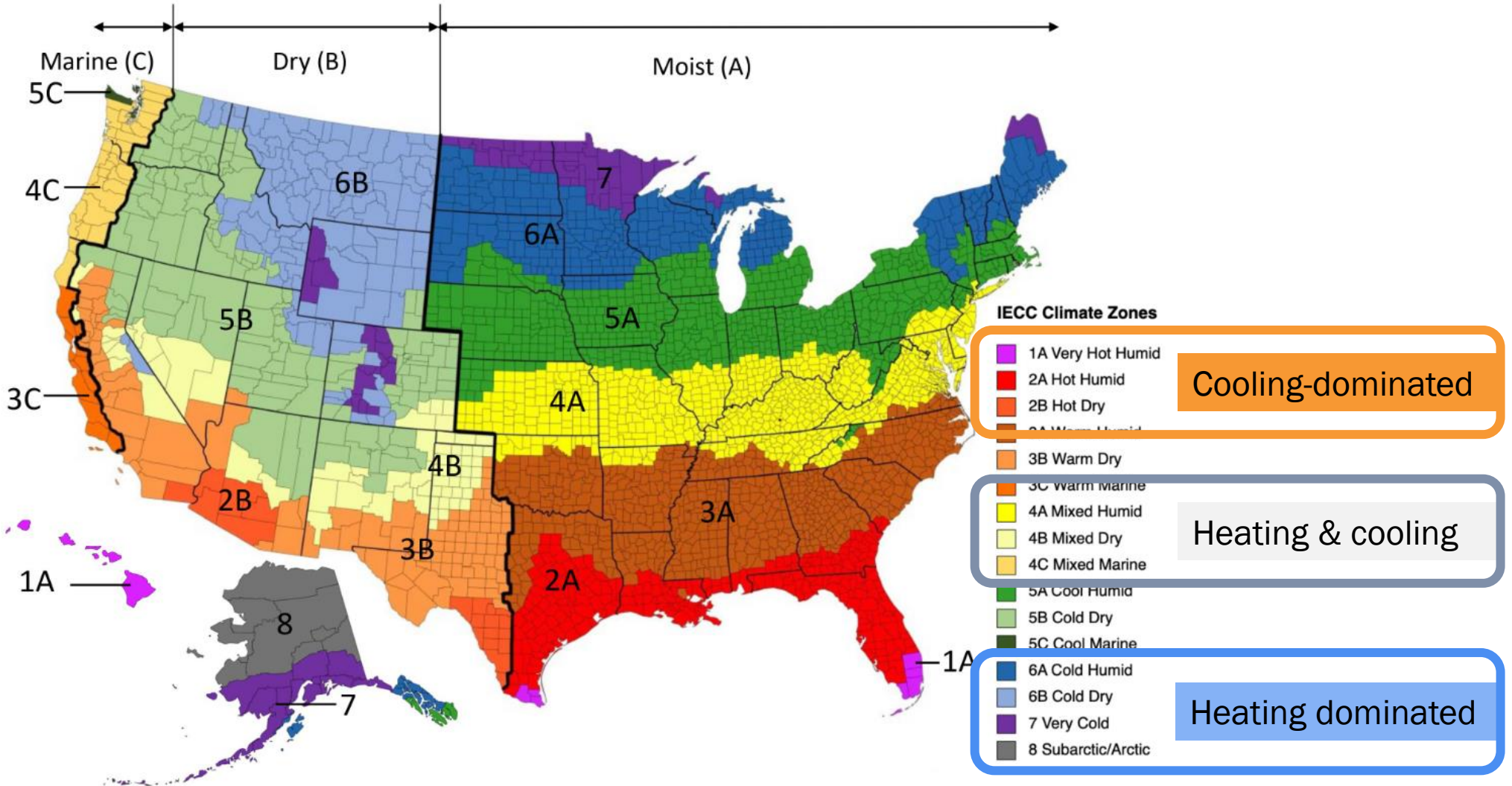




Air Flow	Heat Transfer

• Unintentional Ventilation:
  • Infiltration & Exfiltration
• Intentional Ventilation
  • Mechanical and Passive
	• Conduction
	• Convection
	• Radiation

