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
- Greenhouse Gas

PUSHING THE GLASS ENVELOPE › BUILDINGENERGY 2023
Design Process

TIMELINE

- **Building Permit**: 6/26/2019
- **BPDA Requires Net-Zero Studies**: 8/2019
- **IECC 2018 Adopted**: 2-11/2020
- **Berdo 2.0**: 2021
- **IECC 2021 Adopted**: 1-7/2023
- **Berdo Reporting Starts**: 9/2026
- **MassMutual Net Zero 2030**
- **Building Open**: 11/2021
- **Return to Work Spring 2022**
- **COVID-19**

The timeline also includes a note on pushing the glass envelope for the year 2023.
Design Process

IDENTIFYING ENERGY PERFORMANCE GOALS

MassMutual
LIVING MUTUAL

LEED V4 PLATINUM 2020

80 POINTS

12-15 ENERGY PERFORMANCE POINTS

80 POINTS

12-15 ENERGY PERFORMANCE POINTS

27% PERFORMANCE IMPROVEMENTS OVER ASHRAE 90.1 2010 BASELINE

12 POINTS EARNED

PUSHING THE GLASS ENVELOPE › BUILDINGENERGY 2023 12
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
Leed V4
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
### Baseline Options

#### Fan Coil HVAC
- Rooftop Units, CHW AND HW coils, standard VAV w/zone level reheat. HW & CW: High efficiency gas boilers & high efficiency water cooled chillers.

#### Option A with ECM's
- Gas boilers & high efficiency water cooled chillers. 0.6 LPD in office, 0.12 LP in garage. Gas boilers & high efficiency water cooled chillers. 10% plug load reduction.

#### Fan Coil HVAC: 4 pipe fan coil units, dedicated outside supply air system with heat recovery. HW & CW: High efffiency gas boilers & high efficiency water cooled chillers. 0.6 LPD in office, 0.12 LP in garage. Gas boilers & high efficiency water cooled chillers. 10% plug load reduction.

#### Chilled Beam HVAC: Active chilled beam, dedicated outside supply air system with 80% effective heat recovery. HW & CW: High efficiency. 0.6 LPD in office, 0.12 LP in garage. Gas boilers & high efficiency water cooled chillers. 10% plug load reduction.

#### VRF
- 0.6 LPD in office, 0.12 LP in garage. Gas boilers & high efficiency water cooled chillers. 10% plug load reduction.

### Building Envelope Alternatives

#### Vision Glass: Ratio 40%
- SHGC 0.40
- U/R Values (MIN 10% SAVINGS REQUIRED)
- Vision: 0.45
- Opaque Wall: 0.40
- Roof: 0.90
- LEED V4 Energy Cost Savings: 0.45
- LEED V4 Energy Cost Savings: 0.42

#### Opaque Wall: R-8 (c.i.)
- 0.092
- LEED V4 Energy Cost Savings: 0.27
- LEED V4 Energy Cost Savings: 0.092

#### Roof: 40%
- 30 SAVINGS

### Other
- 30% Target
- ASHRAE 90.1 2013

**NOTE:** Values in italics are approximated based on similar model iterations previously run.
Design Process

BUILDING ENVELOPE: ENVELOPE TRADEOFF ANALYSIS

BASELINE
ASHRAE 90.1

PASSIVE MEASURES
ENVELOPE ALTERNATIVES

PENALTY
0%

SAVINGS

MBTU of Energy

2010
2013
WWR
OPAQUE U
VISION U
ROOF

SPACE COOLING
INTERIOR LIGHTING
VENTILATION FANS
PUMPS & AUX.
SPACE HEATING
GARAGE LIGHTING
MISC. EQUIPMENT
DOMESTIC HW

EXTERIOR WALL

PUSHING THE GLASS ENVELOPE › BUILDINGENERGY 2023
Design Process

BUILDING ENVELOPE: PERFORMANCE DRIVERS

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

ASHRAE BASELINE

BUILDING SYSTEMS

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:

<table>
<thead>
<tr>
<th></th>
<th>Baseline Ashrae 90.1 2010/2013</th>
<th>Market Basis Circa 2010–2018</th>
<th>Alternatives Analyzed</th>
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<tbody>
<tr>
<td><strong>WWR</strong></td>
<td>40%</td>
<td>60+%</td>
<td>45%-65%</td>
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<tr>
<td><strong>Vision Glass</strong></td>
<td>U = 0.45/0.42 SHGC = 0.40</td>
<td>U =~0.35 SHGC =<del>0.30</del>0.35</td>
<td>U= 0.20-0.40 SHGC = 0.13 - 0.140</td>
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<tr>
<td><strong>Opaque Wall</strong></td>
<td>U = 0.064/0.055 R-13 + C.I.</td>
<td>U = 0.15 - 0.20 (Curtain Wall)</td>
<td>U = 0.046-0.30 (Curtain Wall)</td>
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</tbody>
</table>
Design Process

BUILDING ENVELOPE: DESIGN CONSIDERATIONS

› Performance
› Human comfort
› Aesthetics
› Cost
› Constructability
Design Process
BUILDING ENVELOPE: DESIGN BASIS

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

<table>
<thead>
<tr>
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<tr>
<td>WWR</td>
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<tr>
<td>OPAQUE WALL</td>
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</table>
Design Process
BUILDING SYSTEMS: PERFORMANCE ANALYSIS

