Bishop O'Dowd High School | Oakland, CA *Credit: David Wakely Photography*

Getting to Zero in Schools Workshop

October 9, 2019

nbi new buildings institute

Welcome!

nbi new buildings institute

New Buildings Institute

Driving energy and carbon emissions reductions in the built environment.

Program areas include:

1. Advanced buildings
2. Getting to zero leadership
3. Code and policy innovation

Learning Objectives

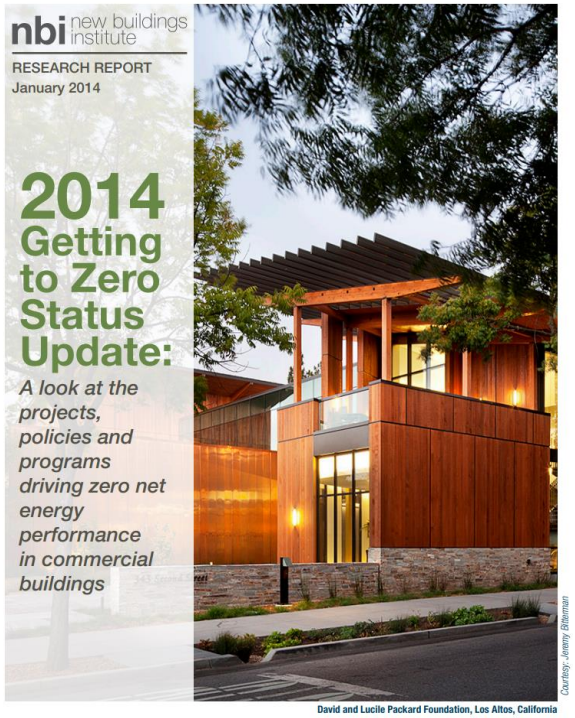
- Participants will understand the process associated with designing and constructing a school to zero energy.
- Participants will be able to utilize lessons learned and approaches uncovered through studies and experience by schools on the path to zero through access to zero energy school experts.
- Participants will be given the opportunity to collaborate with other school districts as they brainstorm how to implement and support zero energy school projects in their own communities.
- Participants will be able to apply planning and technical tools needed to achieve successful zero energy project planning, financing, design, construction, and operations.

Status of Getting to Zero in Schools

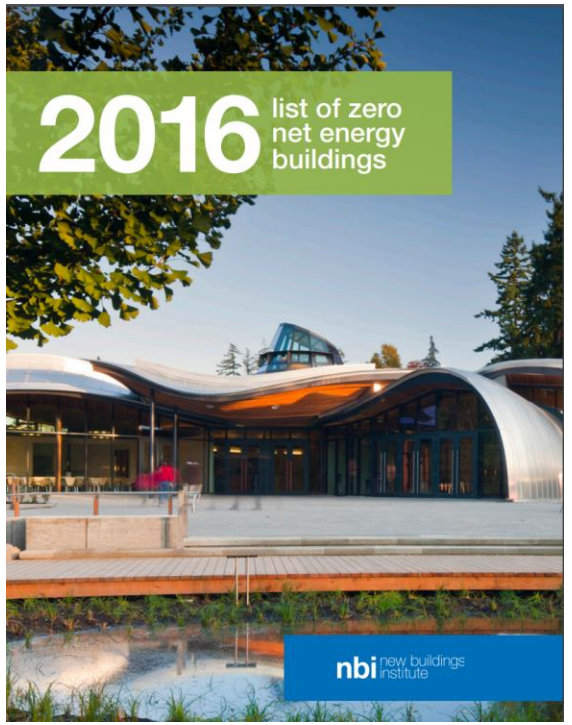
nbi new buildings institute

2012

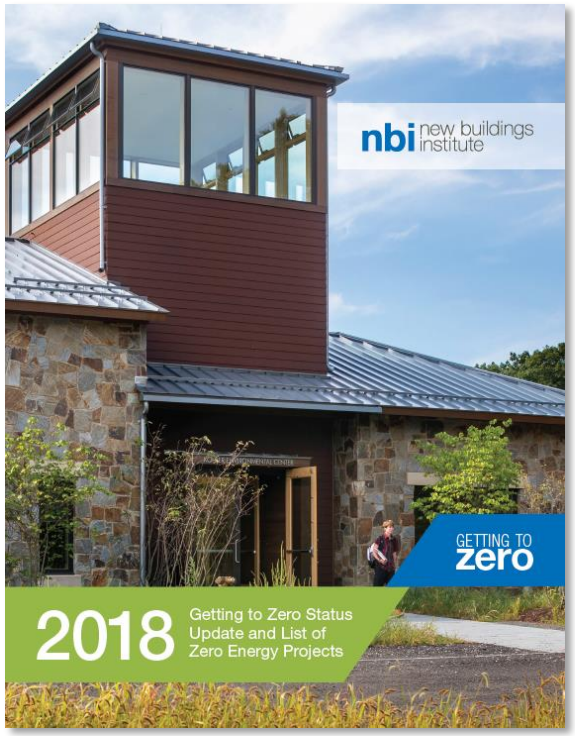
2014



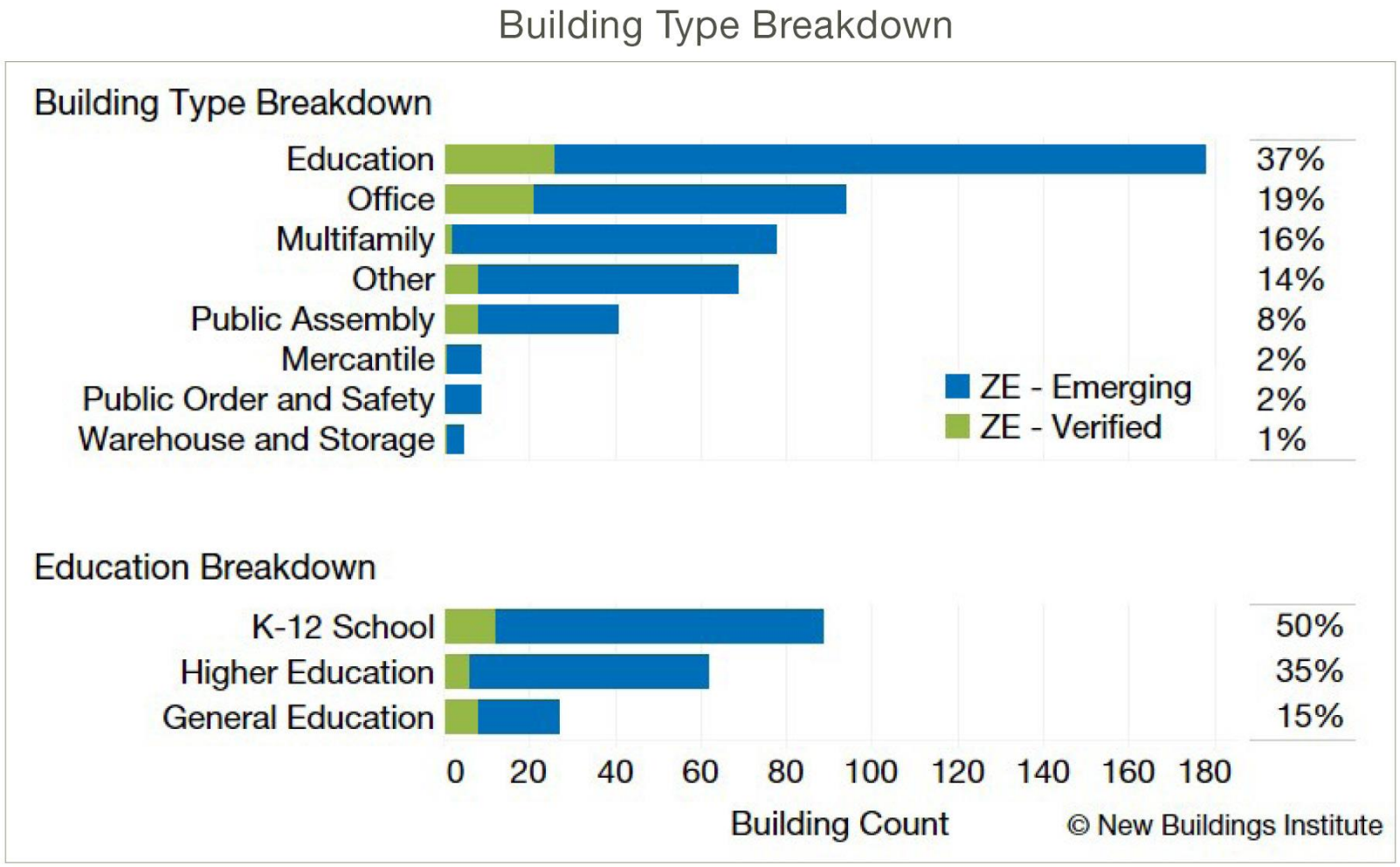
2016

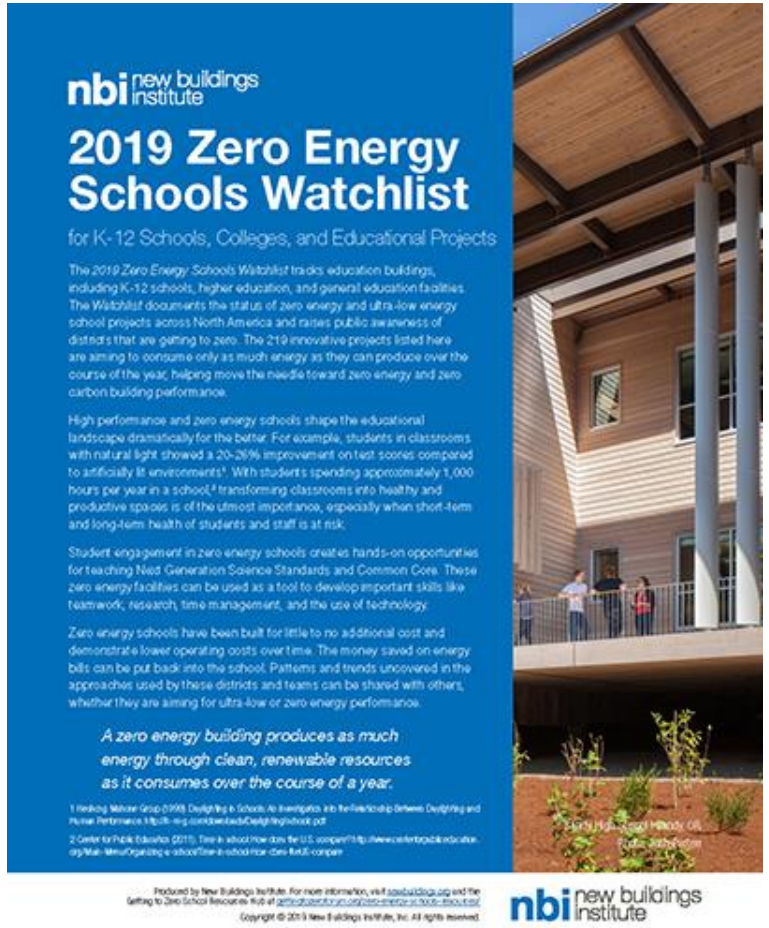


2018

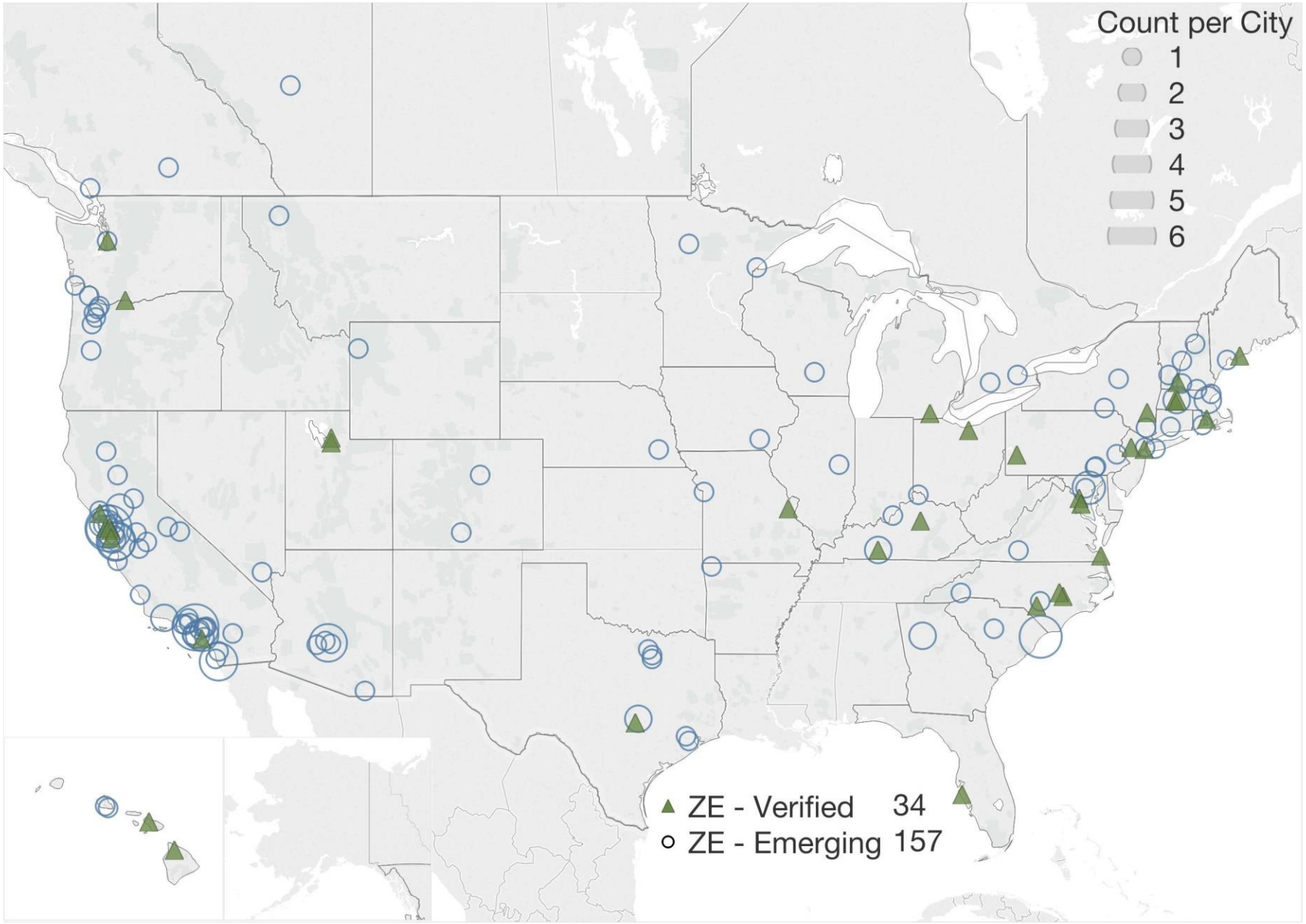


Schools are Leading!





Location of Zero Net Energy Schools



nbi new buildings institute

Energy Performance of Emerging and Verified ZNE Schools

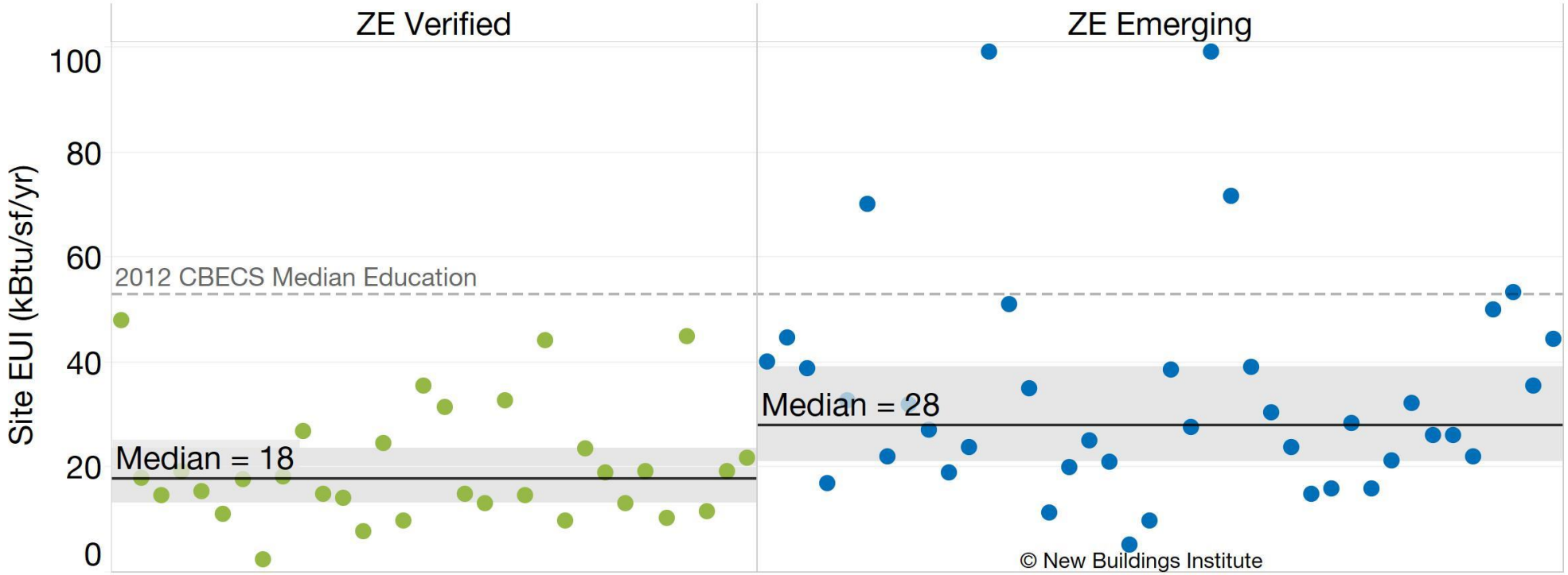
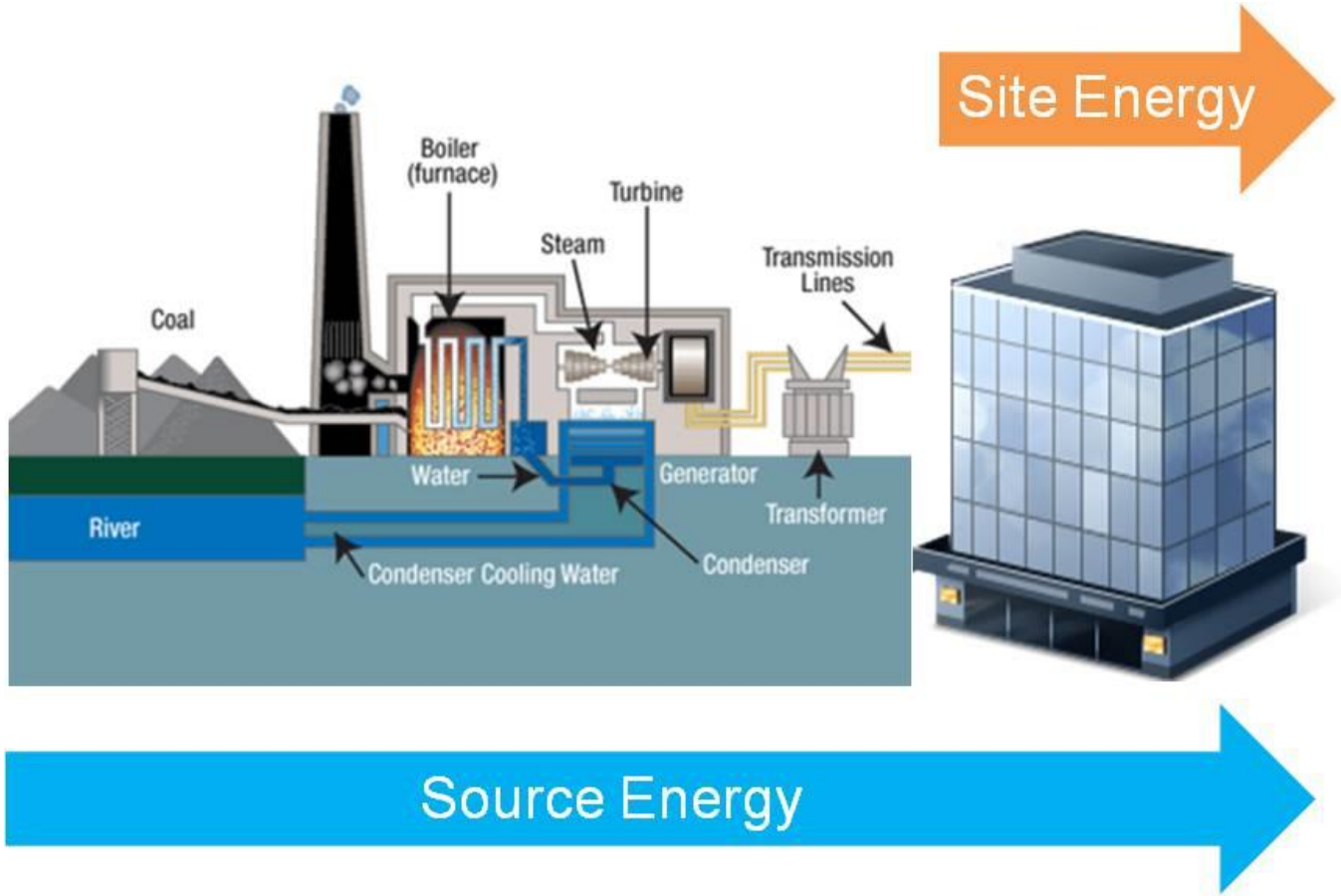


Photo: Richardsville Elementary | Bowling Green, KY *Credit: Sherman-Carter-Barnhart Architects*

Definitions Matter

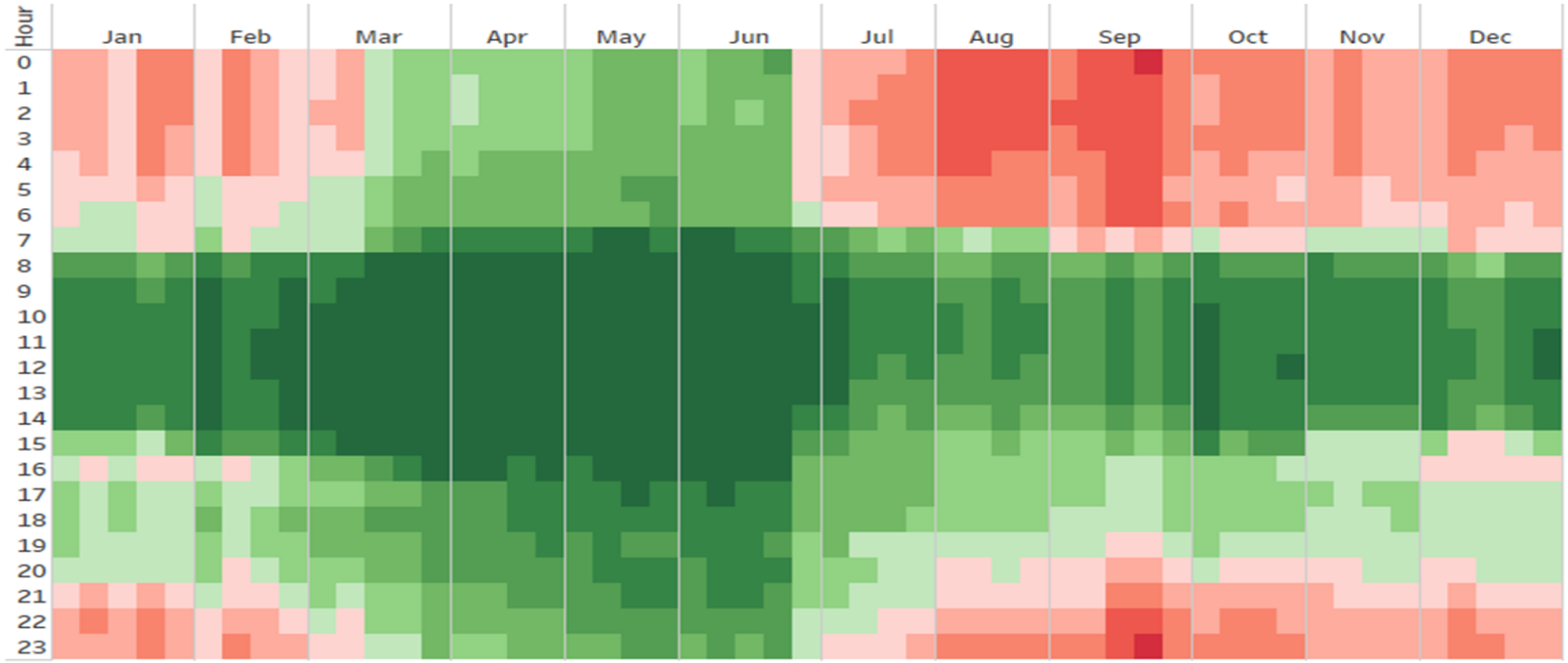


148 kBtu/ft^2/year **Source**

67 kBtu/ft^2/year **Site**

- Zero Net Energy
- Zero Net Energy Site
- Zero Net Energy Source
- Time Dependent Valuation
- Zero Net Carbon

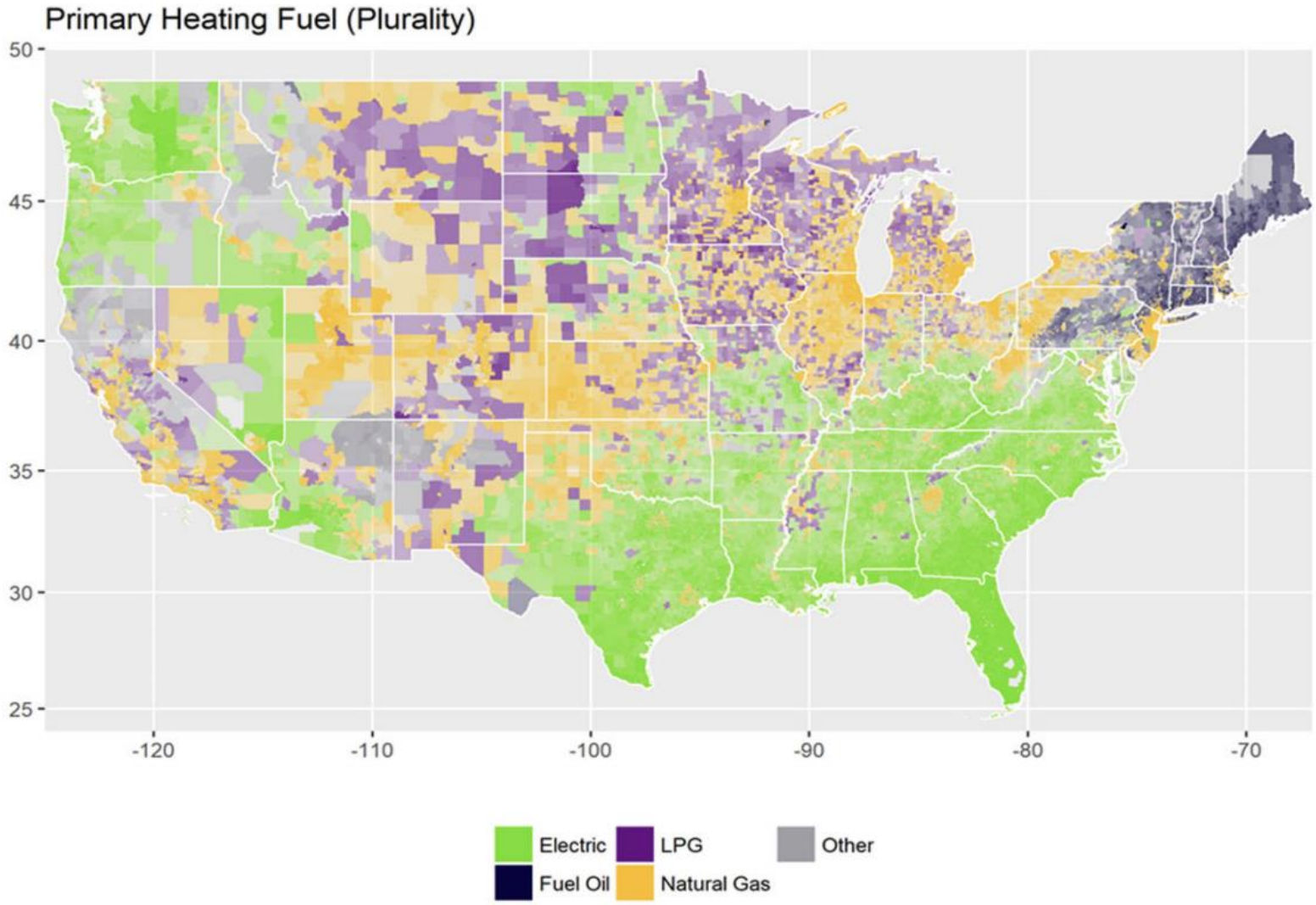
Energy and Carbon Are Not the Same



The carbon intensity of energy use depends on the local grid conditions, the time of the year and the time of the day.

Fuel Choice Greatly Impacts Carbon Emissions

Natural gas provides most space heating in the U.S., but regional differences exist, and climate differences are significant.



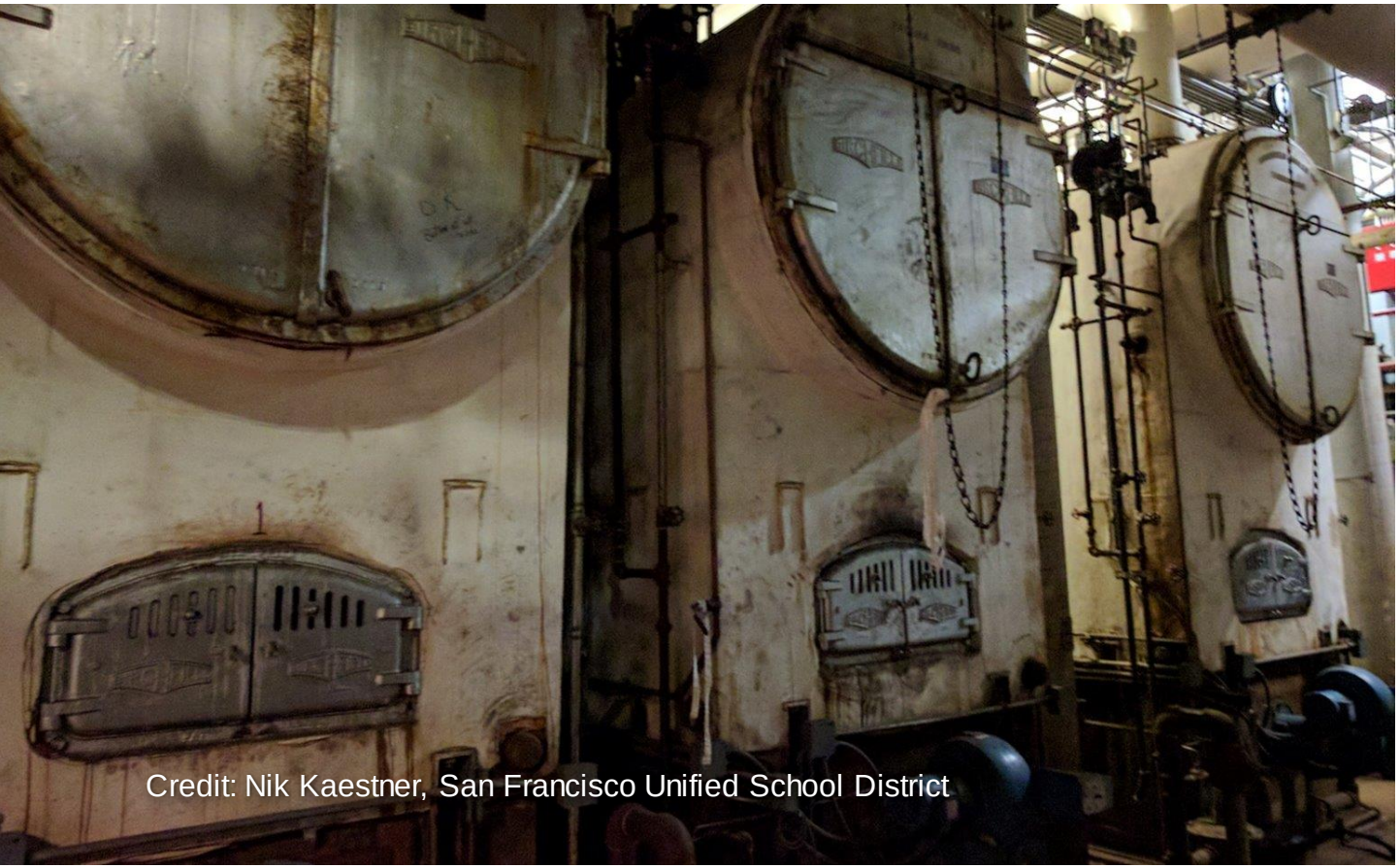
Graphic from Energy + Environmental Economics Pathways to 2050

Factors Influencing Decarbonization

1. Clean energy supply
2. Energy efficiency
3. Demand flexibility

California Lottery Santa Fe Springs | Santa Fe Springs, CA *Credit: LPAS Architecture + Design*

Gas Use in Schools



Credit: Nik Kaestner, San Francisco Unified School District

Credit: CT Brayton and Sons Incorporated

Getting to Zero Over Time

School districts can start now!

- Benchmark
- Set targets and policies
- Align with building lifecycle opportunities
- Load reduction
- System selection
- Renewables
- Electric bus/vehicles

Richardsville Elementary | Bowling Green, KY
Credit: Sherman-Carter-Barnhart Architects

Getting to Zero in Schools: An Introduction to the Process

The Process to Achieve Zero

- Get stakeholder support
- Make a commitment
- Set energy targets
- Integrate targets into policies and contracts
- Use integrated design to design and construct to target
- Optimize operations
- Measure, verify and report

Gain Support Getting to Zero

- Identify stakeholders & key messages
- Share case studies & fact sheets
- Tour nearby schools or share video case studies with decision makers
  - Patriot Hall Video - https://energytrust.org/pathtonetzero/
  - Discovery ES Video - https://www.zeroenergy.org/video-case-study/

High Performance Schools Fast Facts

Did you know that the classroom environment can affect a child's academic progress over a year by as much as

25%[1]

65%

Reduction in asthma cases among elementary students when school indoor environment quality improves.[2]

3%

Reduction in teacher turnover in green schools - saving US$4 per square foot over a 20 year period.[3]

20%

Faster progression in math in schools with good daylighting.[4]

26%

Faster progression in reading in schools with good daylighting.[4]

10%

Increase in overall performance in schools with good daylighting.[4]

School buildings as a tool to enhance student learning.

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

The Winning Pitch for Efficiency

Watt Does it Cost to Use It?

Directions: Using the key on the back of this sheet, your group members and a calculator; complete this energy usage table. Then in the rank column; rank each energy user from highest to lowest "energy hog".

