CMTA, Inc.

Provider #401104249

Carbon Emissions and Achieving Carbon Neutral Buildings

Wyatt Ross, Jerry Noble

October 5, 2022

Pepper Construction
Tomorrow Transformed

CMTA

CONTINUING EDUCATION

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Course Description

This course serves as an introduction to developing carbon neutrality pursuits within the AEC industry. Covering a myriad of case studies and topics, the course identifies where carbon emissions occur in the built environment, and the strategies being proposed to address them. With a full spectrum of considerations covering the entire span of a building's lifecycle, the presentation offers valuable information the attendees can apply to their future projects.

Course Objectives

- Demonstrate an understanding of the design issues affecting Carbon Neutral buildings.
- Identify the stakeholders responsible for achieving a Carbon Neutral building.
- Define the difference between embodied and operational carbon emissions.
- Apply best practices to Carbon Neutral building design, construction, and operations.

Introductions

Wyatt Ross
EIT, CEM, PVA, LEED GA
Building Science Engineer

CMTA

Jerry Noble
Vice President

Pepper Construction
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Agenda

1

Introduction

- Shifting focus on carbon emissions
- Defining carbon neutrality

2

Getting to Neutral

- Steps to reaching carbon neutrality

3

Case Study

- Case Study: Pepper Construction, Cincinnati Office

4

Conclusion

- Q&A

Introduction

The Shift to Carbon

Building Industry

AIA 2030 COMMITMENT

SE2050 COMMITTING TO ZERO

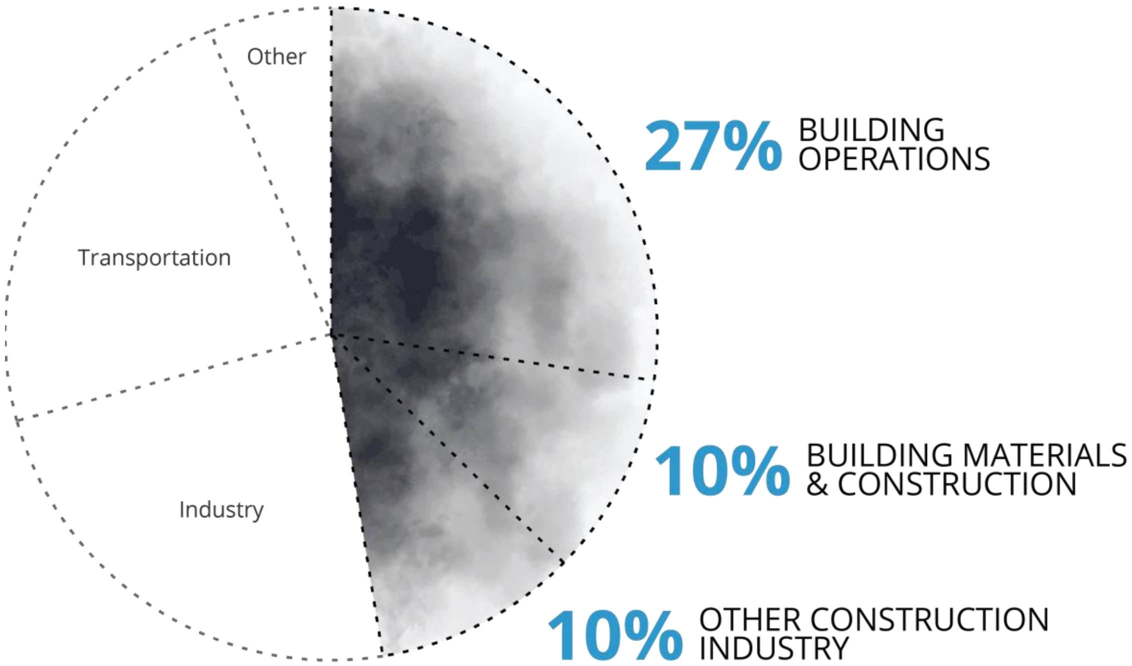
MEP 2040 Committing to Zero

ASHRAE®

ASHRAE TASK FORCE FOR BUILDING DECARBONIZATION

WORLD GREEN BUILDING COUNCIL

Annual Global CO_2 Emissions



Data Sources: Global ABC Global Status Report 2021, EIA

Defining a Carbon Neutral Building

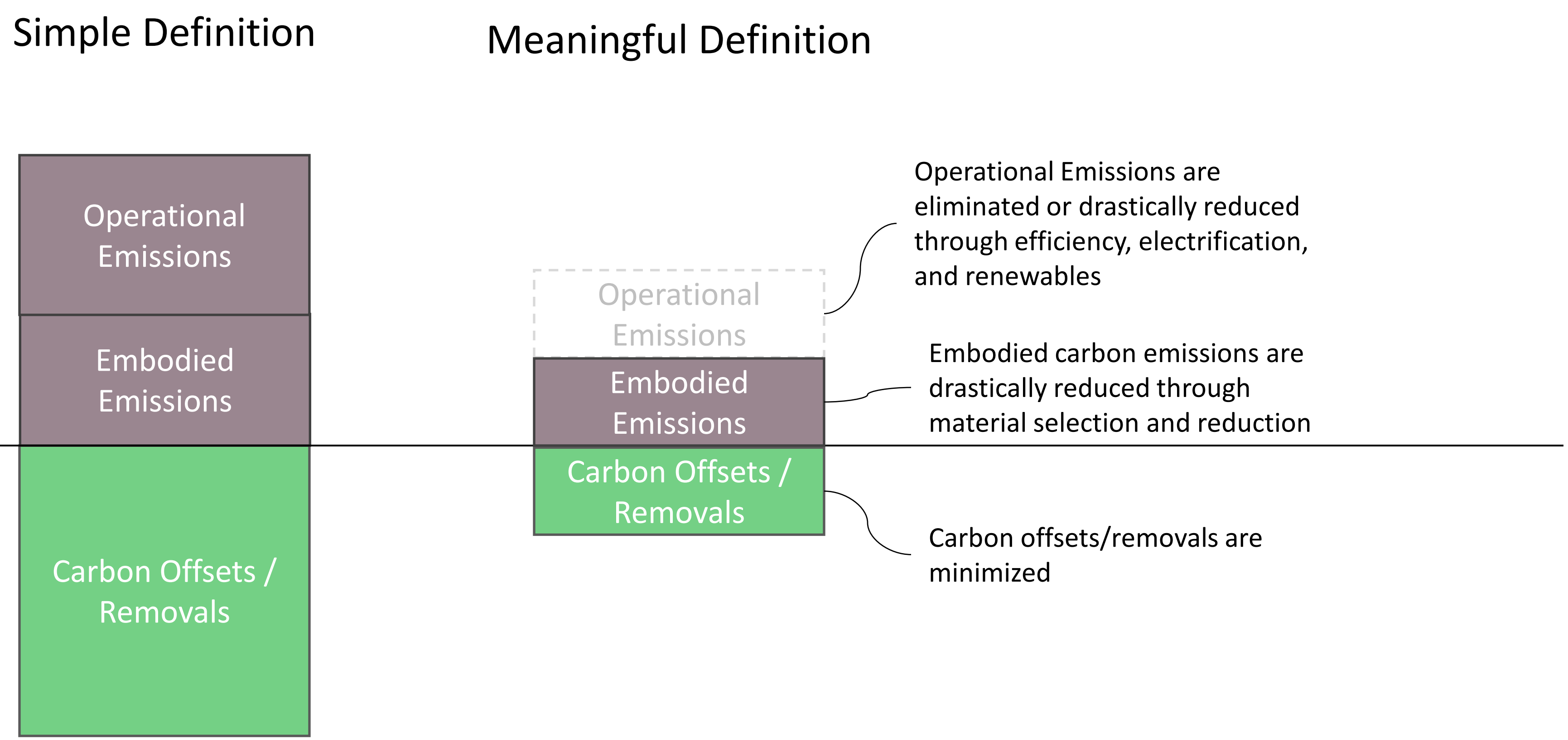
What does it mean to be carbon neutral?

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.	PERFORMANCE OR DESIGN	METRIC	BOUNDARY	COMBUSTION ALLOWED?	EFFICIENCY REQUIRED?	OFFSITE RE ALLOWED?	OTHER REQS.
LIVING BUILDING CHALLENGE					**NEW BUILDINGS:** 70% EBB* w/PV **EXISTING BUILDINGS:** 50% EBB w/PV	Yes, using off-site RE exception.	Must include on-site storage; 20% embodied carbon reduction.
ZERO ENERGY CERTIFICATION					Highest efficiency	Yes, must be local. 75% of roof for solar.	
ZERO CARBON CERTIFICATION					**NEW BUILDINGS:** 25% < 90.1-2010 **EXISTING BUILDINGS:** 30% < CBECS	Yes. Must be *Additional*.	10% Embodied Carbon Reduction
LEED Zero ENERGY					No, but LEED Certified	Yes. See tiered structure for on- and offsite RE	Must be LEED-NC or EBOM certified. Performance in Arc. TOU option for LZC.
LEED Zero CARBON							
ZERO CODE™					Must meet ASHRAE 90.1-2016	Yes. After on-site. Tiered structure applies discount factor to options.	Off-site renewables are discounted.
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes	Embodied carbon may be included later
AIA 2030 Commitment					70% better than CBECS 2003	Yes, but not counted	Seeing to incorporate refined carbon-specific metrics

= Transportation   = Embodied Carbon   = Site Energy Use   = CO2e   = Source Energy Use

Defining a Carbon Neutral Building

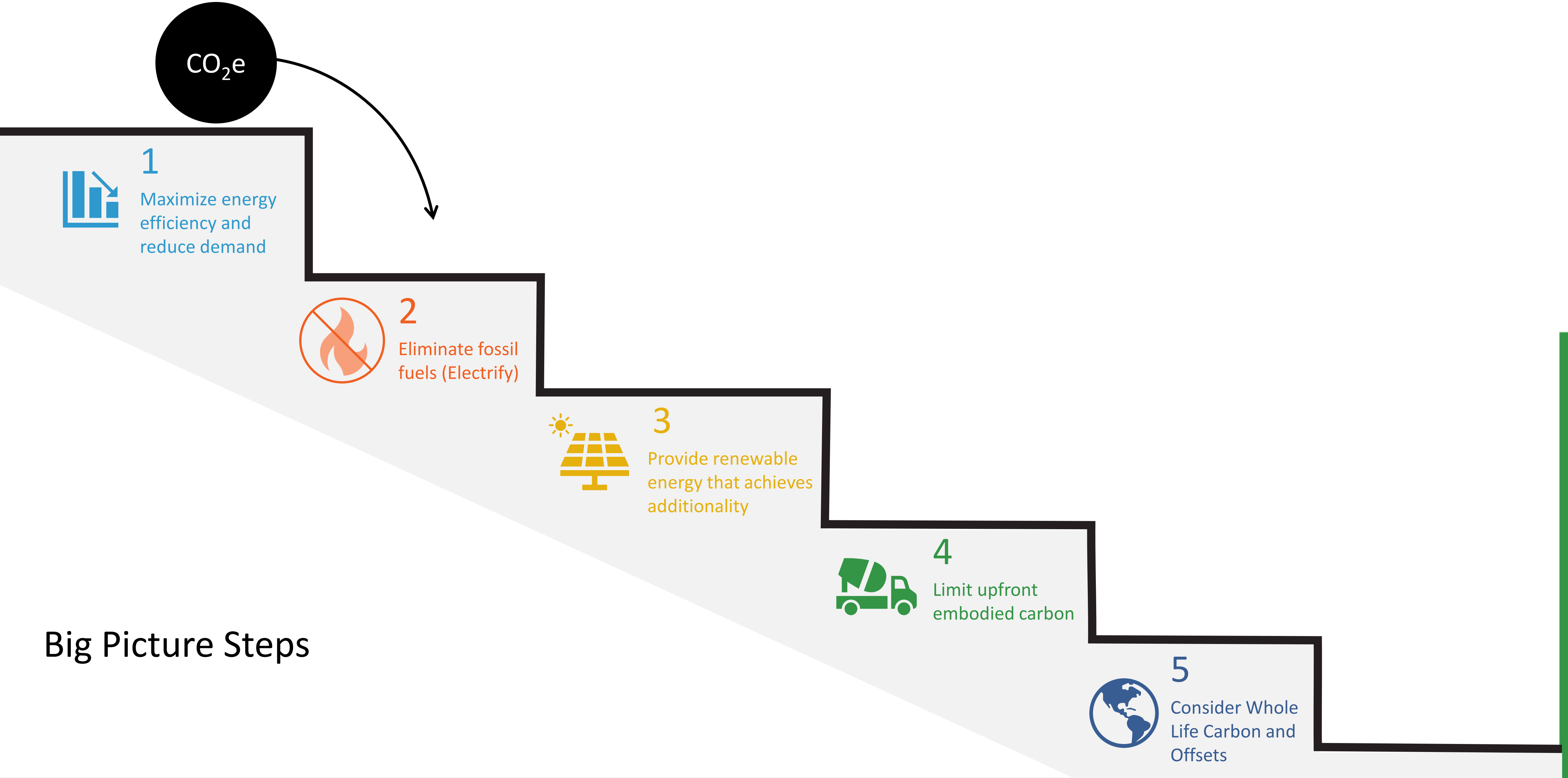
What does it mean to be carbon neutral?



