Building Decarbonization

Darren Port, Buildings & Community Solutions Manager
Northeast Energy Efficiency Partnerships (NEEP)

Building Energy NESEA Conference, Boston, MA

March 14, 2019

About Northeast Energy Efficiency Partnerships

"Assist the Northeast and Mid-Atlantic region to reduce building sector energy consumption 3% per year and carbon emissions 40% by 2030 (relative to 2001)"

Mission

We seek to accelerate regional collaboration to promote advanced energy efficiency and related solutions in homes, buildings, industry, and communities.

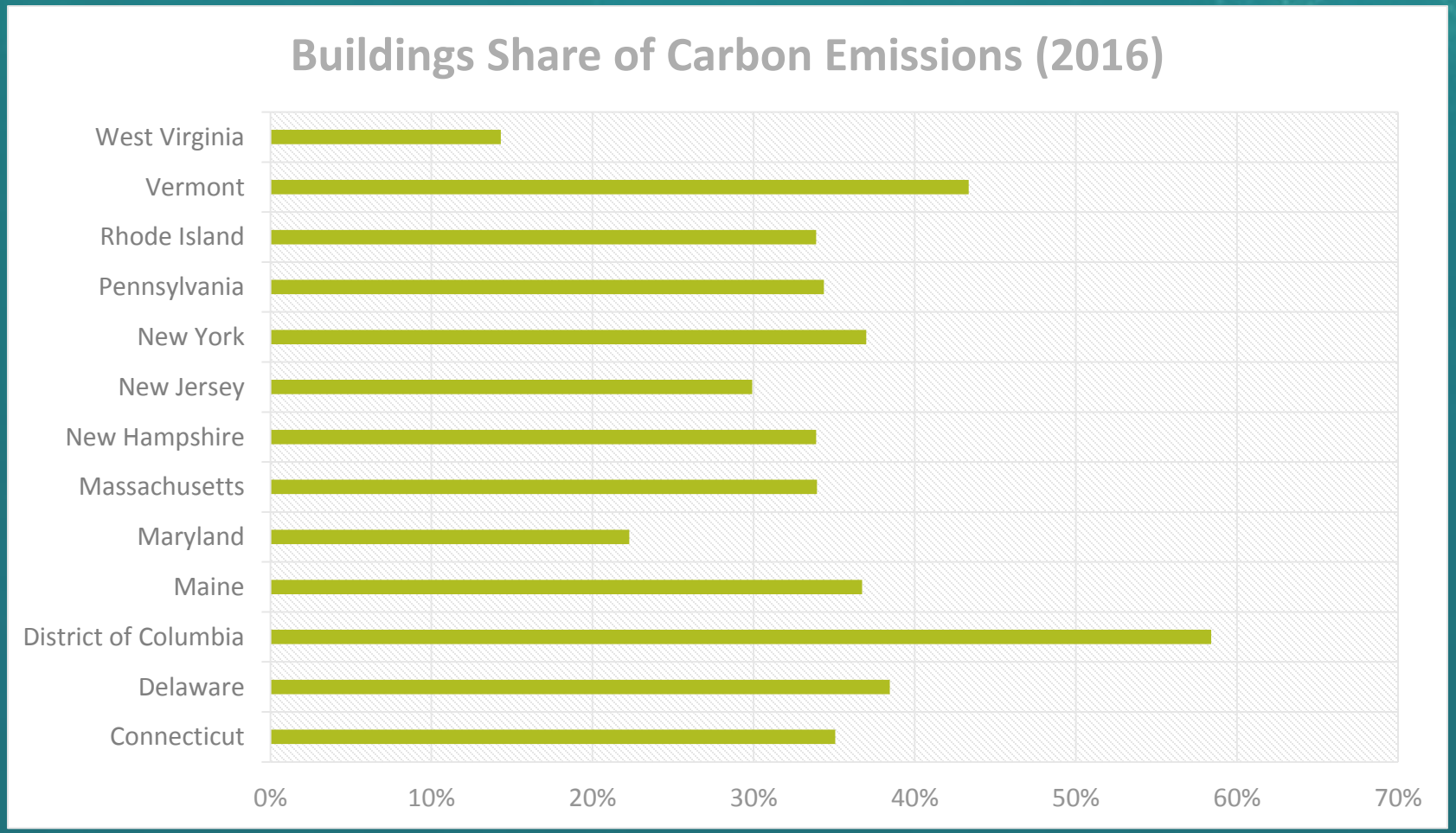
Vision

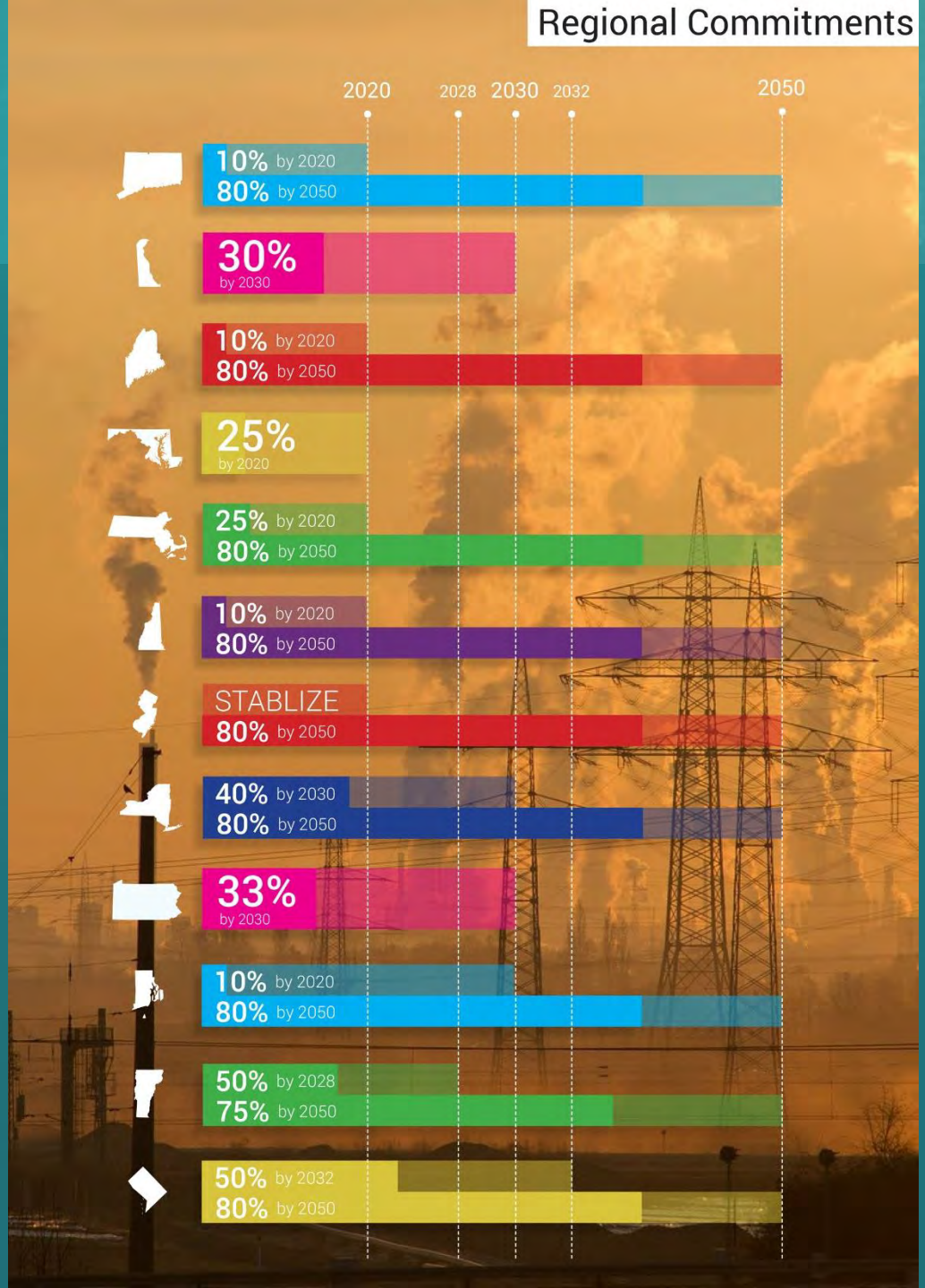
We envision the region's homes, buildings, and communities transformed into efficient, affordable, low-carbon, resilient places to live, work, and play.

Approach

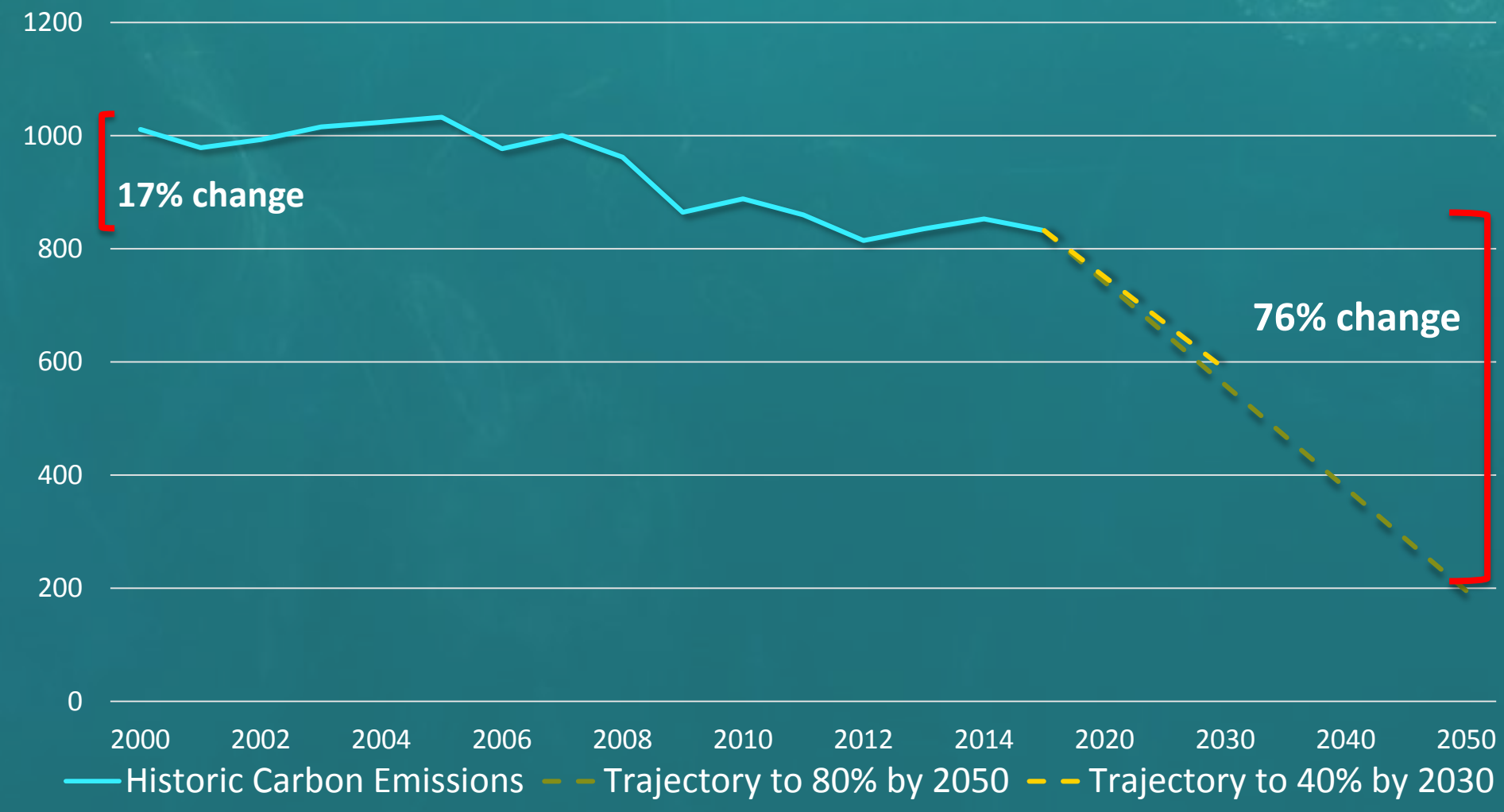
Drive market transformation regionally by fostering collaboration and innovation, developing tools, and disseminating knowledge

NEEP Region Building Carbon Emissions



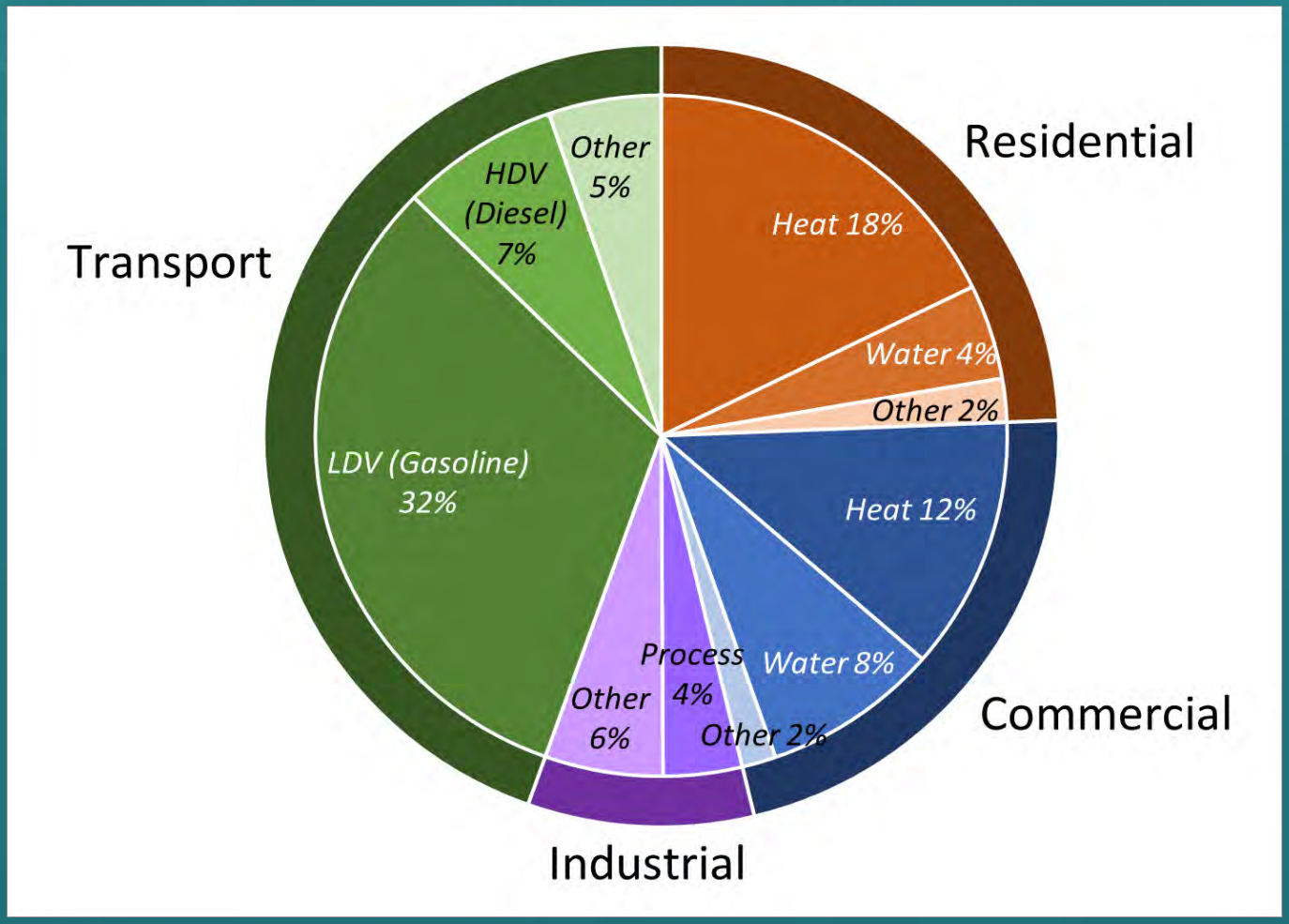

Regional Commitments
2020
2028
2030
2032
2050
10% by 2020
80% by 2050
30%
by 2030
10% by 2020
80% by 2050
25%
by 2020
25% by 2020
80% by 2050
10% by 2020
80% by 2050
STABLIZE
80% by 2050
40% by 2030
80% by 2050
33%
by 2030
10% by 2020
80% by 2050
50% by 2028
75% by 2050
50% by 2032
80% by 2050

Are we on the path to 80% by 2050?



Source: Historic carbon emissions data from EIA, trajectory calculated based on regional carbon levels in 2001

Direct Use of Fossil Fuels (NE/NY)



SIZING UP THE CHALLENGE: Efficiency Retrofits + Electrify Heating New York & New England

- 14.6 million homes
- 20% of regional carbon emissions
- 75% built before 1980
- 80%+ need:
  - \+ Efficiency retrofits and associated improvements
  - \+ Heat pumps
  - = $5,000 - $30,000 per home
- Cost: $200 billion +
- Multiple Benefits – health, comfort, safety, resilience

$13 Billion Annual Regional Spend on Home Heating Fuels

Data Sources – US Census Bureau and US DOE Energy Information Administration

Building Decarbonization – 3 Key Elements

NEEP's analysis points to three critical elements to a strategic electrification pathway that benefits consumers, businesses and the environment. These are:

Advanced Electric Technologies

Space/Water Heating – Heat Pumps

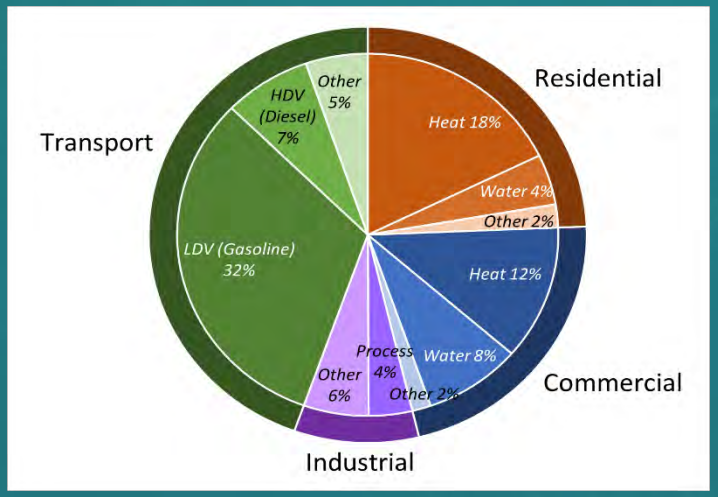
Deep Energy Efficiency

Thermal Improvements

Grid Integration

Flexible use of Low-Carbon Electricity

Advanced Electrification Technologies



Public Policies to Accelerate Building Decarbonization

- Statewide Carbon Reduction Goals
- Utility Regulation
  - Rate Design
  - Efficiency Programs – total building performance, all fuels, low carbon
  - Smart Buildings & Grid investment
- Building Standards
  - Advanced Building Energy Codes
  - Building Energy Rating & Disclosure
  - Time-of-sale or lease building improvements
- Community Leadership
  - Supported by state efforts
- Supporting Policies
  - Renewable Energy
  - Energy Storage
  - Lead-by-Example
  - Workforce Development
  - Financing
  - Policy Linkages
    - Energy Affordability
    - Health Care
    - Community & Economic Development

Highlights of Regional Policy/Program – Buildings Decarbonization

VERMONT

- Incentives for ASHPs and HPWHs through Efficiency VT and utilities
- Tier 3: GMP ASHPs and HPWHs for RES compliance
- Montpelier – Building Energy Standards & Disclosure new and existing homes & buildings

NEW HAMPSHIRE

- Developed first-in-nation **RPS carveout for renewable thermal**
- ASHP and HPWH rebates from individual utilities

MAINE

- Significant uptake in residential ASHP/HPWH through Efficiency Maine rebate and financing programs (**over 20,000 rebates FY14-FY16)**

NEW YORK

- New York REV - Policy
- NYSERDA Clean Energy Investment Plan
- NYSERDA & utility Heat Pump Incentives
- Workforce Development
- NYC Multifamily Retrofit & Heat PU,

MASSACHUSETTS

- Renewable thermal energy into Alternative Portfolio Standard
- ASHP, GSHP, and HPWH rebates via state and utility programs
- Solarize Mass Plus will include heat pumps, EVs, and storage
- Expanded cost-benefit test to recognize health, safety, comfort values of deep efficiency

CONNECTICUT

- Heat pump rebates available through Energize CT
- Home Energy Scores
- DOE ZERH

RHODE ISLAND

- ASHP Incentives, Building Energy Rating
- Exploring **workforce development programs** to drive heat pump uptake (e.g. engaging delivered fuel dealers)

New – Newsletter & Pod Cast

Subscribe https://neep.us3.list-manage.com/subscribe?u=efc742661f1436c5f27ab78ba&id=d09b004d10

For information on how to partner, they can email Dave Hewitt (dhewitt@neep.org) or Sue Coakley (scoakley@neep.org)

NEEP Resources

- NEEP's Strategic Electrification Resource Center: http://www.neep.org/initiatives/strategic-electrification
- Strategic Electrification Resource Catalog: http://www.neep.org/sites/default/files/NEEP%20Strategic%20Electrification_Resource%20Catalogue_Updated%20April%202018.pdf
- Action plan to Accelerate Strategic Electrification in the Northeast and Mid-Atlantic: http://neep.org/reports/strategic-electrification-action-plan
- Regional Assessment of Strategic Electrification Report: http://www.neep.org/reports/strategic-electrification-assessment
- 2017 Strategic Electrification Summit: http://www.neep.org/events/2017-regional-strategic-electrification-summit
- Northeast/Mid-Atlantic ASHP Market Transformation:
  - Regional High Performance Heat Pump Project & Working Group: https://neep.org/ashp
  - Regions ccASHP Market Transformation Strategy: http://www.neep.org/sites/default/files/NEEP_ASHP_2016MTStrategy_Report_FINAL.pdf
  - Cold Climate ASHP Product List: https://neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump

For more information:

www.neep.org

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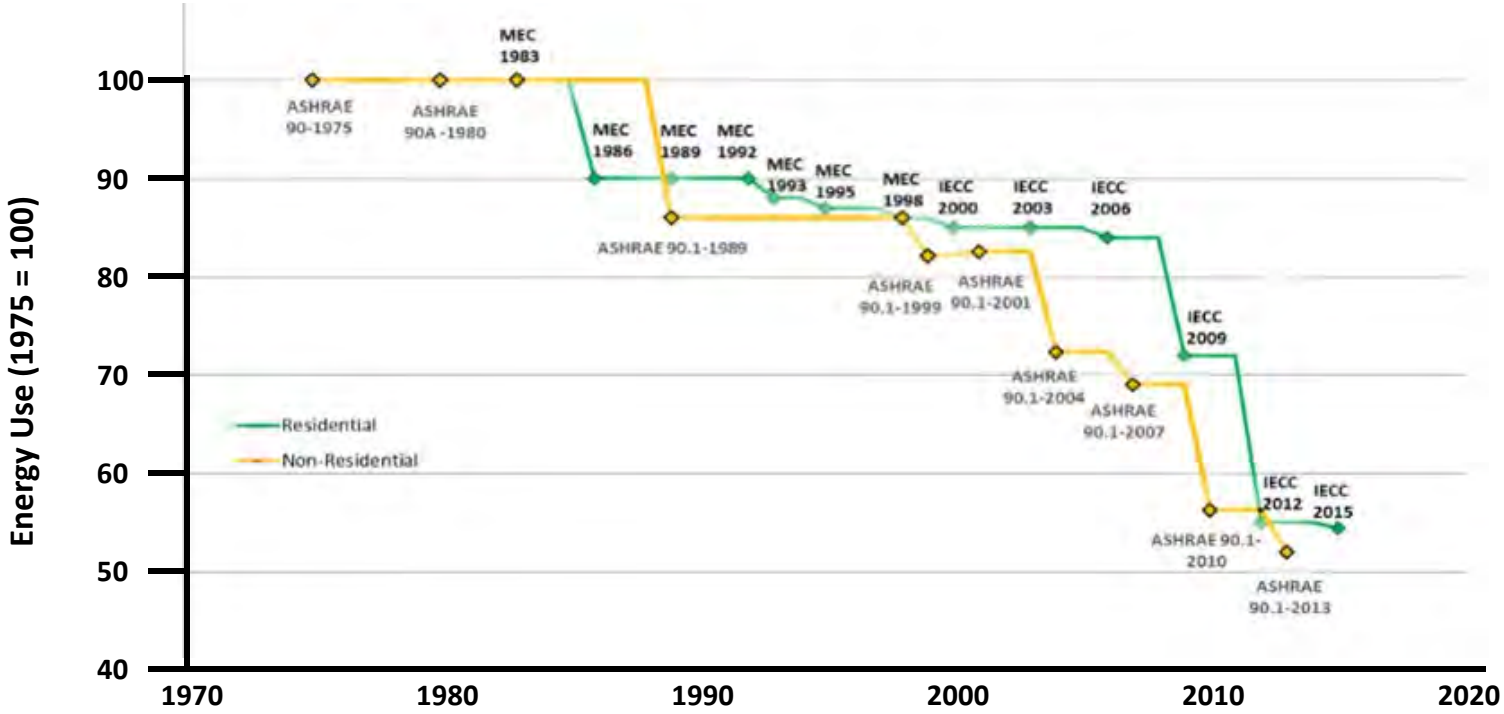
The Race Towards Carbon Neutrality: Drivers and Barriers

March 14 , 2019

Massachusetts Department of Energy Resources



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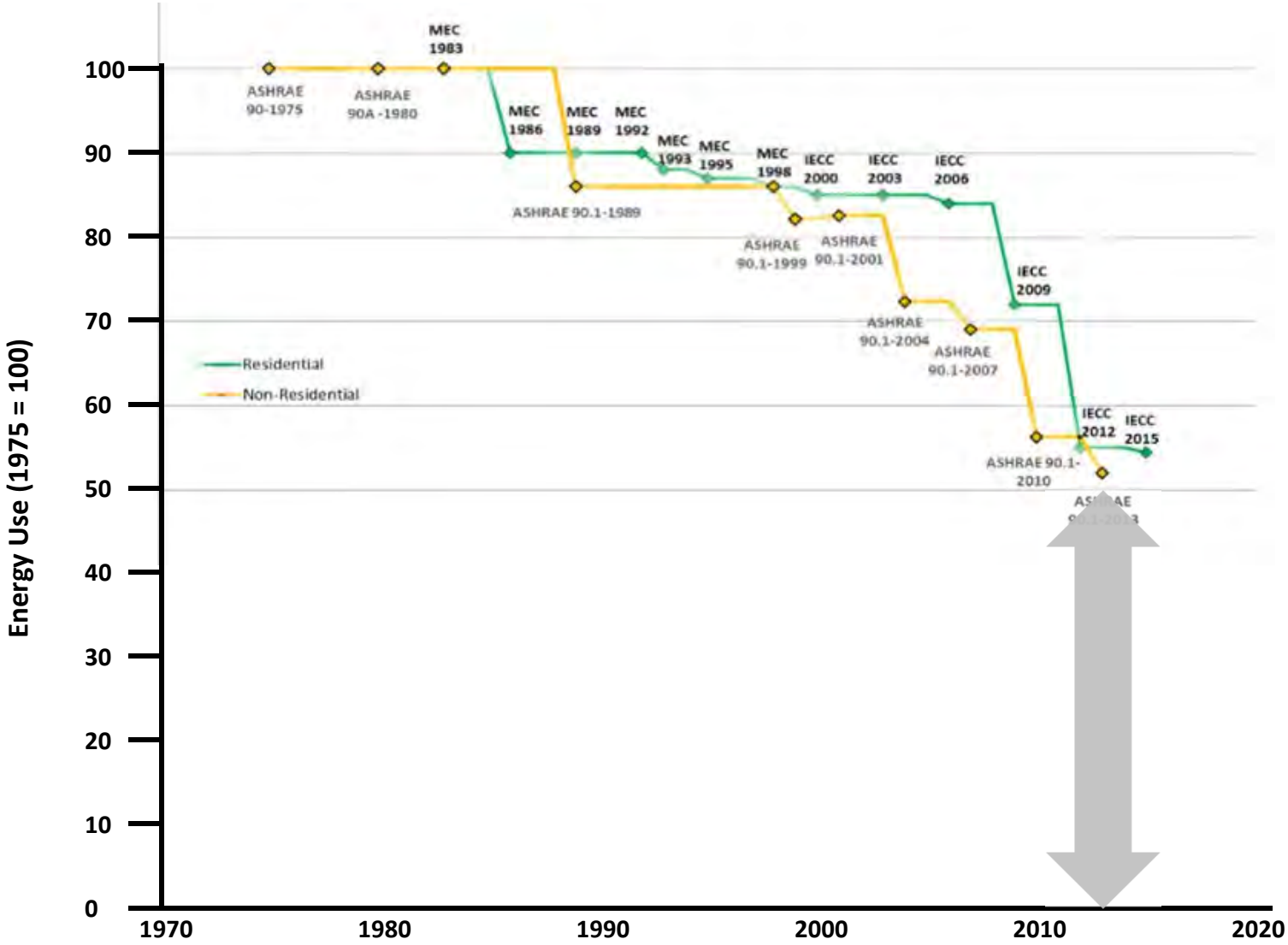

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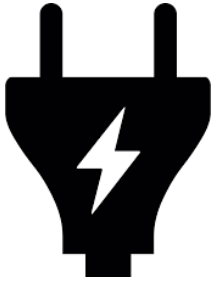

electric energy

=

gas energy

Last 50 years of Code:

all saved energy (saved BTUs)
are the same

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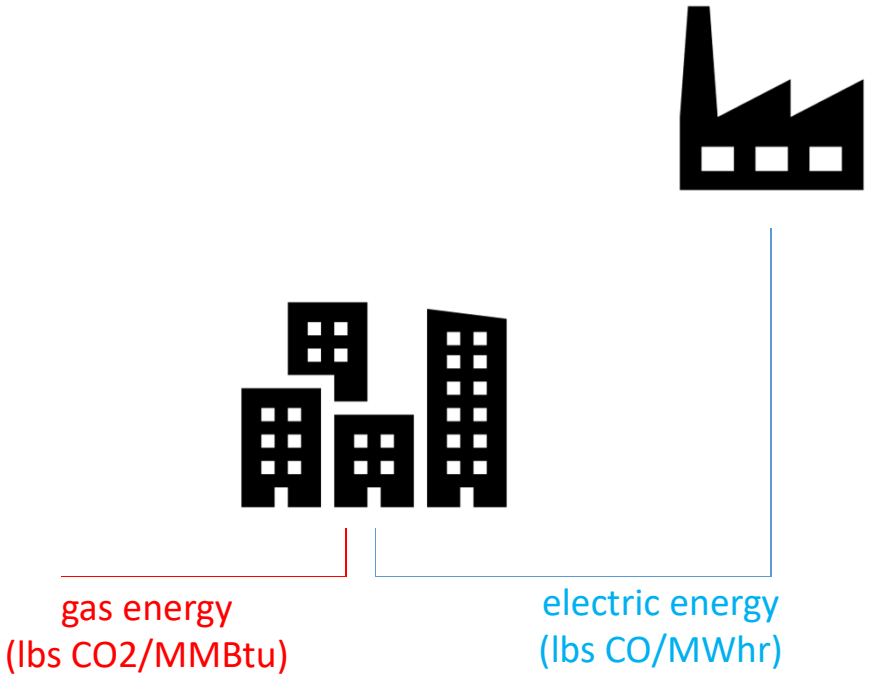

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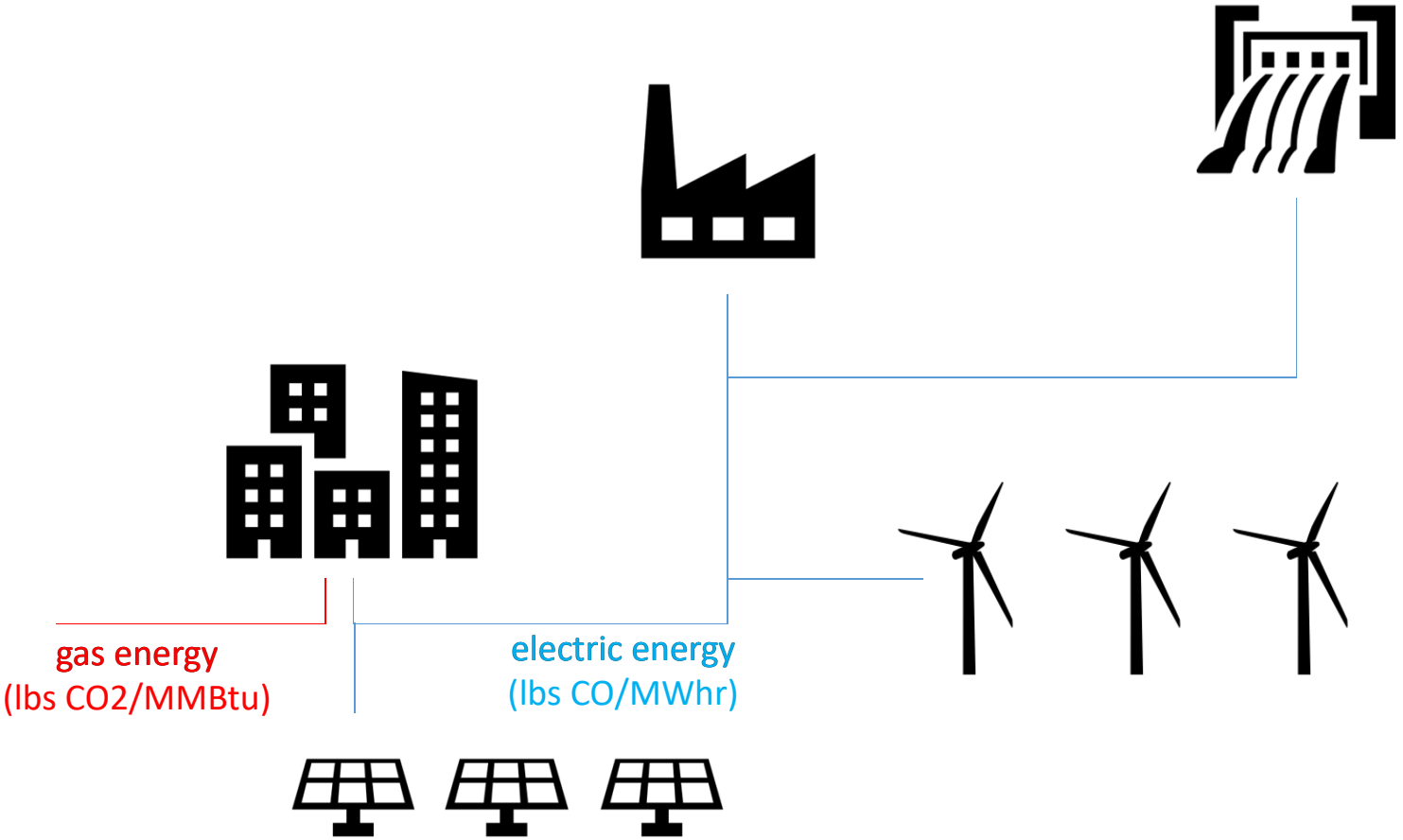

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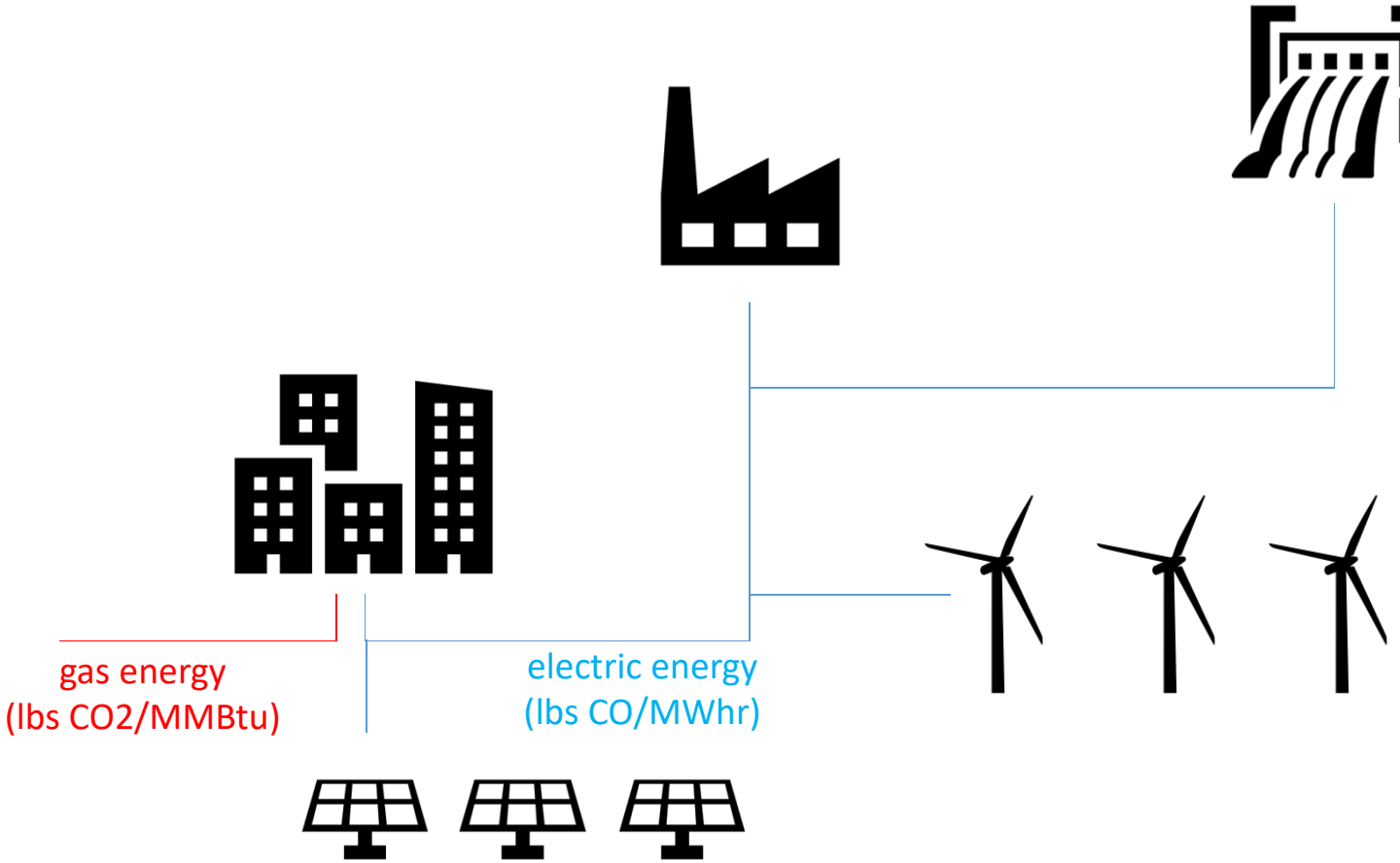

Year	Emission Rate (lbs CO2/MWhr)
2020	700
2030	600
2040	400
2050	200

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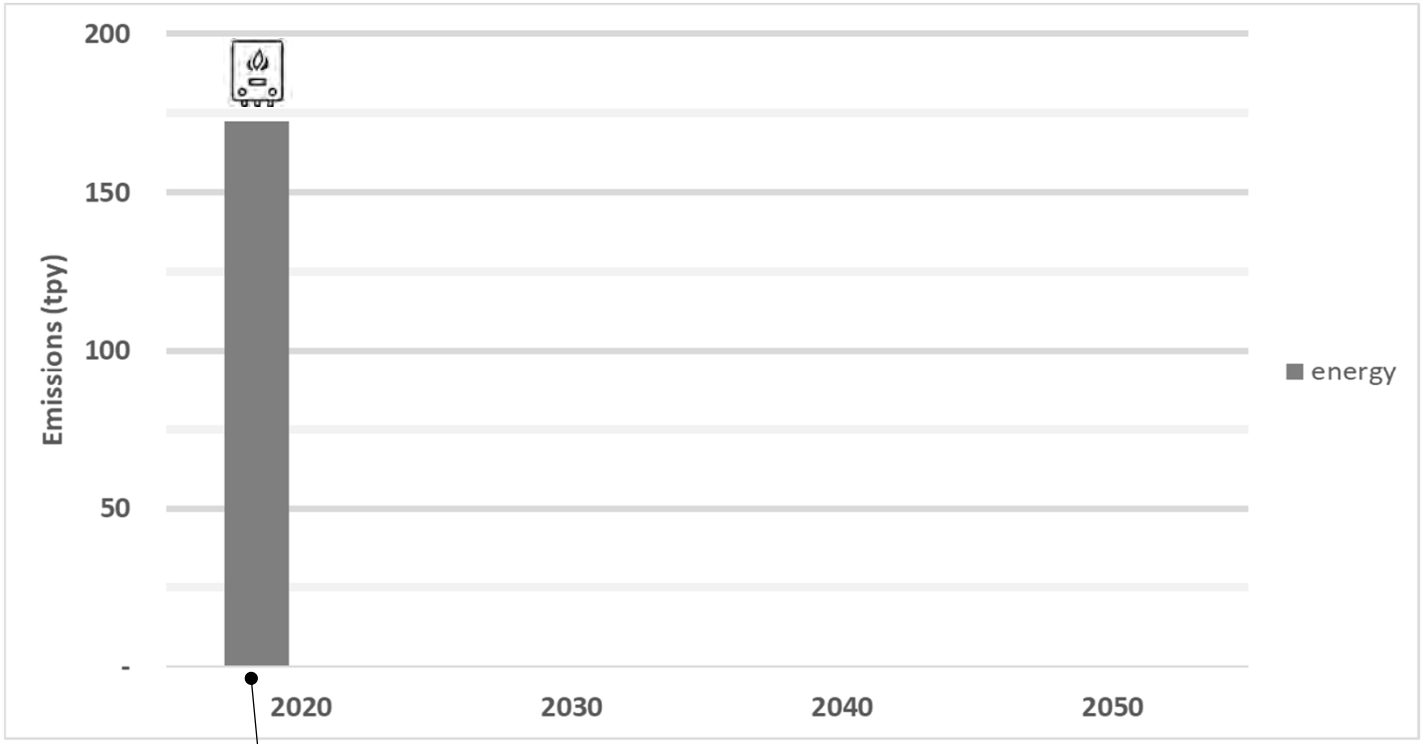
50,000-sf multifamily



Typically better-than-Code building with gas heat and hot water

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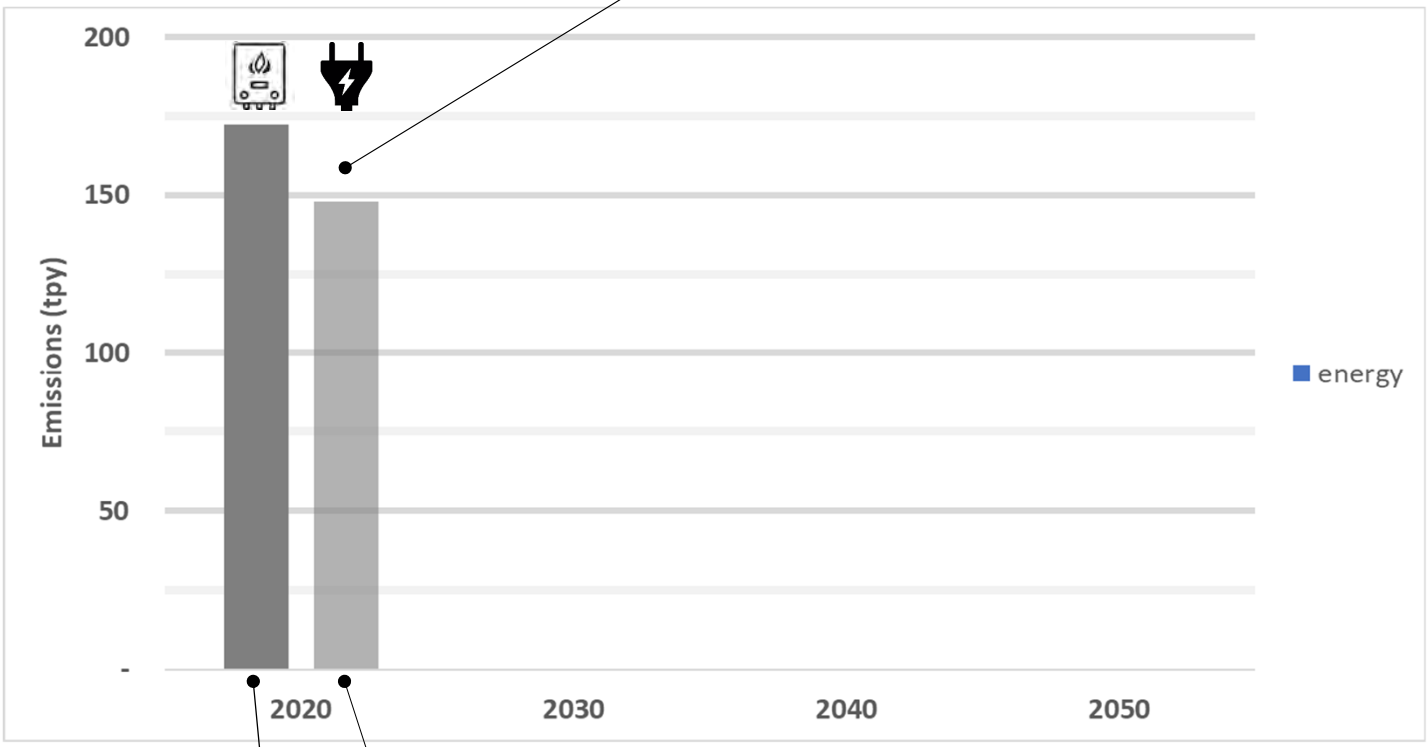
50,000-sf multifamily

