Agenda

1) Introductions
2) Define Zero Energy
3) Past Successes
4) Path Forward
5) Curriculum

December 16, 2019

Net Zero Energy Kickoff Charrette

December 16, 2019

CMTA

Agenda

1) Introductions
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December 16, 2019

CMTA

OUR NEW REALITY

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

Agenda

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December 16, 2019

CMTA

ENERGY.GOV

NET ZERO
ENERGY BUILDING
CERTIFICATION℠

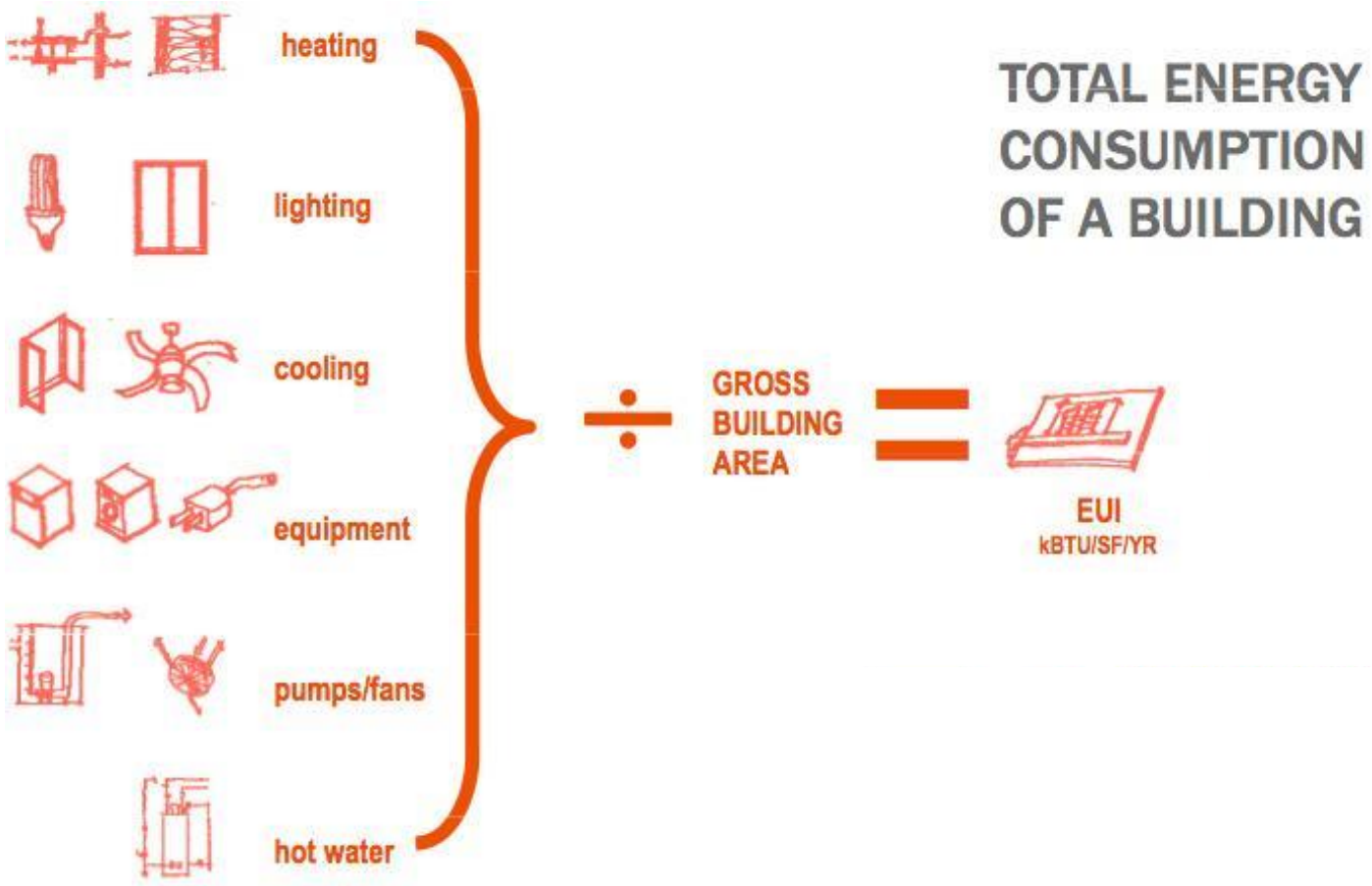
How is NET ZERO ENERGY Defined?

nbi new buildings institute

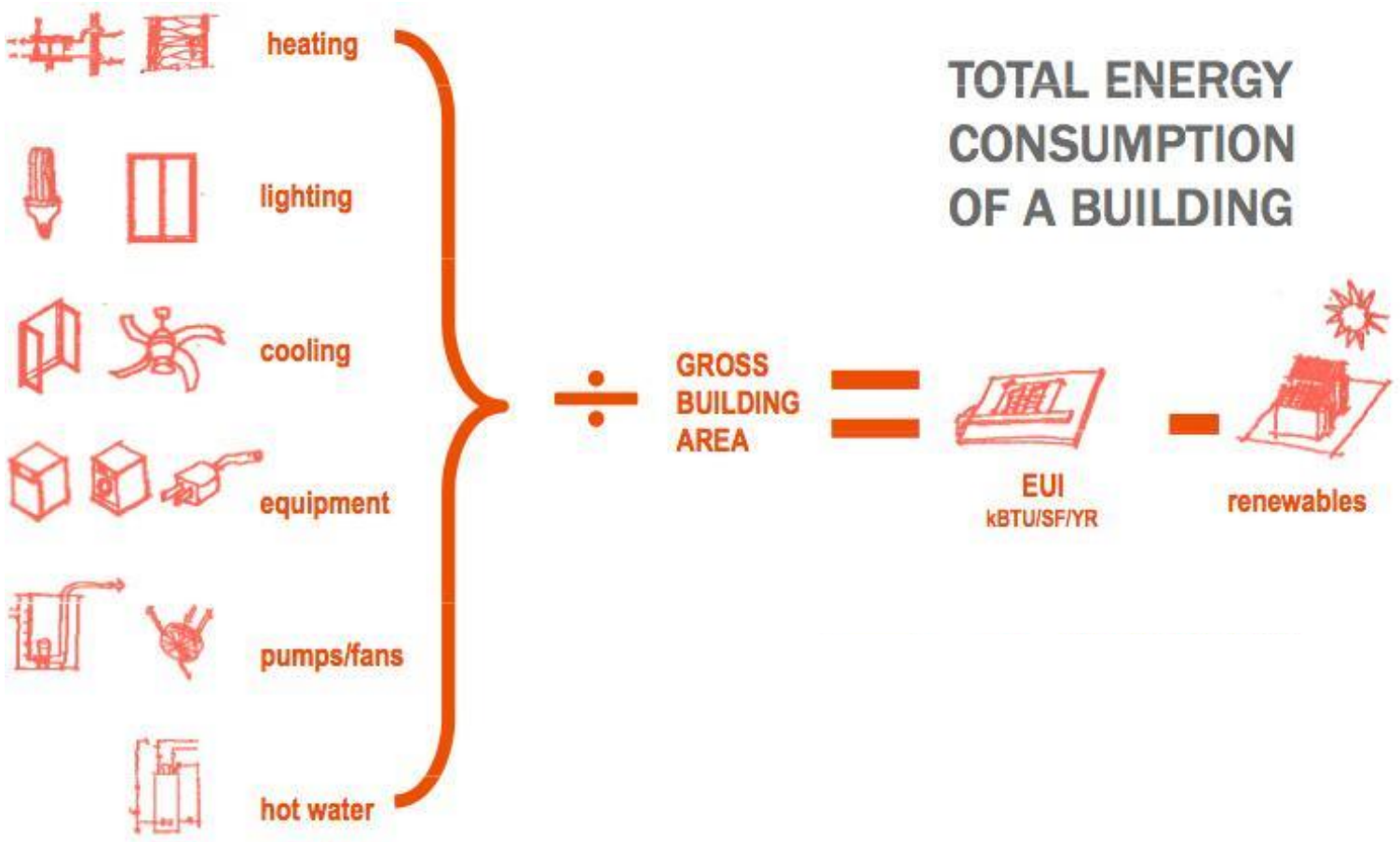
INTERNATIONAL
LIVING FUTURE
INSTITUTE℠

NET ZERO DEFINITION?

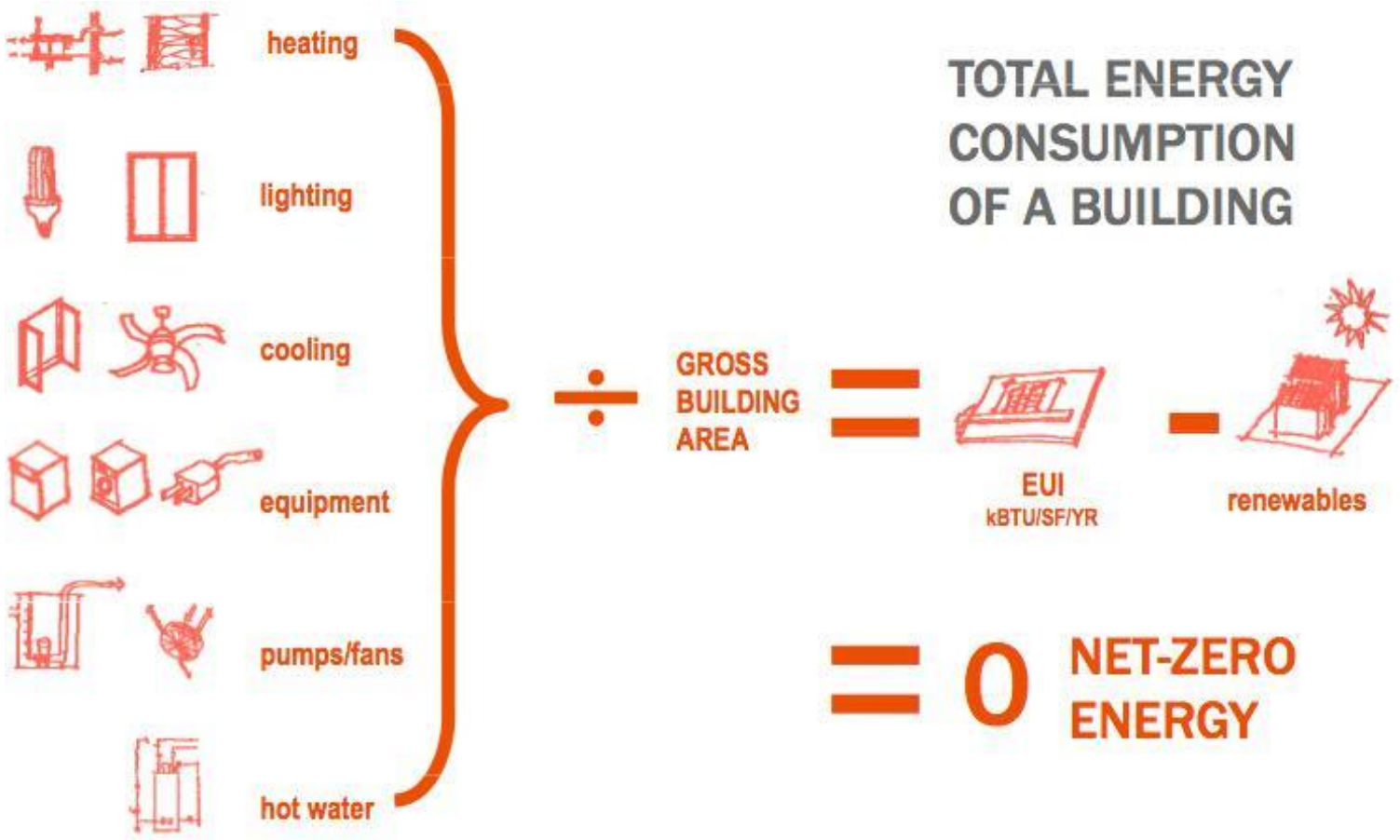
A Net Zero Energy school returns as much energy to the power grid as it uses in a year



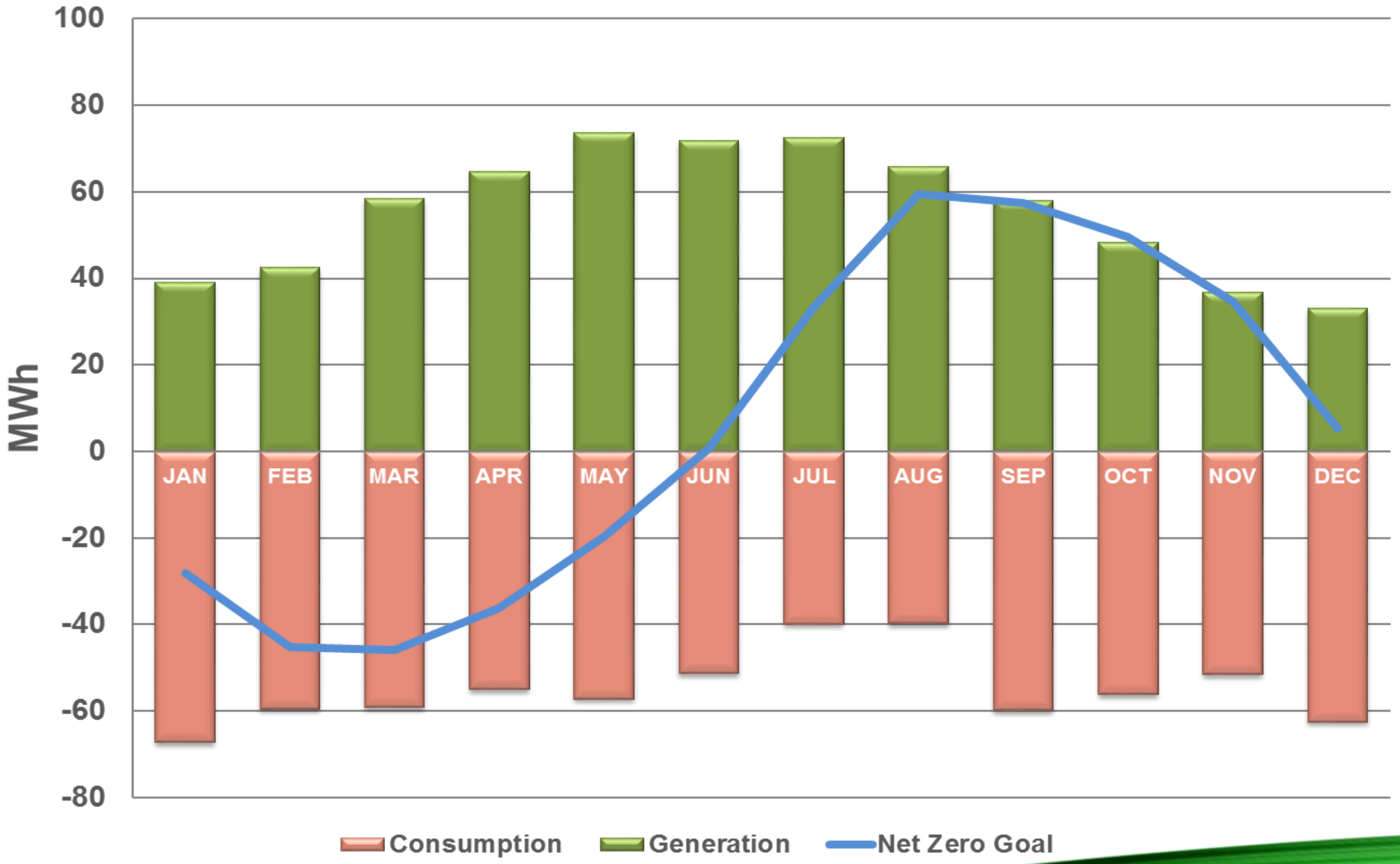
A Net Zero Energy school returns as much energy to the power grid as it uses in a year



A Net Zero Energy school returns as much energy to the power grid as it uses in a year



NET ZERO DEFINITION?