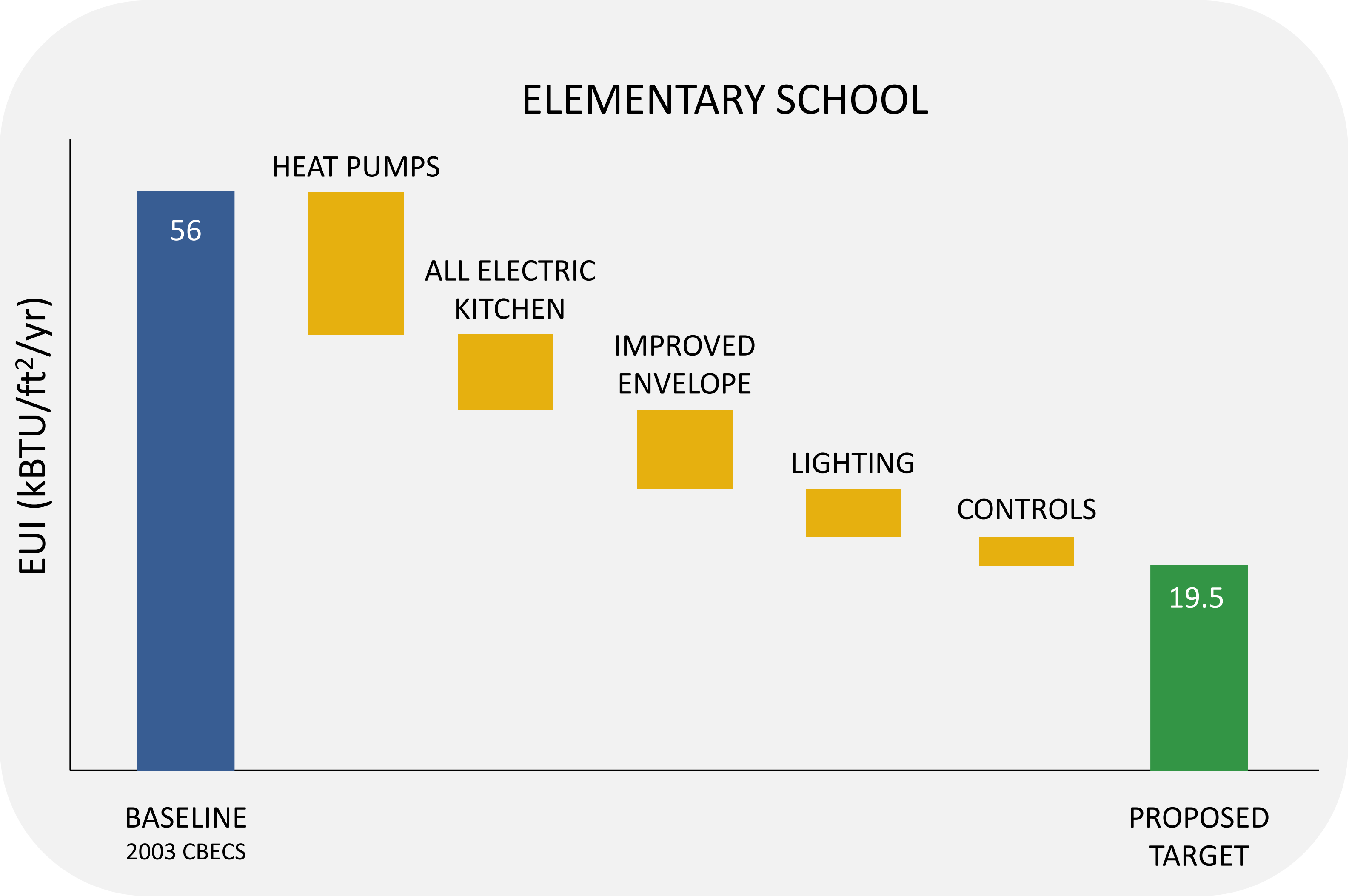
"A **'Net Zero (Whole Life) Carbon' Asset** is one where the **sum total of all asset related GHG emissions**, both operational and embodied, over an asset's life cycle (Modules A1-A5, B1-B7, C1-C4) **are minimized**, meet local carbon, energy and water targets, **and with residual 'offsets', equals zero**."
-Whole Life Carbon Network

Getting To Neutral

Getting to Carbon Neutral



1. Maximize Energy Efficiency



DESIGN STRATEGIES

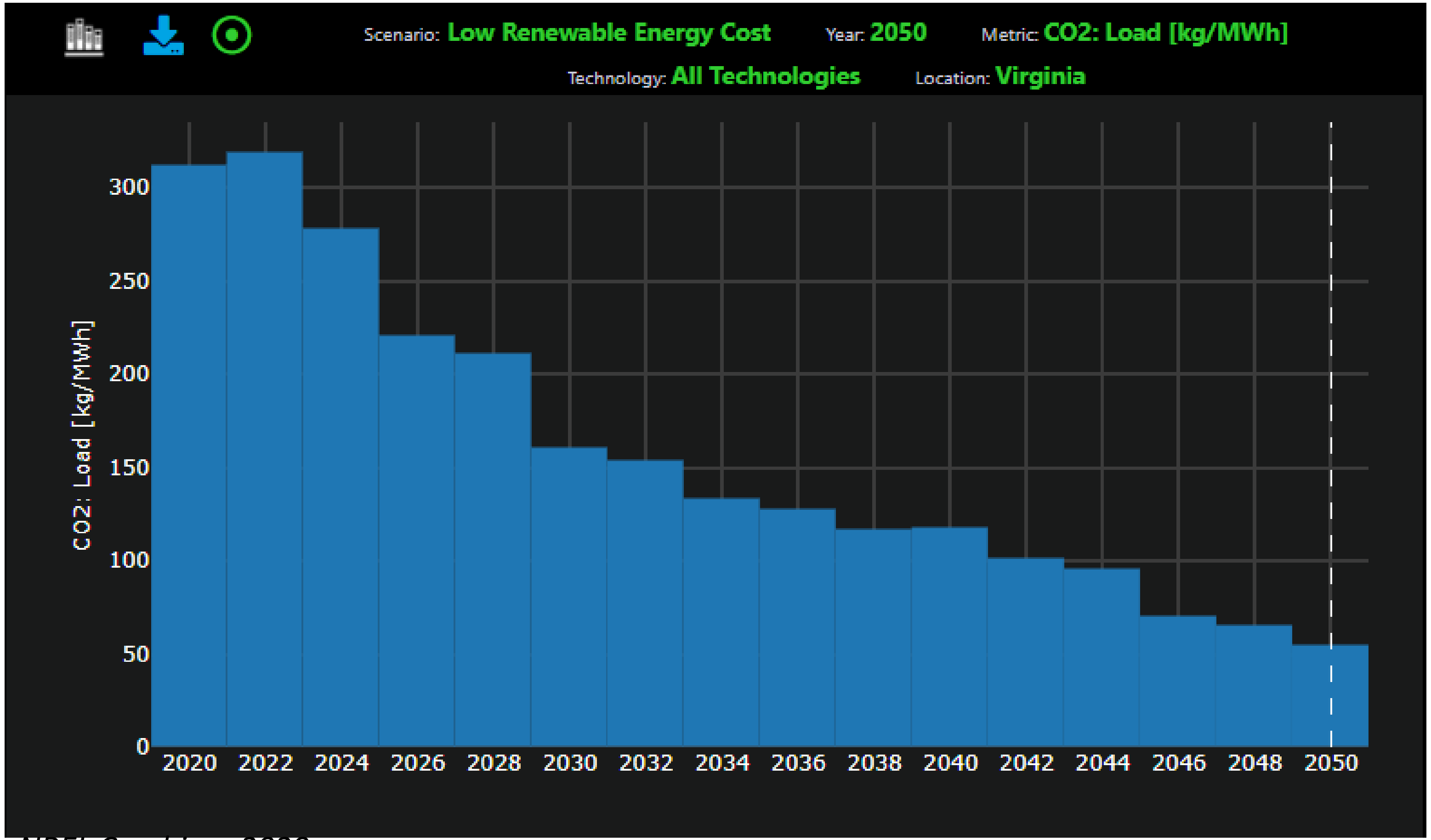
- Efficient HVAC Systems
- Improved Envelopes
- Energy Star Appliances
- LED Lighting
- Etc.

2. Eliminate Fossil Fuels

GRID CHANGES

- **“Electrification”**
- **Wind and solar** capacity estimated to **increase by 350-465% by 2030**
- Eliminating fossil fuels allows buildings to decarbonize with the grid

Grid Emissions Over Time (Predicted)



NREL Cambium 2020

3. Prioritize On-Site Renewables

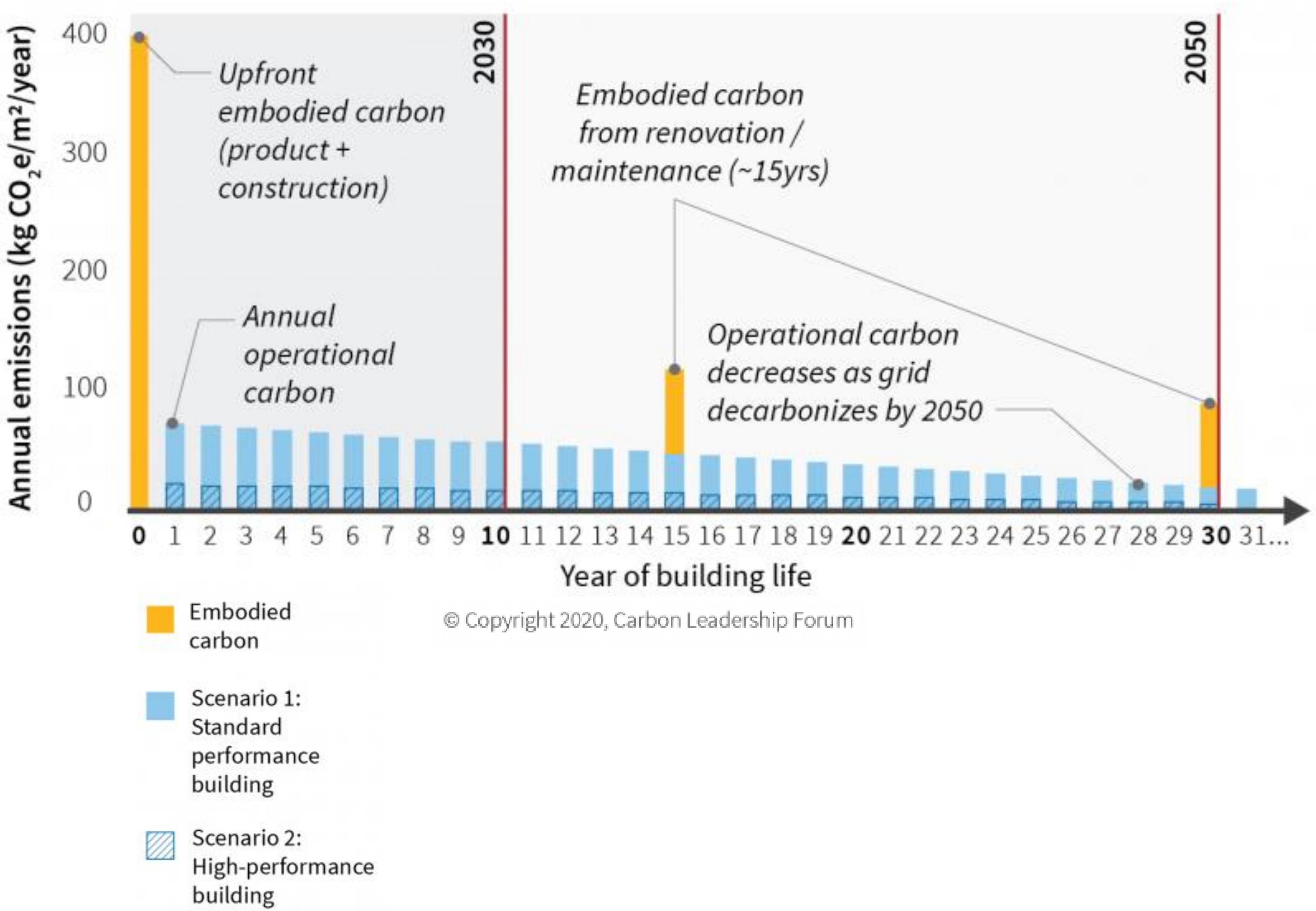
RENEWABLES

- **On-Site Solar**
  - Most likely to achieve true additionality
  - Multiple Installation Options:
    - Roof
    - Parking Structures
    - Ground Mount
    - Building Façade
- **Self-consume as much as possible**
- **Consider off-site if site limitations exist.**

