

# **BUILDINGENERGY BOSTON**

---

## **Pushing the Glass Envelope: A BERDO 2.0 Compliance Pathway for a High Performance Building**

**Samira Ahmadi (enviENERGY Studio)**

**Peter Zmuidzinas (Elkus Manfredi Architects)**

**Sean Anderson (MassMutual)**

**Curated by Shari Rauls and Tammy Ngo**

---

**Northeast Sustainable Energy Association (NESEA)**

**March 29, 2023**

# Learning Objectives

1. Recognize how to create opportunities for creating an innovative building design from aggressive performance goals.
2. Organize an integrative design process that engages owners and tenants in a collaborative and iterative process of optimizing high performance solutions.
3. Evaluate predictive energy models, actual data, and assess future opportunities to improve performance and meet future code requirements.
4. Understand challenges facing recently opened new buildings that will need to decarbonize in the near future.

# Presenters



**Peter Zmuidzinas**

AIA, LEED AP

Vice President

**Elkus Manfredi Architects**



**Samira Ahmadi**

BEMP, LEED AP, WELL AP

Founding Principal

**enviENERGY Studio**



**Sean Anderson**

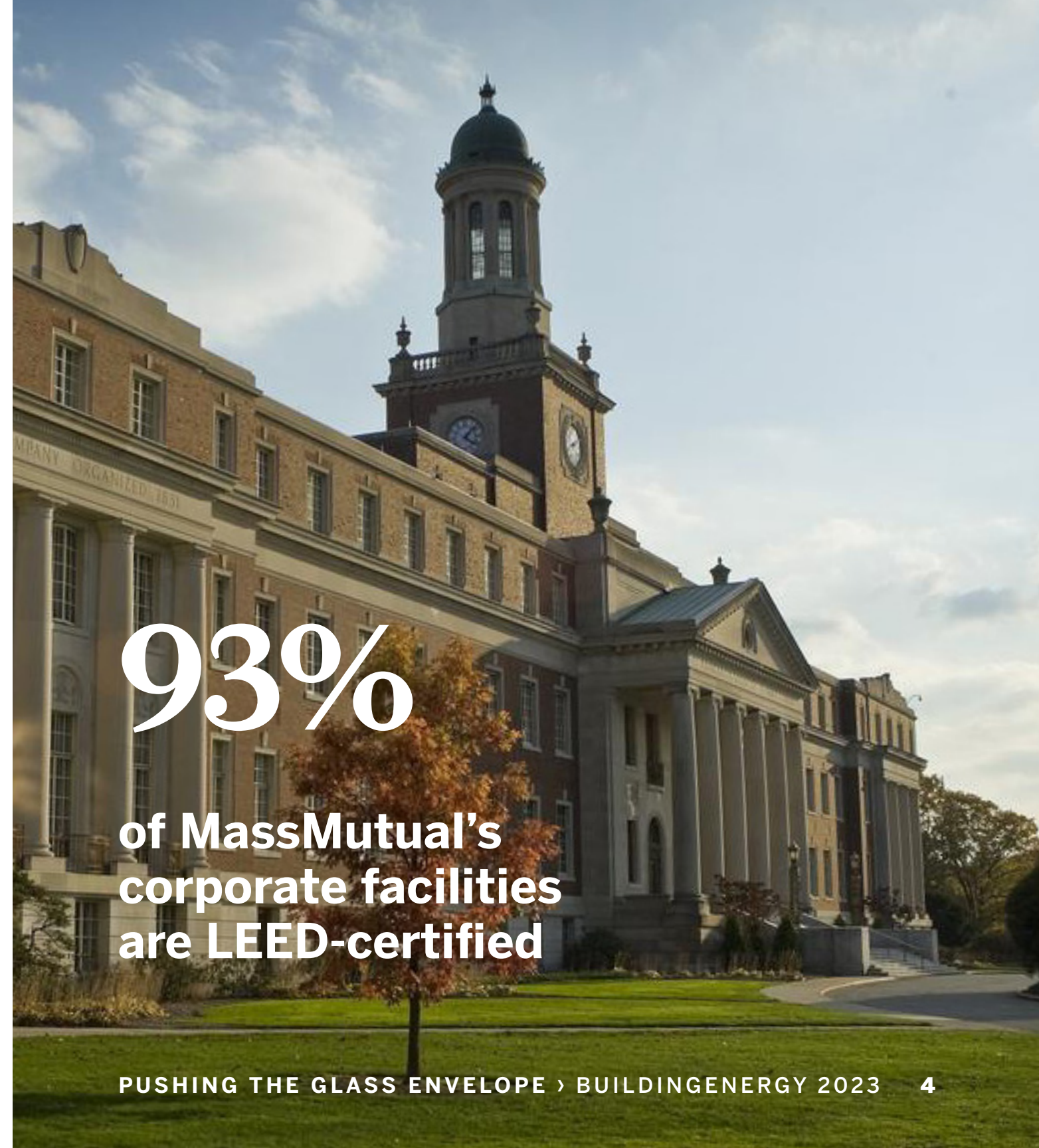
Head of Corp Real Estate

**MassMutual Financial Group**

# MassMutual

## SUSTAINABILITY AND MUTUALITY

- › **Mutually held** since founding in 1851
- › MassMutual's guiding principle is the notion of **living mutual** — that the world is better when we look out for one another
- › **Environmental stewardship** is a critical strategic priority
- › MassMutual is committed to creating a **diverse, equitable, and inclusive workplace**



93%

of MassMutual's  
corporate facilities  
are LEED-certified

# 10 Fan Pier

- › **Location**, Location, Location....
- › Equitable and **healthy environment** for employees
- › Energy efficiency and **stewardship**

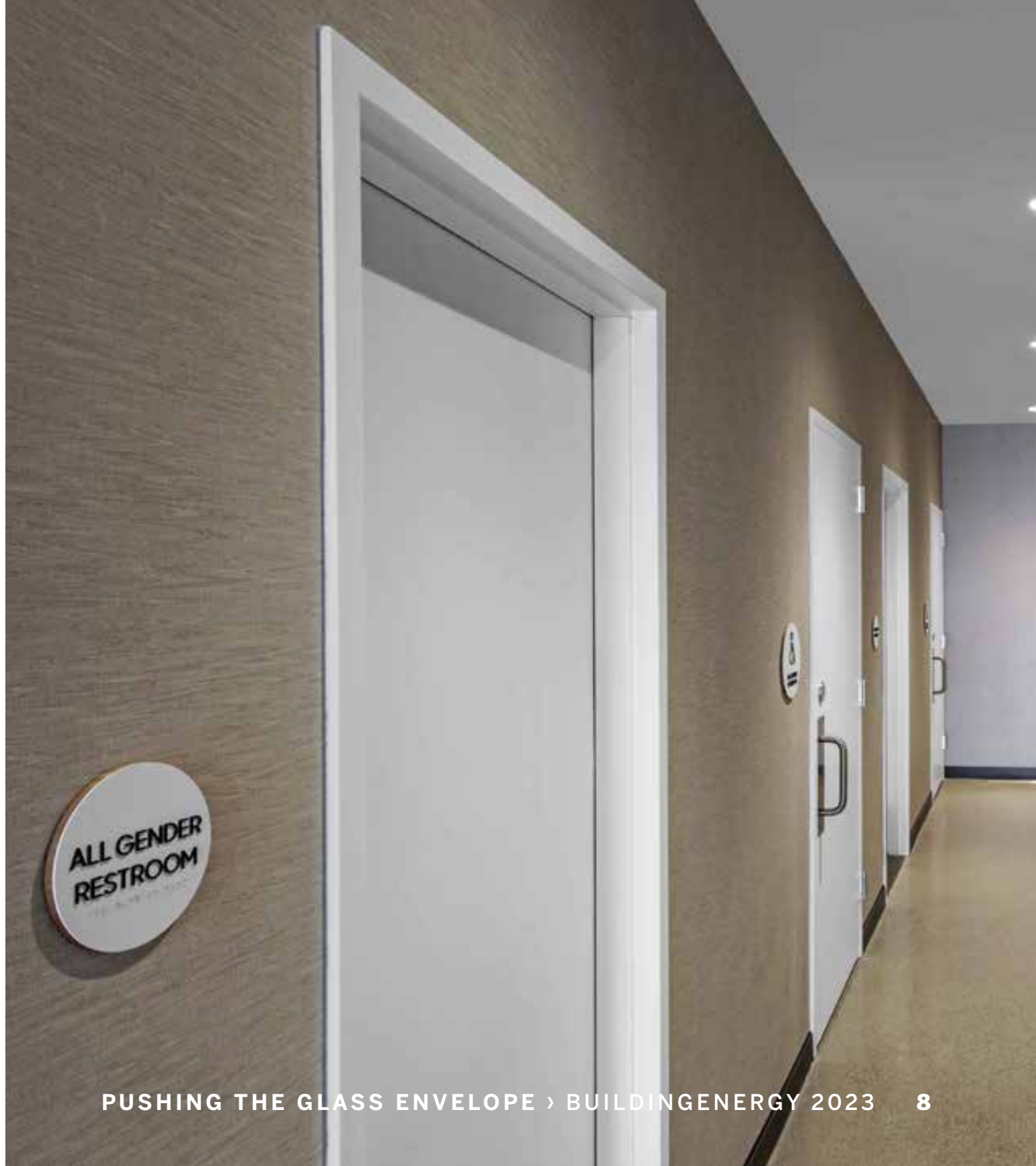


# 10 Fan Pier

- › 1.35 acres in the Seaport
- › 17 Stories
- › 345,000 GSF Office
- › Biophilic design
- › LEEDv4 CS Platinum