100
80
60
40
20
0
-20
-40
-60
-80
MWh
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Consumption
Generation
Net Zero Goal

NZE Summary

Agenda

1) Introductions
2) Define Zero Energy
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5) Curriculum

December 16, 2019

CMTA

NeoCity Academy STEM School
Kissimmee, Florida

Graceland Elementary
Baltimore, Maryland

Banneker High School
Washington, DC

Discovery Elementary
Arlington, Virginia

West Elementary
Washington, DC

Wilde Lake Middle School
Columbia, Maryland

Richardsville Elementary
Bowling Green, Kentucky

Alice West Fleet Elementary
Arlington, Virginia

Semans Griswold Center
Chestertown, Maryland

Richard J. Lee Elementary
Dallas, Texas

Holabird Elementary
Baltimore, Maryland

Locust Trace AgriScience Campus
Lexington, Kentucky

Huge Nationwide Growth in Zero Energy Schools

- 700% Growth in Zero Energy Projects
- Schools Lead All Sectors

Zero Energy Building Growth

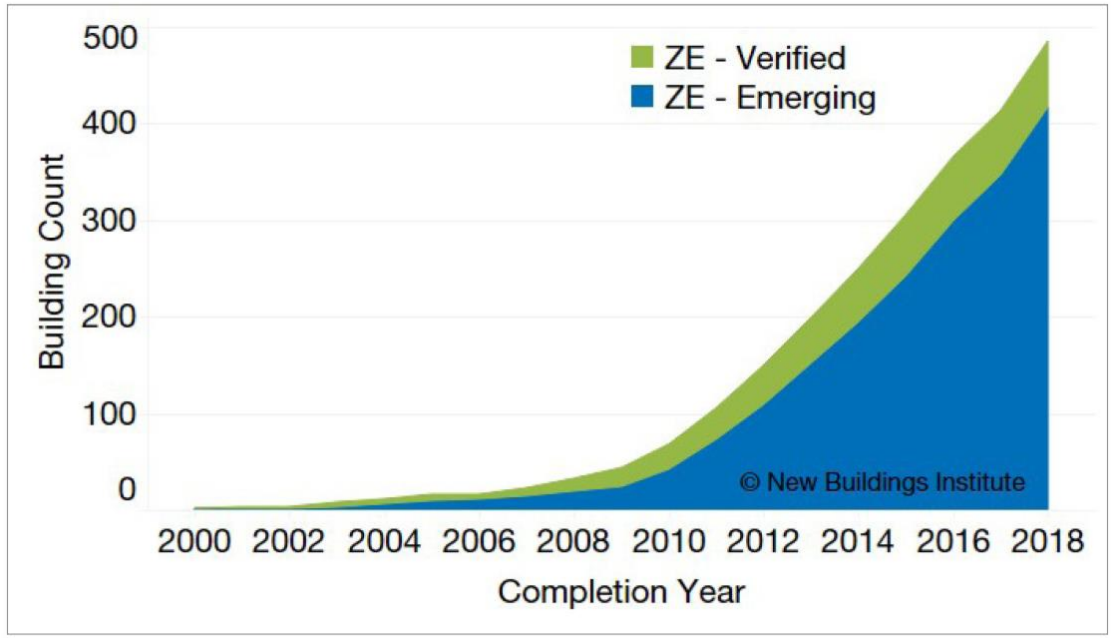


Fig 1. The Buildings List includes nearly 500 projects and is on a steep curve upward, having increased over 700% since 2012.

Building Type Breakdown

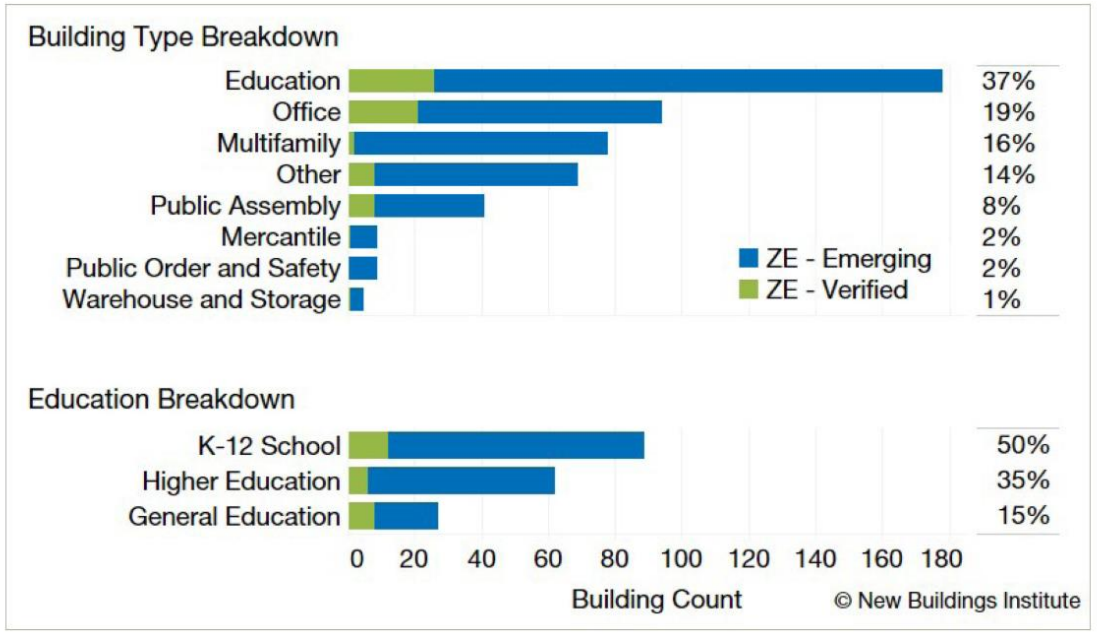


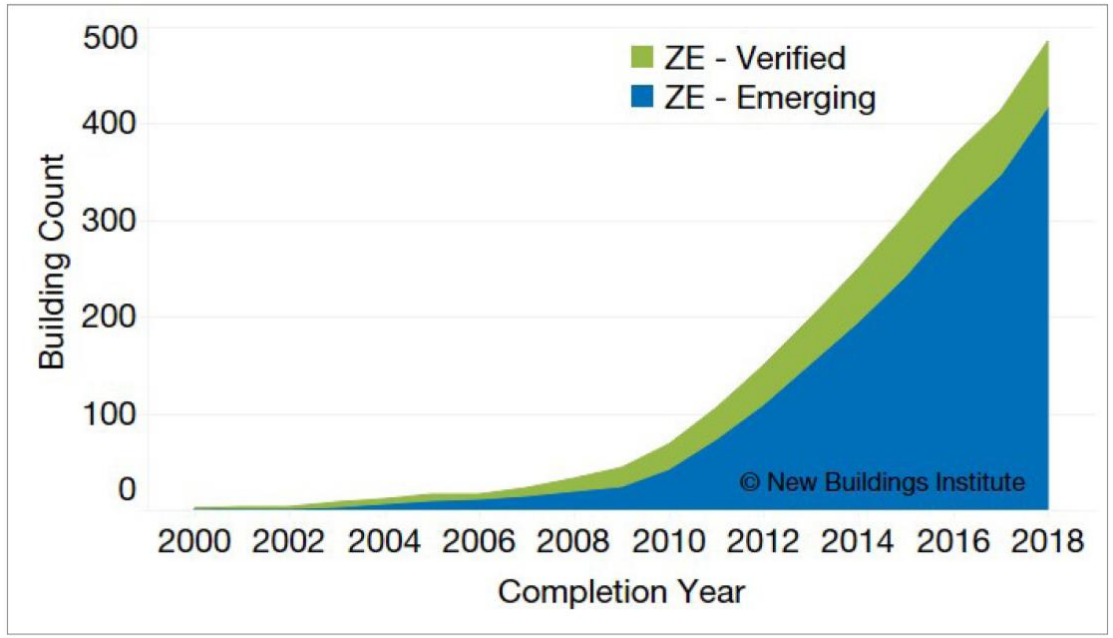
Fig 7. Zero energy buildings can be found across many different building types.

CMTA

Huge Nationwide Growth in Zero Energy Schools

- 700% Growth in Zero Energy Projects
- Schools Lead All Sectors

Zero Energy Building Growth



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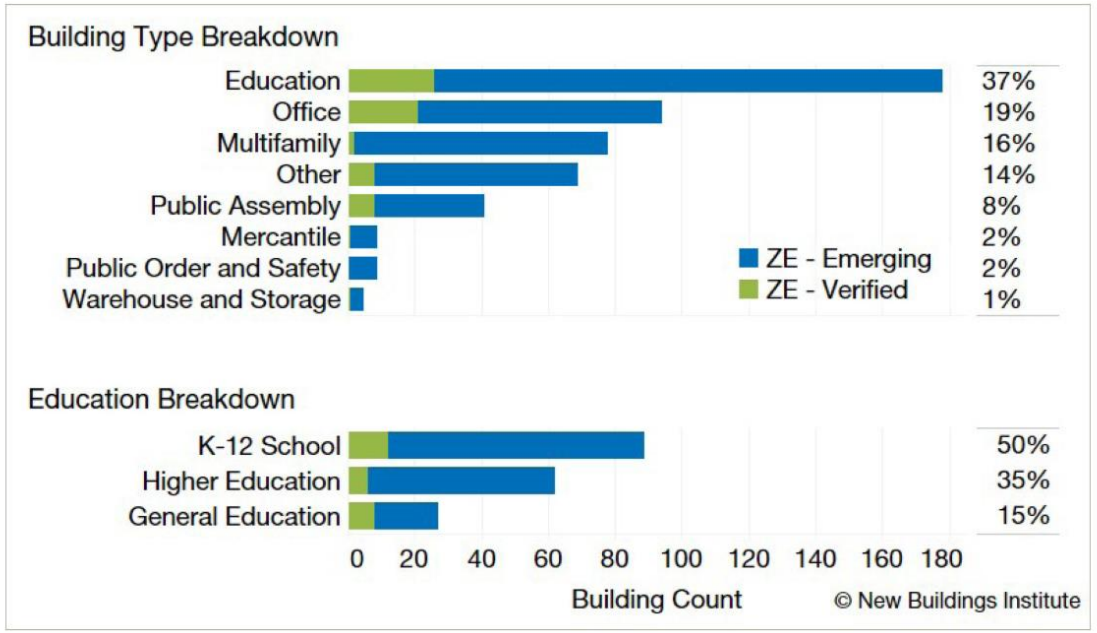
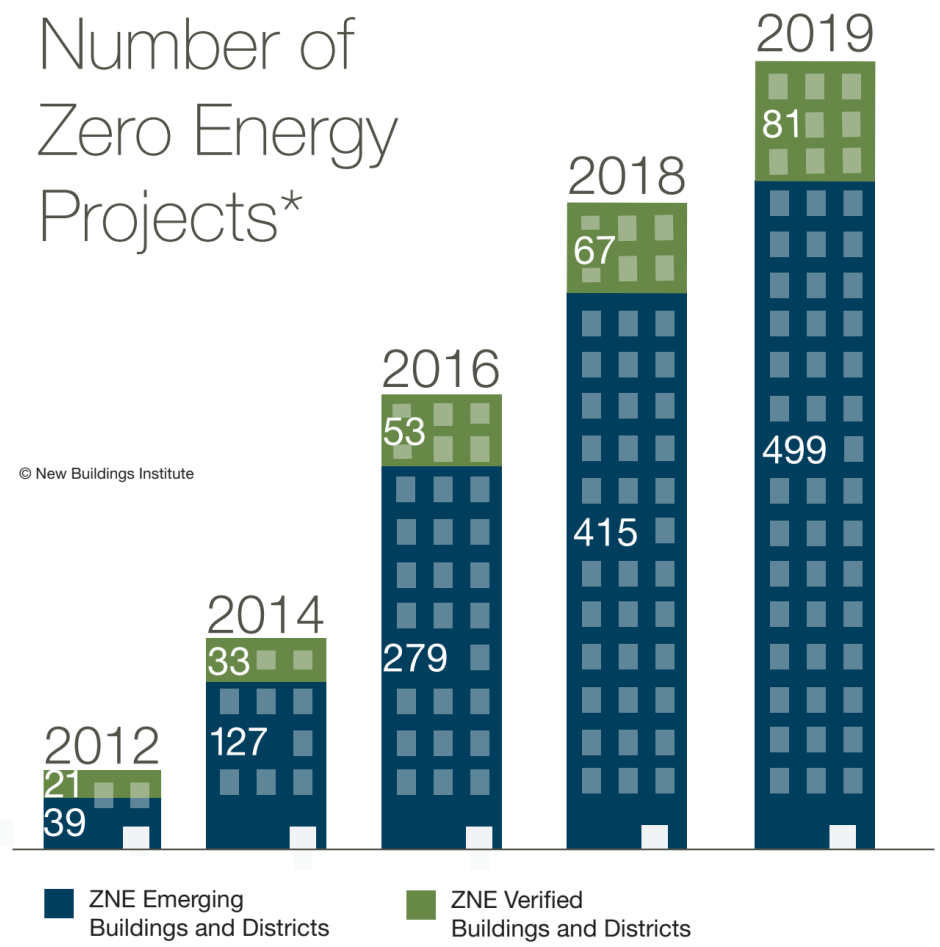


Fig 7. Zero energy buildings can be found across many different building types.

CMTA

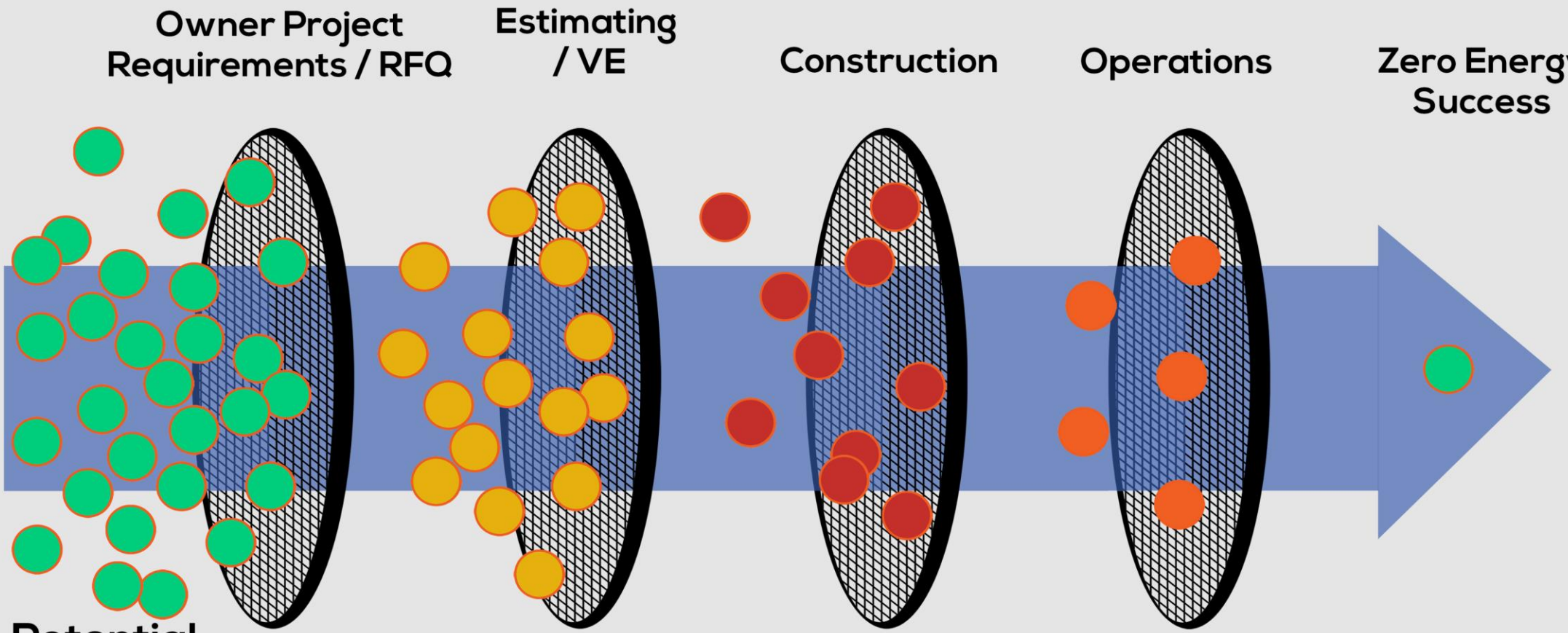
Huge Nationwide Growth in Zero Energy Schools