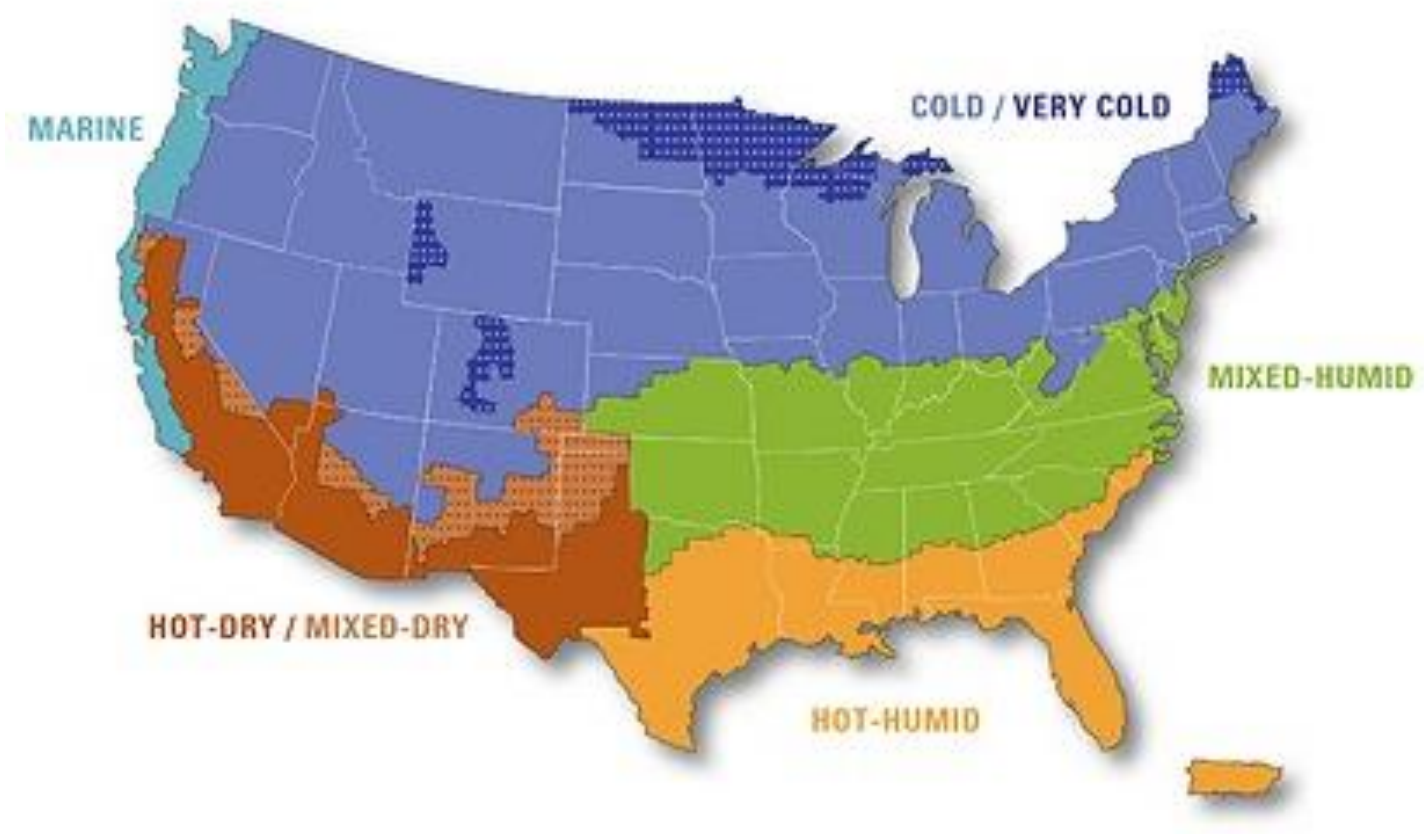
Climate specific design



Source: https://codes.iccsafe.org/content/IECC2021P1

Climate specific design

- Weather norms
  - Precipitation
  - Flooding and stormwater management
  - Tornadoes and high winds
  - Seismic events
  - Forest fires
- Outdoor air pollution levels
- Ambient noise



Source: https://www.energy.gov/eere/buildings/building-america-climate-specific-guidance

Linking back to sustainability

- Consider the building as a system and how to limit environmental impact during all phases of the building life cycle:
  - Proper siting
  - Energy use optimization
  - Water conservation and protection
  - Responsible material selection and use
  - High IEQ
  - Operational & Maintenance Practices

- Many resources and programs offer metrics to assess sustainability

Stretch break!

Please move your body or grab what you need to. This will be quick!

Project Planning

Overall approach

Getting to zero over time is a concept that ensures the correct tools are in place to address a building lifecycle event in a way that aligns with the school district's long-term energy and carbon reduction goals.

2045
Carbon Neutral School Building Portfolio

2040
Portfolio-wide energy consumption **80%** below baseline

2030
Portfolio-wide energy consumption **40%** below baseline

New Construction
EUI of 20 kBtu/sf-yr
All-electric Zero Net Energy capable.