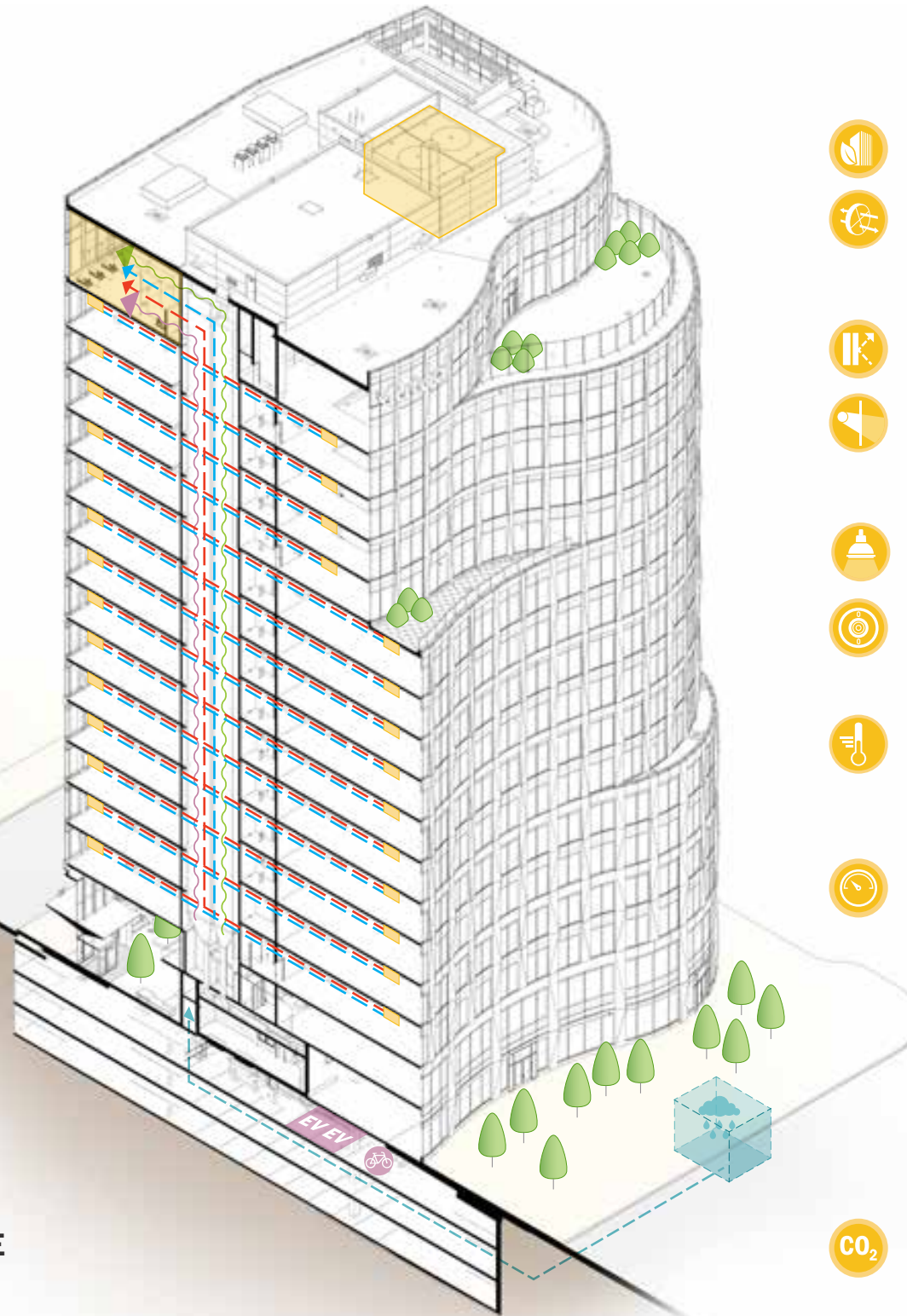











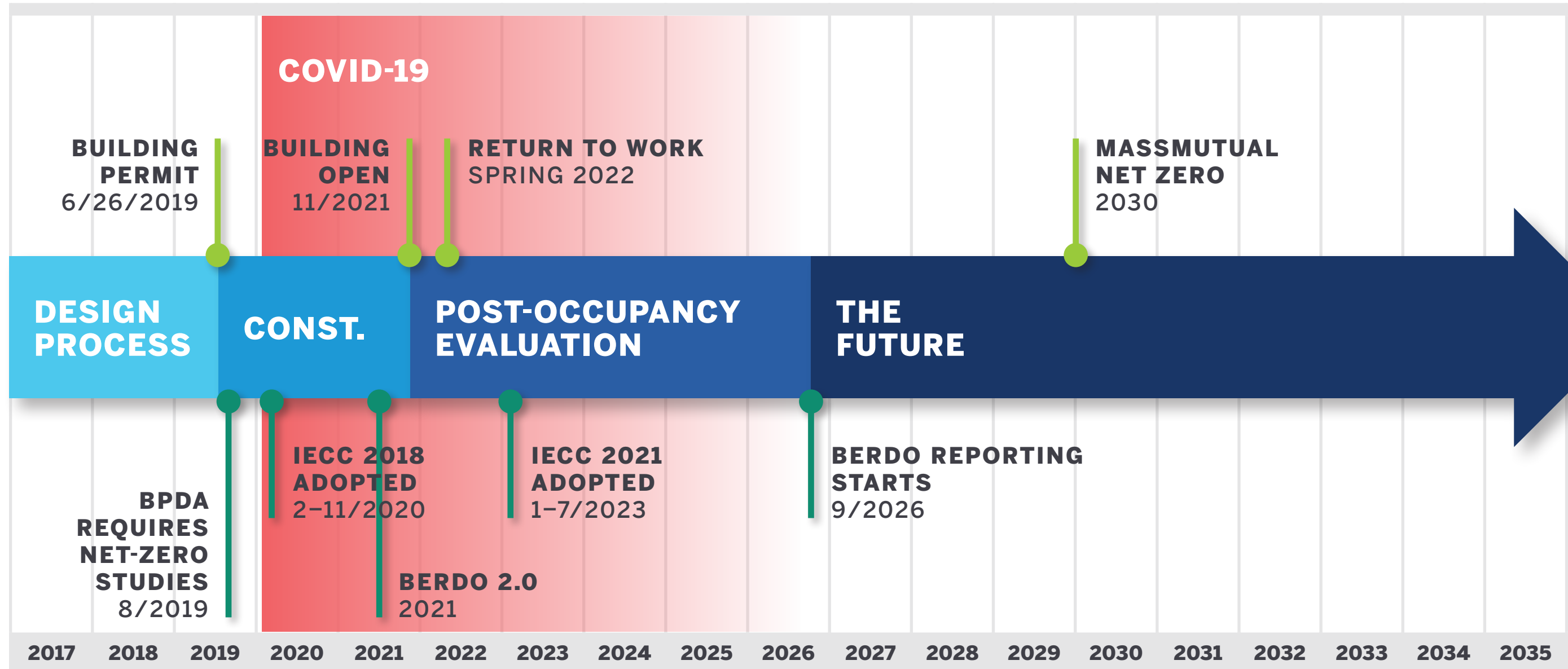
# LEED v4 CS Platinum

-  RESILIENCY
-  RAINWATER HARVESTING
-  HEALTHY INTERIOR AIR QUALITY
-  BIOPHILIC DESIGN
-  CONSTRUCTION WASTE
-  SOIL REMEDIATION
-  HIGHLY URBAN LOCATION
-  BICYCLE FACILITIES
-  ELECTRIC VEHICLE CHARGING



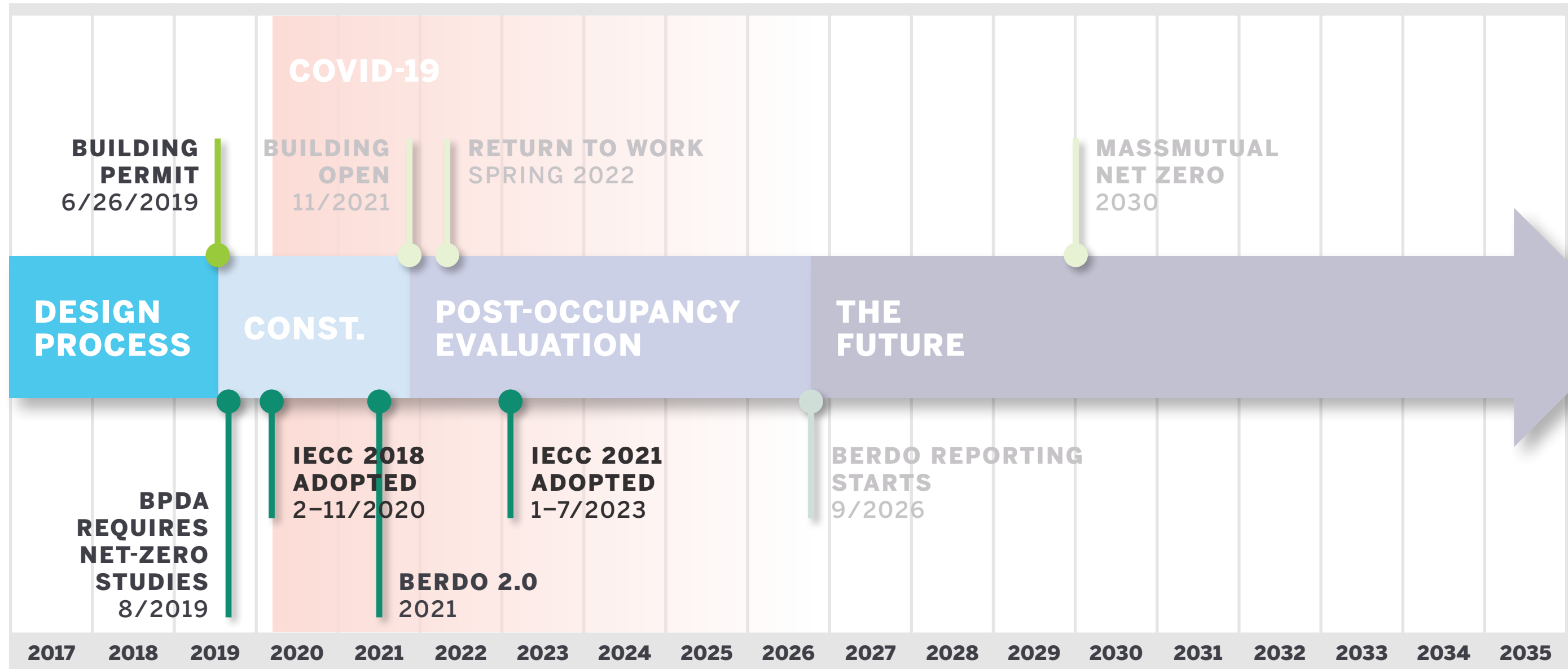
-  ENERGY PERFORMANCE
-  HIGH PERFORMANCE ENVELOPE
-  100% LED LIGHTING
-  REFRIGERATION MANAGEMENT
-  MONITORING OF MAJOR ENERGY SOURCES
-  CO<sub>2</sub> GREENHOUSE GAS

# MassMutual Timeline



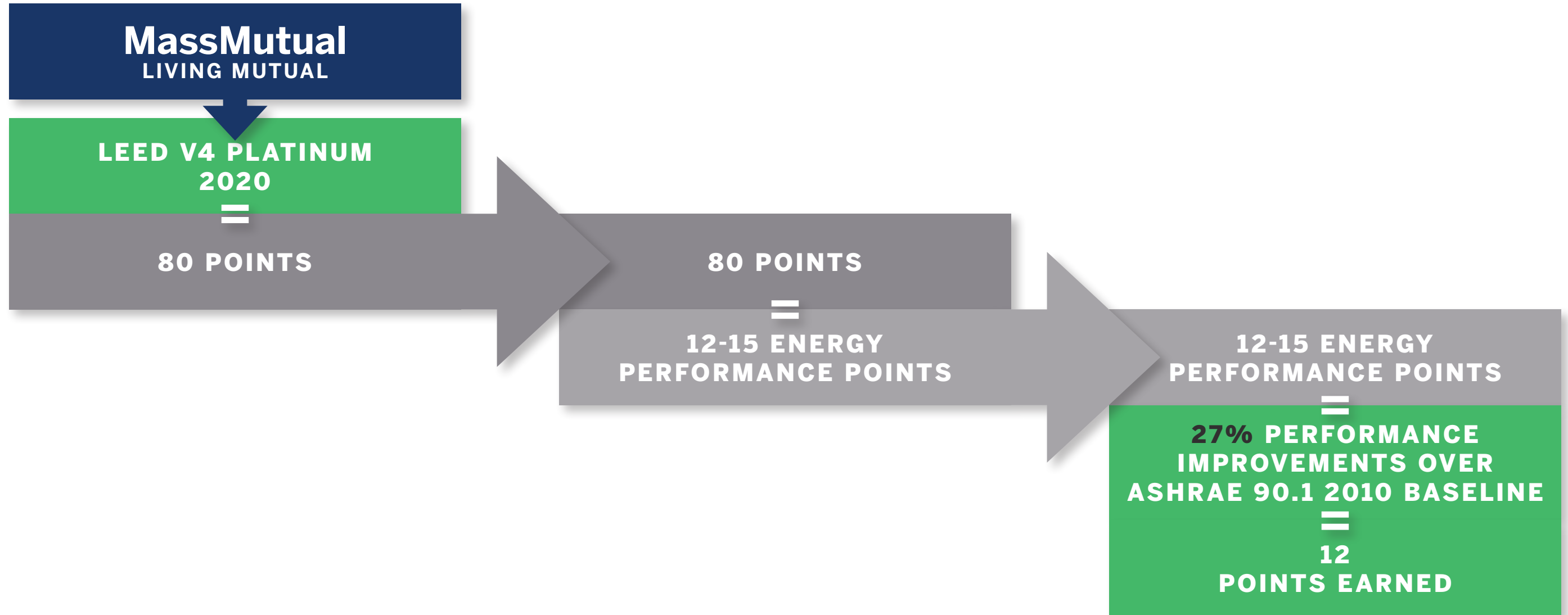
# Design Process

## TIMELINE



# Design Process

## IDENTIFYING ENERGY PERFORMANCE GOALS



# Design Process

## ITERATIVE PROCESS

- › Used LEEDv4 **Integrative Process Credit**
- › Conceptual design in 2017: prior to **BPDA requiring net-zero studies**
- › **Stretch Code:** 30% improvement over ASHRAE 90.1 2013 baseline
- › Early **iterative** simple-box modeling to test a range of combinations
- › **Market informed** set of considerations

FAN PIER E  
ELUIS MANFREDI ARCHITECTS  
MARCH 16, 2018  
PLATINUM EVALUATION

EXTERIOR ENVELOPE ALTERNATES		ENERGY PERFORMANCE MATRIX			
LEED V4 ASHRAE		BASELINE/BASELINE			
0	BASELINE VISION GLASS: RATIO 40% SHGC 0.40 U/R VALUES 0.40 VISION: 0.45 OPAQUE WALL: 0.40 ROOF: 0.055 OTHER: 20	STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>N/A</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>N/A</b>			
1A	40% Window Wall Ratio VISION GLASS: RATIO 40% SHGC 0.36 U/R VALUES 0.45 VISION: 0.45 OPAQUE: (R-20 c.i.) 0.33 ROOF: 0.044 OTHER: 20	STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>33.0%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>34.4%</b>	ALTERNATE 1A/OPTION E STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>33.0%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>34.4%</b>	ALTERNATE 1A/OPTION E' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>34.0%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>35.9%</b>	ALTERNATE 1A/OPTION E'' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>35.3%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>37.5%</b>
1B	40% Window Wall Ratio VISION GLASS: RATIO 40% SHGC 0.36 U/R VALUES 0.45 VISION: 0.45 OPAQUE: (R-20 c.i.) 0.33 ROOF: 0.044 OTHER: 20			ALTERNATE 1B/OPTION E' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>34.6%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>37.0%</b>	ALTERNATE 1B/OPTION E'' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>34.6%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>37.0%</b>
2A	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: (c.i.) 0.092 ROOF: 0.044 OTHER: 40			ALTERNATE 2A/OPTION E' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>30.4%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>34.4%</b>	ALTERNATE 2A/OPTION E'' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>30.4%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>34.4%</b>
2B	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: R-8 (c.i.) 0.067 ROOF: 0.044 OTHER: 40			ALTERNATE 2B/OPTION E' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>31.5%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>34.9%</b>	ALTERNATE 2B/OPTION E'' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>31.5%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>34.9%</b>
2C	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: R-12 (c.i.) 0.052 ROOF: 0.044 OTHER: 40			ALTERNATE 2C/OPTION E' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>32.8%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>35.9%</b>	ALTERNATE 2C/OPTION E'' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>32.8%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>35.9%</b>
2D	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: R-20 (c.i.) 0.044 ROOF: 0.044 OTHER: 40			ALTERNATE 2D/OPTION E' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>34.6%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>37.0%</b>	ALTERNATE 2D/OPTION E'' TCH CODE ENERGY (MIN 10% SAVINGS REQUIRED) <b>34.6%</b> V4 ENERGY COST (MIN 30% SAVINGS TARGET) <b>37.0%</b>
3A	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52.1% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: (c.i.) 0.092 ROOF: 0.044 OTHER: 40	STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>16.7%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>28.1%</b>	ALTERNATE 3A/OPTION E STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>16.7%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>28.1%</b>	ALTERNATE 3A/OPTION E' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>17.7%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>29.1%</b>	ALTERNATE 3A/OPTION E'' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>18.8%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>31.4%</b>
3B	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52.1% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: R-8 (c.i.) 0.067 ROOF: 0.092 OTHER: 40		ALTERNATE 3B/OPTION E STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>26.7%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>30.8%</b>	ALTERNATE 3B/OPTION E' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>27.7%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>32.0%</b>	ALTERNATE 3B/OPTION E'' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>28.3%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>34.2%</b>
3C	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52.1% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: R-12 (c.i.) 0.067 ROOF: 0.092 OTHER: 40		ALTERNATE 3C/OPTION E STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>27.8%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>31.4%</b>	ALTERNATE 3C/OPTION E' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>28.5%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>32.5%</b>	ALTERNATE 3C/OPTION E'' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>29.1%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>34.9%</b>
3D	52% Window Wall Ratio - Argon VISION GLASS: RATIO 52.1% SHGC 0.30 U/R VALUES 0.27 VISION: 0.27 OPAQUE: R-20 (c.i.) 0.044 ROOF: 0.044 OTHER: 40		ALTERNATE 3D/OPTION E STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>29.3%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>32.0%</b>	ALTERNATE 3D/OPTION E' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>30.1%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>33.1%</b>	ALTERNATE 3D/OPTION E'' STRETCH CODE ENERGY SAVINGS (MIN 10% SAVINGS REQUIRED) <b>31.4%</b> LEED V4 ENERGY COST SAVINGS (MIN 30% SAVINGS TARGET) <b>35.0%</b>