- 700% Growth in Zero Energy Projects
- Schools Lead All Sectors



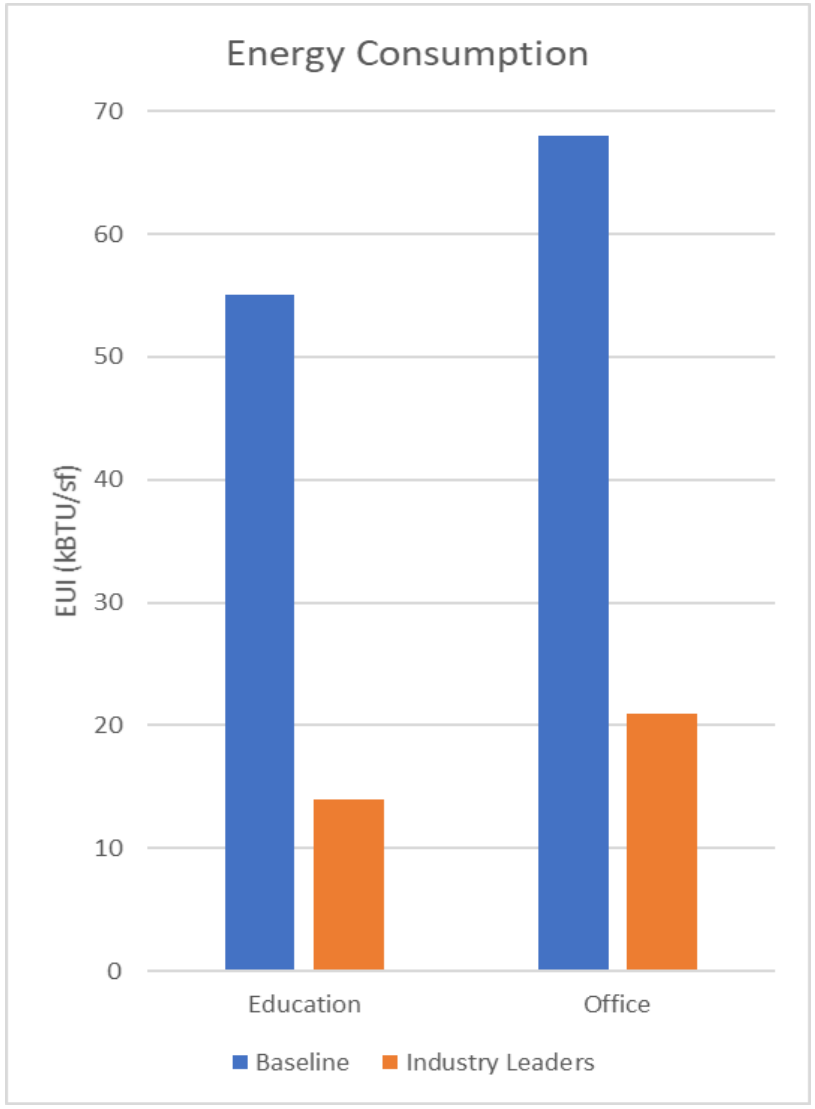
CMTA

ZERO ENERGY FILTERS

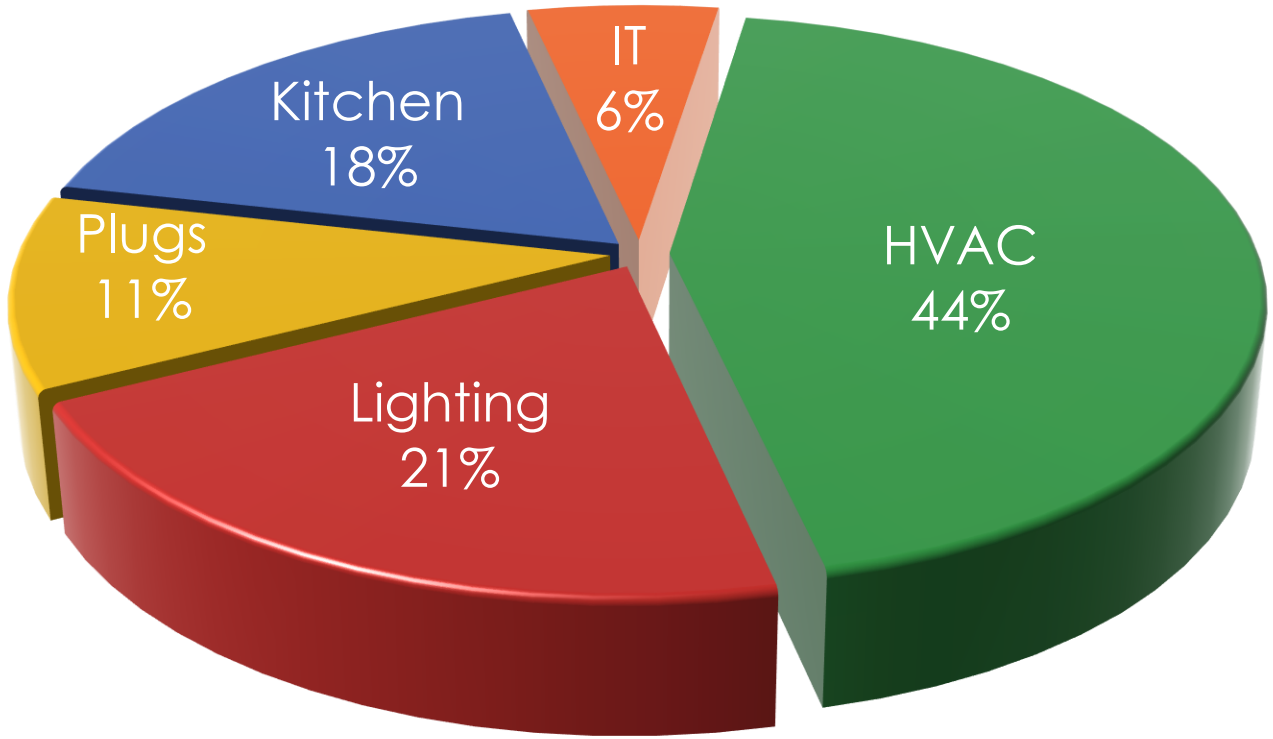


CMTA

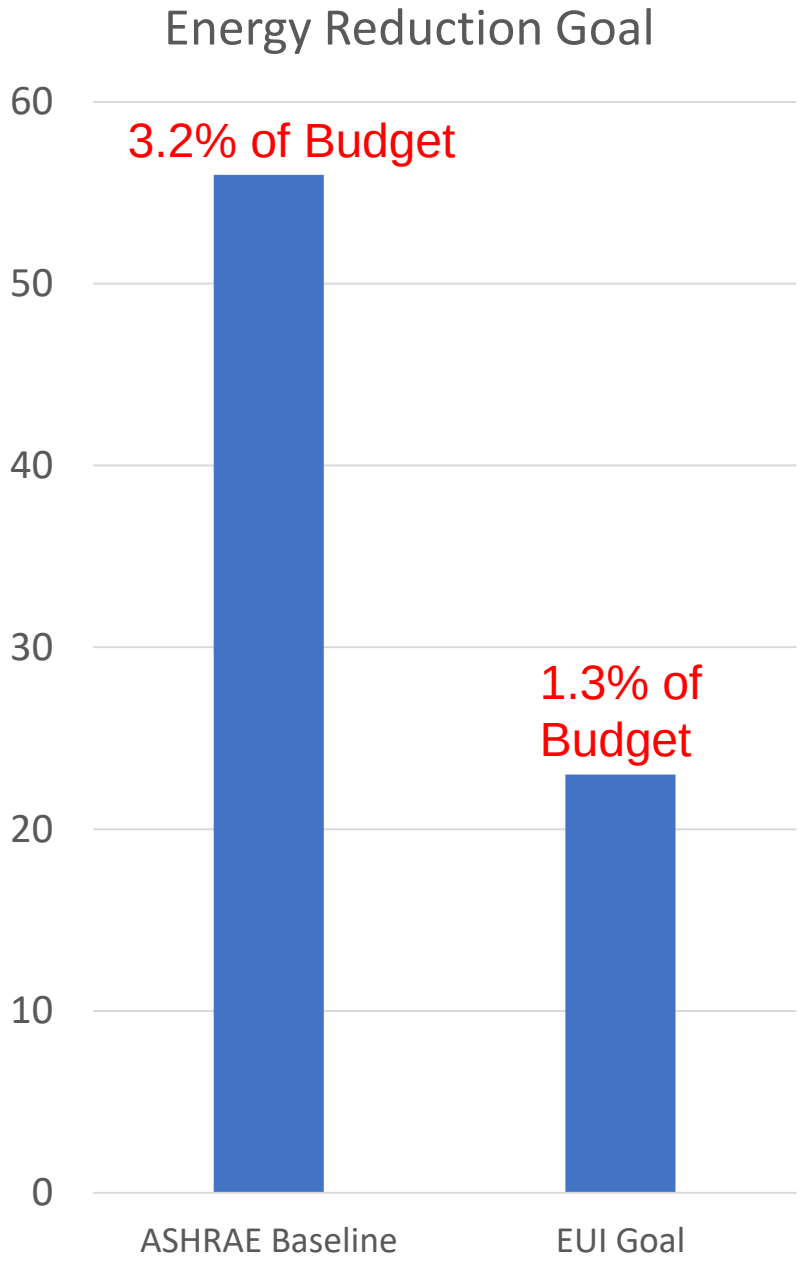
Energy Targets

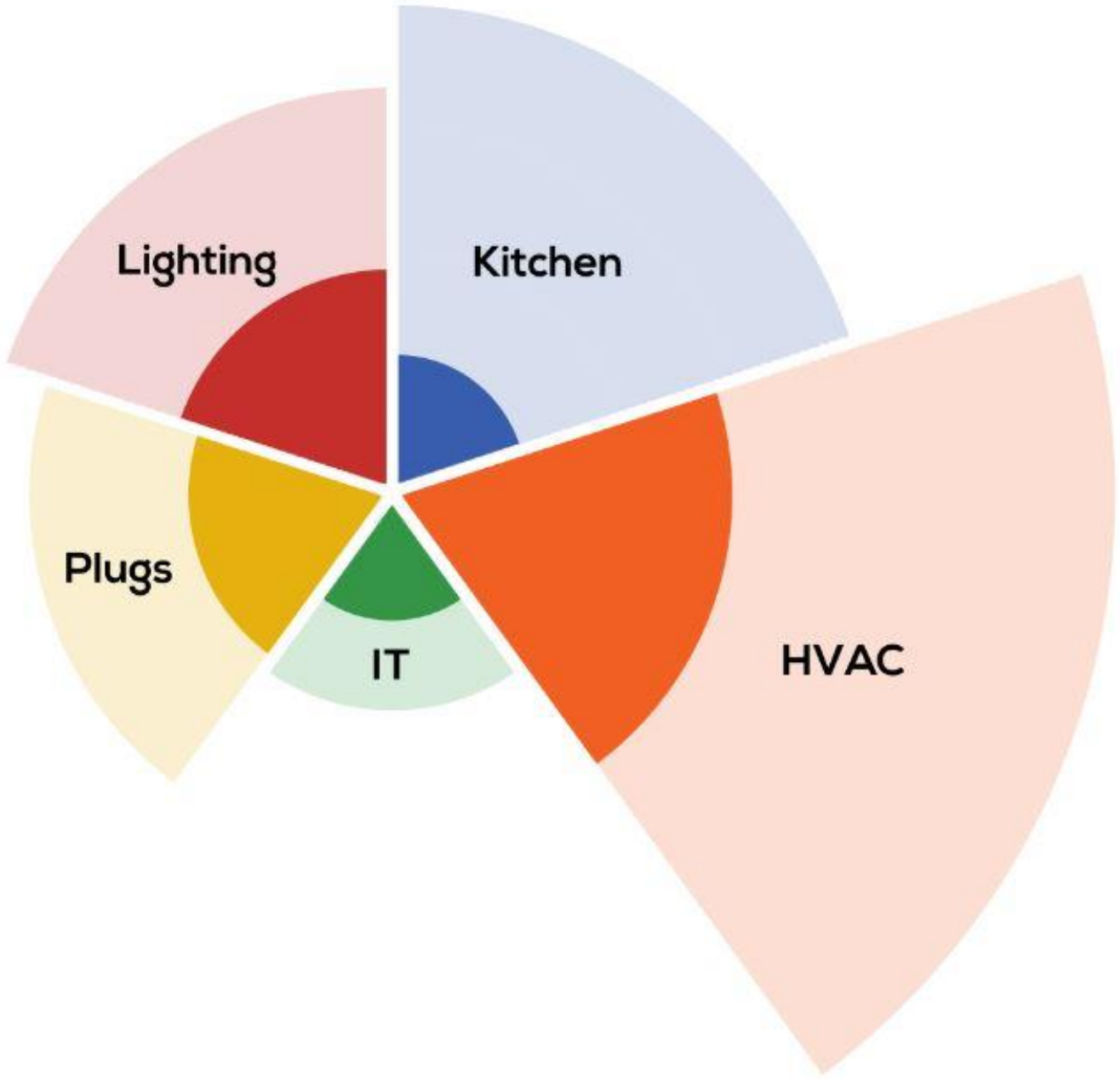


High Performance School Energy Use



CMTA


Energy Reduction Goal
60
50
40
30
20
10
0
3.2% of Budget
1.3% of Budget
ASHRAE Baseline
EUI Goal


Lighting
Kitchen
Plugs
IT
HVAC

Agenda

1) Introductions
2) Define Zero Energy
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4) Path Forward
5) Curriculum

December 16, 2019

CMTA

Collaborative Work Session #72

Deep Dive into Zero Energy Telecomm Systems

DC Public Schools
West Elementary School
4/30/19

Agenda

9:00a **Information Technology**

Attendees: CMTA

11:00a **Kitchen Design / Operations**

Attendees: CMTA

12:30p **Discussion of Next Steps**

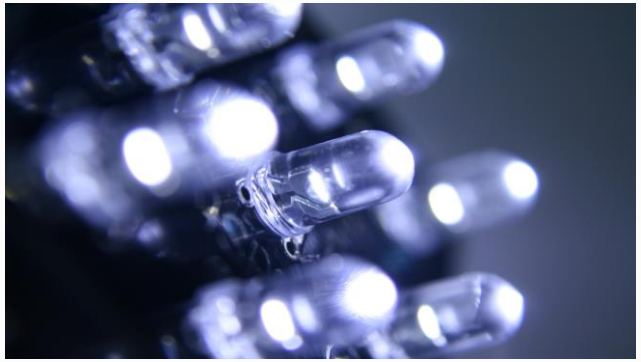
Attendees: CMTA

CMTA

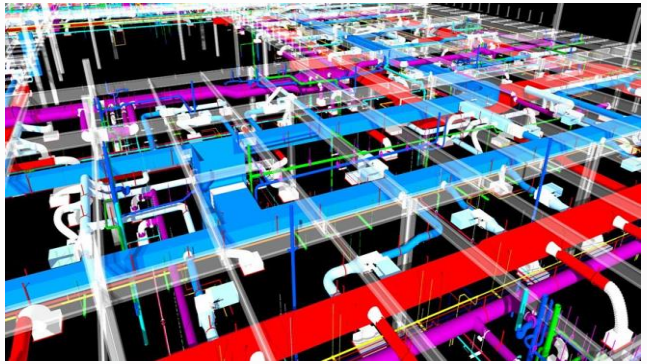
Technology

Zero Energy

Kitchen



Lighting



HVAC

Photovoltaics

Information Technology

Understanding DCPS

Reduction Goal

MDF / IDF Rooms

Wireless

Classroom Ed Tech

Equipment

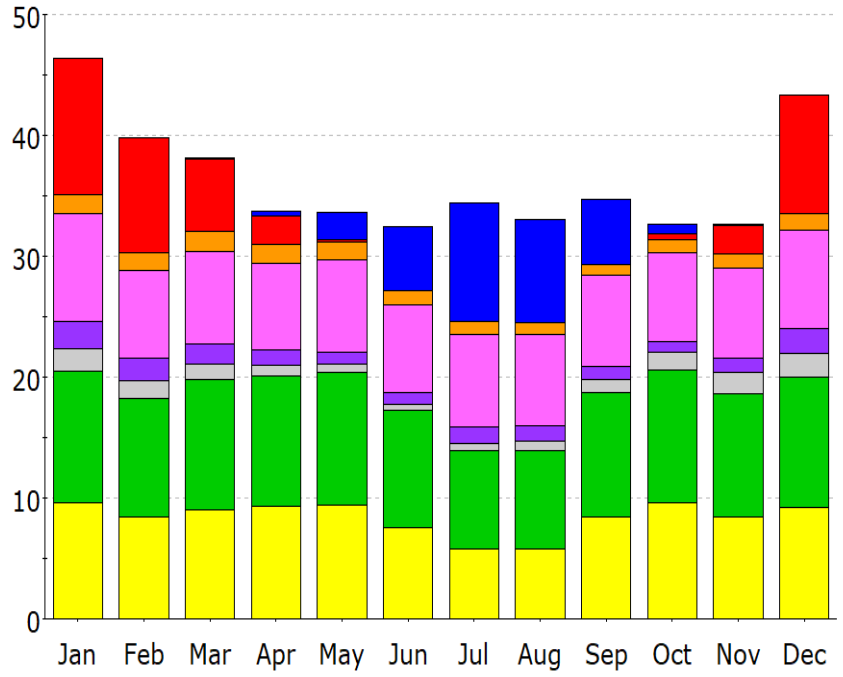
Unoccupied Shutdowns

Follow Up

ITD

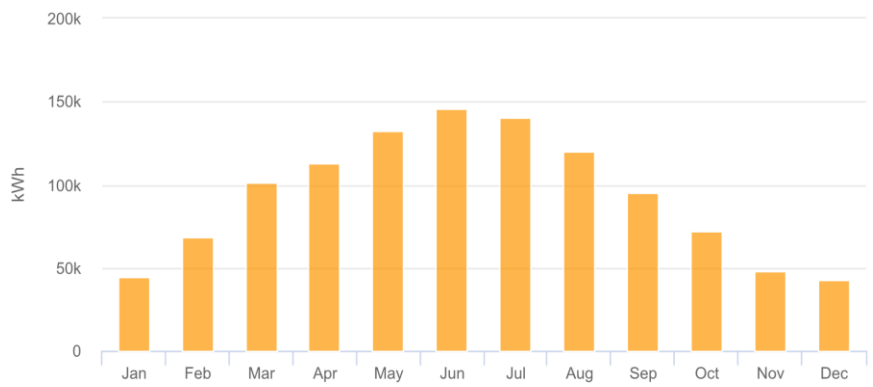
(x000)