14% improvement



Typical better-than-Code building with gas heat and hot water

Swapping gas heat and hot water with electric heat pump heat and hot water

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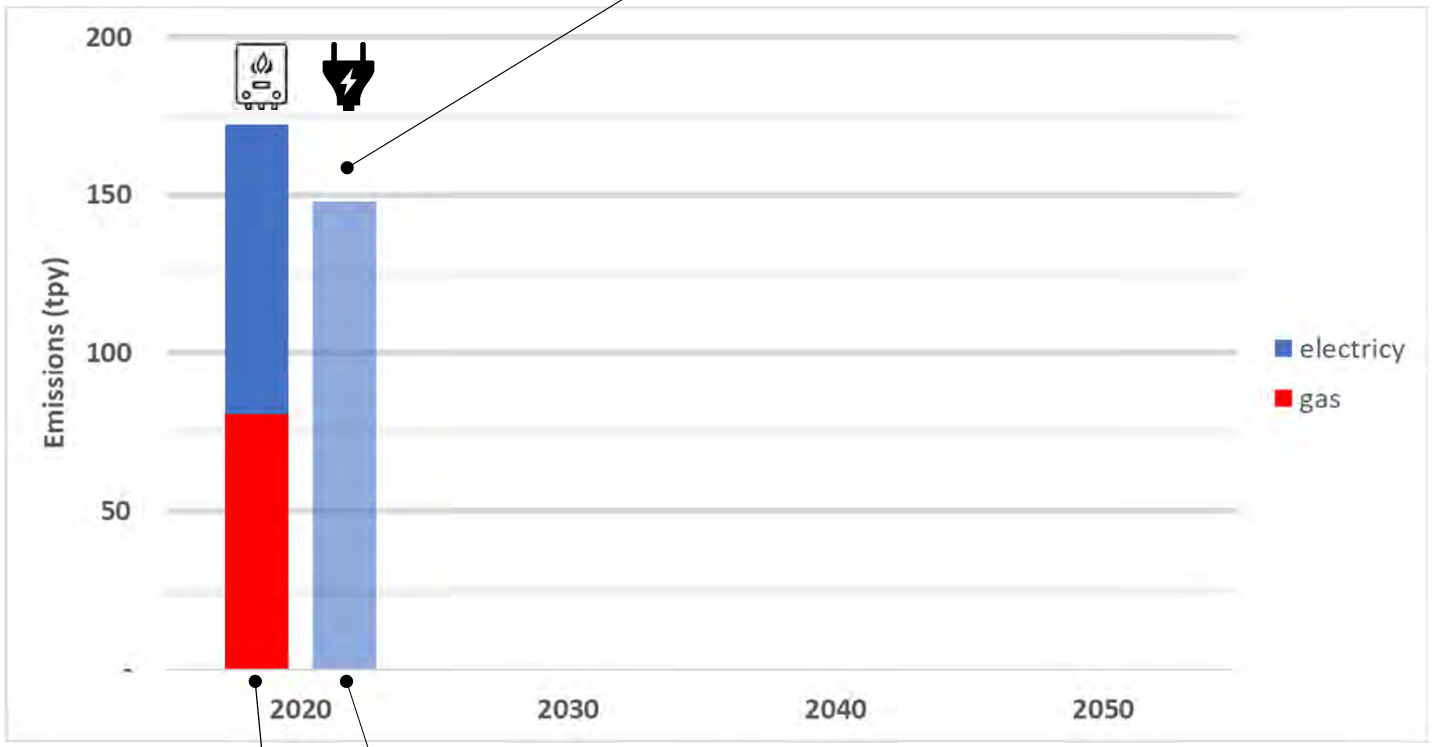
50,000-sf multifamily

14% improvement



Typical better-than-Code building with gas heat and hot water

Swapping gas heat and hot water with electric heat pump heat and hot water

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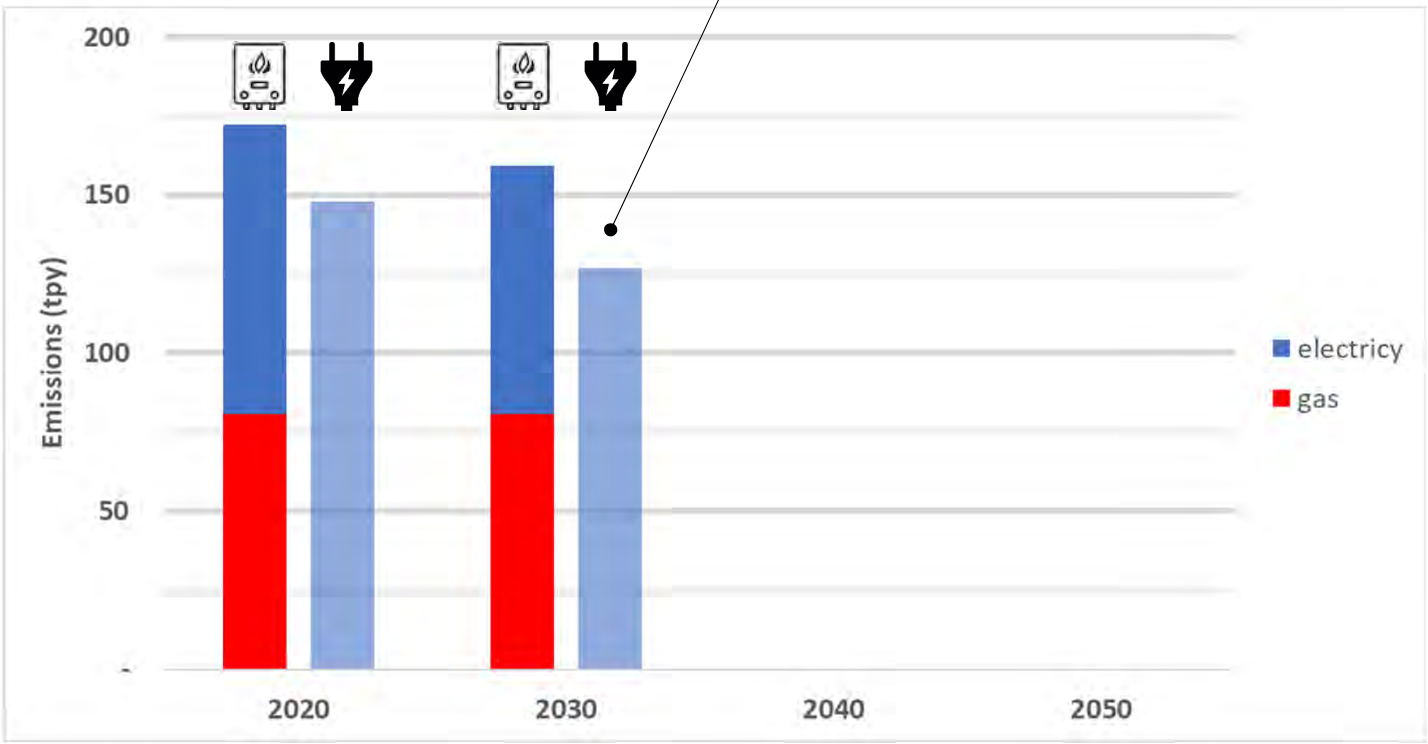
50,000-sf multifamily

20% improvement



Electric Emission Rate (Lbs CO2/ Mwhr)	700	600

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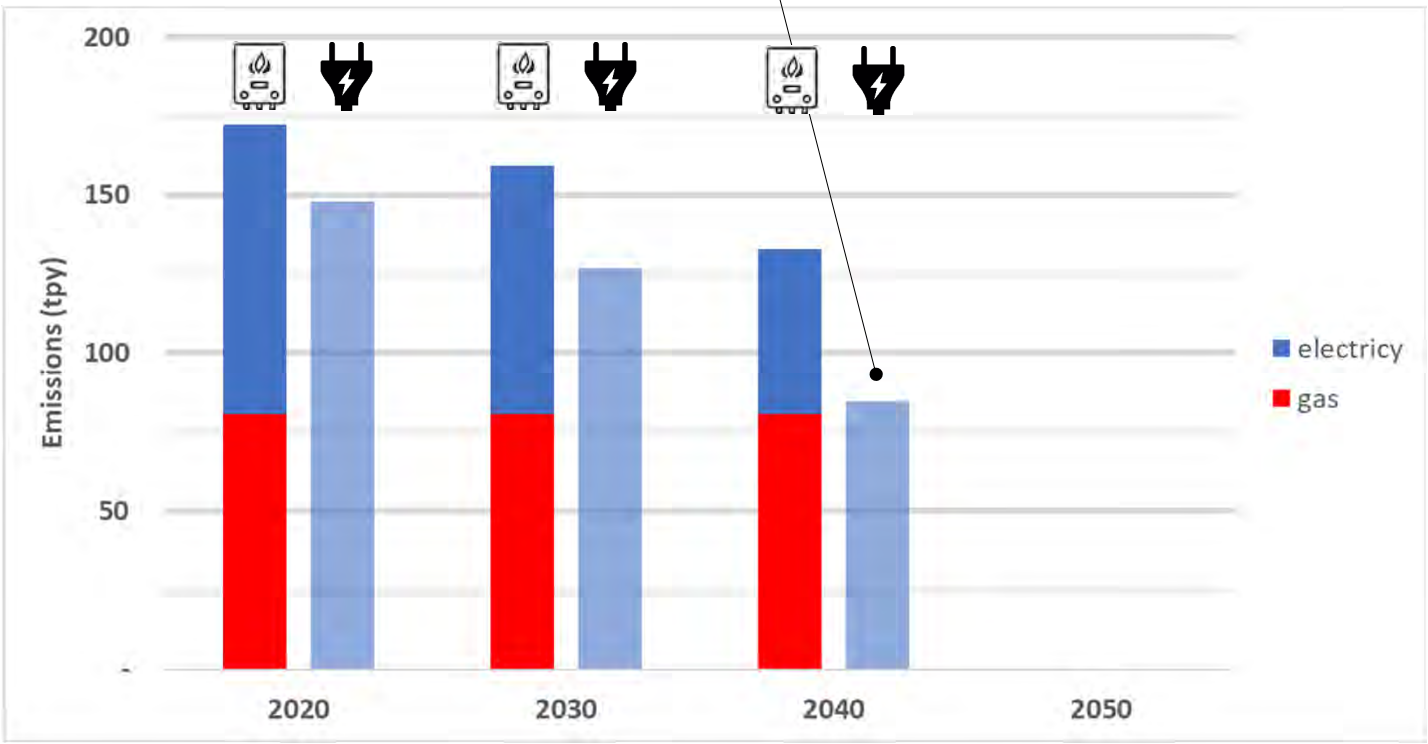
50,000-sf multifamily

36% improvement



Electric Emission Rate (Lbs CO2/ Mwhr)	700	600	400

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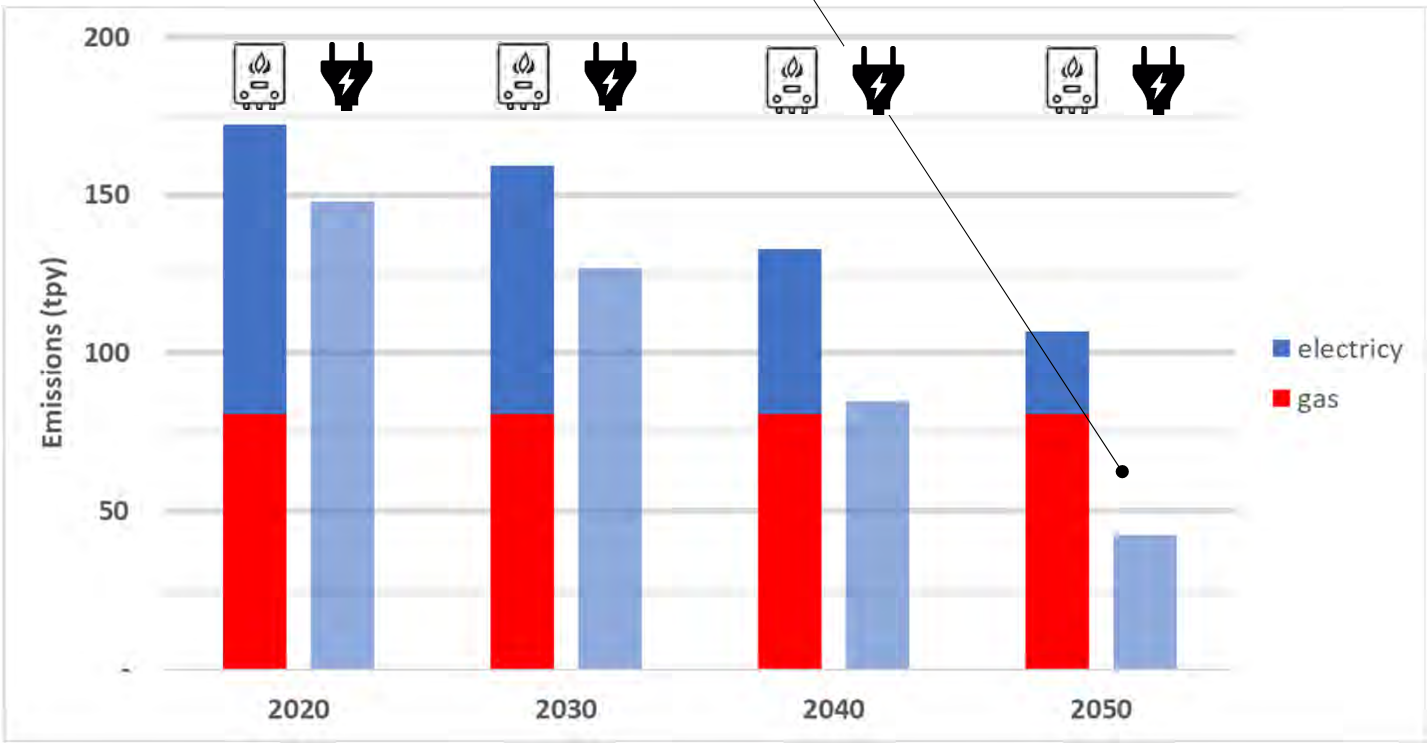
50,000-sf multifamily

60% improvement



Electric Emission Rate (Lbs CO2/ Mwhr)	700	600	400	200

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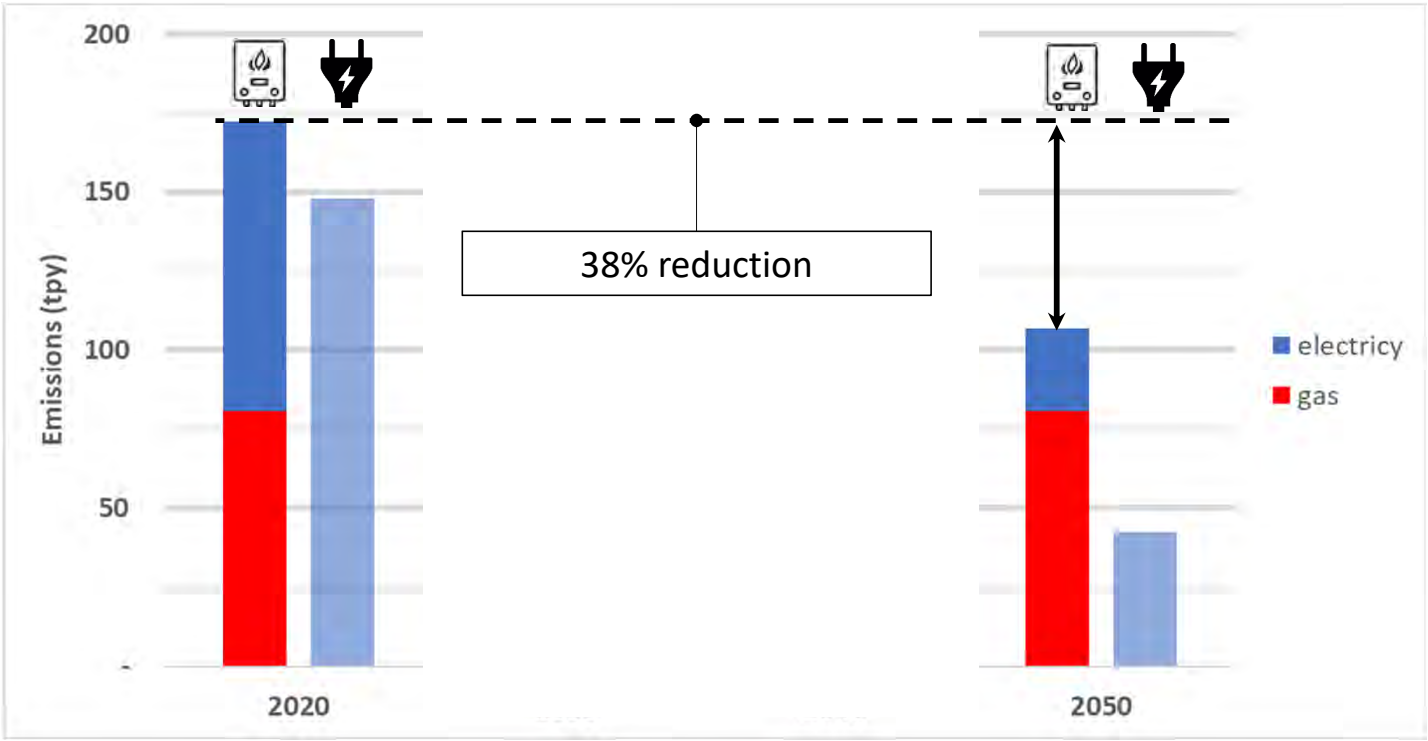
50,000-sf multifamily



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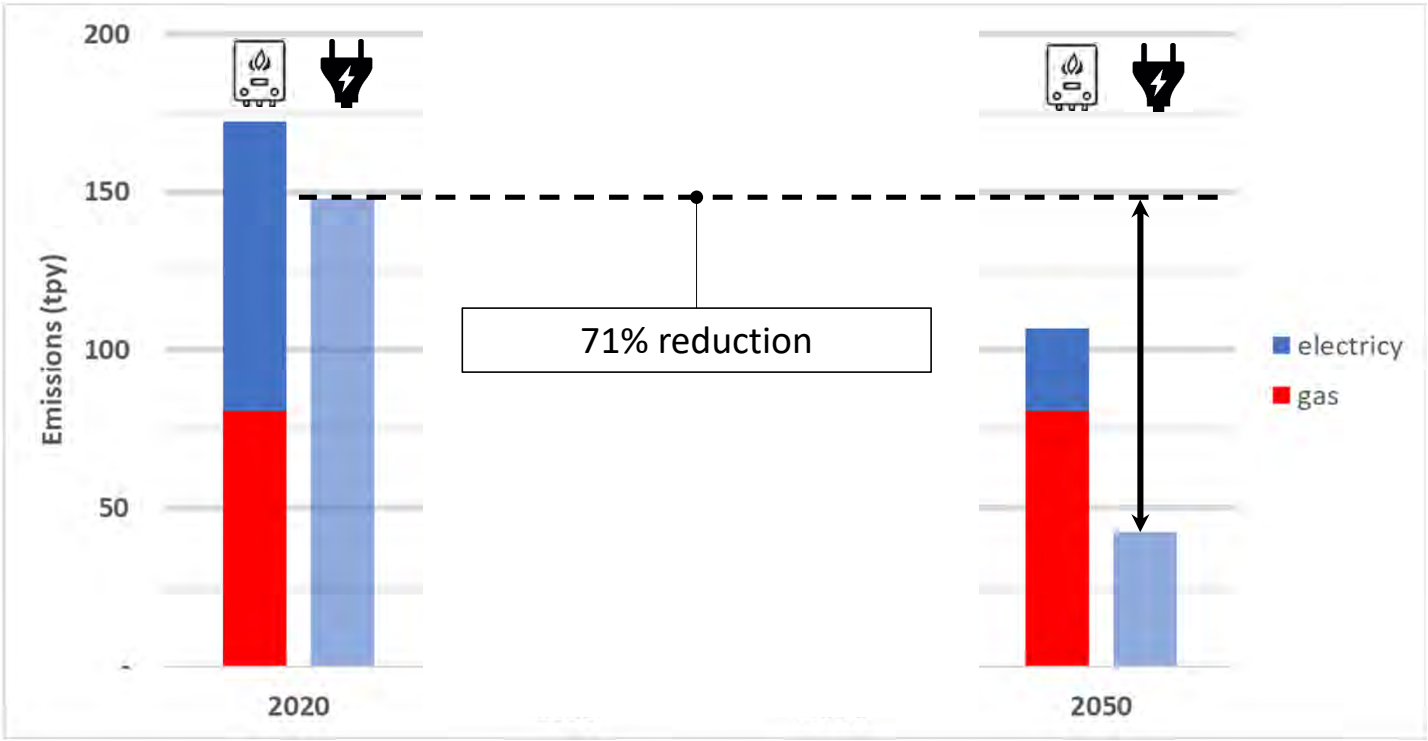
50,000-sf multifamily