**40+**  
**Energy Model Iterations**

# Design Process

## TARGET METRICS

---

**12 pts**

**LEED v4**

Energy cost savings target

**30%**

**STRETCH ENERGY CODE**

Annual energy use reduction target

**70%**

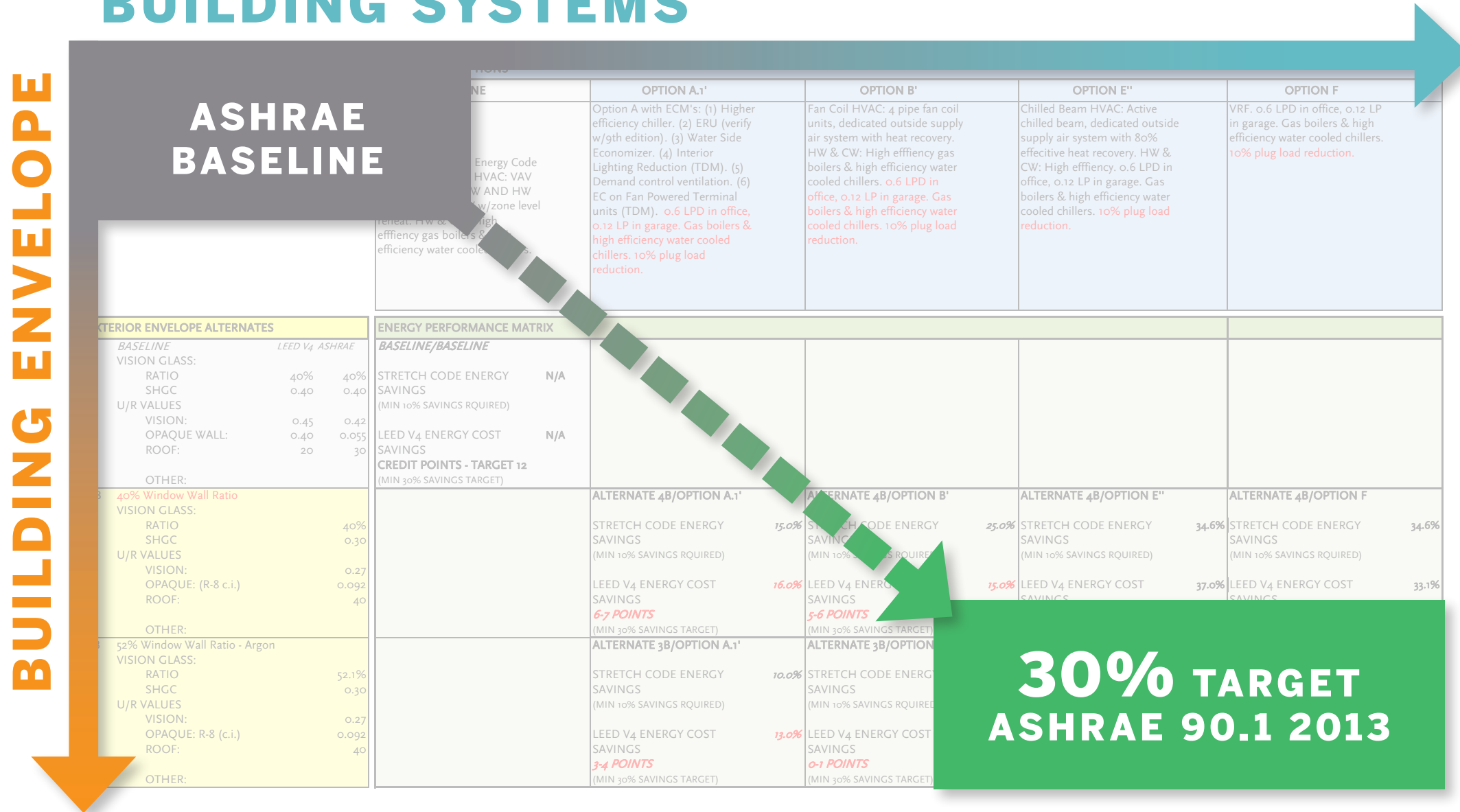
**AIA 2030**

Target reduction over CBECS baseline for office buildings

# Design Process

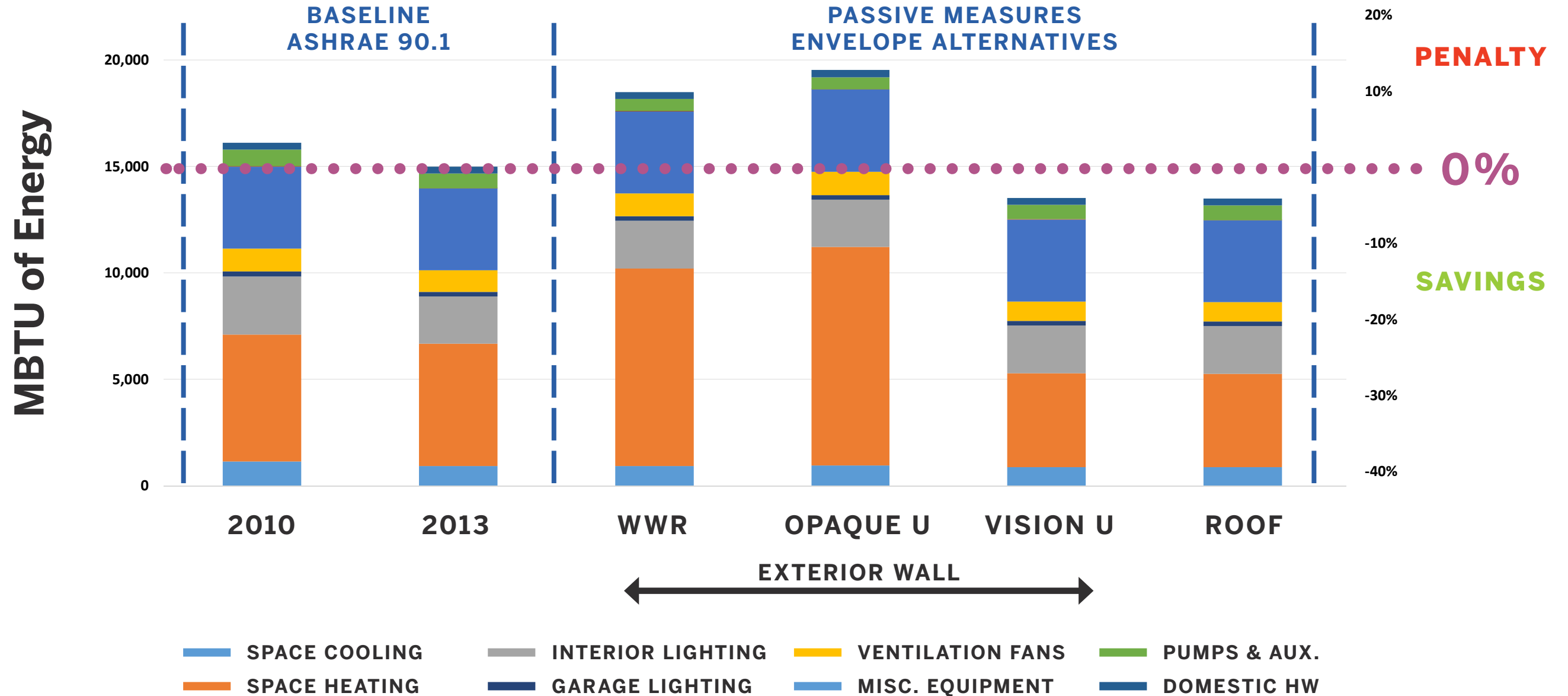
## MODELING MATRIX: ITERATIVE ALTERNATIVES

### BUILDING SYSTEMS



# Design Process

## BUILDING ENVELOPE: ENVELOPE TRADEOFF ANALYSIS





# Design Process

BUILDING ENVELOPE: PERFORMANCE DRIVERS

## BUILDING SYSTEMS

ASHRAE  
BASELINE

ENVELOPE

### ENVELOPE:

WINDOW WALL RATIOS (WWR)  
VISION GLASS U-VALUE  
OPAQUE WALL U-VALUES

BUILDING

30% TARGET  
ASHRAE 90.1 2013

# Design Process

## BUILDING ENVELOPE: PERFORMANCE ANALYSIS

- › Building metrics
- › Vision glass configurations
- › Cladding materials
- › I.G.U. assemblies
- › Assembly U-values

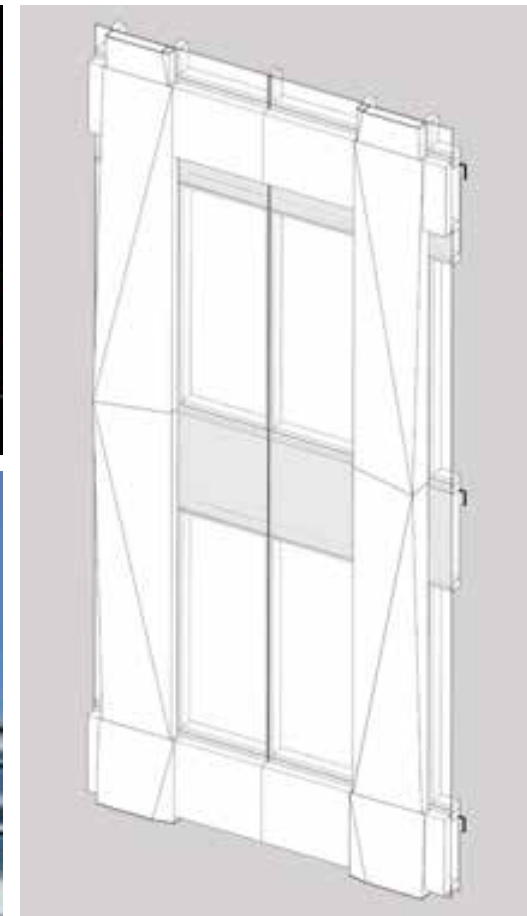
### ENVELOPE ALTERNATIVES ANALYSIS:

	<b>BASELINE ASHRAE 90.1 2010/2013</b>	<b>MARKET BASIS CIRCA 2010-2018</b>	<b>ALTERNATIVES ANALYZED</b>
<b>WWR</b>	40%	60+%	45%-65%
<b>VISION GLASS</b>	U = 0.45/0.42 SHGC = 0.40	U = ~0.35 SHGC = ~0.30~0.35	U = 0.20-0.40 SHGC = 0.13 - 0.140
<b>OPAQUE WALL</b>	U = 0.064/0.055 R-13 + C.I.	U = 0.15 - 0.20 (CURTAIN WALL)	U = 0.046-0.30 (CURTAIN WALL)

# Design Process

## BUILDING ENVELOPE: DESIGN CONSIDERATIONS

- › Performance
- › Human comfort
- › Aesthetics
- › Cost
- › Constructability



# Design Process

## BUILDING ENVELOPE: DESIGN BASIS

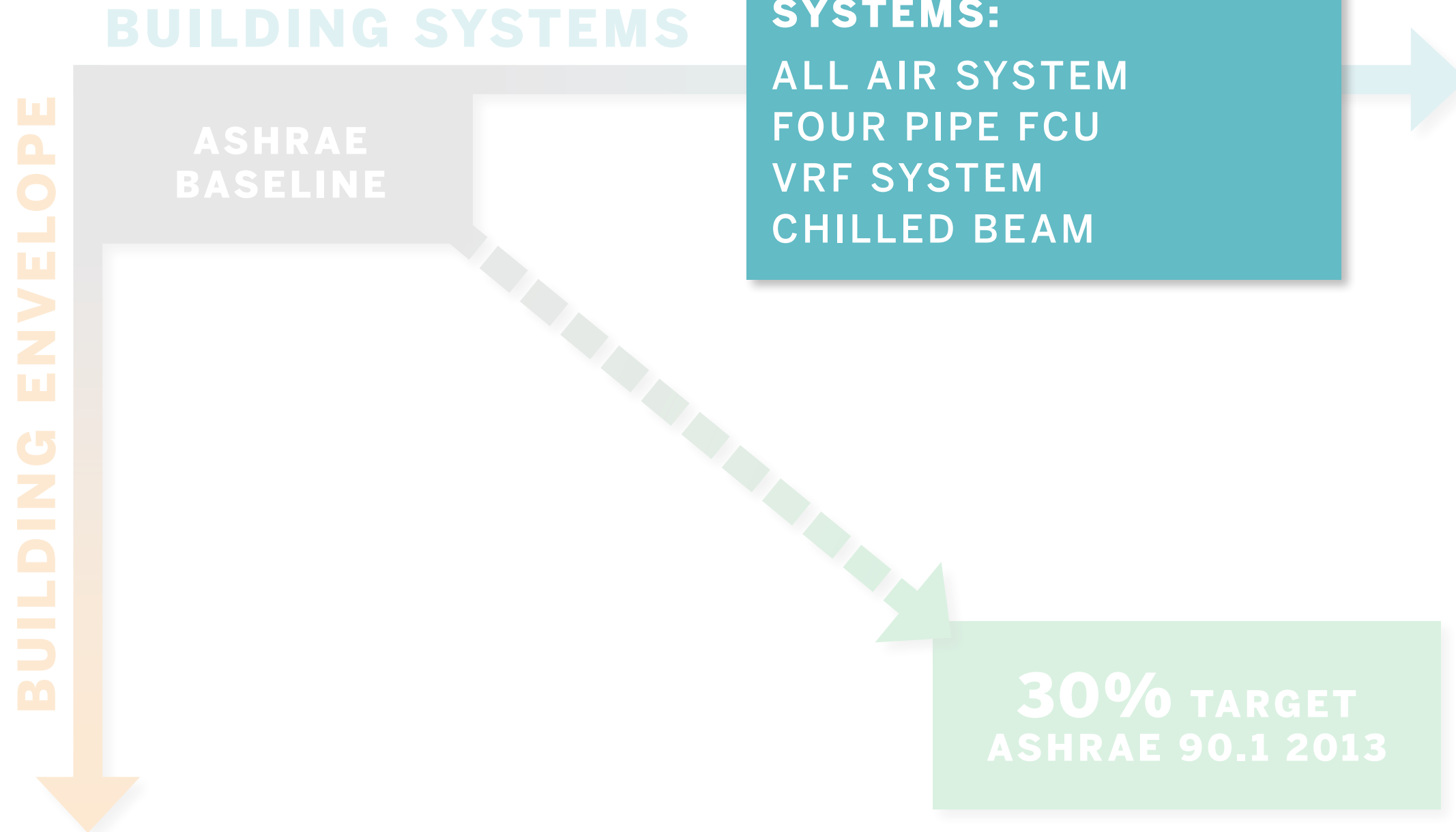
DESIGN BASIS	
WWR	54%
VISION GLASS	U = 0.27 SHGC = 0.29
OPAQUE WALL	U = 0.092 (CURTAIN WALL)