Electric Consumption (kWh)

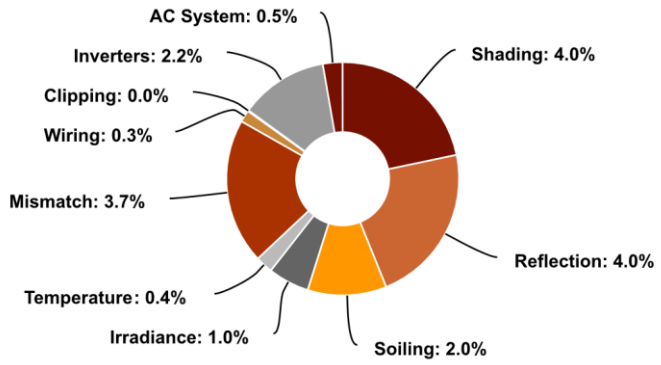


Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

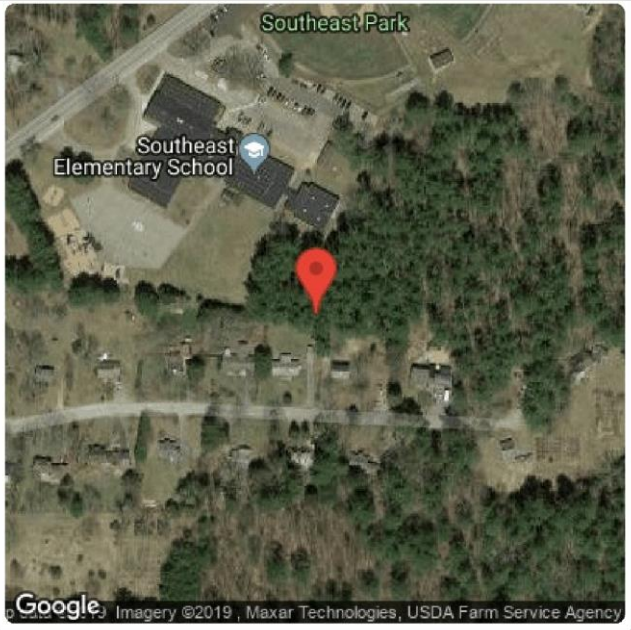
Monthly Production

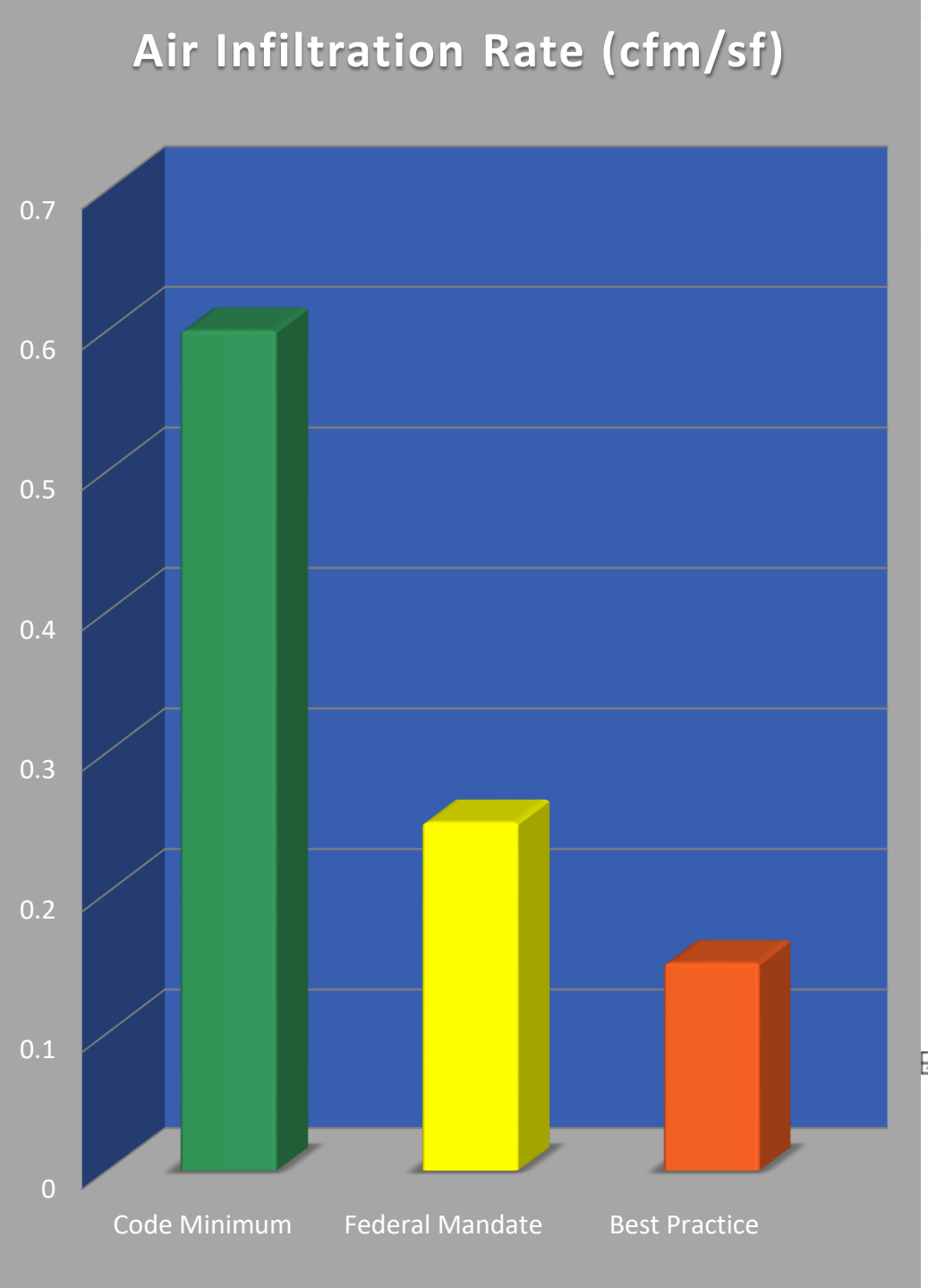


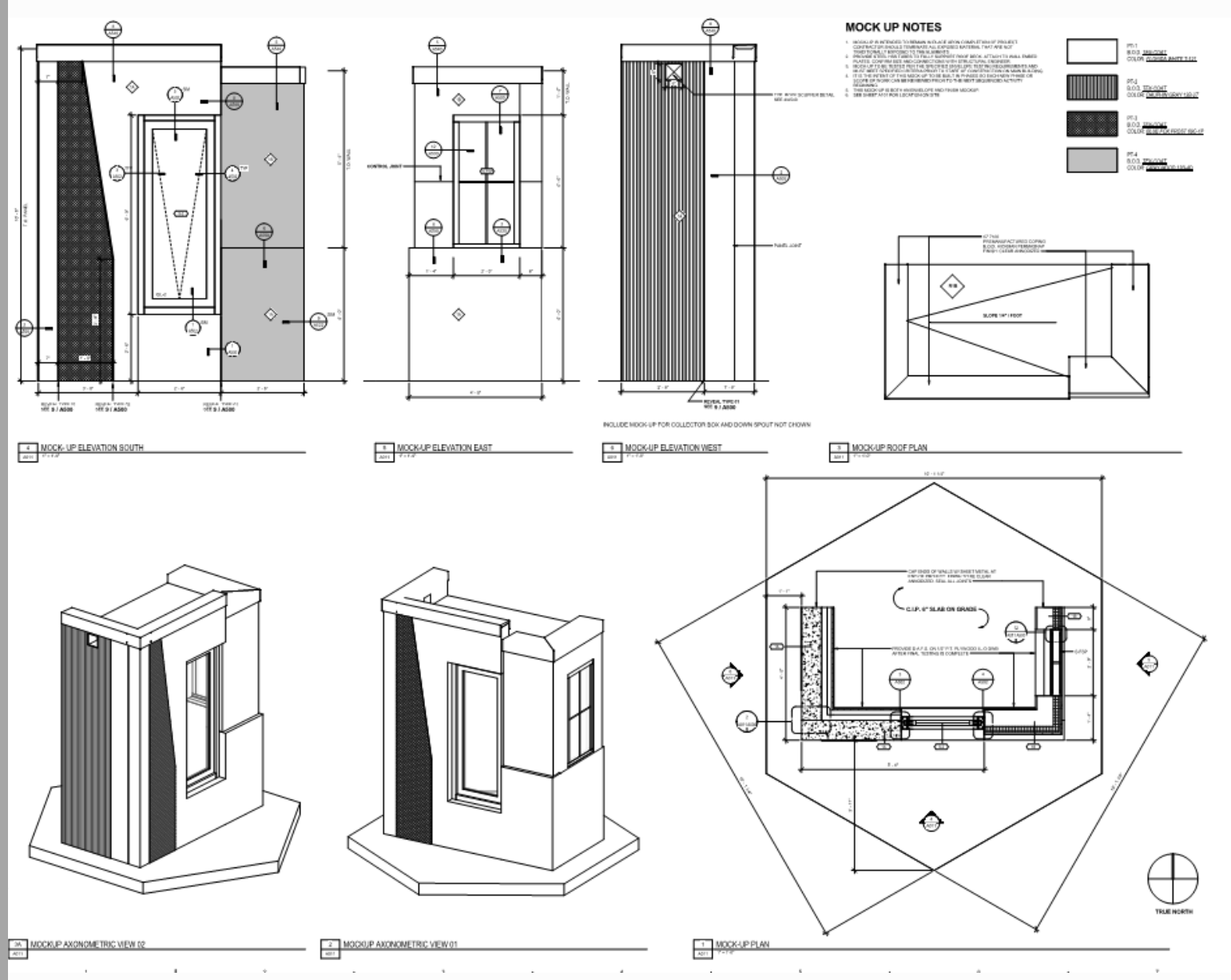
Sources of System Loss



Project Location

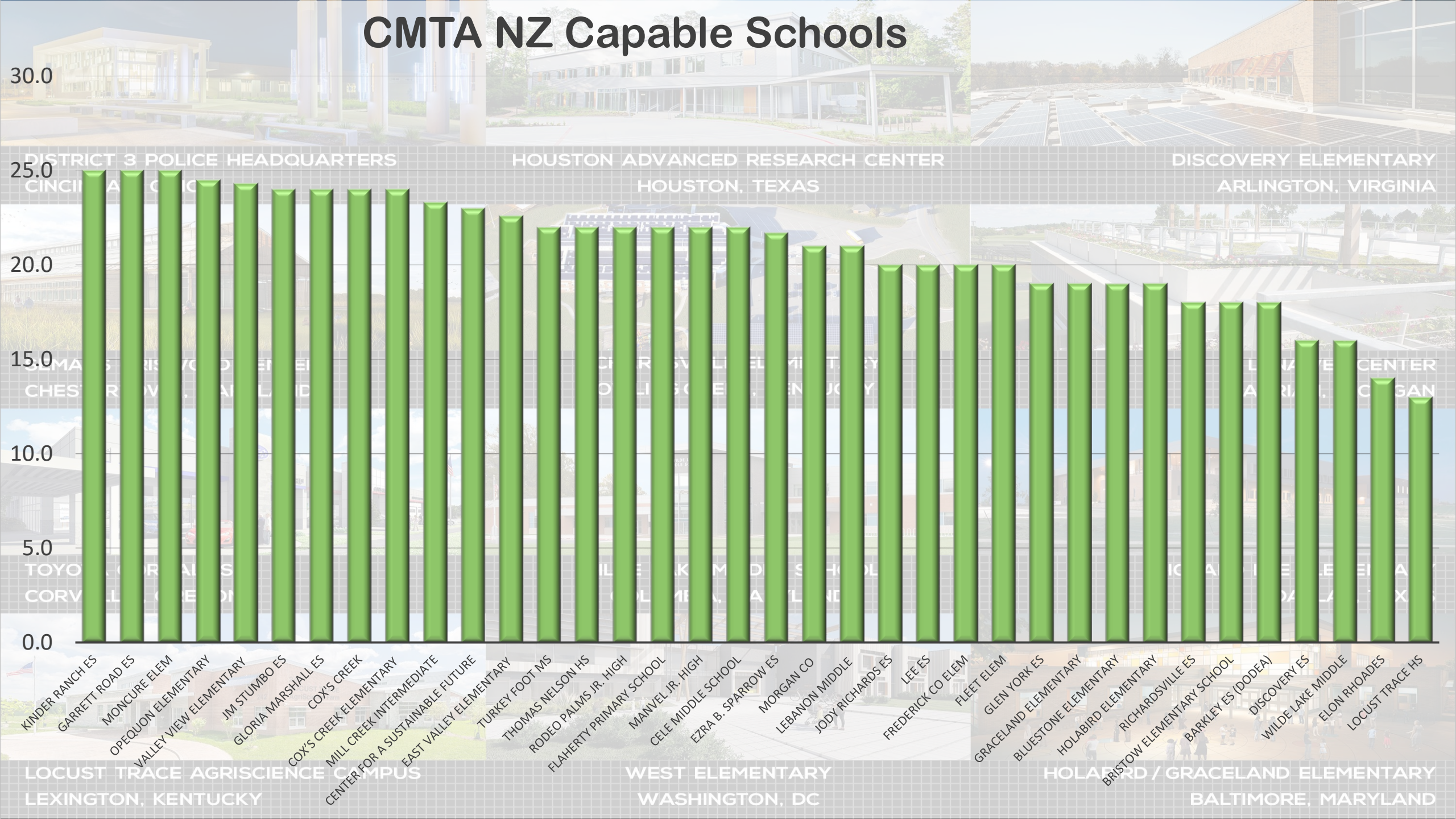






Getting Value out of MOCK-UPS

CMTA NZ Capable Schools



DISTRICT 3 POLICE HEADQUARTERS

HOUSTON ADVANCED RESEARCH CENTER
HOUSTON, TEXAS

DISCOVERY ELEMENTARY
ARLINGTON, VIRGINIA

LOCUST TRACE AGRISCIENCE CAMPUS
LEXINGTON, KENTUCKY

WEST ELEMENTARY
WASHINGTON, DC

HOLABIRD / GRACELAND ELEMENTARY
BALTIMORE, MARYLAND

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December 16, 2019

CMTA

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Zero Energy Schools

Zero Energy Is an A+ for Education: Discovery Elementary

Project:

Discovery Elementary
Arlington, Virginia
Arlington Public Schools District

Project Data:

Grade levels: Pre-K through fifth
Gross Area: 98,000 ft^2
Site area: 15 acres (including playing fields and parking)
Context: Suburban

Discovery Elementary School in Arlington, Virginia, integrates zero energy performance with the curriculum across grades.

Photo ©Alan Karchmer

CMTA

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Zero Energy Schools

Motivation

At a fundamental level, Arlington County district officials believed that integrating environmental stewardship with learning environments would give their schools a competitive edge. The district's strategic plan was centered around creating optimal learning environments while meeting the needs of the whole child—a directive that was often linked to healthy classrooms and an ethic of sustainability.

> The children naturally embrace their own sense of stewardship.

Energy Data: August 2015–July 2016

	Site EUI (kBtu/ft².yr)	Energy Cost/ft²	Net EUI (kBtu/ft².yr)
Typical School in District	69.0	$1.21	69.0
Energy Model: Design Building	21.2	NA	-0.85
Actual Usage	16.2	$0.18	-0.65

Technologies

Windows	Double paned
Envelope	Insulated concrete forms (8 in. concrete core and 4 in. polystyrene)
Heating, Ventilating, and Air Conditioning	Geothermal wells and small, distributed floor-mounted heat pumps; demand-control ventilation
Renewable Energy System	1,700 photovoltaic panels, 496 kW


ART

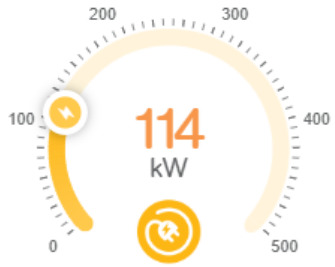
DISCOVERY
ELEMENTARY SCHOOL

LOADING...