Names: _____ School: _____

Item	Wattage (Watt hours, Wh)	Hours used/day	Hours used/month (20 school days/month)	Power needs per month (Wh)	Power needs per month (kWh)	Cost per month ($0.10 per kWh)	Cost per school year (Based on 9 month school yr)	Rank
Fluorescent lights	32 Wh	10 hrs	200 hrs	6,400 Wh	6.4 kWh	$0.6	$6	
Gymnasium high intensity lights	300	24 hrs**	744 hrs					
copy machine	330	24 hrs**	744 hrs					
printer	50	2 hrs	40 hrs	2,000	2.0	$0.2	$2	
computers	200	6 hrs	120 hrs					
refrigerator	350	6 hrs **	186 hrs	65,100	65.1	$6.5	$59	
vending machine	400	6 hrs**	186 hrs					
TV's	200	4 hrs	80 hrs					
smartboards	175	6 hrs	120 hrs	21,000	21.0	$2.1	$19	
Microwave	1000	1 hr	20 hrs	20,000	20.0	$2.0	$18	

Next Generation Science Standards

- **Analyzing and Interpreting Data:** Engineering Design and Human Impacts Energy
- **Influence of Science, Engineering, and Technology on Society and the Natural World:** Engineering Design
- **ESS3.C: Human Impacts on Earth Systems:** Human Impacts
- **Science Addresses Questions About the Natural and Material World:** Human Impacts
- **Constructing Explanations and Designing Solutions:** Energy
- **Engaging in Argument from Evidence:** Energy
- **ETS1.B: Developing Possible Solutions:** Energy **… and more!**

Financing Approaches

- School Bond Funding
- Solar Production Incentives
- Energy Efficiency Incentive Programs
- Energy Efficiency and Solar Grant Program
- Power Purchase Agreements (PPAs)
- Energy Service Company contracts

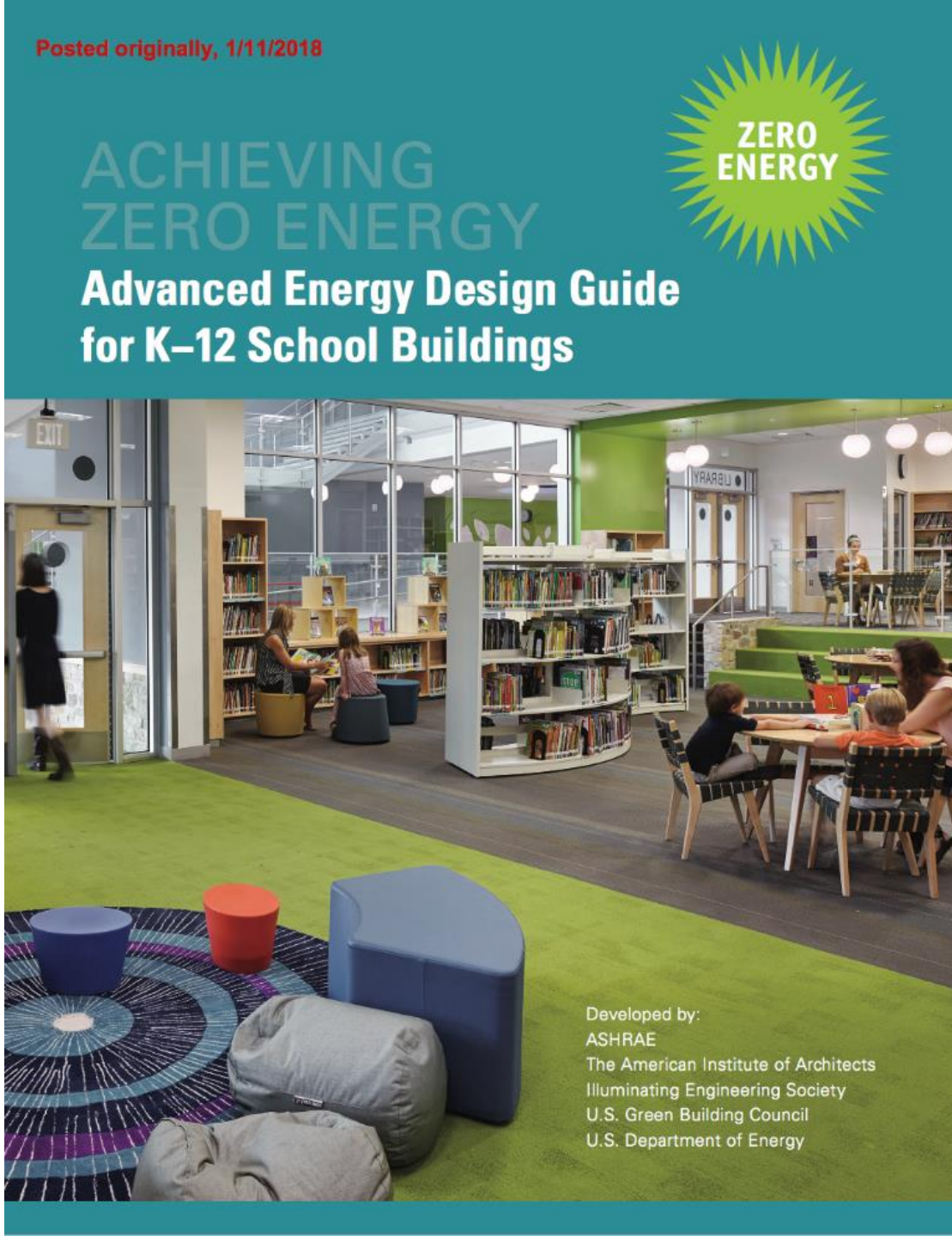
Redding School for the Arts | Redding, CA
Credit: TRILOGY Architecture

Make a Commitment

- Start Early!
- Benchmark
- Set goals
- Select a champion
- Regularly report progress toward goals
- Attend webinars and trainings

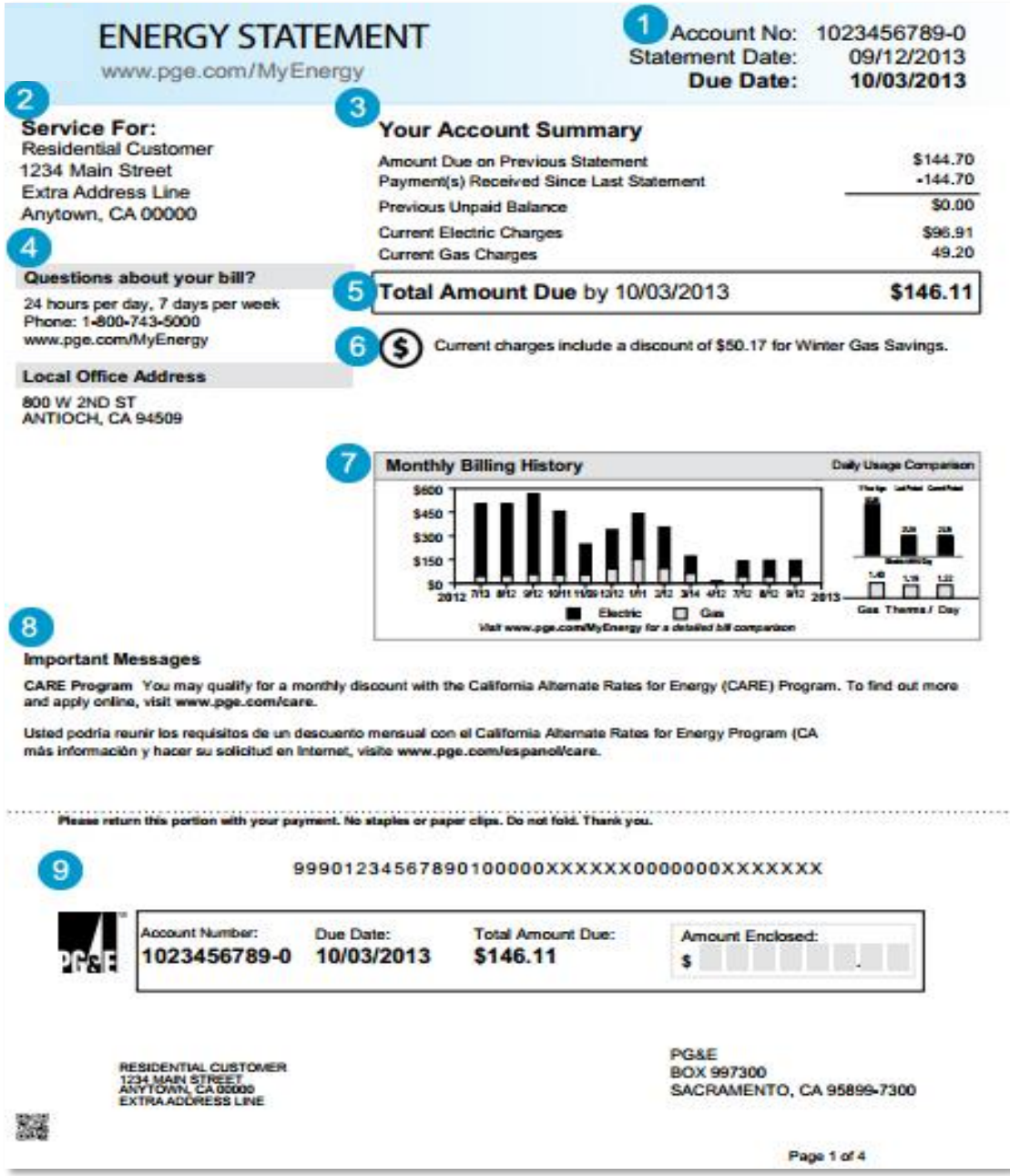
Establish an Energy Target

- More than beyond “xx% better than code”
- Absolute energy ”EUI” target
- EUI of 16-25 kBtu/sf-year
- Link to other sustainability programs and goals
  - CHPS
  - LEED



Benchmarking

- Collect energy consumption
  - 2-3 years
- Benchmark use against
  - CBECS, other schools in district
- Useful tools include :
  - ENERGY STAR Portfolio Manager
  - Online data tracking
  - School Dude & Others
  - Excel, google sheets



ENERGY STATEMENT
www.pge.com/MyEnergy

1 Account No: 1023456789-0
Statement Date: 09/12/2013
Due Date: 10/03/2013

2 Service For:
Residential Customer
1234 Main Street
Extra Address Line
Anytown, CA 00000

3 Your Account Summary

Amount Due on Previous Statement	$144.70
Payment(s) Received Since Last Statement	-144.70
Previous Unpaid Balance	$0.00
Current Electric Charges	$96.91
Current Gas Charges	49.20

4 Questions about your bill?
24 hours per day, 7 days per week
Phone: 1-800-743-5000
www.pge.com/MyEnergy

5 Total Amount Due by 10/03/2013 $146.11

6 $ Current charges include a discount of $50.17 for Winter Gas Savings.

Local Office Address
800 W 2ND ST
ANTIOCH, CA 94509

7 Monthly Billing History
Daily Usage Comparison
Electric Gas
Visit www.pge.com/MyEnergy for a detailed bill comparison

8 Important Messages
CARE Program You may qualify for a monthly discount with the California Alternate Rates for Energy (CARE) Program. To find out more and apply online, visit www.pge.com/care.

Usted podría reunir los requisitos de un descuento mensual con el California Alternate Rates for Energy Program (CA más información y hacer su solicitud en Internet, visite www.pge.com/espanol/care.

Please return this portion with your payment. No staples or paper clips. Do not fold. Thank you.

9 9990123456789010000OXXXXXX0000000XXXXXXX

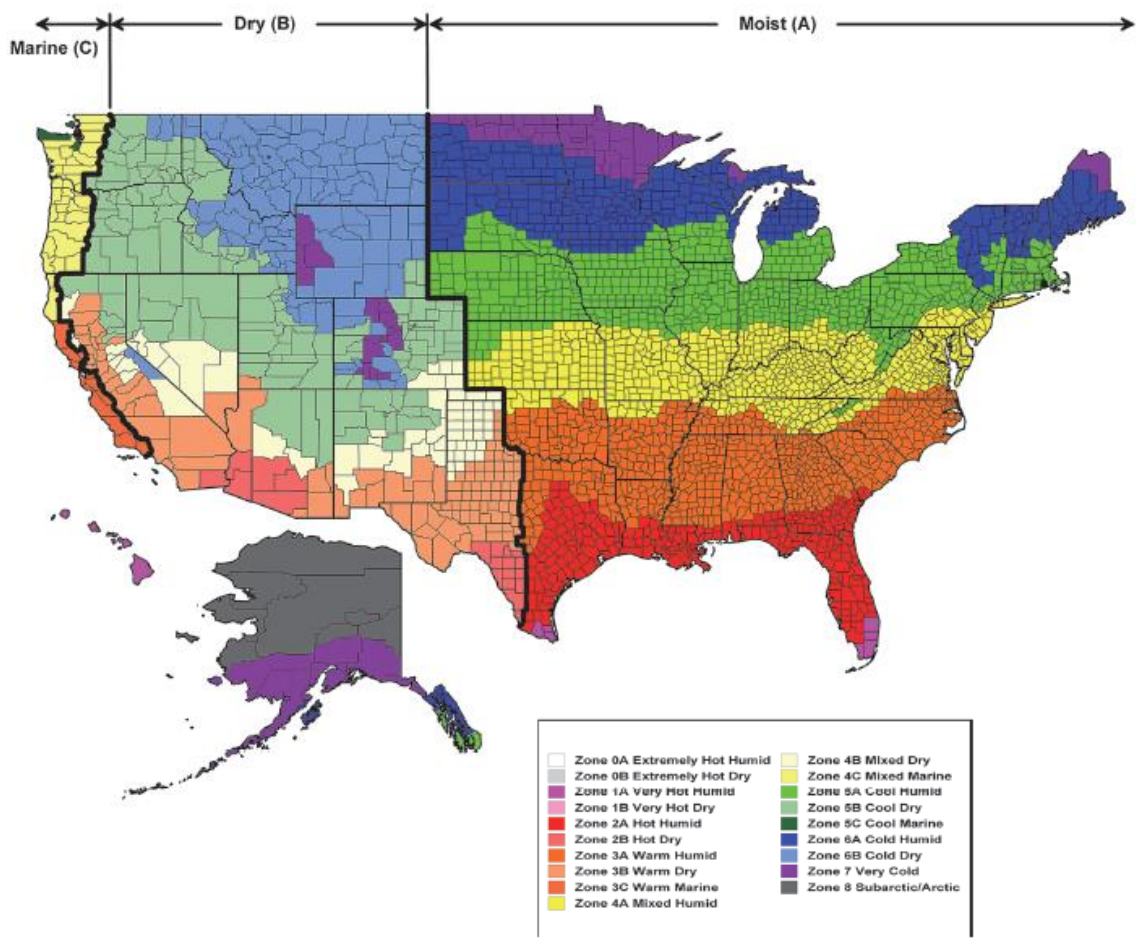
Account Number:	Due Date:	Total Amount Due:	Amount Enclosed:
1023456789-0	10/03/2013	$146.11	$

RESIDENTIAL CUSTOMER
1234 MAIN STREET
ANYTOWN, CA 00000
EXTRA ADDRESS LINE

PG&E
BOX 997300
SACRAMENTO, CA 95899-7300

Page 1 of 4

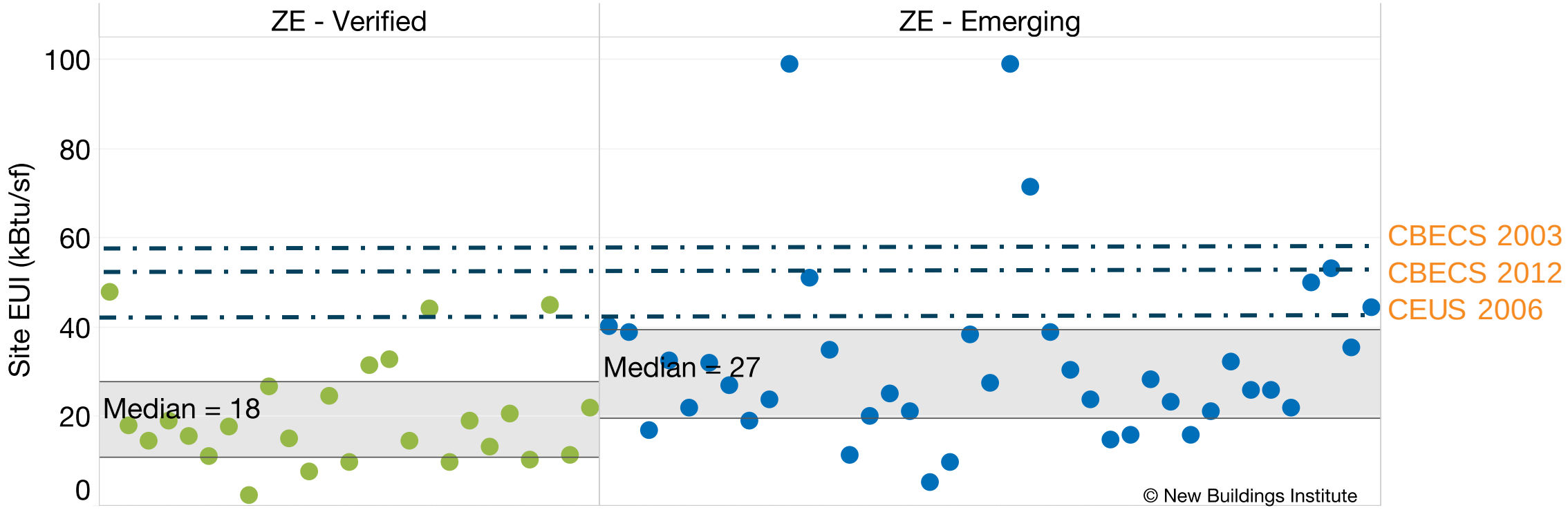
Zero Energy Use Intensity (EUI) Targets for Schools



Climate Zone	Site Energy		Source Energy	
	Primary School EUI, kBtu/ft^2·yr	Secondary School EUI, kBtu/ft^2·yr	Primary School EUI, kBtu/ft^2·yr	Secondary School EUI, kBtu/ft^2·yr
0A	22.5	22.9	69.1	70.5
0B	23.1	23.2	71.4	71.6
1A	21.3	21.1	65.5	65.0
1B	21.7	21.6	66.6	66.6
2A	20.9	21.3	63.8	65.1
2B	19.6	19.9	59.7	60.8
3A	18.8	19.1	56.7	57.7
3B	19.0	19.4	57.3	58.8
3C	17.5	17.6	52.6	52.8
4A	18.8	18.9	56.3	56.7
4B	18.4	18.5	55.1	55.5
4C	17.5	17.6	51.9	52.3
5A	19.2	19.1	57.1	56.9
5B	18.7	19.0	55.6	56.6
5C	17.4	17.6	49.7	52.3
6A	21.1	20.6	62.8	61.2
6B	19.5	19.5	57.9	57.9
7	22.3	21.5	66.2	63.7
8	25.2	23.8	71.1	70.7

AEDG Zero Energy K-12 Schools Guide: https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download

EUI Range of Performance in Schools



Using Energy Targets in Policies and Practices

SFUSD PROJECT REQUIREMENTS

ZERO NET ENERGY

All buildings will use less than 20 kBTU/sf/yr by 2040

STRATEGY

The District has many opportunities to improve the carbon footprint of its buildings:

BOND PROJECTS: voter-approved funding for new construction & major renovations provides the best opportunity for deep energy retrofits

MONITORING: post-occupancy commissioning and energy monitoring can identify opportunities to adjust operation to meet design intent

OPERATIONS & SHARED SAVINGS: preventative maintenance, energy and water monitoring, and engagement of users prevent rising energy and water usage as buildings age

FACILITIES PROJECTS: major repairs and deferred maintenance projects provide an opportunity to improve energy and water efficiency

These *SFUSD Owner's Project Requirements* were created to assist design teams in supporting the District's ambitious zero carbon goals. The following pages describe the process for incorporating ZNE-ready design into new buildings, bond modernizations, and facilities projects. In summary:

New Buildings will be designed to achieve an Energy Use Intensity (EUI) < 20 kBTU/sf/yr. SFUSD's preferred strategies for achieving such exemplary energy efficiency are outlined in the *ZNE Guidelines* at the end of this document. While the addition of renewable energy is generally outside the scope of new projects, solar readiness should be built into the building.

Bond Modernizations will focus on improvements to the lighting systems and building envelope as outlined in *ZNE Assessments* commissioned by the District for every project prior to the design phase. These assessments will also look for opportunities to improve heating and ventilation systems, but these items will generally be tackled in future bonds unless broken equipment necessitates earlier action.

Facilities Projects generally have limited scope and will support ZNE goals by upgrading building elements as they wear out. In each case, the *ZNE Guidelines* below and *District Design Standards + Guidelines* (DDSG) will inform the design and selection of materials and/or equipment for these projects.

PROCESS

New Buildings

Ensuring that the District's energy targets are faithfully met in new construction projects requires a rigorous design process, stellar construction techniques, and attention to quality control. To ensure the best possible outcome on each and every project, SFUSD requires architects to incorporate the following elements into the process of creating new buildings:

CHARRETTE: All projects will commence with an architect-led design charrette specifically focused on identifying the strategies and systems necessary for meeting the EUI performance goal. At a minimum, the Project Manager, Sustainability Office, Buildings & Grounds, Design Team, Commissioning Agent, and Electrical/Mechanical/Civil consultants will attend.

ENERGY MODELING: Building form, massing, orientation, and roof layout (among other design parameters) have a significant impact on energy usage and solar energy production. Therefore, design decisions shall be evaluated against a constantly refined energy model from the earliest stages of a project. In this way, project architects will have many opportunities for course correction should site conditions or non-energy parameters make achievement of ZNE goals difficult.

COMMISSIONING: Commissioning agents hired by the District will be brought into the design process early on and follow each project through design, construction, and post-occupancy to ensure that design intent is achieved as outlined in this document and reflected in the Basis of Design (BOD). The *Commissioning Plan* will include design reviews, construction inspections, functional testing, development of a maintenance manual, and systems training (see Commissioning Procedures in the 2016 Bond Program *Procedures + Standards Binder*).

First ZNE Projects

SFUSD is in the process of designing its first new ZNE building at Claire Lilienthal School on Divisadero St. The building will house the middle school program of this K-8 school and replaced eight existing bungalows. The second ZNE project is a PG&E-supported modernization of Garfield Elementary on Telegraph Hill. The utility is particularly interested in identifying design solutions in the constrained urban environment.

Mention Zero Energy Goal and EUI Targets in Request for Proposals & Qualifications

D.C. DEPARTMENT OF GENERAL SERVICES

REQUEST FOR PROPOSALS
DCAM-18-AE-0125

ARCHITECTURAL/ENGINEERING SERVICES
WEST ELEMENTARY SCHOOL

September 12, 2018

The A/E firm shall consider all DGS FM Building Standards, such as Sustainability/High Performance Best Practices, Building Automation Systems (BAS), Smart Roof Design Guide, and NREL Net Zero Guidelines. The Project shall be designed in such a way so as to achieve, at a minimum, LEED for Schools – Gold certification and must meet the requirements of the recently adopted International Green Construction Code and DOEE storm water management requirements. As part of the LEED certification, we will require the innovation LEED Pilot Credit – Integrative Process for Health Promotion (https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-healthc-106), the Green Roof Credit Program addressed, and Energy Star Certification. In addition, the District is particularly interested in West Elementary becoming a Net Zero energy building and require the A/E firm to explore net zero strategies in the building's design. The A/E firm shall apply for and achieve Energy Start Certification and file the DOEE Green Roof grant application.

The A/E firm shall use BIM, or similar type software (recognized in the industry), to develop and coordinate the Design Documents.

- Define desired team
  - Engage team from design through operations
  - Energy modeler to inform the design
  - Building commissioner
  - Controls integration
- Incorporate energy targets into RFP/RFQ

Selecting the Project Team

- During interviews ask about ZNE experience
- NBI has a list of questions to ask prospective teams
- Pre-bid and pre-construction conferences
- Clarify how renewables will be addressed

Hood River Middle School | Hood River, OR
Credit: Michael Mathers

Zero Energy Integrated Design Charrette

- Educate all the participants.
- Foster teamwork for an integrated design process.
- Diminish adversity
- Agree on energy target and other sustainability goals.
- Get goal “buy-in”
- Brainstorm potential technologies and strategies to achieve target.
- Identify synergies
- Document decisions

Design to the Target

- Making it all work together: Building automation and controls integration
- Use the Owners Project Requirements (OPR's) to guide the ZNE process
- Plan for measurement and verification
- Beware of value engineering!
- Controls considered from design through operation
- Keep the operators and occupants in mind

Bishop O'Dowd High School | Oakland, CA
Credit: David Wakely Photography

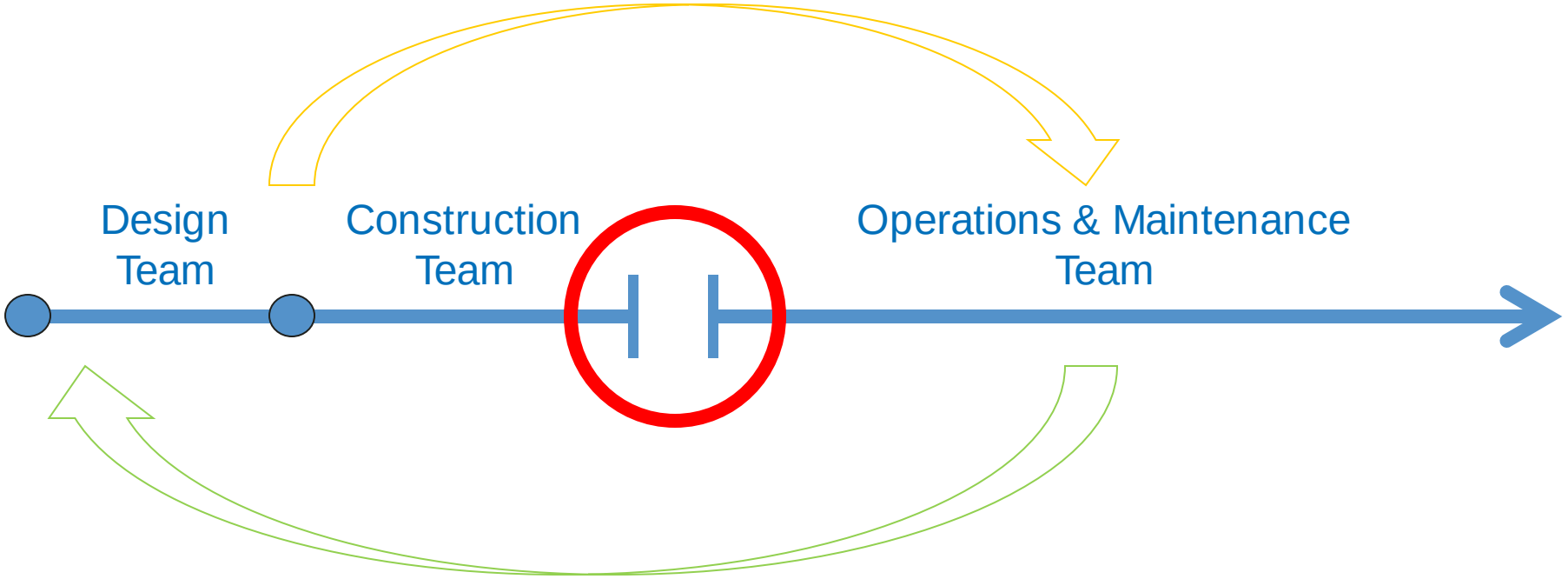
Common Technologies to Zero

- Passive measures
- Envelope and air tightness
- Space conditioning, separate from ventilation
- Plug load management
- On-site renewable energy generation, electric vehicle/bus charging and storage

Turkey Foot Middle School | Turkey Foot, KY Credit: Kenton County School District

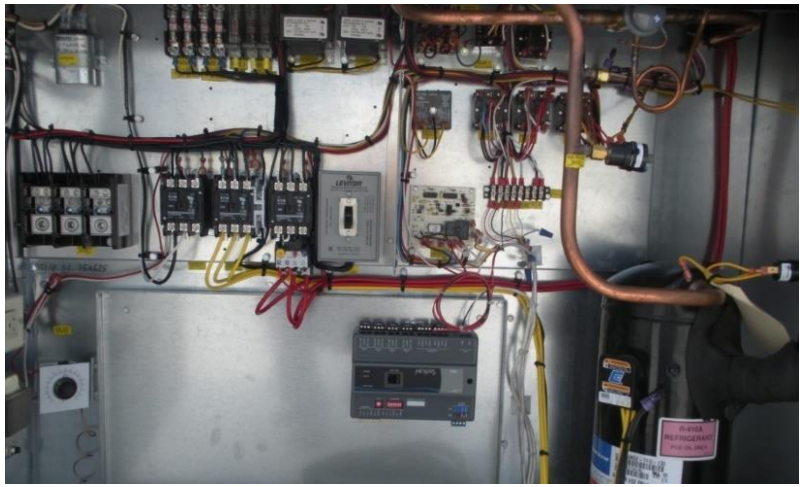
Hand Off from Design to Operations is Critical!

Integrating operations team into the design process



Continue Design to Operations

- Develop O&M manual and program
- Train building operators and occupants
- Meter and monitor energy performance
- Coordinate with commissioning agent
- Building automation system review
- Compare to predictions
- Report on progress toward goals

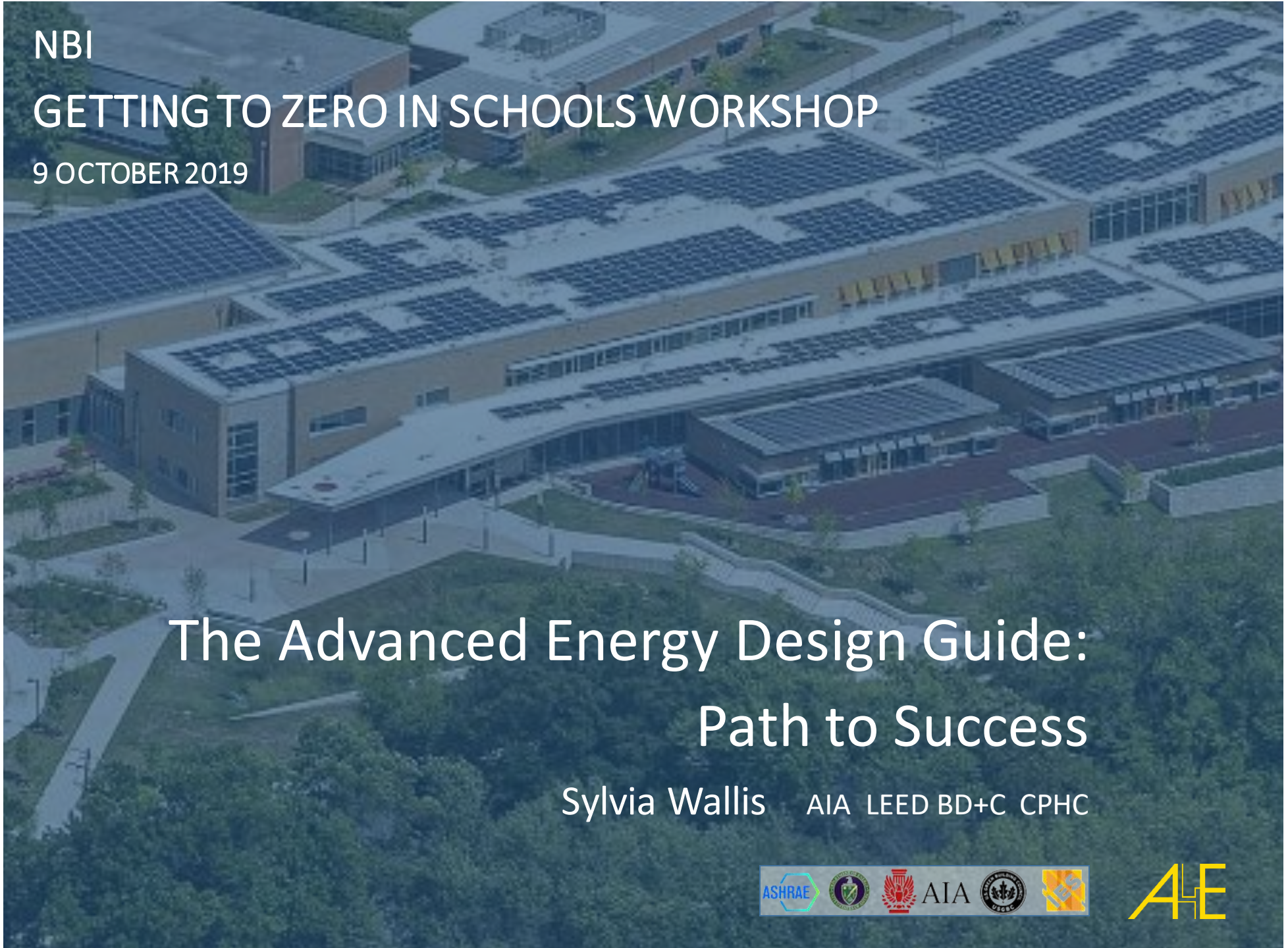


Engage Occupants and Operations

- Engage operations and occupants on design and O&M strategies
  - Share anticipated performance
  - Provide real time energy use feedback
  - Education program for teachers, staff and students
- Integrate zero into facilities job descriptions
- Provide visual display and feedback for users
- Form a green team (students & staff)

Discovery School | Arlington, VA Credit: VMDO

Verify Performance



NBI

GETTING TO ZERO IN SCHOOLS WORKSHOP

9 OCTOBER 2019

The Advanced Energy Design Guide: Path to Success

Sylvia Wallis AIA LEED BD+C CPHC

20-27 SEPTEMBER 2019

6.6 million people

Berlin Uganda Pakistan London San Francisco Melbourne Croatia Hamburg Los Angeles the Netherlands Capetown Afghanistan Ireland Stockholm the Arctic New Delhi Brazil the Solomon Islands New York Katmandu Montreal North Korea Peru Italy Australia Hungary Japan Singapore Chile Turkey Mexico Finland Austria Denmark New Zealand







"In a well-ordered society, when kids make a reasonable request their elders should say yes – in this case with real pride and hope that the next generations are standing up for what matters."

Bill McKibben

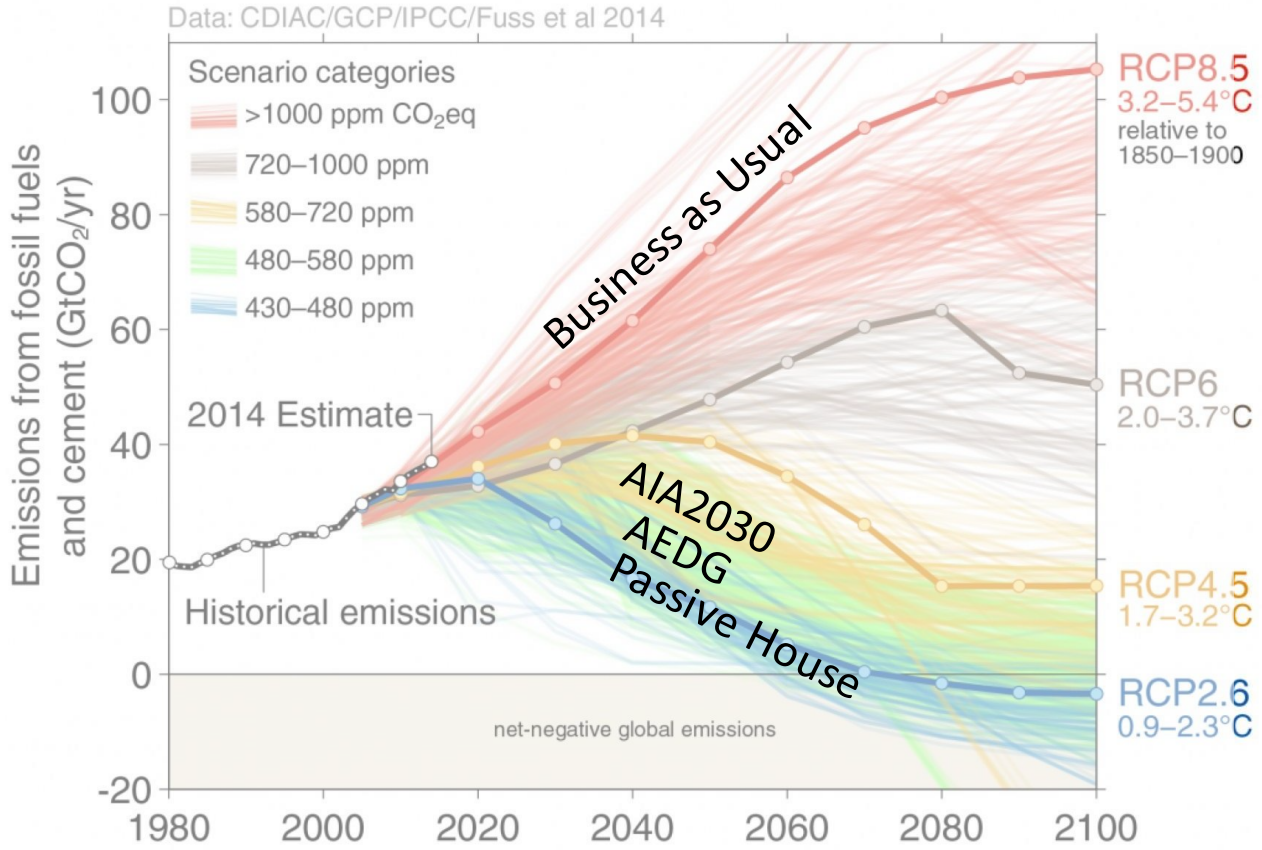
9/18/19 *The Guardian*

“THE CLIMATE IS CHANGING; WHY AREN’T WE?”

UN IPCC Report
October 2018

Urgent and unprecedented changes needed within next 12 years

to limit temperature change to a maximum of 1.5 °C and avoid catastrophic environmental breakdown



The IPCC's fifth assessment outlines for future warming scenarios — RCP2.6, RCP4.5, RCP6, and RCP8.5 — for carbon dioxide emissions from fossil fuels and cement. The black line marks our former choices. The red line — RCP8.5 — represents what will happen if habits don't change. Photo by the Global Carbon Project

"How dare you pretend that [climate change] can be solved with just 'business as usual' and some technical solutions? With today's emissions levels, [the earth's] remaining CO2 budget will be entirely gone within less than 8 1/2 years."

Greta Thunberg

Address to U.N.'s Climate Action Summit, 9/23/2019, New York City

Swiss Mourn the Passing of Pizol Glacier

What lever can we pull, to act quickly and globally?...

Bill McKibben

9/17/19 *The New Yorker*

Using Schools to Shift our Mind-Set and Break Dependence on Fossil Fuels

The Willow School, MacClay Architects

Sbrega Heath & Science Building, Sasaki

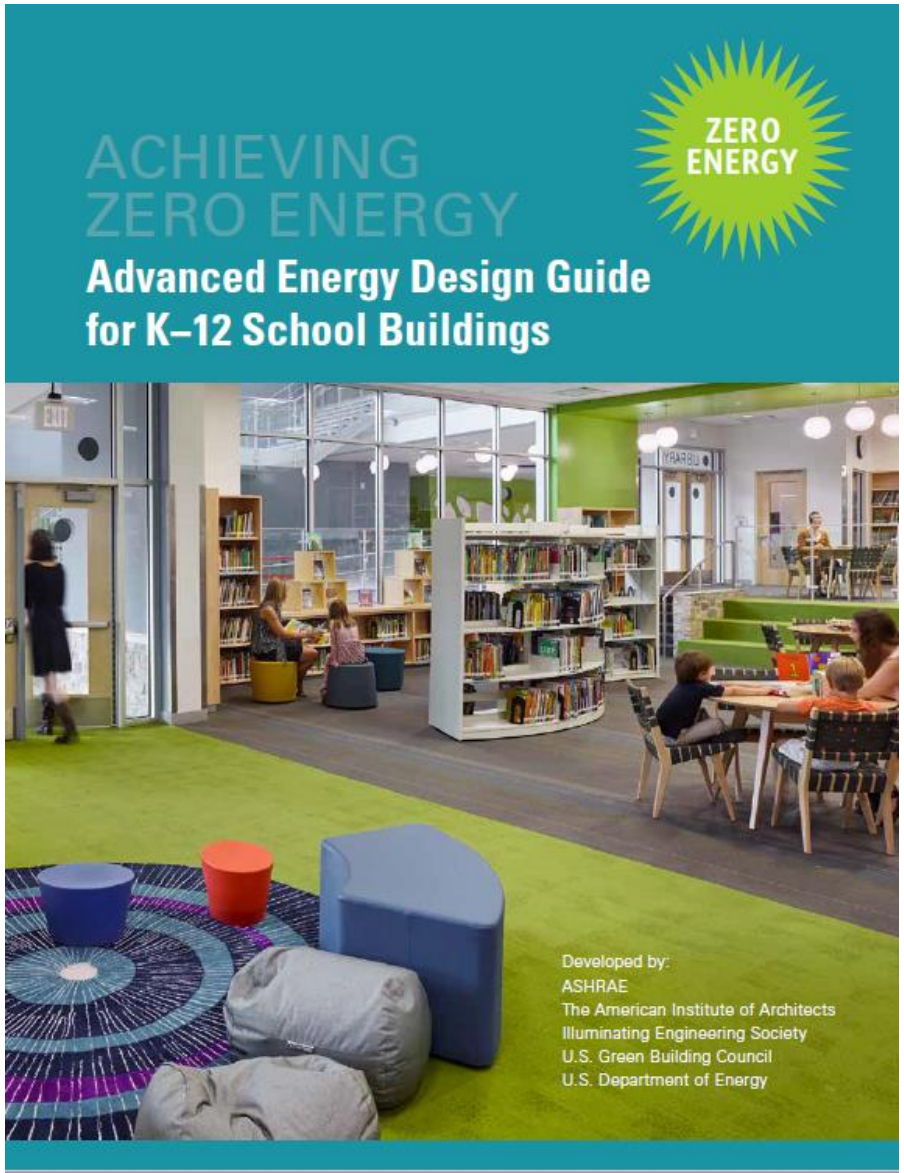
Sacred Heart Schools Stevens Library, WRNS

ADVANCED ENERGY DESIGN GUIDE

A Tool to Accelerate Change

Building Cultural Change through the School Community

A concise guide with the rationale and tools to get everyone on the same page



Available as free download:
www.ashrae.org/technicalresources/aedgs

What's in the Guide

Speaks to multiple audiences to build consensus

- School Owners (Board, Facilities, Administration)
- Engineers and Architects
- Students, Families, and Community Stakeholders

Rationale for Zero Energy

ADVANCED ENERGY DESIGN GUIDE

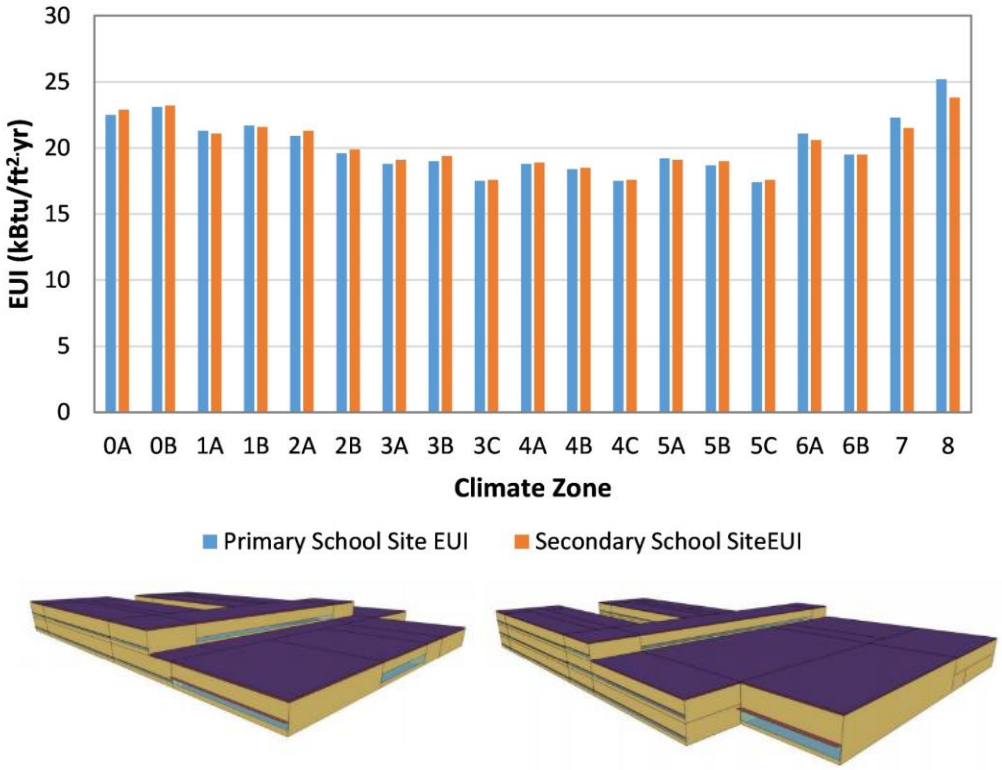
What's in the Guide

Measurable energy goals

- Financially feasible
- Operationally workable
- Readily achievable

Methodology for designing and constructing feasible zero energy schools

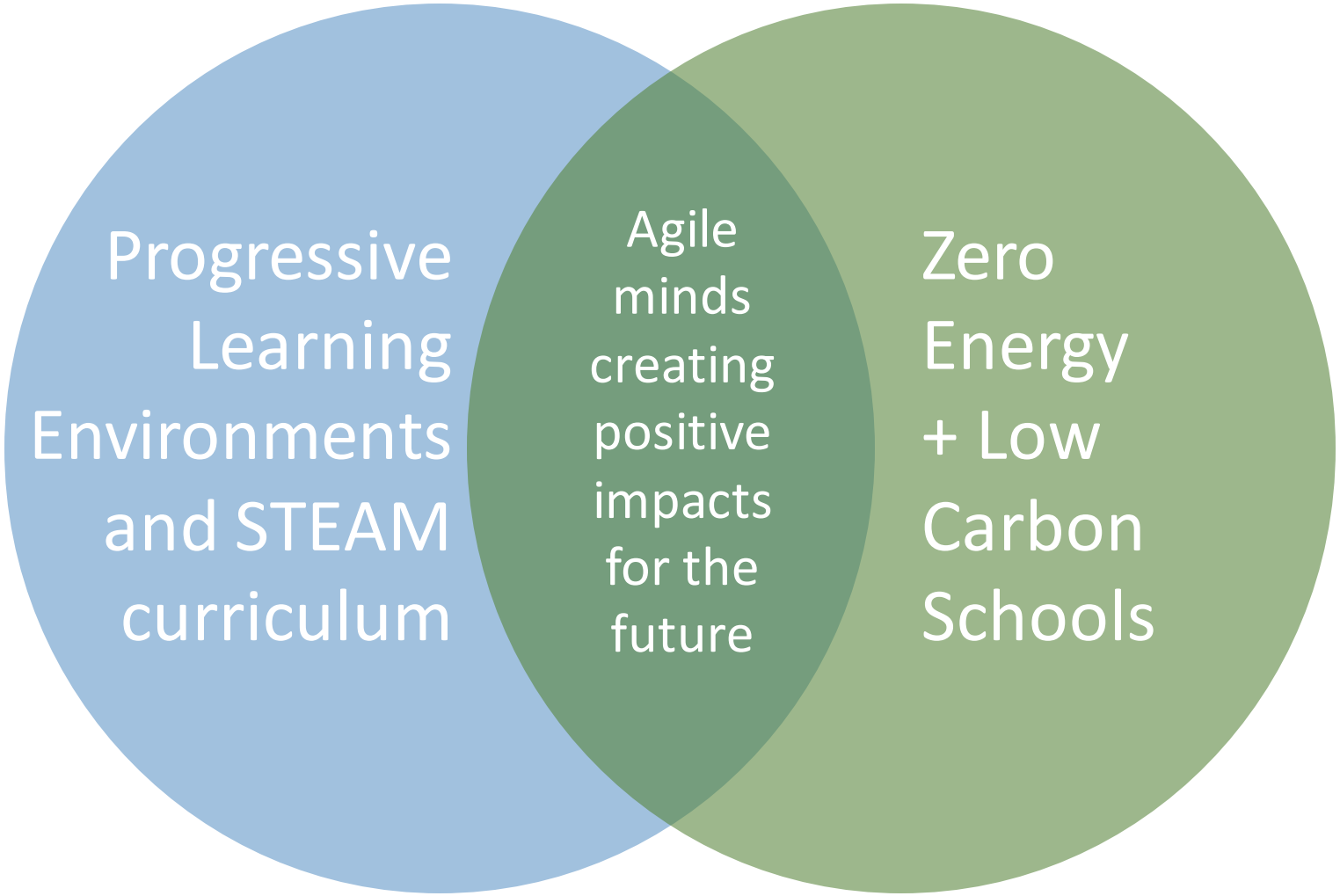
- Keys to Success
- How to Strategies
- Case Studies



NREL Building Simulations to establish EUI targets feasible for each climate zone

WHY ZERO ENERGY FOR SCHOOLS?