Major Modernization
EUI of 25-30 kBtu/sf-yr
Remove natural gas where possible.

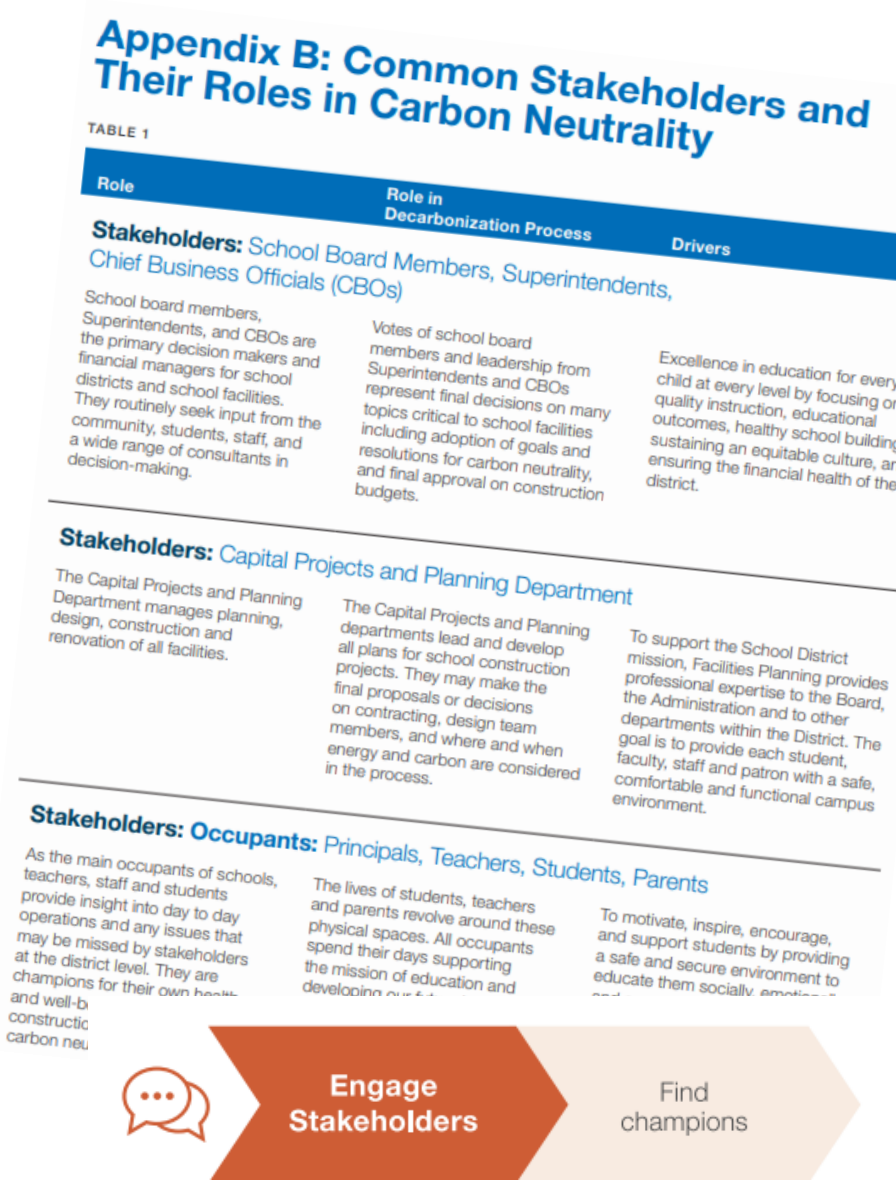
Retrofits
Highly efficient systems.
Remove natural gas where possible.

System Replacement
Always replace with "better-than" systems.

High-level process

Assembling a team

Decision makers	School Business Officer or Official
	Superintendent or Asst Superintendent
Planning & Development	Planning and Construction
	Sustainability
Support Staff	Kitchen and Nutrition Services
	Facilities and Grounds
	Transportation
	Maintenance and Operations
	Information Technology
Occupants	Teachers
	Students
Community	Communications Team
	PTA