- › Reduced window wall ratio
- › Room-side Low-E assembly
- › Early adoption of enhanced envelope performance



# Design Process

BUILDING SYSTEMS: PERFORMANCE ANALYSIS

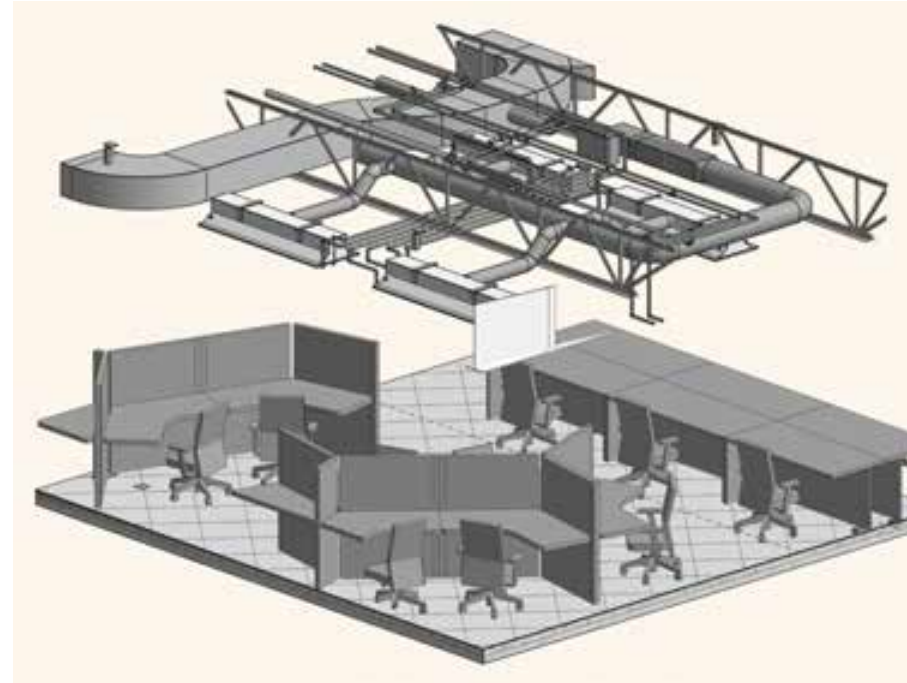


# Design Process

## SYSTEM ALTERNATIVES

### Active Chilled Beam

- › Fan energy savings
- › Higher CHW temperature resulting in higher chiller efficiency (dedicated to ACBs)

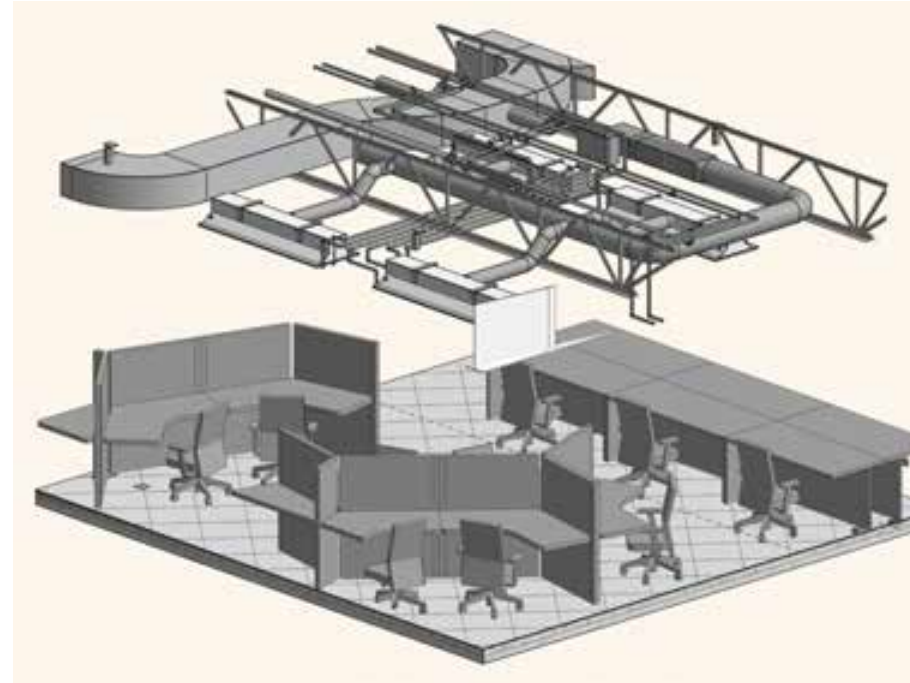


# Design Process

## SYSTEM ALTERNATIVES

### Architectural Considerations

- › Cost tradeoffs - ductwork vs. piping
- › Space allocation/ clear heights
- › Lighting/MEP/FP coordination
- › Acoustic performance



# Design Process

PERFORMANCE OPTIMIZATION

## BUILDING SYSTEMS

ENVELOPE

ASHRAE  
BASELINE

### SYSTEMS:

ACTIVE CHILLED BEAM  
HIGH EFFICIENCY BOILERS  
LPD REDUCTION  
DOAS ENERGY RECOVERY

### PERFORMANCE DRIVERS:

WWR = 54%  
VISION U = 0.27 (ROOM SIDE LOW E)  
OPAQUE U = 0.092 (ADDITIONAL INSULATION)  
SHGC = 0.29

BUILDING

**31.5% ENERGY  
SAVINGS OVER  
ASHRAE 90.1 2013**



# Design Process

ACTUAL METRICS

---

**12+1 pts**

**LEED v4**

Actual EApc 95 GHG emission  
and source energy savings

**31.5%**

**STRETCH ENERGY CODE**

Actual annual energy use  
reduction

**71%**

**AIA 2030**

Actual reduction over CBECS  
baseline for office buildings

# Design Process

FINDING THE BALANCE



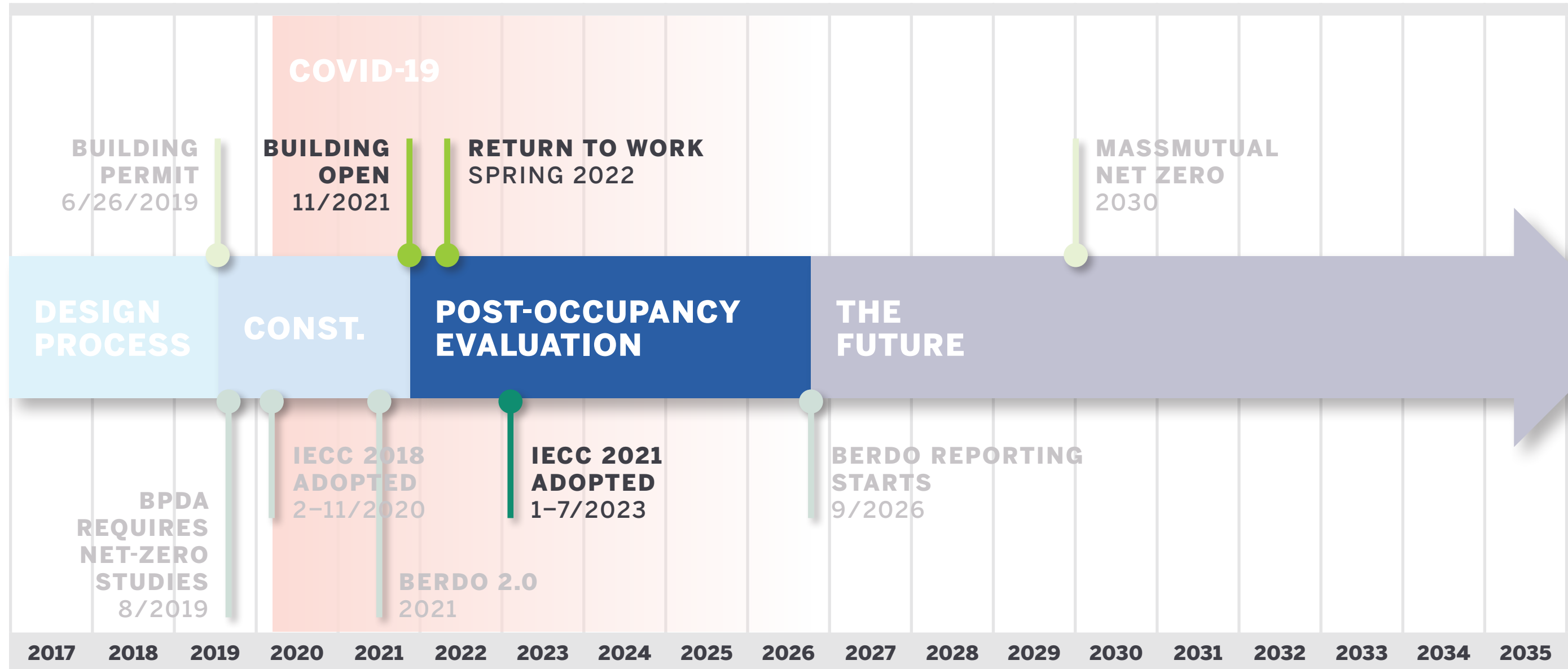
**ENERGY  
PERFORMANCE**

**OCCUPANT  
COMFORT**

**AESTHETICS**

# Post-Occupancy Evaluation

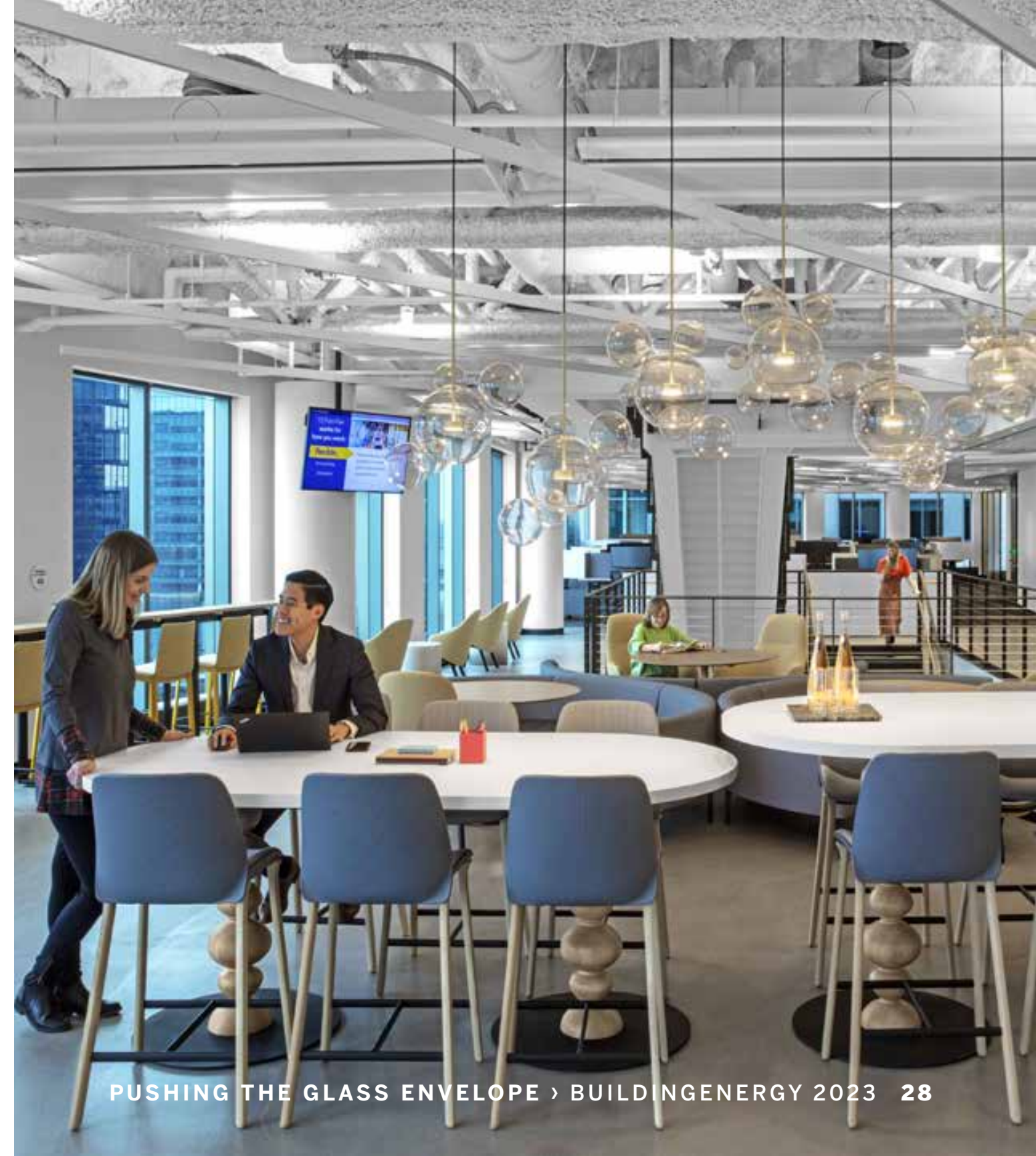
## TIMELINE



# Post-Occupancy Evaluation

## MILESTONES

- › COVID-19 start: March 2020
- › Occupancy: November 2021
- › Return to work: Spring 2022
- › Commissioning
- › Ongoing pandemic impact