4. Minimize Embodied Carbon

DESIGN STRATEGIES

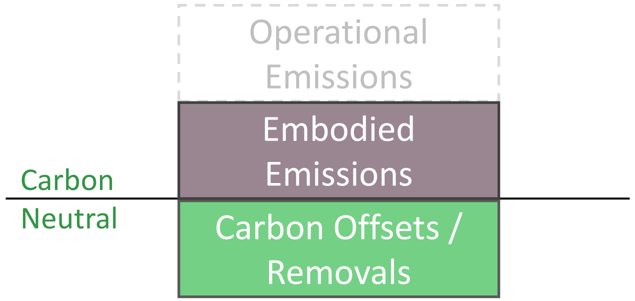
- Prioritize adaptive reuse
- Reduce and optimize building materials by utilizing EPDs and WBLCA Modeling Tools
- Minimize High GWP Refrigerants

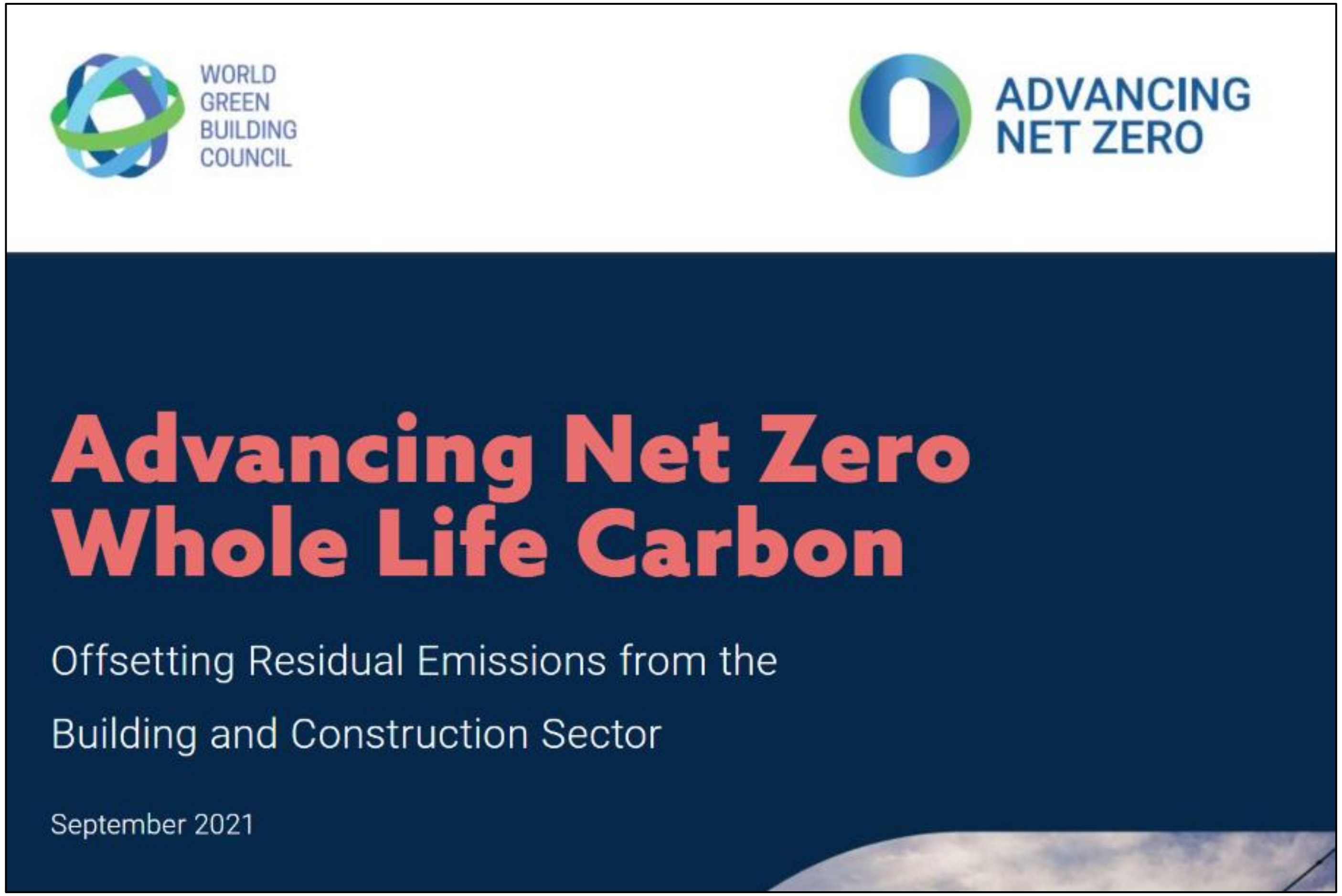


5. Whole Life Carbon and Offsets

Additional Considerations

- Consider the purchase of carbon offsets/removals to “neutralize” emissions from embodied and/or operational carbon





Big Idea

Can a historic building receive Historic Preservation status and simultaneously achieve Net Zero Energy and Carbon Neutrality?

Case Study

Pepper Construction, Cincinnati Office

Historic Preservation	25,000 SF Office	1912 Original Construction	Health and Wellness	Community	Drawdown at Pepper Climate Drawdown

Preliminary Goals

Drawdown at Pepper

5 Drawdown Solutions

- **Rooftop Solar**
- **Refrigerants**
- **Insulation**
- **Water Savings**
- **Carbon-Infused Concrete**

118
Drawdown Analyses completed

82,752
People living, learning, and working in healthier buildings from the four Drawdown solutions

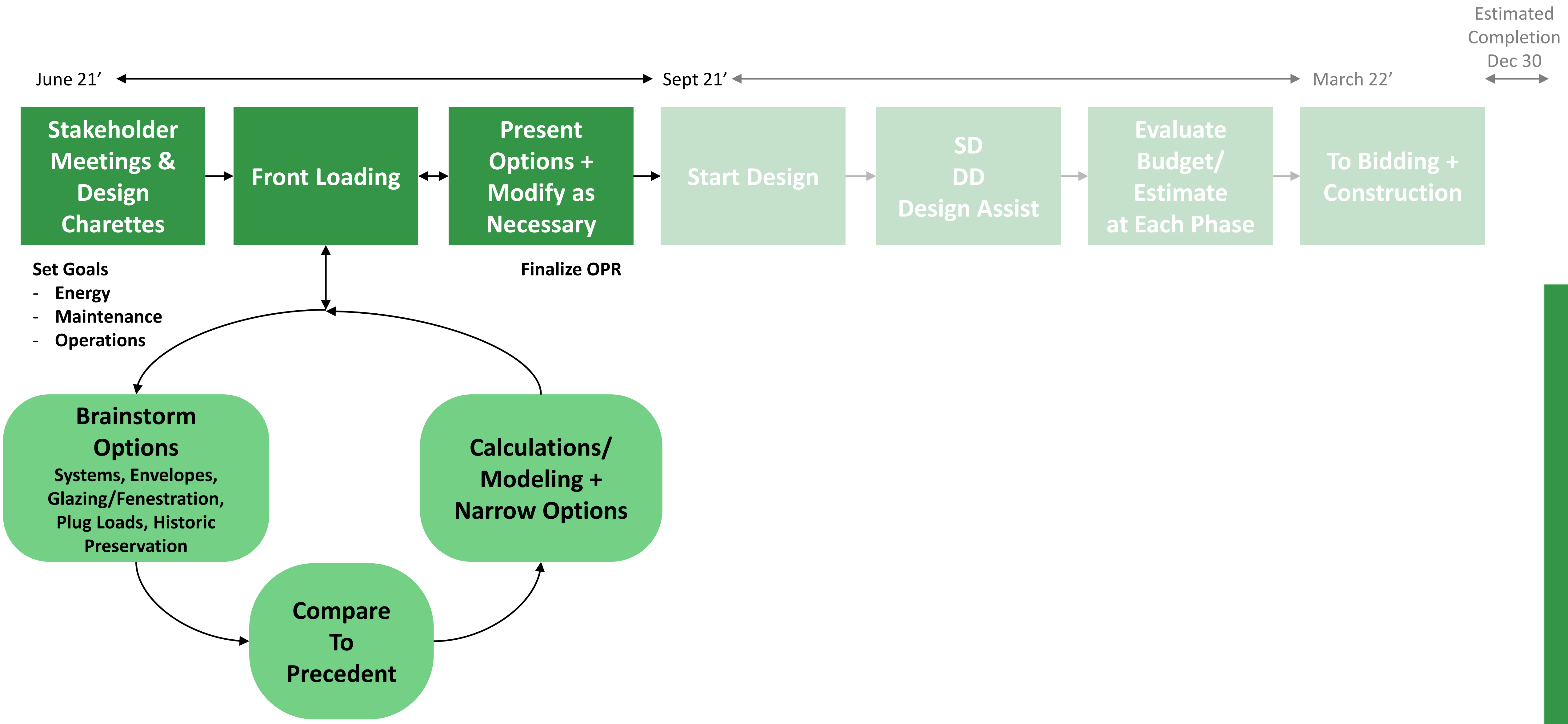
272,696
Tons of CO_2 that wasn't emitted into the atmosphere [equivalent to driving around the globe 24,850 times]

25,730,422
Gallons of water saved [enough water to fill 39 Olympic-sized pools]

85,926
MWh generated [enough solar electricity to power 12,359 homes for a year]

35,110,481
kBtu saved [enough natural gas and electricity to heat 385,125 homes for a year]

Project Timeline



Finalized OPR

OWNER PROJECT REQUIREMENTS

Pepper Construction
Tomorrow Transformed

Building Owner	Pepper Construction Cincinnati HQ		**Project #:**	032102
Building Address	5215			
Building Type	Office	**Climate Zone** 4A		
Building Size	25000 **SF**			
Construction Budg		**Occupant Load** 80		
Baseline EUI (ZeroTool)	85 **kBTU/SF/YR**			
Target EUI	30 **kBTU/SF/YR**			

DESIGN TEAM - Targets and Goals

ENERGY PERFORMANCE

Baseline EUI		**85**	kBTU/sf/yr
PREDICTED EUI	**65%**	**30**	kBTU/sf/yr
2030 Challenge	**80%**	**17**	kBTU/sf/yr

Note: values in Green are highest performing EUI targets

EMBODIED CARBON PERFORMANCE

Baseline CO2e		**434**	kg $CO2e/m^2$
PREDICTED CO2e	**45%**	**238.70**	kg $CO2e/m^2$
Stretch CO2e	65%	151.90	kg $CO2e/m^2$
ILFI Zero Carbon		< 500	kg $CO2e/m^2$

BUILDING ENCLOSURE PERFORMANCE

Component	Minimum Performance	Lead	Commission
Roof	**R-35 / U-0.0286**	Arch	Met: ____
Wall	Tuckpoint Existing	Cont	Met: ____
Windows	**U-0.35**	Arch	Met: ____
Infiltration	**< 0.15 CFM_{75}/ft^2**	Arch	Met: ____
Air Barrier	**> 30 perm vapor diffusion**	Arch	Met: ____

PROJECT REQs

- Energy Intensity
- Embodied Carbon
- Envelope Performance
- Air Quality
- Light
- Sound
- Certifications
- Historic Preservation
- Budget
- Etc.