The ideal building type to push zero energy design



WHY ZERO ENERGY FOR SCHOOLS?

Enhanced Learning Environment

- Healthy, comfortable, and inspiring environments
- Opportunities for collaboration, inquiry, and hands-on learning
- Mind-set and technical knowledge to create positive change

Rio del Sol K-8 STEAM School, Architecture for Education

WHY ZERO ENERGY FOR SCHOOLS?

Space Impacts Learning

Thermal Comfort

Air Quality

Daylight

Acoustics

More Alert

More Creative

More Collaborative

Better Concentration

WHY ZERO ENERGY FOR SCHOOLS?

An Engaging Collaborative Enterprise

- **Discovery**
- **Problem-solving**
- **Social Action**

WHY ZERO ENERGY FOR SCHOOLS?

Inspire a Trajectory for the Future

WHY ZERO ENERGY FOR SCHOOLS?

Inspire a Trajectory for the Future

2017 DOE U.S. Energy Employment Report

WHY ZERO ENERGY FOR SCHOOLS?

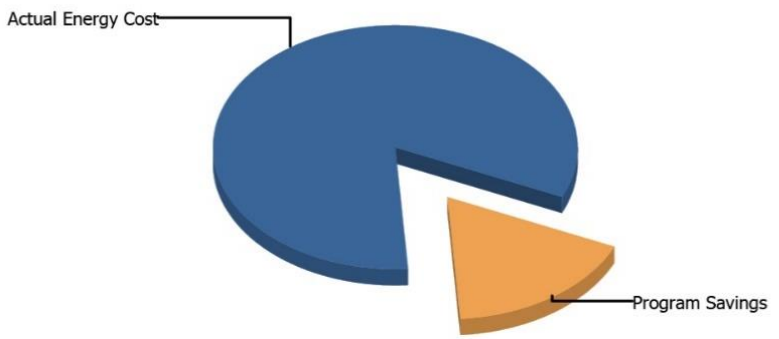
Spend Resources Wisely

Owner-occupied schools directly benefit from operating cost savings

Energy Conservation Program CAP - 19

Cumulative Cost Savings — **November 2018**

Expected Energy Cost	$19,433,945
Actual Energy Cost	$16,079,096
Program Savings	$3,354,849
Percent Savings	17.3%
Other Savings	$239,144
Total Savings	$3,593,993



Zero Energy K-12 Case Studies

Discovery ES, CZ 4A, EUI 15.8
VMDO Architects, Image: Digital Design + Imaging

Dearing ES, CZ 2A, EUI 23.5
Barry Nebhut, Architect, Image: Stantec

Richard J. Lee ES, CZ 3A, EUI 18.9
Image: Stantec

Zero Energy K-12 Case Studies

Odyssey ES, CZ 5B, EUI 15.0
VCBO Architects, photographer: Dana Sohm

Hollis Montessori, CZ 5A, EUI 9.6
Windy Hill Assoc. Architects, Photo: Eric Roth

Friends School, CZ 6A, EUI 11.7
Kaplan Thompson Architect, ncob photo

Two Fundamental Principles

- **Create and reinforce a culture for zero energy:** connect student learning/success with Zero Energy and educators will buy in

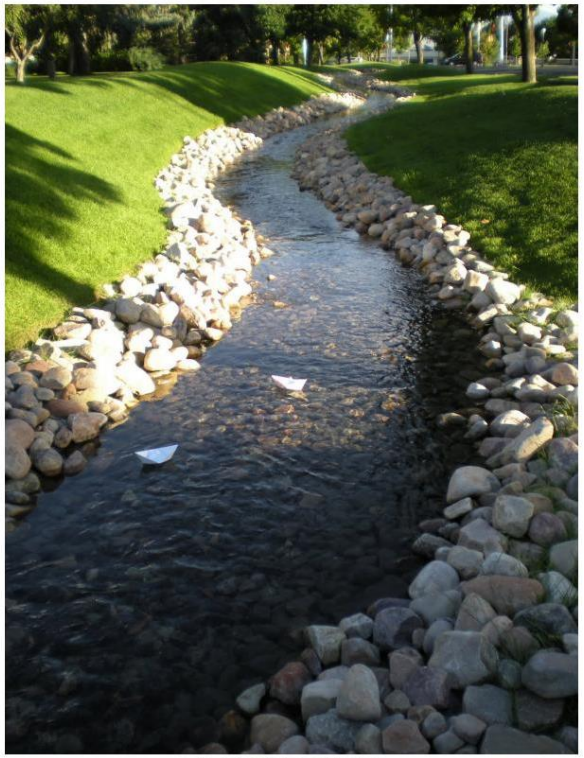
- **Adopt a collaborative and integrated team process**

Discovery Elementary School, Virginia -- VMDO Architects

CREATING A CULTURE FOR ZERO ENERGY

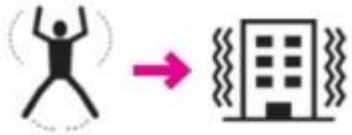
Nurturing Environmental Stewards

The idea of caring about the environment permeates the whole school



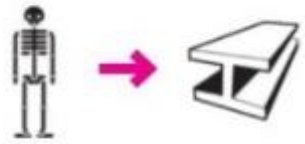
Building a Story around Sustainability

BODY + BUILDING



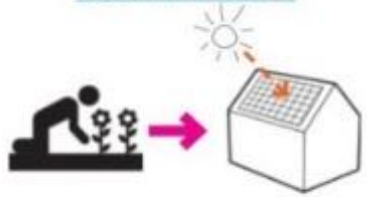
body in motion → building in motion

skin=largest organ → building skin= biggest component



strongbones → strong structure

SUSTAINABILTY



body convertsfood to energy → building converts sunlight to energy

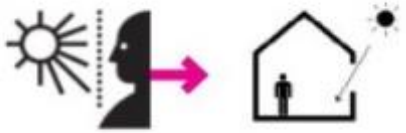
body breathes → building ventilates

body stores water → building stores water

LIGHT

heartbeat → building beats

body @ rest → serene space



sun provides vitamin D → sun provides natural light

CREATING A CULTURE FOR ZERO ENERGY

Measuring and Sharing Success

The Interactive Dashboard:

A curriculum of experiential learning developed by students, administrators, and teachers around the sustainability facets of the buildings

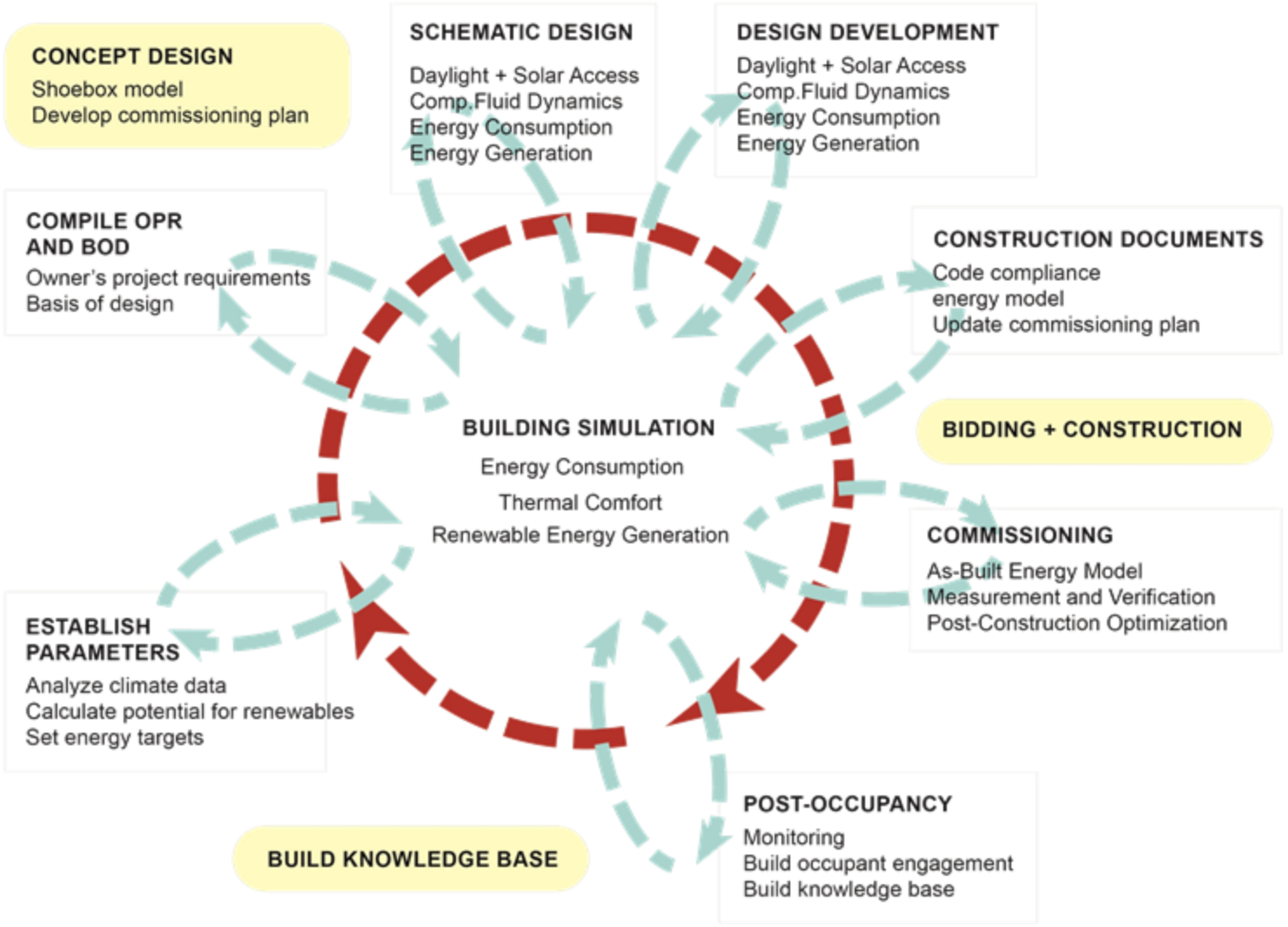
Discovery Elementary School, Virginia -- VMDO Architects

COLLABORATIVE AND INTEGRATED PROCESS

Building Stakeholder Buy-in

COLLABORATIVE AND INTEGRATED PROCESS

Putting Building Simulation at the Center to Reach Measurable Goals



COLLABORATIVE AND INTEGRATED PROCESS

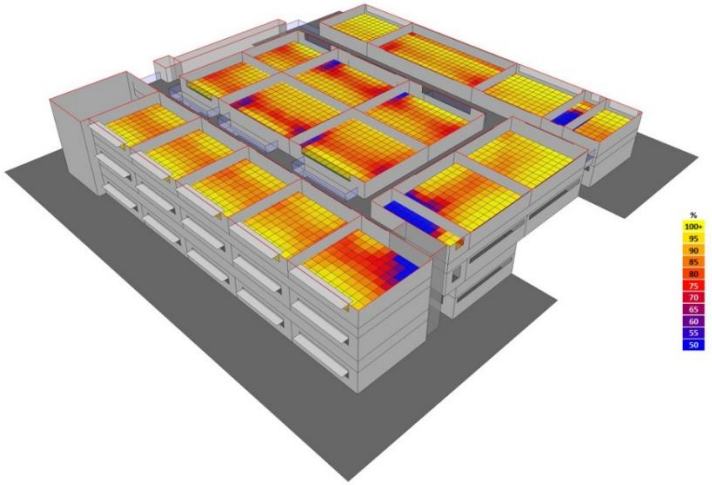
Iterative Simulations

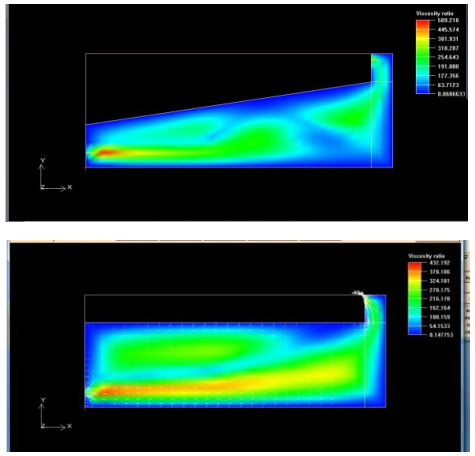
Simulate / Model / Commission / Measure / Verify

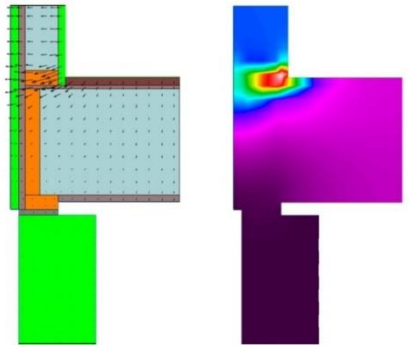
Identify key measurable performance parameters for systems and components in Owner's Project Requirements

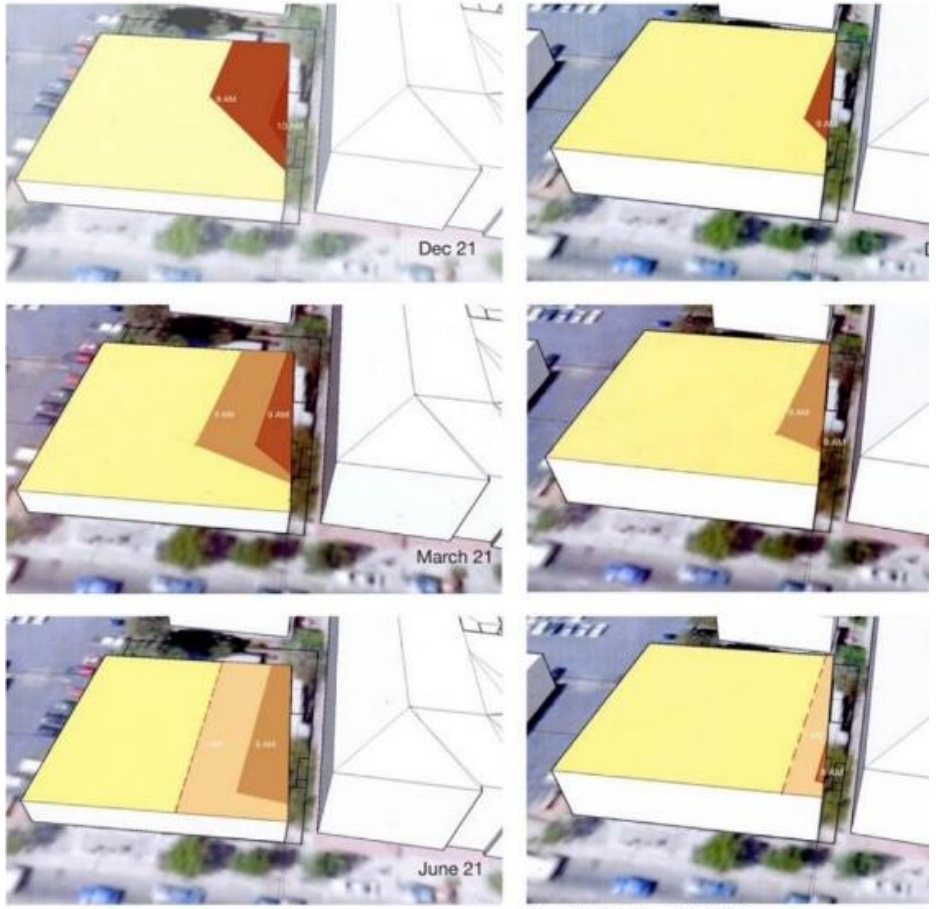
COLLABORATIVE AND INTEGRATED PROCESS

Putting Building Simulation at the Center









Roof Height: 12'-0"

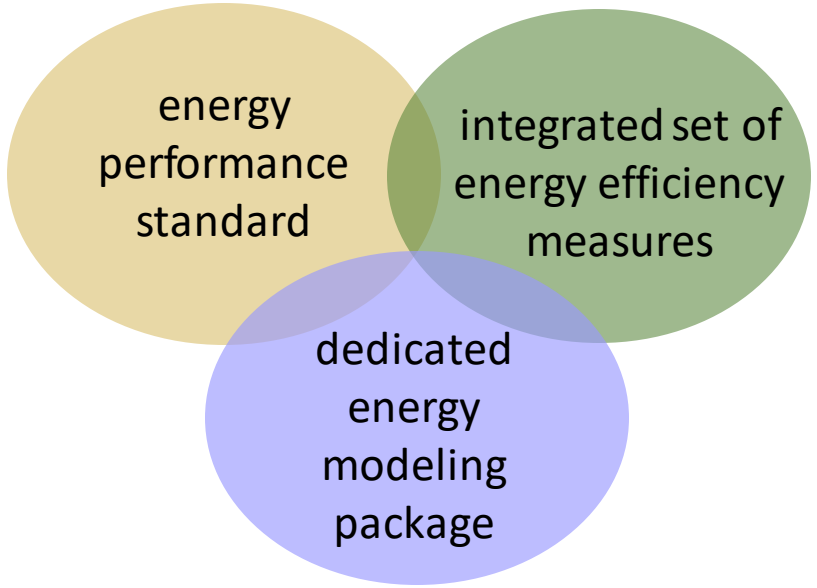
Roof Height: 24'-0"

Solar Access Analysis

COLLABORATIVE AND INTEGRATED PROCESS

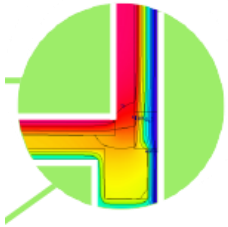
The Passive House Integrated Process –

Calibrated To Actual Post-occupancy Energy Consumption



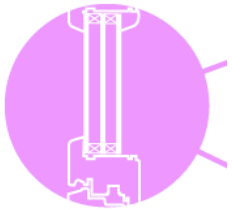
Friends School of Portland, Maine -- Kaplan Thompson Architects

Climate-specific Insulation



Thermal-bridge free Details

Airtightness



High-performance windows + Doors
w/ Controlled Solar Gain

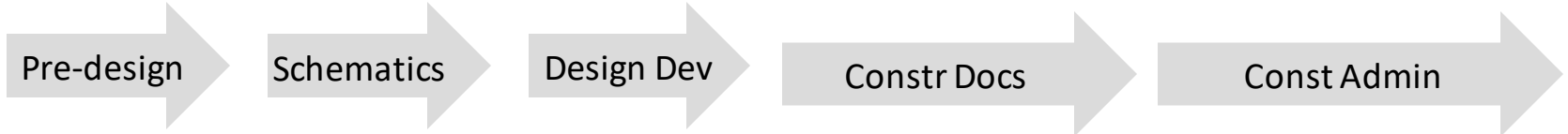
Balanced Continuous Ventilation

KEYS TO SUCCESS

Project Planning

A realistic budget and schedule:

- closer attention to front end planning and post occupancy commissioning and user engagement



Standard design process

Integrated Zero Energy design process

KEYS TO SUCCESS

Setting Targets For High Performance

- Measurable EUI Targets
- Zero Energy: Site or Source
- Optimize Building/Grid Interactions
  - Battery Storage
  - Thermal Storage
  - Smart Grids/Microgrids
- Zero Greenhouse Gas Emissions
- Reduced Carbon Footprint of Materials and Maintenance
- Optimized Transportation to/from school

KEYS TO SUCCESS

Achieving Low EUI First

Reidberg School
Frankfurt, Germany

Central School
Nordhorn, Germany

Montessori School
Aufkirchen, Germany

Oakmeadow School
Wolverhampton, United Kingdom

KEYS TO SUCCESS

Prioritization

STEP 1

Energy Efficiency Measures

Efficient building construction

Efficient systems and appliances

Operations and maintenance

Change in user behavior

STEP 2

Demand Response

Shifting electricity usage from peak periods to periods of lesser demand

STEP 3

Renewable Energy

On-site energy generation

STEP 4

Distributed Generation

Power generation at the point of consumption

KEYS TO SUCCESS

Prioritization

STEP 1

Energy Efficiency Measures

Efficient building construction
Efficient systems and appliances
Operations and maintenance
Change in user behavior

Canada
Overcast, Snow, Colder Extremes: Passive House Standard

STEP 2

Demand Response

Shifting electricity usage from peak periods to periods of lesser demand

STEP 3

Renewable Energy

On-site energy generation

California
Lots of Sunshine, Temperate Climate: Photovoltaic Panels

STEP 4

Distributed Generation

Power generation at the point of consumption

KEYS TO SUCCESS

Quality assurance and commissioning

Dearing Elementary School, Barry Nebhut Architect, Texas

KEYS TO SUCCESS

Ensuring optimal long-term energy performance

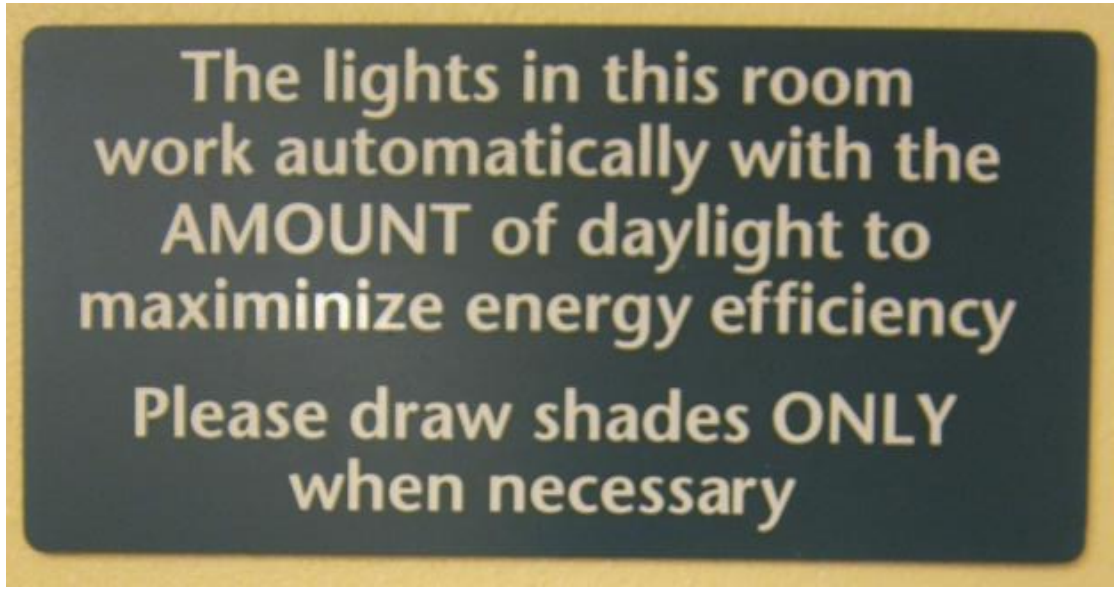
Requires owner and occupant engagement throughout the lifetime of the building

- Create a communications strategy to engage users
- Build the knowledge base for future projects

Discovery Elementary School, VMDO Architects

KEYS TO SUCCESS

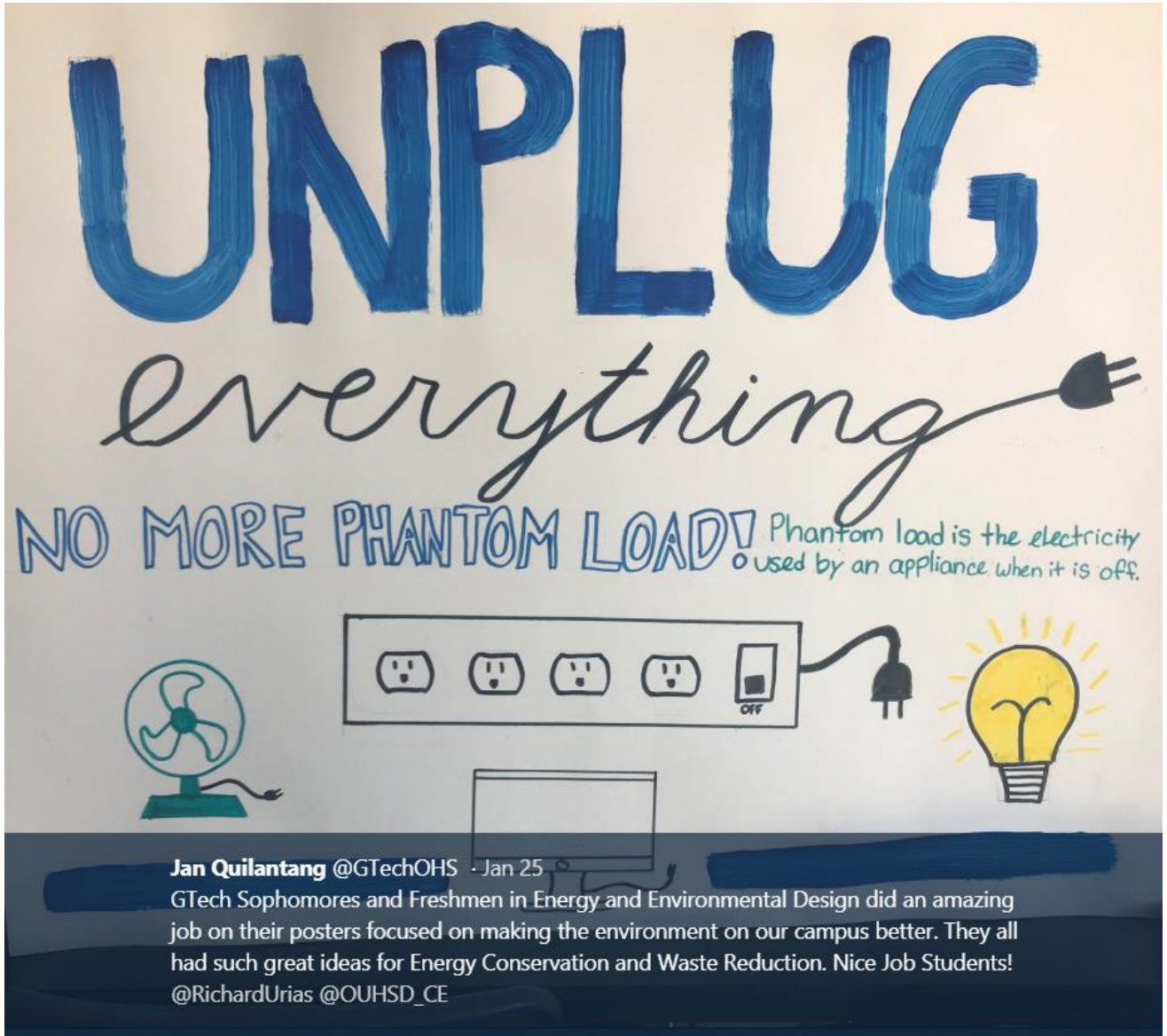
Ensuring optimal long-term energy performance



KEYS TO SUCCESS

Engaging all levels of staff and students

- education
- friendly reminders
- shutdown checklists
- site visits at all hours of the day and night to check for compliance



HOW-TO STRATEGIES

How to Achieve Low EUI's Before Adding Renewables


Building and Site Planning


Envelope


Lighting


Daylighting


Plug Loads


Kitchen Equipment


Water Heating


HVAC Systems


Renewable Energy

HOW-TO STRATEGIES

Find Opportunities to Simplify

Reduce Heating + Cooling Loads

- Architecture
- Program

Utilize Environmental Resources

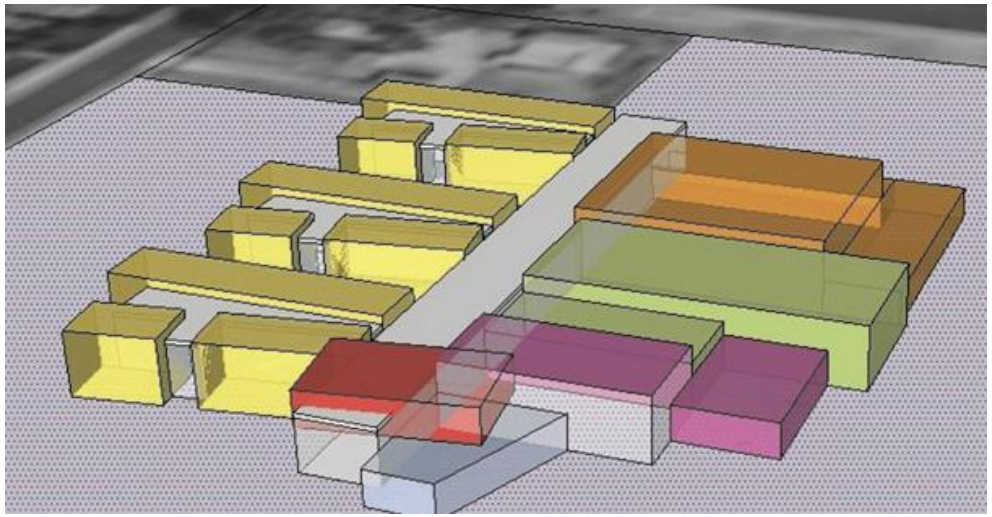
- Daylighting
- Natural Free Cooling/Ventilation

Socastee Elementary School, South Carolina, Stantec

HOW-TO STRATEGIES

Building and Site Planning

- Site Selection
- Massing
- Building Orientation
- Solar Access
- Roof or Site Area for Solar Panels
- Program Zoning for Partial Shut-downs
- Classroom Configuration
- Classroom Utilization



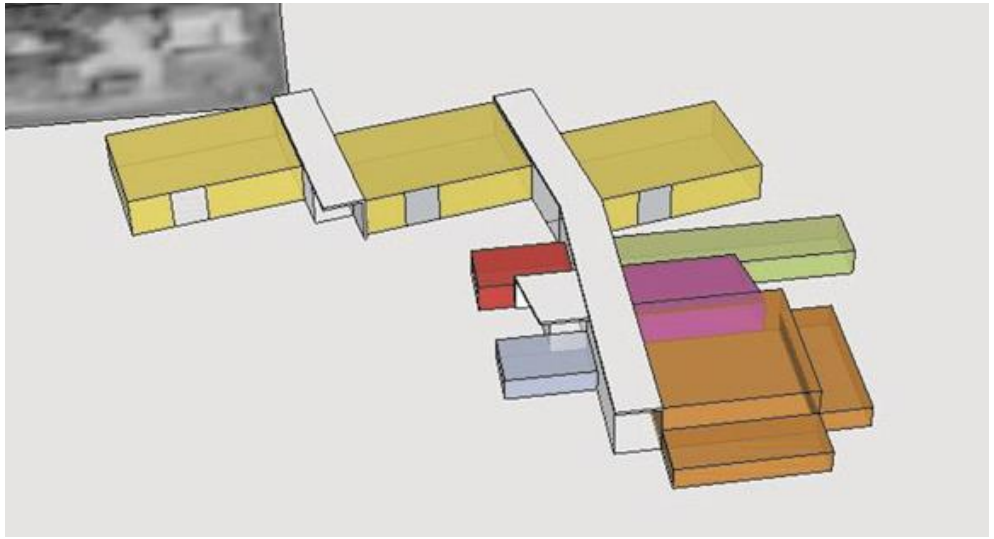


Image Credit: M.E. Group

HOW-TO STRATEGIES

Building and Site Planning

Provision of a Roof Suitable for PV

- PV Area as a percent of Gross Floor Area
- Does not include a net-to-gross area factor of 1.25

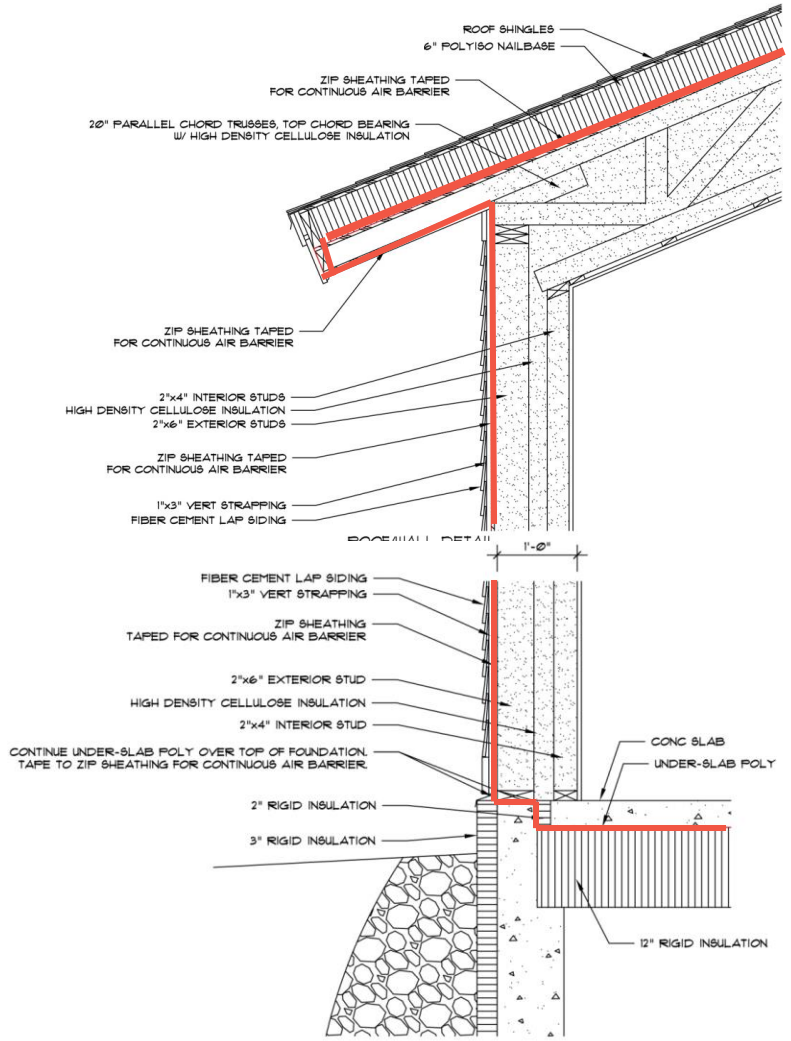
CLIMATE ZONE	CZ 0A	CZ 1A	CZ 2A	CZ 3A	CZ 4A	CZ 5A	CZ 6A	CZ 7	CZ 8
Primary	0.27	0.20	0.21	0.20	0.23	0.25	0.27	0.31	0.45
Secondary	0.27	0.20	0.21	0.20	0.23	0.24	0.26	0.29	0.44

HOW-TO STRATEGIES

Building Enclosure

Air Barrier Continuity:

- Establish Air Infiltration Goals
- Drawing the Red-Line



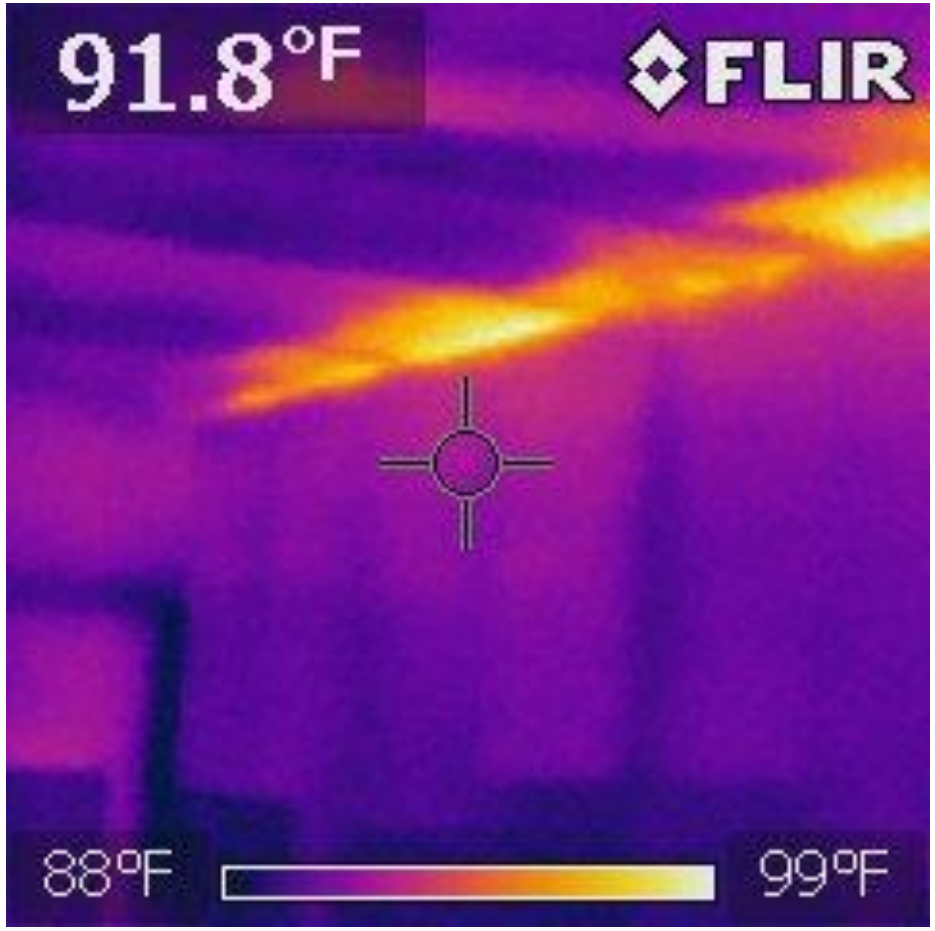
Hollis Montessori School
Credit: Windy Hill Associates