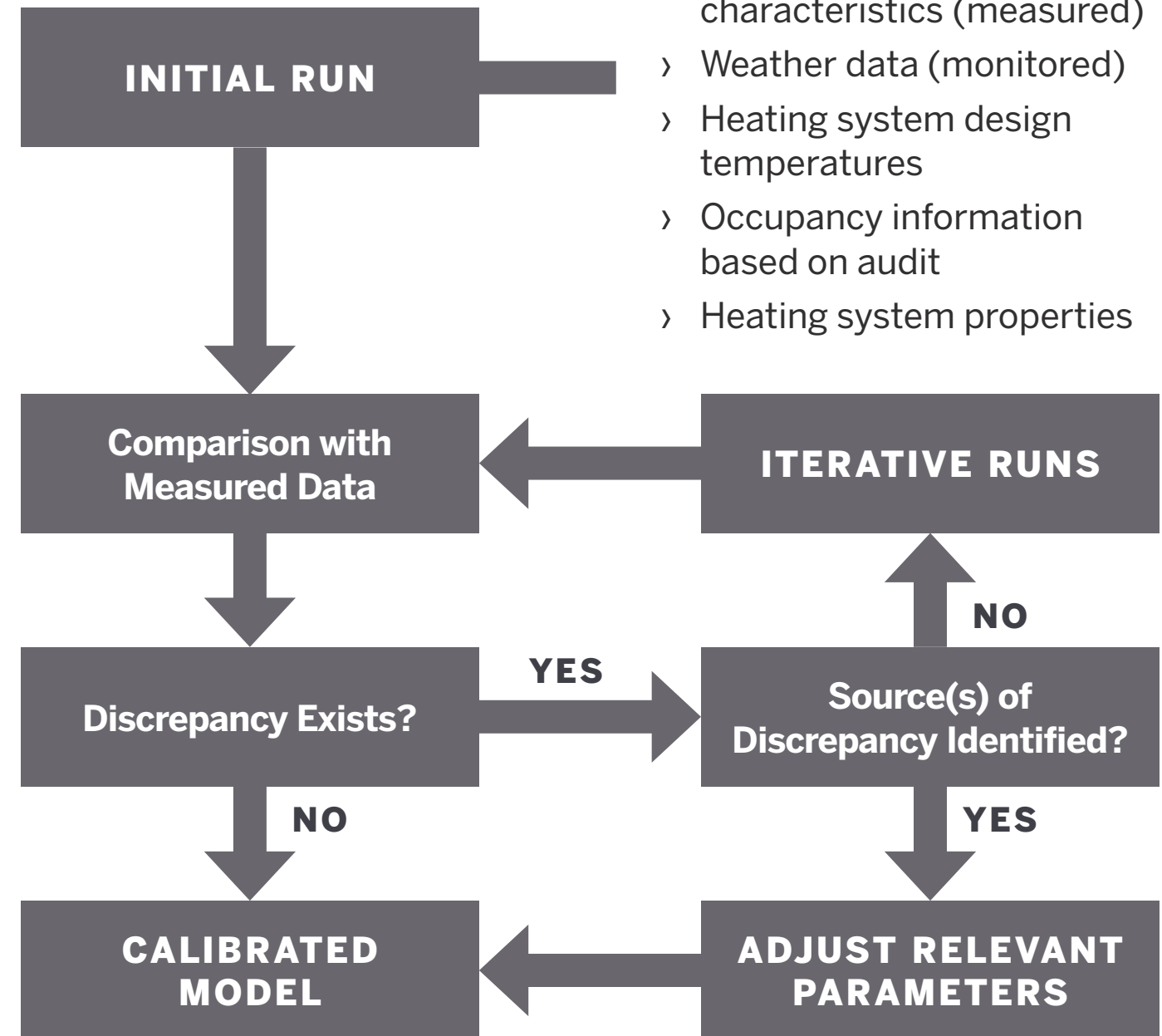
# Post-Occupancy Evaluation

## ENERGY MODEL CALIBRATION

- › IPMVP and ASHRAE Guideline 14
- › Gather **occupancy** and internal load schedules
- › Compare the **weather** file to actual weather data
- › A work in progress: **one year utility data is not sufficient** for model calibration

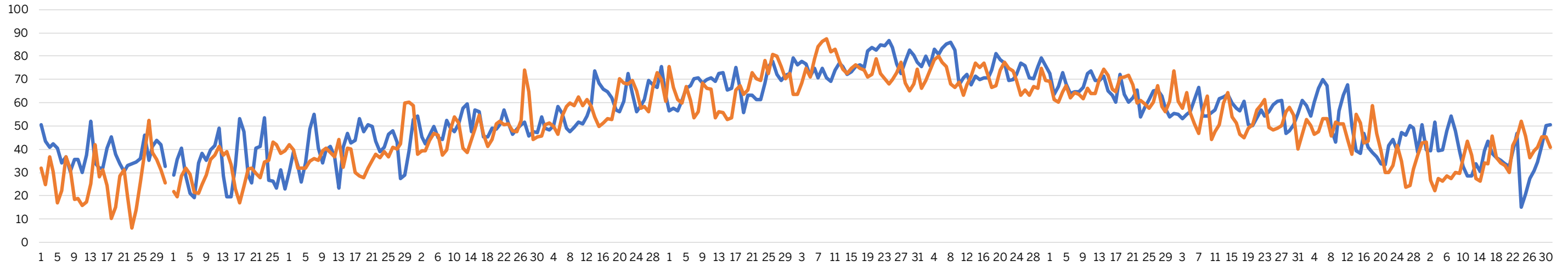
### INCLUDES:

- › As built information
- › Building envelope characteristics (measured)
- › Weather data (monitored)
- › Heating system design temperatures
- › Occupancy information based on audit
- › Heating system properties



# Boston Weather

## ACTUAL VS MODELED

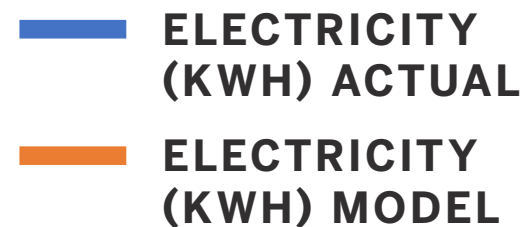


- BOSTON 2022-23
- MODEL AVERAGE (TMY3)

# Post-Occupancy Evaluation

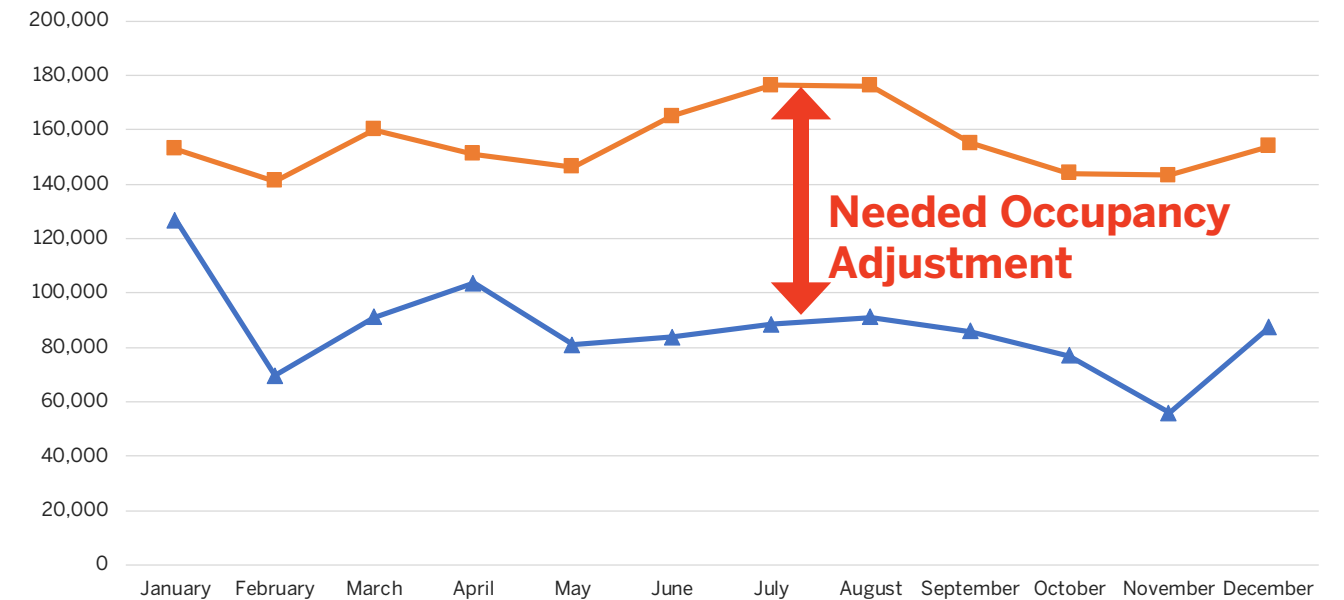
## ELECTRIC CONSUMPTION

- › Energy Model was developed and finalized pre-pandemic, assuming 90% occupancy throughout the week
- › Per 2022 weekly schedule, the occupancy is at 30%
- › Occupancy, lighting, and equipment densities were adjusted in the calibrated model to represent the actual schedules

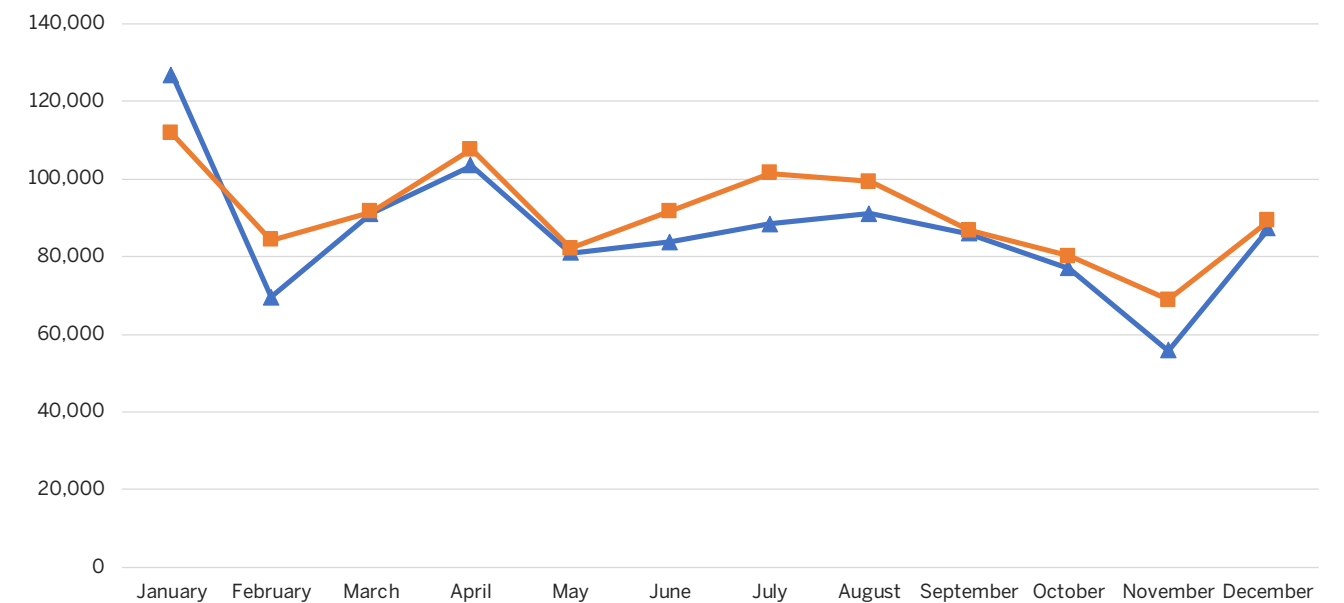


Uncalibrated

**MONTHLY ELECTRIC CONSUMPTION: ACTUAL VS MODELED**



Calibrated

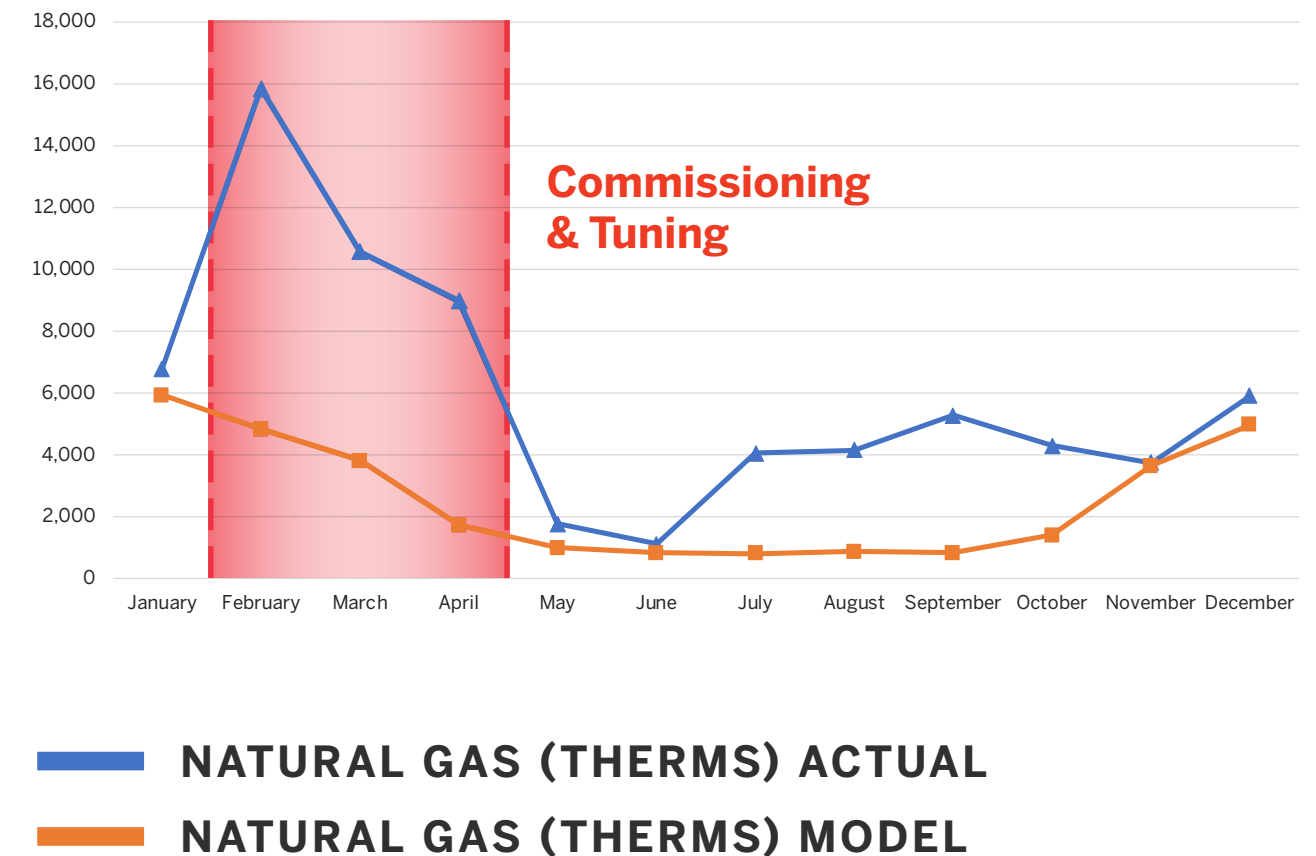


# Post-Occupancy Evaluation

## NATURAL GAS CONSUMPTION

- › Predicted vs Actual
- › Work in progress - one year utility data is not enough for model calibration
- › Commissioning: February, March and April
- › Monitoring-Based Commissioning in progress