Project Timeline

June 21' ⟷ Sept 21' ⟷ March 22' ⟷ Estimated Completion Dec 30

Stakeholder Meetings & Design Charettes → Front Loading ⟷ Present Options + Modify as Necessary → Start Design → SD DD Design Assist → Evaluate Budget/ Estimate at Each Phase → To Bidding + Construction

Set Goals

- **Energy**
- **Maintenance**
- **Operations**

Finalize OPR

Brainstorm Options
Systems, Envelopes, Glazing/Fenestration, Plug Loads, Historic Preservation

Calculations/ Modeling + Narrow Options

Compare To Precedent

Big Picture Steps

1 Maximize energy efficiency and reduce demand

2 Eliminate fossil fuels (Electrify)

3 Provide renewable energy that achieves additionality

4 Limit upfront embodied carbon

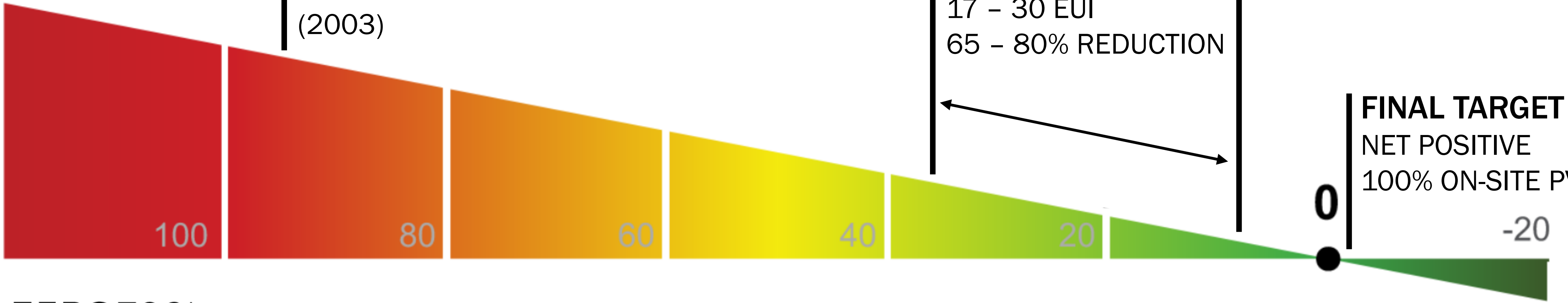
5 Consider Whole Life Carbon and Offsets

Maximize Energy Efficiency

BASELINE
85 EUI
OFFICE BUILDING
(2003)

TARGET BEFORE PV
17 – 30 EUI
65 – 80% REDUCTION

FINAL TARGET
NET POSITIVE
100% ON-SITE PV



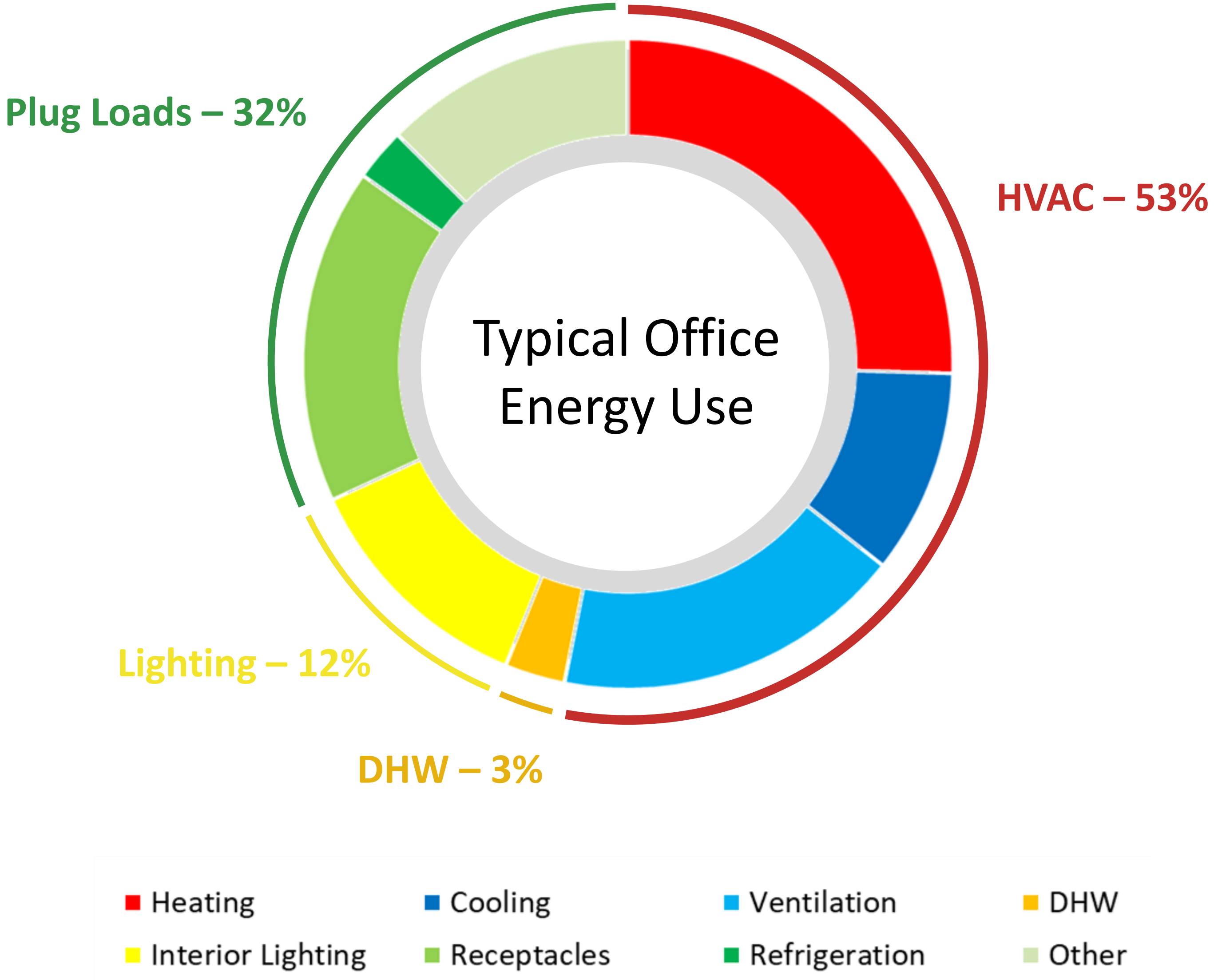
ZEROTOOL

Maximize Energy Efficiency

Identifying ECMs

- **Load Reduction**
  - Improved Existing Envelope
  - High Performance HVAC
  - Office Equipment
  - LED Lighting and Daylighting

- **Constraints**
  - SHPO Requirements
  - Existing Structure/Envelope
  - Costs