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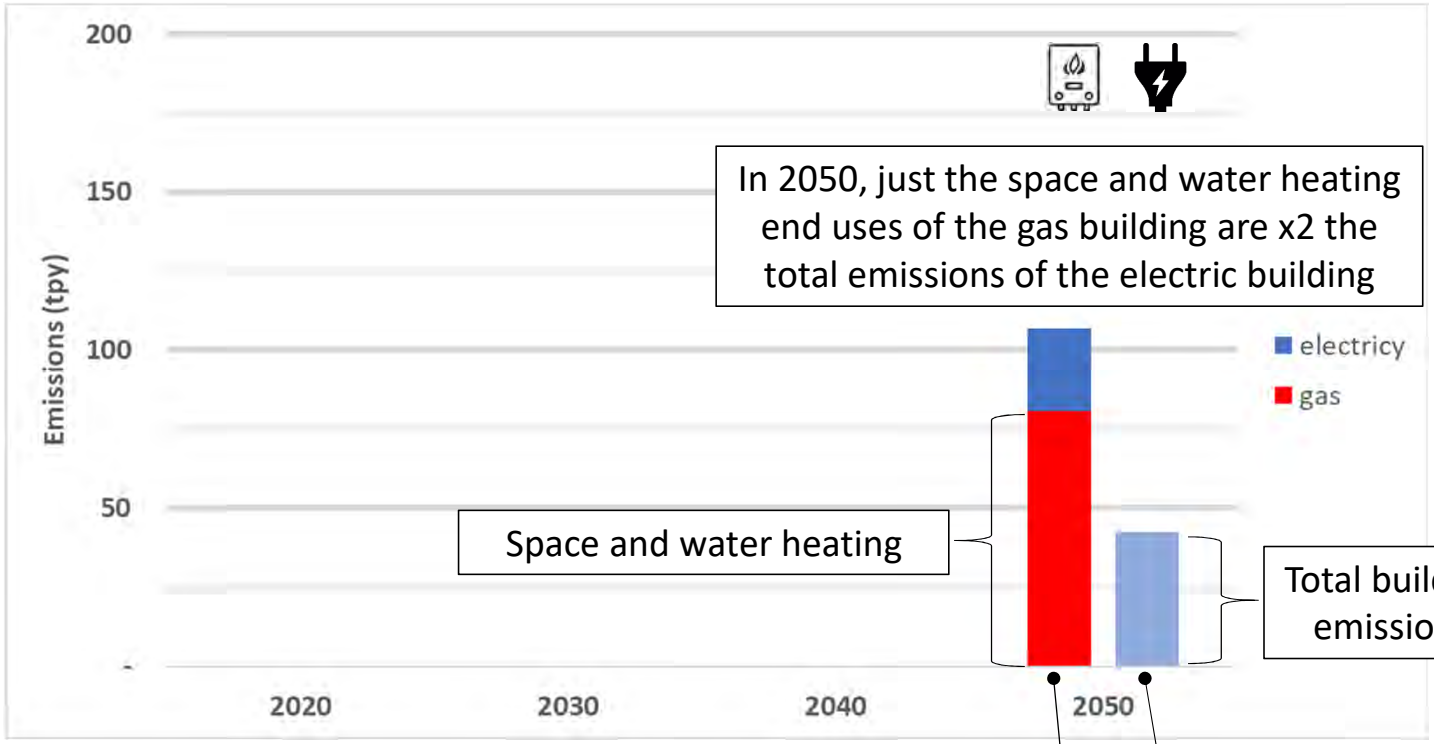
50,000-sf multifamily



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50,000-sf multifamily

$1/therm
$0.20/kWhr

Annual Cost	 Space heating and hot water with Gas	 Space heating and hot water with electric heat pumps
Gas	$14,000	$0
Electricity	$52,000	$85,000
Total	**$66,000**	**$85,000**

least cost

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50,000-sf multifamily

$1.50/therm
$0.20/kWhr

Annual Cost	Space heating and hot water with Gas	Space heating and hot water with electric heat pumps
Gas	$21,000	$0
Electricity	$52,000	$85,000
Total	**$73,000**	**$85,000**

least cost

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50,000-sf multifamily

$1.50/therm
$0.20/kWhr

Peak space heating: 12.4 btu/hr-sf

Peak space heating: 4.4 btu/hr-sf

Annual Cost	Space heating and hot water with Gas	Space heating and hot water with electric heat pumps	+ PH Space heating and hot water with electric heat pumps and Passivehouse
Gas	$21,000	$0	$0
Electricity	$52,000	$85,000	$64,000
Total	**$73,000**	**$85,000**	**$64,000**

least cost

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ENABLING STEPS

- Envelope
- Air tightness
- *Peak heat limit?*
- *Total heat limit?*

ELECTRIFICATION OF HEATING

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Idea	Implementation into Code
Not all Btus are the same	• Emissions basis, not Btu basis • Recognize future grid emission rates
Electrify space and water heating	• Heat pump space heating • Heat pump water heating
Enabling Steps to Electrify	• Heating peak limits (btu/sf-hr); total heat limits (btu/sf-yr) • Envelope backstop