MONTHLY GAS CONSUMPTION: ACTUAL VS MODELED





# Post-Occupancy Evaluation

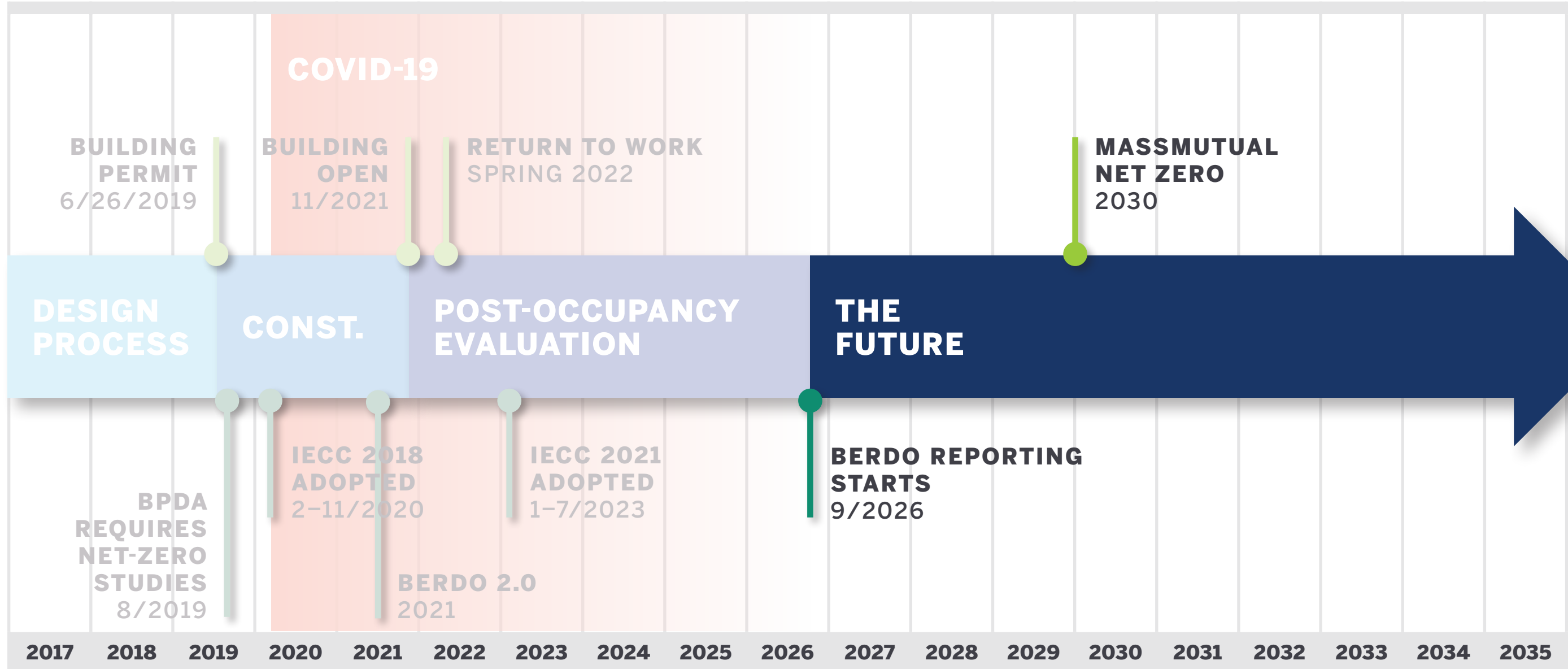
## WHAT DID WE LEARN?

- › **Employee experience** goals were met and exceeded
- › **BMS lighting** controls required adjustment
- › Lack of internal heat gain due to **unoccupied floors**
- › **Data mining** needs to be real time, and ongoing
- › We are still **learning!**



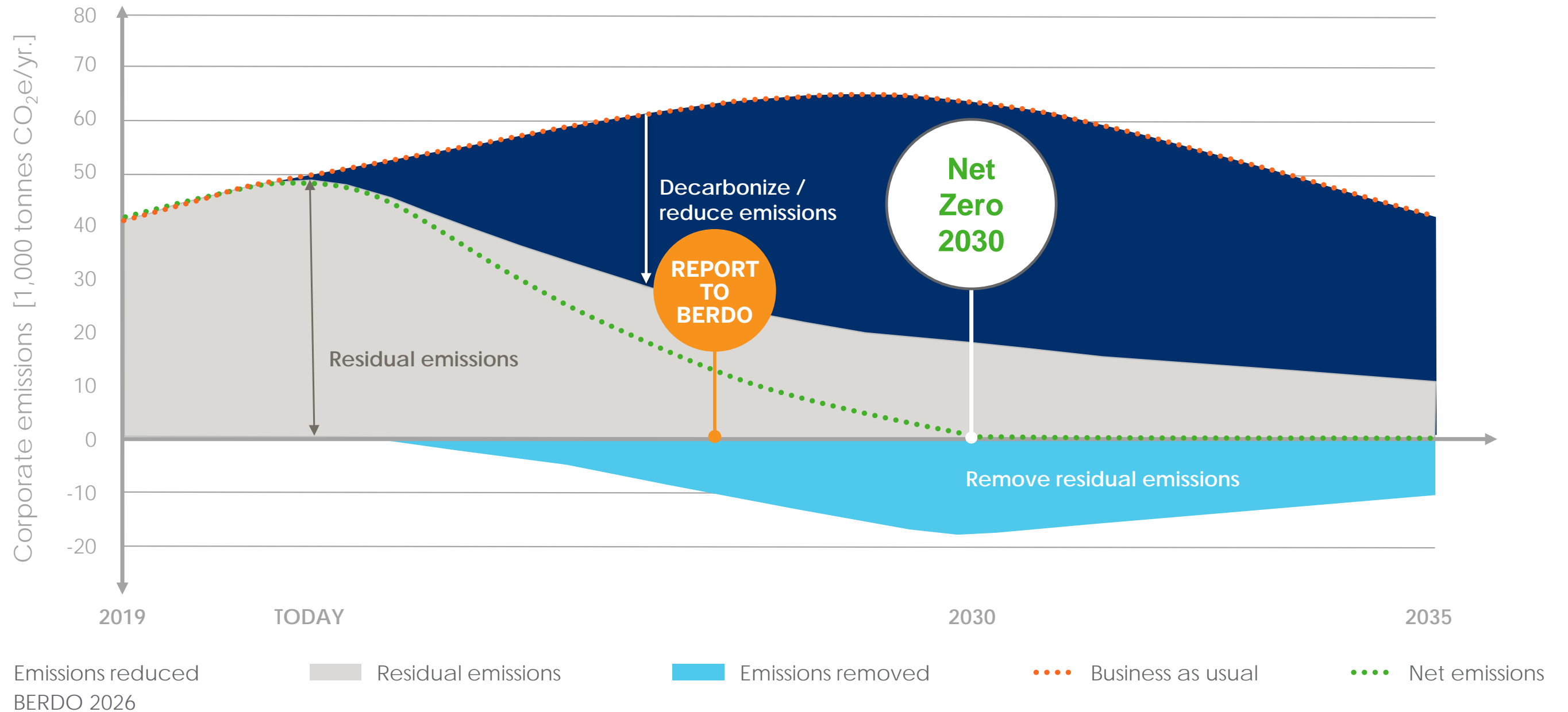
# The Future

## TIMELINE



# The Future

## MASSMUTUAL NET ZERO 2030 GOALS



# The Future

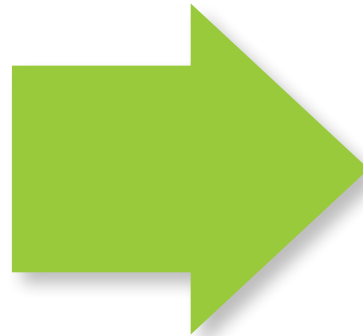
## BERDO — BOSTON'S BUILDING EMISSIONS ORDINANCE

---

# 2013

### BERDO

Building Energy **Reporting** and Disclosure Ordinance (BERDO) required properties >35,000 sf to **report** annual energy and water use.



---

# 2021

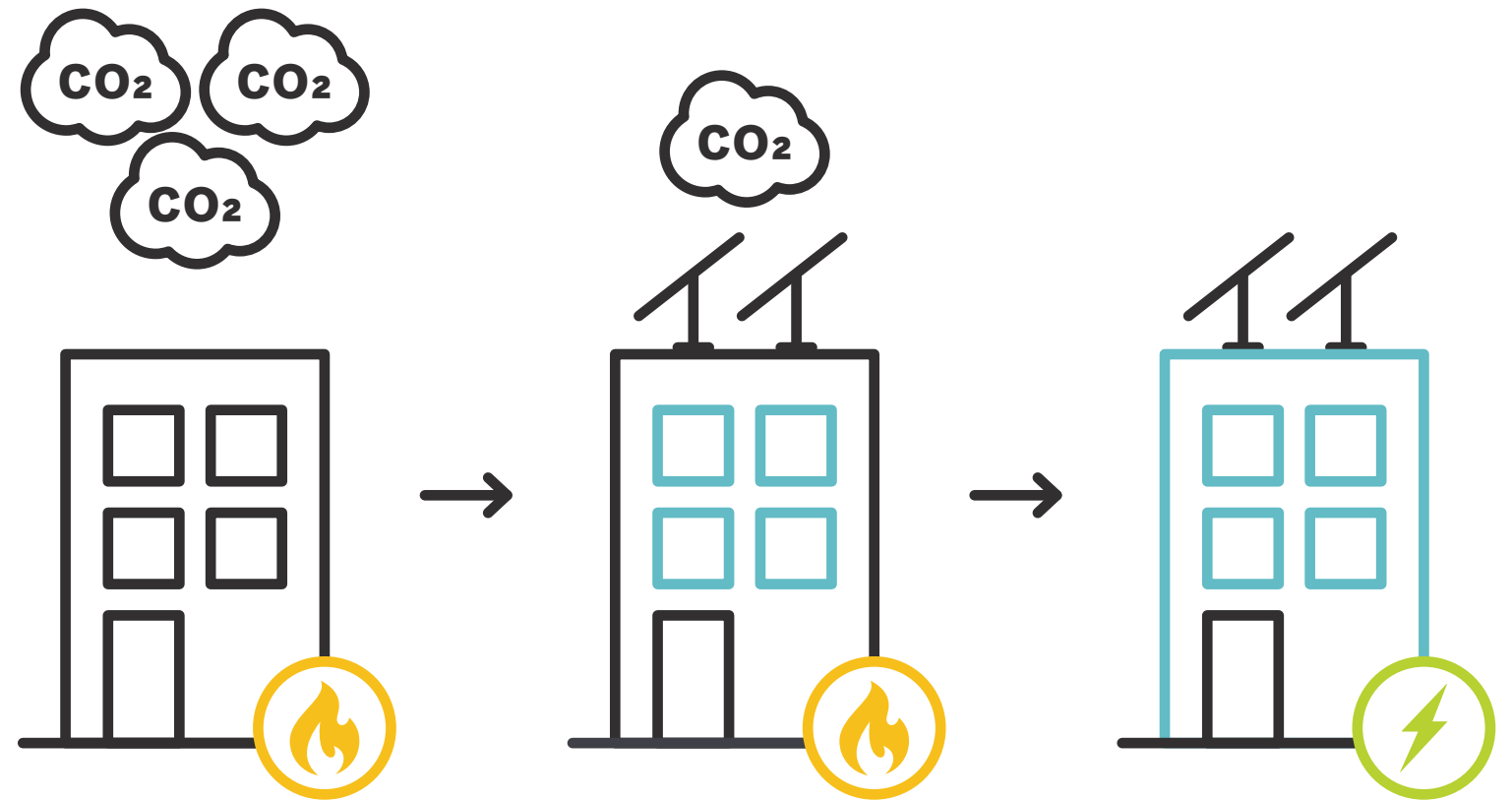
### BERDO 2.0

Building Emissions **Reduction** and Disclosure Ordinance (BERDO) actively **regulates** the annual emissions of buildings >20,000 sf

# The Future

## BERDO — BOSTON'S BUILDING EMISSIONS ORDINANCE

- › The goal is to reduce greenhouse gas emissions gradually to **net zero by 2050**
- › All buildings will be held to **carbon emission limits starting in 2025**
- › Building owners will need to **progressively decarbonize** their buildings



# The Future

## BERDO – BOSTON'S BUILDING EMISSIONS ORDINANCE

Building typology	Year	Emission standards (kgCO <sub>2</sub> e/SF)					2050–
		2025– 2029	2030– 2034	2035– 2039	2040– 2044	2045– 2049	
Assembly		7.8	4.6	3.3	2.1	1.1	0.0
College/University		10.2	5.3	3.8	2.5	1.2	0.0
Education		3.9	2.4	1.8	1.2	0.6	0.0
Food Sales & Service		17.4	10.9	8.0	5.4	2.7	0.0
Healthcare		15.4	10.0	7.4	4.9	2.4	0.0
Lodging		5.8	3.7	2.7	1.8	0.9	0.0
Manufacturing/Industrial		23.9	15.3	10.9	6.7	3.2	0.0
Multifamily housing		4.1	2.4	1.8	1.1	0.6	0.0
Office		5.3	3.2	2.4	1.6	0.8	0.0
Retail		7.1	3.4	2.4	1.5	0.7	0.0
Services		7.5	4.5	3.3	2.2	1.1	0.0
Storage		5.4	2.8	1.8	1.0	0.4	0.0
Technology/Science		19.2	11.1	7.8	5.1	2.5	0.0

Source: Synapse model using BERDO data and historical Boston GHG emission inventories.

# The Future

## DECARBONIZATION APPROACHES

### DEEP ENERGY RETROFITS

---

- › Envelope
- › HVAC+R
- › Lighting
- › Water heating
- › Plug load

### BUILDING-LEVEL FUEL SWITCHING

---

- › Electrification:
  - Cooking
  - Space heating
  - Space cooling

### DISTRICT ENERGY FUEL SWITCHING

---

- › Electrification
- › Low-carbon fuels

### ON-SITE RENEWABLE ENERGY

---

- › Solar PV

### OFF-SITE RENEWABLE ENERGY

---

- › Community choice electricity
- › Community renewables
- › Power purchase agreements
- › Unbundled RECs
- › Self-owned



**IMMEDIATE OR OCCUPANT TURNOVER OR CAPITAL IMPROVEMENTS**

# The Future

WHAT DOES THIS MEAN FOR MASSMUTUAL?