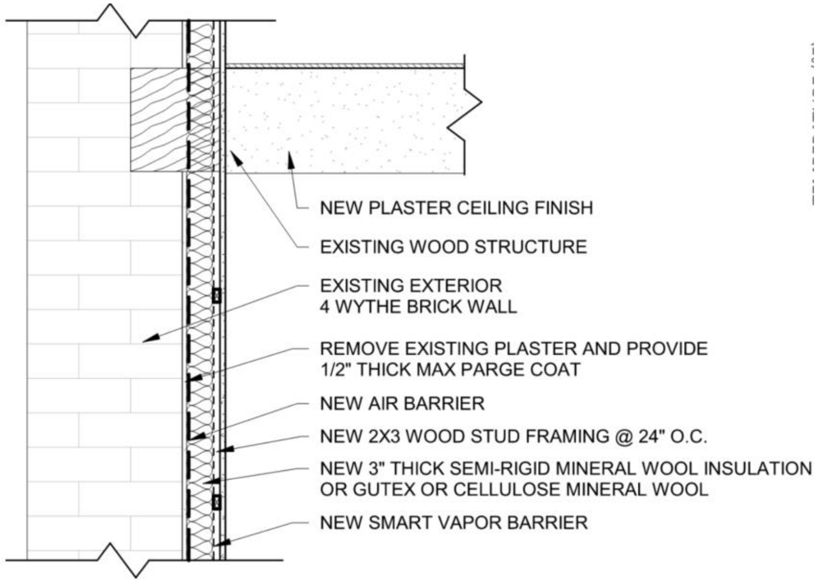


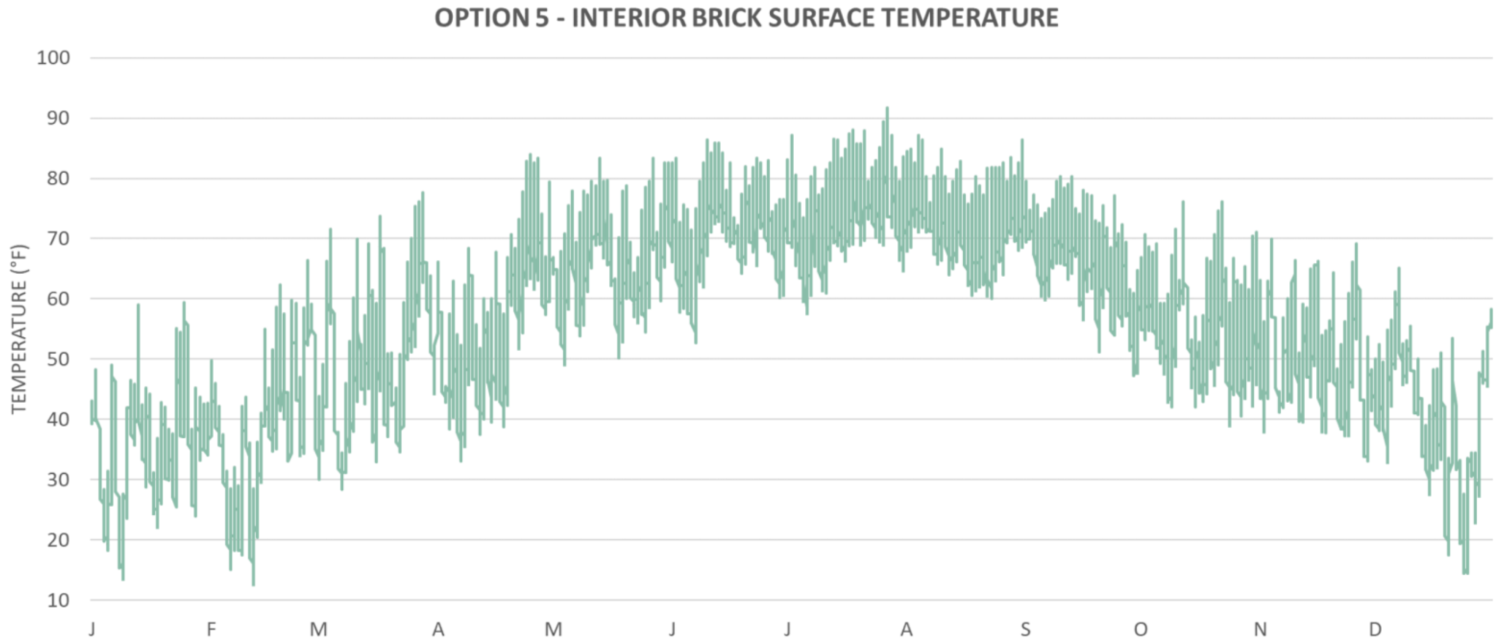
Maximize Energy Efficiency

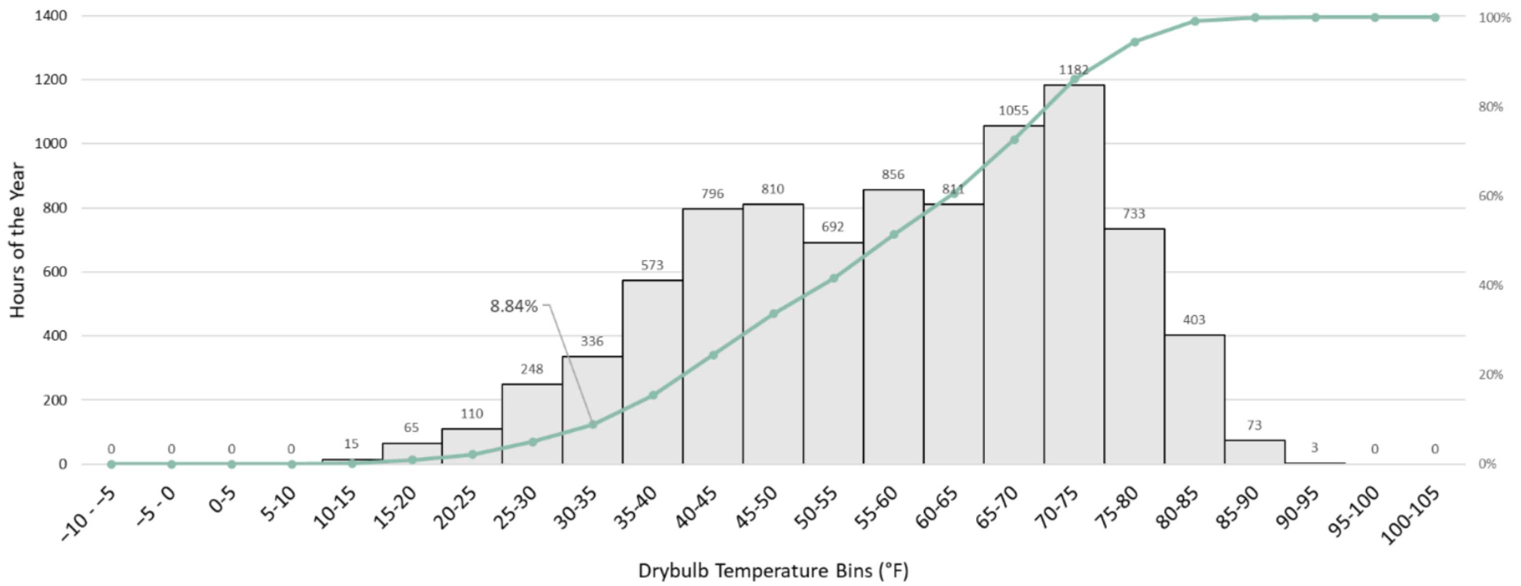
Envelope Selection

Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Repair Only	High Performance Lime Plaster	Air Barrier, No Insulation	Air Barrier, Insulation, Smart Vapor Barrier	Air Barrier, Insulation, Smart Vapor Barrier	No Air Barrier, Insulation	Air Barrier, Insulation

Maximize Energy Efficiency







Option 5

- Interior Insulation
- Air-Sealing Using Liquid Applied Air Barrier

Maximize Energy Efficiency

Option 3

Air Barrier, No Insulation

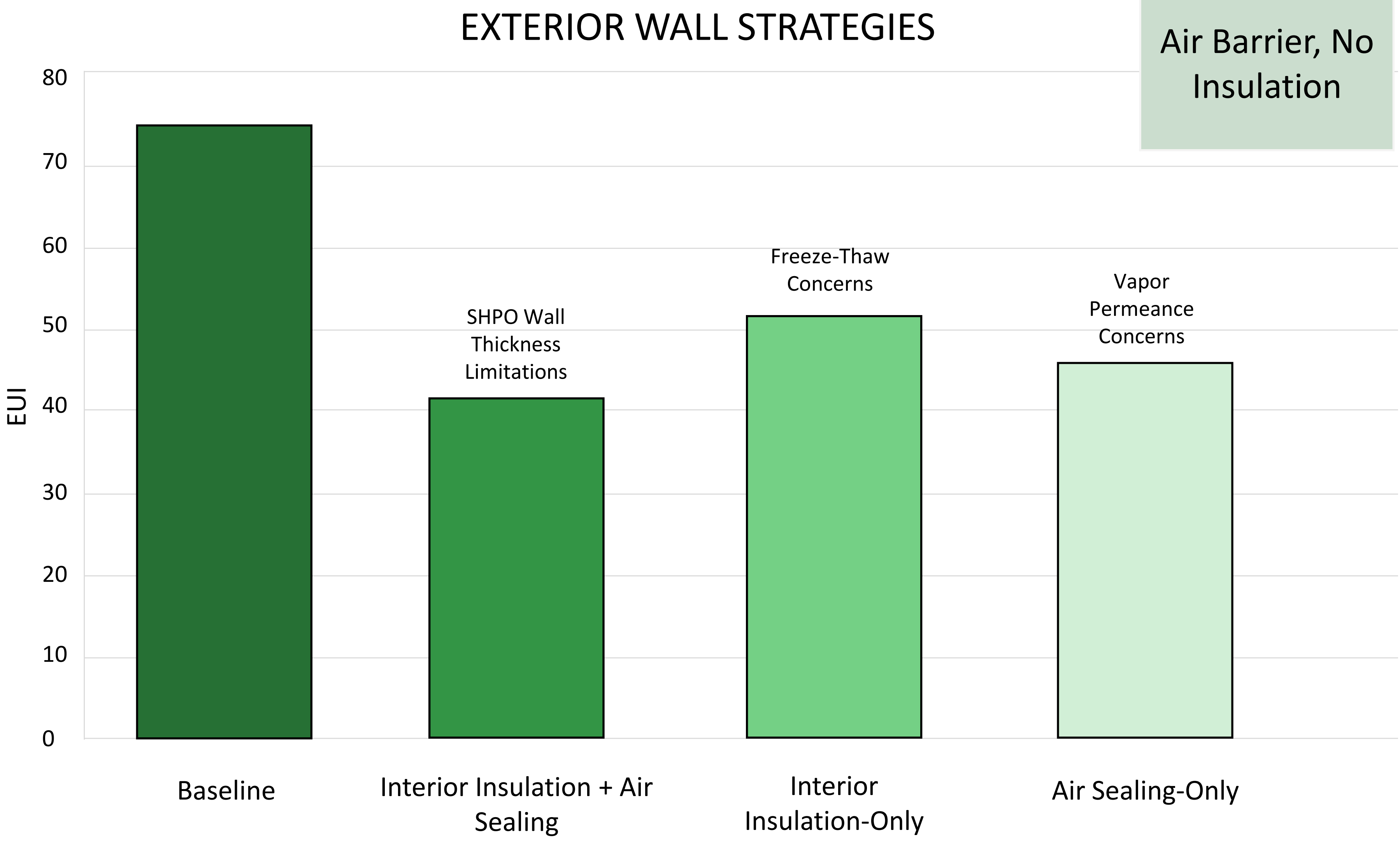
ENVELOPE

Effective **Wall** R-Value: R-5.5

Target **Infiltration** Rate = 0.27 CFM/SF @75Pa

Effective **Roof** R-Value: R-35

Interior Storm Windows



Maximize Energy Efficiency

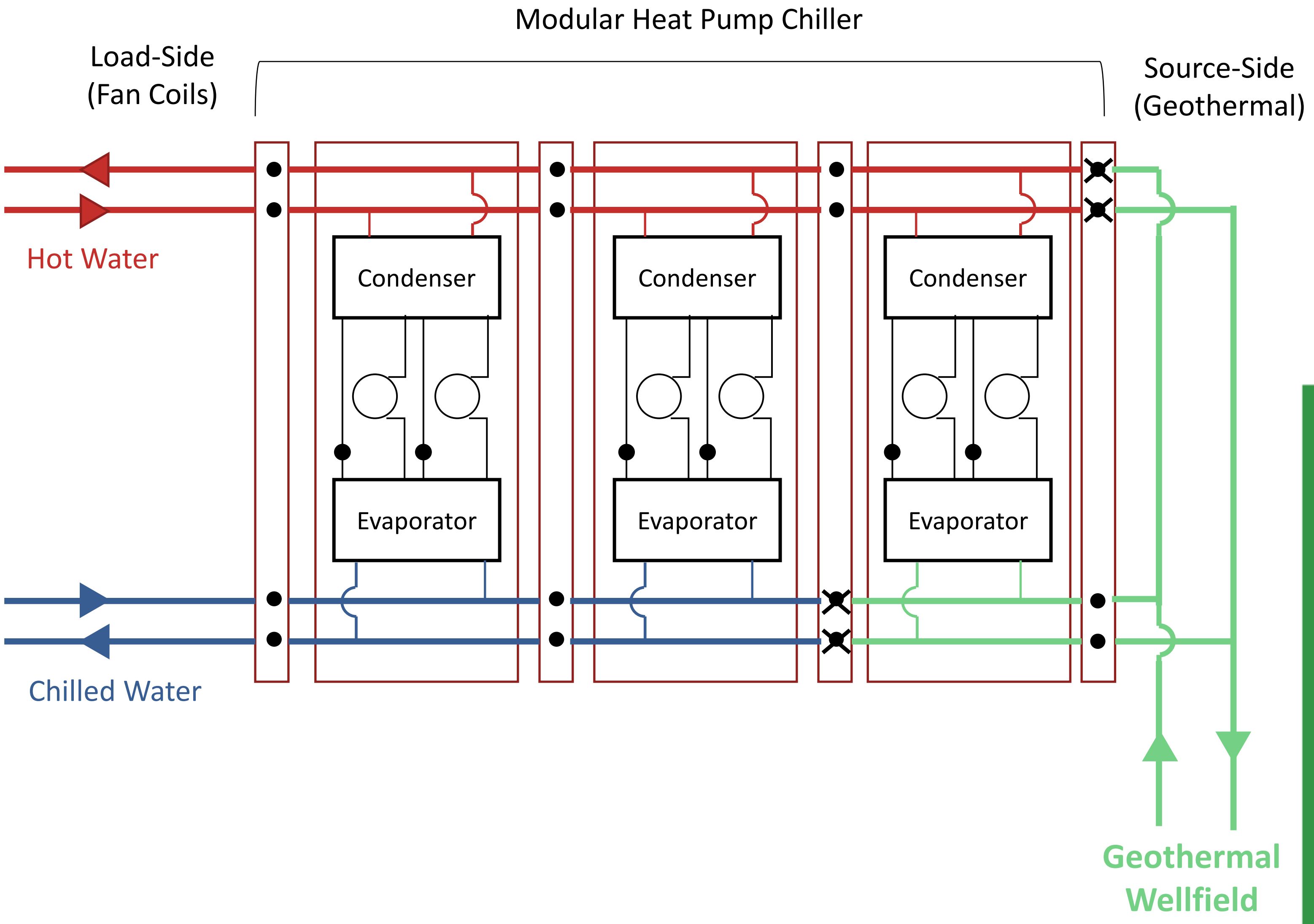
HVAC Selection

	Geothermal Water Cooled VRV/VRF	Geothermal Heat Recovery Chiller W/Fan Coils
$/S.F. Includes Geothermal Well Field Cost	$56/Square Foot = $1,341,078	$61/Square Foot = $1,461,078
Replacement Cycle	15 – 20-year replacement of entire system including refrigerant piping.	20 – 25-year replacement of Chiller. 30 – 40-year replacement of fan coils. Infrastructure remains in place.
15/20 Year LCA	$1,618,000/$3,050,650	$1,728,000/$1,916,500
Refrigerant Volume Based on 40 Tons	284 lbs. of Refrigerant	Factory Sealed Refrigerant System. 48 lbs. of Refrigerant