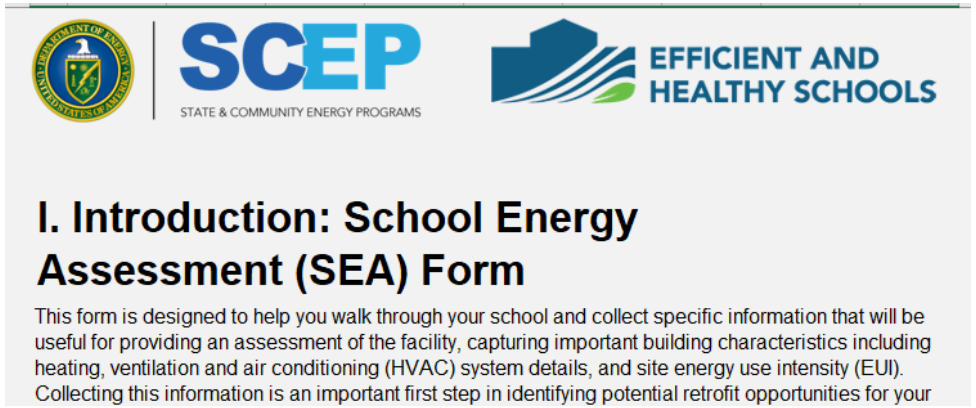
Appendix B: Common Stakeholders and Their Roles in Carbon Neutrality

TABLE 1

Role	Role in Decarbonization Process	Drivers
Stakeholders: School Board Members, Superintendents, Chief Business Officials (CBOs)		
School board members, Superintendents, and CBOs are the primary decision makers and financial managers for school districts and school facilities. They routinely seek input from the community, students, staff, and a wide range of consultants in decision-making.	Votes of school board members and leadership from Superintendents and CBOs represent final decisions on many topics critical to school facilities including adoption of goals and resolutions for carbon neutrality, and final approval on construction budgets.	Excellence in education for every child at every level by focusing on quality instruction, educational outcomes, healthy school building sustaining an equitable culture, ar ensuring the financial health of the district.
Stakeholders: Capital Projects and Planning Department		
The Capital Projects and Planning Department manages planning, design, construction and renovation of all facilities.	The Capital Projects and Planning departments lead and develop all plans for school construction projects. They may make the final proposals or decisions on contracting, design team members, and where and when energy and carbon are considered in the process.	To support the School District mission, Facilities Planning provides professional expertise to the Board, the Administration and to other departments within the District. The goal is to provide each student, faculty, staff and patron with a safe, comfortable and functional campus environment.
Stakeholders: Occupants: Principals, Teachers, Students, Parents		
As the main occupants of schools, teachers, staff and students provide insight into day to day operations and any issues that may be missed by stakeholders at the district level. They are champions for their own health and well-b constructic carbon neu	The lives of students, teachers and parents revolve around these physical spaces. All occupants spend their days supporting the mission of education and developing our fut	To motivate, inspire, encourage, and support students by providing a safe and secure environment to educate them socially, emotion and

Assessment Phase

- ❑ Stock take
- ❑ Understand current energy use:
  - Utilities
  - Meters
  - Tracking mechanism



SCEP
STATE & COMMUNITY ENERGY PROGRAMS

EFFICIENT AND HEALTHY SCHOOLS

I. Introduction: School Energy Assessment (SEA) Form

This form is designed to help you walk through your school and collect specific information that will be useful for providing an assessment of the facility, capturing important building characteristics including heating, ventilation and air conditioning (HVAC) system details, and site energy use intensity (EUI). Collecting this information is an important first step in identifying potential retrofit opportunities for your

The Decarbonization Roadmap Guide for School Building Decision Makers Toolbox

This document is part of the Decarbonization Roadmap Guide for School Building Decision Makers toolbox, download the full document at: https://newbuildings.org/resource/decarbonization-roadmap-guide-for-school-building-decision-makers/

South Tahoe High School | South Lake Tahoe, CA Credit: LPA Inc.

Documents to Inform the Stock Take

Before you get started on the roadmap development, take stock of current stakeholders and activities in the district as they pertain to sustainability, energy, and/or carbon emissions. This initial data dive is called a stock take. It is helpful to uncover relevant plans, goals, and policies as they currently exist in the district.

This document includes a list of common documents uncovered in a stock take that can inform the roadmap. Not all districts will have these documents, and some may have other relevant items to be added. The result of this process may uncover gaps that should be filled, which can become part of the roadmap planning effort.

Roadmap Planner Table 1

Stock Take List and Location of Documents to Inform Roadmap in the Roadmap Planner can be used as a place to track and organize documents.

Documents to Inform Roadmap Collected During the Stock Take

Goals: A list of documentation of any district goals regarding buildings, health, efficiency, or sustainability. Might be found in district resolutions formally or informally adopting sustainability goals, plans, or practices.

Technical specifications for district facilities: Technical design and construction specifications for building projects. Often found in Capital Planning or Facility department documents.

Procurement requirements: Policies or documentation outlining procurement practices. These might apply to equipment or buildings and may even apply down to food and paper products. Typically, these documents are found in Capital Planning of Facility department documents, but also may be centralized in the administrative team in smaller districts.