SYSTEMS:
- ALL AIR SYSTEM
- FOUR PIPE FCU
- VRF SYSTEM
- CHILLED BEAM

ASHRAE BASELINE

30% TARGET
ASHRAE 90.1 2013
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

Ashrae Baseline

Performance Drivers:

- WWR = 54%
- VISION U = 0.27 (Room Side Low E)
- Opaque U = 0.092 (Additional Insulation)
- SHGC = 0.29

Systems:

- Active Chilled Beam
- High Efficiency Boilers
- LPD Reduction
- DOAS Energy Recovery

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

2021 COVID-19

2022 RETURN TO WORK SPRING 2022

THE FUTURE

2023 MASSMUTUAL NET ZERO 2030

2024

2025

2026

2027

2028

2029

2030

2031

2032

2033

2034

2035

IECC 2021 ADOPTED 1–7/2023

BERDO REPORTING STARTS 9/2026

BPDA REQUIRES NET-ZERO STUDIES 8/2019

IECC 2018 ADOPTED 2–11/2020

BERDO 2.0 2021

POST-OCCUPANCY EVALUATION

2021 BUILDING PERMIT 6/26/2019

BUILDING OPEN 11/2021

RETURN TO WORK SPRING 2022

THE FUTURE

2023 MASSMUTUAL NET ZERO 2030

2024

2025

2026

2027

2028

2029

2030

2031

2032

2033

2034

2035

IECC 2021 ADOPTED 1–7/2023

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BPDA REQUIRES NET-ZERO STUDIES 8/2019

IECC 2018 ADOPTED 2–11/2020

BERDO 2.0 2021

POST-OCCUPANCY EVALUATION

2021 BUILDING PERMIT 6/26/2019

BUILDING OPEN 11/2021

RETURN TO WORK SPRING 2022
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
Boston Weather

ACTUAL VS MODELED

BOSTON 2022–23

MODEL AVERAGE (TMY3)
Post-Occuancy 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
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
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

- **COVID-19**
- **Design Process**
- **Construction**
- **Post-Occupancy Evaluation**
- **Future**

**Events:**
- **Building Permit:** 6/26/2019
- **Building Open:** 11/2021
- **Return to Work Spring 2022**
- **IECC 2018 Adopted:** 2–11/2020
- **IECC 2021 Adopted:** 1–7/2023
- **Berdo 2.0:** 2021
- **MassMutual Net Zero 2030**
- **BPDA Requires Net-Zero Studies:** 8/2019
- **Berdo Reporting Starts:** 9/2026

**Timeline Years:**
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024
- 2025
- 2026
- 2027
- 2028
- 2029
- 2030
- 2031
- 2032
- 2033
- 2034
- 2035
The Future

MASSMUTUAL NET ZERO 2030 GOALS

Our Net Zero 2030 operations goal is a commitment to reduce corporate emissions and to remove residual emissions. The graph illustrates the progress towards achieving this goal, with a focus on decarbonization and a net zero target by 2030. The timeline shows the reduction in corporate emissions from 2019 to 2030, with specific targets for emissions reduction and removal of residual emissions by 2035.
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

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

**Decarbonization Approaches**

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<tr>
<td>Plug load</td>
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</tbody>
</table>

**Immediate or Occupant Turnover or Capital Improvements**
The Future

WHAT DOES THIS MEAN FOR MASSMUTUAL?

MassMutual LIVING MUTUAL

BERDO + 2030/2050 GOALS

40 NEW BUILDINGS
1 SQUARE MILE
**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 CO2e/sf.yr)
## The Future

<table>
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<th>Predicted CEI</th>
<th>Actual CEI</th>
<th>2035 CEI</th>
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<td>2.06</td>
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CURRENT PERFORMANCE
The Future

MEETING BERDO

ACTUAL GAS HIGHER DUE TO TUNING & COMMISSIONING

Annual Emissions (kg CO2e) vs. Annual CEI (CO2e/SF)

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

PUSHING THE GLASS ENVELOPE › BUILDINGENERGY 2023
The Future
MEETING BERDO

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

The Future
MEETING BERDO

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

The Future
MEETING BERDO

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

The Future
MEETING BERDO

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

The Future
MEETING BERDO

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

The Future
MEETING BERDO

REPLACEMENT OF GAS EQUIPMENT WITH HIGH-EFFICIENCY ELECTRIC EQUIPMENT AFTER 2040
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<th>Actual CEI</th>
<th>BERDO CEI</th>
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**kg CO2e/sf.yr**

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<td>1.6</td>
</tr>
<tr>
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<td>1.6</td>
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<tr>
<td>2042</td>
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## The Future

### MEETING BERDO

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<th>Actual CEI</th>
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<td>2.06</td>
<td>1.78</td>
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<tr>
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</table>

**BERDO =**

- 2022: BERDO = 2.4
- 2035: BERDO = 1.6

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**GREENER GRID**
The Future

MASSMUTUAL NET ZERO 2030 GOALS

We will need to address our corporate emissions in order to reach and maintain Net Zero beyond 2030.

Projected business as usual emissions growth if we take no action to reduce or compensate.

2030 Net Zero goal

Maintain Net Zero beyond 2030
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