Maximize Energy Efficiency

HVAC SELECTION

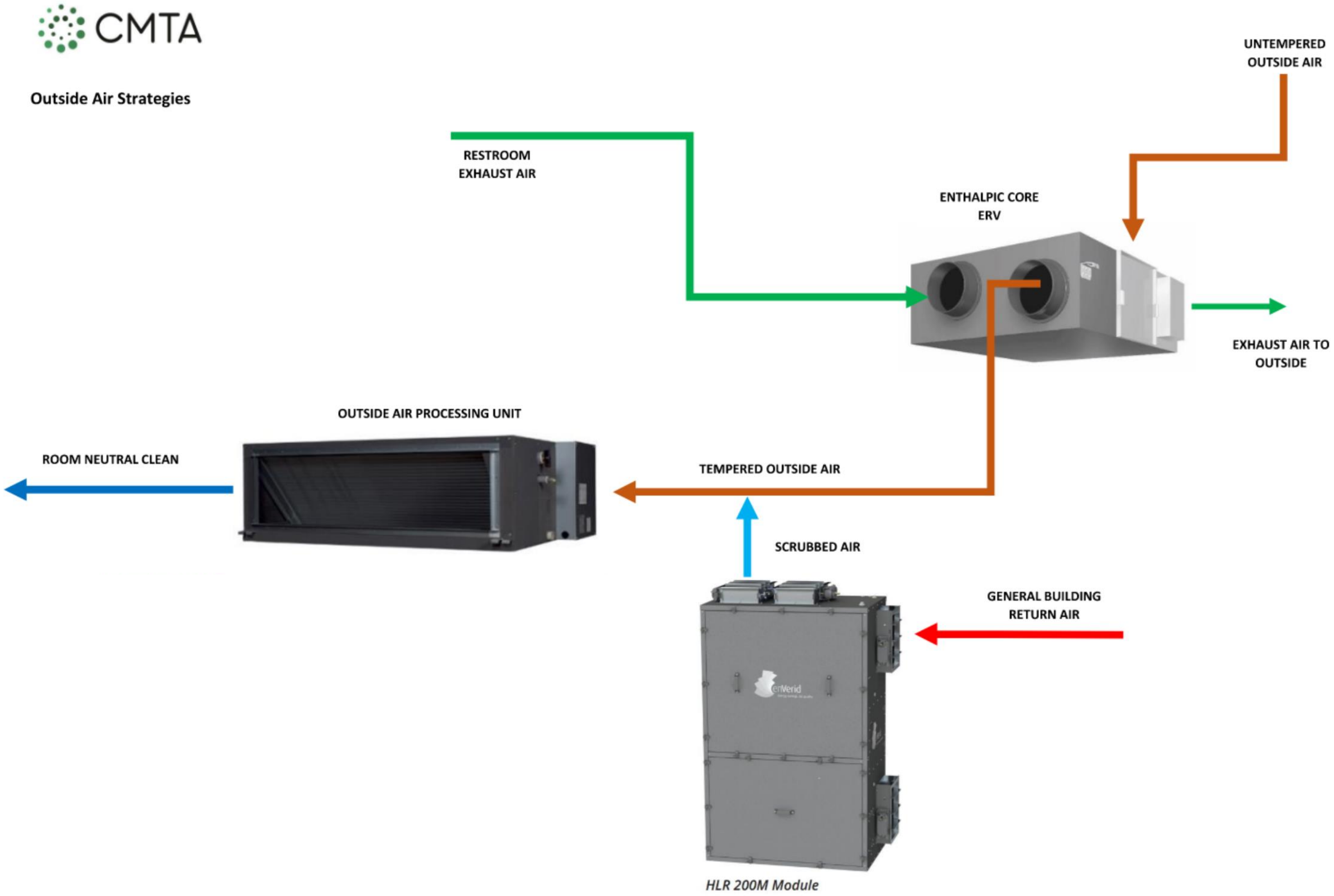
- **Heat Pump Chiller + Fan Coils**



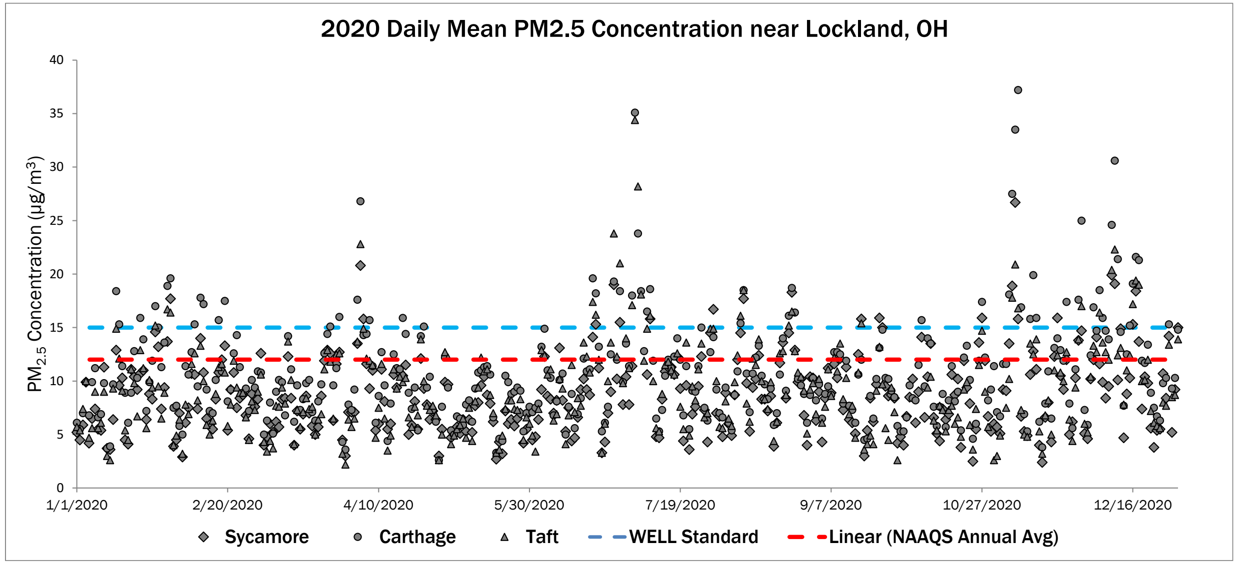
Maximize Energy Efficiency

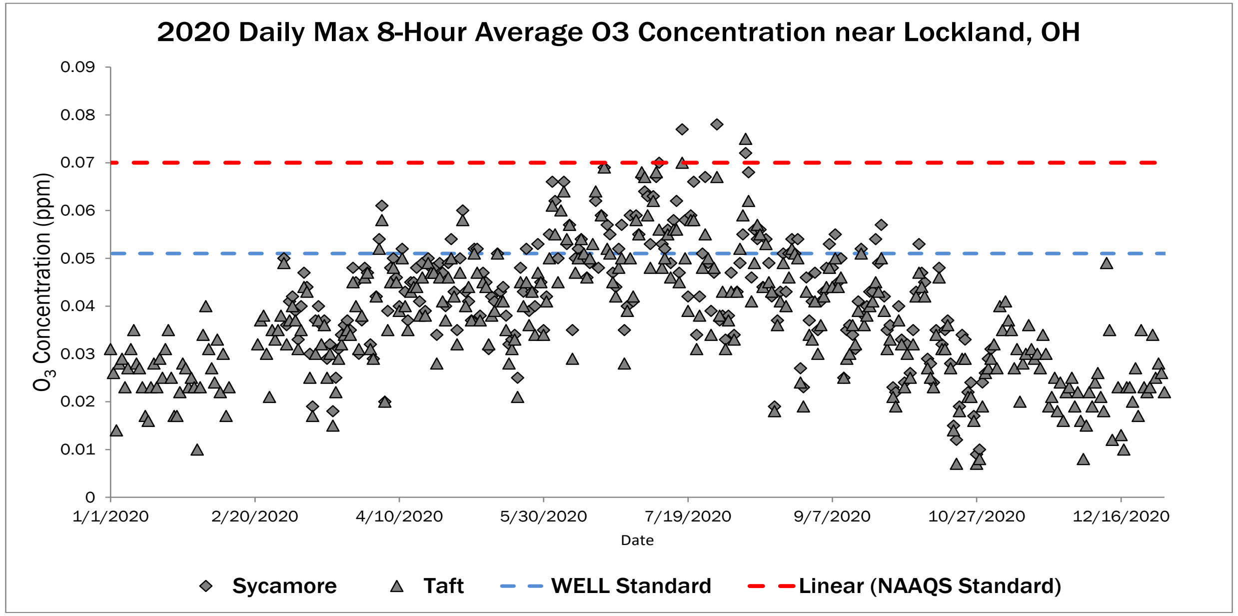
HVAC SELECTION

- **Heat Pump Chiller + Fan Coils**
- **Ventilation Air Conditioning**
  - Enverid
  - Energy Recovery
  - IAQ Monitoring
  - MERV-13