Technical specifications: "Tech specs" are detailed descriptions indicating all the requirements that cannot be represented or described clearly in construction drawings. In schools, these are often related to the educational specifications that articulate a district's educational philosophy, approach, programs, and goals and translates them into facility requirements. The technical specifications then describe the technical requirements that achieve the facility requirements.

Owners Project Requirements (OPR): An OPR forms the basis from which all design, construction and acceptance decisions are made for construction projects. Often these can be found in the Capital Planning department if this is a document your construction teams utilize.

Energy or carbon report to school board: In districts that have begun public reporting of energy use or carbon emissions. This can be in the form of a simple graph, a website, or more comprehensive annual report. Check with your facilities or sustainability team to see if something like this exists for your district.

School district organizational chart: Chart of school district departments to help identify stakeholders and decision makers.

Stock Take


Key Stakeholders
Goals
Energy Use
Stock Take
Facility O&M Projects
Building List
Capital Project Plans
Facility Master Plans


Assess Building Stock
Benchmark and track performance

Existing Building Assessments

- Unique design features
- Daylighting opportunities, shading
- Air sealing and heat recovery ventilation
- Lighting, unique conditions
- HVAC condition and replacement schedule
- Portables – lighting and HVAC condition
- BMS/occupancy sensors and patterns
- Opportunities in the kitchen

Newcastle Elementary School, Newcastle, CA
Photo Courtesy of Point Energy Innovations

ASHRAE Audits

- Formal energy audit/assessment framework that can be used as an evaluation tool
- Three Levels, depending on where you are at:
  - **Level 1**: identify low-cost or no-cost opportunities for energy savings and areas of energy waste
  - **Level 2**: more detailed building characteristics survey, energy usage and cost analysis
  - **Level 3**: focus on the capital-intensive improvements identified during the level 2 analysis, including comprehensive energy models and a detailed report with project costs, expected savings, and a thorough life cycle cost analysis

Goal Setting: M&V

- How will project success be evaluated?
  - Energy savings
  - GHG reduction
  - EUI (based on energy consumption)
  - Occupant satisfaction
  - ROI
- Measurement & Verification is used to:
  - Determine baselines and estimated savings
  - Verify post-project performance of energy efficiency measures
  - Document ongoing performance