HOW-TO STRATEGIES

Building Enclosure

Airtightness Testing and Verification:

- Blower door test
- Smoke testing
- Infrared thermography



HOW-TO STRATEGIES

Building Enclosure

Building Insulation:

- Appropriate U-Factors for Roof, Walls and Floors
- Effective Installation
- Maintain Adequate Interior Surface Temperatures

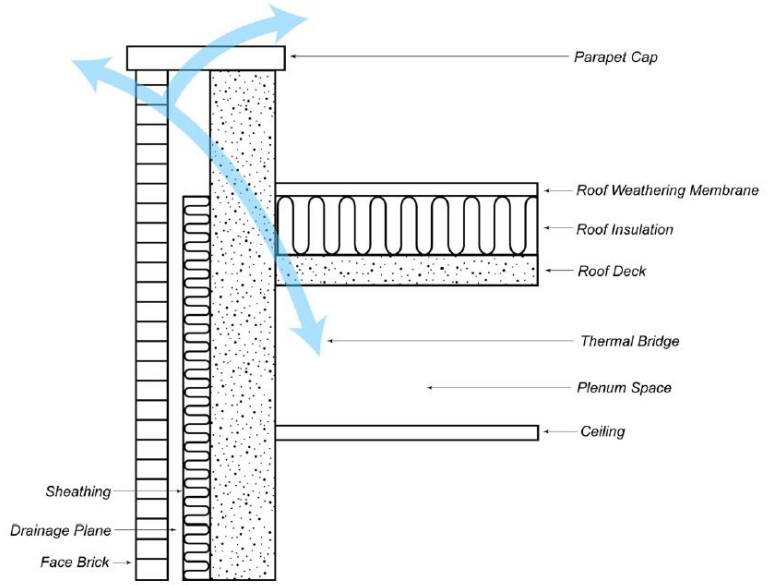
West Berkeley Public Library, HED

HOW-TO STRATEGIES

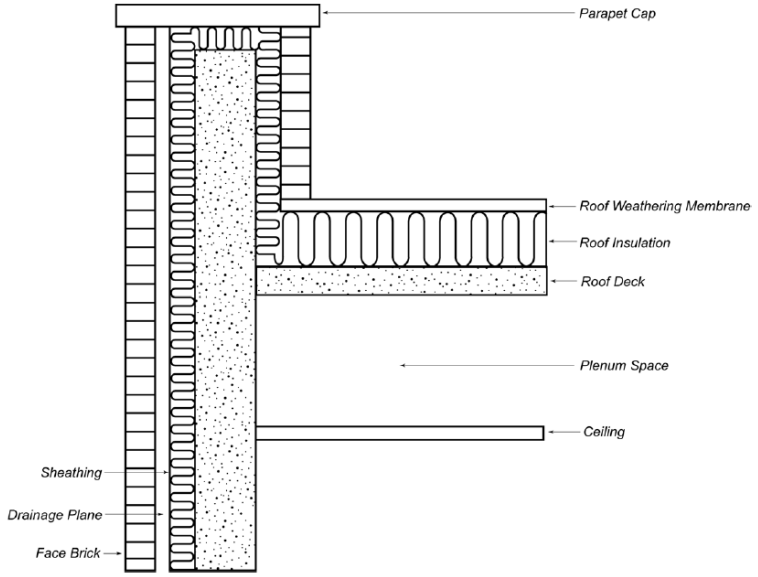
Building Enclosure

Detailing for Continuous Insulation

- Parapets
- Shelf Angles
- Below-Grade Transitions
- Canopies
- Balconies
- Roof and Wall Penetrations



(a) Problem



(b) Solution

HOW-TO STRATEGIES

Building Enclosure

Strategies to Optimize Fenestration

- Installation Sequencing
- Glazing
- Frames
- Doors
- Operable Windows
- Shading and Daylighting

Gateway Community Charter, Architecture for Education

	CZ 0	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8
U-Value	0.45	0.45	0.45	0.45	0.36	0.36	0.34	0.31	0.28
SHGC	0.21	0.24	0.24	0.24	0.34	0.36	0.38	0.43	0.43
Min. VT/SHGC	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10

HOW-TO STRATEGIES

Daylighting

- Control glare
- Daylight sensors to integrate with electric lighting

Oregon Episcopal School, Portland, Oregon, Hacker Architects

HOW-TO STRATEGIES

Interior Lighting

- Fixture Layout
- Controls
- Space Finishes
- Integration with Daylight

Mira Costa High School, HED

HOW-TO STRATEGIES

Exterior Lighting

Discovery Elementary School, VMDO Architects

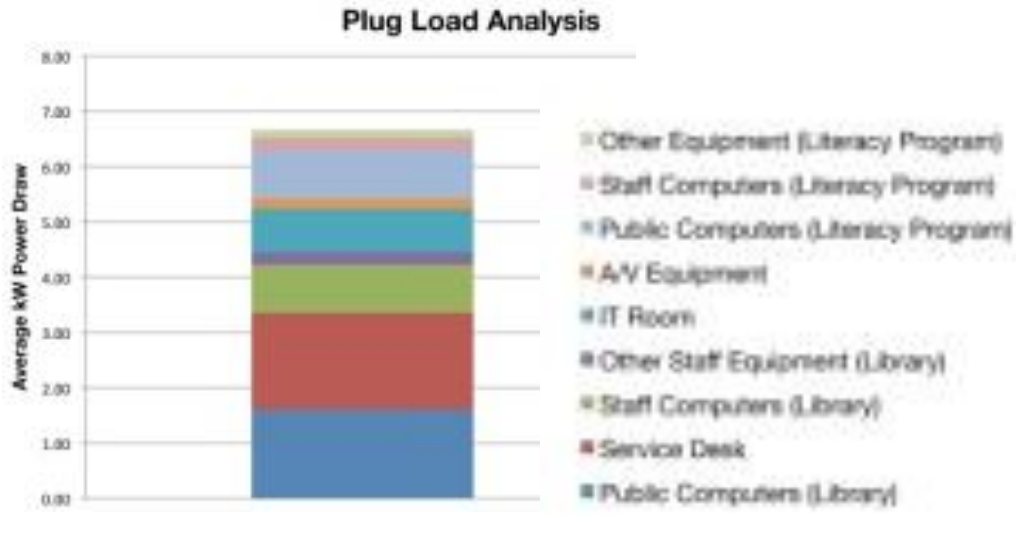
- Vary design light levels per night usage and safety considerations
- Photosensor controls
- Highest efficacy lamps and fixtures

HOW-TO STRATEGIES

Plug Loads and Power Distribution

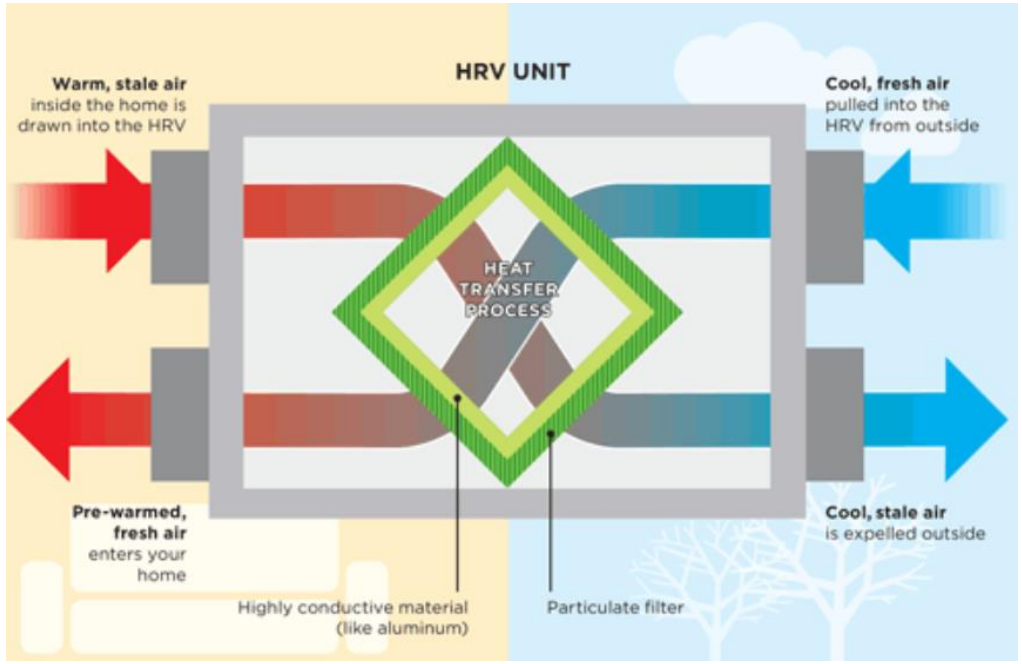
Anticipate the unexpected!

- Plug loads change over time as school programs evolve
- Develop a plug load policy and re-calibrate each year with staff
- Engage the students in managing plug loads



HOW-TO STRATEGIES

HVAC Design + Equipment Options



- **Simplify!**
- Maximize full and part load efficiency
- Minimize air ducts
- Demand-control to ensure adequate ventilation, critical for student performance
- Separate ventilation/ dehumidification and temperature control
- Air-to-air energy recovery
- Eliminate reheat

HOW-TO STRATEGIES

Kitchen Equipment

Chatham University, Eden Hall Campus Kitchen, Mithun

- **Heat the food, not the room**
- Healthy menus align with lower energy consumption
- Less heat and smoke = less exhaust and make-up airflow
- Demand-control kitchen hoods

HOW-TO STRATEGIES

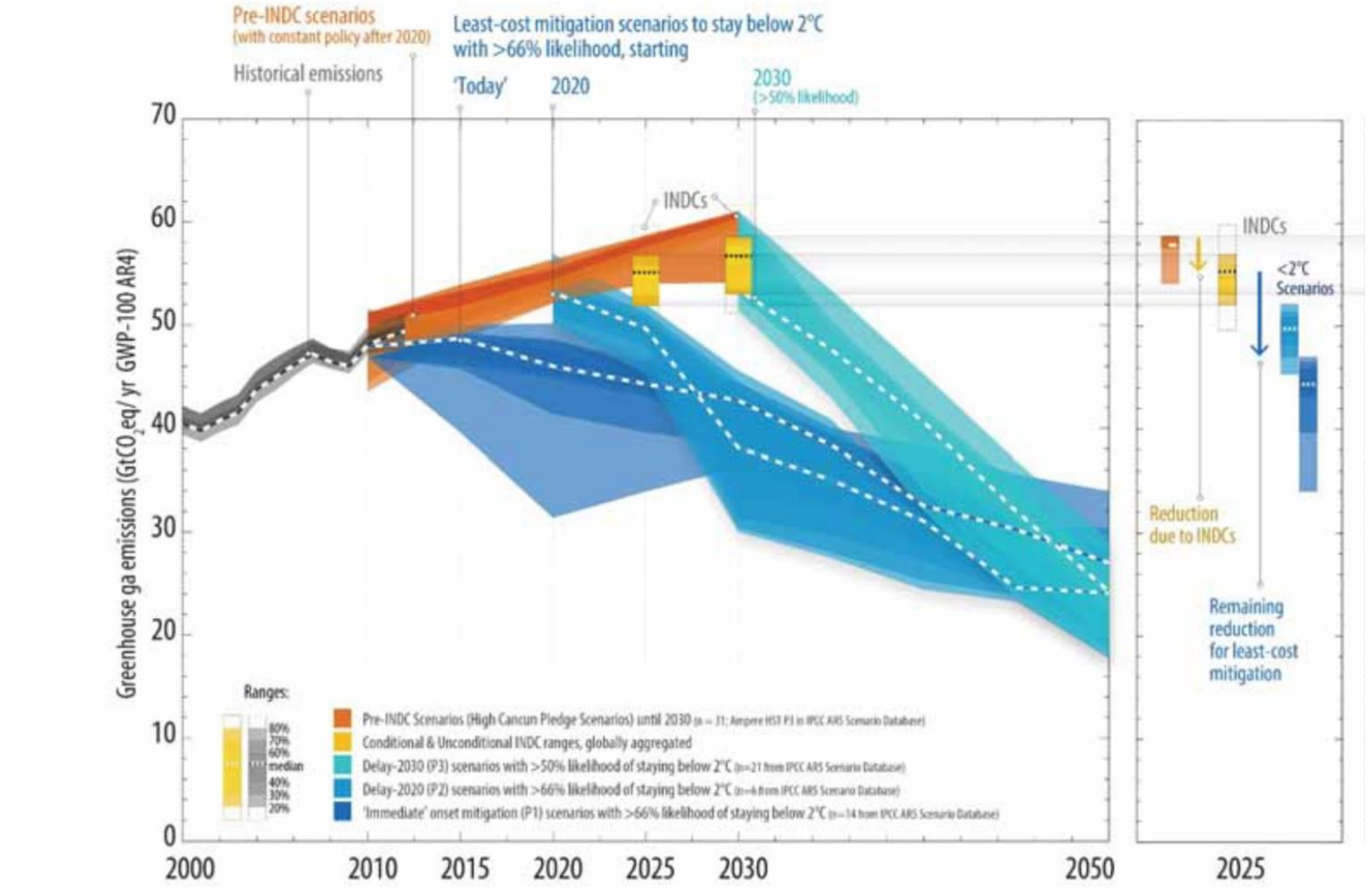
Renewable Energy Systems

Discovery Elementary School, Virginia -- VMDO Architects

- Size array based on optimized building EUI
- Configure roof to optimize photovoltaic panels
- Negotiate power contract with local utility

IT'S FEASIBLE NOW ---

No Time to Wait



UNFCCC: SYNTHESIS REPORT ON THE AGGREGATE EFFECT OF INTENDED NATIONALLY DETERMINED CONTRIBUTIONS (INDCs), November 2015

IT’S FEASIBLE NOW ---

No Time to Wait

In California,

6,000 new classrooms needed every year.

With 60-year building life-span

decisions made today will still be with us in 2080!

IT'S FEASIBLE NOW ---

No Time to Wait

Sylvia Wallis, AIA, LEED BD+C, CPHC

swallis@architecture4e.com

ACHIEVE

ZERO ENERGY

AT

NO COST

BRIAN TURNER

CMTA

ZACHARY SCHNEIDER

CMTA

CMTA

DISTRICT 3 POLICE HEADQUARTERS
CINCINNATI, OHIO

HOUSTON ADVANCED RESEARCH CENTER
HOUSTON, TEXAS

DISCOVERY ELEMENTARY
ARLINGTON, VIRGINIA

SEMANS GRISWOLD CENTER
CHESTERTOWN, MARYLAND

RICHARDSVILLE ELEMENTARY
BOWLING GREEN, KENTUCKY

LENAWEE CENTER
ADRIAN, MICHIGAN

TOYOTA CORVALLIS
CORVALLIS, OREGON

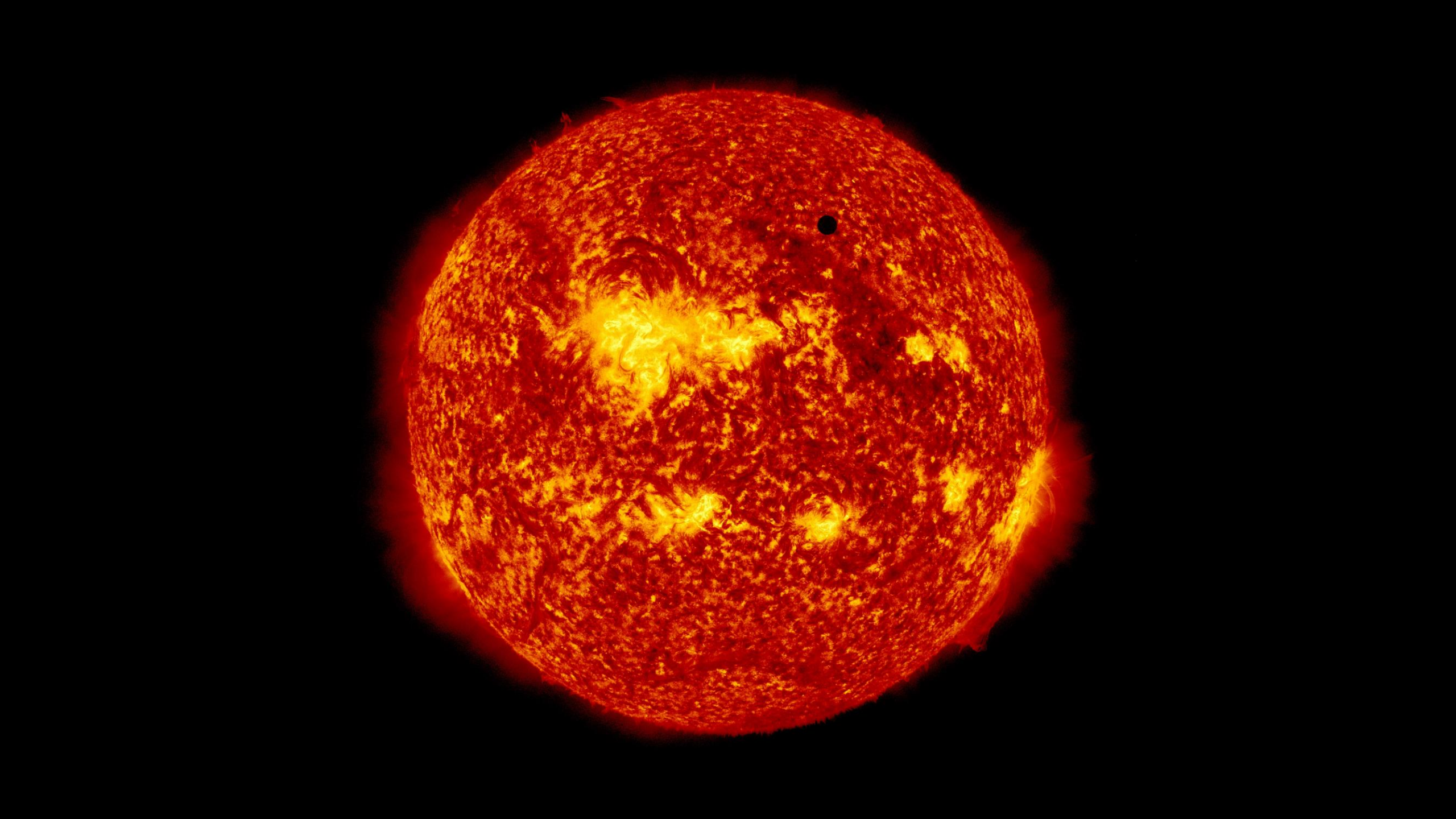
WILDE LAKE MIDDLE SCHOOL
COLUMBIA, MARYLAND

RICHARD LEE ELEMENTARY
DALLAS, TEXAS

LOCUST TRACE AGRISCIENCE CAMPUS
LEXINGTON, KENTUCKY

WEST ELEMENTARY
WASHINGTON, DC

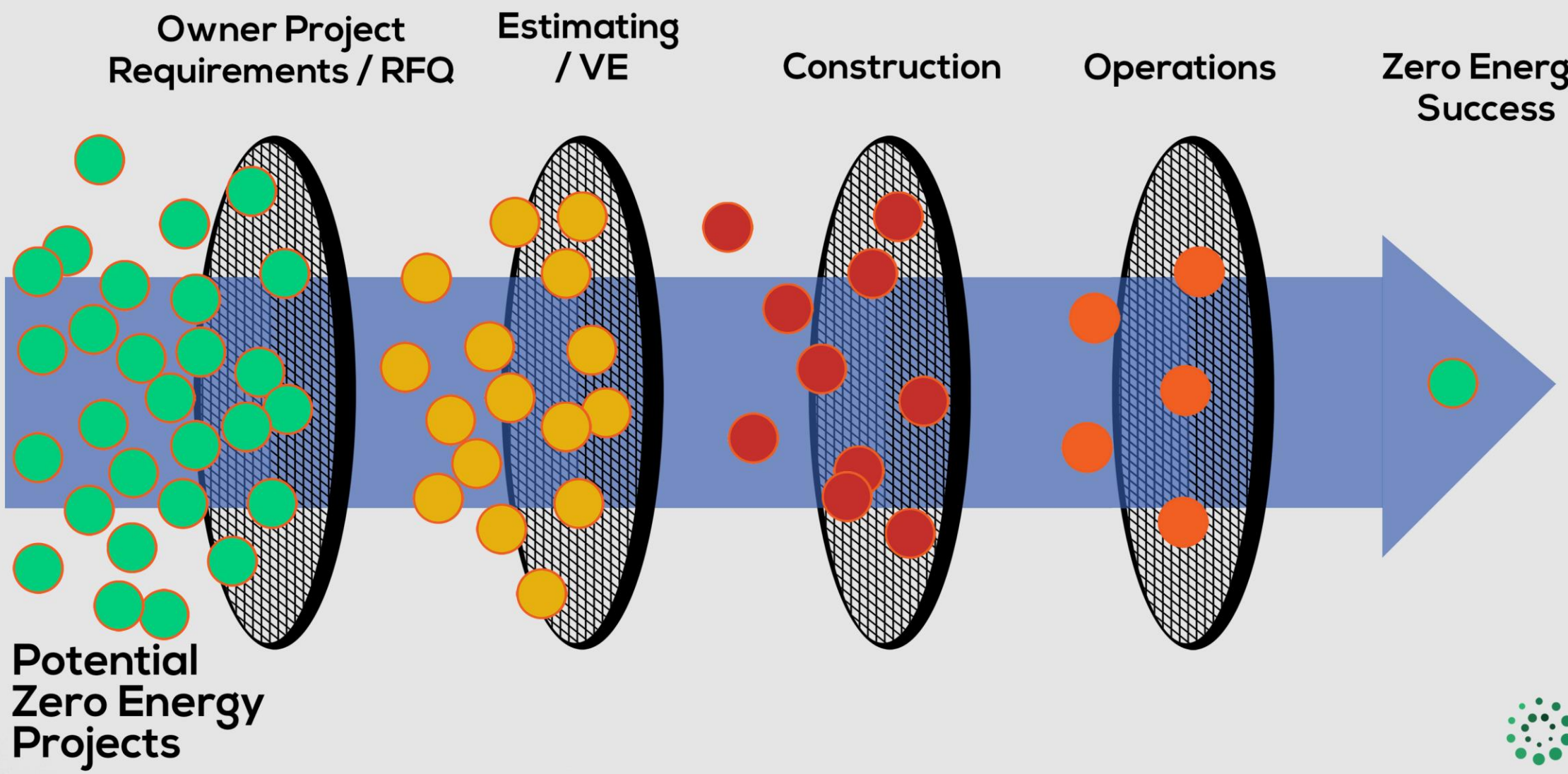
HOLABIRD / GRACELAND ELEMENTARY
BALTIMORE, MARYLAND



OUR NEW REALITY

U.S. school districts spend $6B each year on energy — second only to salaries.

ZERO ENERGY FILTERS

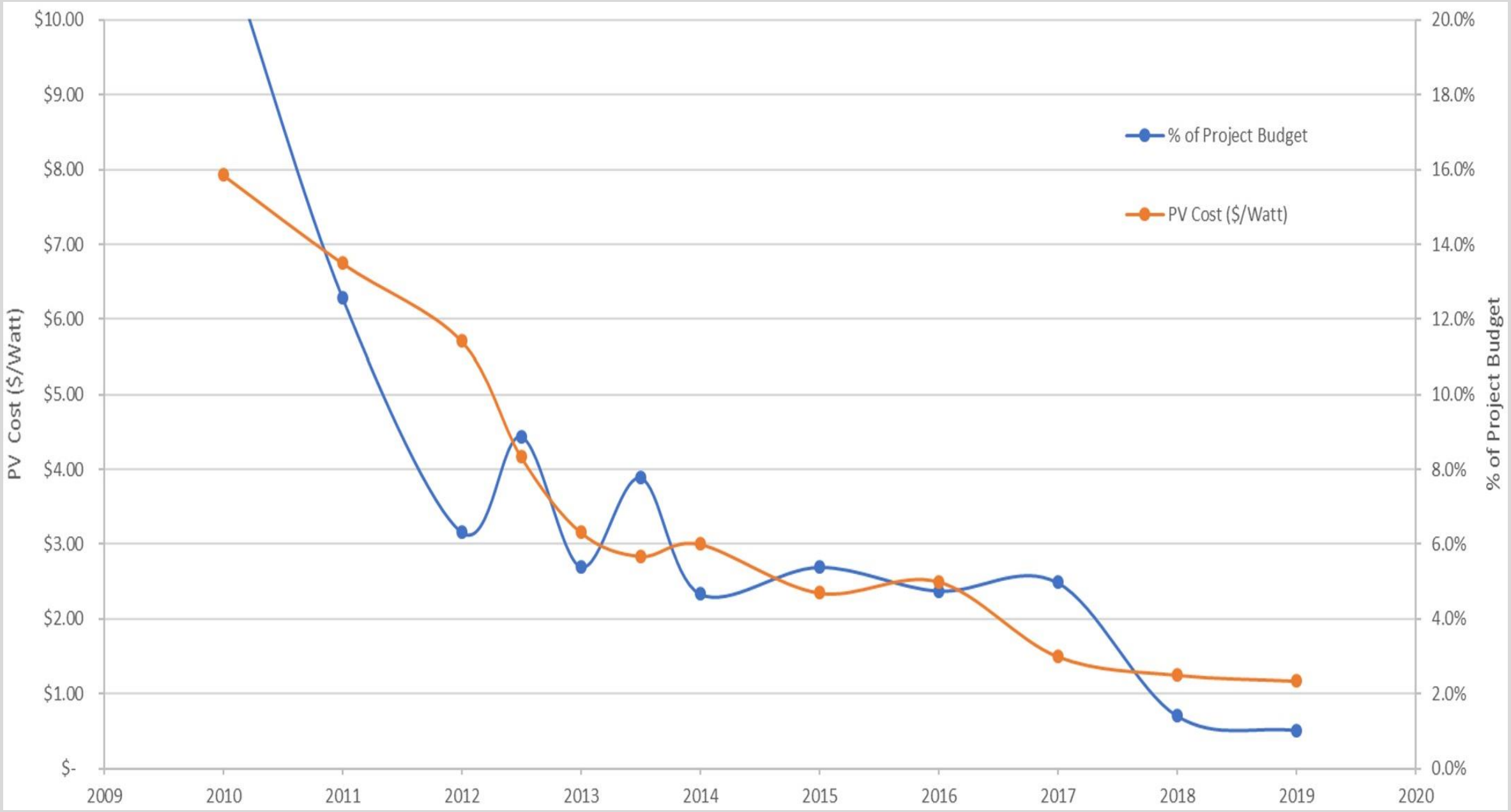


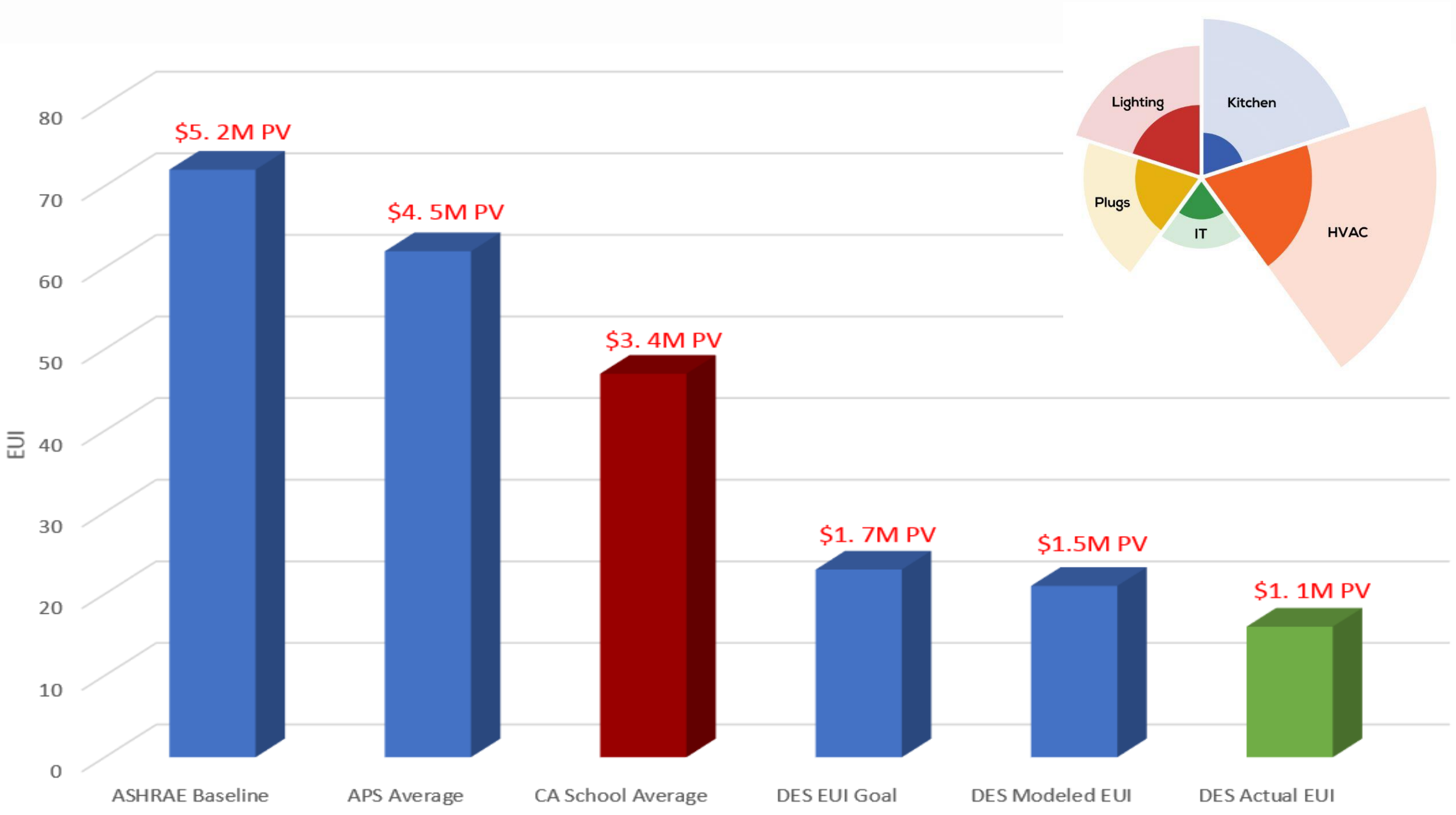
CMTA

Any building can be zero-energy…


If you can afford
a solar array big
enough

COST TO ACHIEVE ZERO ENERGY




80
70
60
50
40
30
20
10
0
EUI
$5. 2M PV
$4. 5M PV
$3. 4M PV
$1. 7M PV
$1.5M PV
$1. 1M PV
ASHRAE Baseline
APS Average
CA School Average
DES EUI Goal
DES Modeled EUI
DES Actual EUI
Lighting
Kitchen
Plugs
IT
HVAC

MUST DO

SHOULD DO

COULD DO

CMTA

MUST DO

CMTA

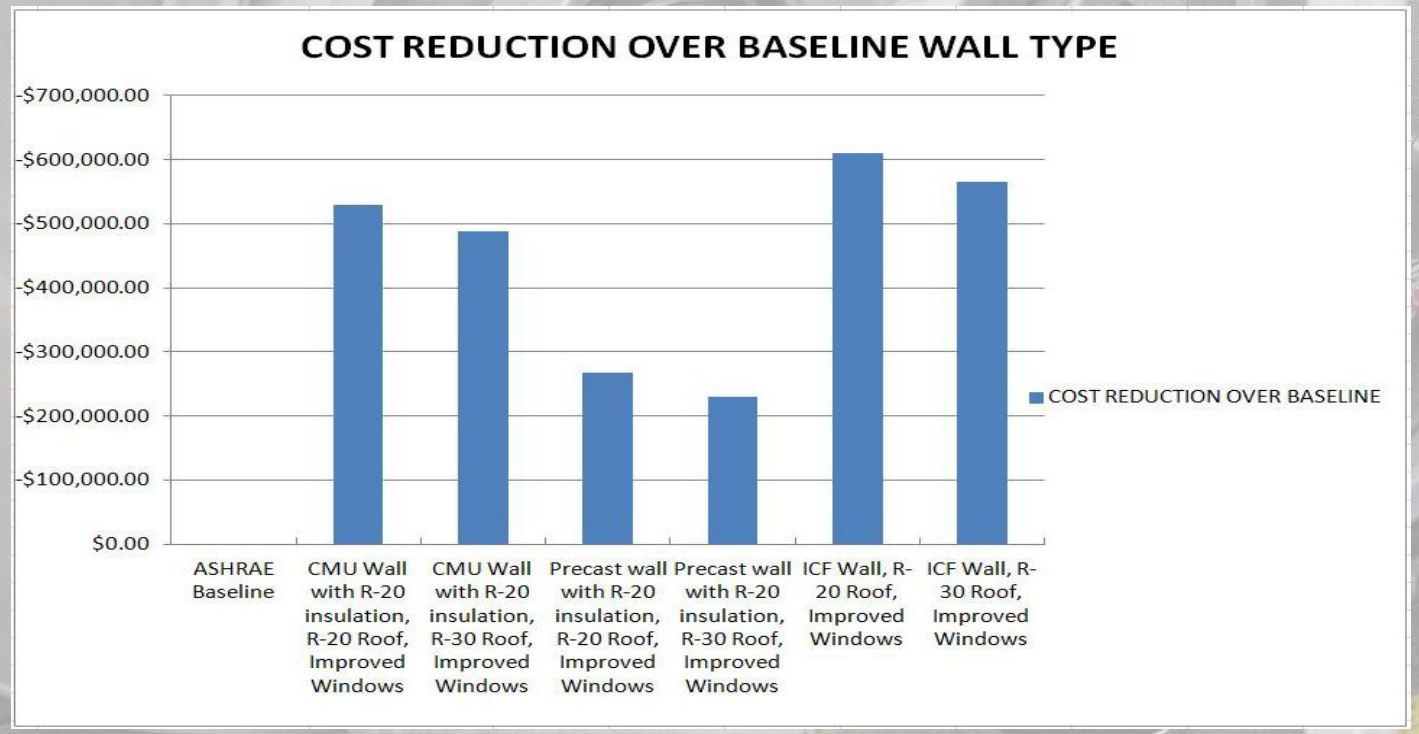
MECHANICAL SYSTEM DESIGN CRITERIA

	 BUILDING ENVELOPE	 VENTILATION	 HEATING & COOLING	 HUMIDITY
TRADITIONAL VAV	Prescriptive Design	Through AHU for critical zone, over ventilate all other spaces	Cools air to 55 degrees and reheat to setpoint temperature	Relies on temperature control to address levels
HIGH-PERFORMANCE	Performance Design	DOAS – Outdoor air is dehumidified and delivered to spaces needed	Distributed heat pumps cool or heat the air to setpoint temperatures	Monitor and control with hot gas reheat and supplement with DOAS dehumidification

CMTA

Right Sizing HVAC

ENVELOPE TYPE	INFILTRATION (cfm per square foot of wall)	COST OF ENVELOPE of envelope	COST OF HVAC SYSTEM	TOTAL COST	COST REDUCTION OVER BASELINE	HVAC Tons
ASHRAE Baseline	0.3	$3,747,526	$6,983,966	$10,731,492	0	543
CMU Wall with R-20 insulation, R-20 Roof, Improved Windows	0.1	$4,169,425	$6,033,039	$10,202,464	-$529,028	382
CMU Wall with R-20 insulation, R-30 Roof, Improved Windows	0.1	$4,288,254	$5,954,186	$10,242,440	-$489,052	369
Precast wall with R-20 insulation, R-20 Roof, Improved Windows	0.15	$4,447,324	$6,016,595	$10,463,919	-$267,573	379
Precast wall with R-20 insulation, R-30 Roof, Improved Windows	0.15	$4,566,153	$5,935,599	$10,501,752	-$229,740	366
ICF Wall, R-20 Roof, Improved Windows	0.08	$4,185,772	$5,935,599	$10,121,371	-$610,121	366
ICF Wall, R-30 Roof, Improved Windows	0.08	$4,304,601	$5,860,813	$10,165,414	-$566,078	353

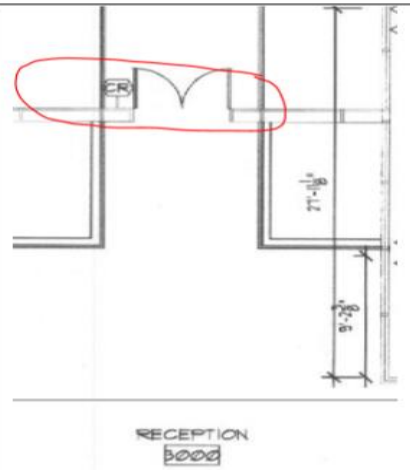


CMTA

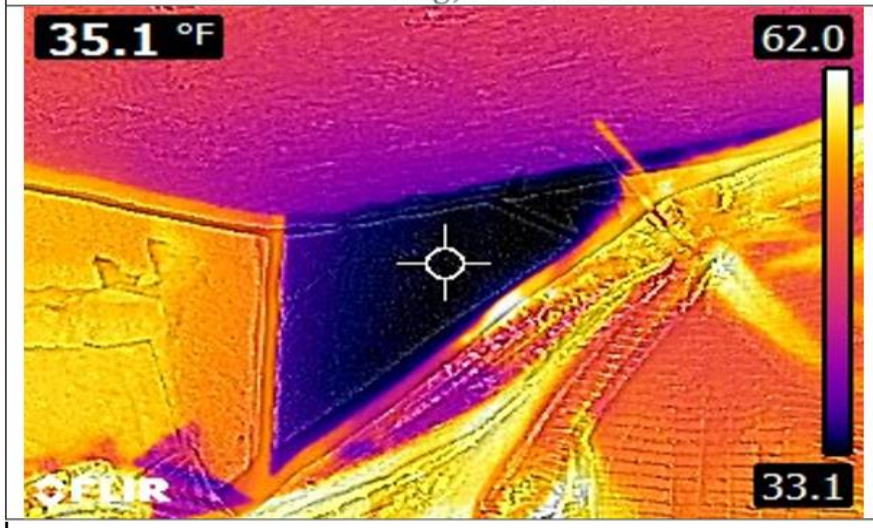
A major portion of a building's energy loss is by air leakage through the building's skin