Maximize Energy Efficiency

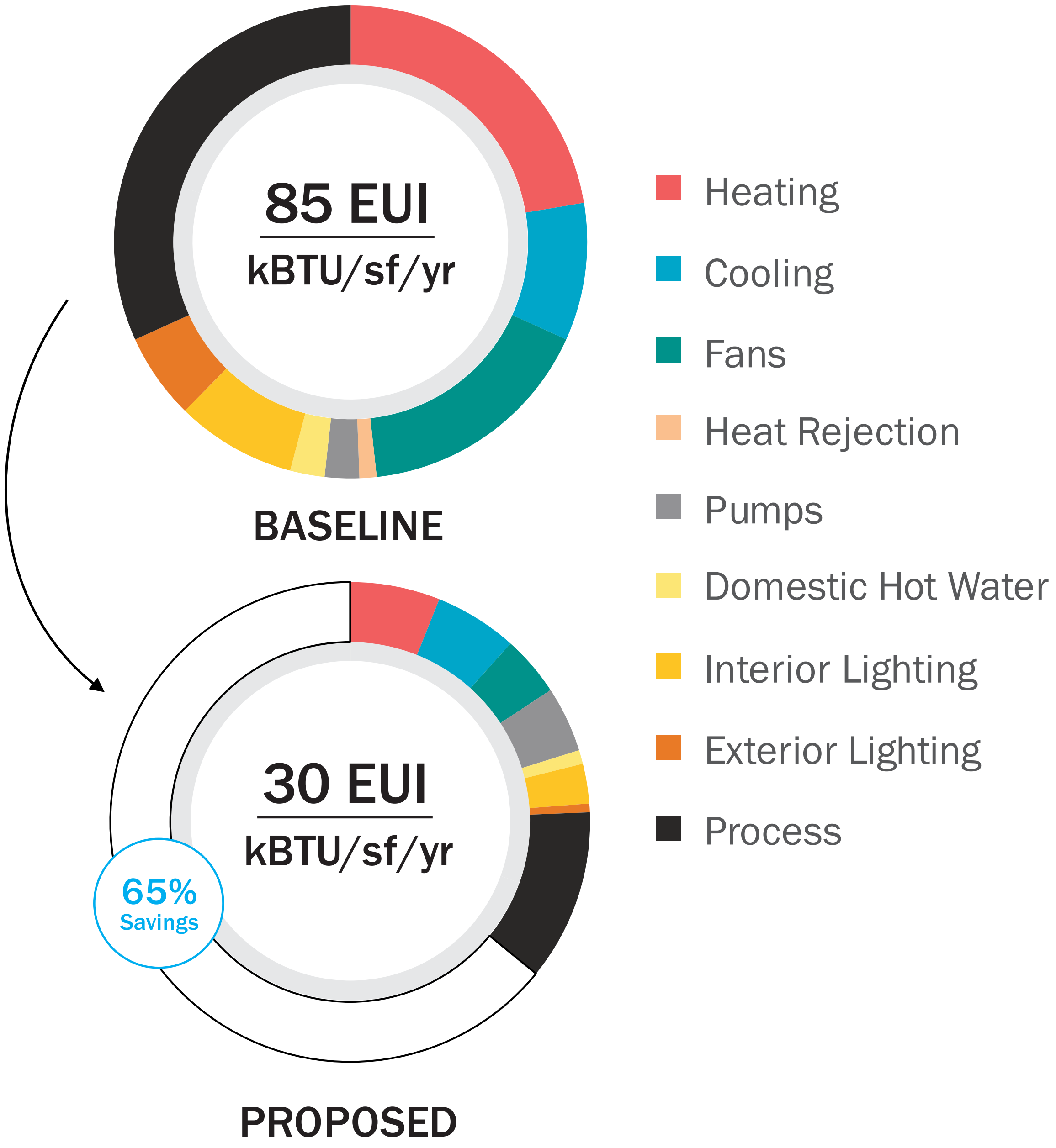




Maximize Energy Efficiency

Additional Efficiency Measures

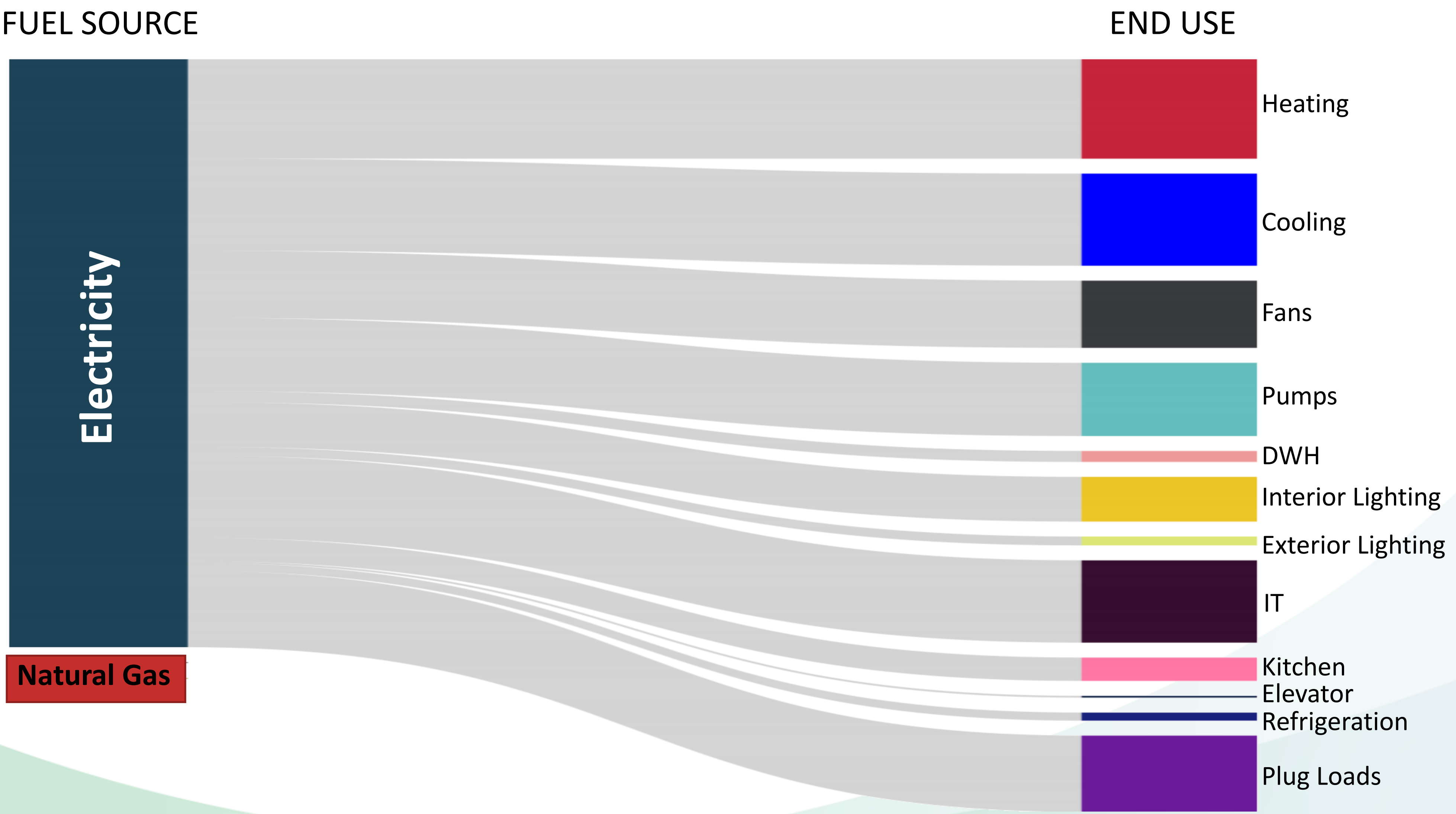
- **Lighting:**
  - 0.35 W/sf
  - Interior and Exterior Lighting Controls
- **Plug Loads:**
  - Laptop Docking Stations
  - Energy Star Appliances
  - No bevi Machines
- **DHW**
  - Low Flow Fixtures
  - Heat Pump DWH Heaters



Eliminate Fossil Fuels

No fossil fuels combusted on-site

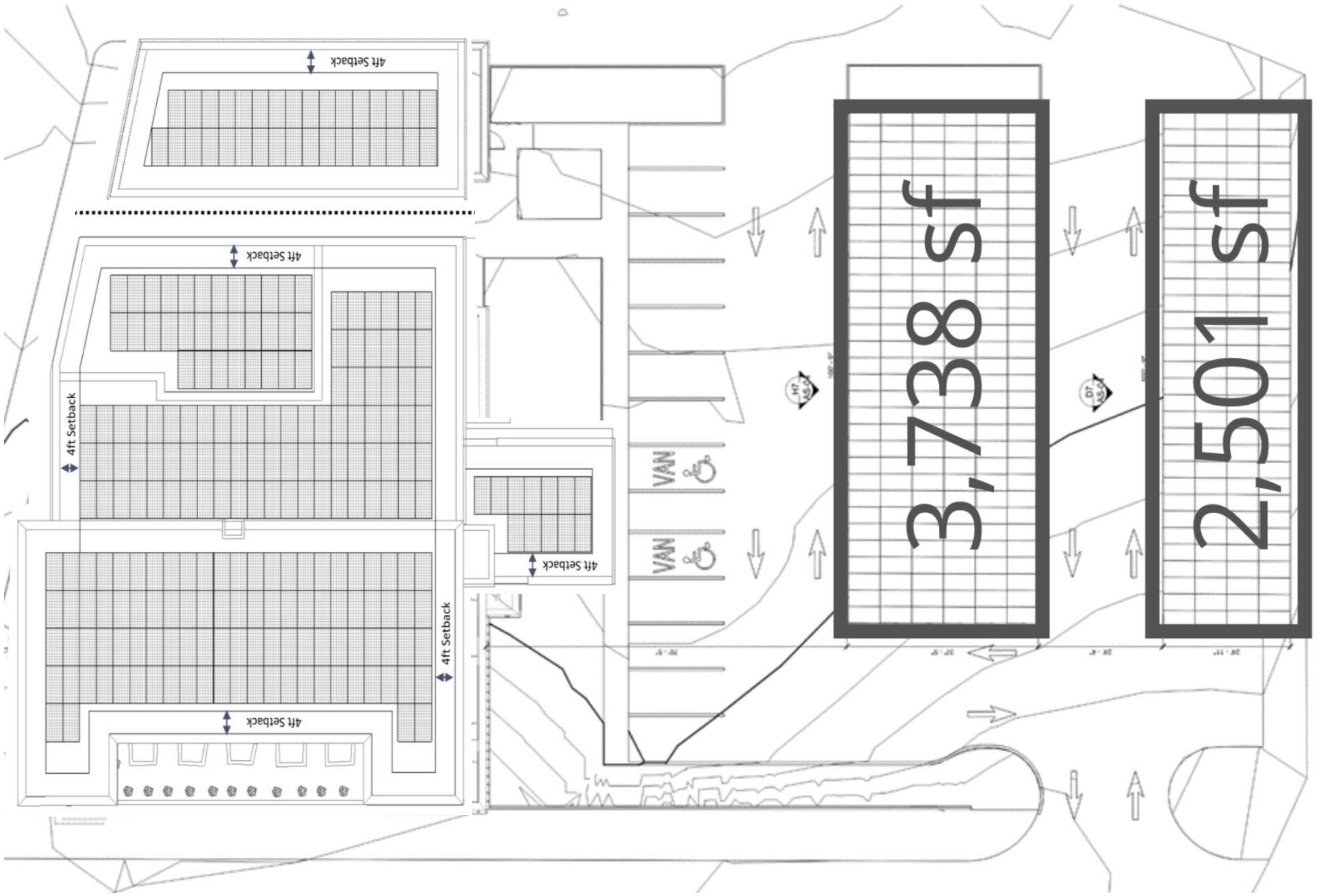
- Geothermal Heat Pumps
- DHW Heat Pumps
- All-Electric Appliances



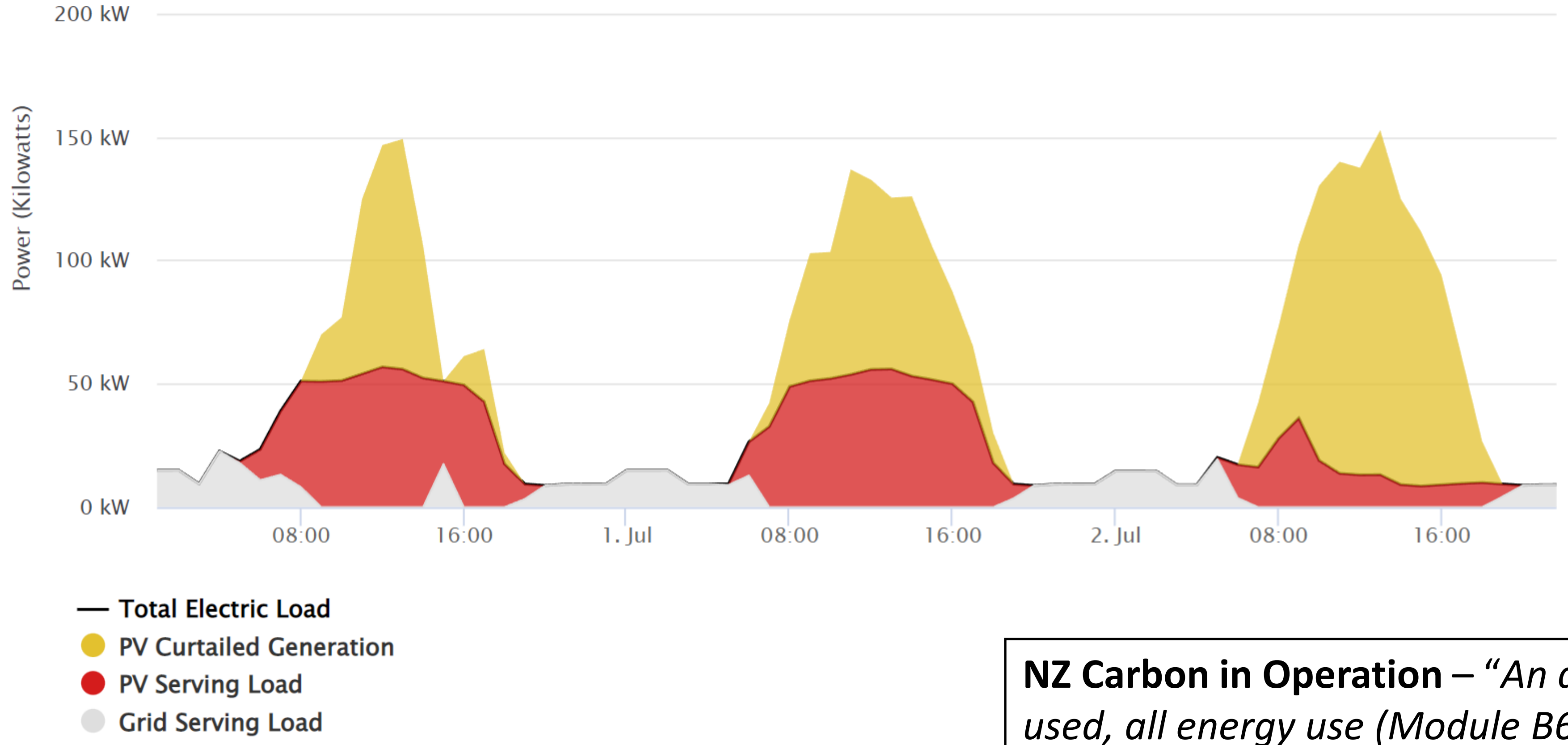
Prioritize On-Site Renewables

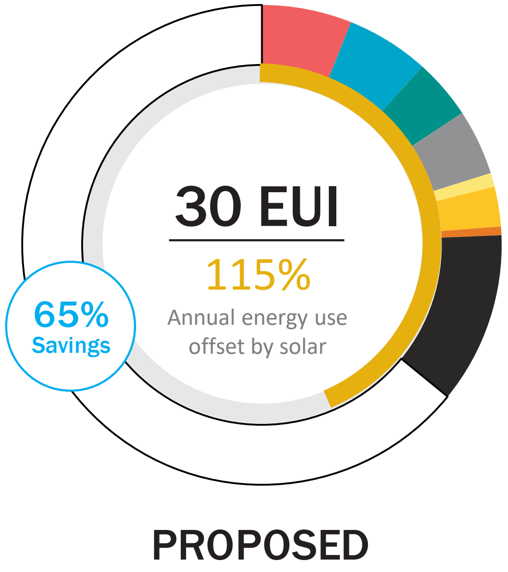
Solar Array

- DC Capacity = 214.5 kW
- AC Capacity = 200 kW
- Annual Production = 250,000 kWh
- Net Positive Energy