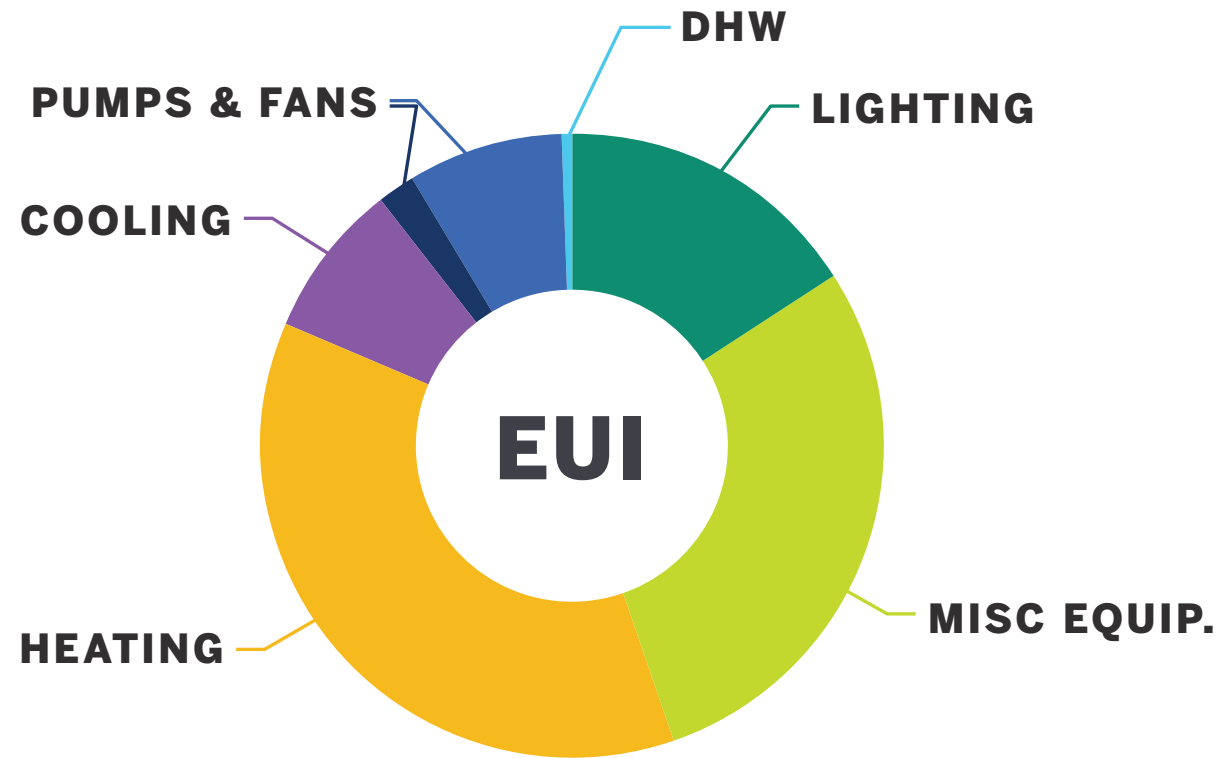
**MassMutual**  
LIVING MUTUAL

**BERDO +  
2030/2050 GOALS**



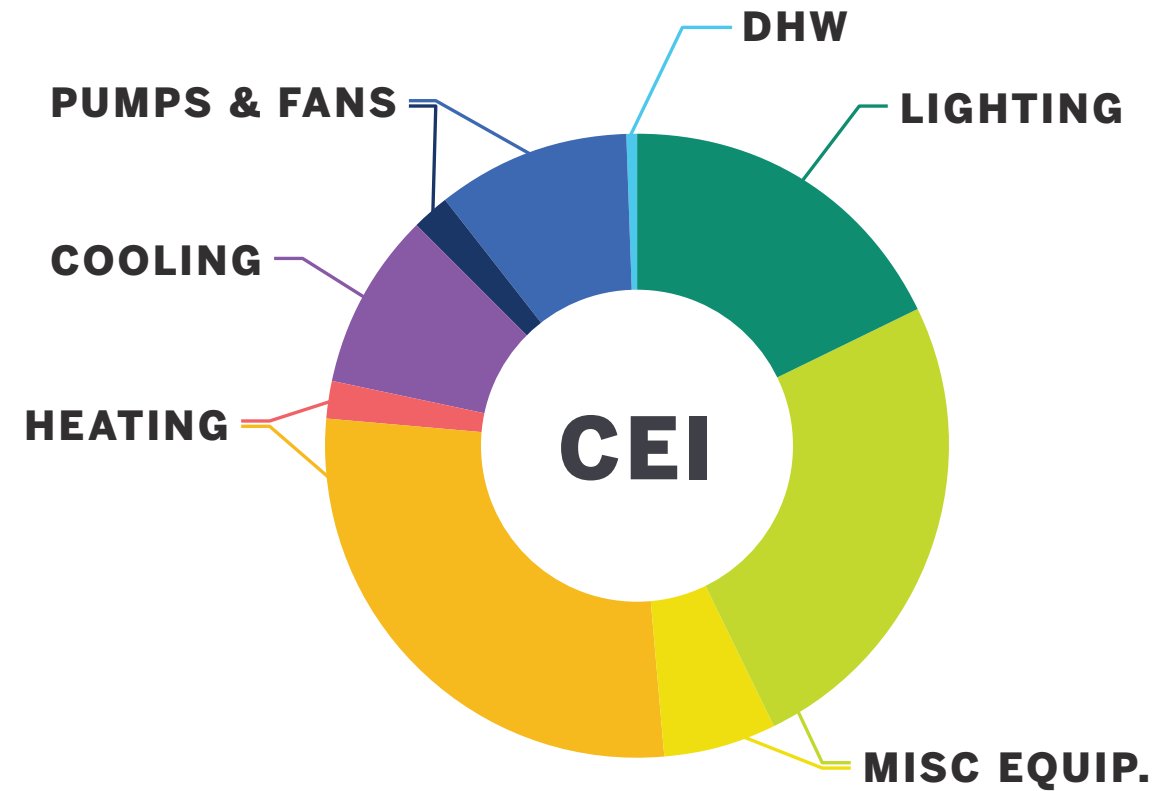
# The Future

## EVALUATION METRICS



### pEUI (PREDICTED EUI)

Energy Use Intensity of the building, predicted via energy simulation. EUI is the building annual energy consumption, divided by the total net area of the building (kBTU/sf.yr)



### pCEI (PREDICTED CEI)

Carbon Emissions Intensity of the building, predicted via energy simulation. CEI is the building annual operational carbon emissions, divided by the total net area of the building (kg CO<sub>2</sub>e/sf.yr)

# The Future

CURRENT PERFORMANCE

**2022**

---

**1.51**

Predicted CEI

**2022**

---

**2.06**

Actual CEI

**2035**

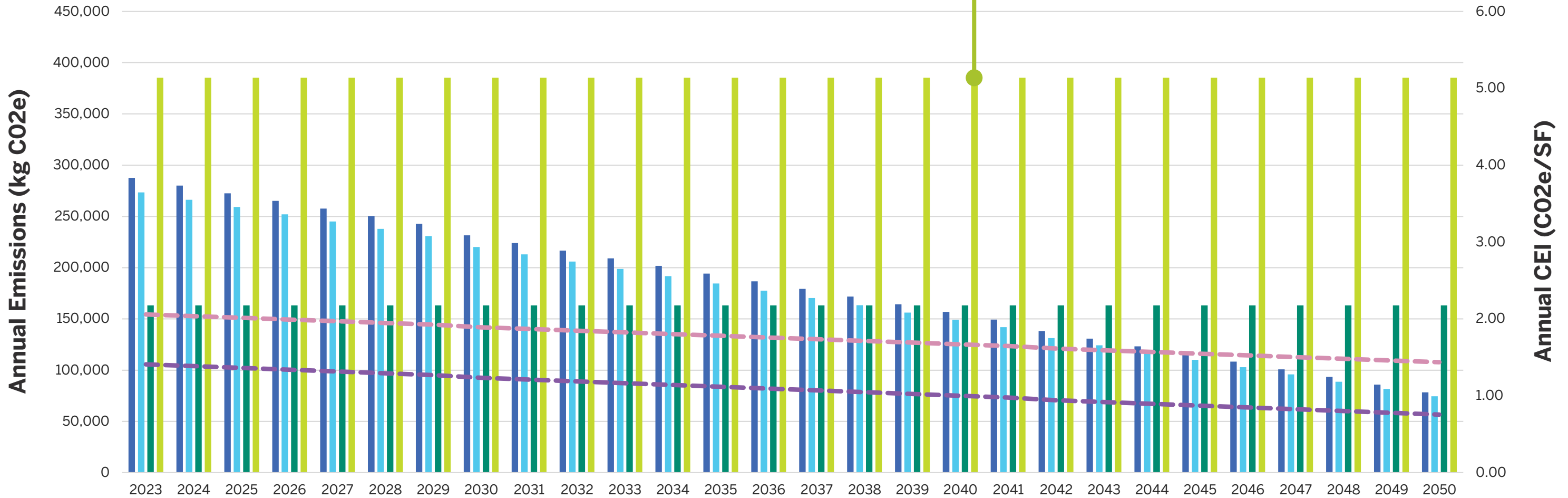
---

**1.78**

2035 CEI

# The Future

## MEETING BERDO

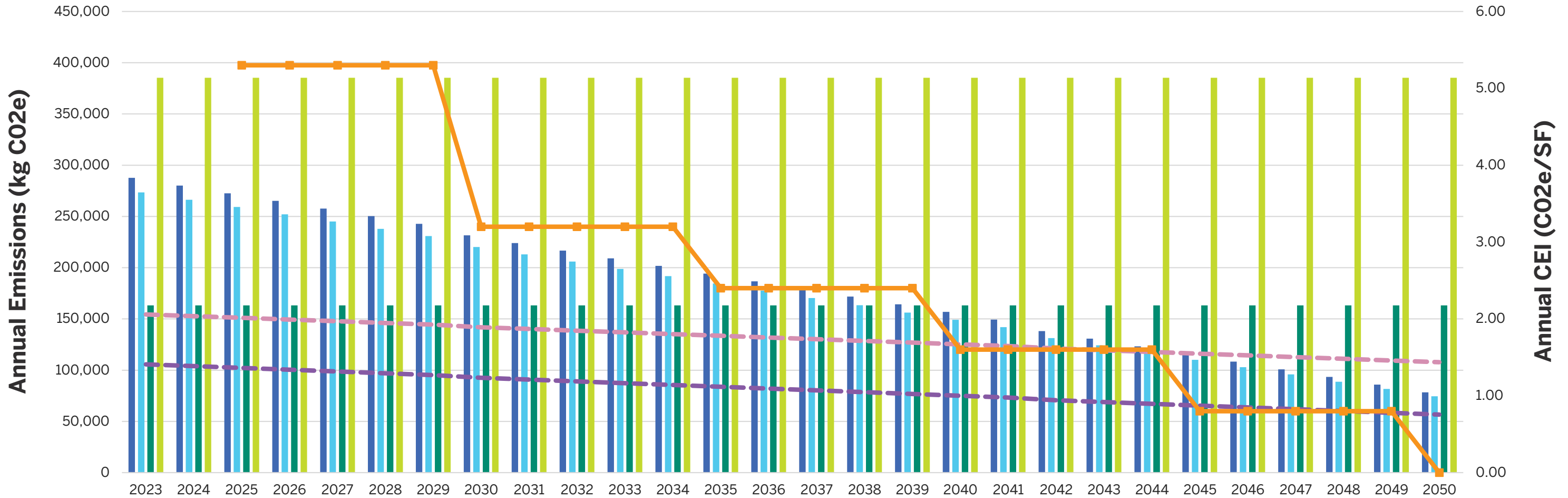


**ACTUAL GAS HIGHER  
DUE TO TUNING &  
COMMISSIONING**

- MODEL CEI
- MODEL ELECTRICITY
- MODEL GAS
- ACTUAL CEI
- ACTUAL ELECTRICITY
- ACTUAL GAS
- BERDO CEI

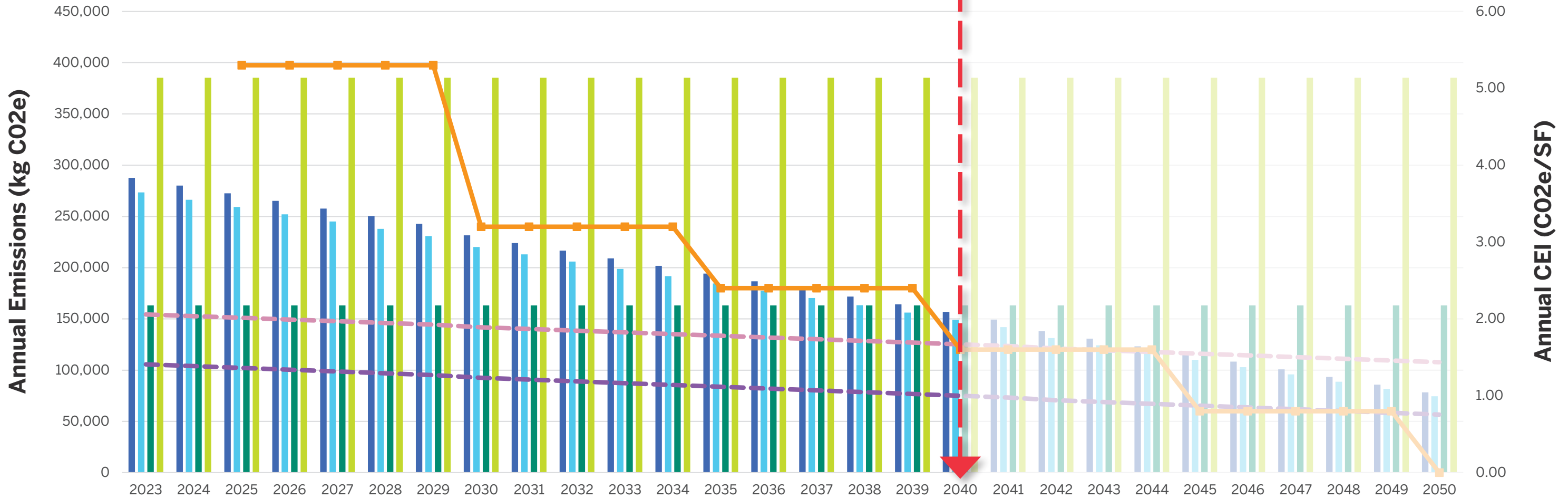
# The Future

## MEETING BERDO



# The Future

## MEETING BERDO



**REPLACEMENT OF GAS EQUIPMENT WITH HIGH-EFFICIENCY ELECTRIC EQUIPMENT AFTER 2040**

- MODEL CEI
- ACTUAL CEI
- BERDO CEI
- MODEL ELECTRICITY
- ACTUAL ELECTRICITY
- MODEL GAS
- ACTUAL GAS

# The Future

## MEETING BERDO

Year	Actual CEI	BERDO CEI
2025	2.01	5.3
2026	1.99	5.3
2027	1.97	5.3
2028	1.95	5.3
2029	1.93	5.3
2030	1.89	3.2
2031	1.87	3.2
2032	1.85	3.2
2033	1.83	3.2
2034	1.80	3.2
2035	1.78	2.4
2036	1.76	2.4
2037	1.74	2.4
2038	1.71	2.4
2039	1.69	2.4
2040	1.67	1.6
2041	1.65	1.6
2042	1.61	1.6
2043	1.59	1.6
2044	1.57	1.6
2045	1.55	0.8
2046	1.53	0.8
2047	1.50	0.8
2048	1.48	0.8
2049	1.46	0.8
2050	1.44	0