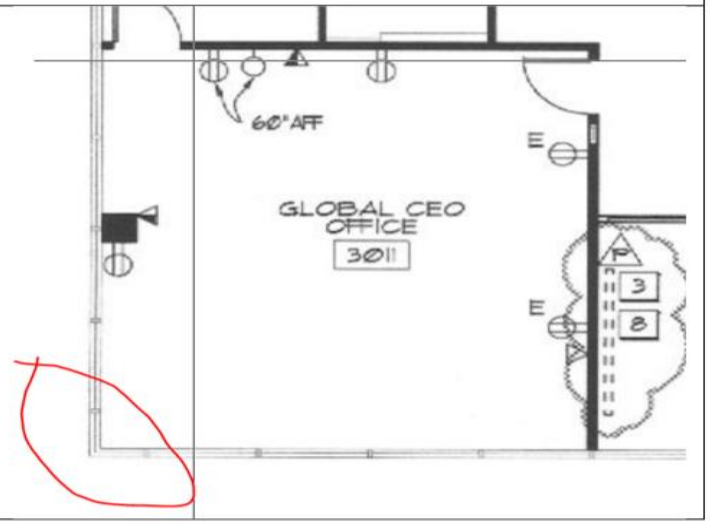
MINIMIZE AIR LEAKAGE >> RIGHT SIZE MECH. SYSTEM >> REDUCE ENERGY FOOTPRINT

Atrium Entrance Door



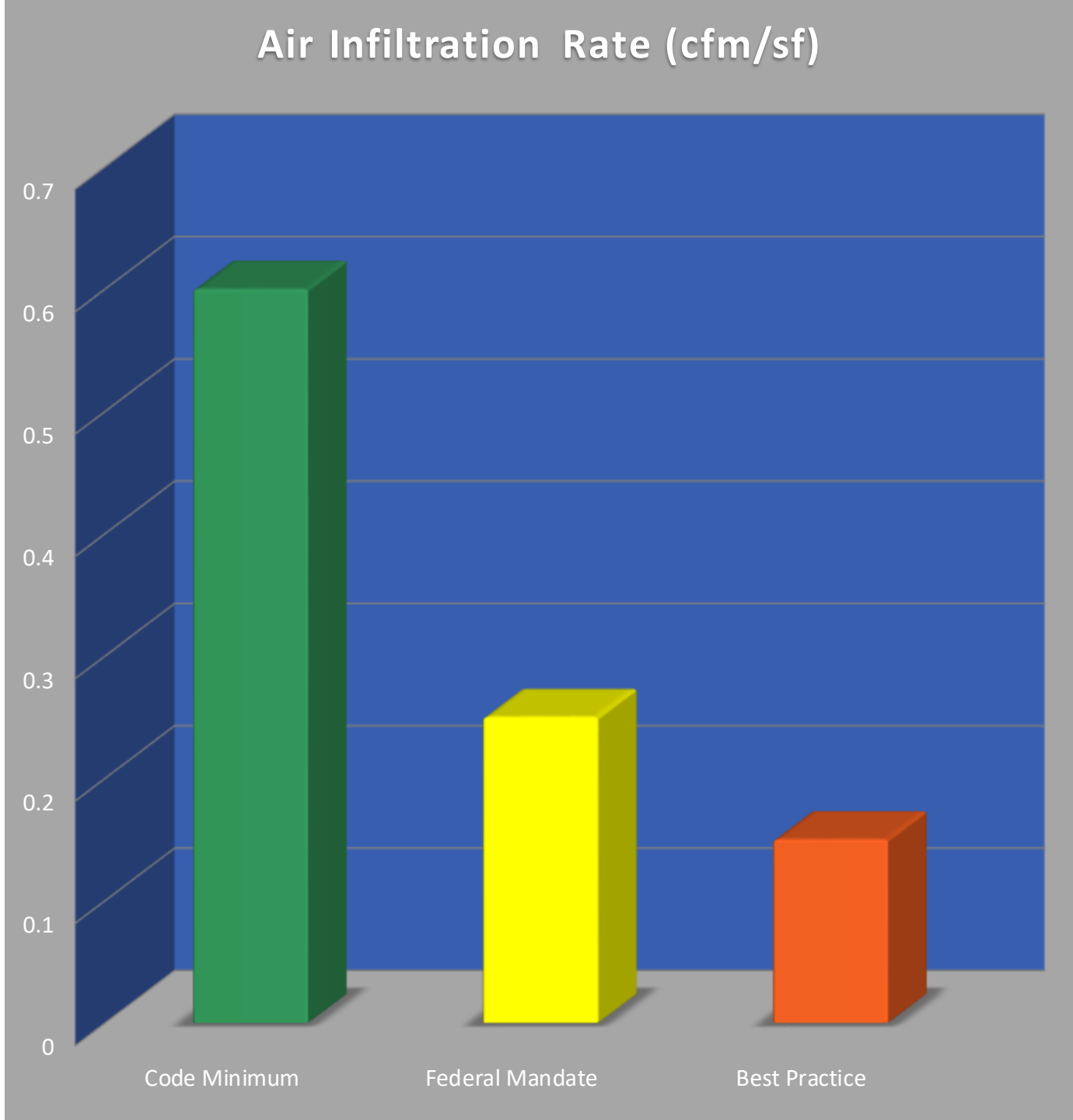
Corner office above ceiling, room 3011





Pressure Testing

- Air Infiltration
  - Code Minimum
  - Federal Mandate
  - Industry Standard
- Testing Standards
  - ASTM E779
  - ASTM E1827



QA/QC is everyone's job but it starts at the sub contractor level

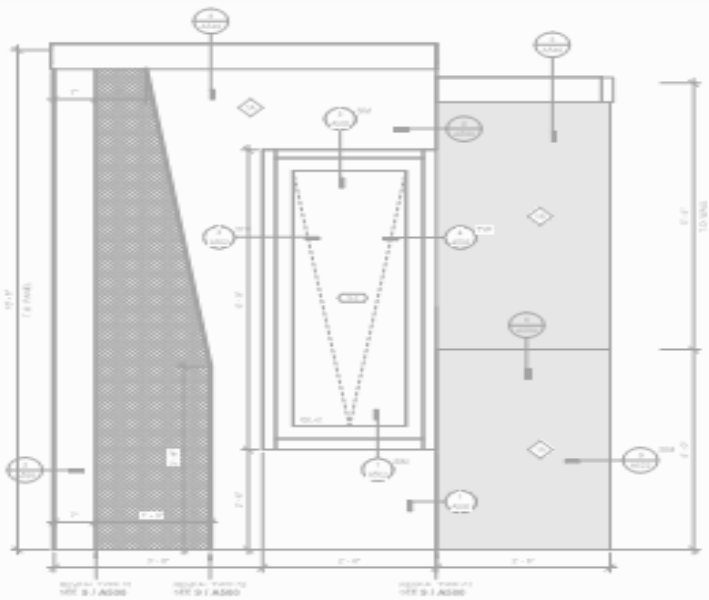
Summary of Envelope Assembly

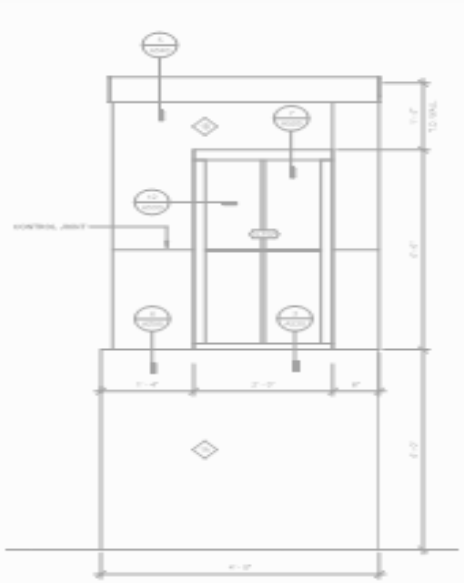
Step #	Tilt Panel Joint Assembly	TC SIGN OFF	GC SIGN OFF
	BEGINNING AT EXTERIOR SIDE OF THE JOINT		
1	Scrape Joint Clean.		
2	Install backer rod from the exterior 3" deep into the joint.		
3	Install the SikaFlex following the backer rod 3/4" depth in the joint.		
4	Install the LDF with a 2" depth in the joint.		
5	Install another back rod on the exterior.		
6	Install the Sikaflex.		
	ON THE INTERIOR SIDE OF THE JOINT		
7	Install LDF along the backer rod.		
8	Let LDF cure and expand.		
9	Trim the LDF flush with the face of the tilt panel.		
10	Prime tilt panel and LDF at the joint.		
11	Apply Blueskin at the joint covering LDF and primer.		
12	Roll and compress Blueskin with weighted roller		
13	Seal edges of the tape on the tilt panel with Butyl Sealant.		

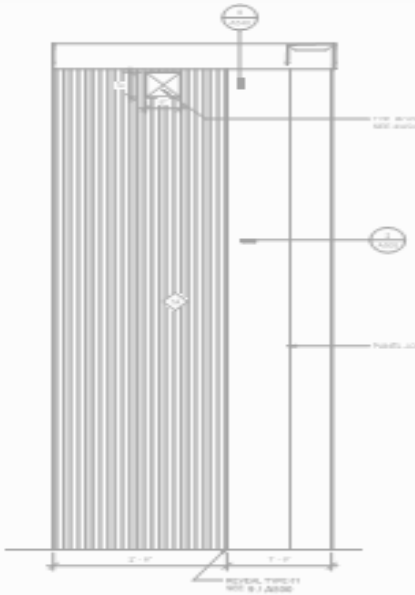
CMTA


TESTING

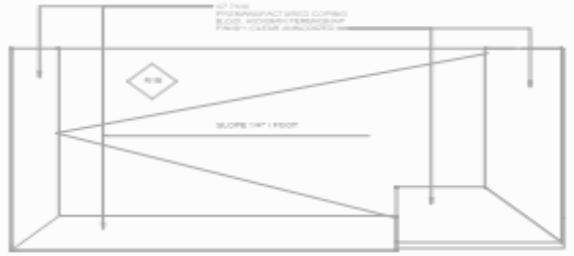

AND MORE TESTING
JCB
510-56
10222915
EQUIPMENT SERVICES





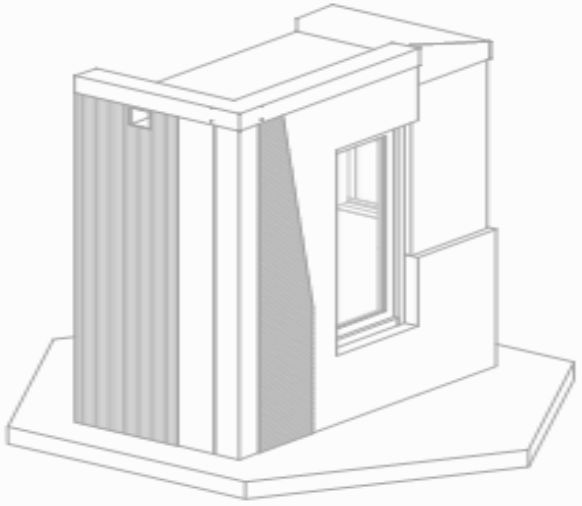


MOCK UP NOTES

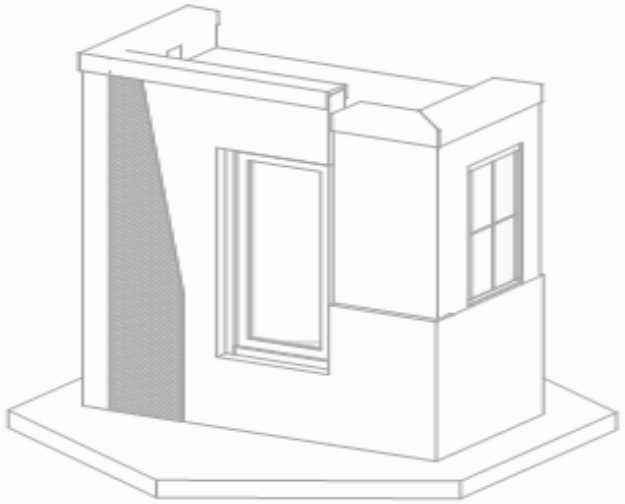


INCLUDE MOCK-UP FOR COLLECTOR BOX AND DOWN SPOUT NOT SHOWN

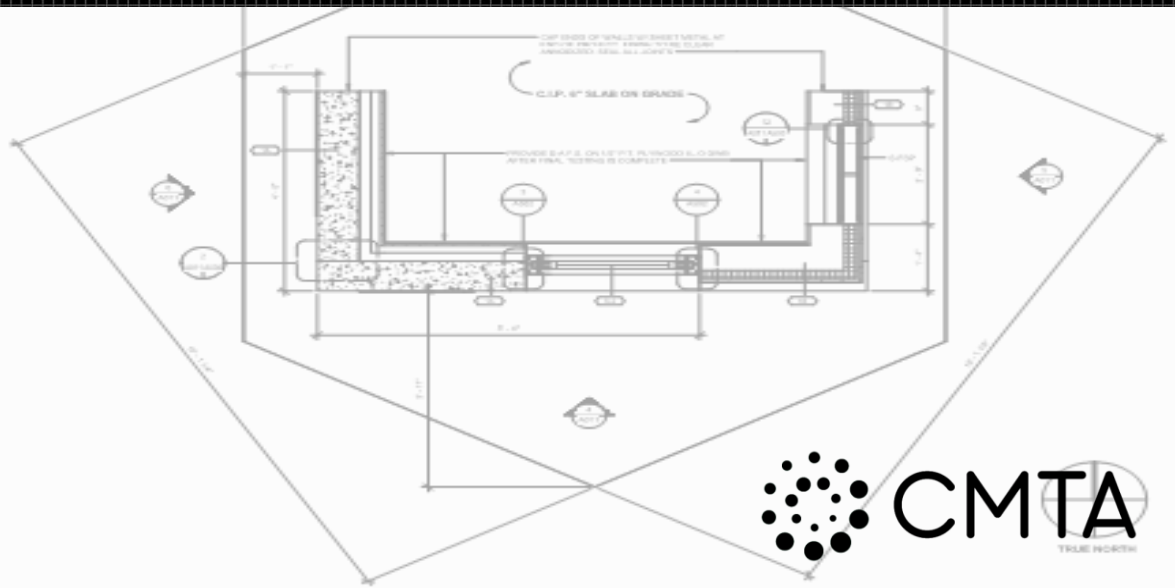
MOCK-UPS ARE NON-NEGOTIABLE



MOCKUP AXONOMETRIC VIEW 02



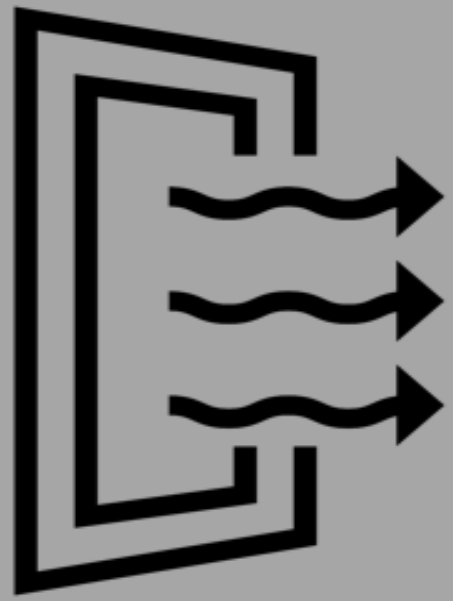
MOCKUP AXONOMETRIC VIEW 01



MOCK-UP PLAN

CMTA
TRUE NORTH

WHOLE BUILDING AIR LEAKAGE
AREA OF ENVELOPE: 73,286 SF



10,993 CFM

.15 cfm (at 75 Pascals)

REQUIRED RATE

WHOLE BUILDING AIR LEAKAGE
AREA OF ENVELOPE: 73,286 SF

1,970 CFM

.027 cfm (at 75 Pascals)

TESTED RATE

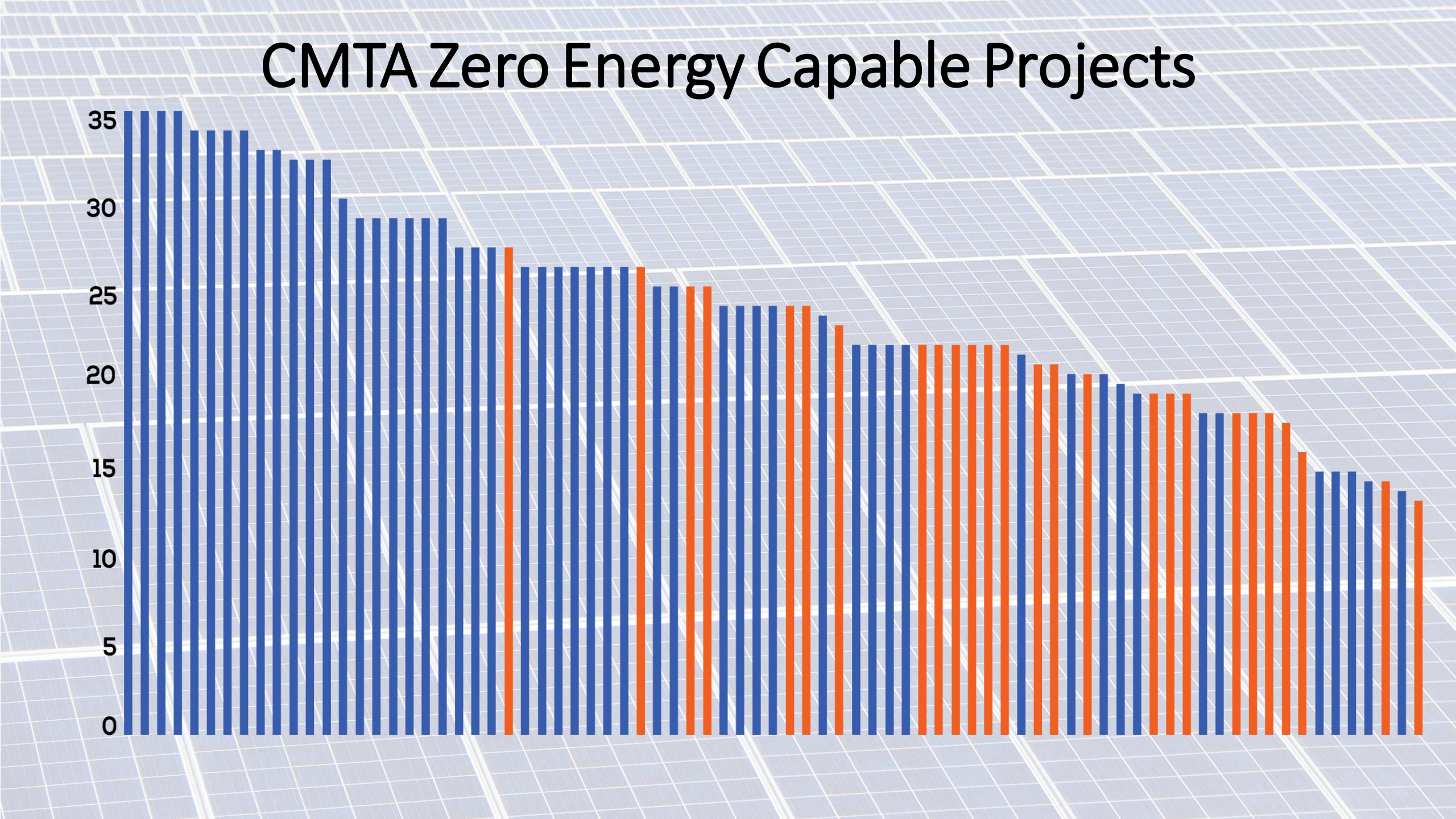
82% better than required! That's 68 tons of cold air loss less than code!

SHOULD DO

Cost Shifting:
Total cost of building reduced while reducing energy.

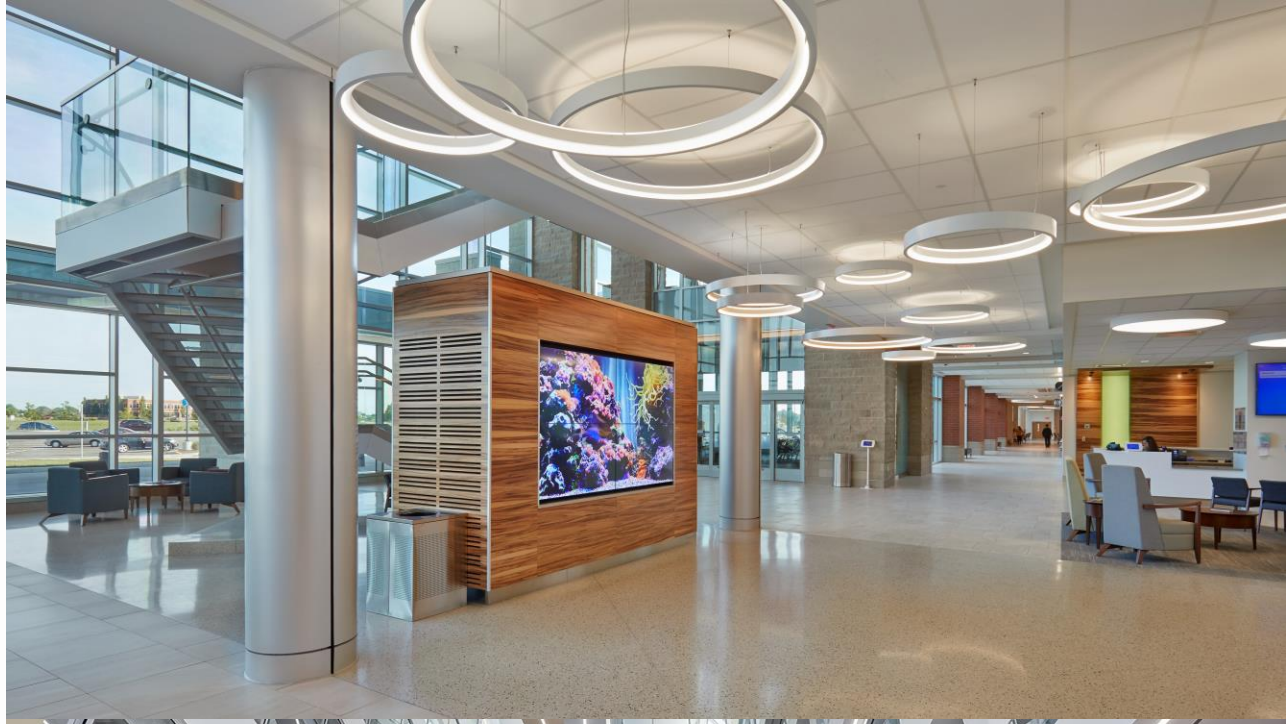
- Building Envelope/Right sizing HVAC system
- Simplified Lighting Controls
- Lighting Design Impact
- Reduced Electrical Service Size
- Glazing Choices

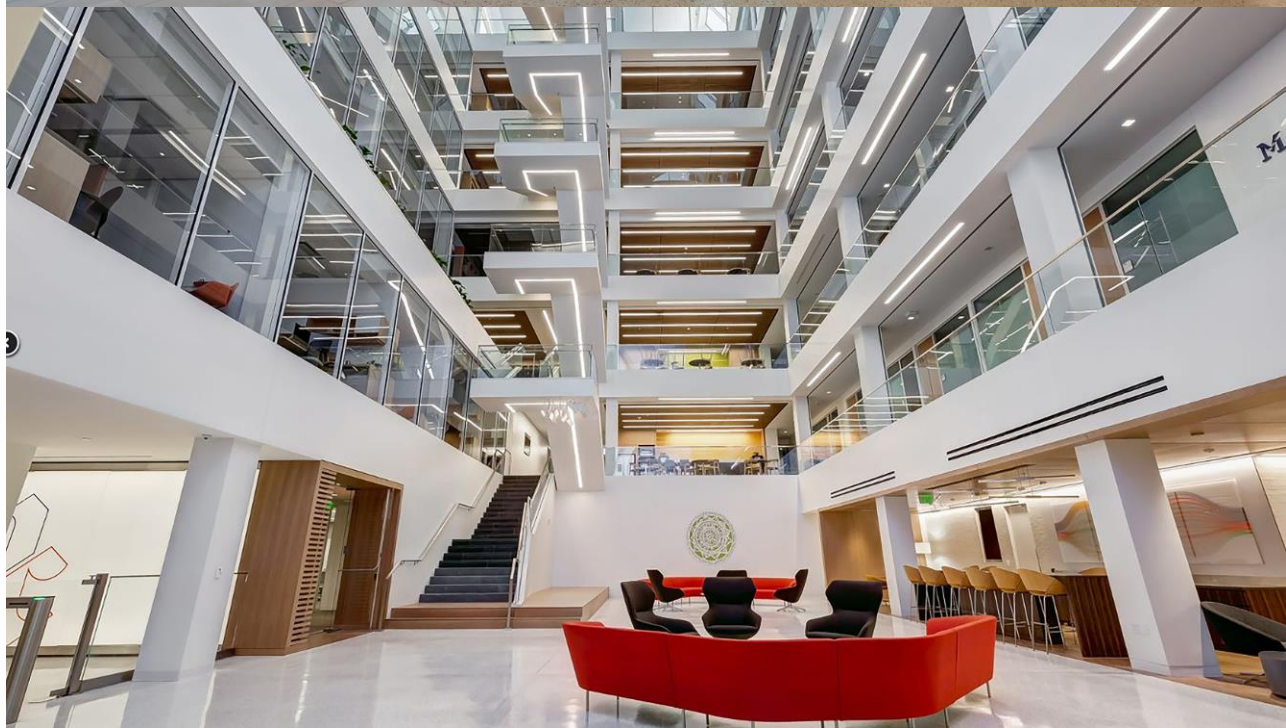
CMTA Zero Energy Capable Projects



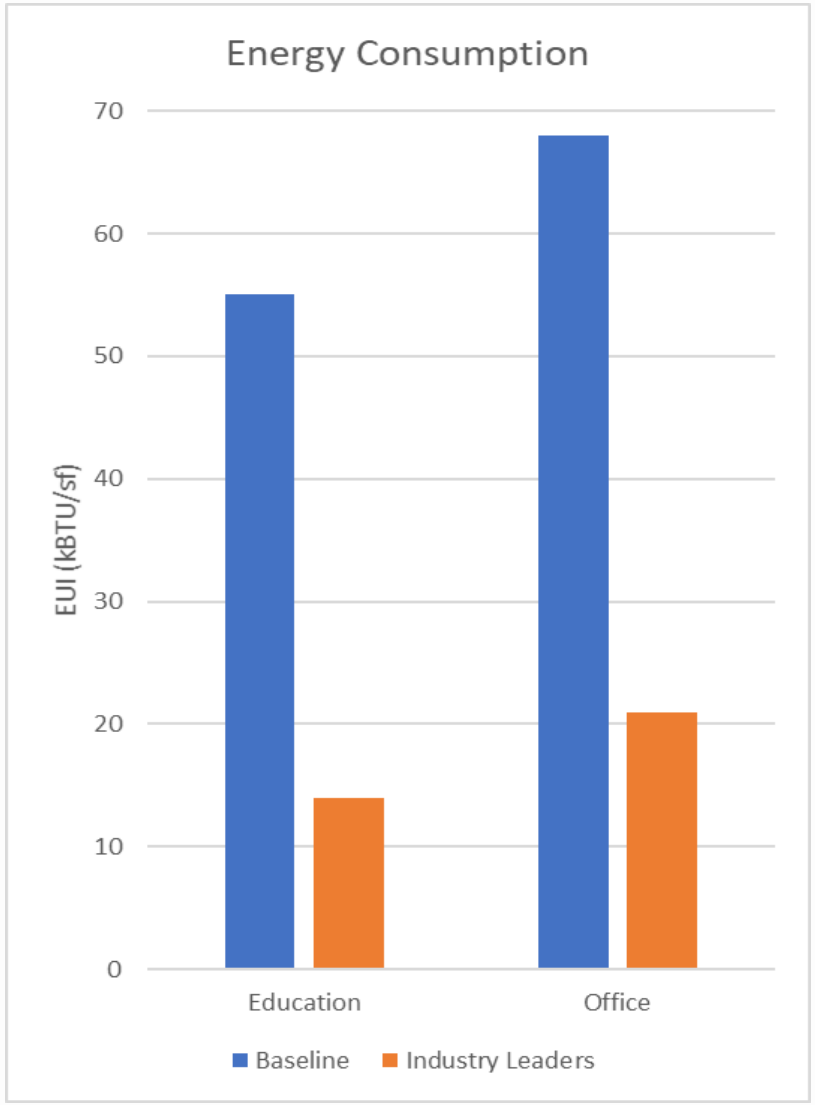
Lighting

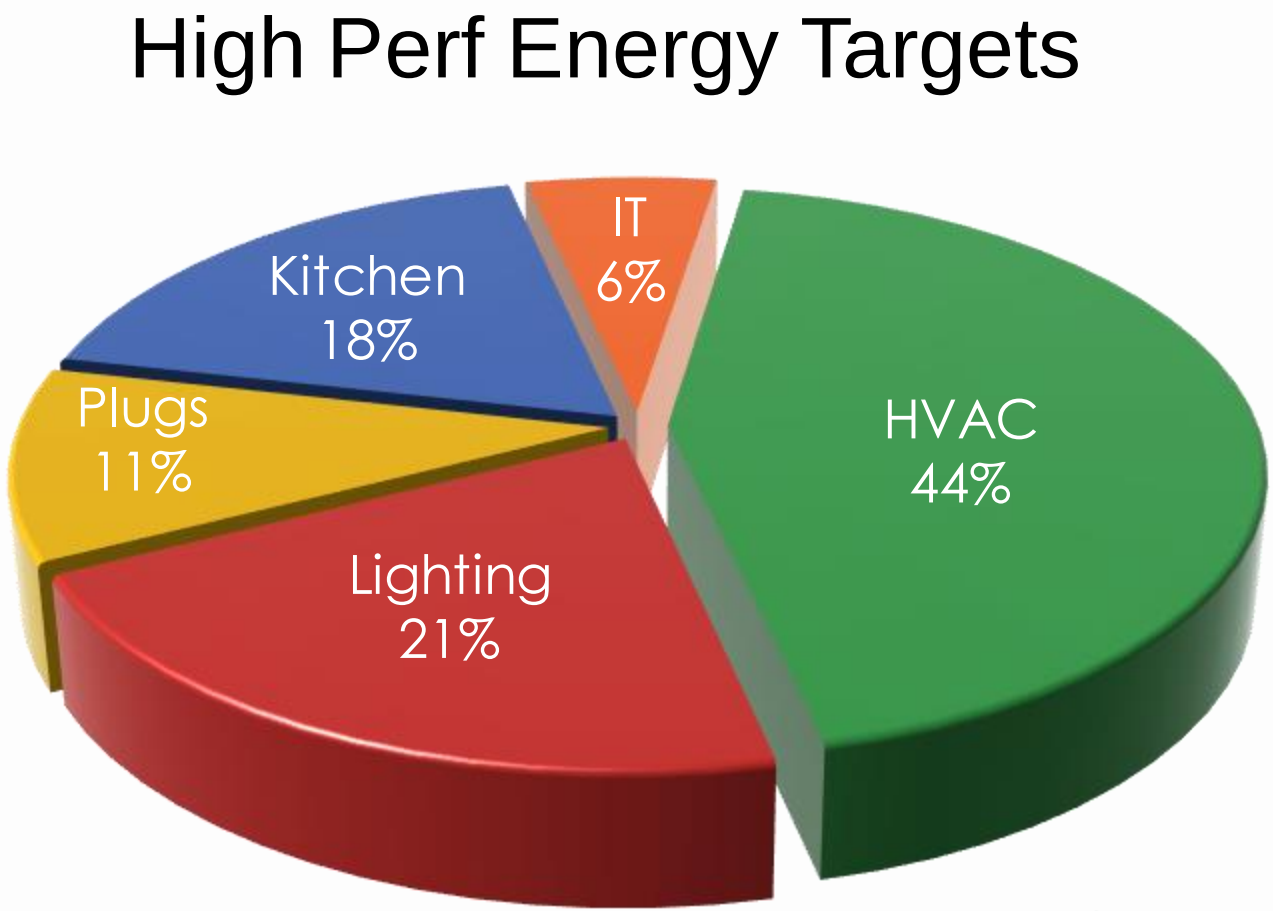
- Connected watts/sq.ft. to below .4 watts/sq.ft.
- Correct Lighting Levels for the space
- Vacancy Controls
- Daylighting
- Keep it Simple





Energy Targets





CMTA

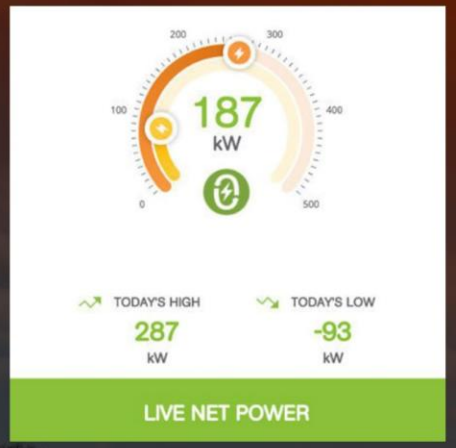
Kitchen

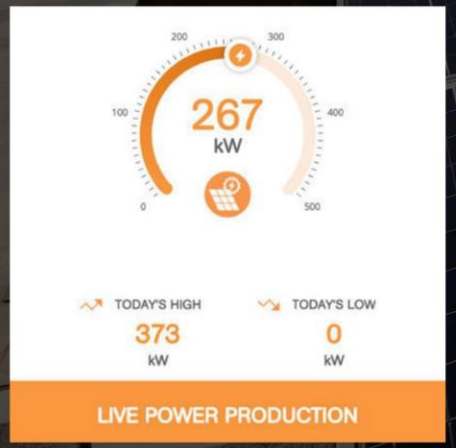
- 18% of energy in typical school was consumed by kitchen
- Few energy reductions made in past projects
- Need to change paradigm

COULD DO

CMTA

SUSTAINABILITY





CMTA Sphere

REAL-TIME BUILDING ENERGY USAGE

ENERGY EFFICIENCY EDUCATION

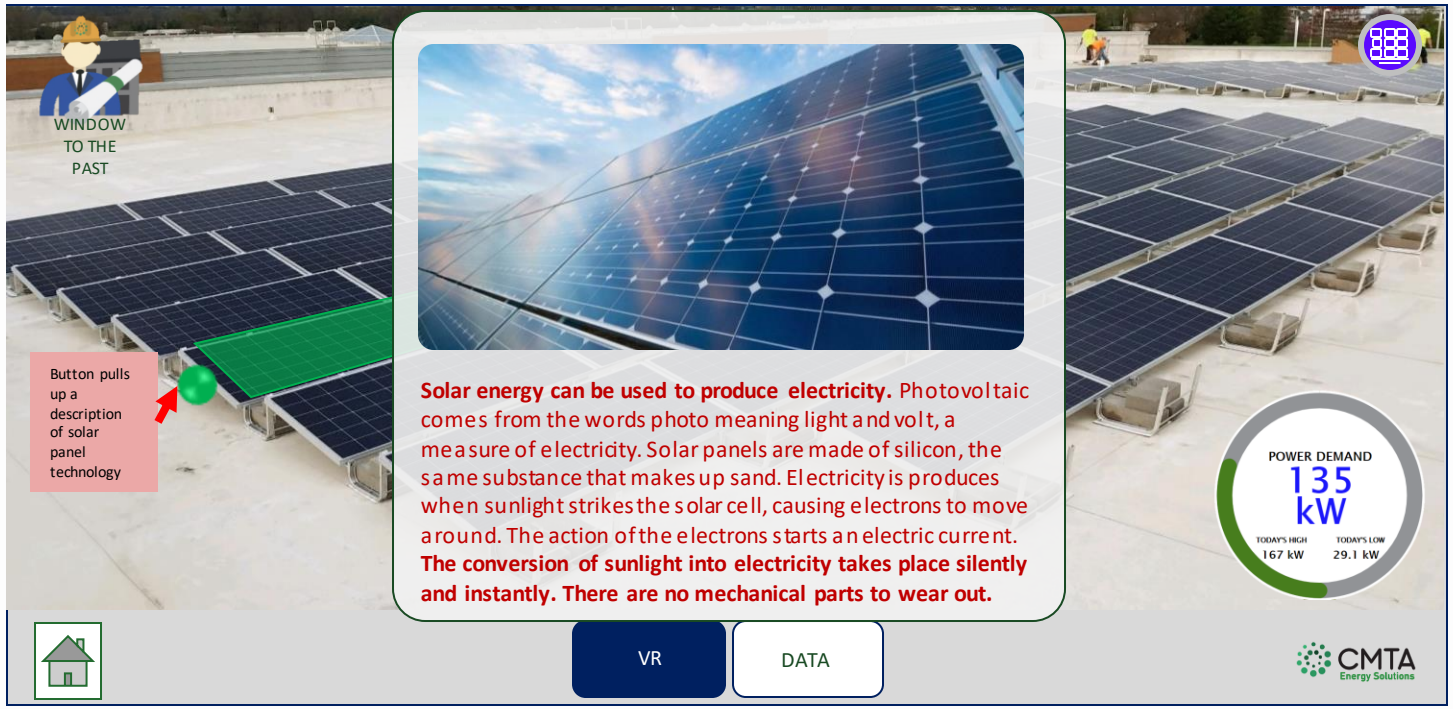
INNOVATIVE SOLUTIONS

- CMTA SPHERE -

Virtual Reality

CMTA

Virtual Reality



CMTA

Solar Lab


DISCOVERY


PRODUCTION
CONSERVATION
DISCOVERY ELEMENTARY SCHOOL
NET ZERO ENERGY

WELL / Healthy Building

CMTA

COST PER STUDENT STATION

Florida Public Schools

Elementary School

$22,760

/ STUDENT STATION

Middle School

$24,578

/ STUDENT STATION

High School

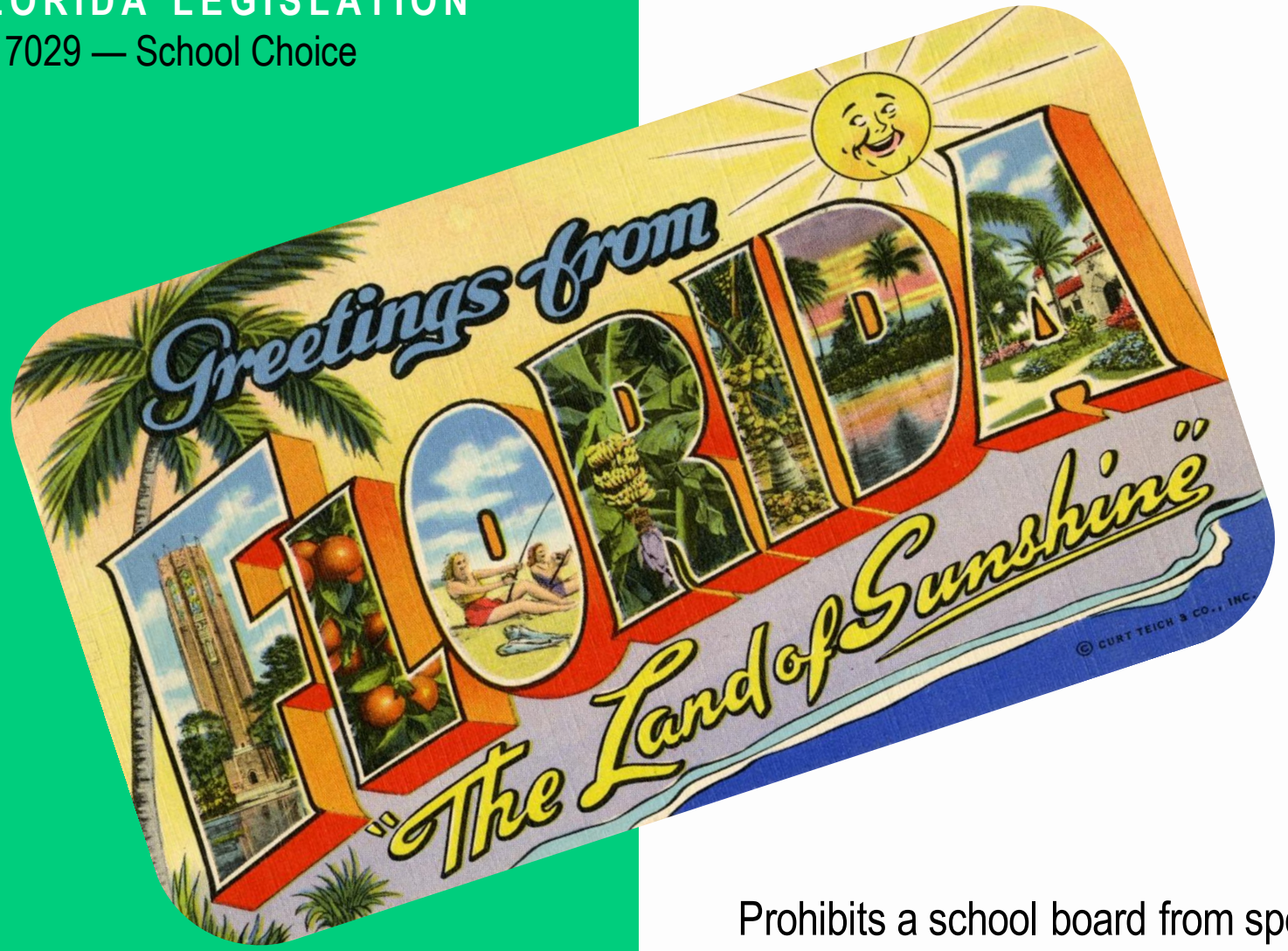
$31,925

/ STUDENT STATION

CMTA

2017 FLORIDA LEGISLATION

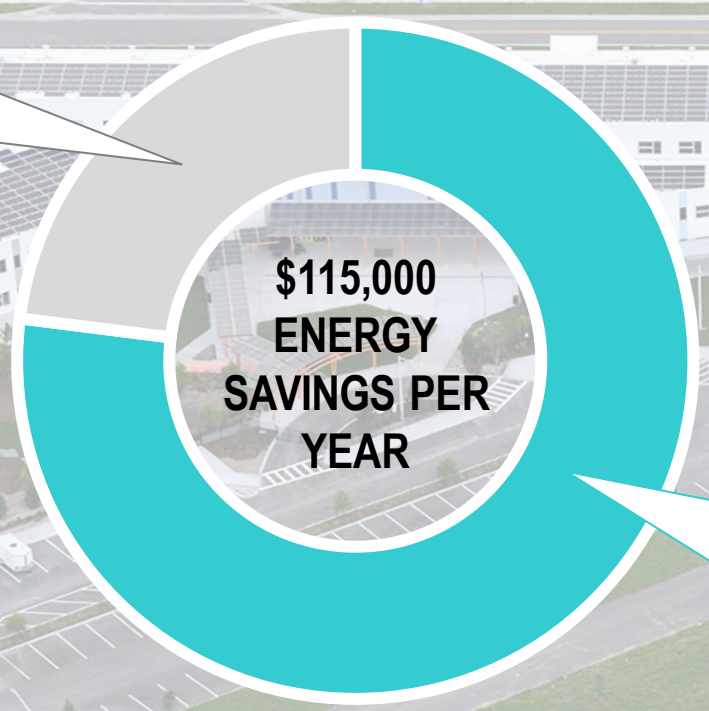
CS/CS/HB 7029 — School Choice



Prohibits a school board from spending funds from any source on new educational plant construction, including change orders, that exceeded the statutory cost per student station.