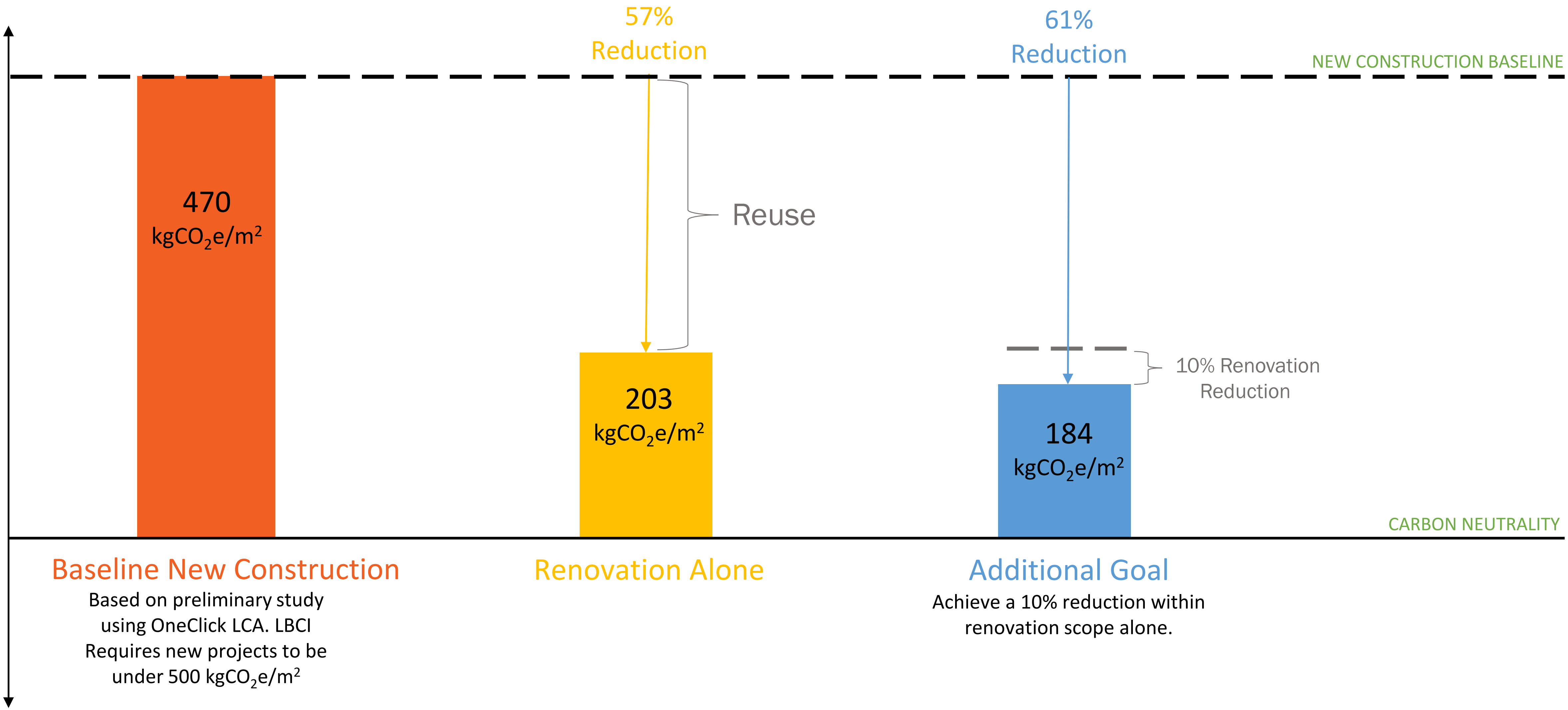
Prioritize On-Site Renewables





NZ Carbon in Operation – *"An asset where no fossil fuels are used, all energy use (Module B6) has been minimized and meets the local energy use target, and all energy use is generated on- or off-site using renewables that represent additionality"*
- WLCN, LETI, RIBA

Minimize Embodied Carbon



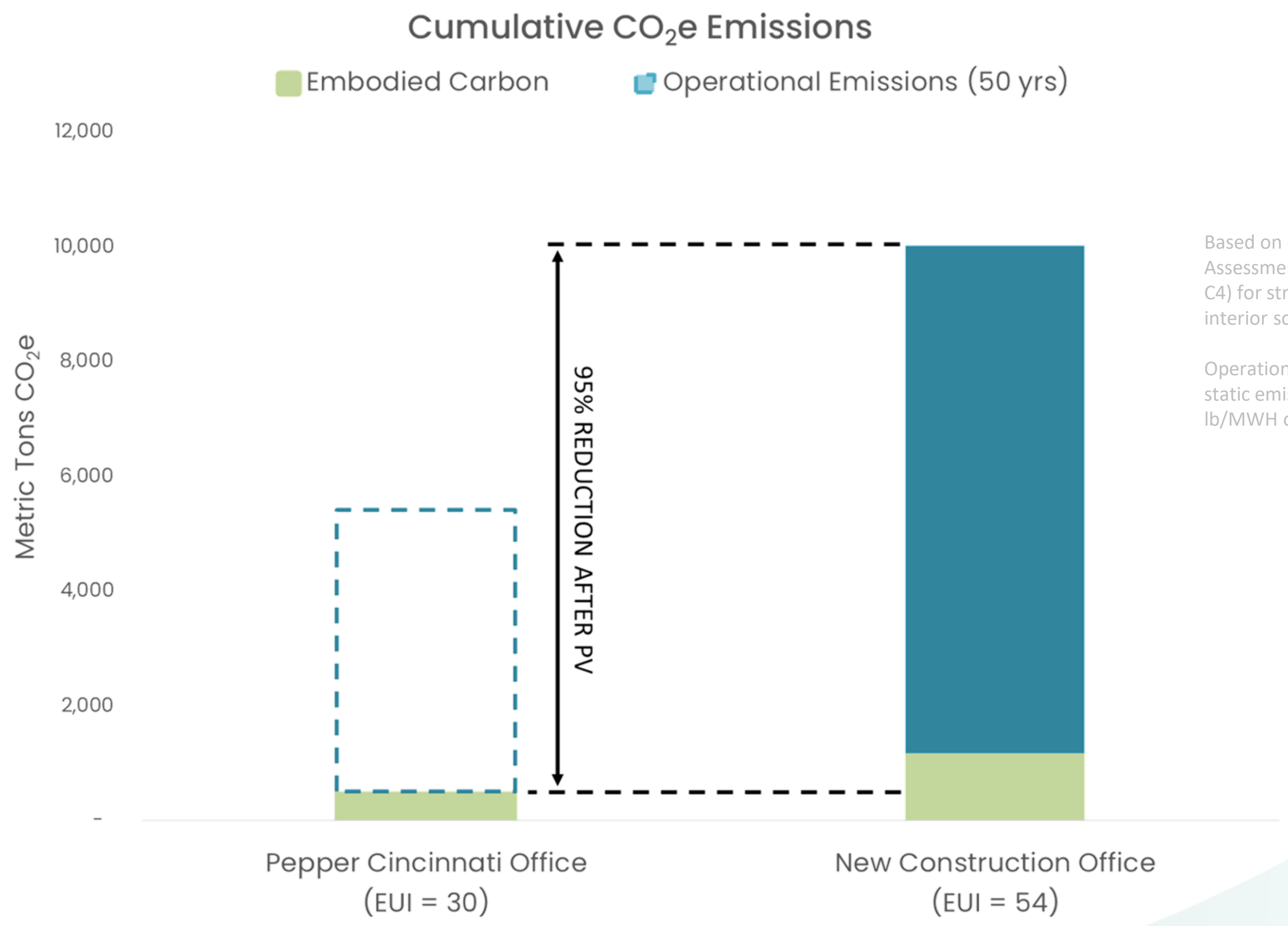
Based on early-stage Life Cycle Assessments (A1-A5, B1-B5, C1-C4) for structure, enclosure, and interior scopes.

Carbon Comparison

Equivalent Emissions

1,197 US Homes
Over One Year

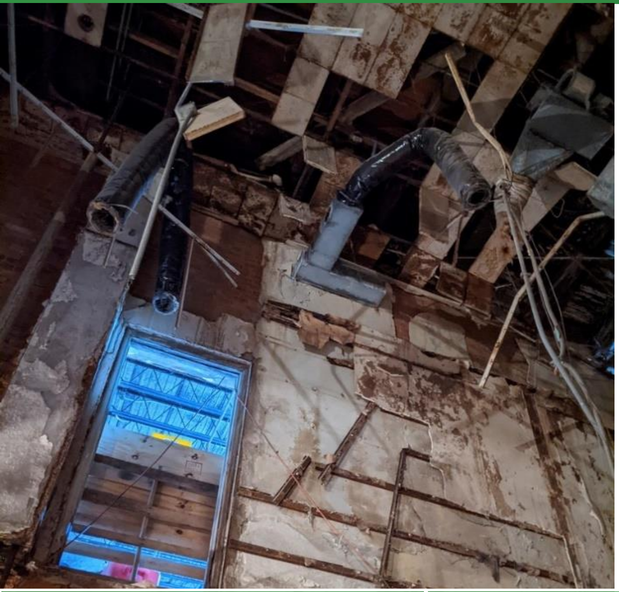
2,048 Vehicles
Driven for a Year



Based on early-stage Life Cycle Assessments (A1-A5, B1-B5, C1-C4) for structure, enclosure, and interior scopes.

Operational emissions based on a static emissions factor of 985 lb/MWH of electricity consumed.

Pepper Construction, Cincinnati Office



30
Designed EUI

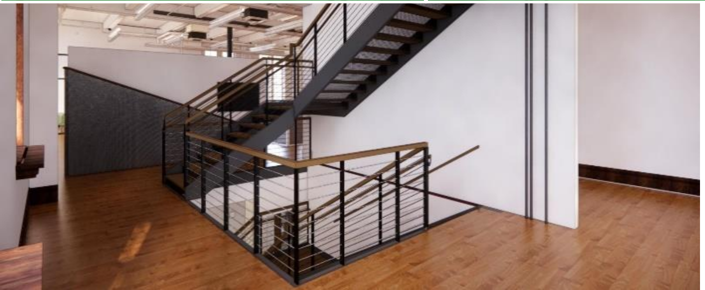
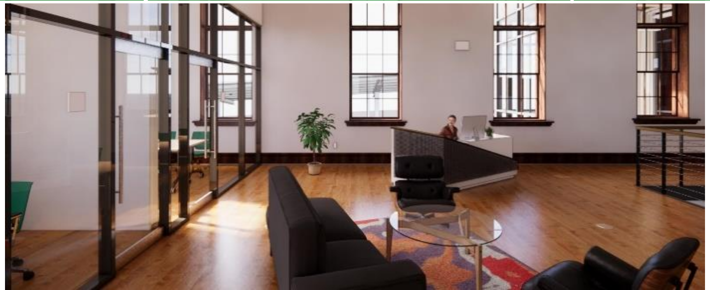
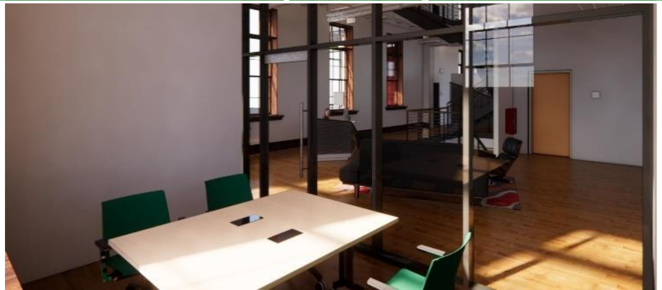
WELL Silver

LEED Gold

Net Zero Energy

Net Zero Carbon Operations

Carbon Neutral ??


THANK YOU

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