VMDO cmta

HOME

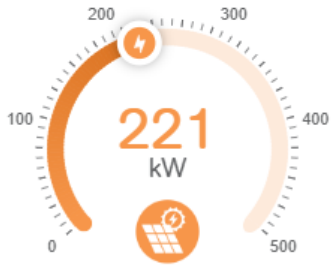
3:46 PM | WEDNESDAY, APRIL 10 2019



TODAY'S HIGH
124
kW

TODAY'S LOW
0
kW

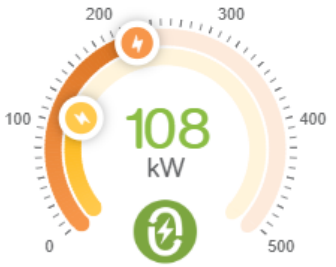
LIVE POWER CONSUMPTION



TODAY'S HIGH
373
kW

TODAY'S LOW
0
kW

LIVE POWER PRODUCTION



TODAY'S HIGH
287
kW

TODAY'S LOW
-69
kW

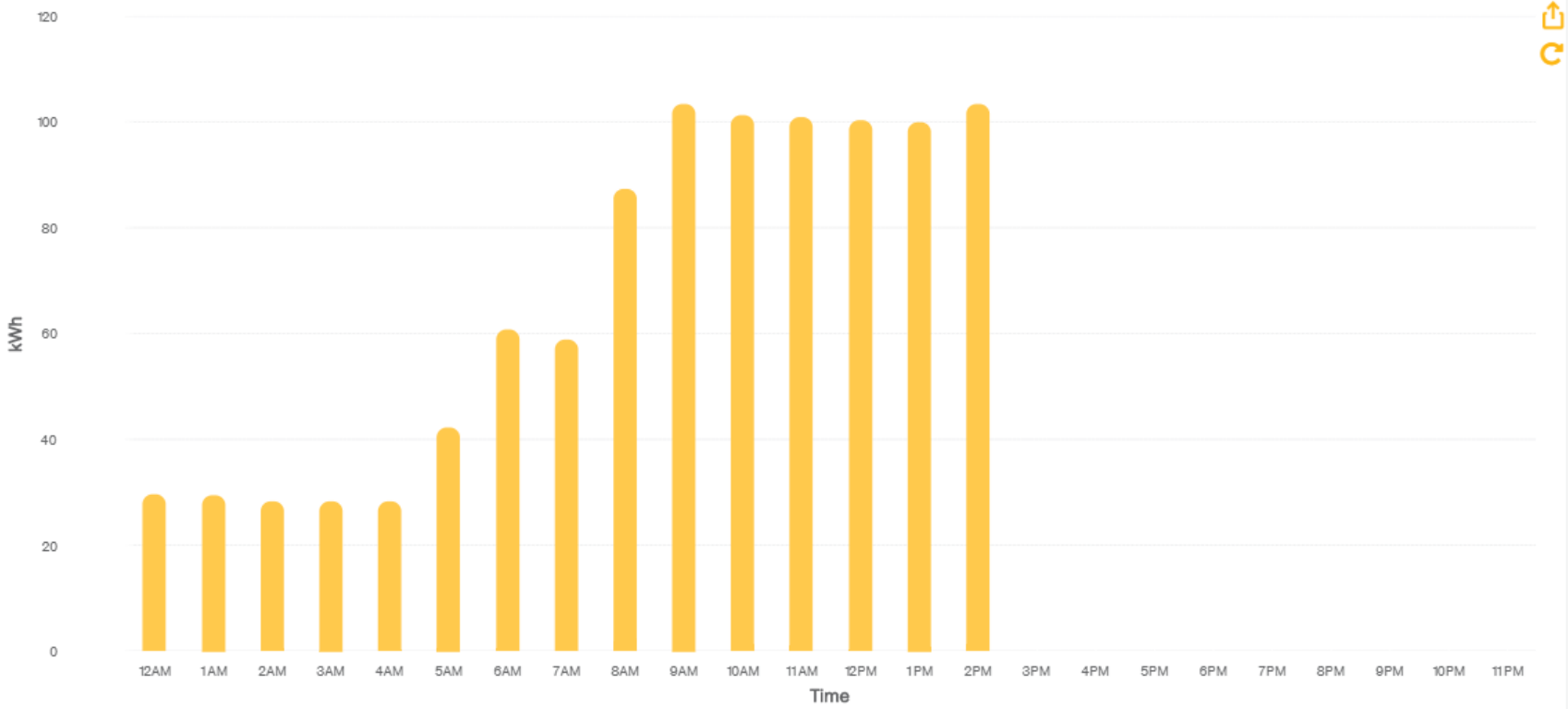
LIVE NET POWER

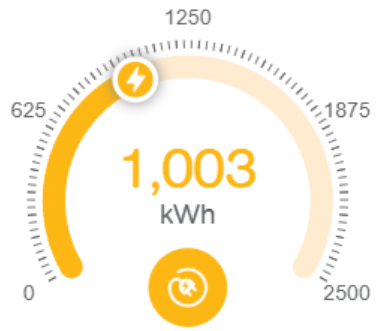
ENERGY CONSUMPTION

ALL HVAC LIGHTING KITCHEN PLUG IT

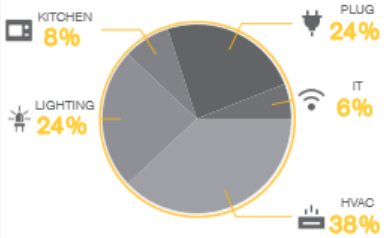
04-10-2019/04-10-2019

DAY WEEK MONTH YEAR SCHOOL YEAR





TOTAL ENERGY CONSUMPTION



ENERGY CONSUMPTION BREAKDOWN

WHAT DOES THIS DATA MEAN?

This shows the total amount of energy used to operate Discovery Elementary today. This means all energy required to heat, cool and light the building, store and prepare food, operate technology, and power everything plugged into outlets.

PERCENT CHANGE

(from previous period)

↘ 23.1 %

EQUIVALENTS

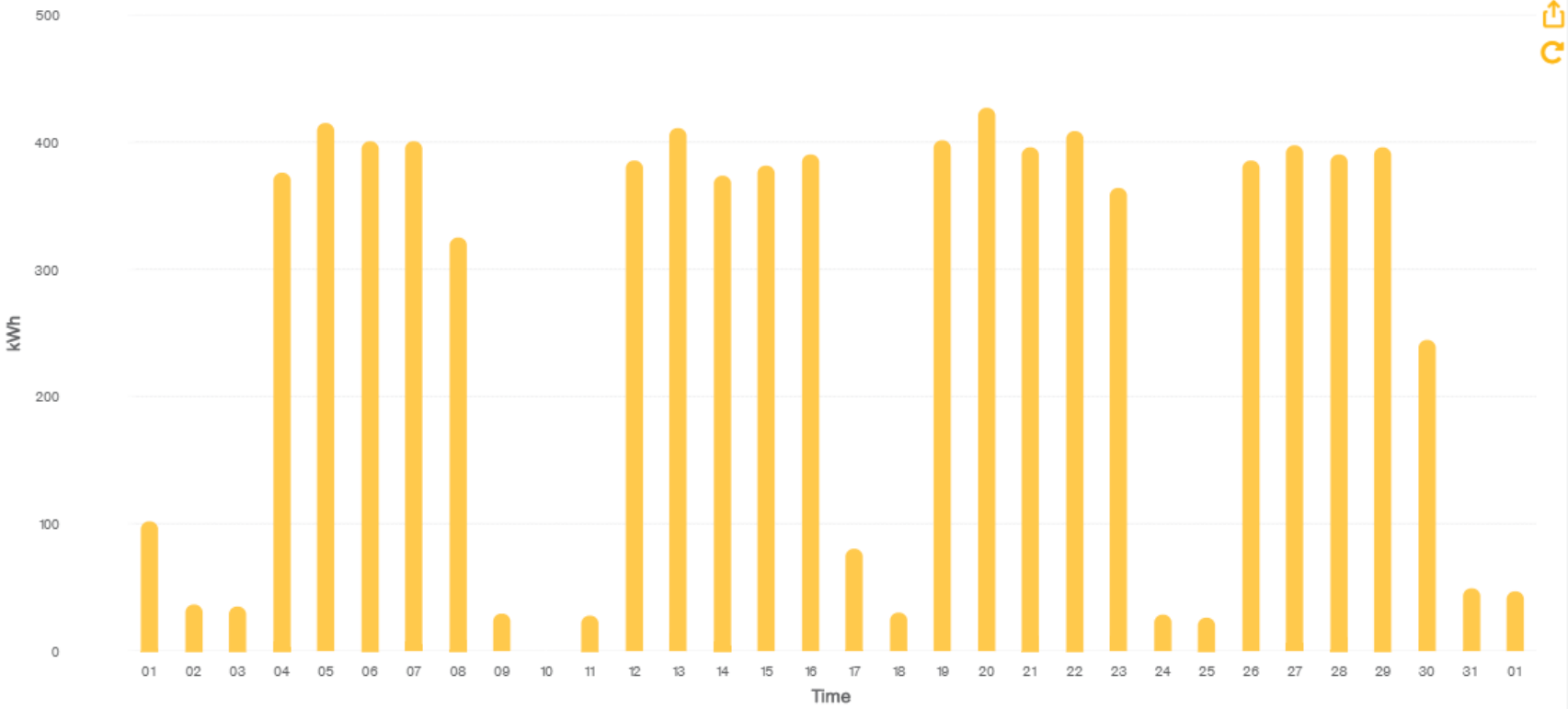
Typical Houses	33
Typical 60 watt LED Bulbs	4,642
Typical Smartphones charged	105,539

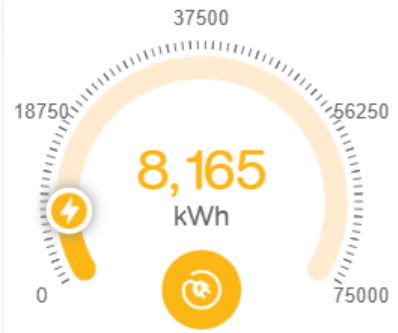
ENERGY CONSUMPTION

ALL HVAC **LIGHTING** KITCHEN PLUG IT

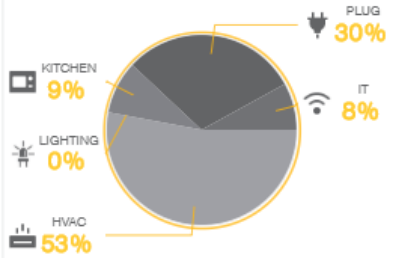
03-01-2019/03-31-2019

DAY WEEK **MONTH** YEAR SCHOOL YEAR





TOTAL ENERGY CONSUMPTION



ENERGY CONSUMPTION BREAKDOWN

WHAT DOES THIS DATA MEAN?

This shows the total amount of energy used to power all of Discovery Elementary's interior and exterior lights this month. All of these light fixtures are Light Emitting Diodes (LED), which consume far less energy – and produce less heat – than incandescent or florescent lights.

PERCENT CHANGE

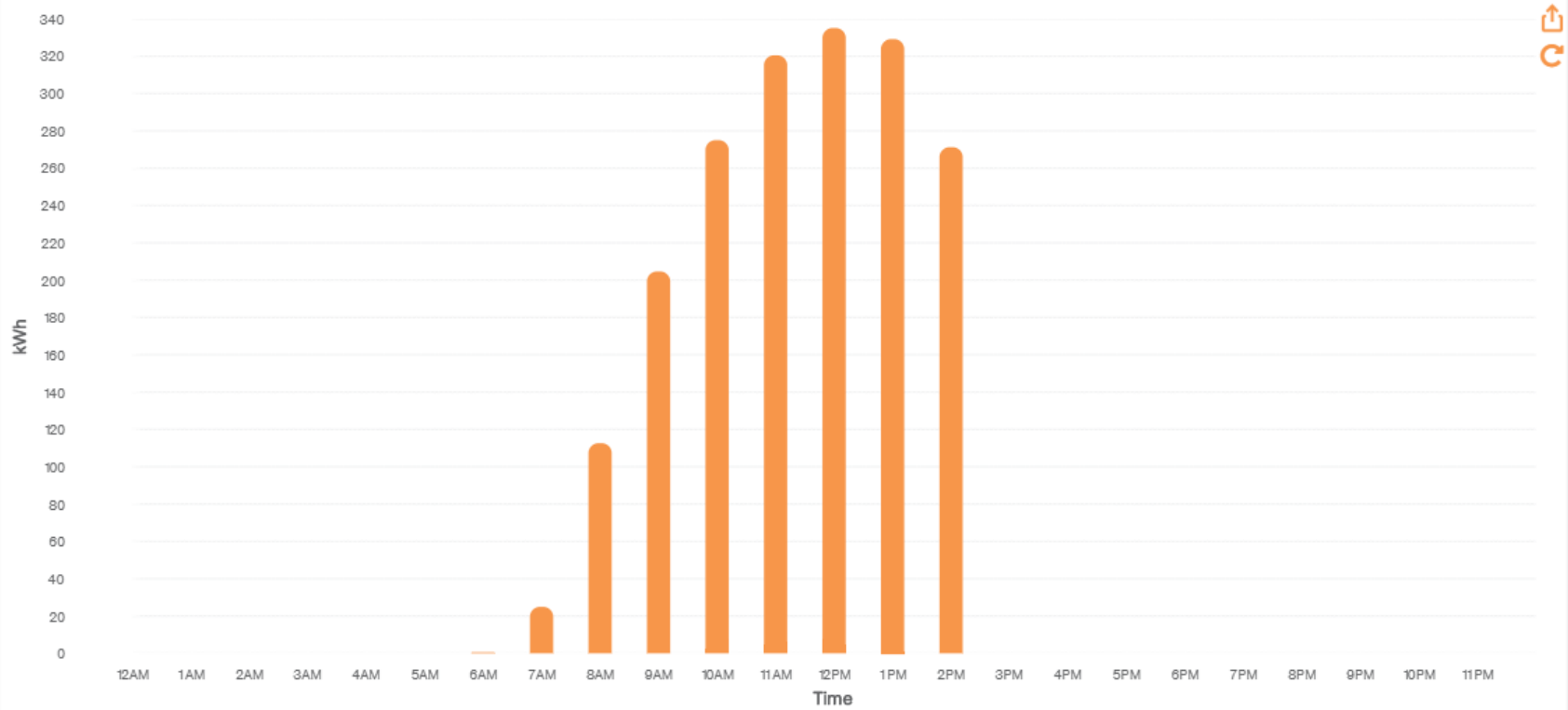
(from previous period)

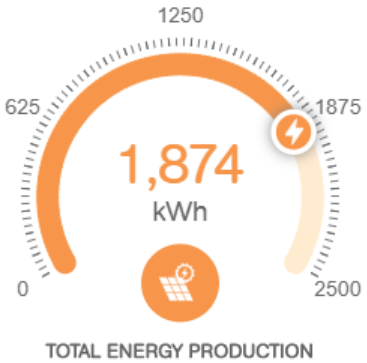
14.1 %

EQUIVALENTS

Typical Houses	272
Typical 60 watt LED Bulbs	37,801
Typical Smartphones charged	859,470

ENERGY PRODUCTION





TOTAL ENERGY PRODUCTION

WHAT DOES THIS DATA MEAN?

This shows the total amount of energy that the rooftop solar panels produced today. The panels can produce energy even in very low light, but are most productive in direct sunlight.