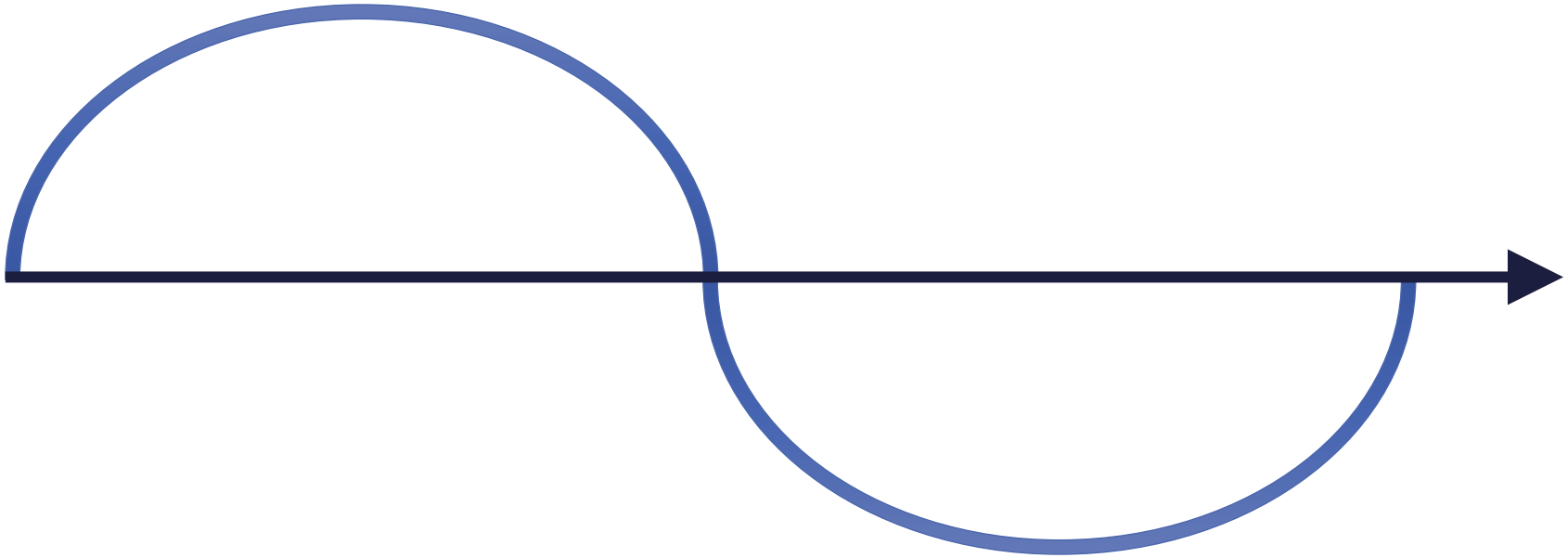
Goal Setting: M&V Plans

- Measurement & Verification (M&V) Plans outline how projects will be evaluated to ensure goals are achieved, including:
  - Baseline data
  - Documentation of all assumptions and data sources
  - Who, what, when of M&V activities
  - Details of engineering analysis (if applicable)
  - How energy and cost savings will be calculated
  - Reporting responsibilities, content, and format

Lifecycle Opportunities

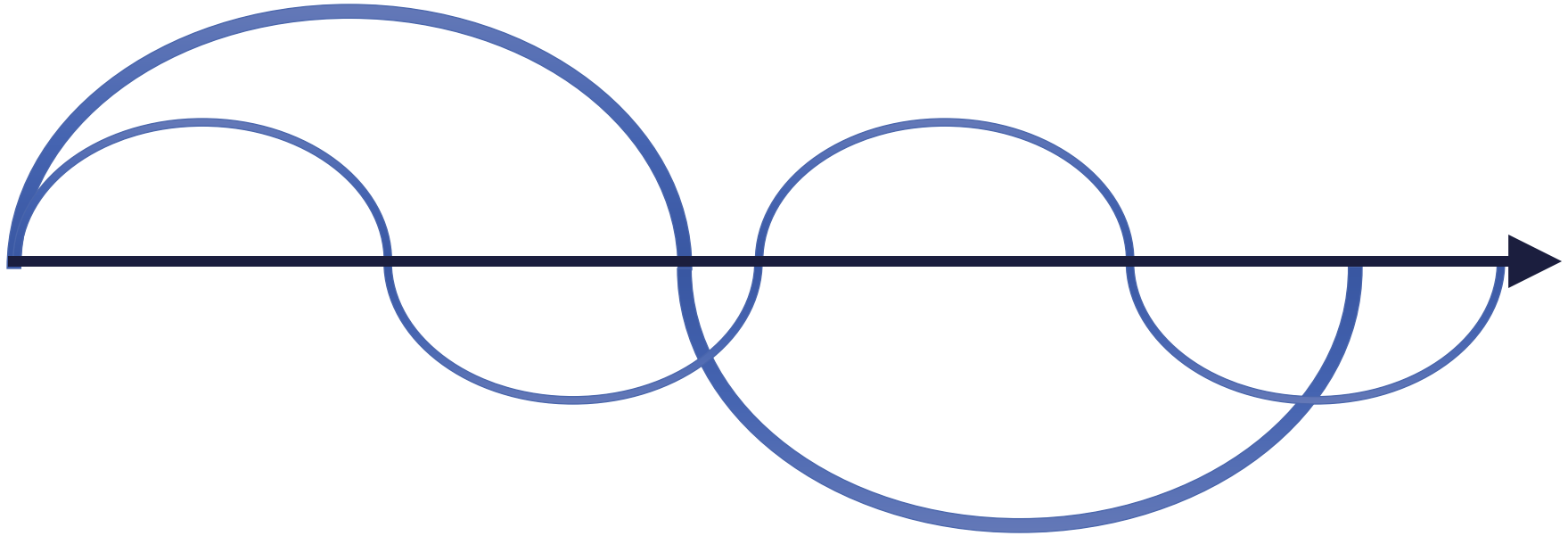
- New Construction
- Major Renovation
- Equipment Replacement
- Operations and Retro-Commissioning
- Bond and Stakeholder Turnover