CMTA

NEOCITY ACADEMY



23%
Solar Panel

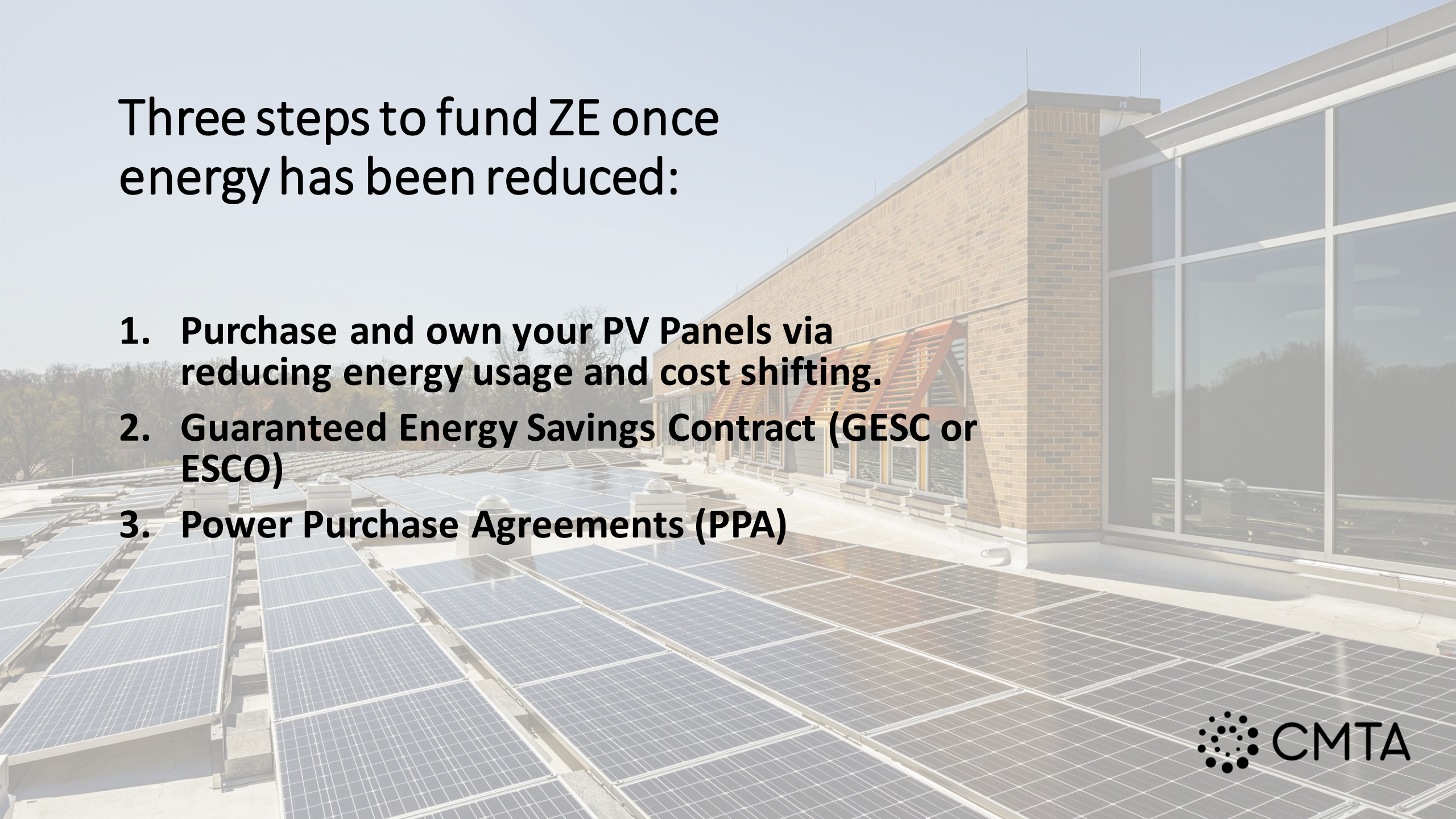
77%
High-performance

Less than ¼ of those savings are from solar panel production

CMTA

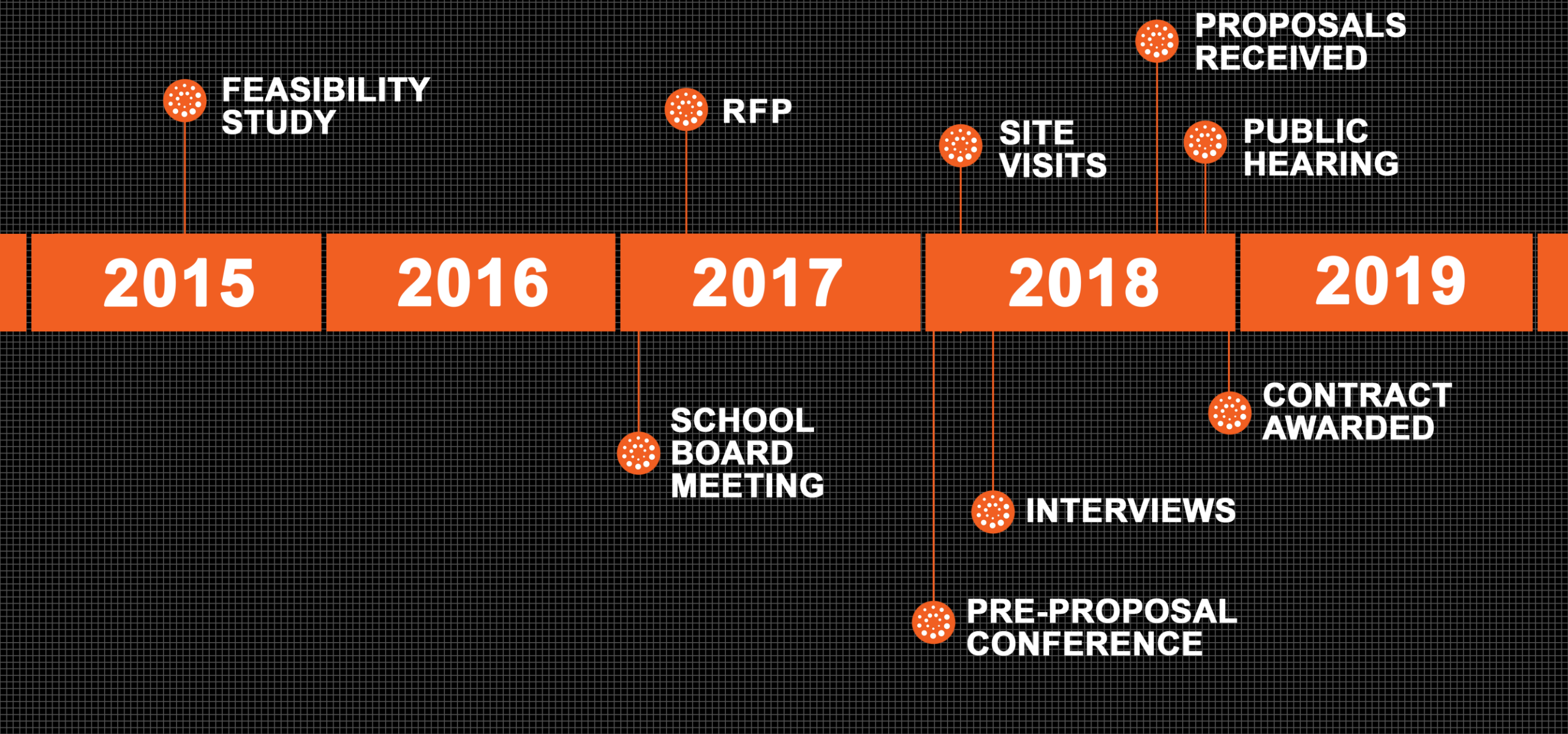
Three steps to fund ZE once energy has been reduced:

1. **Purchase and own your PV Panels via reducing energy usage and cost shifting.**
2. **Guaranteed Energy Savings Contract (GESC or ESCO)**
3. **Power Purchase Agreements (PPA)**



FLEET SOLAR PPA

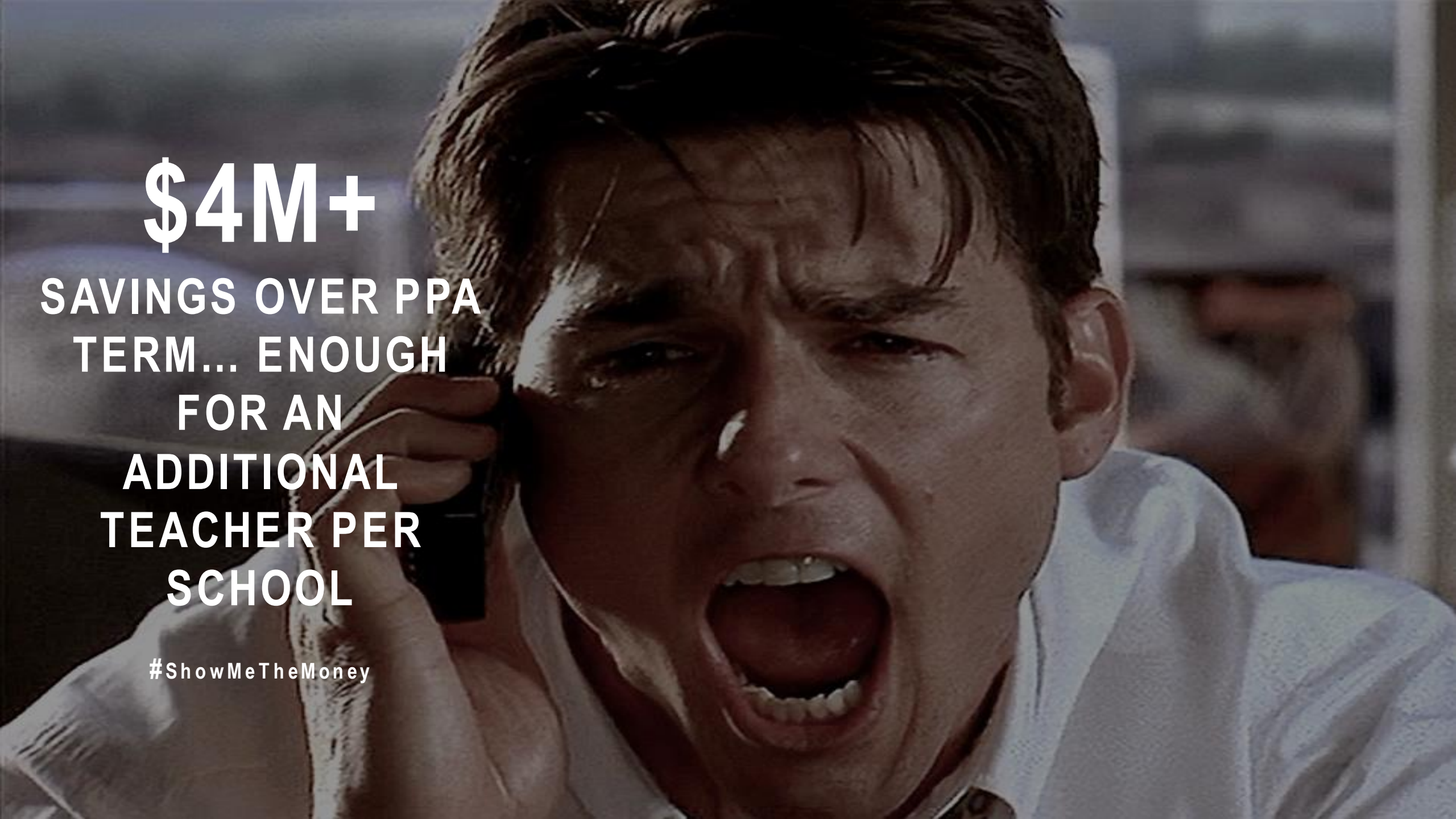
- Leverages available tax incentives
- Aligns with zero energy school design
- Hedge against rising electricity costs
- Provide authentic teaching and learning opportunities
- Support Arlington County's Community Energy Plan


FEASIBILITY STUDY
RFP
SITE VISITS
PROPOSALS RECEIVED
PUBLIC HEARING
2015
2016
2017
2018
2019
SCHOOL BOARD MEETING
CONTRACT AWARDED
INTERVIEWS
PRE-PROPOSAL CONFERENCE

FLEET SOLAR PPA

School Site	System Size (kW_{DC})	PV Array Production (kWh)
Fleet ES	574.9	748,900
Jefferson MS	382.0	525,400
Kenmore MS	533.2	742,000
Tuckahoe ES	22.0	29,700
WLHS	1000.0	1,363,000

- 25-Year Contract Term
- ~15% Discount
- 5 Schools Total
- 2.5MW Capacity
- Option to Buy at Year 7


$4M+
SAVINGS OVER PPA TERM... ENOUGH FOR AN ADDITIONAL TEACHER PER SCHOOL
#ShowMeTheMoney

LIFECYCLE COSTS

$115K

SAVED PER YEAR
ON ENERGY COSTS

$3.2M

SAVED OVER 20 YRS ON ENERGY
& MAINTENANCE COSTS

44,560 SF

500

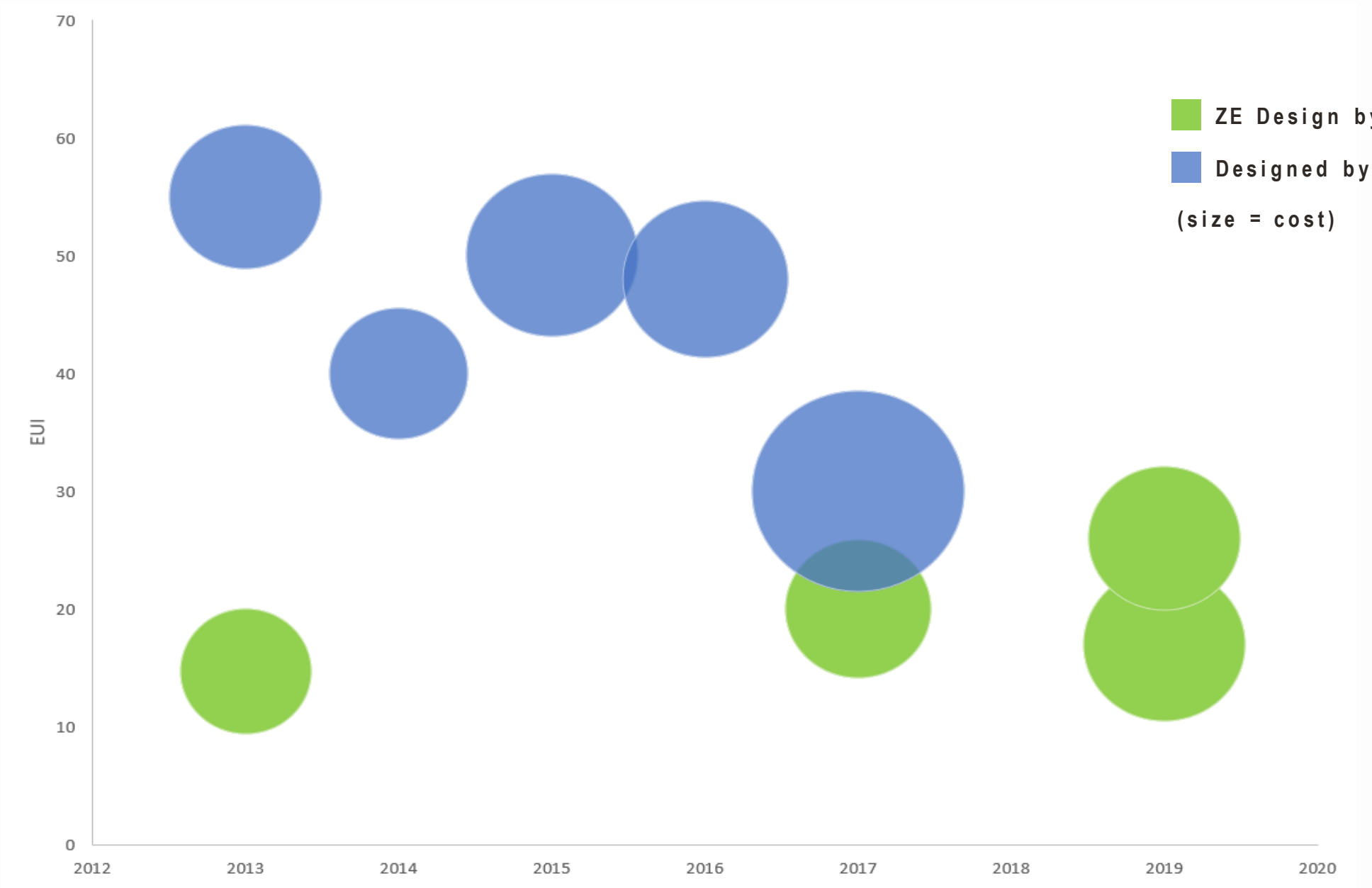
STUDENTS

(CAPACITY IS 625)

WITHIN COST
PER STUDENT
STATION &
SREF

CMTA

Arlington Public Schools – Construction Cost per Student & EUI



CMTA

What's Next?

Carbon Neutral

BRIGHT ENERGY 101™
ENERGY EFFICIENCY & RENEWABLE ENERGY

Monitoring and Verification
Engaging Students in Getting to Zero at Schools

Bill Kelly

October 9, 2019

Agenda

- Introduction to BE101
- About the Pilot with Porterville USD
- Program Elements
- Support Provided to Schools
- Q&A

Preparing students for college & career, high-demand and high-paying jobs

Bright Energy 101 (BE101)

a Public Benefit Corporation founded in 2018

BRIGHT ENERGY 101™
ENERGY EFFICIENCY & RENEWABLE ENERGY

…. to create and drive paths toward a clean energy economy, and provide exciting opportunities for youth to shape those paths.

Founders of Bright Energy 101

Porterville Unified School District

BRIGHT ENERGY 101™
ENERGY EFFICIENCY & RENEWABLE ENERGY

A Strong Foundation & History:

Innovating in **STEM Education & Clean Energy**

PUSD Pathways LINKED LEARNING

PROJECT LEAD THE WAY PLTW

Bright Energy 101 Program Elements

Monitoring & Verification Software (EIS Software)

The BE101 Program

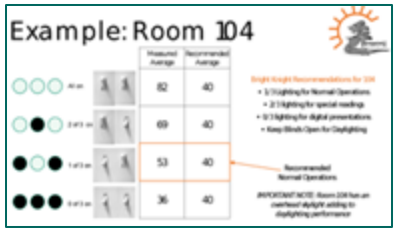
Conservation Efficiency & Renewables

Student Driven Work Based Learning

Audit & Data Collection

Interviews

Research



Analysis / Recommendation

Presentations

Celebrating Accomplishments

Student Driven: Interviews, Audit & Energy Model

- Learn of progress to date on efficiency & renewable energy
- Get recommendations on potential opportunities
  - Conservation
  - Efficiency
  - Electrification
  - Renewables
- Insights and advice to shape the students' approach

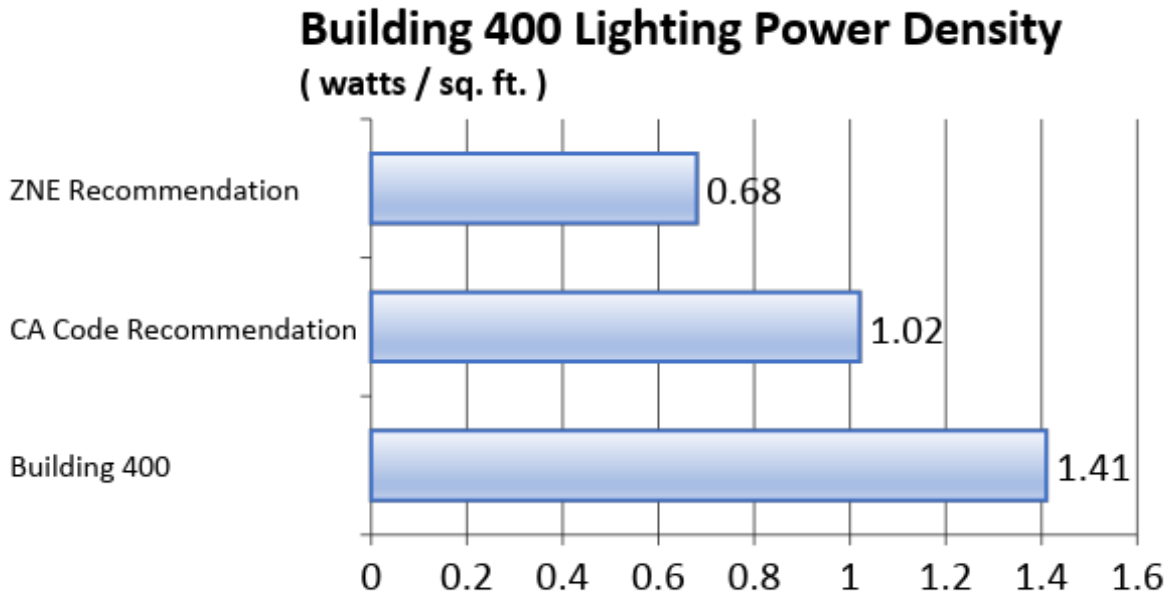
Student Driven: Audit and Observe

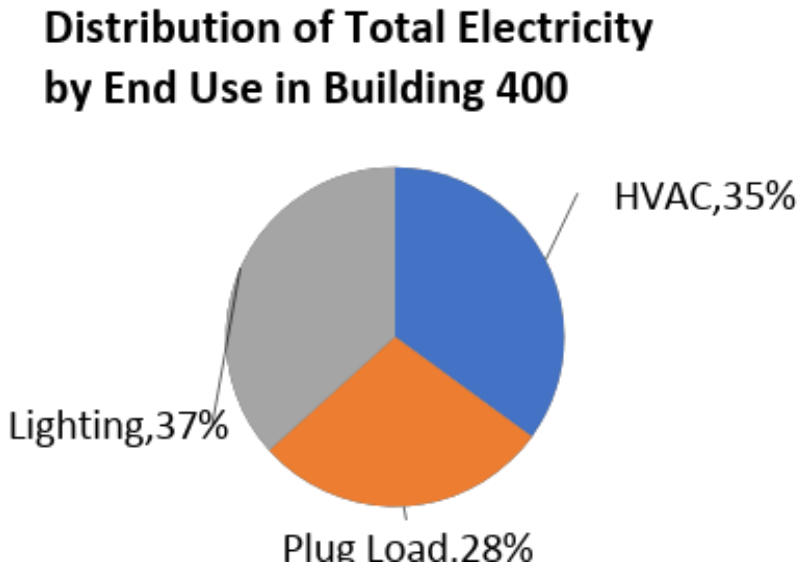
- Lighting
- Plug Loads
- Heating, Ventilation, and Air Conditioning (HVAC)
- Energy Management System (EMS)

Student Driven: Building Energy Model (sample)

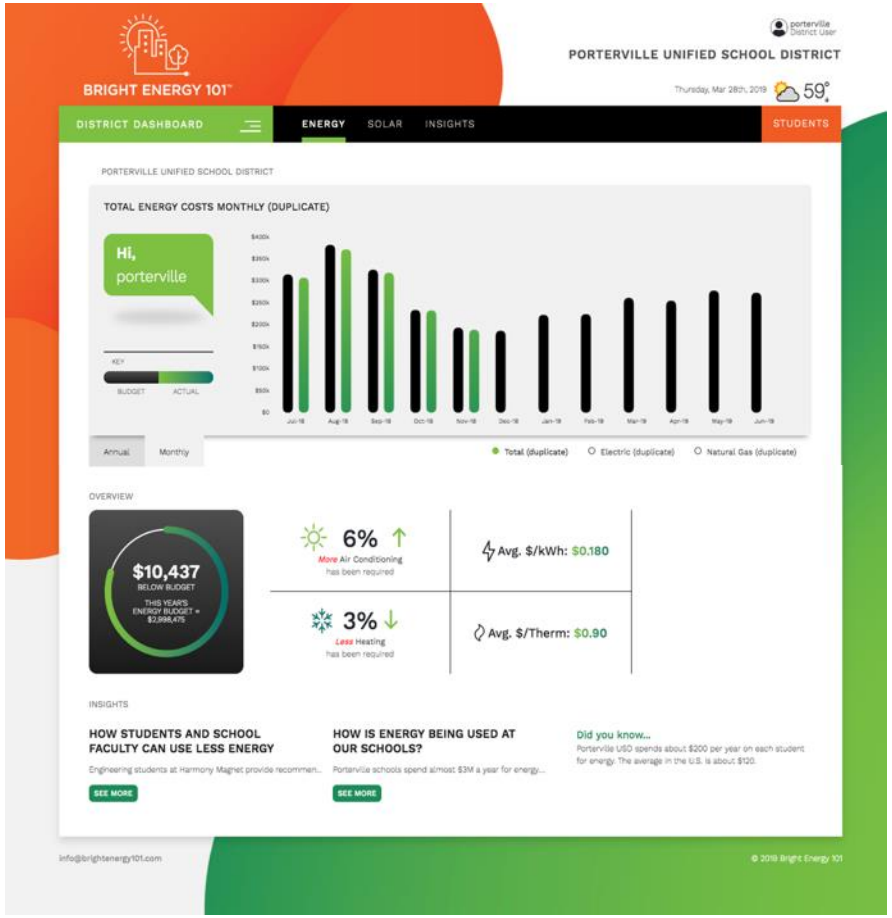
Current EUI	**36**
Target EUI	**19**
ZNE Cost Savings	**$14,400**

% of PHS sq.ft.	7.2%
% of electricity use	6.5%





Students working to support each school reach ZE .....



Monitoring & Verification - EIS Software

Bright Knights
Harmony Magnet Academy

HM A Teacher Presentation

Conservation Competition

Bright Knights Recommendations

LIGHTING

- Consider 1/3 or 2/3 Lighting with DAYLIGHT for normal class operation
- Invite a Bright Knight to your class for a Technical Consultation
  - Should only take about 5 minutes
  - Don't worry, our weapon is our brain – not a sword!
  - It will be fun!!

PLUG LOADS

Consider switching off power strips, printers and computers each night – those vampire loads need to be taught a lesson

Plan for Each School

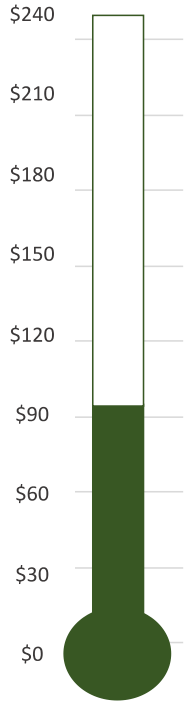
and .....

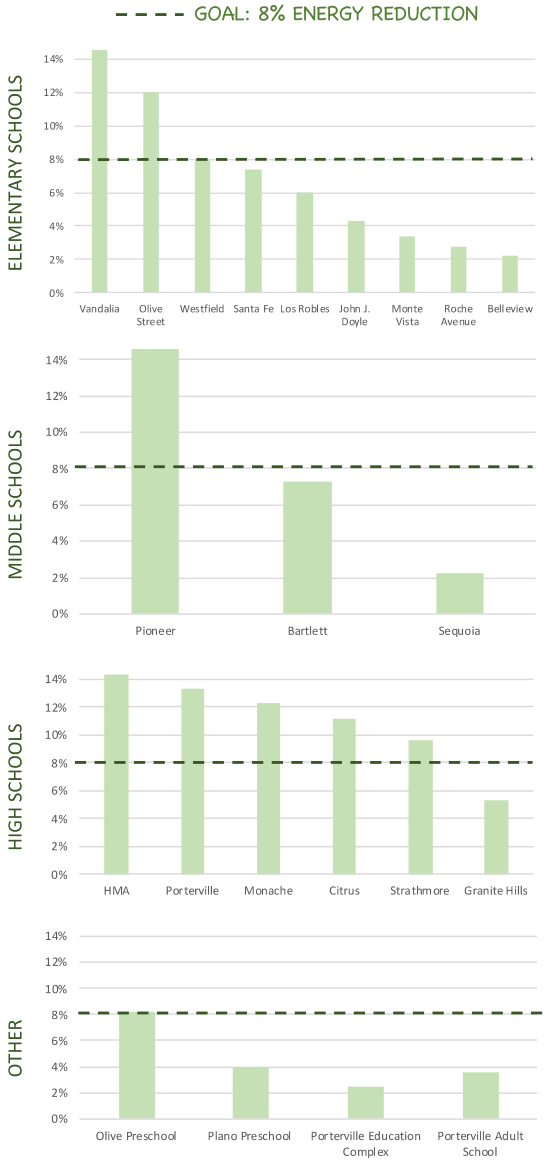
Panda Dollars for Porterville

Leader Board (SAMPLE)

Q1 2019 RESULTS

DISTRICTWIDE SAVINGS
(thousands)





Introducing three of the interns, the Bright Knights …..

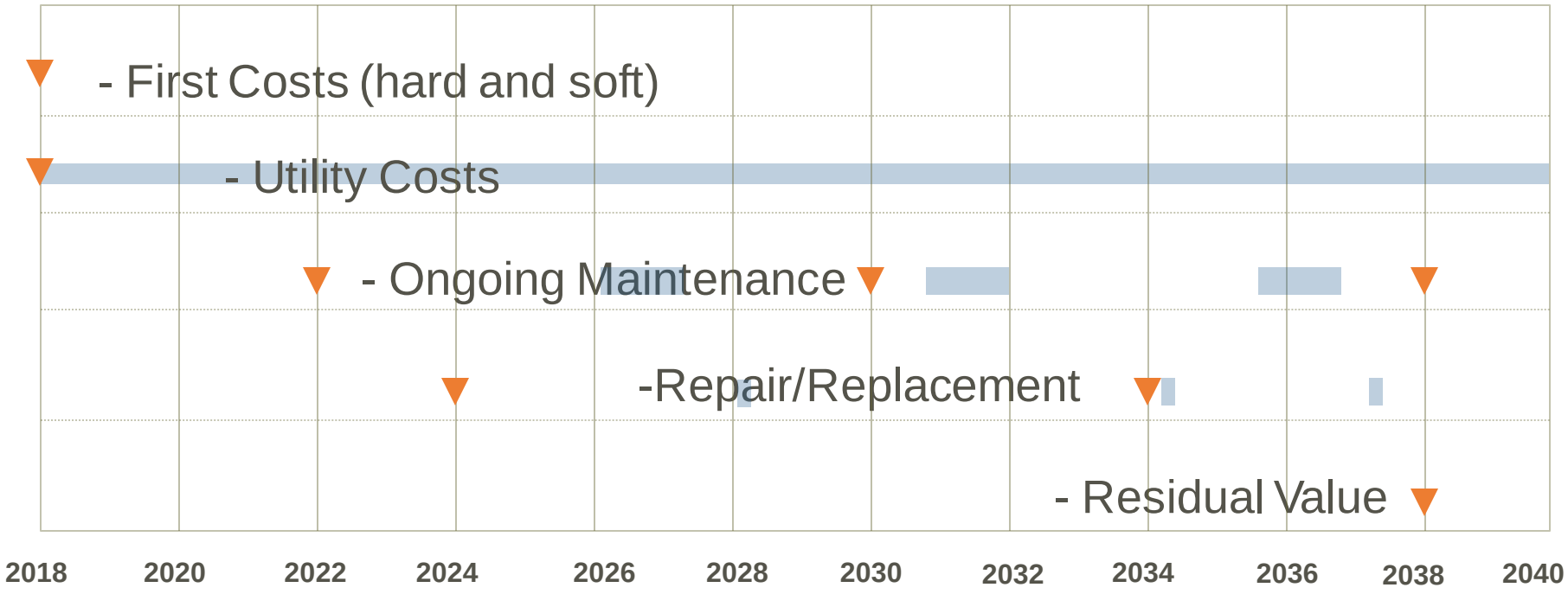
Q&A

Cost of Getting to Zero

Life Cycle Cost Analysis

- What is the real cost of a building?

Life Cycle Cost = Net Present Value of:



nbi new buildings institute

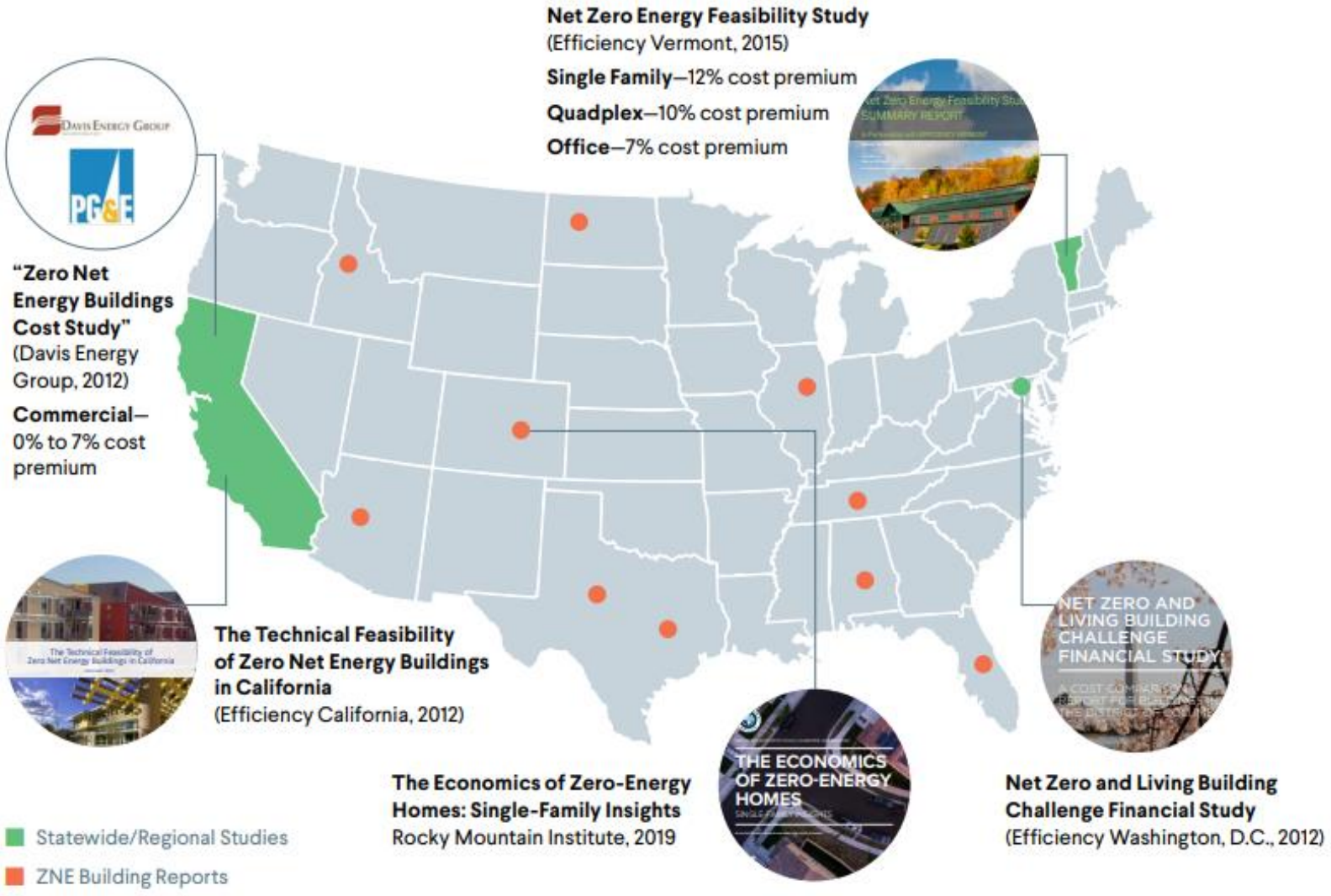
Cost of Zero Studies

- California Technical Feasibility
- District of Columbia
- Efficiency Vermont
- PG&E Case Studies, Volumes 1-3
- Rocky Mountain Institute
- USGBC Massachusetts

FIGURE 3

ZE Studies in the US

Multiple studies have been conducted around the county on the upfront cost premium of ZE buildings.