PERCENT CHANGE

(from previous period)

43.1 %

EQUIVALENTS

Typical Houses	62
Typical 60 watt LED Bulbs	8,676
Typical Smartphones charged	197,263

TableCMTA (5) - Excel

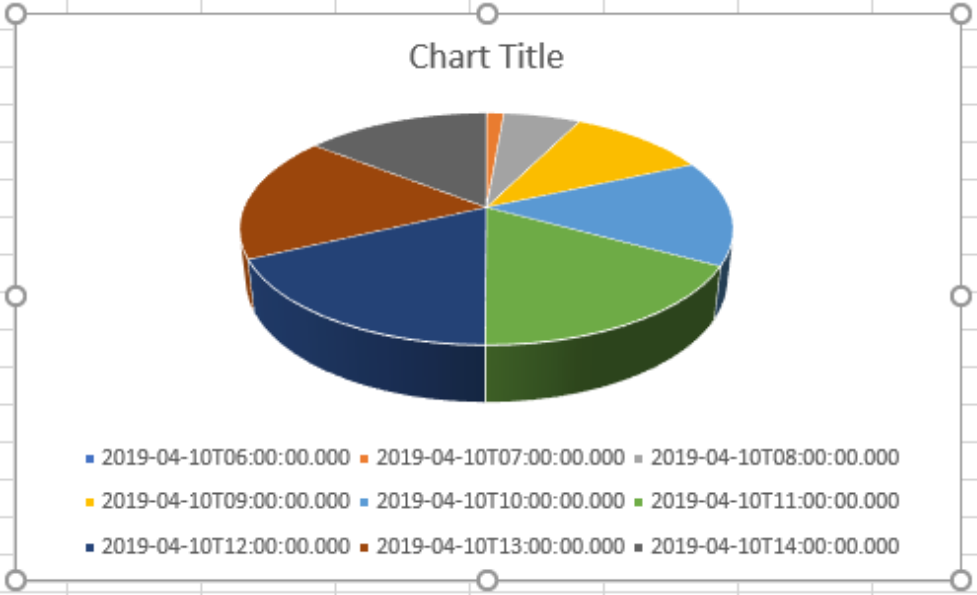
Chart Tools

File Home Insert Page Layout Formulas Data Review View Help BLUEBEAM Team Design Format Tell me what you want to do

Add Chart Element | Quick Layout | Change Colors | Chart Layouts | Chart Styles | Switch Row/ Column | Select Data | Data | Change Chart Type | Type | Move Chart | Location

Chart 1

	A	B
1	timestamp	production
2	2019-04-10	0
3	2019-04-10	0
4	2019-04-10	0
5	2019-04-10	0
6	2019-04-10	0
7	2019-04-10	0
8	2019-04-10	0.5177806
9	2019-04-10	25.012152
10	2019-04-10	112.61154
11	2019-04-10	204.52646
12	2019-04-10	274.95474
13	2019-04-10	320.549
14	2019-04-10	334.99966
15	2019-04-10	329.33505
16	2019-04-10	271.26868
17	2019-04-10	0
18	2019-04-10	0
19	2019-04-10	0
20	2019-04-10	0
21	2019-04-10	0
22	2019-04-10	0
23	2019-04-10	0
24	2019-04-10	0
25	2019-04-10	0



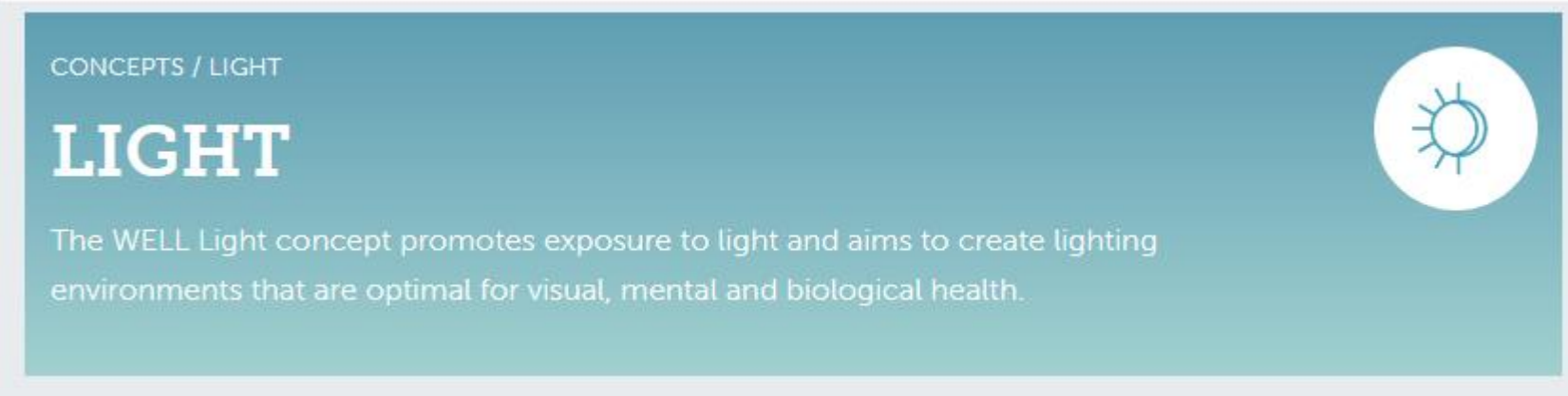

Classroom
Solar Lab
Roof
Kitchen
Mechanical room
Outside Air Room
Mechanical Closet

SOLAR SHADES

The sun rises low in the east, hangs high overhead to the south, and sets in the west. Our school is oriented with the sun by having almost all of its windows face north or south. Our south windows are equipped with solar shades, which help keep the excess heat out.


Classroom
Solar Lab
Roof
Kitchen
Mechanical room
Outside Air Room
Mechanical Closet

Daylighting & Artificial Lighting



Light Exposure and Education
Circadian Lighting Design
Enhanced Daylight Access
Electric Light Quality
Spectral Power Density (SPD)

Visual Lighting Design
Glare Control
Visual Balance
Corrected Color Temperature (CRI)
Occupant Control

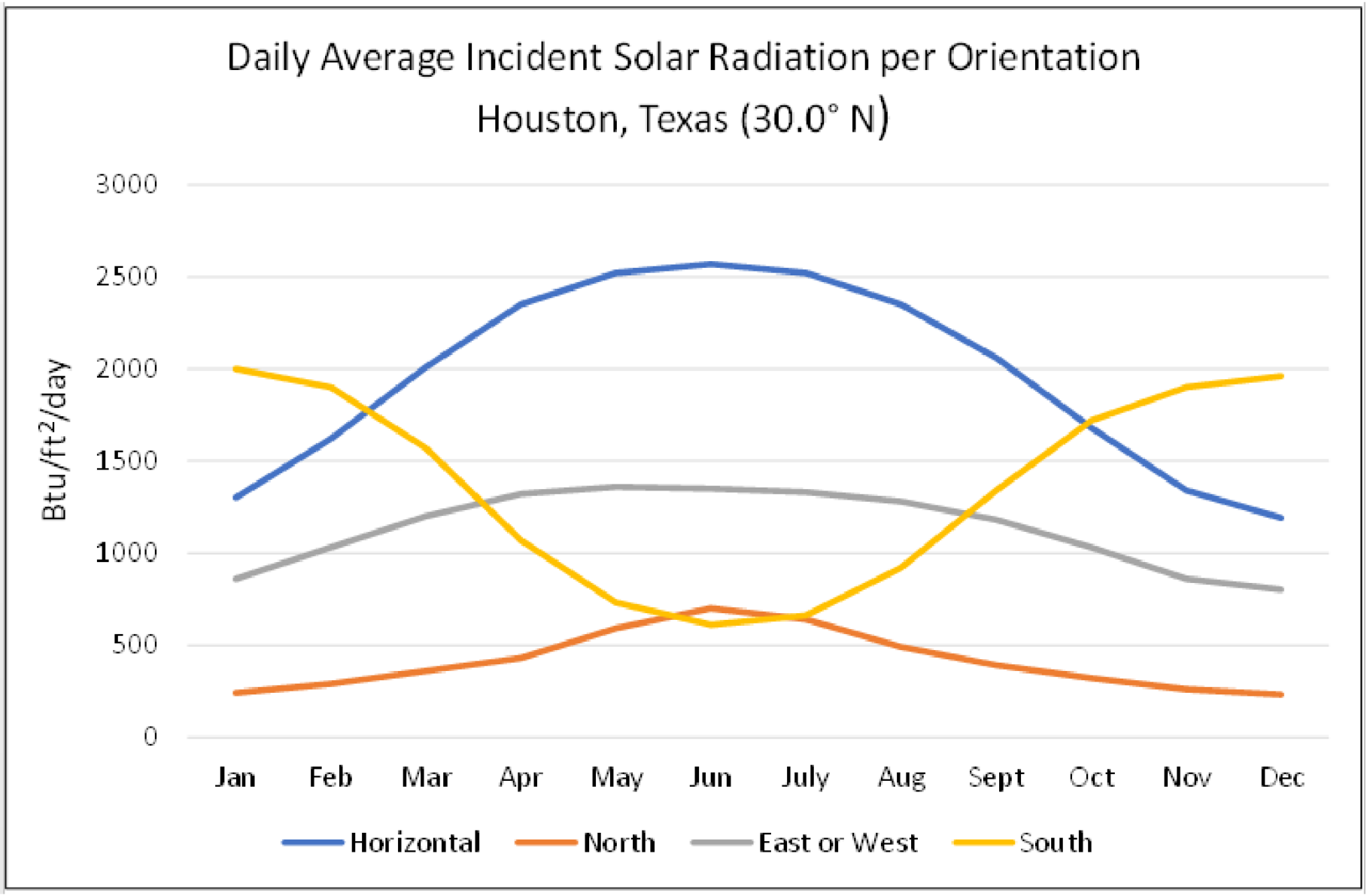
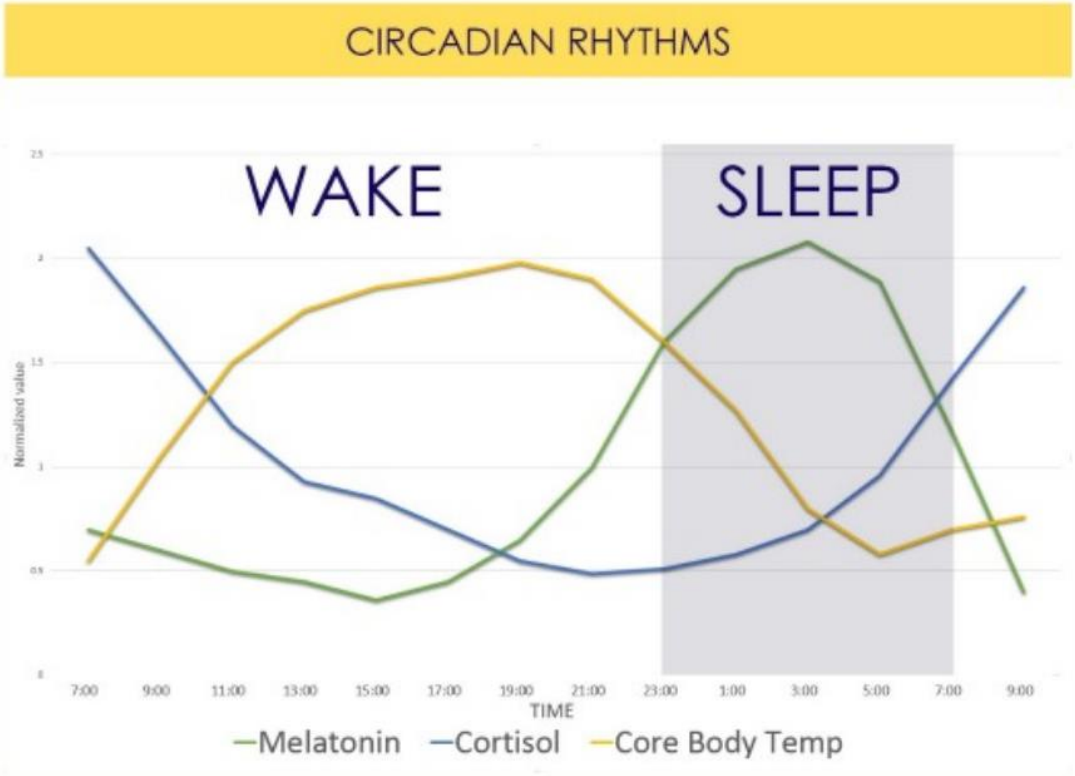


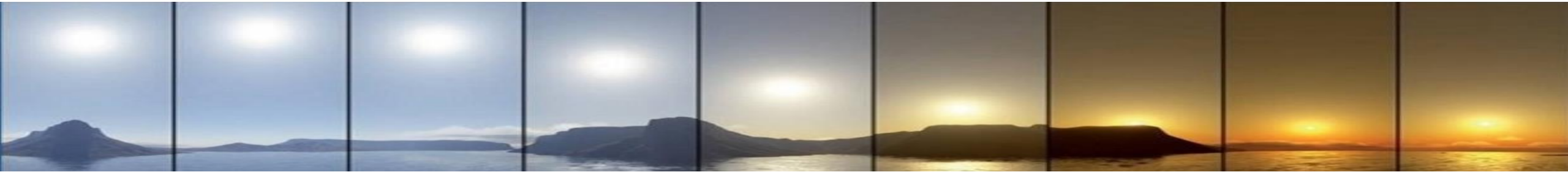
Figure 5-4 (BP5) Daily Average Incident Solar Radiation by Orientation for Diverse Locations

CMTA

On the Nature of Sleep

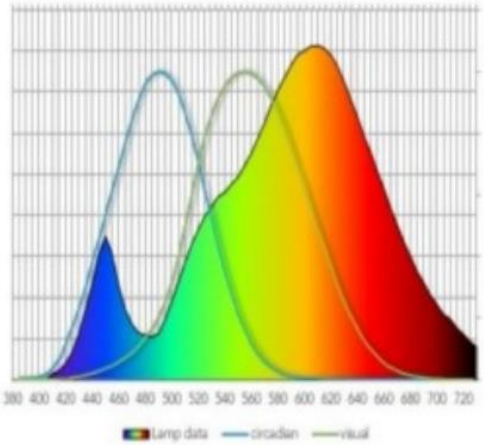
- Biological process that occurs throughout the day
- The **act** of sleep happens at night
- Not enough bright light during day hurts sleep
- Bright light at night hurts sleep