Lifecycle Opportunities



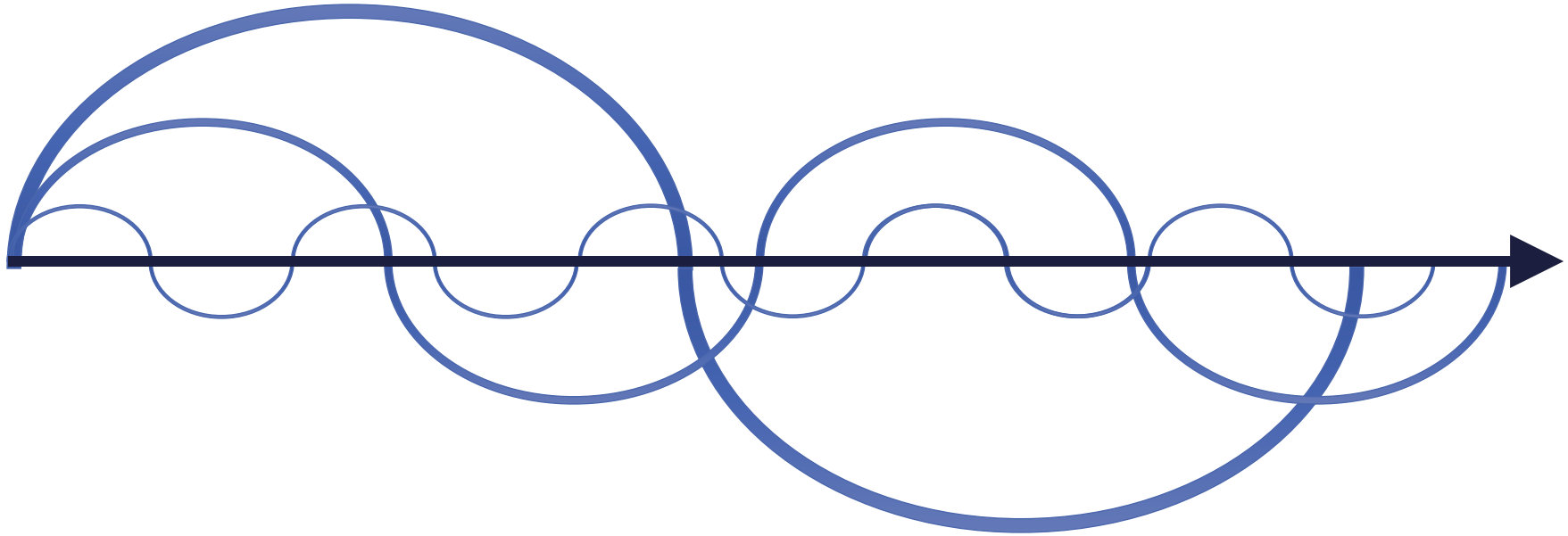
Major Renovation – 30-50 Years

Lifecycle Opportunities



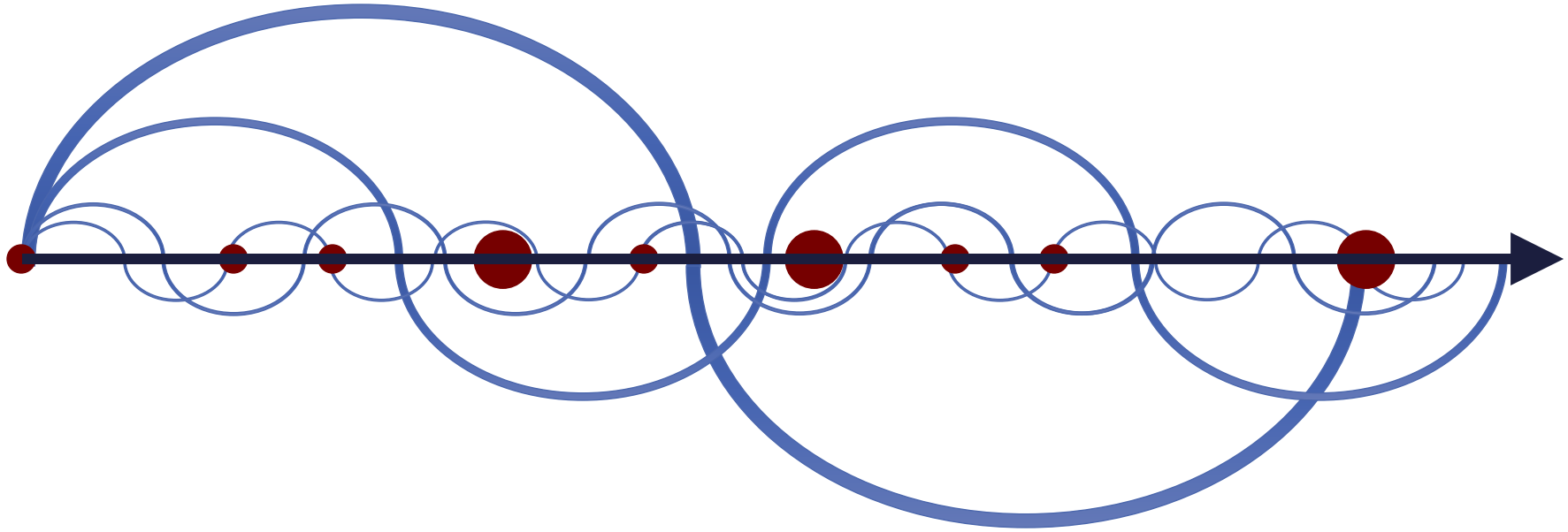
HVAC Replacement – 15-20 Years

Lifecycle Opportunities



Lighting Retrofit – 5-7 Years

Lifecycle Opportunities



Bond Measures and Stakeholder Turnover

Loading order

1. Consider comfort & health first
   - Thermal, acoustic, lighting, views
2. Start with load reduction via efficiency measures
   - Daylighting & other envelope measures
   - Plug loads
   - Lighting loads
3. Look for additional load reduction using mechanical system selection decisions
   - HVAC equipment
4. Investigate EVs, PVs, and renewables

Retrofit Considerations

- Small renovations/repairs, using operating budget vs. large capital construction projects
- Consider unique conditions:
  - Planned retrofits
  - Behavior and preferences
  - Maintenance team needs
  - Peculiar local requirements/inspectors
  - Savings-to-investment ratio limitations

Source: CMTA, Inc.

New Construction Considerations

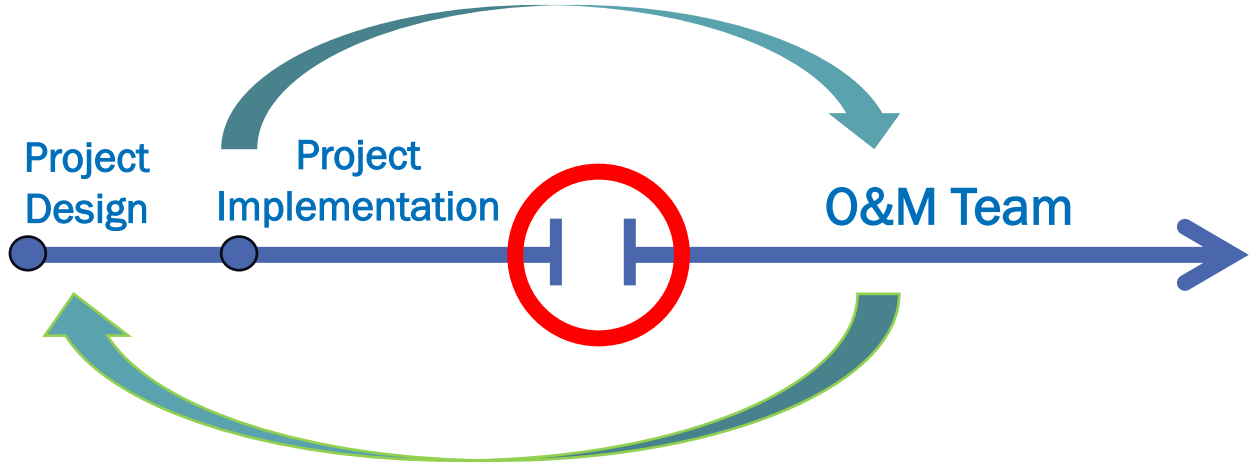
- Orientation and passive design
- Ensuring there is adequate site infrastructure (e.g., electric capacity)
- Selecting efficient, all-electric technologies
- Specify centralized controls
- Consider renewables, EVs, and battery integration
  - Make choices to enable these more easily in the future if not an option at present

The importance of commissioning

- Commissioning ensures the building is delivered according to the OPR
- A Commissioning Agent can train owners and occupants to properly use the system(s) for maximum efficiency
- Ongoing retrocommissioning ensures the system continues to provide expected performance
- Maintain records to track findings and provide a quality assurance mechanism

Operations

- Design with O&M in mind
- Set points and scheduling
- Develop O&M manual and program
  - Include equipment specifications
  - Coordinate with OPR
  - Energy evaluation
  - Benchmarking and metering is key
- Train building operators and occupants
- Conduct ongoing commissioning



Operations

- Meter and monitor energy performance
  - Provide real time energy use feedback
    - Smart energy meters can be relatively cheap, and also inform on power quality or used by IT at locations with significant IT infrastructure
  - Provide visual display and feedback for users
    - Education program for teachers, staff, and students
  - Use M&V, commissioning records, benchmarking to measure and report regularly
- Building automation system review
- Compare to predictions
- Report on progress toward goals

Discussion

1. What ways do you see building systems directly impacting your staff and students?
2. What aspects or systems of your building have been the most successful? Most challenging?
3. What building systems are you most interested in learning about in Live Session 2?

Thank you!

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