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March 14, 2019

NESEA Building Energy Boston

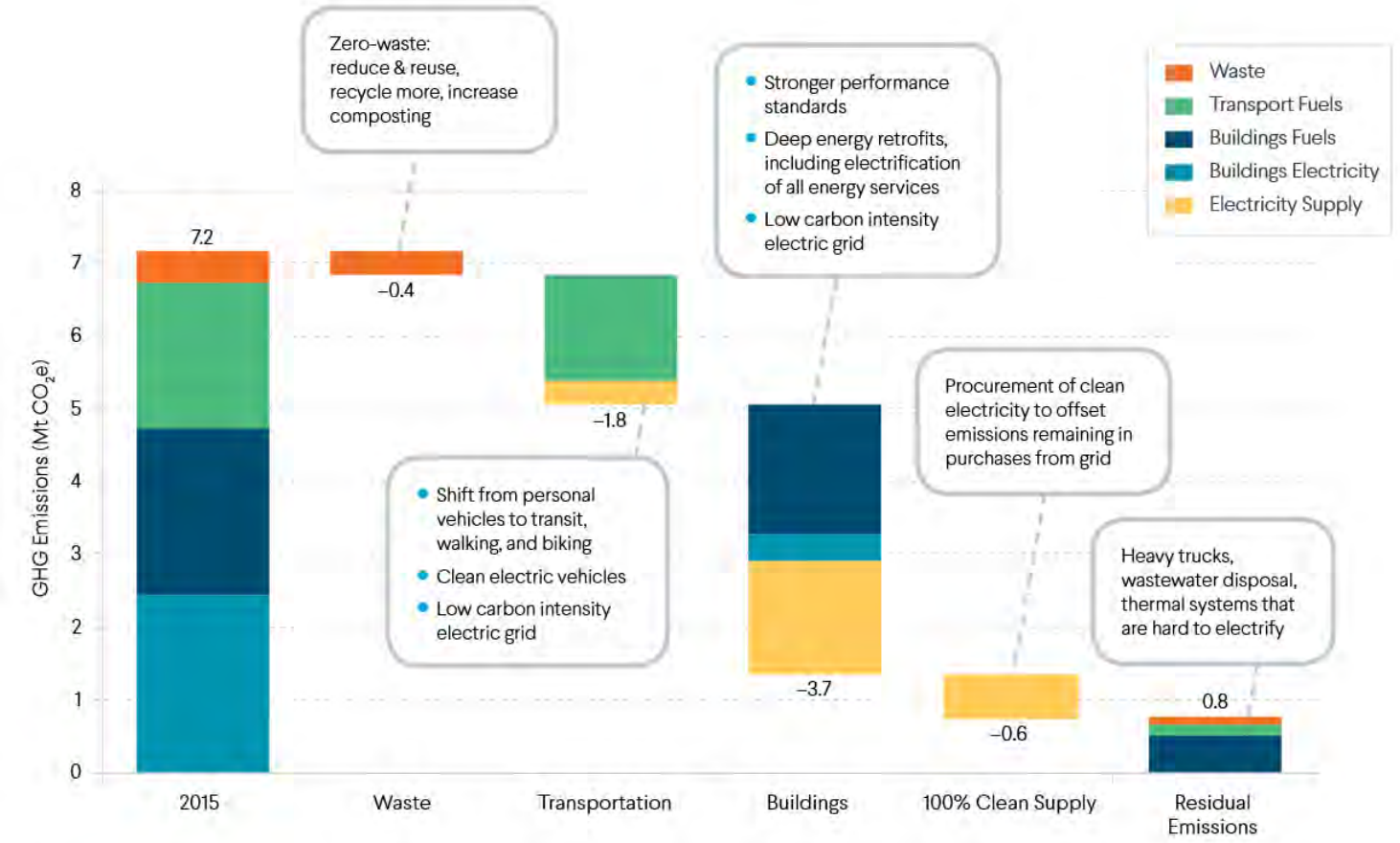
The Race Toward Decarbonization

Elizabeth Galloway PE, CEM, CPHD, WELL AP, LEED AP BD+C

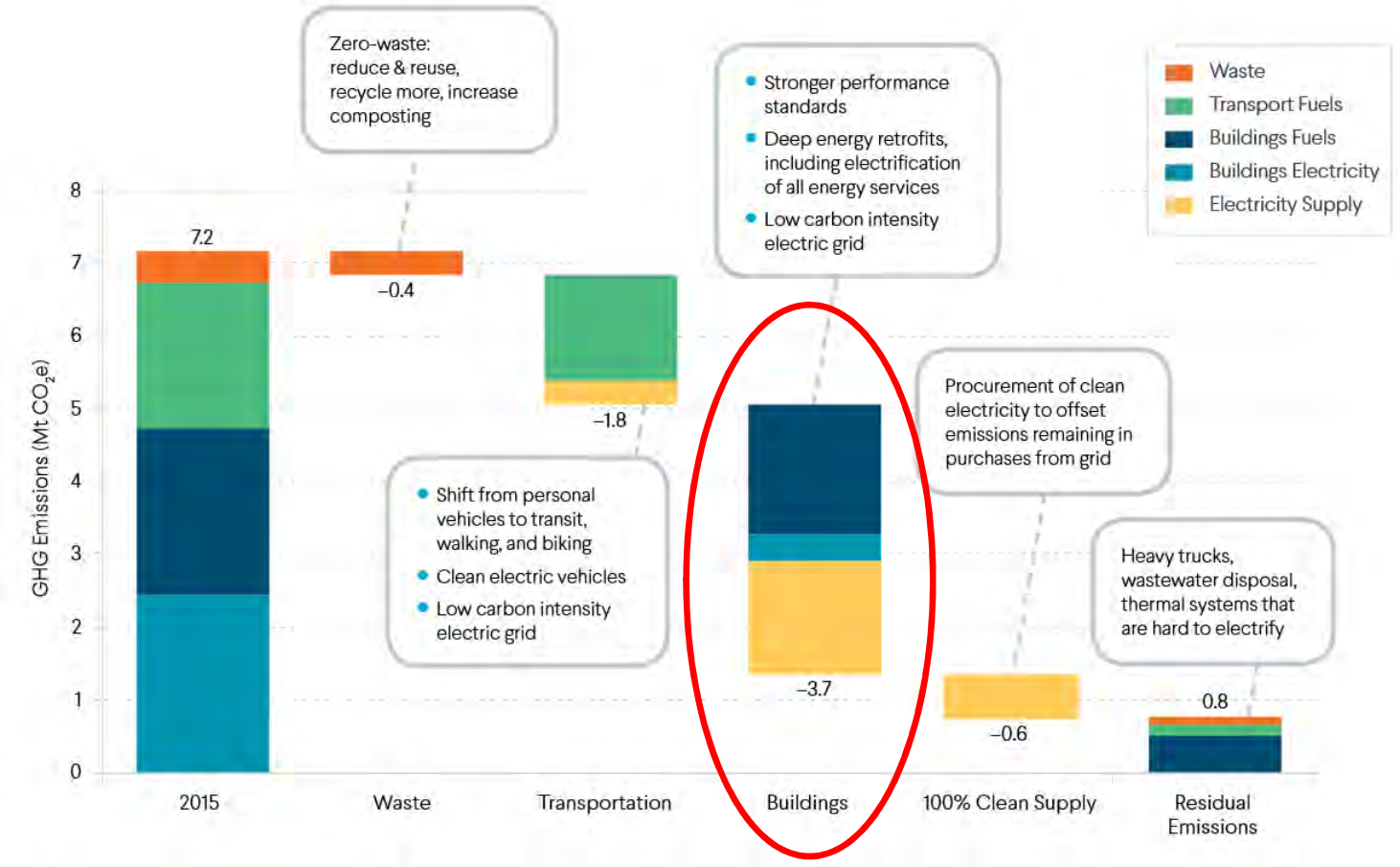
FUSION OF DESIGN + PERFORMANCE

PAYETTE

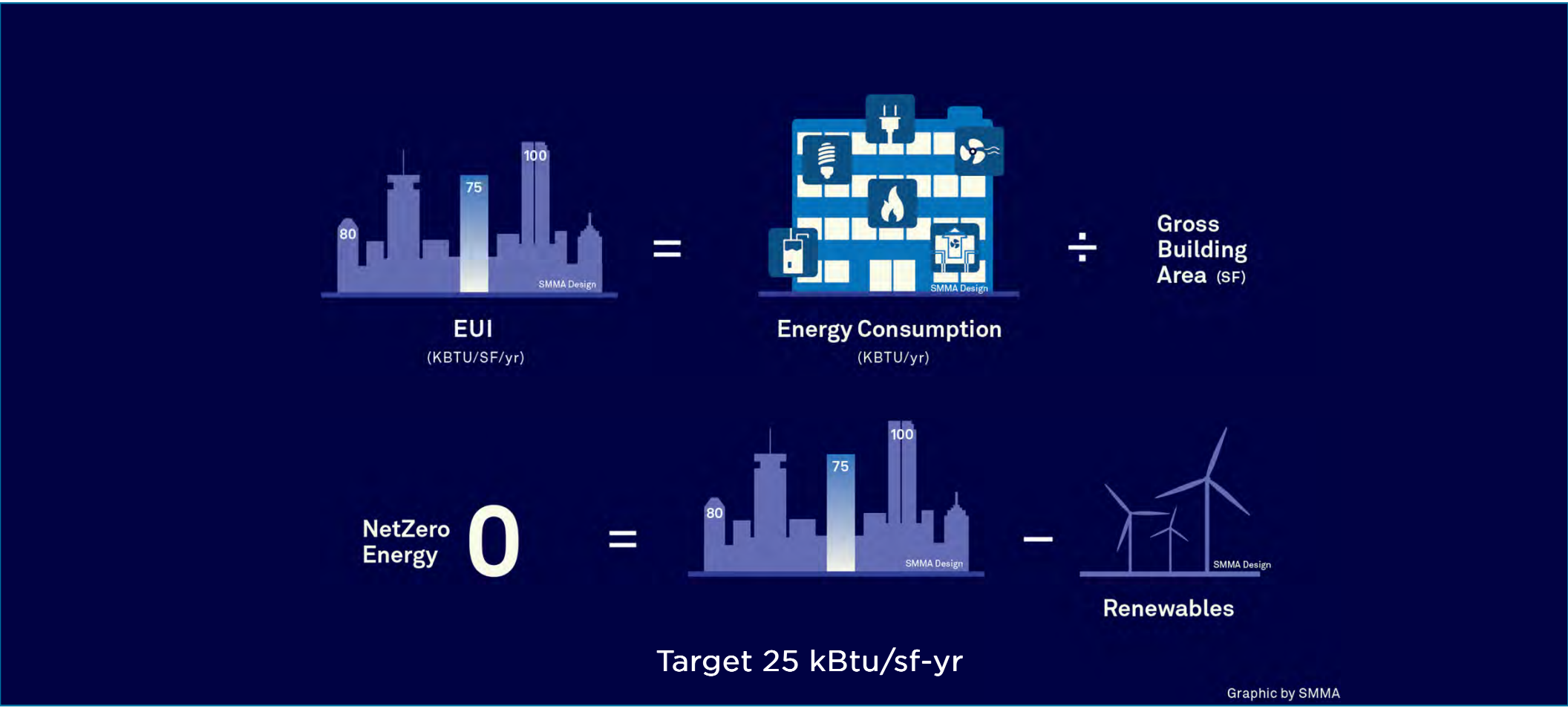
CARBON FREE BOSTON SUMMARY REPORT



CARBON FREE BOSTON SUMMARY REPORT



ENERGY USE INTENSITY



2017 BERDO DATA

Average EUI of office buildings constructed since 2007

80
Kbtu/sf-vr

35-150
Kbtu/sf-vr

RELATIVE VERSUS ABSOLUTE METRICS

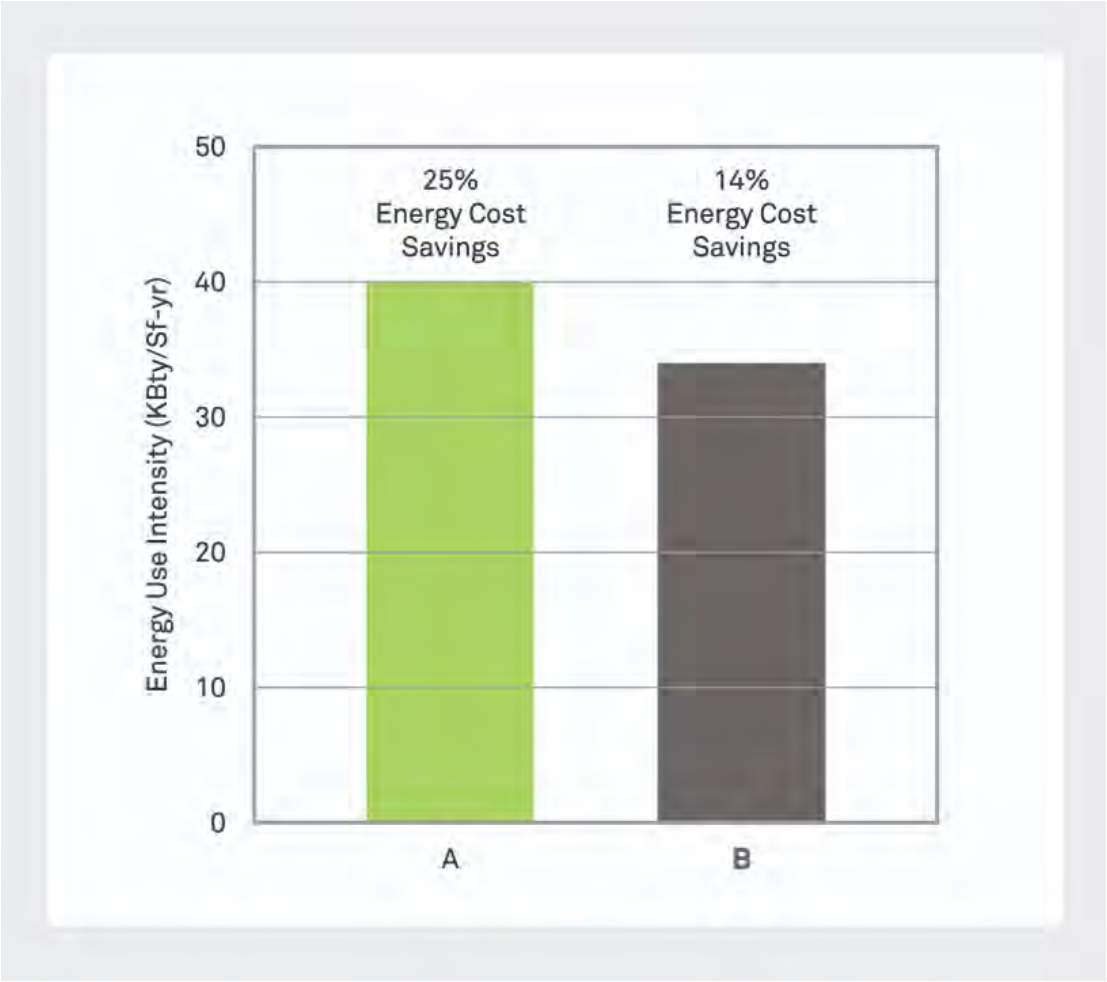
Core and Shell Office

250,000 SF

8 Stories

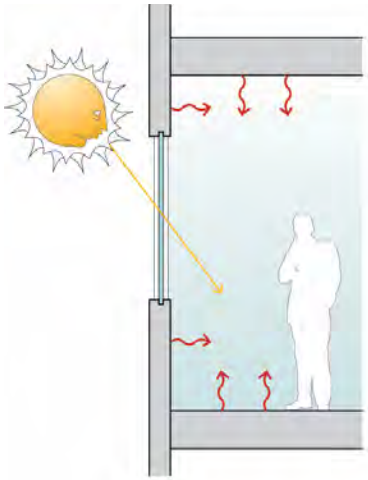
LEED 2009

Modeled against ASHRAE 90.1-2007



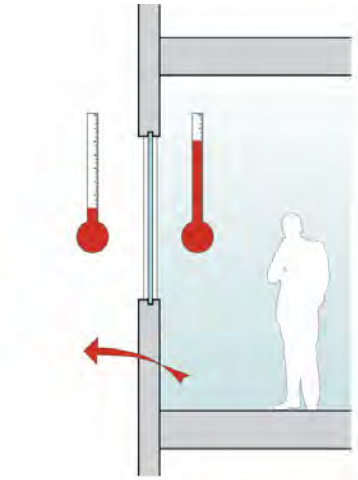
ENVELOPE INFLUENCE ON ENERGY

Thermal Mass

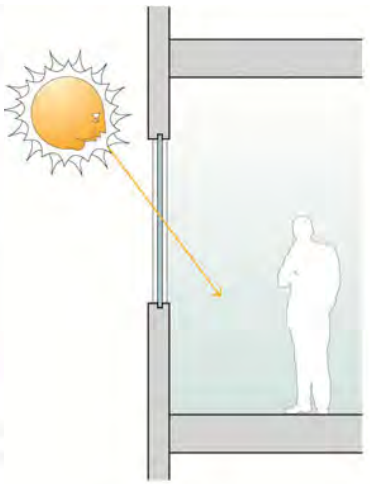


Infiltration

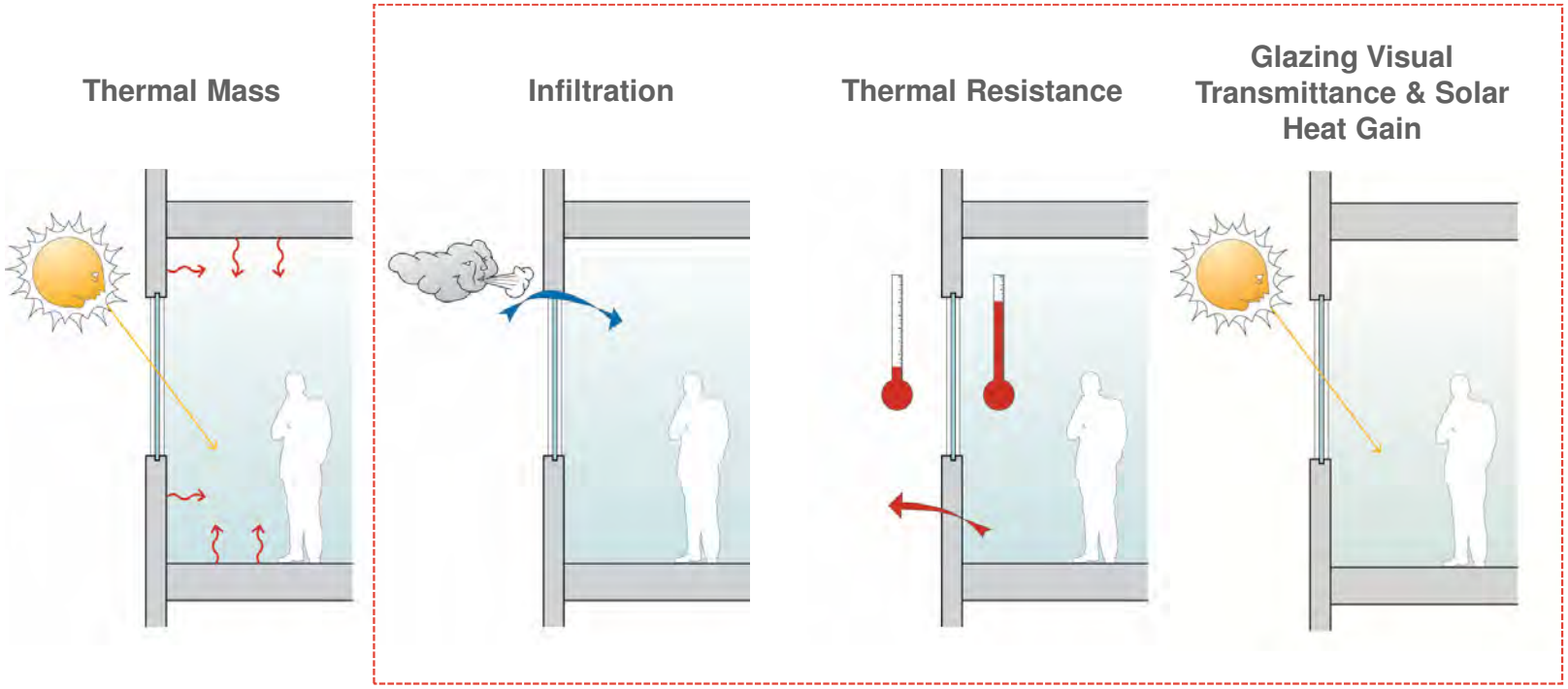
Thermal Resistance



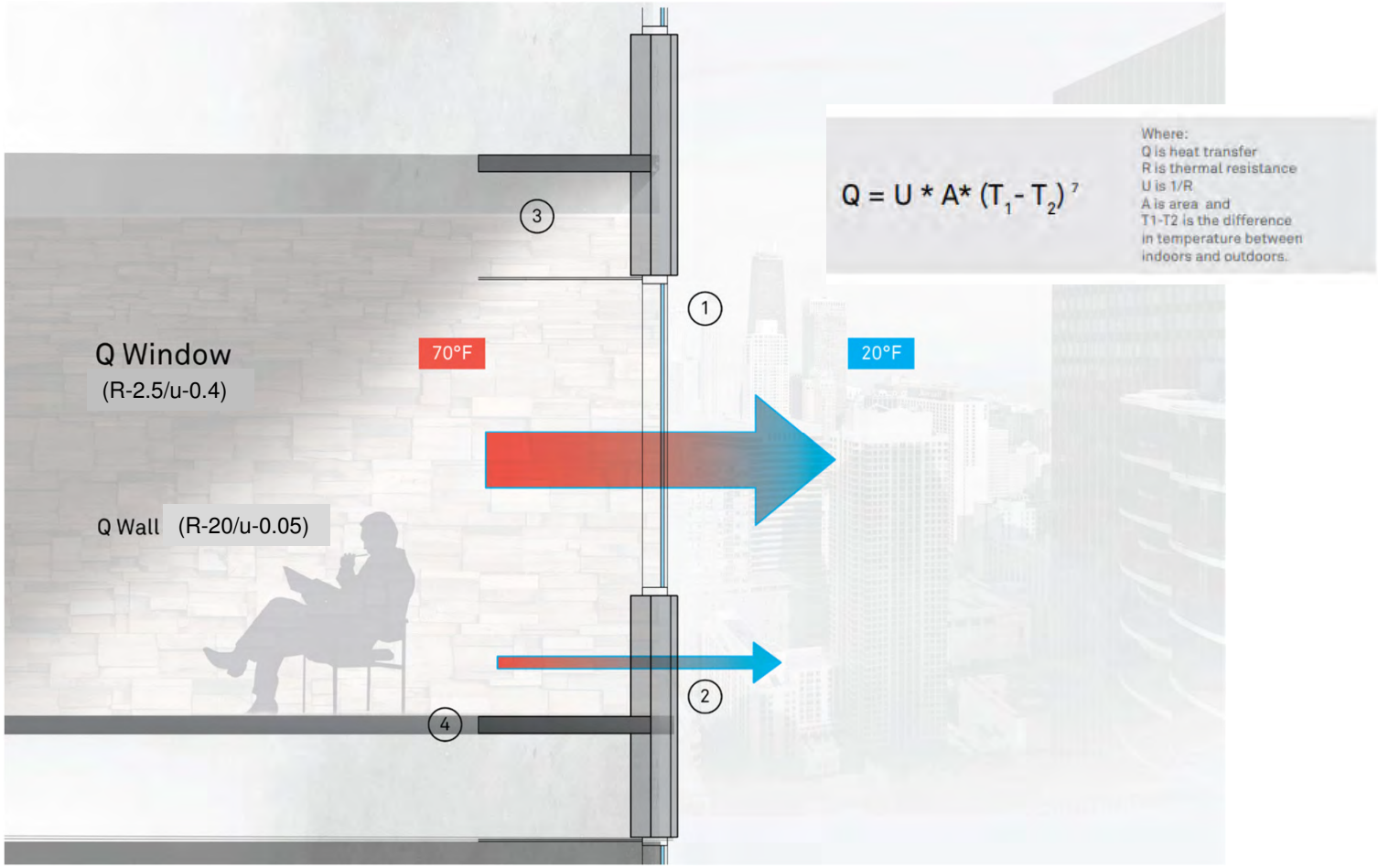
Glazing Visual Transmittance & Solar Heat Gain



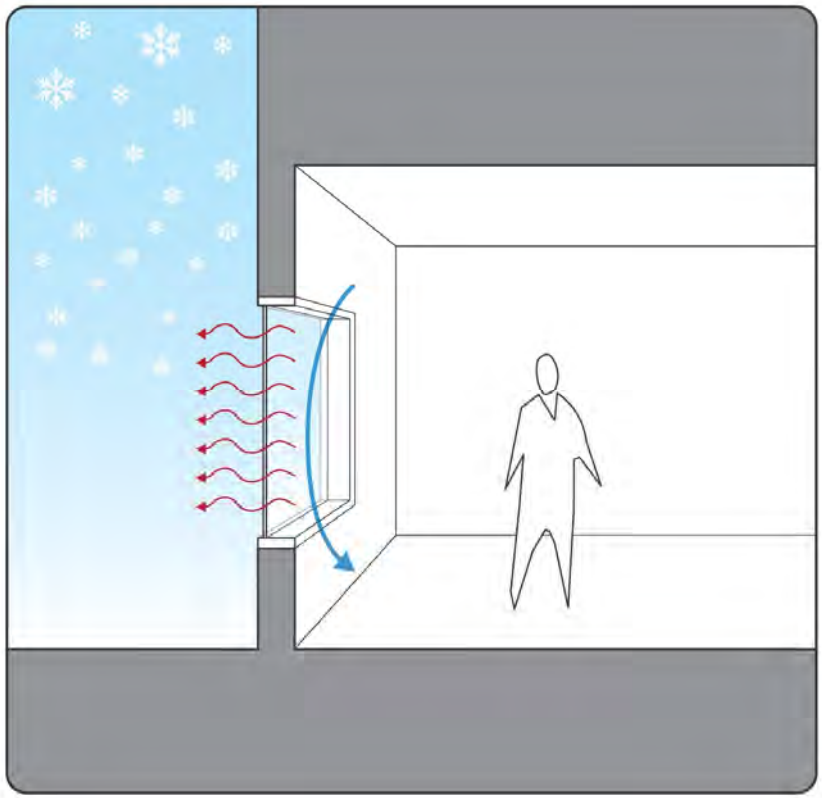
ENVELOPE INFLUENCE ON ENERGY



HEAT LOSS

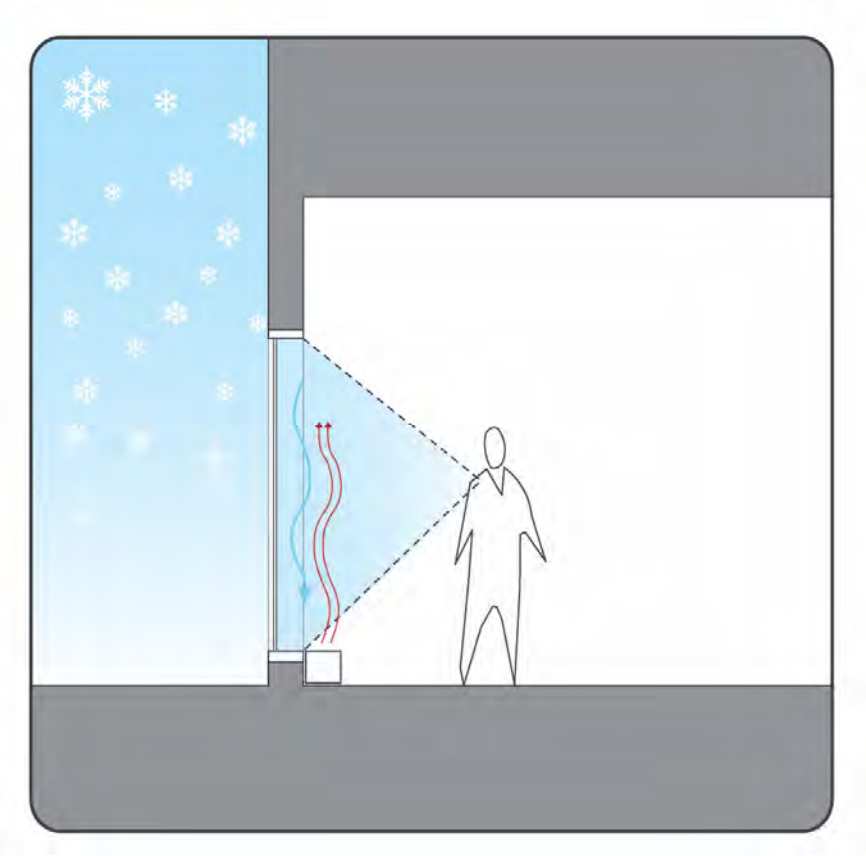

Q = U * A* (T1 - T2)
Where:
Q is heat transfer
R is thermal resistance
U is 1/R
A is area and
T1-T2 is the difference
in temperature between
indoors and outdoors.
Q Window
(R-2.5/u-0.4)
70°F
20°F
Q Wall (R-20/u-0.05)
1
2
3
4

COMFORT | THERMAL COMFORT FACTORS



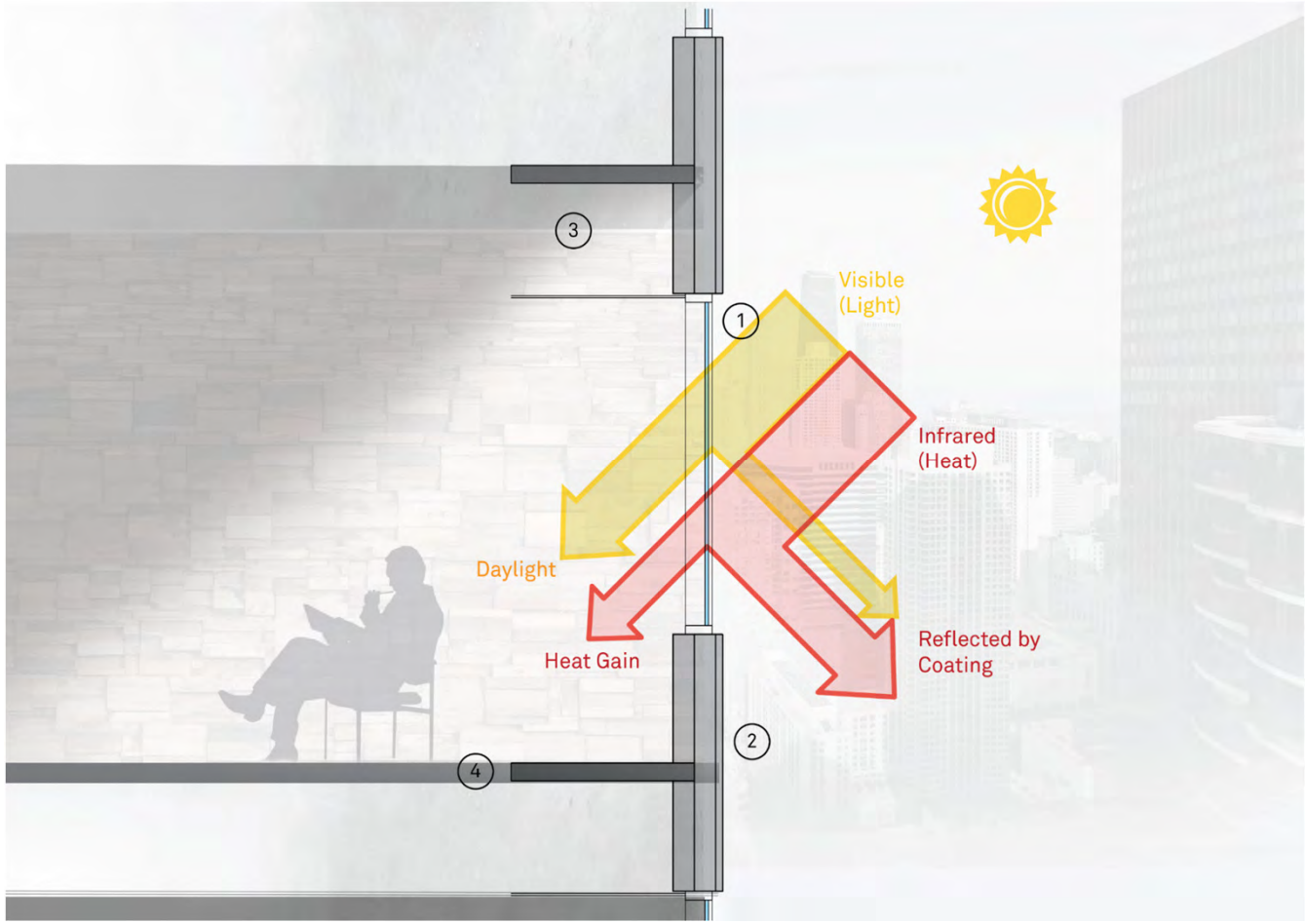
- Radiant Temperature
- Air Speed

COMFORT | MECHANICAL CONTROL

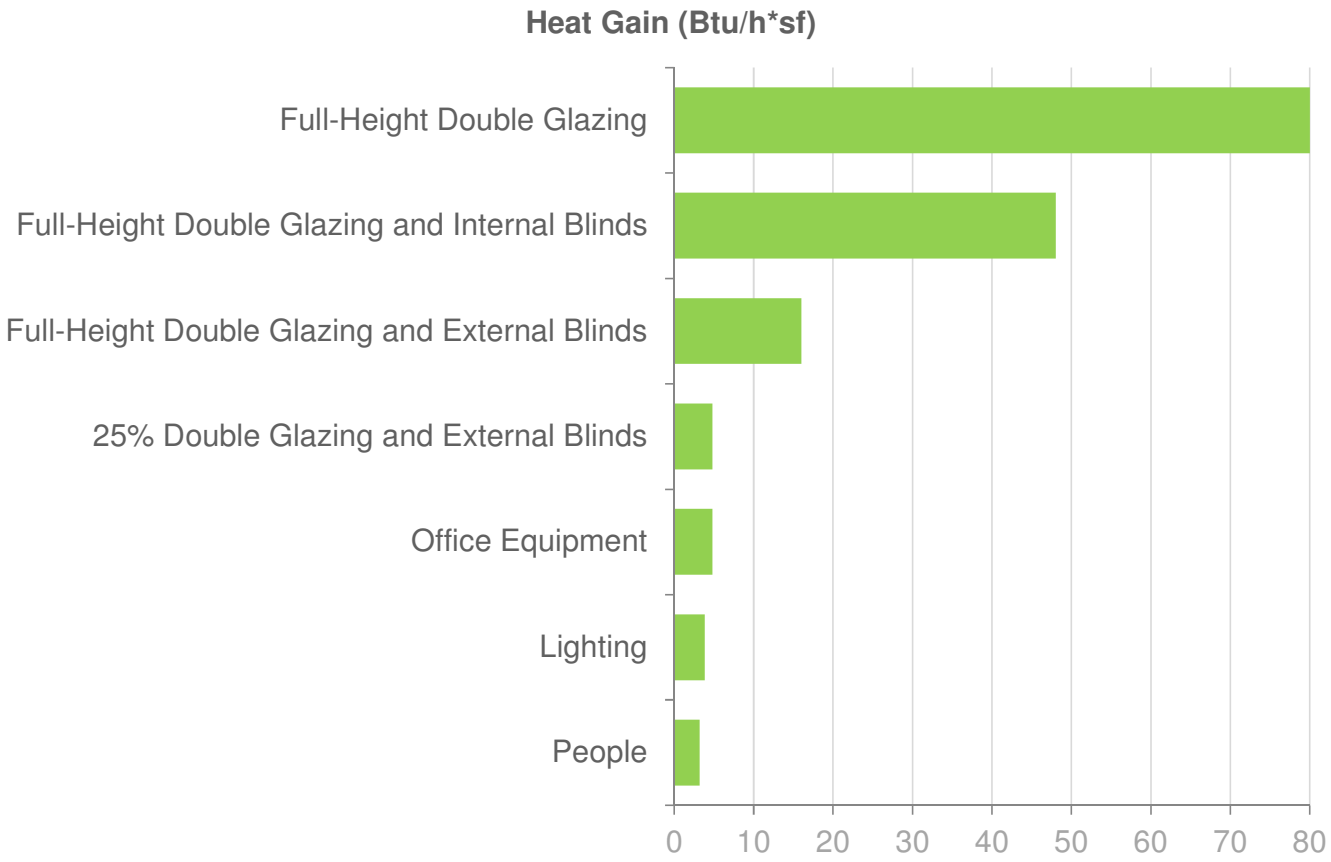


- With large expanses of glass perimeter heating is needed to counteract these factors and maintain comfort