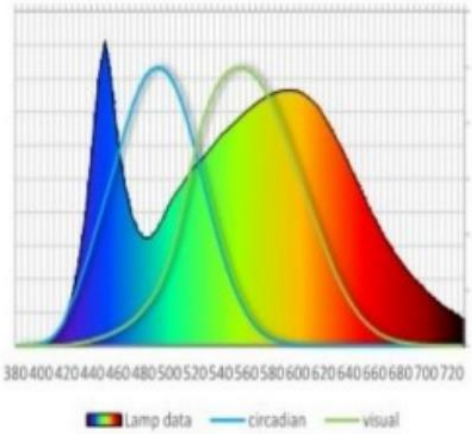


On the Nature of Daylight

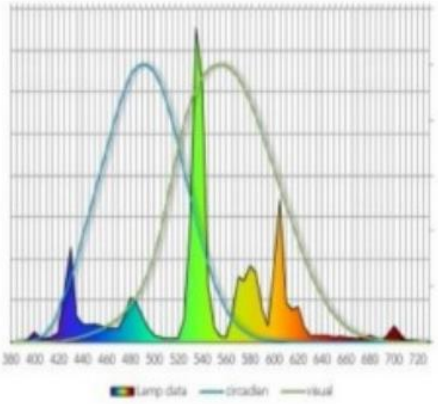
2700 K LED: $R_M = 0.44$



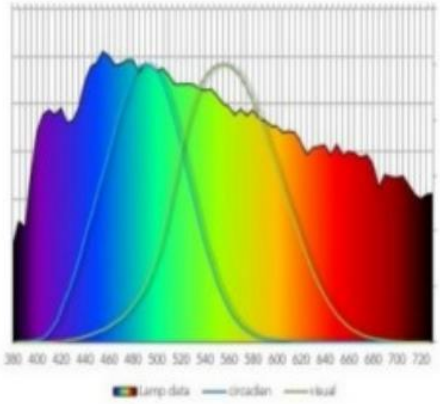
4000 K LED: $R_M = 0.76$

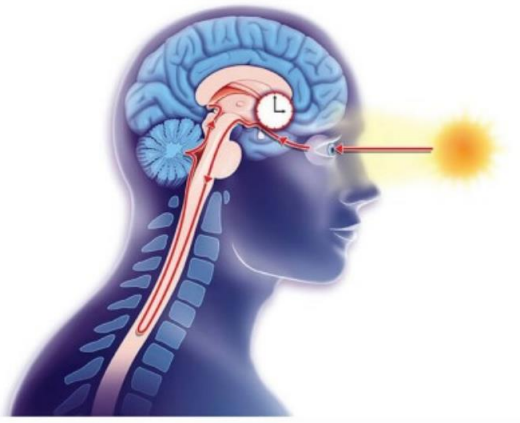


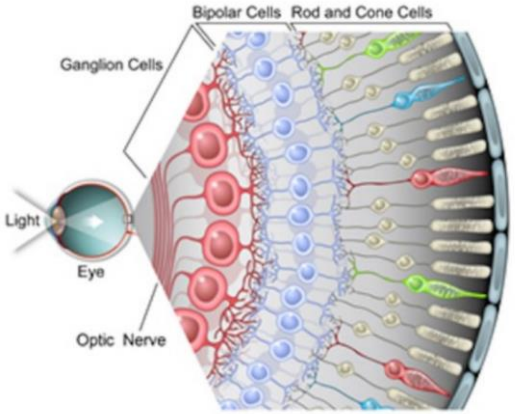
4000 K FLUORESCENT: $R_M = 0.59$



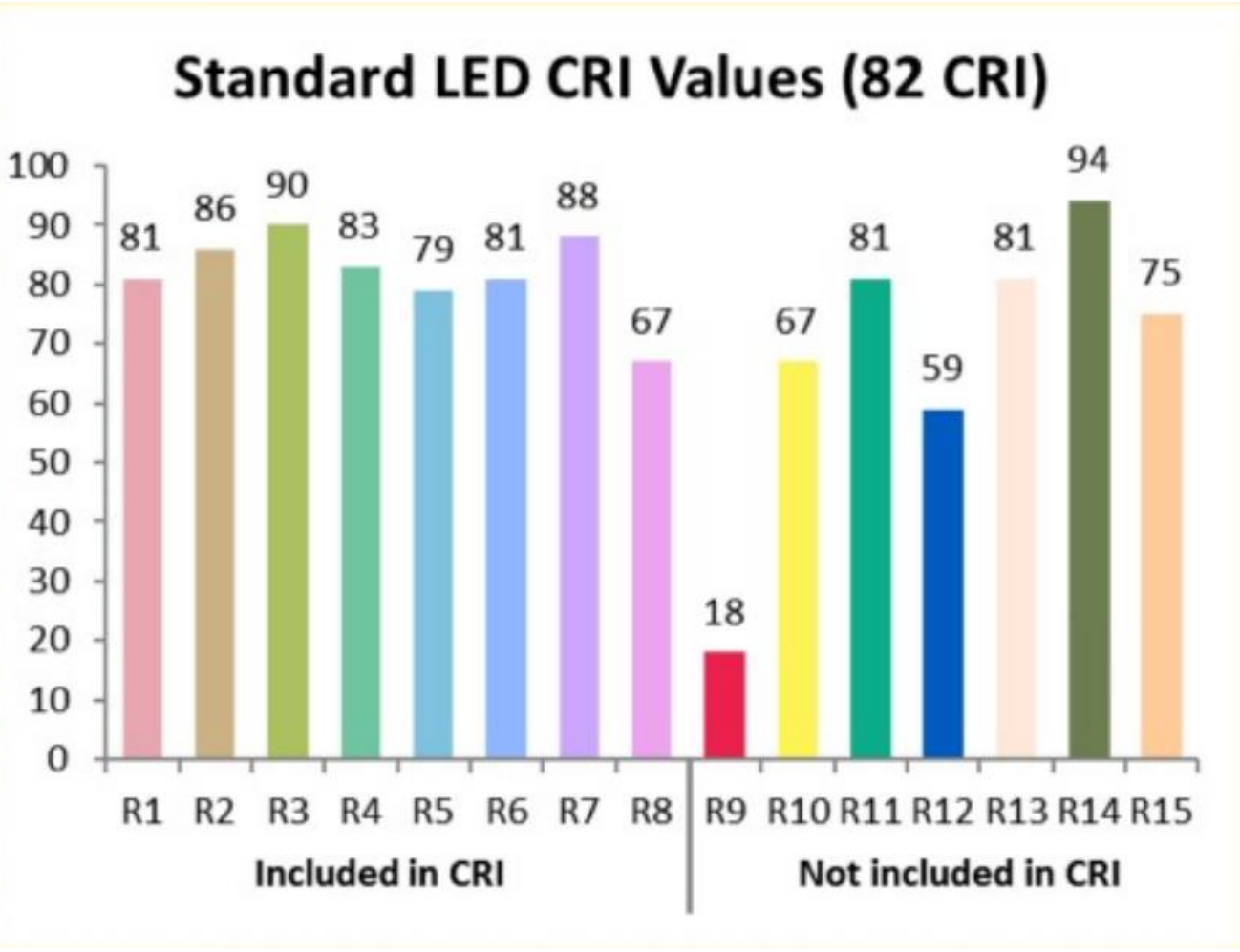
NATURAL LIGHT: $R_M = 1.13$

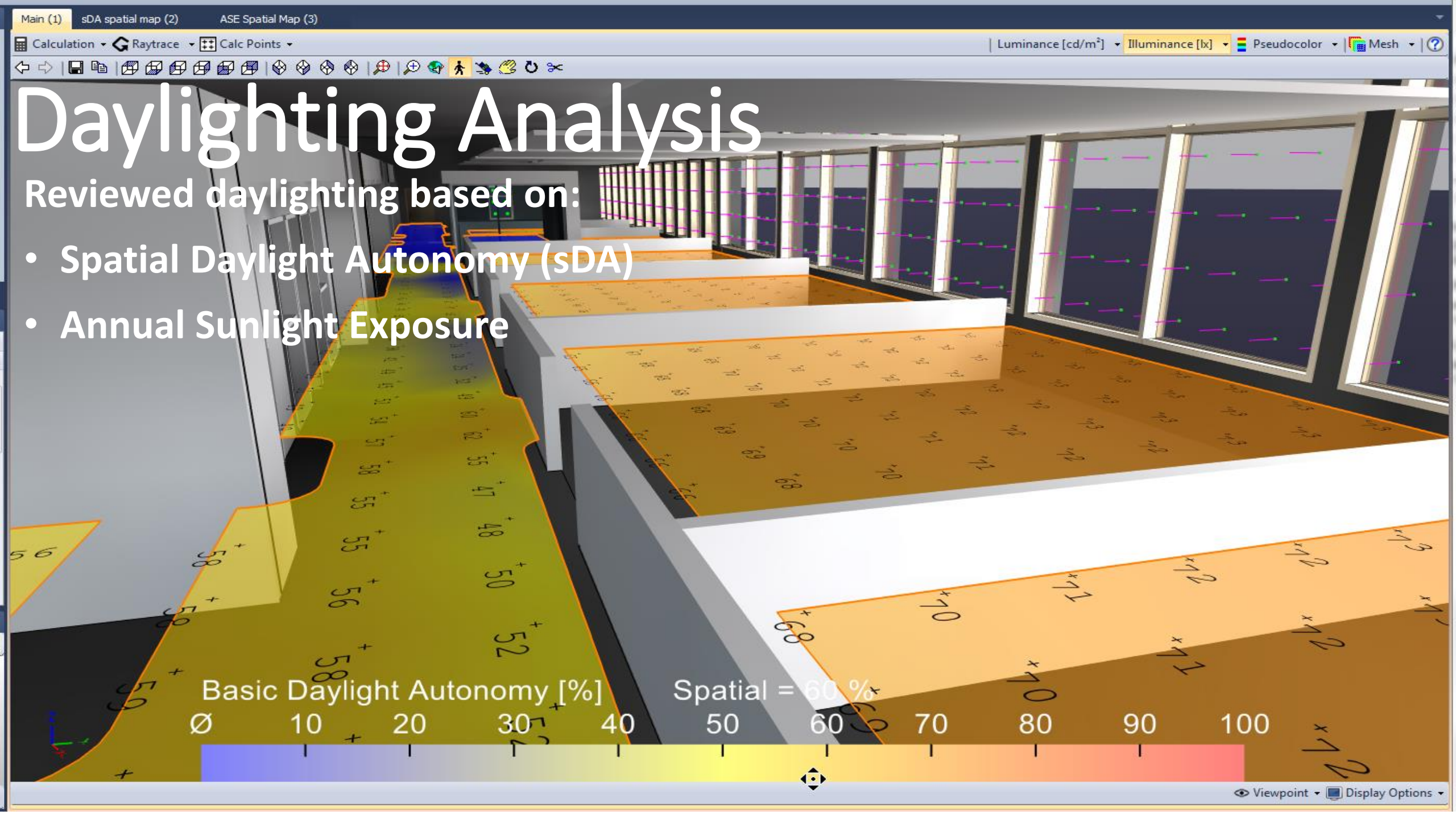






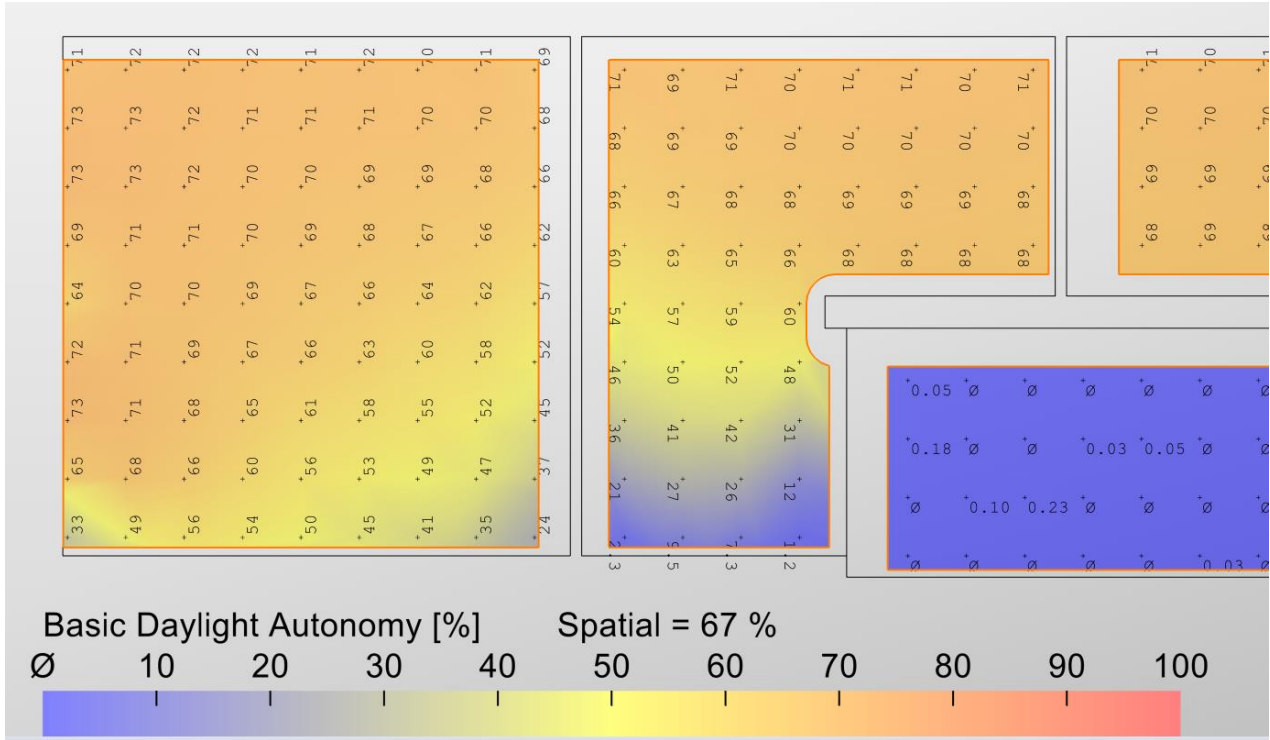
Color Rendering Index

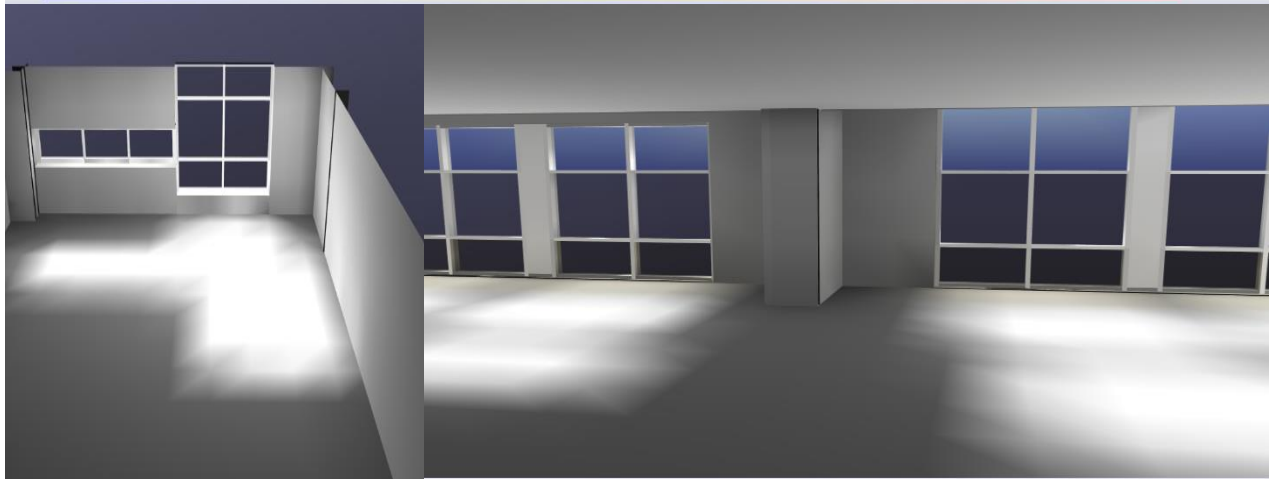



Main (1)
sDA spatial map (2)
ASE Spatial Map (3)
Calculation
Raytrace
Calc Points
Luminance [cd/m²]
Illuminance [lx]
Pseudocolor
Mesh
Daylighting Analysis
Reviewed daylighting based on:
• Spatial Daylight Autonomy (sDA)
• Annual Sunlight Exposure
Basic Daylight Autonomy [%]
Spatial = 60 %
Ø 10 20 30 40 50 60 70 80 90 100
Viewpoint
Display Options

Spatial Daylight Autonomy (sDA)

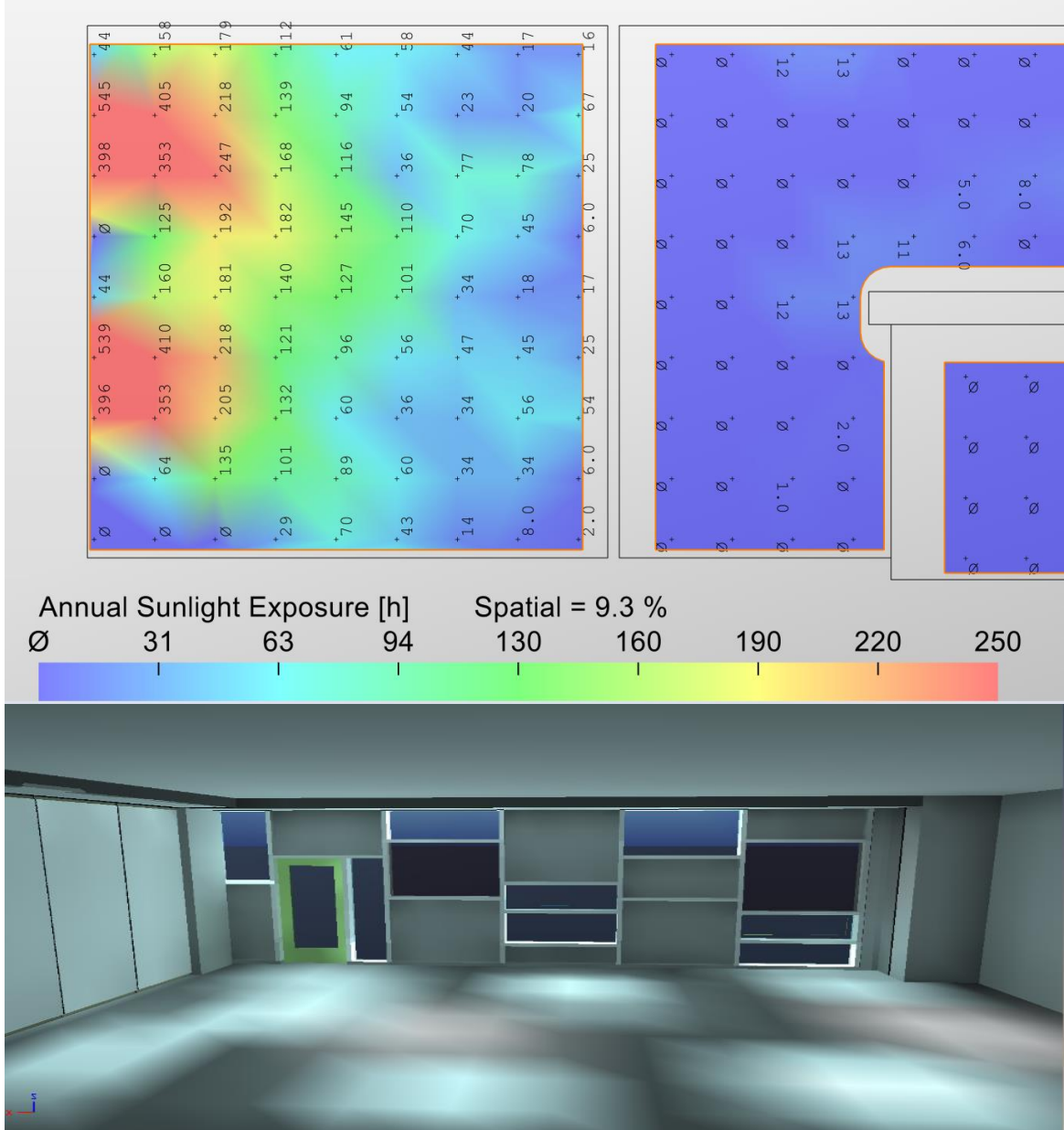
- Daylight Autonomy (DA)
  - A percentage value that indicates the fraction of occupied hours per year where the illuminance at a point is greater > or = to a target threshold value.
- Spatial Daylight Autonomy (sDA)
  - A percentage value that indicates the fraction of area where DA meets a minimum daylight illuminance level for a specified fraction of operating hours per year
  - $sDA_{300/50\%}$ = the percentage of analysis points that meet or exceed 300 lux for at least 50% of the operating hours.
- Recommended Performance Criteria
  - <u>Preferred</u> Daylight Sufficiency $sDA_{300/50\%}$ >= 75%
  - <u>Nominally Accepted</u> Daylight Sufficiency $sDA_{300/50\%}$ >= 55%
  - WELL building requires at least 55% of calculation points in **regularly occupied spaces** meet the 300,50% threshold
  - LEED
    - 2 points for $sDA_{300/50\%}$ >= 55%
    - 3 points for $sDA_{300/50\%}$ >= 75%