USGBC Massachusetts - *Zero Energy Buildings in MA: Saving Money from the Start*

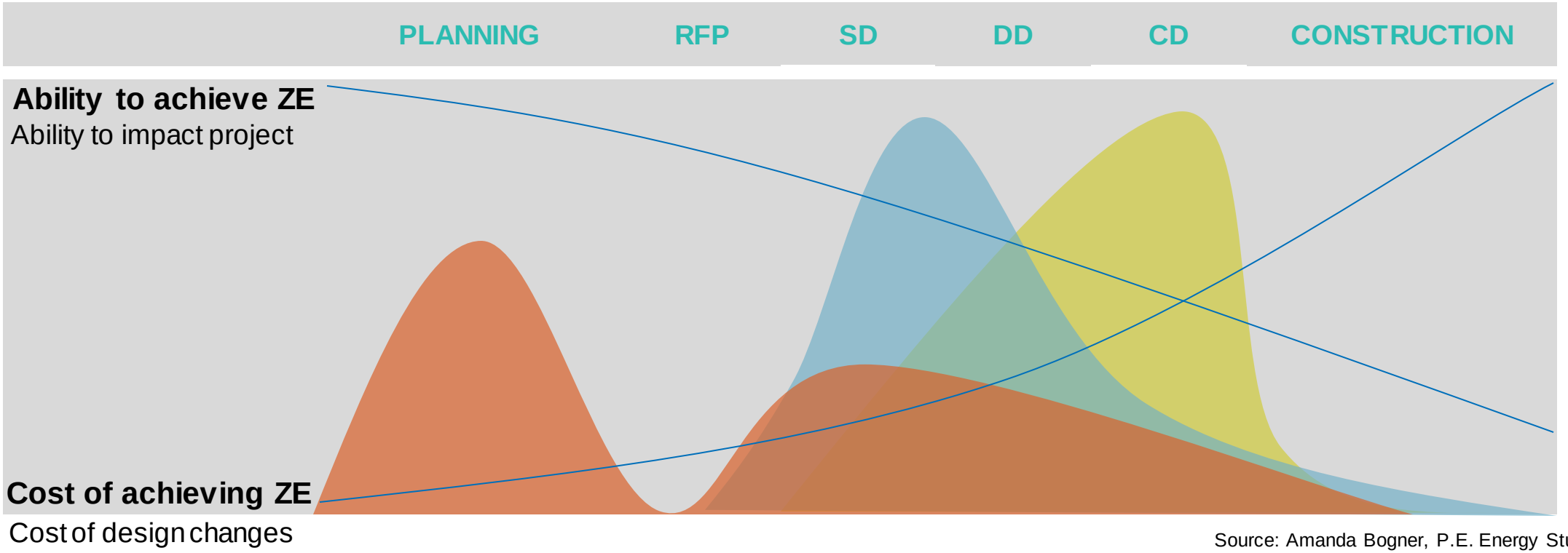
Change the Conversation

"The prevailing industry perception is that zero energy is cost prohibitive and suitable only for showcase projects with atypical, large budgets; however, ***there is mounting evidence that zero energy can, in many cases, be achieved within typical construction budgets****."*

nbi new buildings institute

Manage Costs

MacLeamy Curve

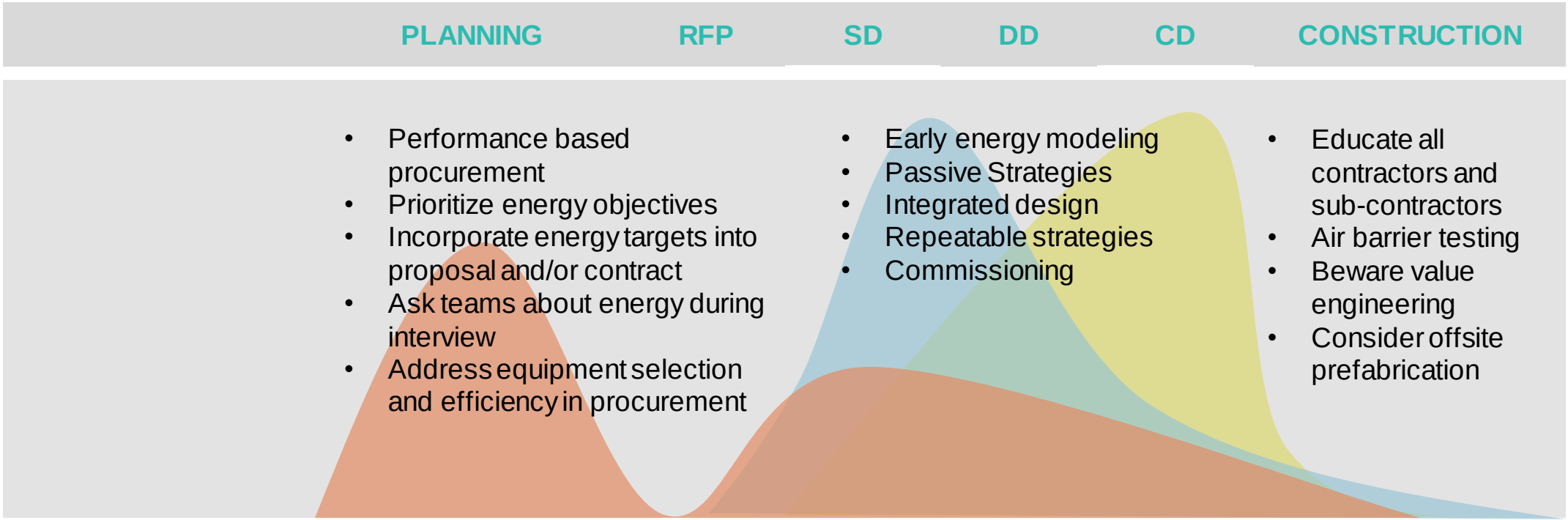


Source: Amanda Bogner, P.E. Energy Studio

nbi new buildings institute

Manage Costs

MacLeamy Curve

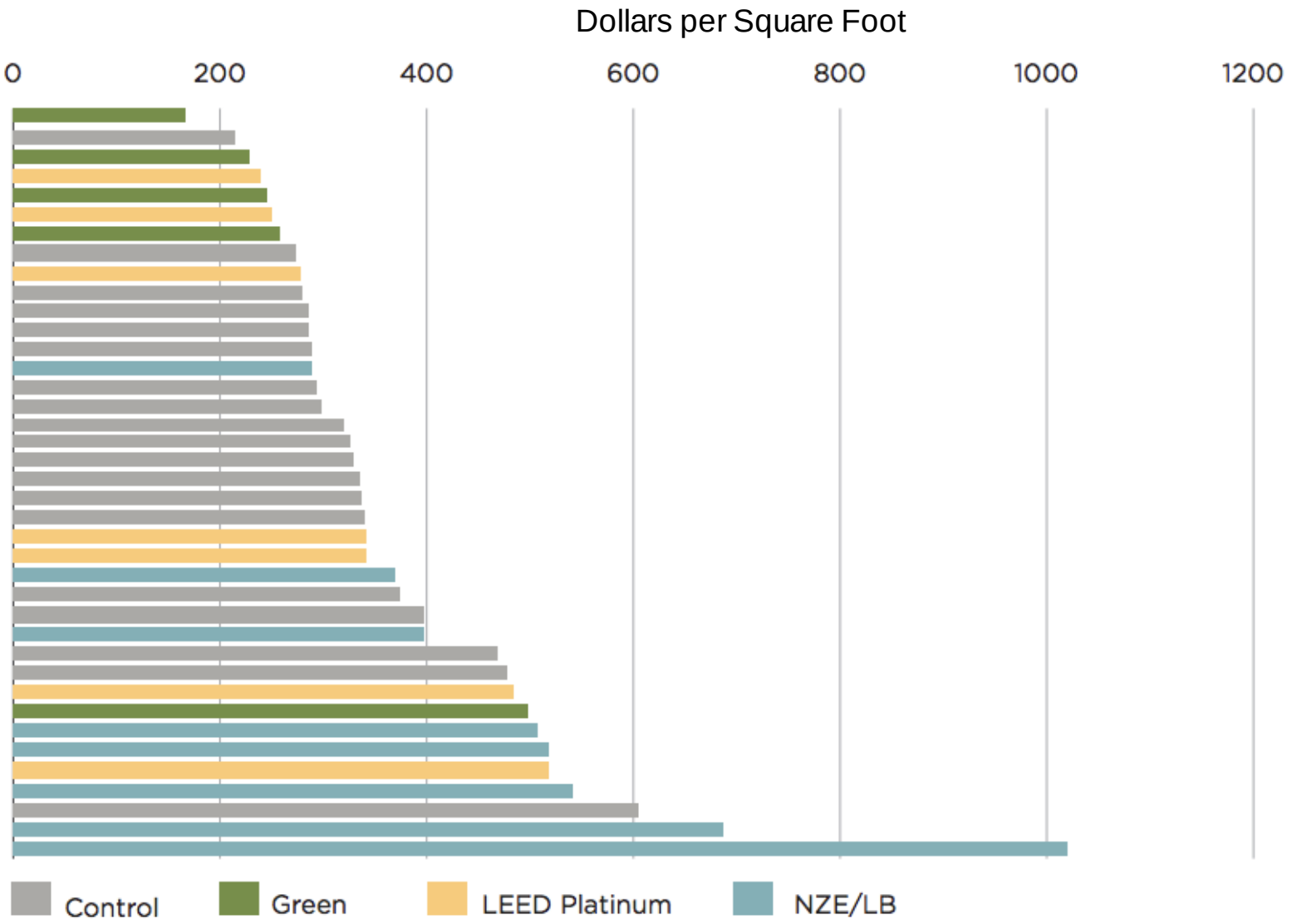


Source: Amanda Bogner, P.E. Energy Studio

nbi new buildings institute

Power of Zero: Optimizing Value For Next Generation Green

- Cost for “next generation green” projects are approaching those of conventional buildings
- Values and determination are a key differentiator



2013: BNIM, Integral Group, Davis Langdon, AIA COTE

From Zero Energy to Zero Carbon

Alice Sung, AIA, LEED AP, BD+C, ISSP-SA
Principal, ***Greenbank Associates***

Think Globally

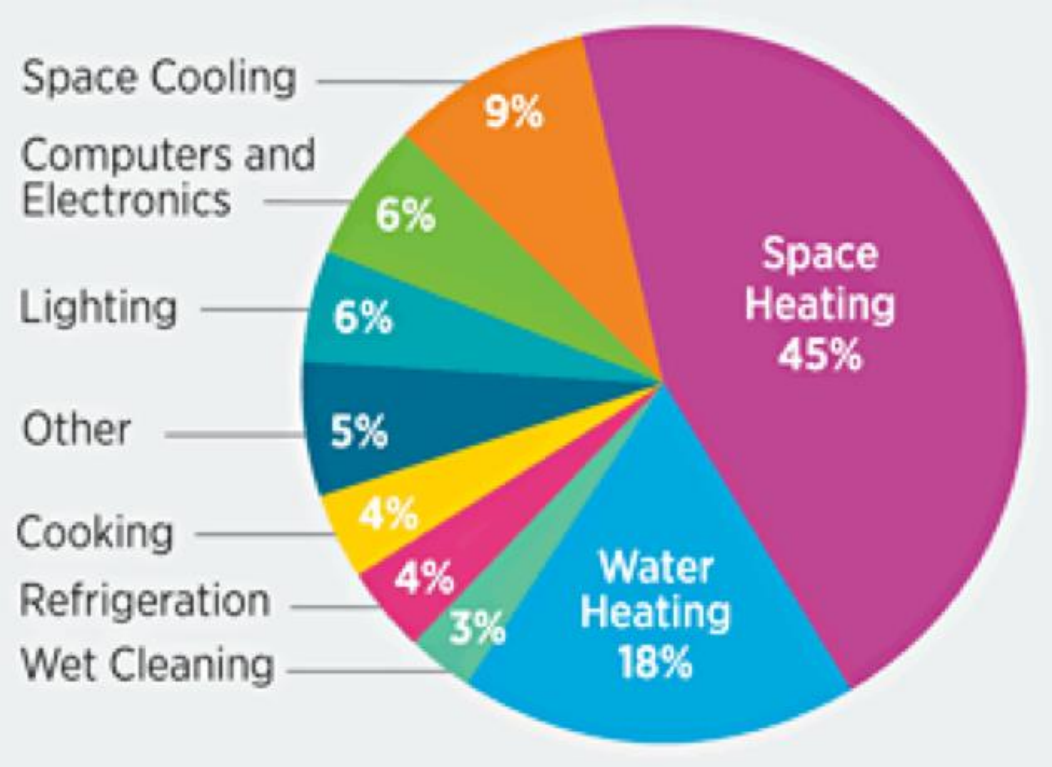
Photo: NASA

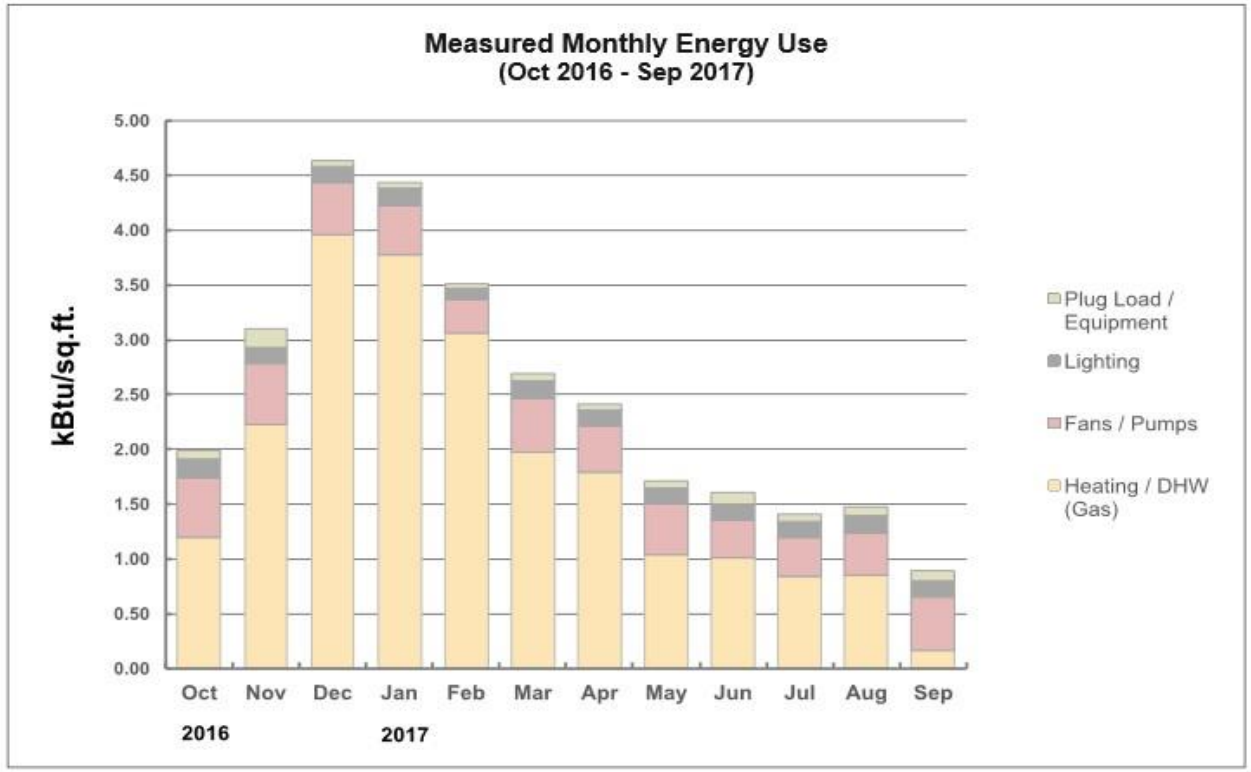
Act Locally

Bishop O Dowd High School | Oakland, CA
Credit: David Wakely

GETTING TO zero FORUM 2019

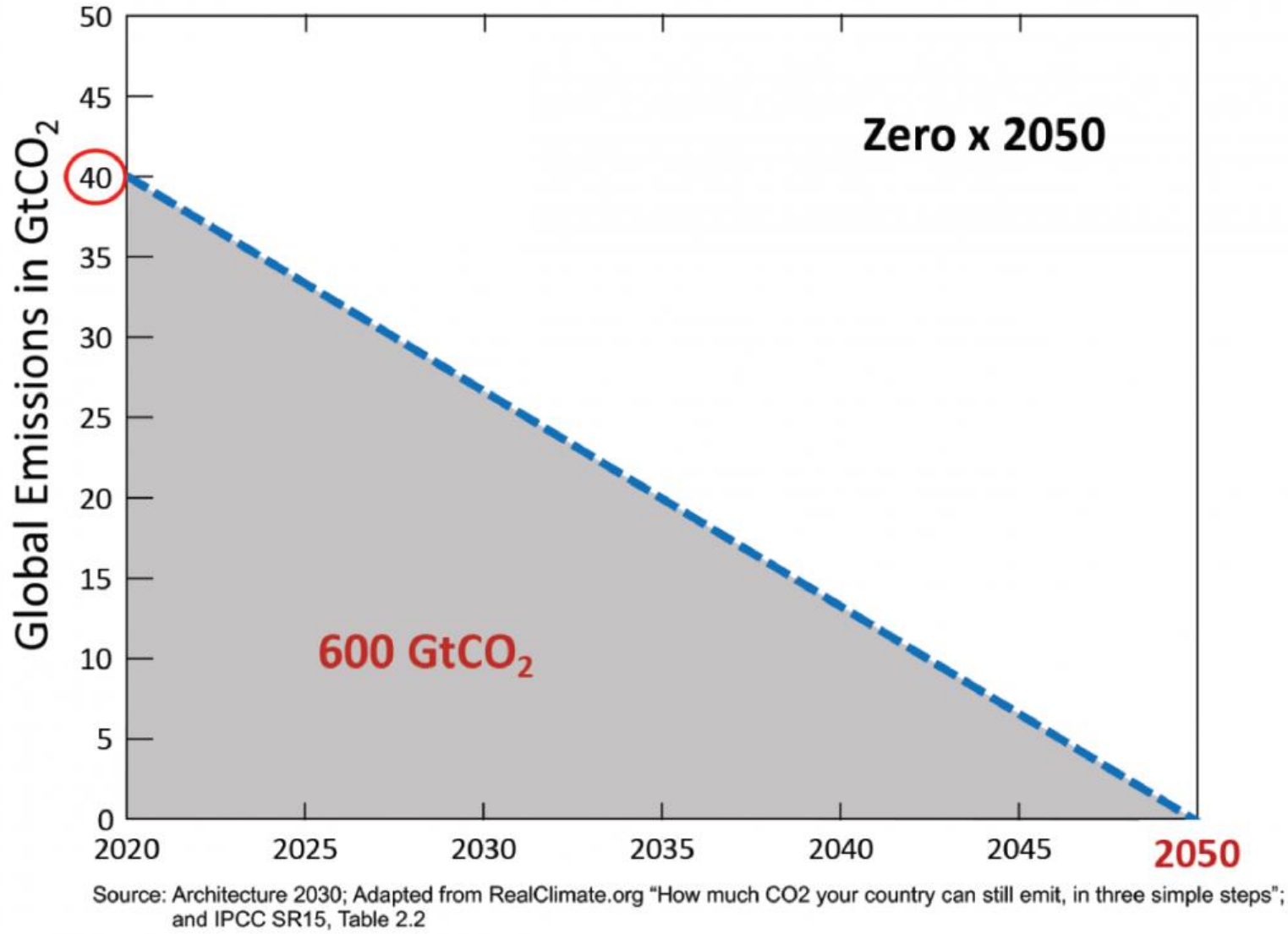
Pop Quiz


Space Cooling
Computers and Electronics
Lighting
Other
Cooking
Refrigeration
Wet Cleaning
9%
6%
6%
5%
4%
4%
3%
Space Heating 45%
Water Heating 18%


Measured Monthly Energy Use
(Oct 2016 - Sep 2017)
kBtu/sq.ft.
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
2016
2017
Plug Load / Equipment
Lighting
Fans / Pumps
Heating / DHW (Gas)

Long Term Goal of Zero by 2050 exceeds 500 GtCo2

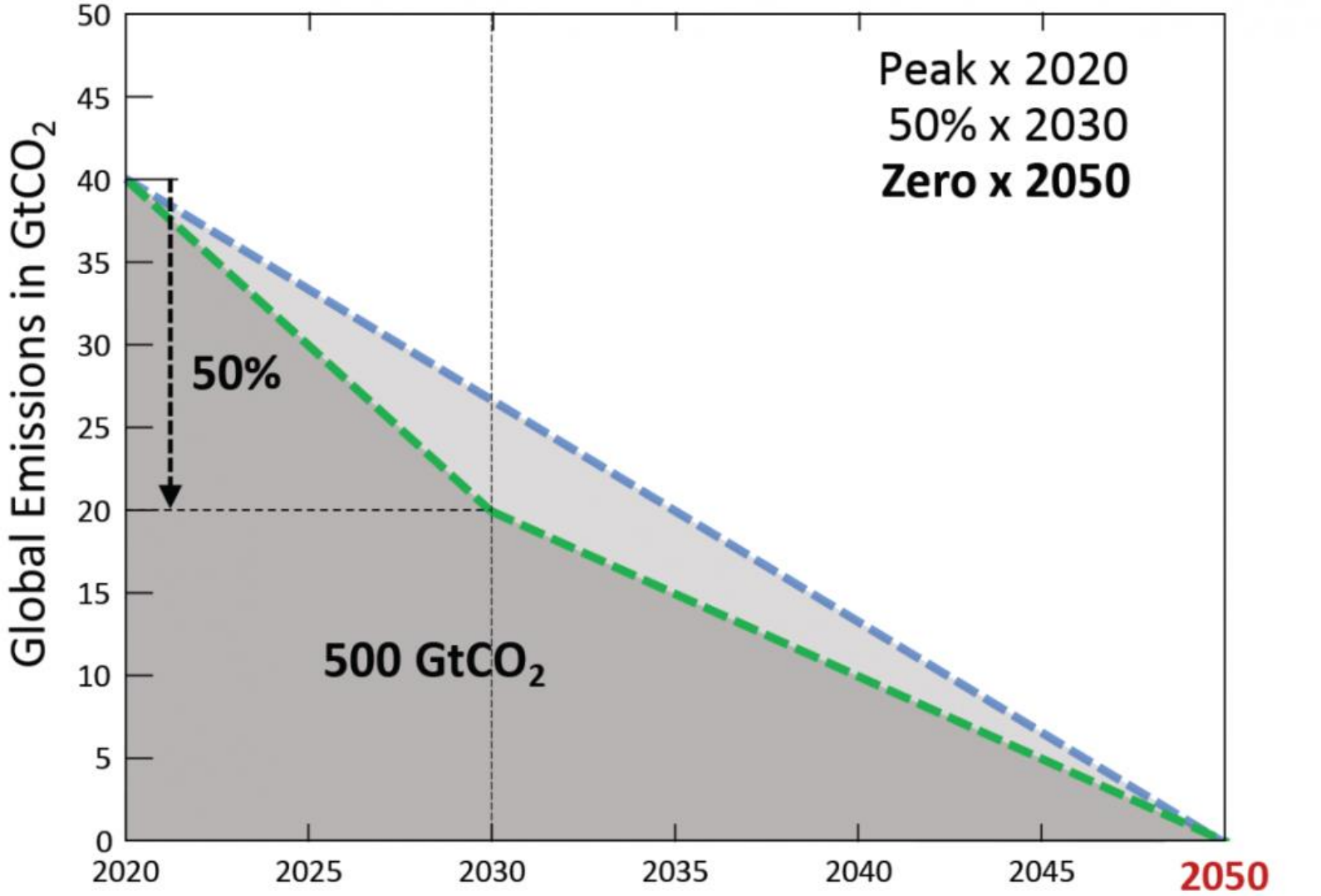
Global Zero Carbon Goal



Source: Architecture 2030; Adapted from RealClimate.org "How much CO2 your country can still emit, in three simple steps"; and IPCC SR15, Table 2.2

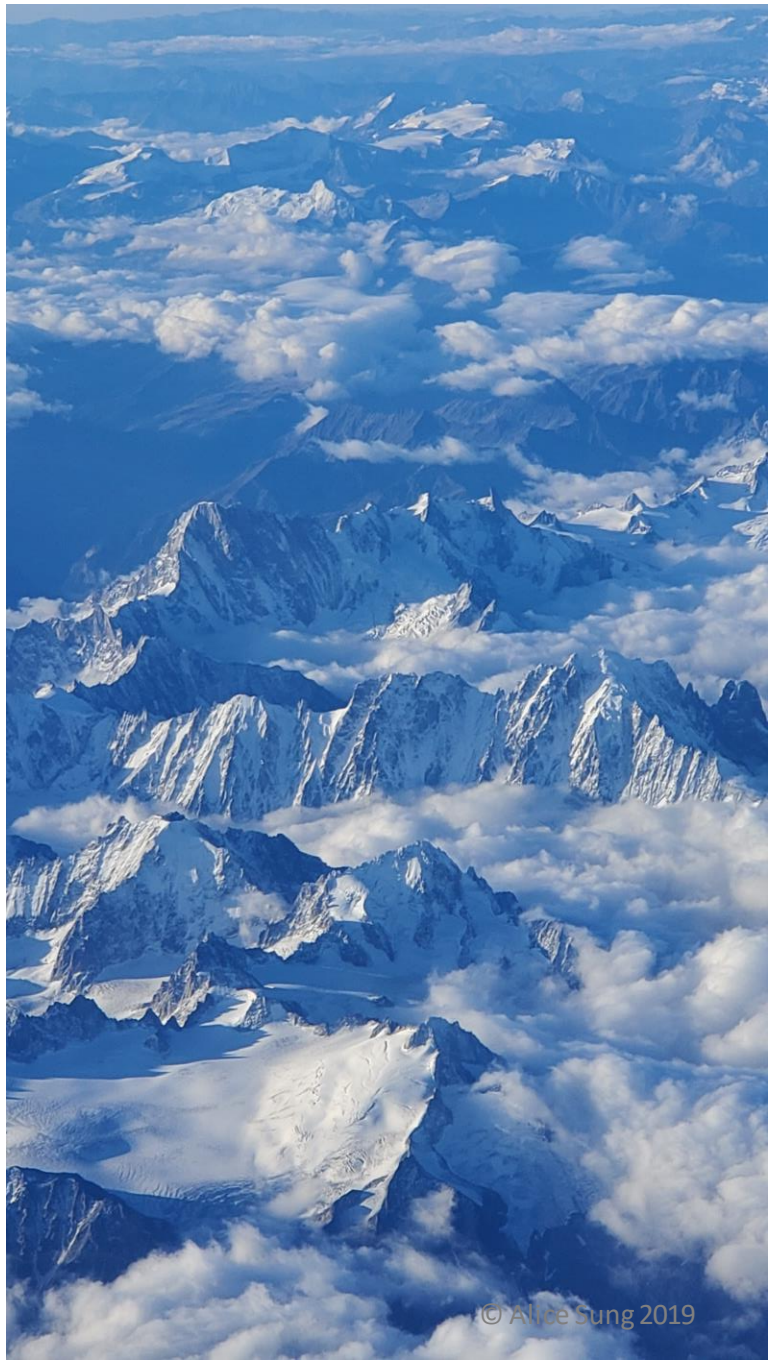
50% emissions reduction by 2030 < 500 GtCo2

Path to Global Zero Carbon Goal



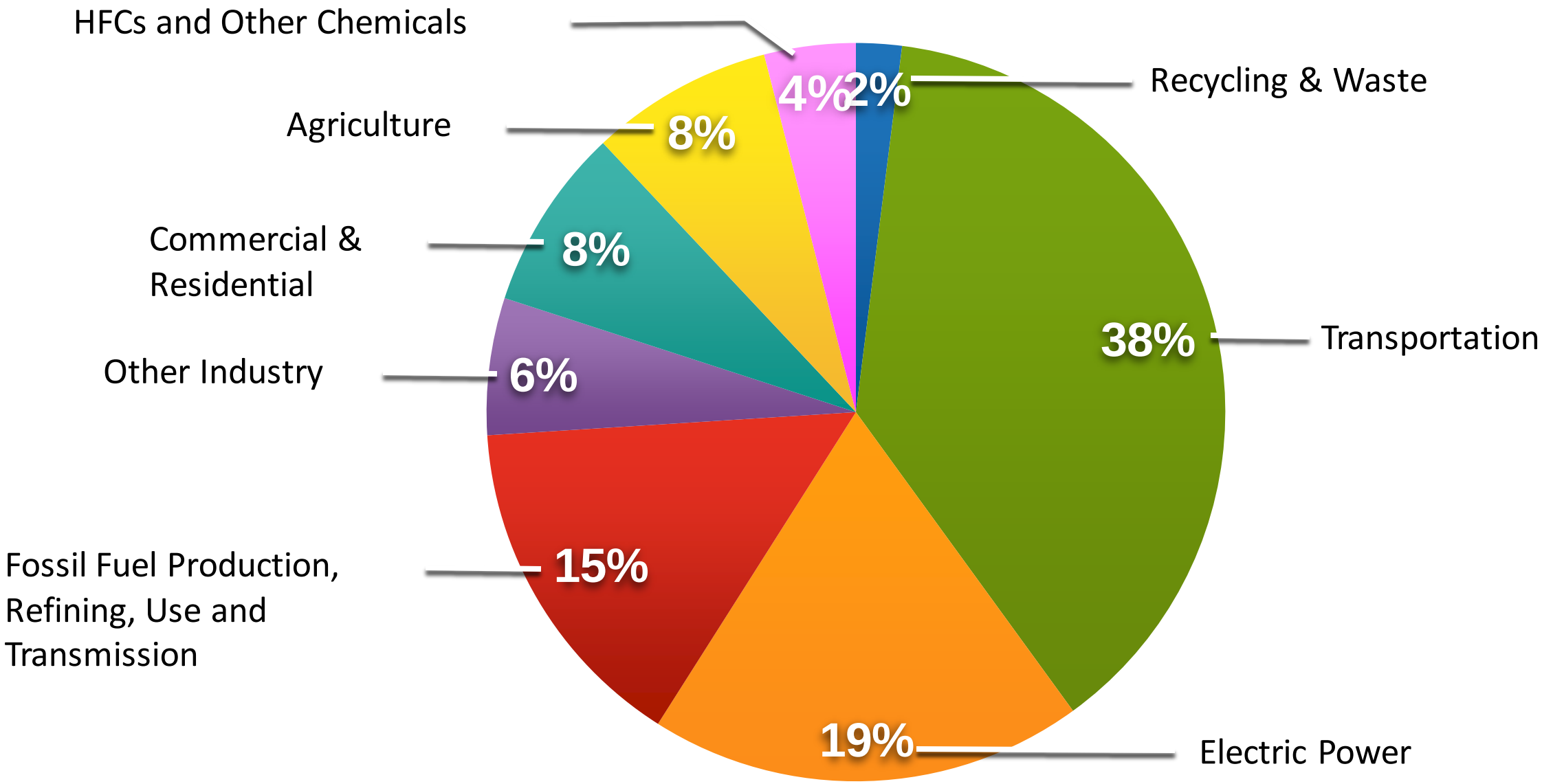
Source: Architecture 2030; Adapted from RealClimate.org "How much CO2 your country can still emit, in three simple steps"; and IPCC SR15, Table 2.2

Global to National



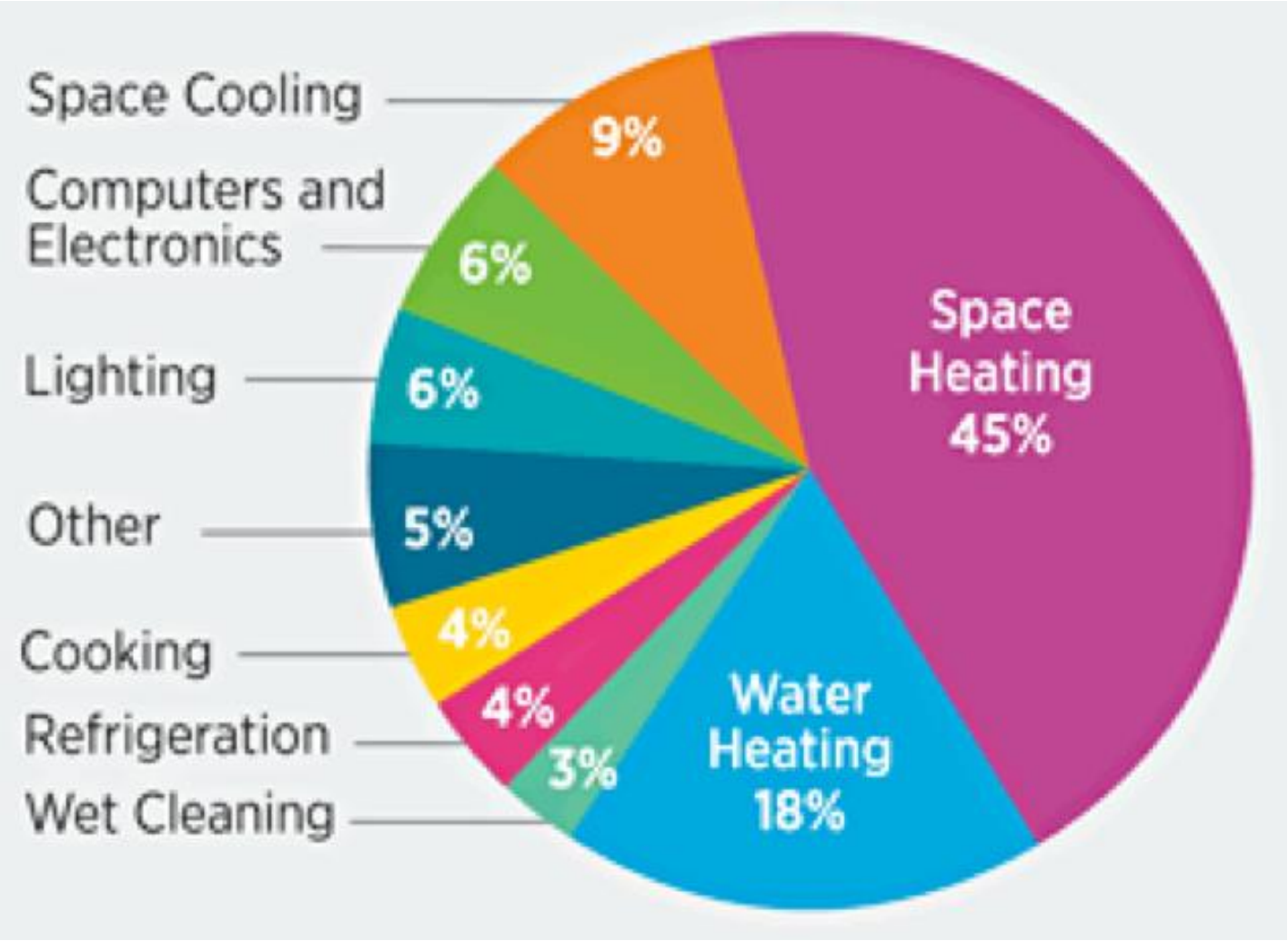
National to State

California State GHG Emissions by Sector- 0 by 2045

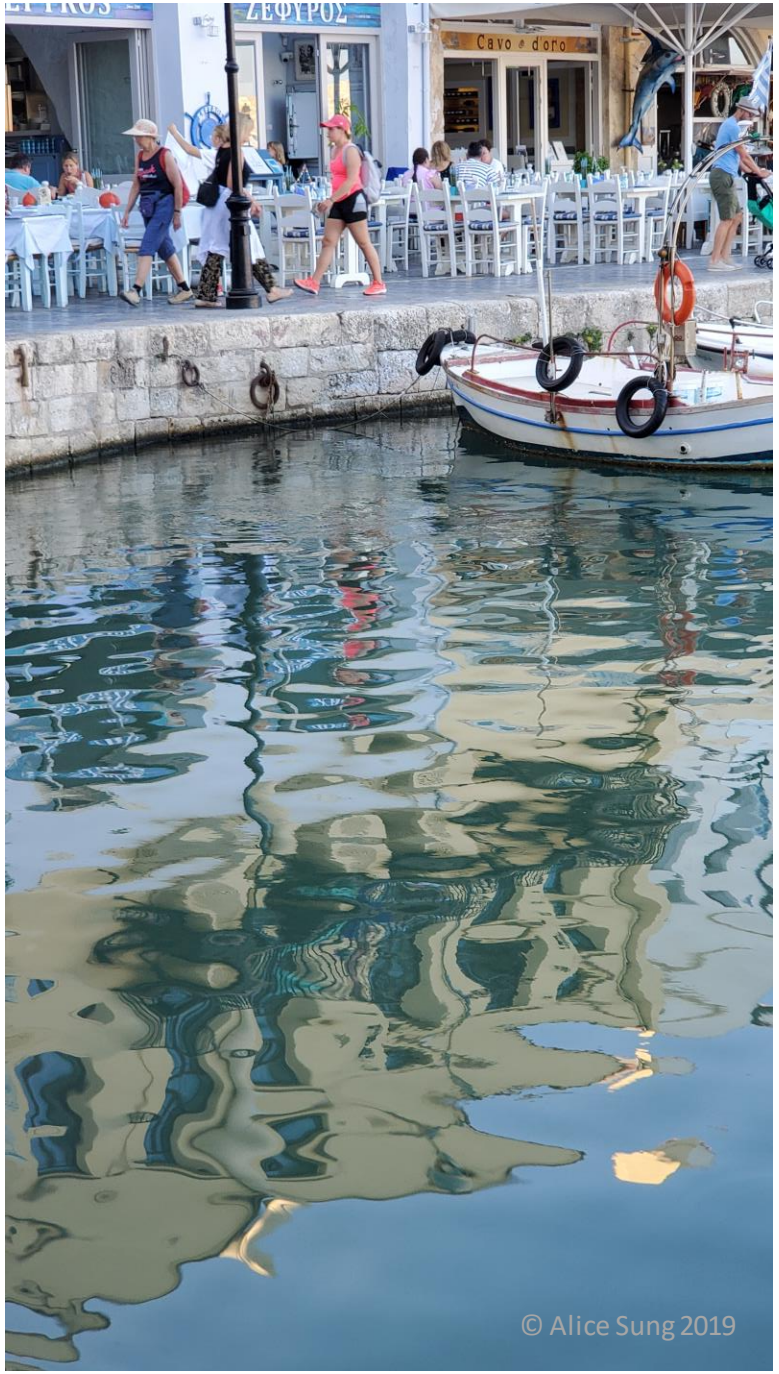


State
to
District

What does Zero Carbon mean for my K-14 school facilities?

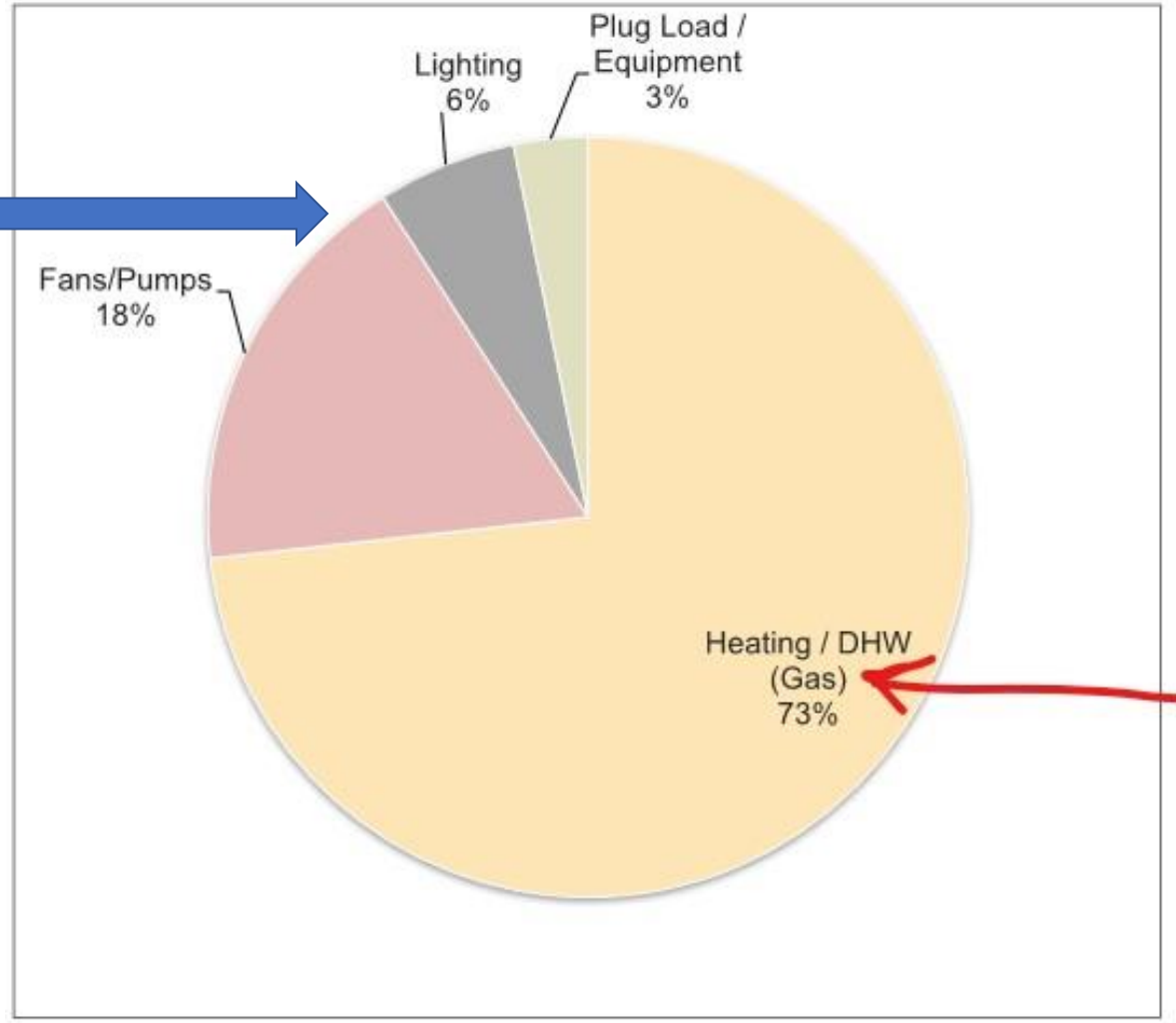


District to School Building



ZNE School Building with 100% renewable electricity

If all of this electrical energy use is sourced through 100% clean renewables, it's portion of any carbon footprint is ZERO!