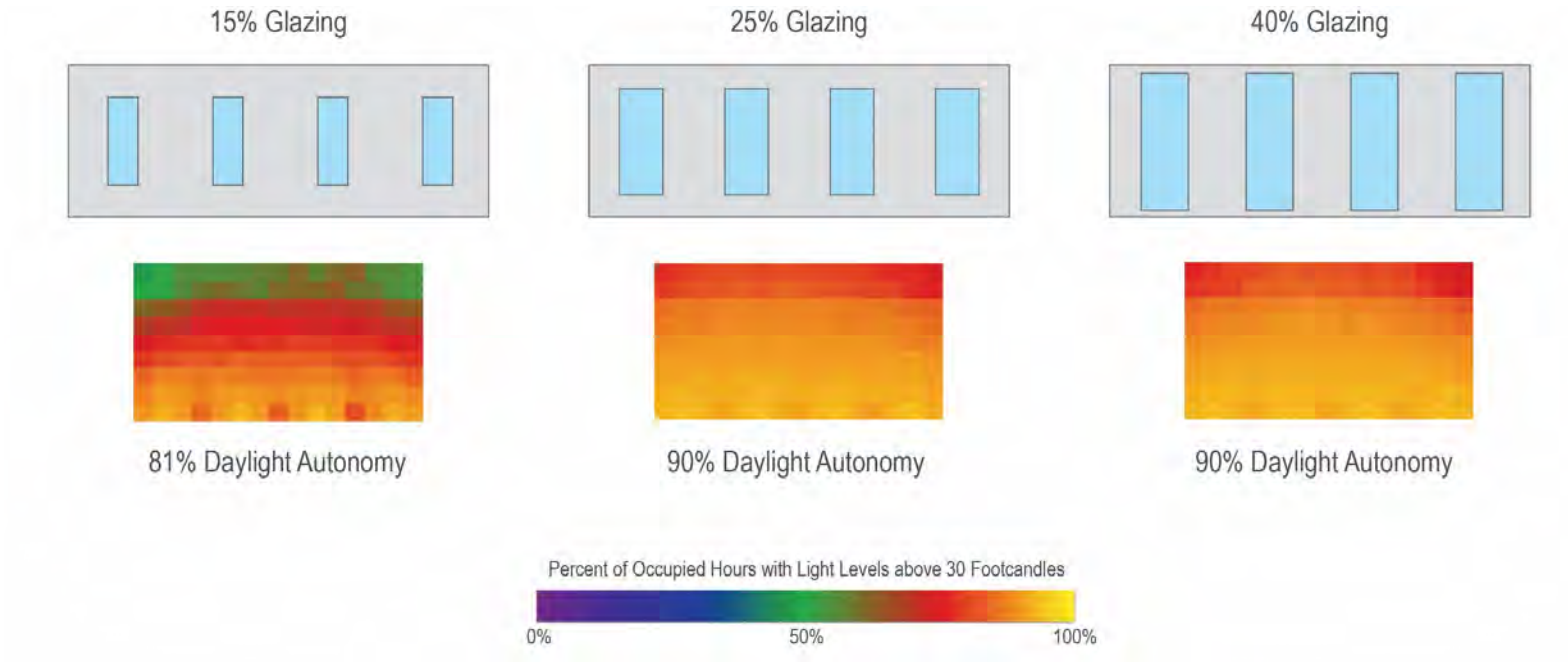
SOLAR GAIN


3
1
Visible
(Light)
Infrared
(Heat)
Daylight
Heat Gain
Reflected by
Coating
2
4

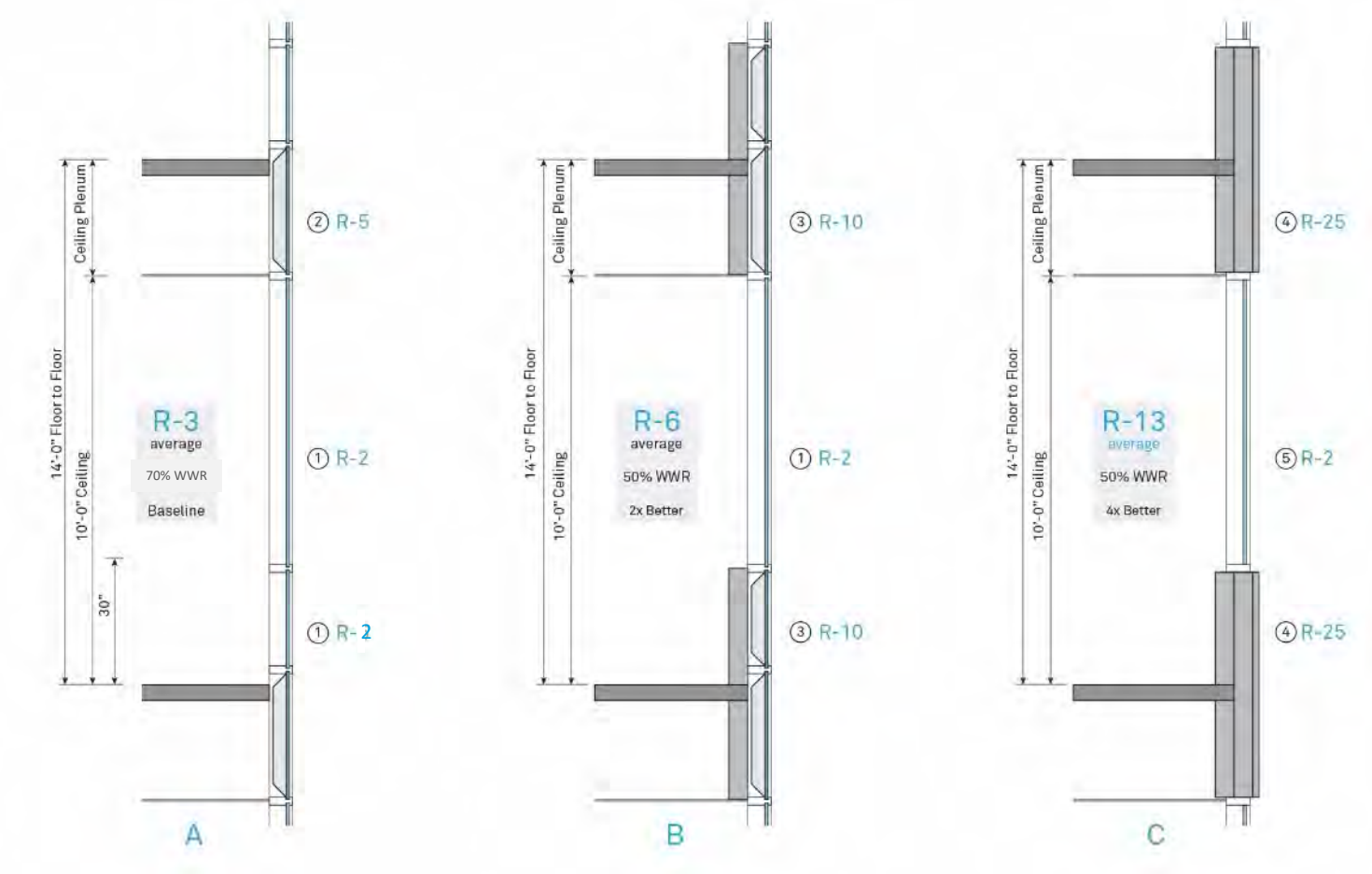
ENERGY | IMPACT ON LOADS



DAYLIGHT | HOW MUCH GLASS DO WE REALLY NEED?

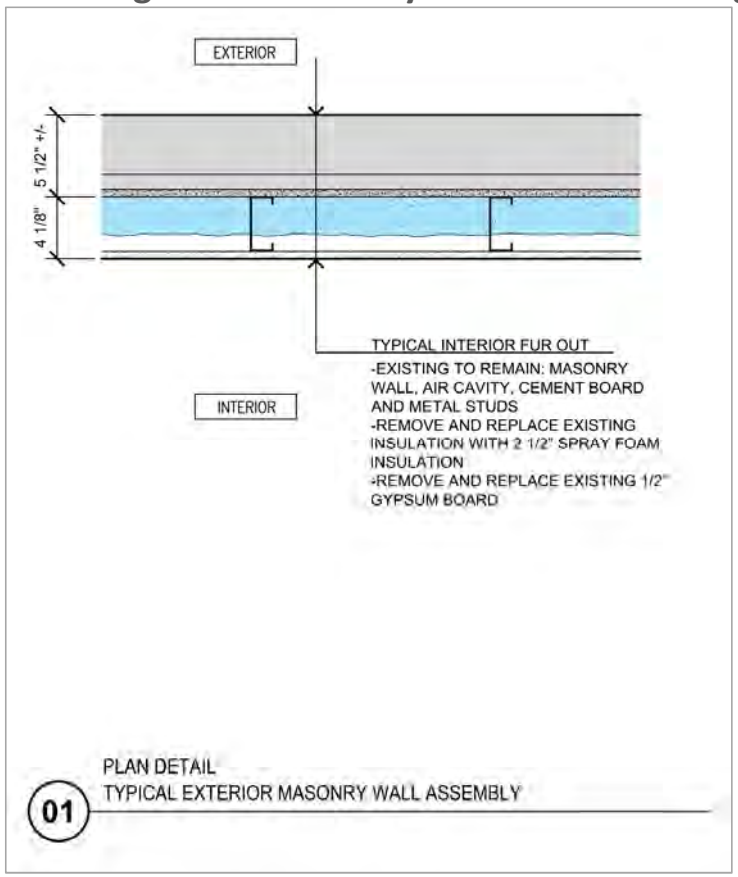


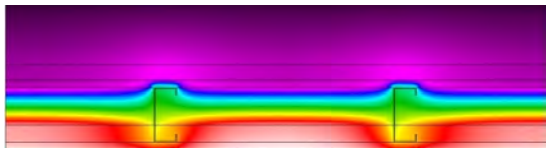
EFFECTIVE OVERALL R-VALUE



THERMAL BRIDGING – EXISTING MASONRY WALL ASSEMBLIES

Building 1- studs directly attached to existing wall → resulting in a decrease of 59% of baseline R-value





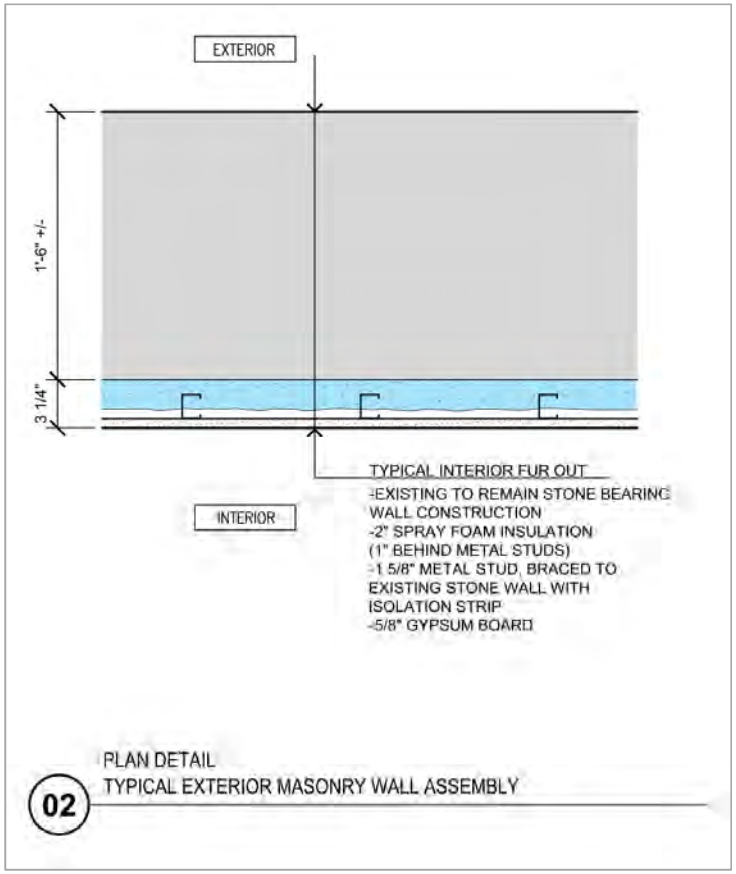
Calculated R-Value= 19.53

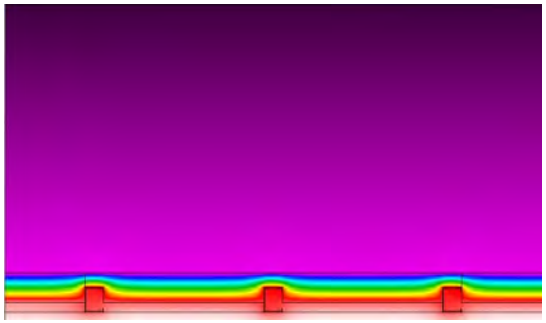
Observed R-Value= 4.15

Simulated R-Value= 8.05 **-59%**

THERMAL BRIDGING – EXISTING MASONRY WALL ASSEMBLIES

Building 2- studs pulled 1” back from existing wall → results in a decrease of 16% of baseline R-value





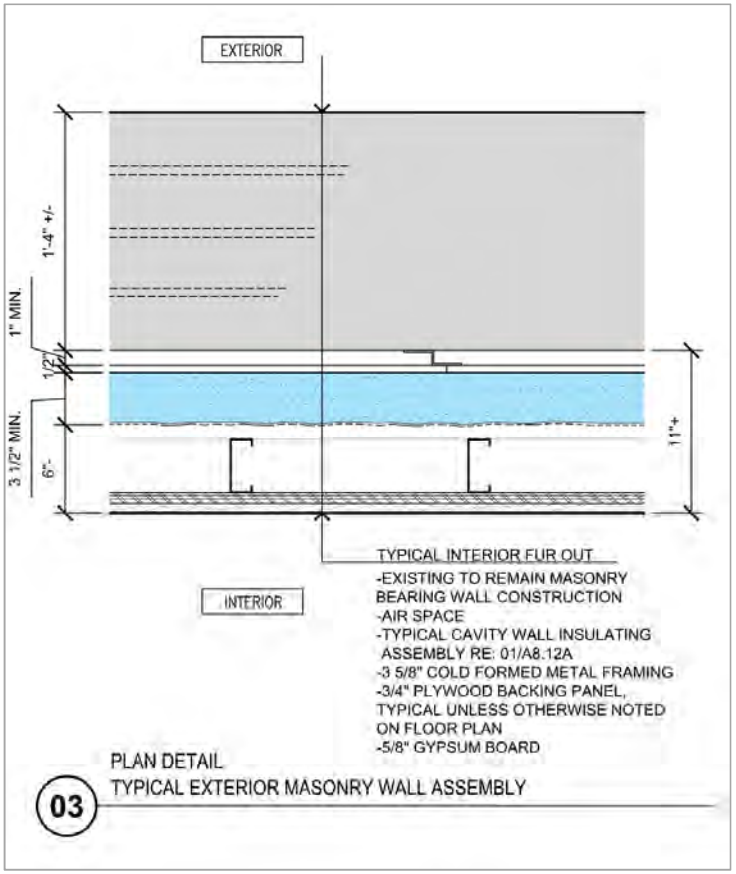
Baseline R-Value= 16.84

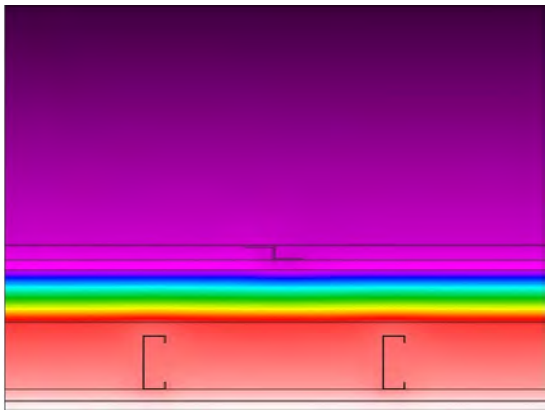
Observed R-Value= 12.44

Simulated R-Value= 14.11 **-16%**

THERMAL BRIDGING – EXISTING MASONRY WALL ASSEMBLIES

Building 3- studs separated from insulation → resulted in a decrease of 2% of baseline R-value



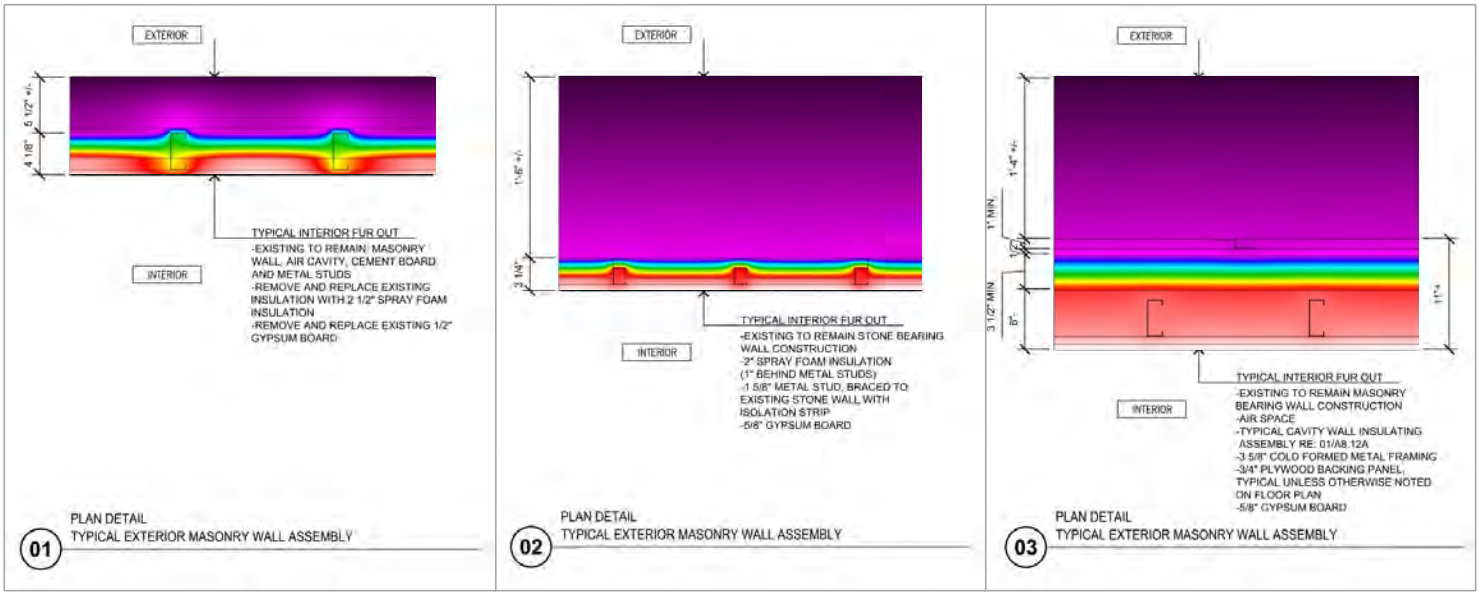


Baseline R-Value= 29.23

Observed R-Value= 20.16

Simulated R-Value= 28.78 **-2%**

THERMAL BRIDGING – EXISTIGN MASONRY WALL ASSEMBLIES



41%
of Baseline R-Value

84%
of Baseline R-Value

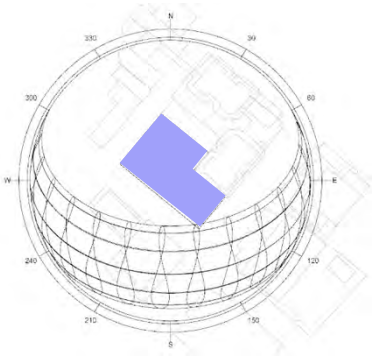
98%
of Baseline R-Value

AIR TIGHTNESS

- Passivehaus Feasibility Study by fxcollaborative
  - 86% reduction in infiltration compared to the base case
    - Base case 0.263 cfm/ft^2 @ 50 Pa
      (ASHRAE 90.1-2010 0.4 cfm/ft^2 @ 75 Pa)
    - Proposed case 0.036 cfm/ft2
- Cornell Tech Tower
  - 0.14 ACH50 (PH reqt 0.6 ACH50)
- “% Better Than” approach models infiltration the same in the baseline and proposed case

CONNECTING ENCLOSURE PERFORMANCE TO HVAC SYSTEMS

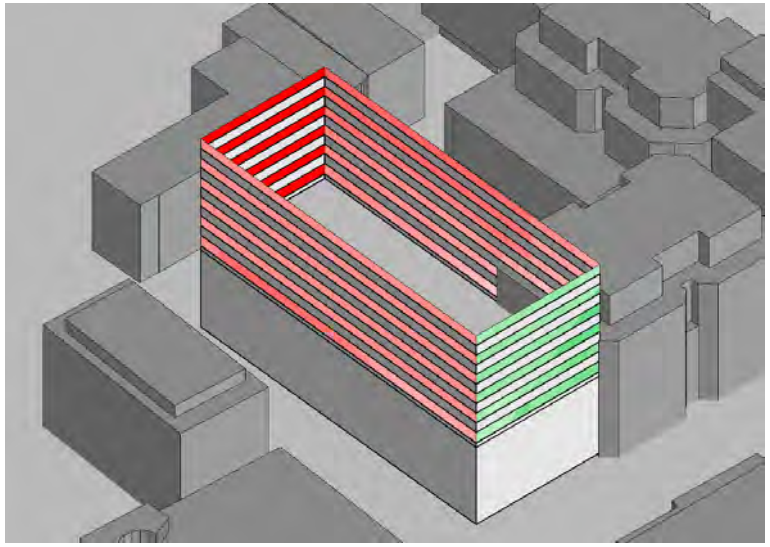
OPTIMIZING MASSING | SOLAR BENEFIT STUDY



NET RADIATION (kWh/m2)

Beneficial Radiation — Harmful Radiation

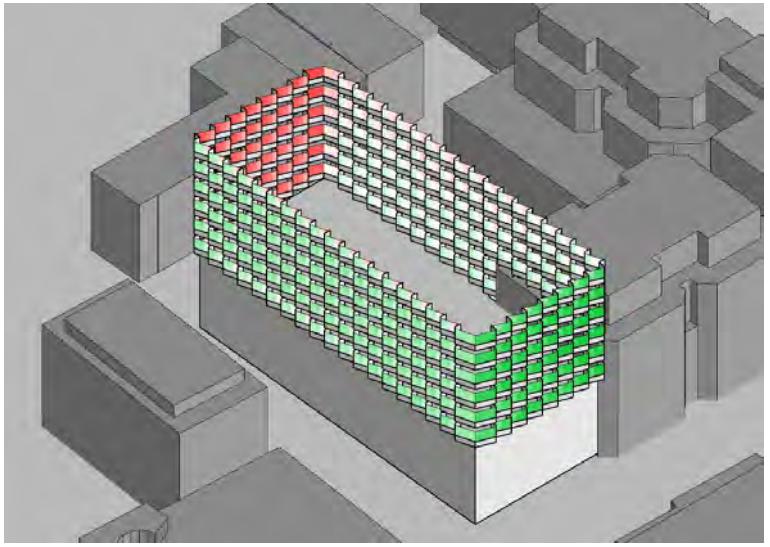
0 -75 -150



6%
Reduction in patient room energy

15%
Reduction in peak solar load

54%
Decrease in direct solar radiation



PARAMETRIC EARLY ENERGY MODEL

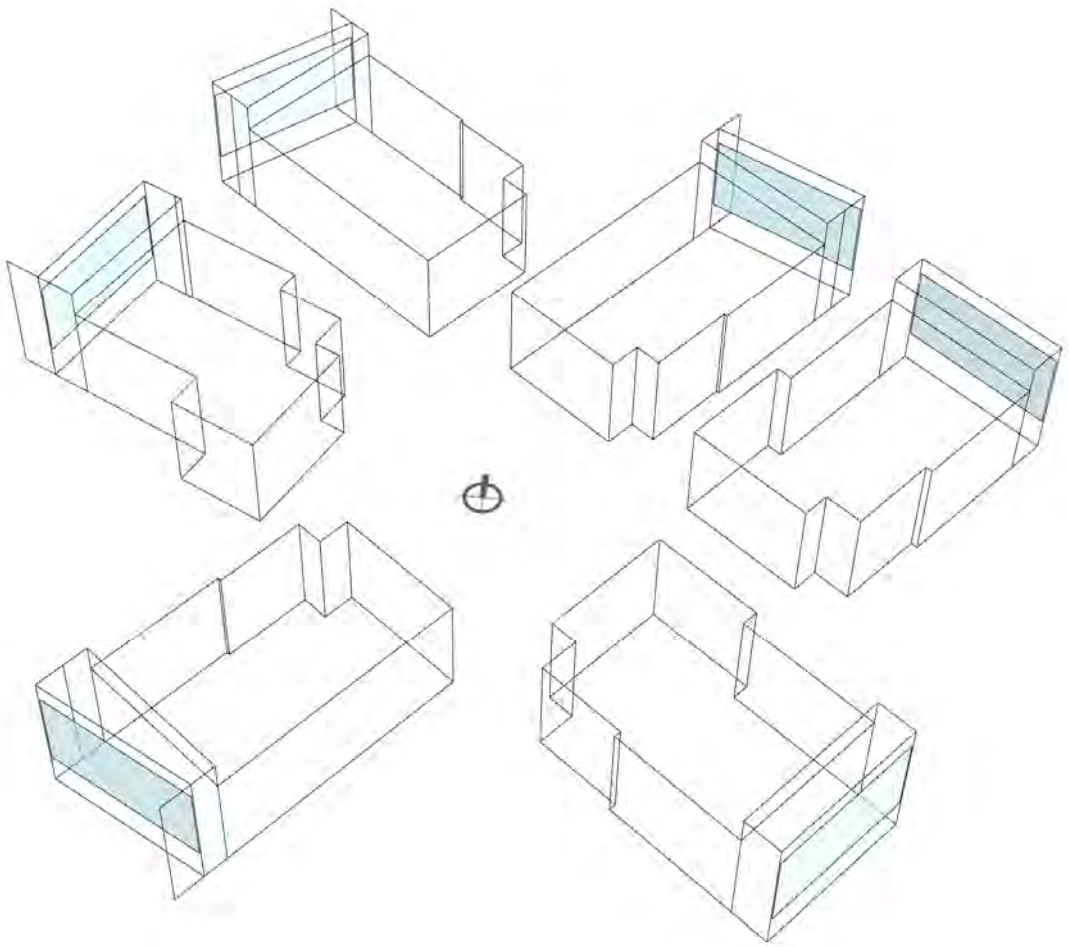
INPUTS:

- Glazing Ratio (40%, 50%, 60%, 70%)
- R-Value (spandrel, solid)
- Glazing U-Value (0.4, 0.25)
- Exterior Vertical Fins (0”, 15”, 30”)
- Orientation
- HVAC Type (VAV, Hydronic)

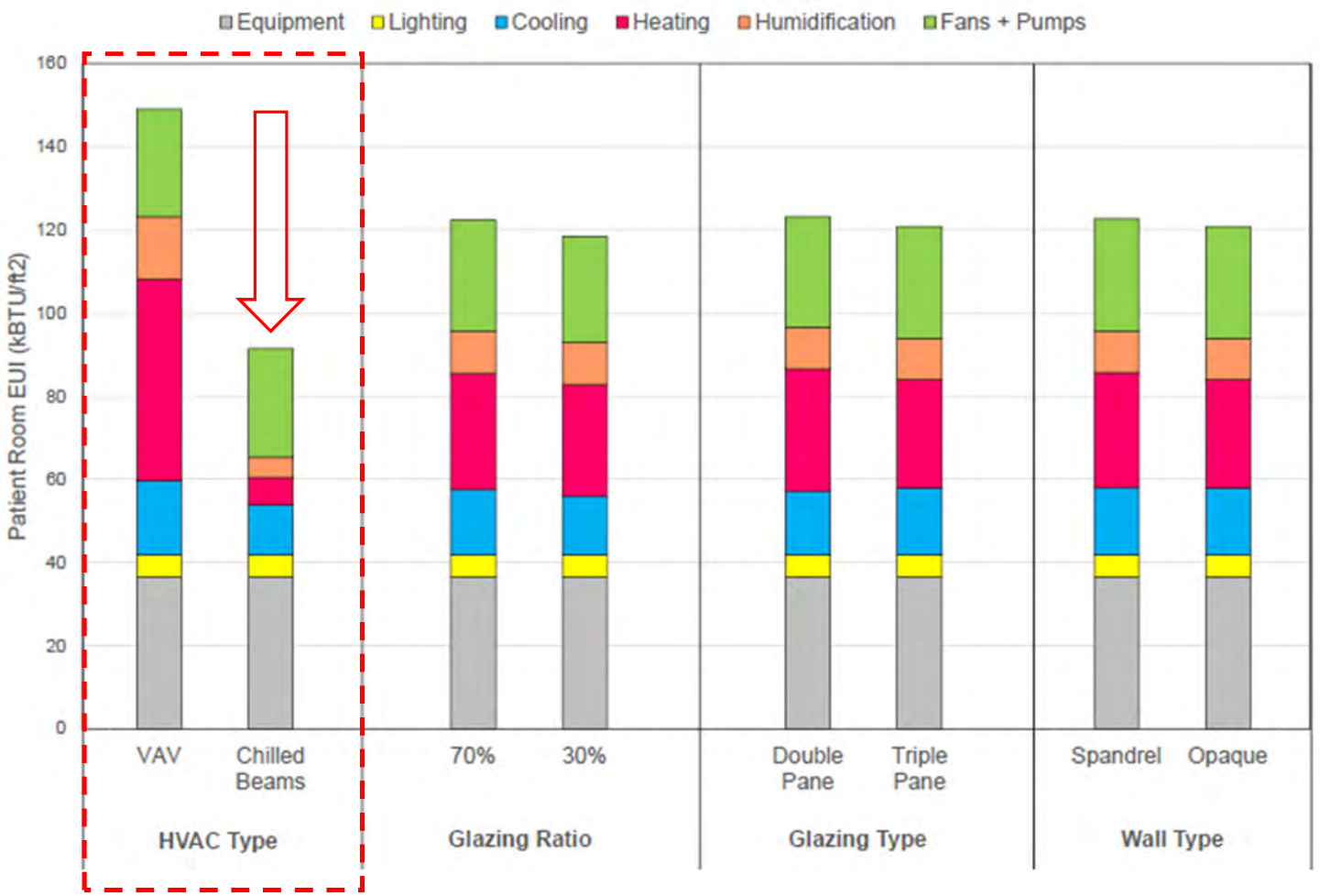
= 576 SIMULATIONS

OUTPUTS:

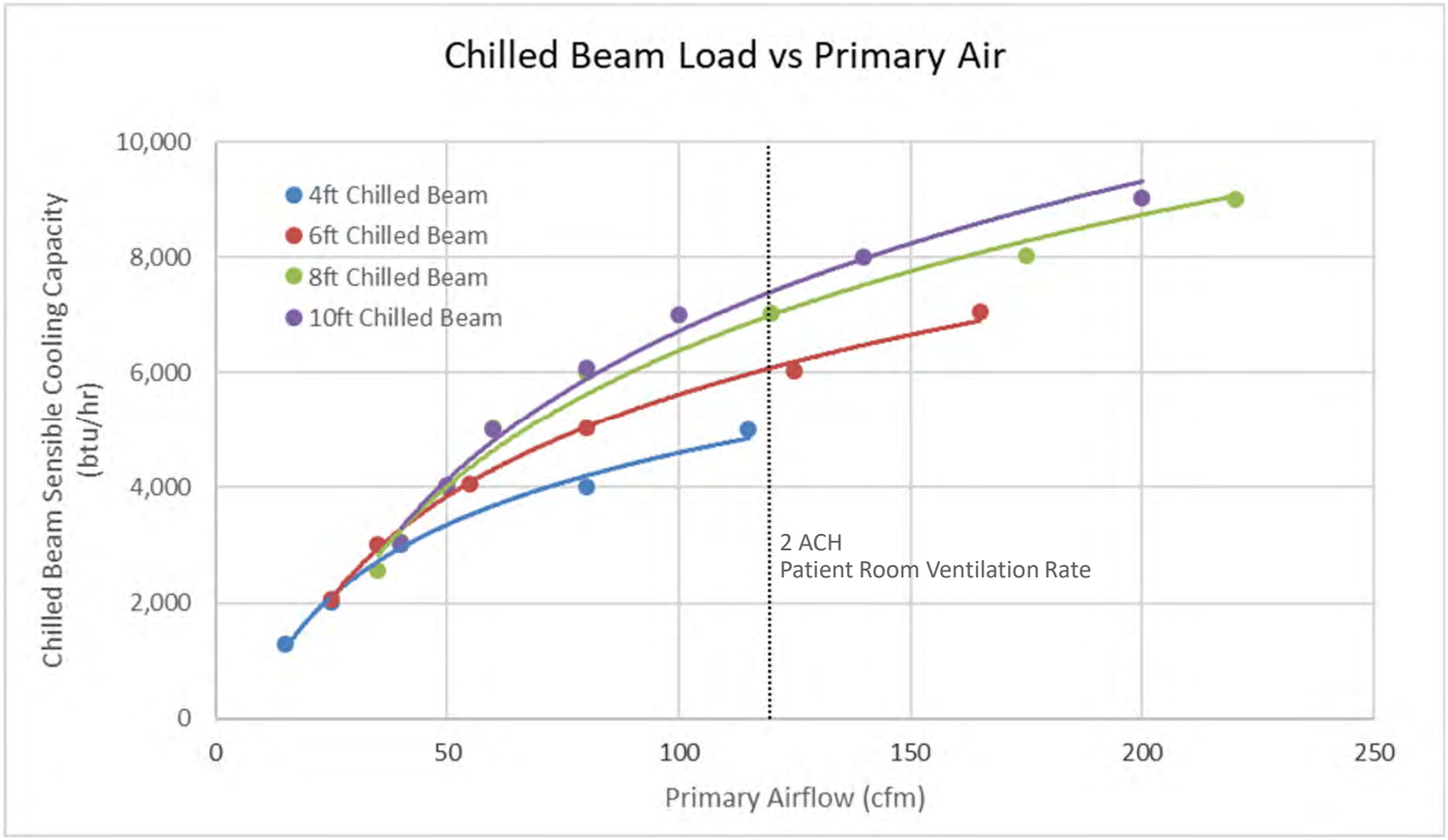
- EUI
- Peak Cooling
- Peak Heating
- HVAC Size