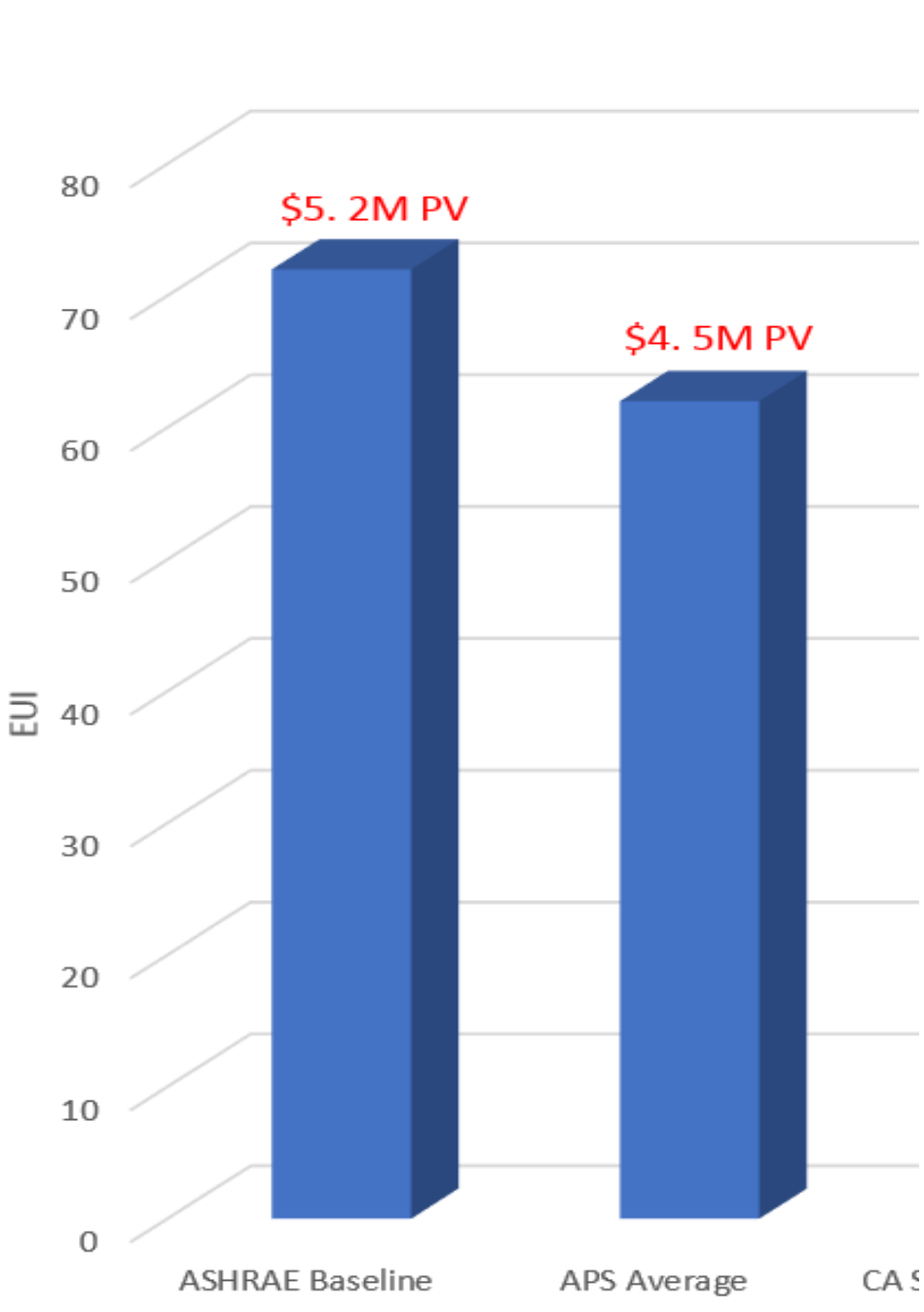


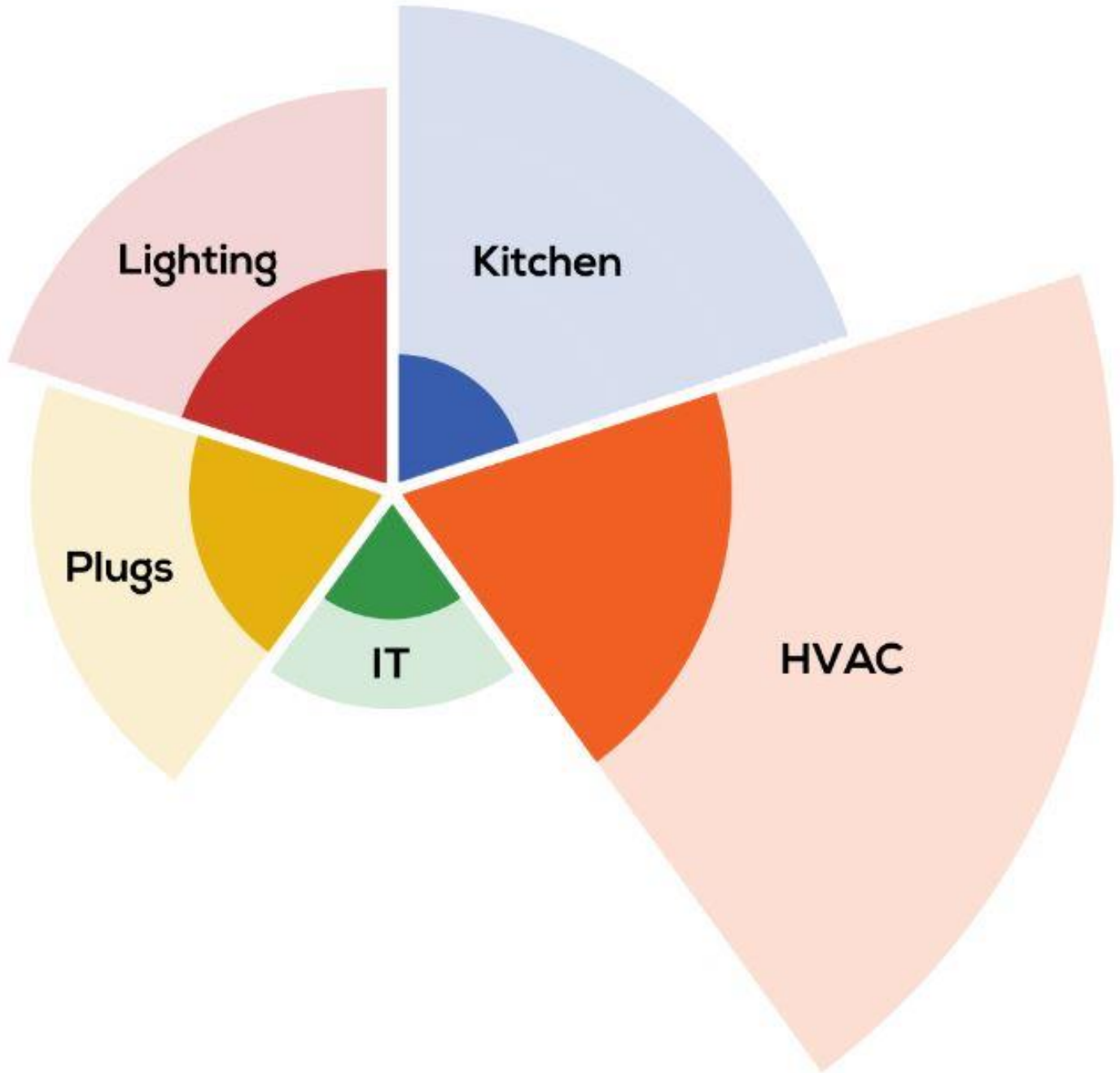


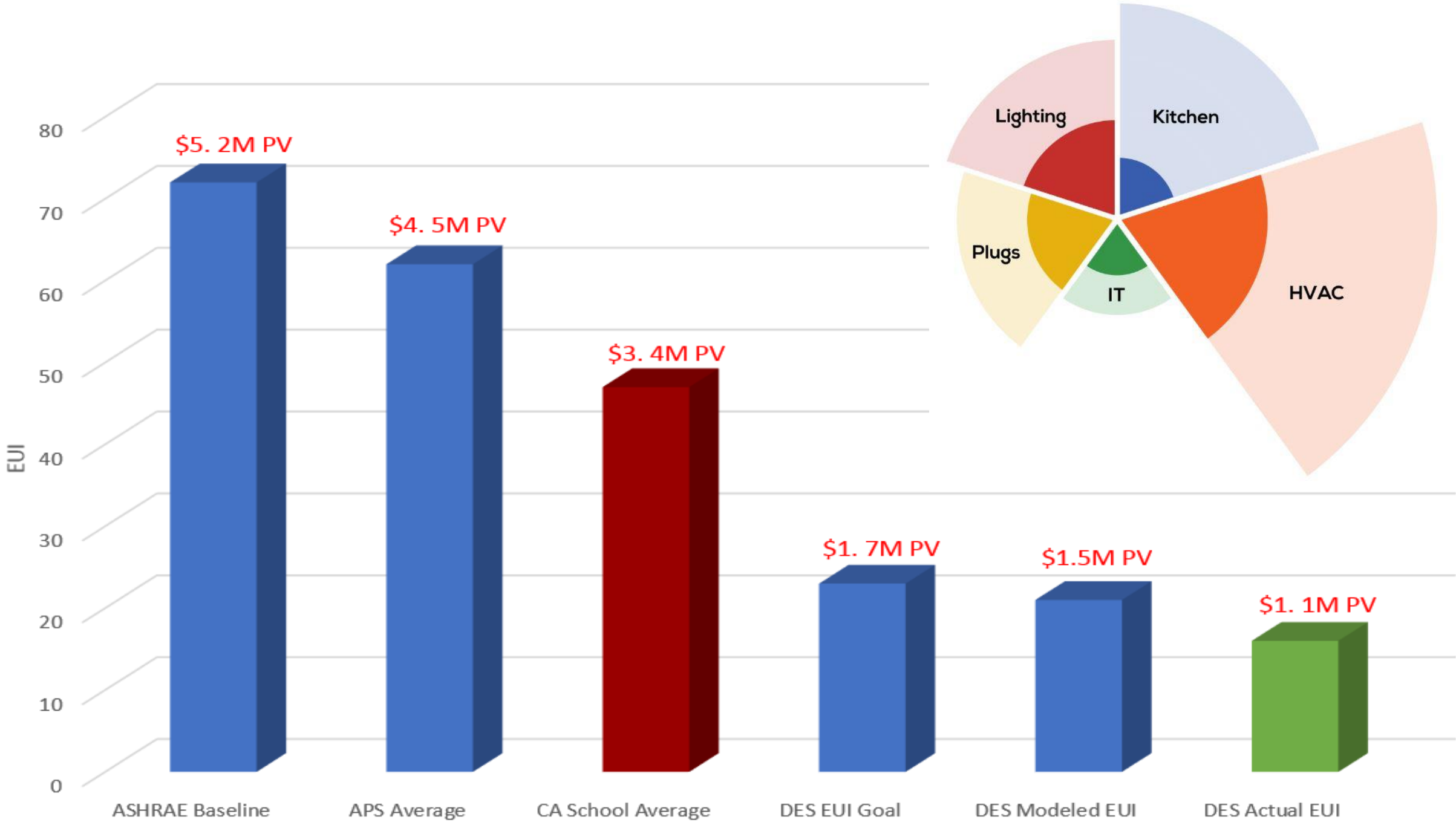
Annual Sunlight Exposure (ASE)

- To avoid overglazing, we must also measure areas that receive too much direct sunlight. Excessive sunlight can cause glare and visual discomfort
- A percentage value that indicates the number of points on a calculation grid that exceed a specified direct sunlight illuminance level for a specified number of hours per year
- (ASE 1000,250) = the percentage of analysis points that are exposed to more than 1000 lux of *direct sunlight* for more than 250 hours per year.
- WELL building requires no more than 10% of calculation points in **regularly occupied spaces** exceed the 1000,250 threshold.

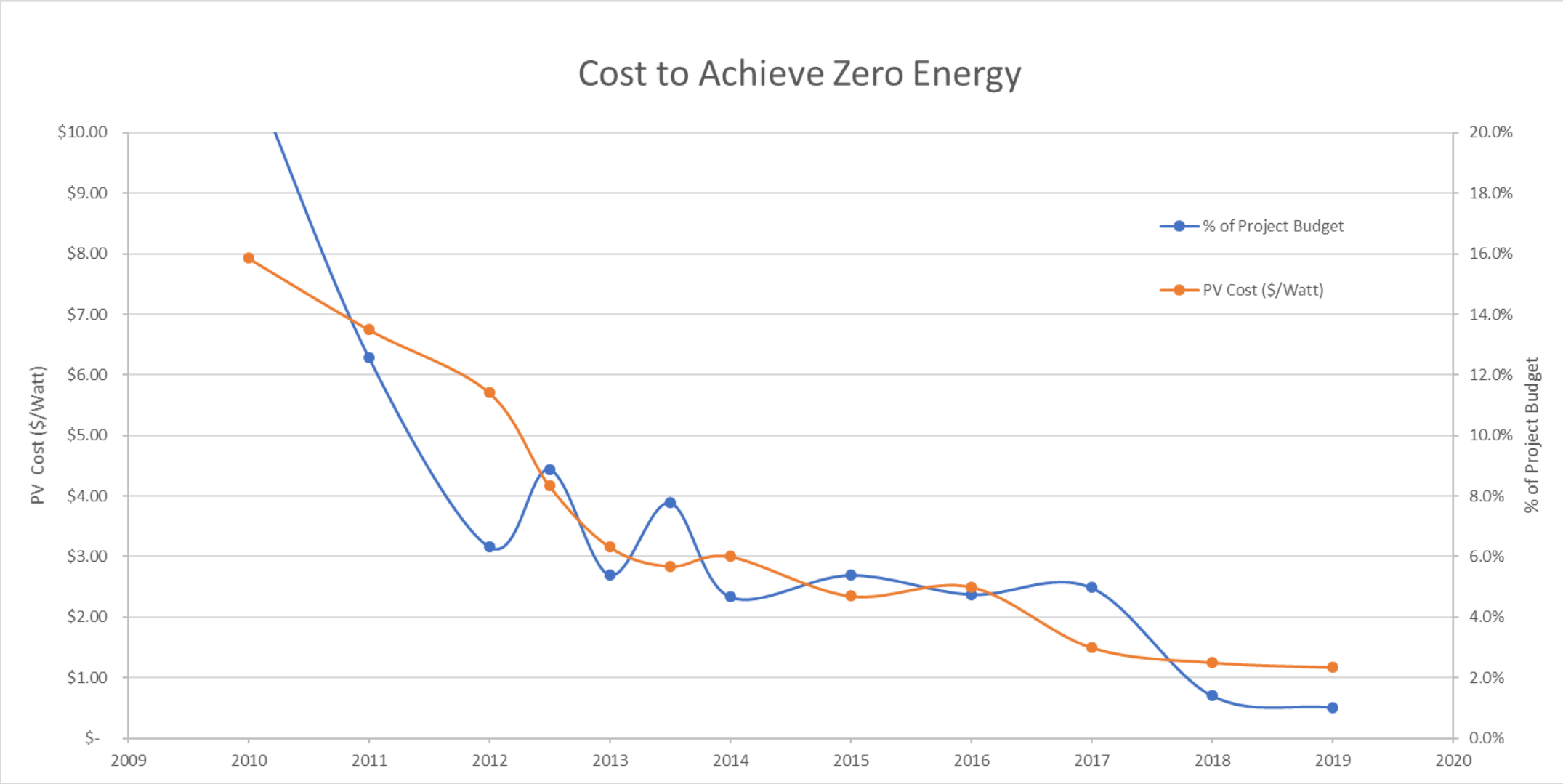



80
70
60
50
40
30
20
10
0
EUI
$5. 2M PV
$4. 5M PV
ASHRAE Baseline
APS Average


Lighting
Kitchen
Plugs
IT
HVAC


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

When is NZE the right choice?



Agenda

1) Introductions
2) Define Zero Energy
3) Past Successes
4) Path Forward
5) Curriculum

December 16, 2019

Agenda

1) Introductions
2) Define Zero Energy
3) Past Successes
4) Path Forward
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December 16, 2019

Draft Agenda:

1) Superintendent Intro (opportunity in front of district, etc)
2) Define Zero Energy
3) History of ZE projects, challenges, goals and successes
4) Pathway Forward (Paradigm shifts through energy charettes - Schedule)
5) Opportunity for Engaging students / Integrating Curriculum

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