IF Natural Gas uses were to be "DECARBONIZED" using heat pump technology and induction/all- electric for cooking, we get to ZERO CARBON operating emissions!

Metrics and Emission Factors Matter

- Understand your energy use data & carbon footprint (GHG Inventory)
- Understand the emission factor of your purchased Grid electricity

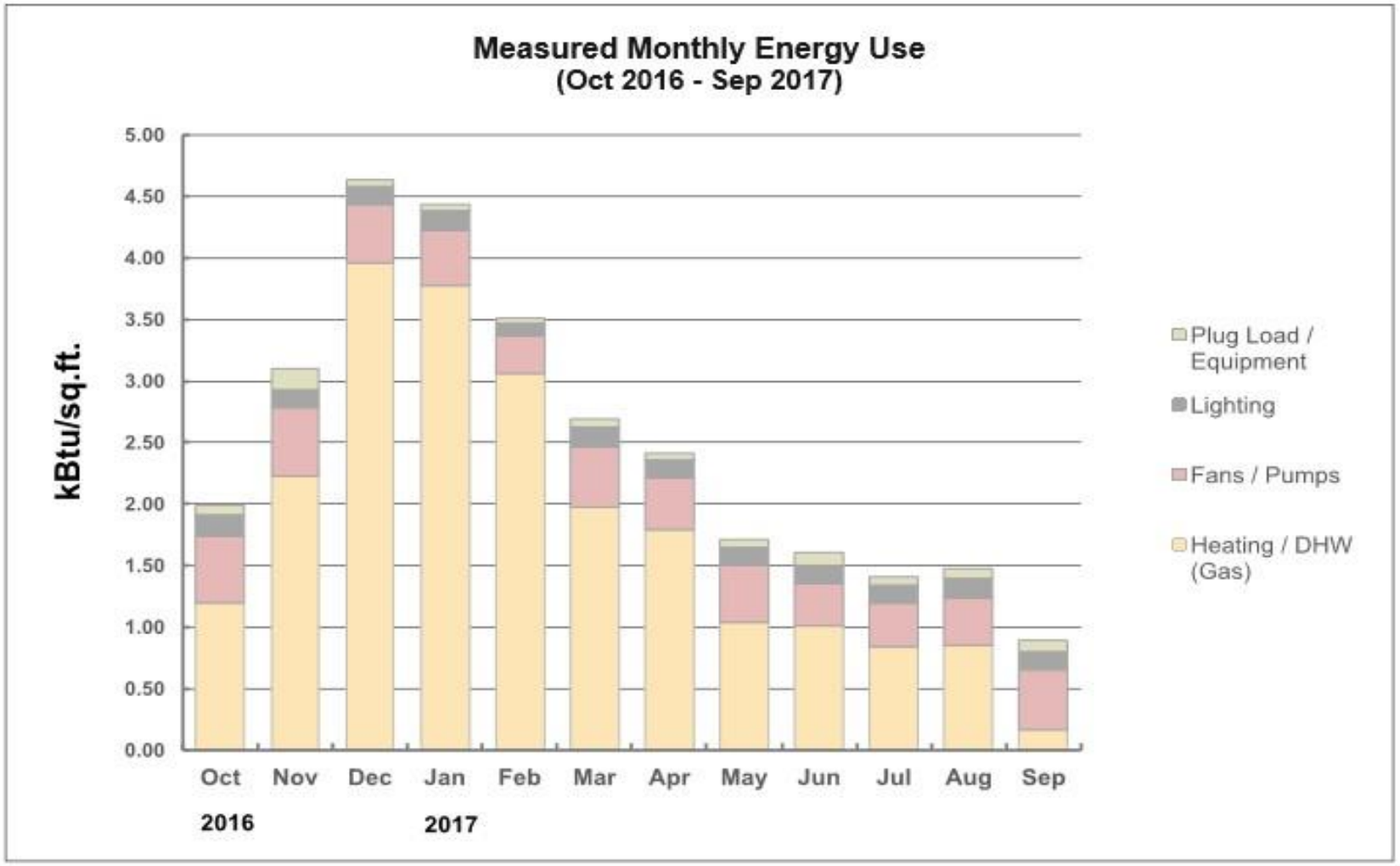
Sources are your utility, the e-grid, and other national sources such as EPA

- i.e. PG&E 2013 emission factor: 427 lbs. Co2/MWh; 1 kWh= 0.427 lbs. Co2 This is decreasing due to a CA mandate to 0 by 2045
- 1 kWh =3.412 kBtu ; 1 kBtu = 0.29307 kWh
- Emission factor of natural gas: 1 therm = 11.7 lbs. of Co2

or 0.00531 Metric ton Co2/therm ; or 0.12 lbs./ cubic ft. gas

- 1 therm = 99.976 kBtu ; 1 kBtu = 0.0100024 therms
- Emission factor of On-site renewable energy = 0 lbs. Co2 !
- FACT: The cleaner your Grid or electricity purchased through a CCA or Direct Access is, the easier it is to get from ZNE to zero carbon!

Natural Gas use is Large Source of Carbon Emissions



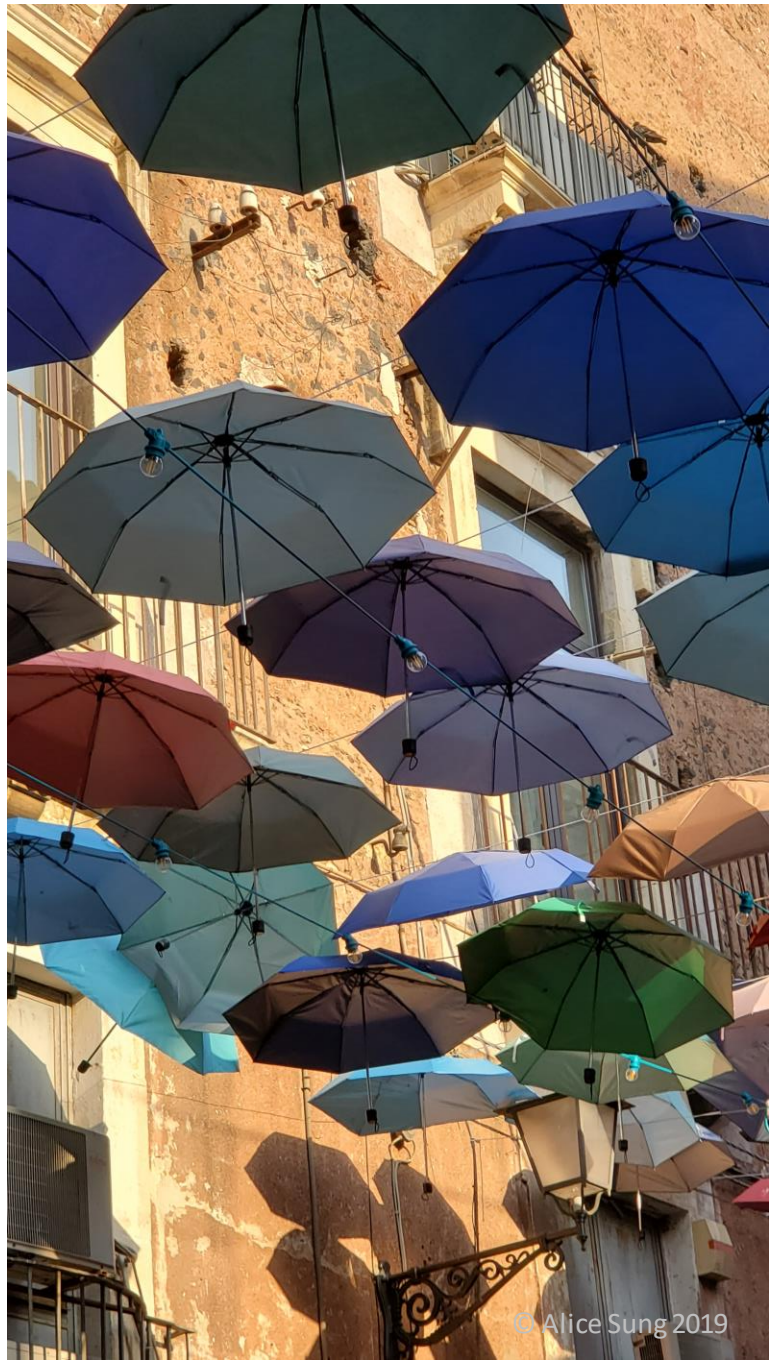
1 kBtu of natural gas use = 0.12 lbs Co2

1 kBtu of electricity Co2 depends on the emission factor(s), BUT
If it sourced by 100% renewable energy, the e factor=0 !

After On-Site solar and wind, Opt up to 100% Renewable Energy = Zero carbon emissions

- Sonoma Clean Power — Local. Renewable. Ours.
- East Bay Community Energy
- MCE Clean Energy — My community. My choice.
- San Jose Clean Energy
- CleanPowerSF — Same Service • Cleaner Energy
- Silicon Valley Clean Energy
- Peninsula Clean Energy
- Monterey Bay Community Power

The Pathway to Zero Carbon Schools



Benchmark + ZNE + Decarbonization = Zero Carbon

NEW CONSTRUCTION SOLUTION

- Design for ZNE as all-electric building
- Target under 20-25 EUI
- Provide all electricity with Grid-optimized on-site renewables+ storage, w/100% carbon-free purchased electricity from a clean Grid, CCA, or Direct Access supplemented as needed

EXISTING BUILDINGS SOLUTION

- Deep Energy Retrofit to ZNE targeting 20-25 EUI
- Decarbonize by transitioning natural gas fueled equipment for space and water heating to high efficiency (COP of 3.5-5) heat pump technology; and gas cooktops to induction over next ten+ years
- Provide 100% renewable energy with storage

From Zero Energy to Zero Carbon

Thank You !

Questions ?

Alice Sung, AIA, LEED AP, BD+C, ISSP-SA
Principal, ***Greenbank Associates, asung1@gmail.com***


© Alice Sung 2019

Resources for Getting to Zero

Discovery Elementary School, Arlington, VA

nbi new buildings institute

Getting to Zero Resources HUB

https://gettingtozeroforum.org/zero-energy-schools-resources/

nbi new buildings institute

ZNE Case Studies

ULTRA-LOW ENERGY

BUILDING TYPE: K-12 SCHOOL

TURKEY FOOT MIDDLE SCHOOL

EDGEWOOD, KY

VIEW CASE STUDY

ZERO ENERGY

BUILDING TYPE: K-12 SCHOOL

HOOD RIVER MIDDLE SCHOOL MUSIC & SCIENCE BUILDING

HOOD RIVER, OR

VIEW CASE STUDY

COMMERCIAL

BUILDING TYPE: K-12 SCHOOL

GARDEN GROVE UNIFIED SCHOOL DISTRICT

GARDEN GROVE, CA

VIEW CASE STUDY

https://gettingtozeroforum.org/schools/

nbi new buildings institute

2019 Schools Zero Energy Watch List

nbi new buildings institute

Zero Energy Schools Watchlist

for K-12 Schools, Colleges, and Educational Projects

The *Zero Energy Schools Watchlist* tracks education buildings, including K-12 schools, higher education, and general education buildings. The *Watchlist* documents the status of ZE school projects across North America and raises public awareness of districts that are getting to zero. The 219 innovative projects listed here are aiming to consume only as much energy as they can produce over the course of the year, helping move the needle toward zero energy and zero carbon building performance.

High performance and zero energy schools shape the educational landscape dramatically for the better. For example, students in classrooms with natural light showed a 20-26% improvement on test scores compared to artificially lit environments[1]. With students spending approximately 1,000 hours per year in a school,[2] transforming classrooms into healthy and productive spaces is of the utmost importance, especially when short-term and long-term health of students and staff is at risk.

Student engagement in zero energy schools creates hands-on opportunities for teaching Next Generation Science Standards and Common Core. These zero energy facilities can be used as a tool to develop important skills like teamwork, research, time management and the use of technology.

Zero energy schools have been built for little to no additional cost and demonstrate lower operating costs over time. The money saved on energy bills can be put back into the school. Patterns and trends uncovered in the approaches used by these districts and teams can be shared with others, whether they are aiming for ultra-low or zero energy performance.

A zero energy building produces as much energy through clean, renewable resources as it consumes over the course of a year.

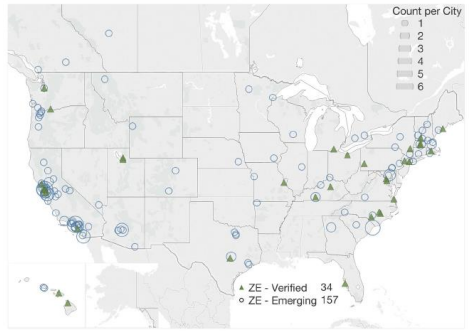
1 Heshong Mahone Group (1999). Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance. http://h-m-g.com/downloads/Daylighting/schoolc.pdf

2 Center for Public Education (2011). Time in school: How does the U.S. compare? http://www.centerforpubliceducation.org/Main-Menu/Organizing-a-school/Time-in-school-How-does-theUS-compare

Since 2010, when NBI began tracking zero energy buildings, educational facilities have been a leading market sector.[3] The number of zero energy educational buildings has increased more than 110% since 2014 due to early adopter school districts and stakeholders that recognized the long- and short-term benefits of these buildings.

Zero Energy educational buildings in North America are located across 37 states and three provinces. The top five states for zero energy schools are California, Kentucky, Massachusetts, Oregon and Texas. Followed closely behind by Arizona, New York and South Carolina. Fueled by aggressive public policies and "Proposition 39" funding, California has 34 buildings with verified zero energy performance and 157 more with a publicly stated zero energy goal.

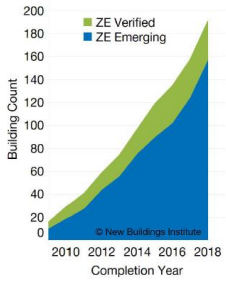
Locations of Zero Energy School Buildings



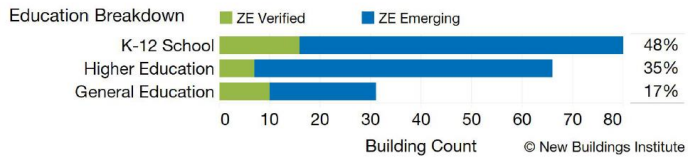
	Ultra-low Verified	Emerging	Verified	Total
California	10	72	6	88
Kentucky	4	4	2	10
Massachusetts	1	5	3	9
Oregon	0	8	1	9
Texas	1	7	1	9

Within the education market, 48% of the buildings are K-12 schools. However, a variety of educational building types are pursuing a zero energy goal. 35% of the list is composed of community college and higher education buildings. The remainder is general education buildings such as libraries, science centers and individual classrooms.

Count of Zero Energy School Buildings



Zero Energy Educational Building Types



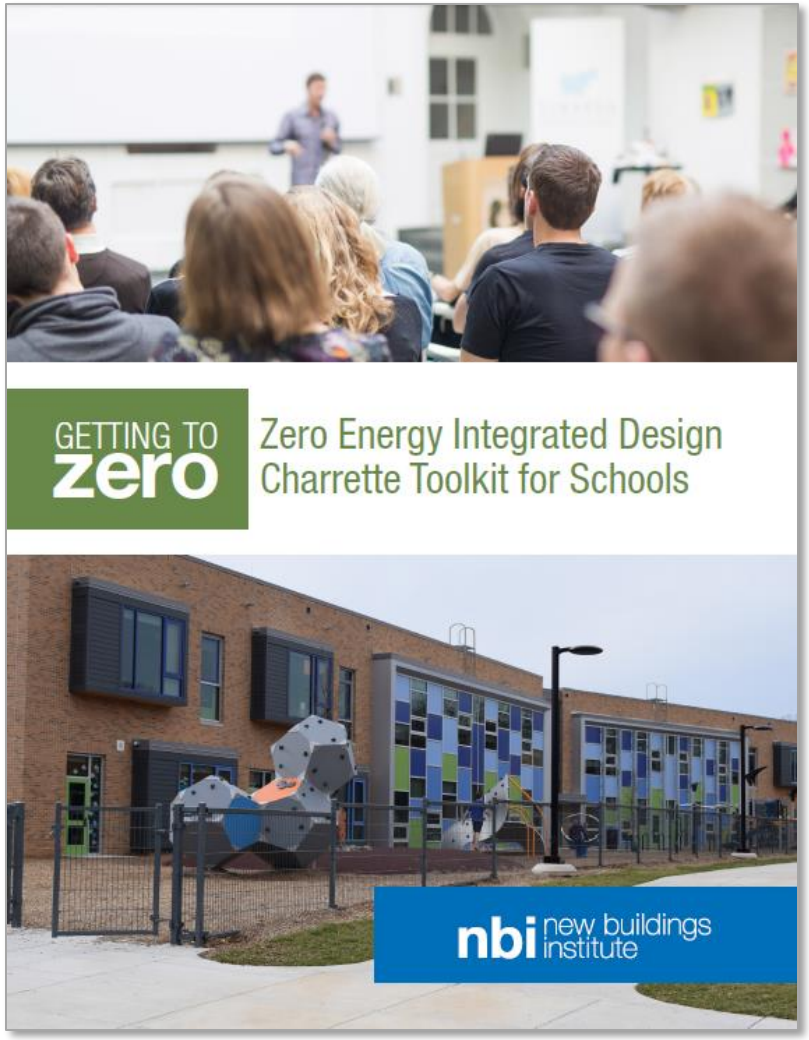
Zero Energy Verified

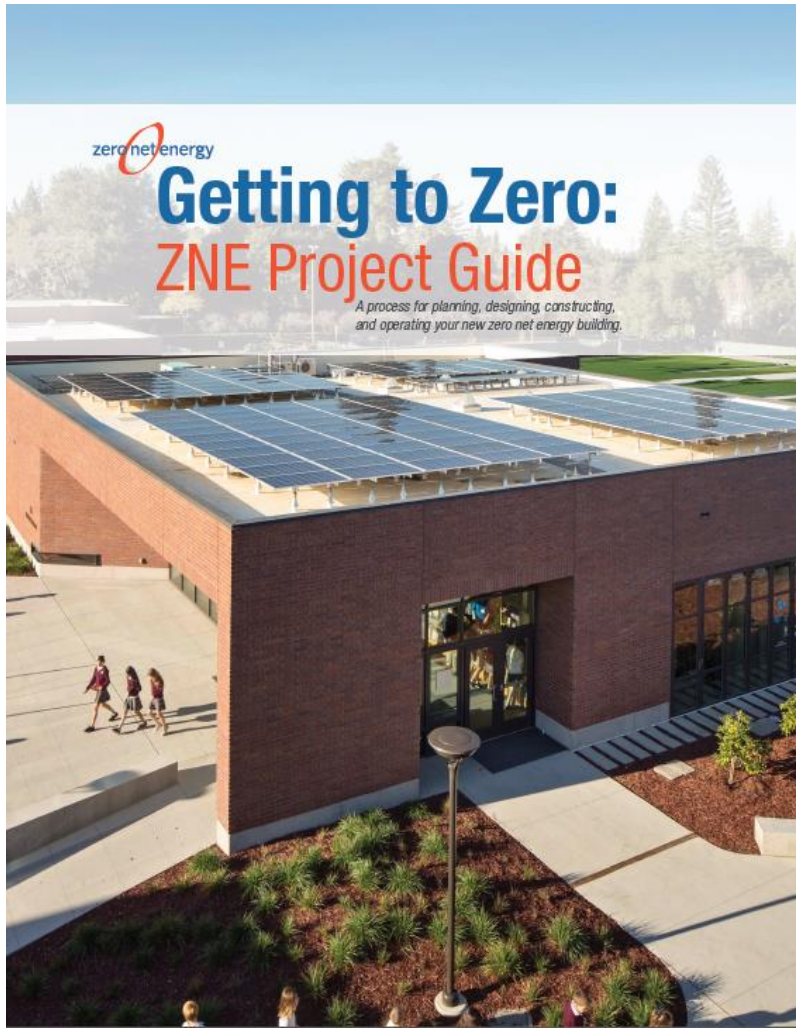
Year Completed	Project Name	City	State	Building Type	Size (sf)	Total EUI	Source EUI	Site RPI	Source RPI	Net EUI	Net Source EUI	zEPI Score
2000	Oberlin College Lewis Center (M)	Oberlin	OH	Higher Education	13,600	31.4	87.8	36.9	103.3	-5.5	-15.5	-5
2001	Environmental Tech. Center Sonoma State (M)	Rohnert Park	CA	Higher Education	2,200	2.3	6.5	3.8	10.6	-1.5	-4.1	-2
2008	Environmental Nature Center (M) (L)	Newport Beach	CA	General Education	8,535	17.6	49.3	27.7	77.6	-10.1	-28.3	-12
2011	EcoCenter at Heron's Head Park (off grid) (M) (L)	San Francisco	CA	General Education	2,400							
2013	IBEW Local 595 Zero Net Energy Center (M)	San Leandro	CA	General Education	45,001	15.0	42.0	21.0	58.8	-6.0	-16.8	-7
2013	Lenawee Intermediate School District Center for a Sustainable Future (M)	Adrian	MI	K-12 School; Primary School	8,750	7.7	21.6	10.1	28.3	-2.4	-6.7	-2
2014	Odyssey Elementary School (M)	Woods Cross	UT	K-12 School; Primary School	84,785	15.0	42.0	16.8	47.0	-1.8	-5.0	-2
2015	Bishop O'Dowd High School, Environmental Science Center (M) (L)	Oakland	CA	K-12 School; Secondary School	3,275	18.0	50.3	18.6	52.2	-0.7	-1.9	-1
2015	Discovery Elementary School	Arlington	VA	K-12 School; Primary School	98,000	15.5	43.4	19.1	53.5	-3.6	-10.1	-4
2015	Grantham Middle School (M)	Goldsboro	NC	K-12 School; Primary School	86,400	18.2	51.0	26.1	73.0	-7.9	-22.0	-8
2015	P.S. 62 (Kathleen Grimm School of Leadership and Sustainability) (M)	Staten Island	NY	K-12 School; Primary School	68,680	32.7	88.2	33.7	94.3	-1.0	-6.1	-1
2015	Potomac Watershed Center (M)	Accokeek	MD	General Education	3,971	44.2	123.9	46.0	128.7	-1.7	-4.8	-2
2015	R W Kern Center at Hampshire College	Amherst	MA	Higher Education	16,950	23.4	65.6	26.4	74.0	-3.0	-8.4	-3
2015	Sarasota Audubon Nature Center (M) (L)	Sarasota	FL	General Education	2,500	10.3	28.8	15.6	43.7	-5.3	-14.9	-5
2016	Kay's Creek Elementary School (M)	Kaysville	UT	K-12 School; Primary School	84,785	14.2	39.8	16.1	45.2	-1.9	-5.4	#N/A
2016	Maui Army Reserve Center (M)	Wailuku	HI	Training Center	15,361	35.5	99.5	35.6	99.6	-0.1	-0.1	#N/A
2016	Sbrega Technology and Learning Center - Bristol Community College (M)	Fall River	MA	Higher Education	50,679	45.0	104.3	60.9	170.5	-15.9	-66.2	-15
2016	Spring Creek Middle School (M)	Seven Springs	NC	K-12 School; Primary School	96,000	19.2	53.7	22.6	63.3	-3.5	-9.6	-3
2018	Lakeline Learning Center	Austin	TX	General Education	6,000							

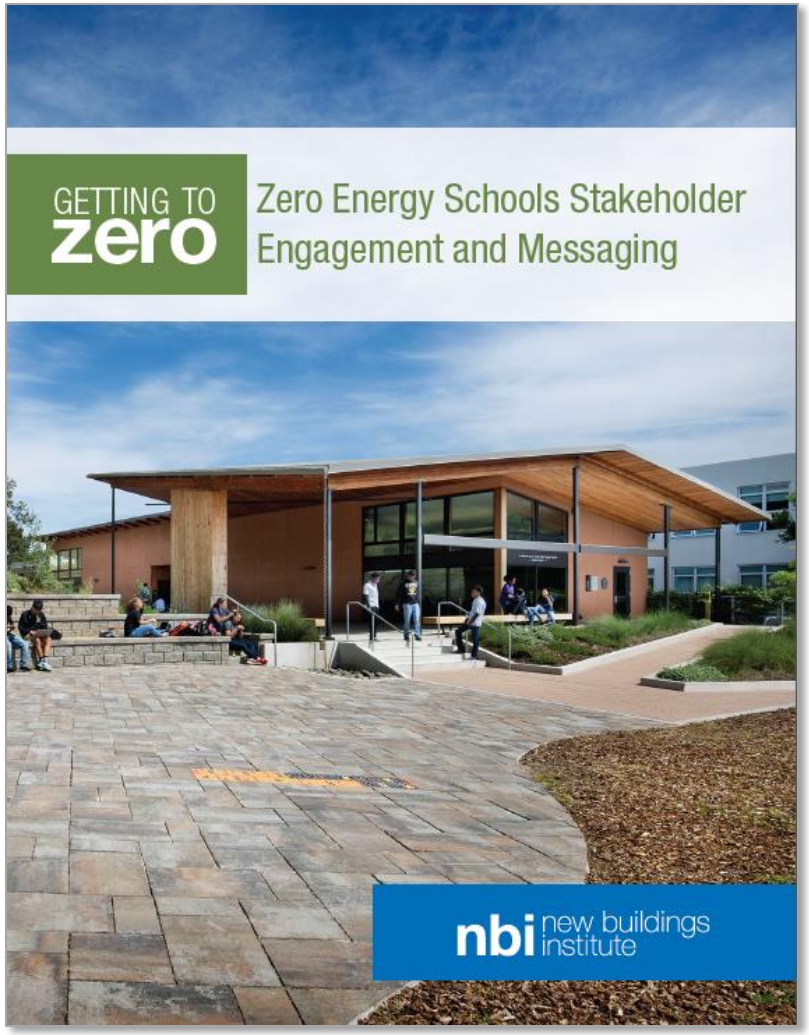
newbuildings.org/resource/2019-zero-energy-schools-watchlist/

nbi new buildings institute

NBI's Tools for Zero Energy Schools

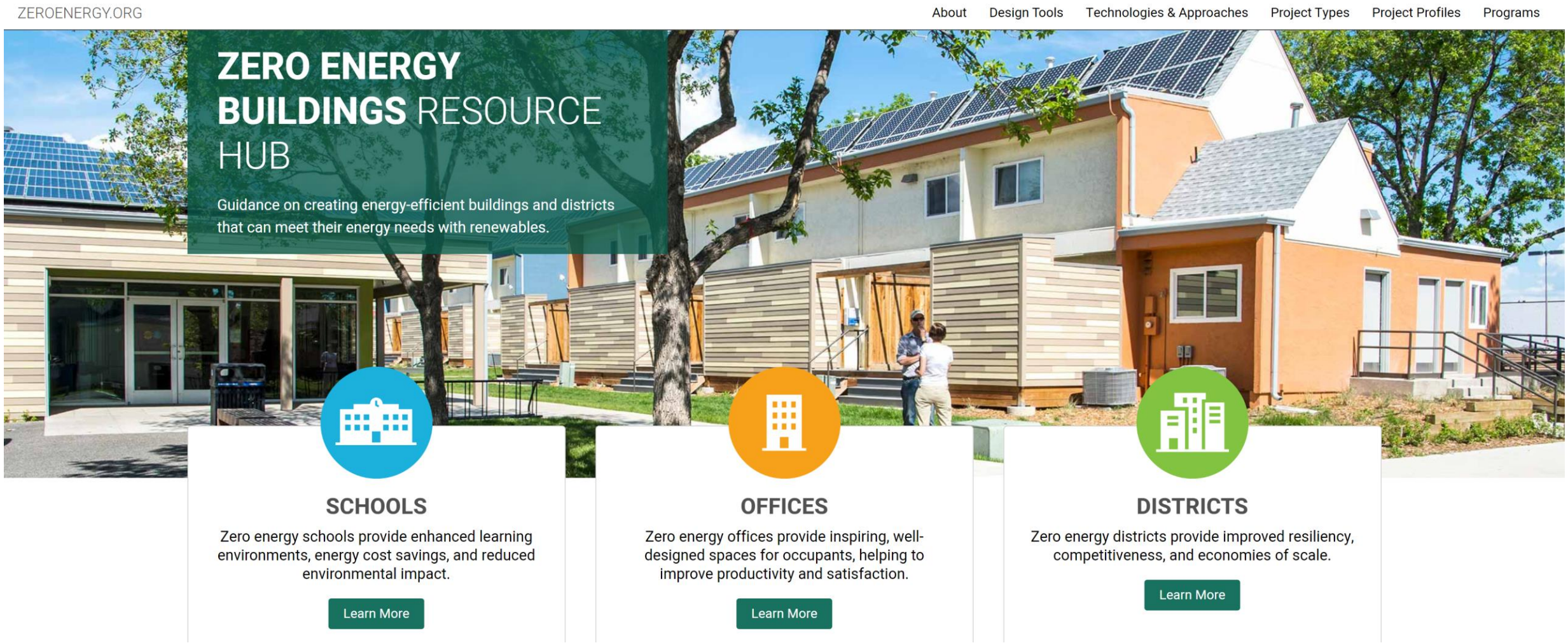






nbi new buildings institute

ZEROENERGY.ORG



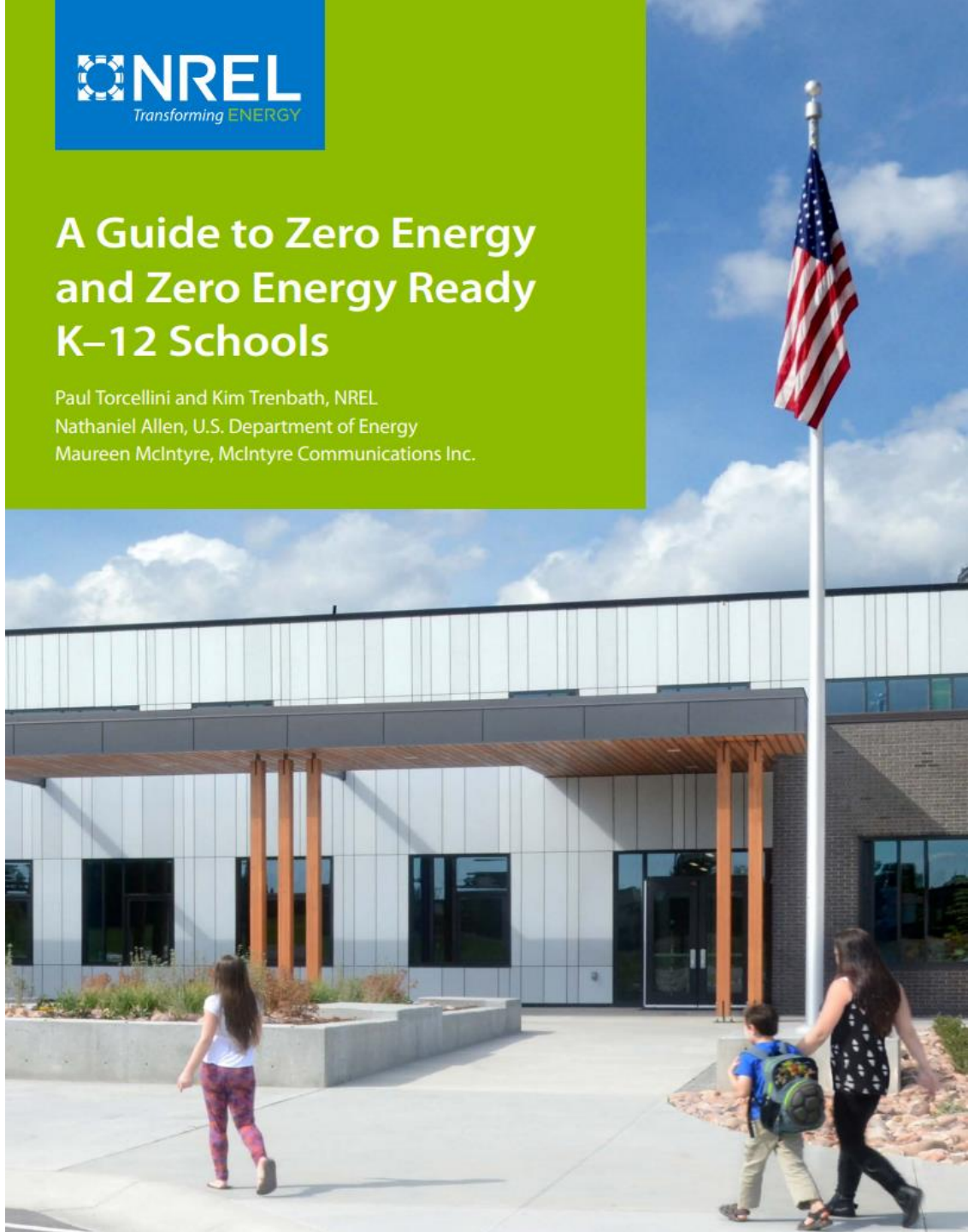
Zero Energy Process Guide

By NREL and US Department of Energy

A complimentary guide to the Advanced Energy Design Guide for Zero Energy Schools

https://www.nrel.gov/docs/fy19osti/72847.pdf

nbi new buildings institute



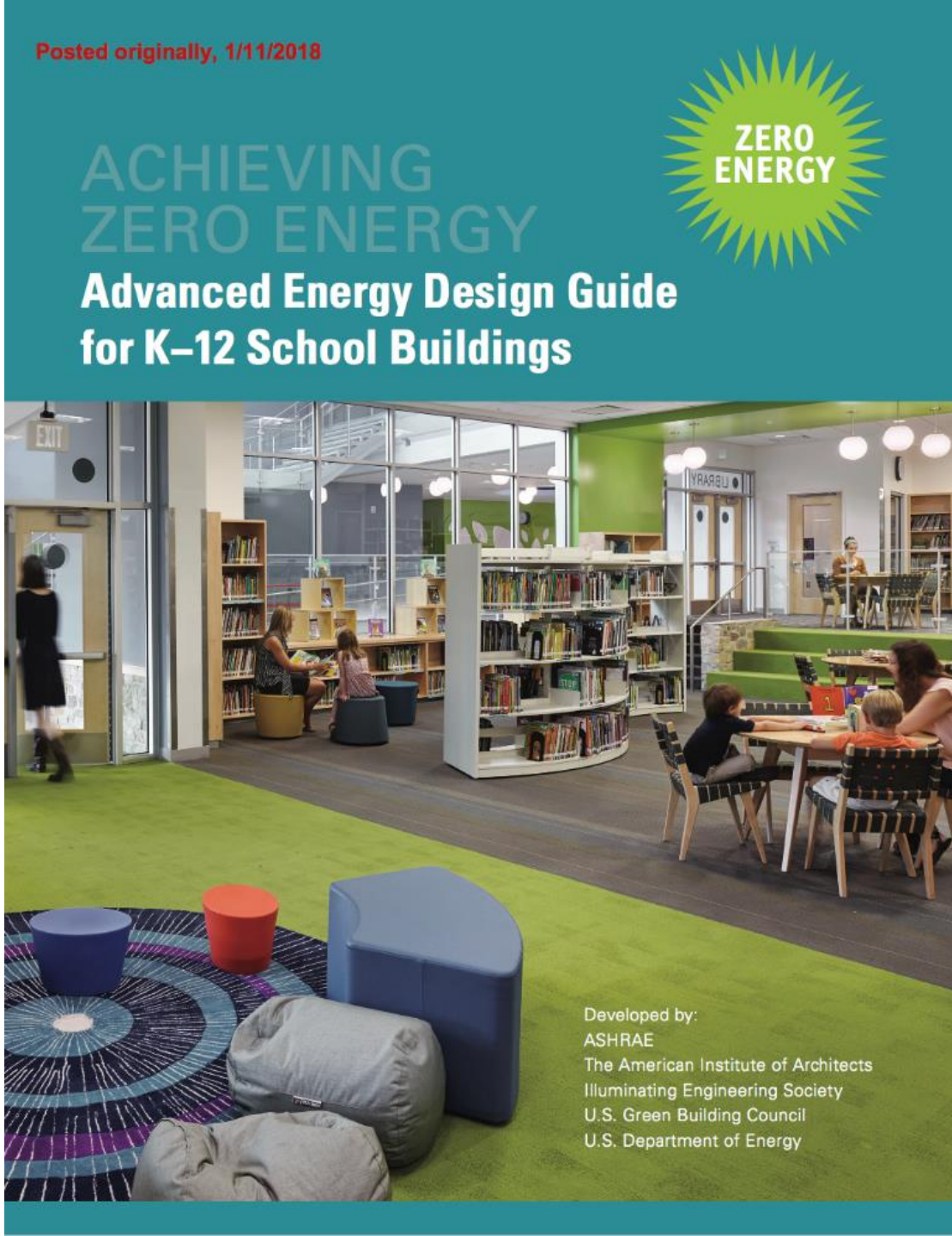
Advanced Energy Design Guide (AEDG) for Zero Energy Schools

By ASHRAE

Free download available at:

https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download

nbi new buildings institute



Seattle Public Schools Getting to Zero Resources

- The Green Resolution: https://www.seattleschools.org/UserFiles/Servers/Server_543/File/District/Departments/ResourceConservation/20130501_GreenResolution.pdf
- Climate Resolution: https://www.seattleschools.org/UserFiles/Servers/Server_543/File/District/Departments/ResourceConservation/climateresolution.pdf
- Policies and Procedures for Natural Resource Conservation: https://www.seattleschools.org/UserFiles/Servers/Server_543/File/District/Departments/School%20Board/Procedures/Series%206000/6810SP.pdf

nbi new buildings institute

Additional Resources

- Energy Star Portfolio Manager: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager
- NEEP High Performance Schools: http://www.neep.org/initiatives/energy-efficient-buildings/high-performance-schools
- USGBC Center for Green Schools: https://www.centerforgreenschools.org/
- Green Ribbon Schools: https://www2.ed.gov/programs/green-ribbon-schools/index.html
- NCEF School Buildings Assessment Methods: http://www.ncef.org/pubs/sanoffassess.pdf
- Collaborative for High Performance Schools: https://chps.net/chps-criteria
- NREL Technical Feasibility for K-12 Schools: http://www.nrel.gov/docs/fy17osti/67233.pdf
- DOE Toolkit: K-12 Solutions for Building Energy Excellence: https://betterbuildingsinitiative.energy.gov/toolkits/k-12-solutions-building-energy-excellence

nbi new buildings institute