kg CO2e/sf.yr

2038	1.71	2.4
2039	1.69	2.4
2040	1.67	1.6
2041	1.65	1.6
2042	1.61	1.6

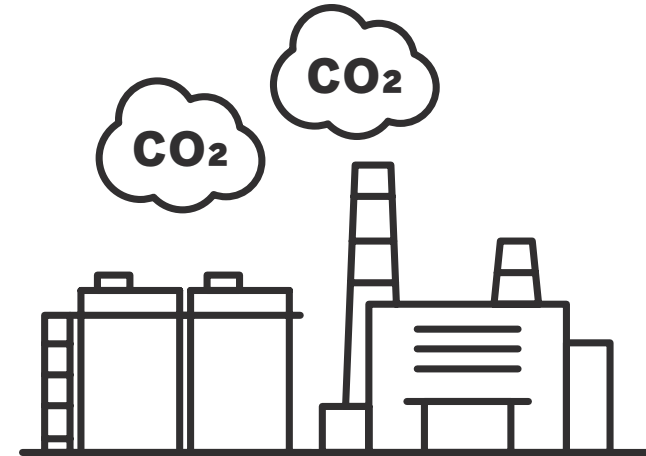
# The Future

MEETING BERDO

2022

1.51

Predicted CEI



2022

2.06

Actual CEI



2035

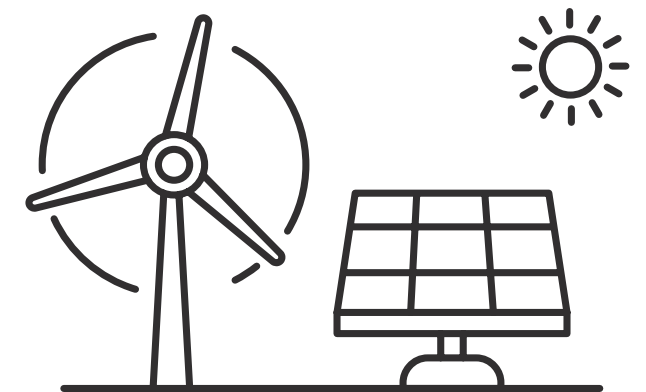
1.78

Actual CEI  
BERDO = 2.4

2040

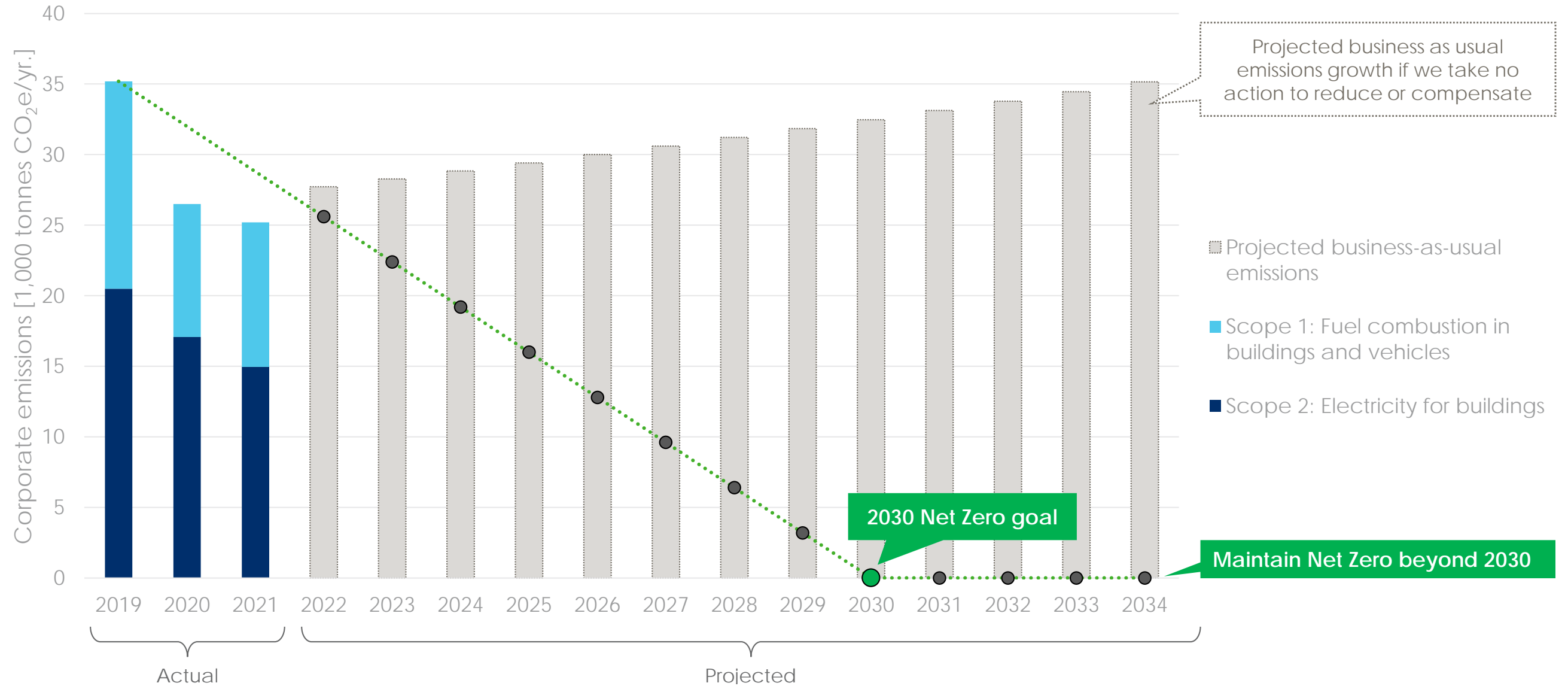
1.67

Actual CEI  
BERDO = 1.6



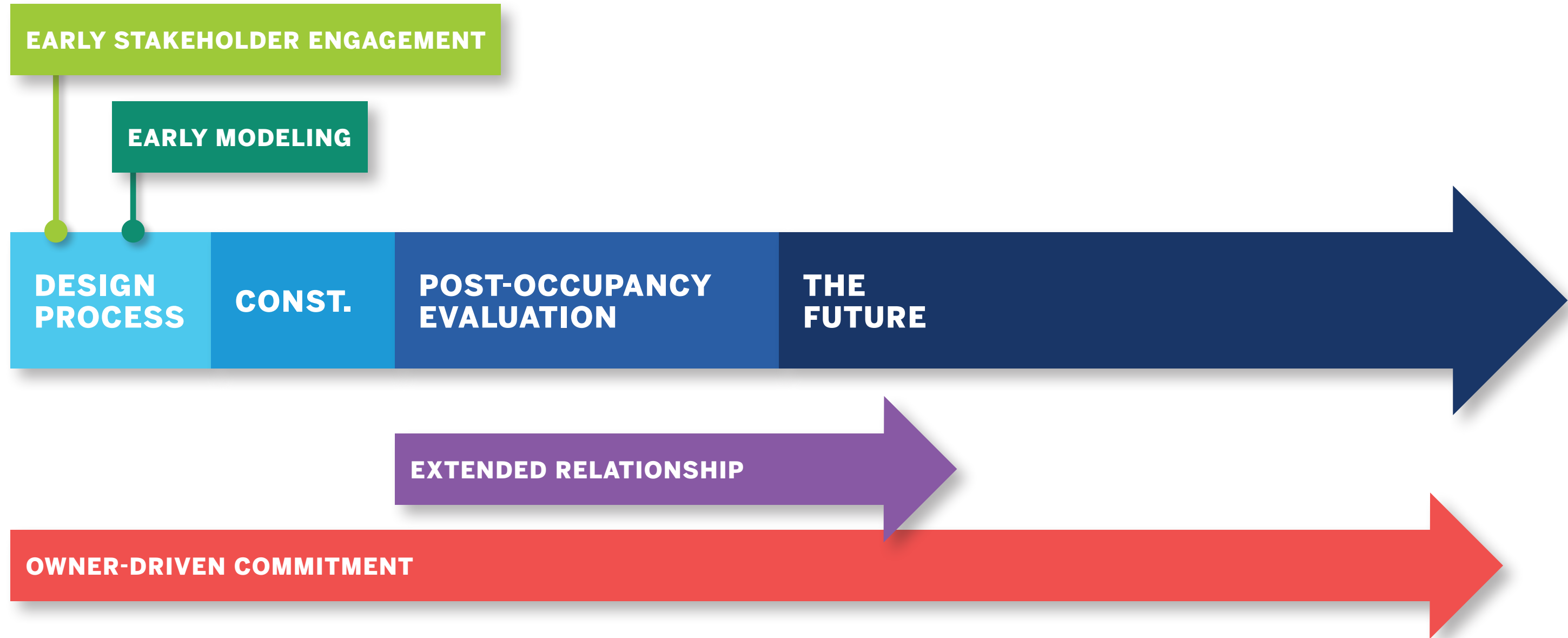
# The Future

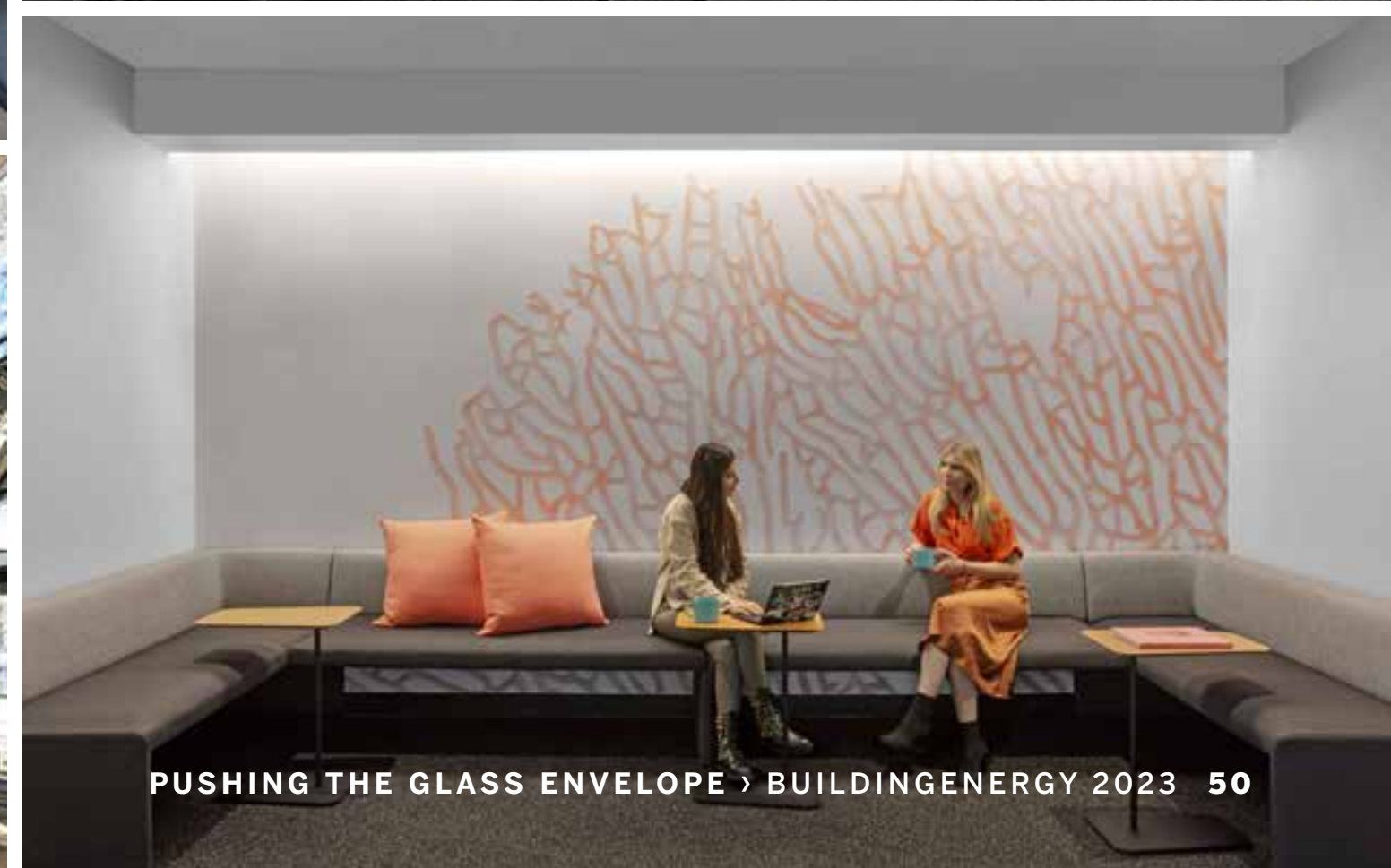
## MASSMUTUAL NET ZERO 2030 GOALS





# Pushing the Glass Envelope...





# **BUILDINGENERGY BOSTON**

---

## **Pushing the Glass Envelope: A BERDO 2.0 Compliance Pathway for a High Performance Building**

**Samira Ahmadi (enviENERGY Studio)**

**Peter Zmuidzinas (Elkus Manfredi Architects)**

**Sean Anderson (MassMutual)**

**Curated by Shari Rauls and Tammy Ngo**

---

**Northeast Sustainable Energy Association (NESEA)**

**March 29, 2023**