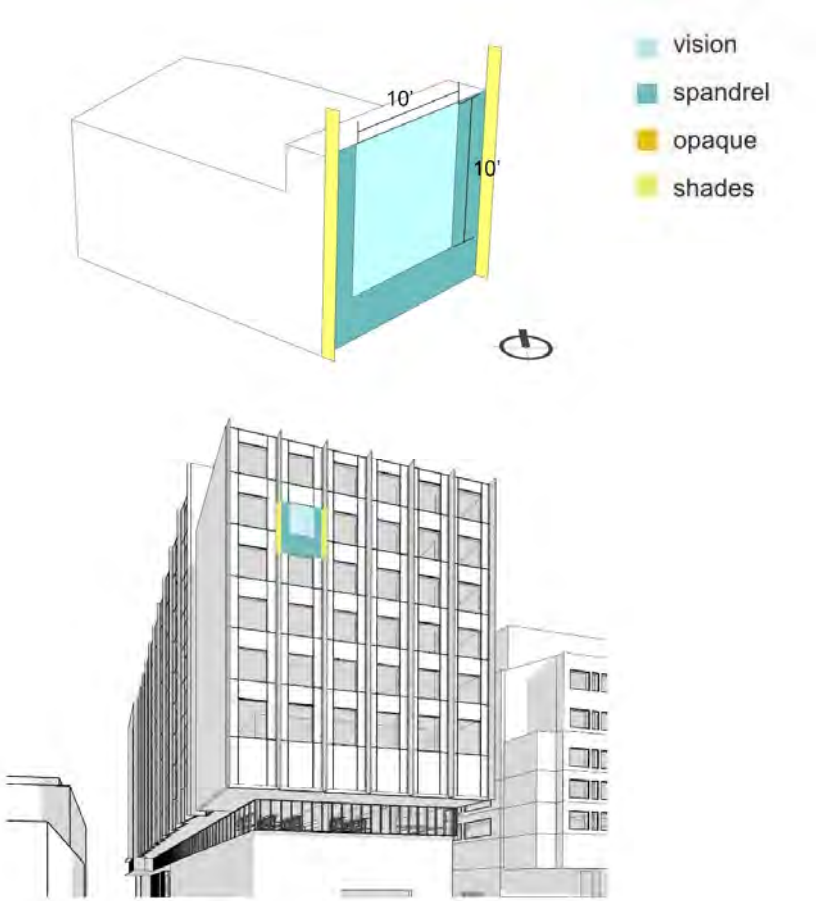
THE IMPACT OF CHILLED BEAMS

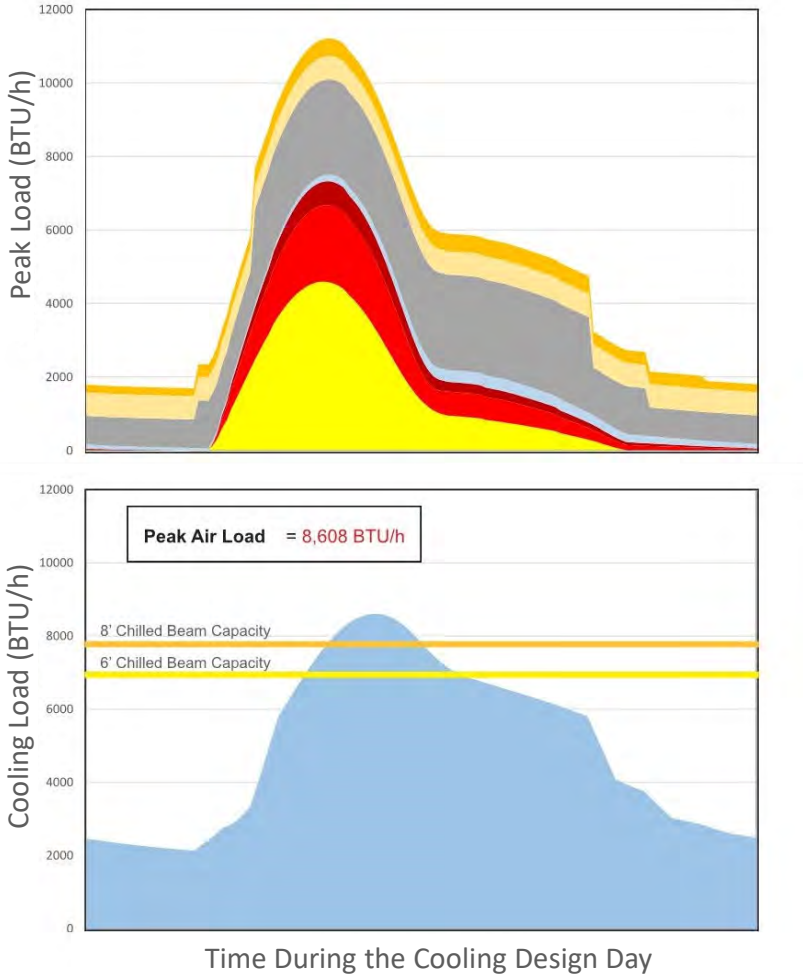


CHILLED BEAM COOLING CAPACITY

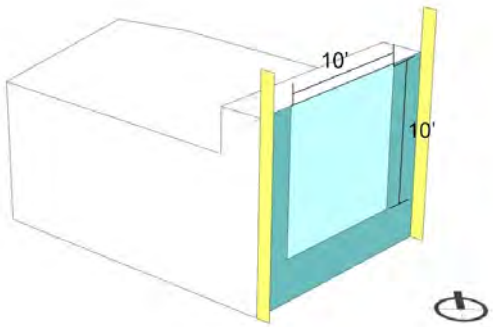


ITERATING THROUGH DESIGN OPTIONS



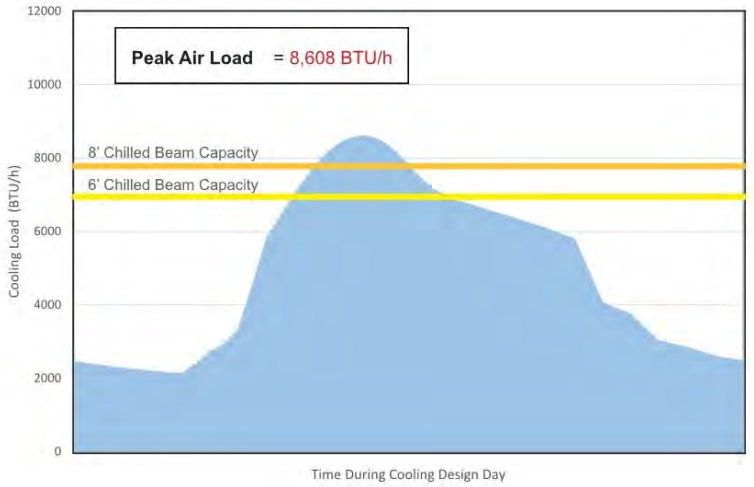


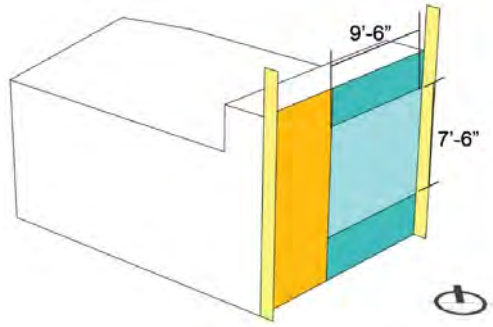
ITERATING THROUGH DESIGN OPTIONS

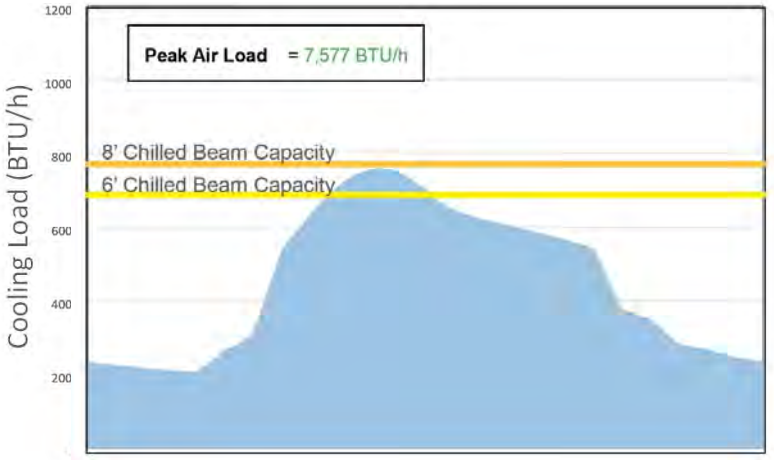


vision
spandrel
opaque
shades

SHGC = 0.35

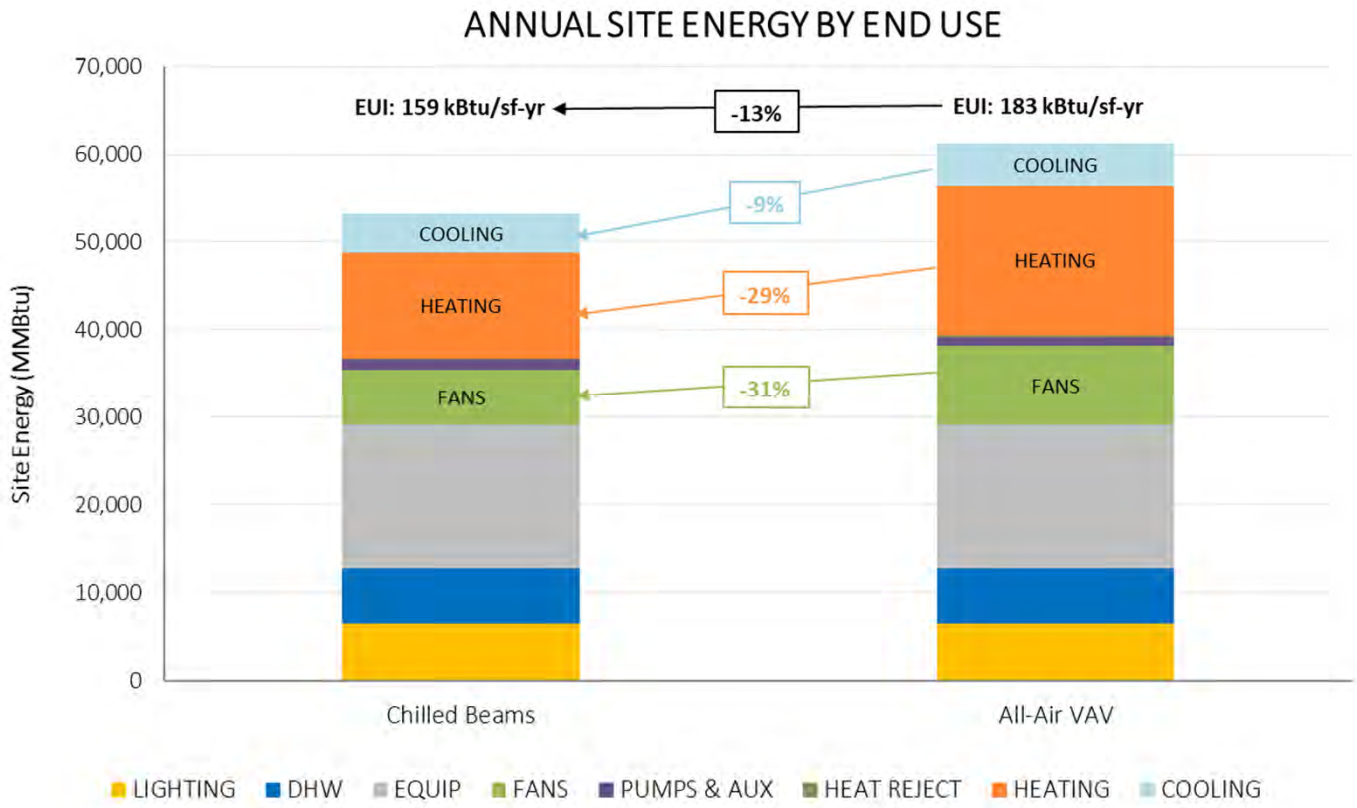




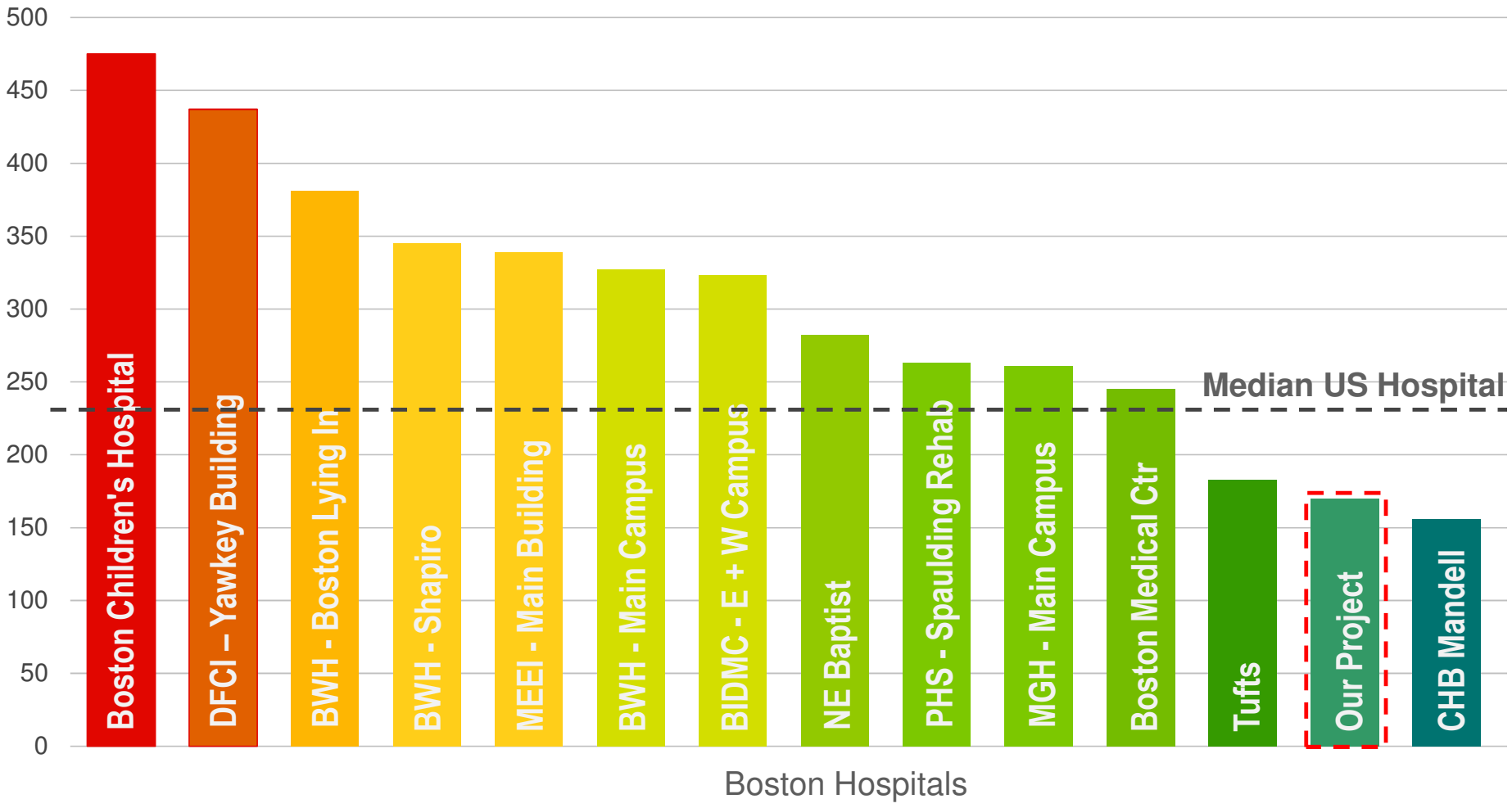


Time During the Cooling Design Day

ENERGY SAVINGS FOR OPTIMIZED DESIGN



BOSTON HOSPITALS ENERGY USE INTENSITY (EUI) – KBTU/SF-YR



SUMMARY

- Current standards and policies are not resulting in the necessary levels of energy performance necessary to meet our climate goals
- Absolute metrics are more useful if our goal is actual emissions reductions
- Enclosure design is critical for
  - Reducing peak loads
  - Eliminate perimeter heating
  - Enabling low energy HVAC design including all-electric systems
- “Passive house like” that is building type appropriate

Decarbonization & Codes for New & Existing Buildings

Darren Port, Buildings & Community Solutions Manager
Northeast Energy Efficiency Partnerships (NEEP)

Building Energy NESEA Conference, Boston, MA

March 14, 2019

Decarbonization Plan

Establish Goals, Policies, and Programs for Strategic Electrification with Deep Efficiency

Build Public-Private Relationships to Accelerate Strategic Electrification Activities

Protect Consumers

Support Market Development for Key Electrification Pathways

Encourage Local Leadership

Prioritize Low-Income Consumers as a Near-Term Focus

Advance Strategic Electrification with Thermal Efficiency in Homes and Buildings

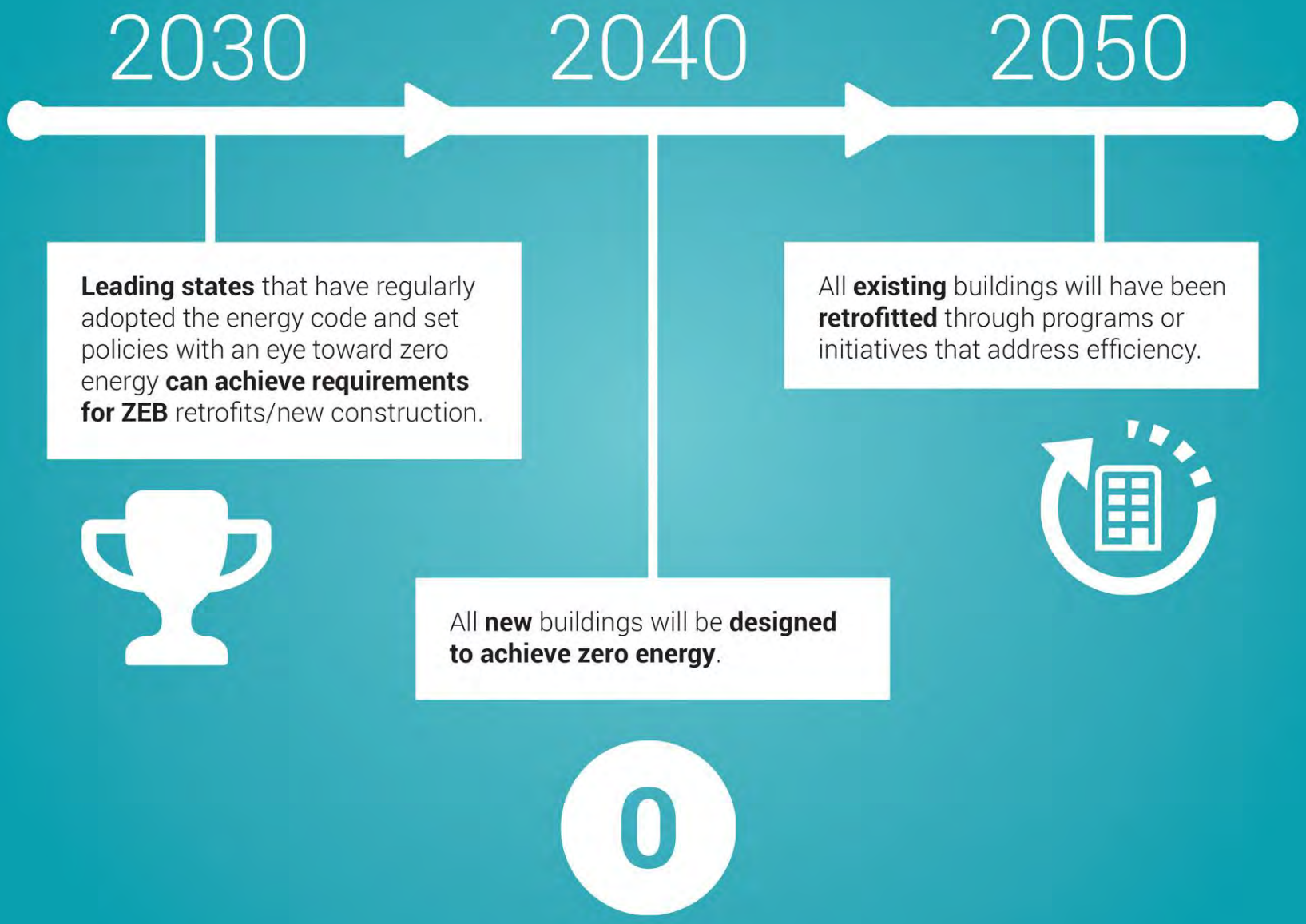
Provide Public and Consumer Outreach and Education

Address Grid Preparedness to Effectively Manage New, Dynamic Loads

Action Area #1

Establish Goals, Policies, and Programs for Strategic Electrification with Deep Efficiency

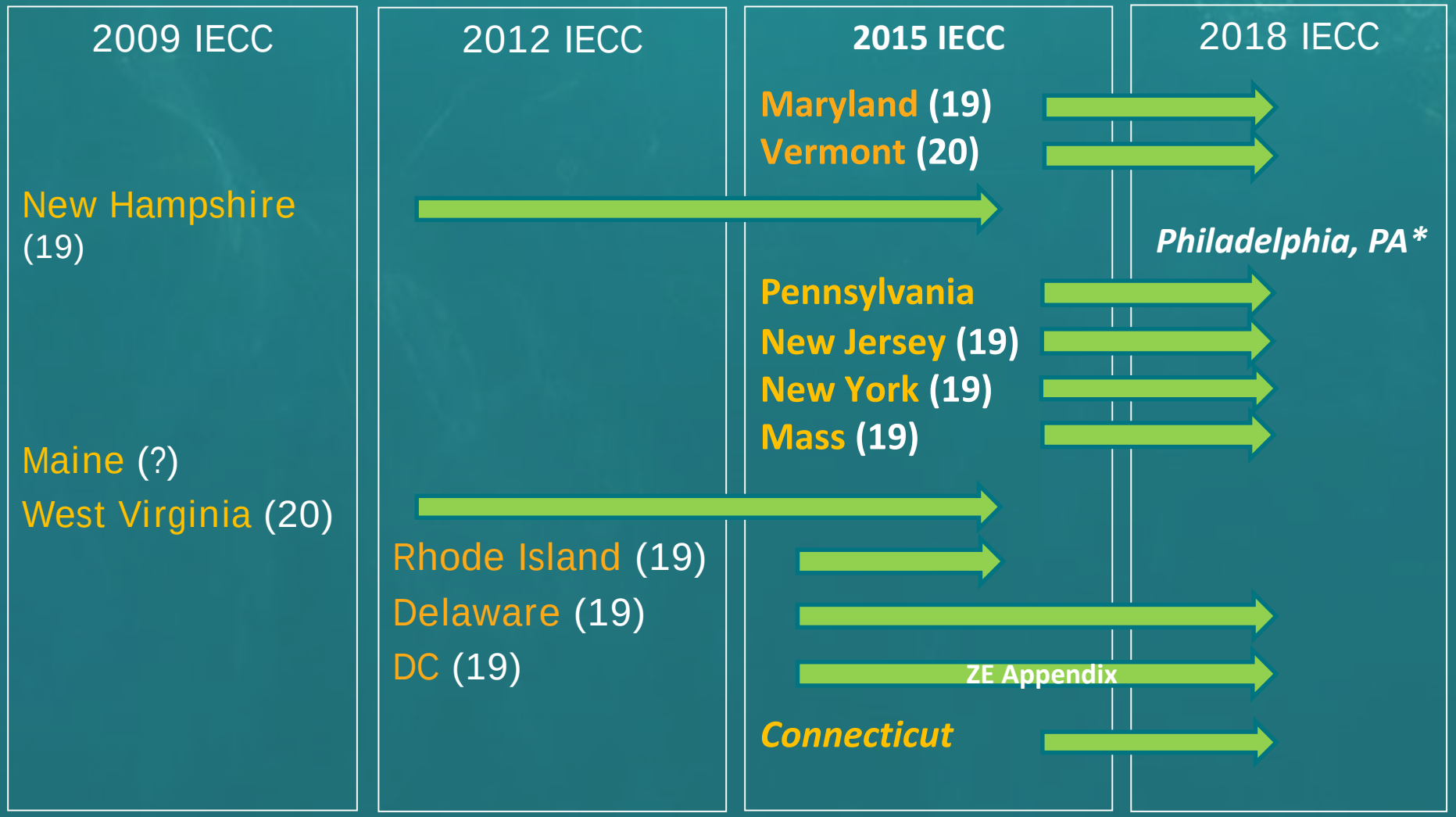
- Create market certainty through targets, goals, and mandates
- Lead by example
- Adopt building energy codes (New & Existing)
- Create mechanisms to support local government
- Develop metrics for clean energy programs


2030
2040
2050
Leading states that have regularly adopted the energy code and set policies with an eye toward zero energy **can achieve requirements for ZEB** retrofits/new construction.
All **existing** buildings will have been **retrofitted** through programs or initiatives that address efficiency.
All **new** buildings will be **designed to achieve zero energy**.
0

Codes Toward Decarbonization

- **NEEP Region**
  - **All 13 States Moving Toward "Modern" Code**
  - **Six States with Advanced Stretch Codes (MA, RI, VT, NY, DC, MD)**
  - **DC (Omnibus Act 2018), NYC, NY, VT, RI, MA States on Track to ZE Codes**
  - **Massachusetts Achieving Zero Energy (MAZE)**
- **Trends Toward Strategic Electrification (New & Existing Buildings)**
  - **PV Ready**
  - **EV Ready**
  - **ASHP (Ready)**
  - **Battery Storage**
  - **Lighting Power Density Reduction**
  - **Alternative Compliance Paths**
    - Passive House; Living Building Challenge; DOE ZERH

BUILDING ENERGY CODE ADOPTION

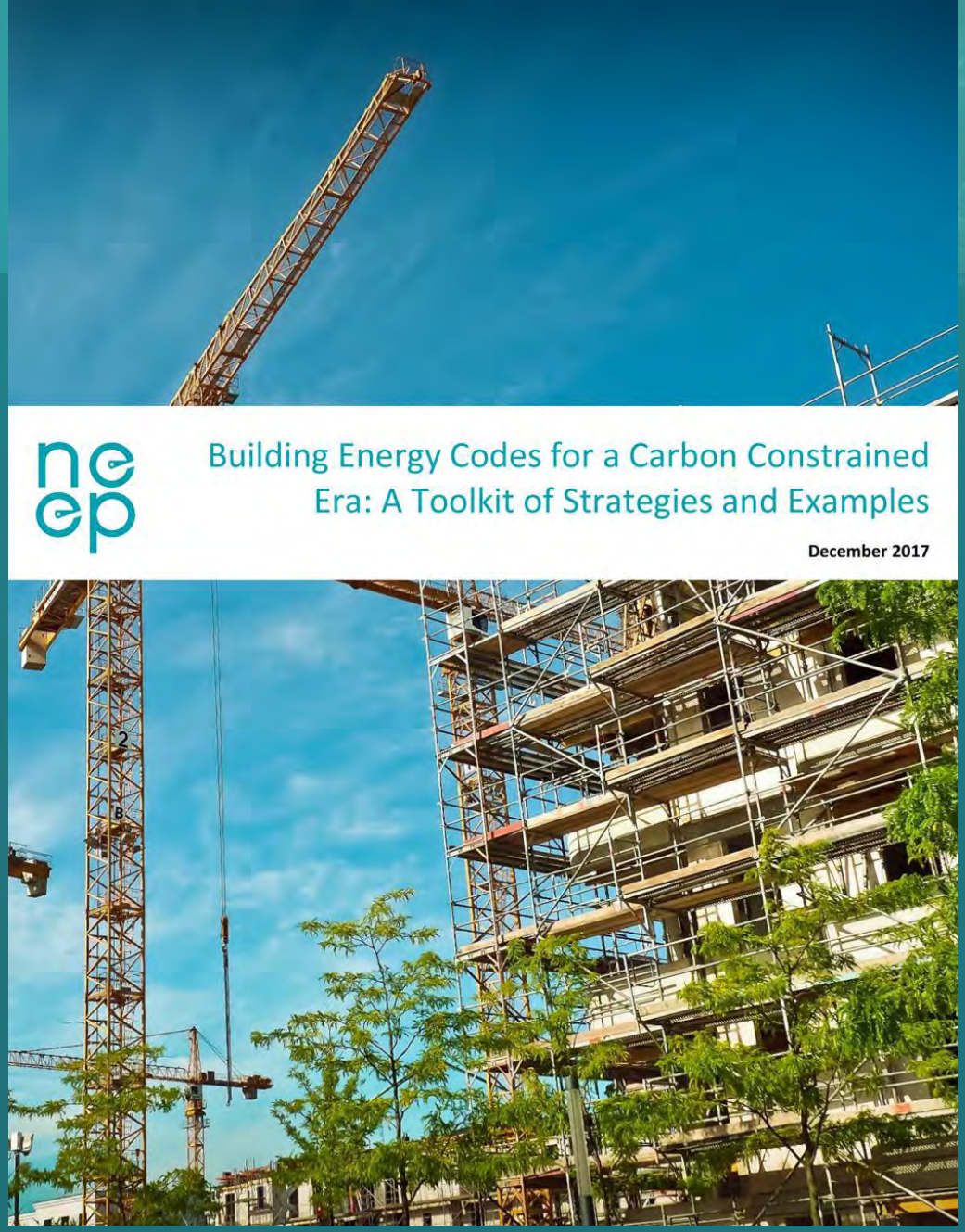


March 2019

Codes Toward Decarbonization

- **Nationally**
  - **States:**
    - **Washington**
      - **Performance Based Codes / Stretch Codes**
      - **1631 Carbon Emissions Fees (Defeated)**
    - **California –**
      - **CEC Title 24 – 2020 residential buildings zero energy, 2025 commercial Buildings; ASHP, Storage, Thermal Efficiencies**
      - **SB1477 (Sept 2018) – Near zero technologies buildings**
      - **20+ cities (LA, San Jose) exceeding CEC codes with reach codes.**
  - **Cities:**
    - **NYC, DC, Denver, Boulder, Seattle, Atlanta and Chicago**

- ICC 2021 IECC Code Hearings



www.neep.org/building-energy-codes-carbon-constrained-era-toolkit-strategies-and-examples

For more information:

www.neep.org

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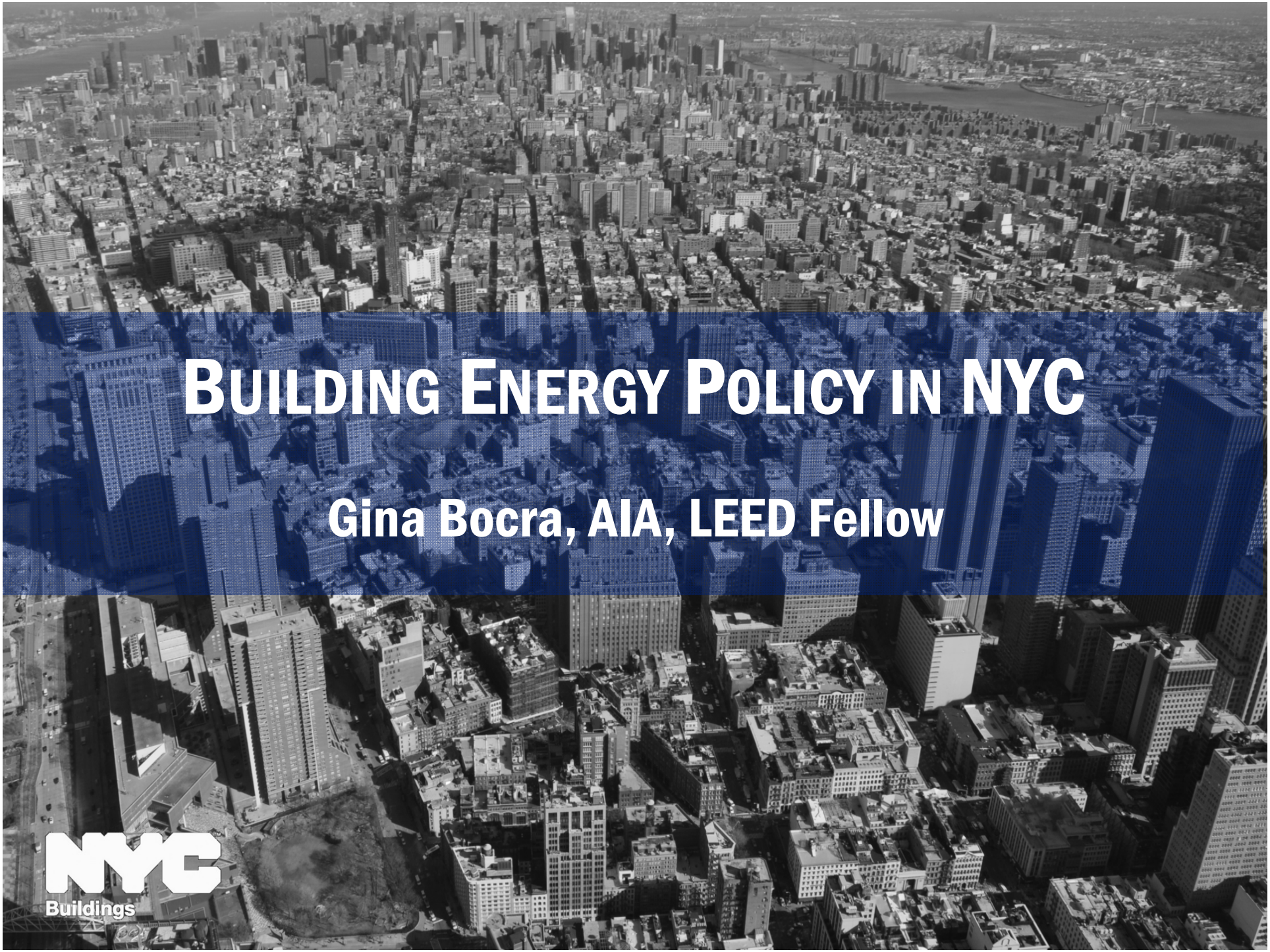


BUILDING ENERGY POLICY IN NYC

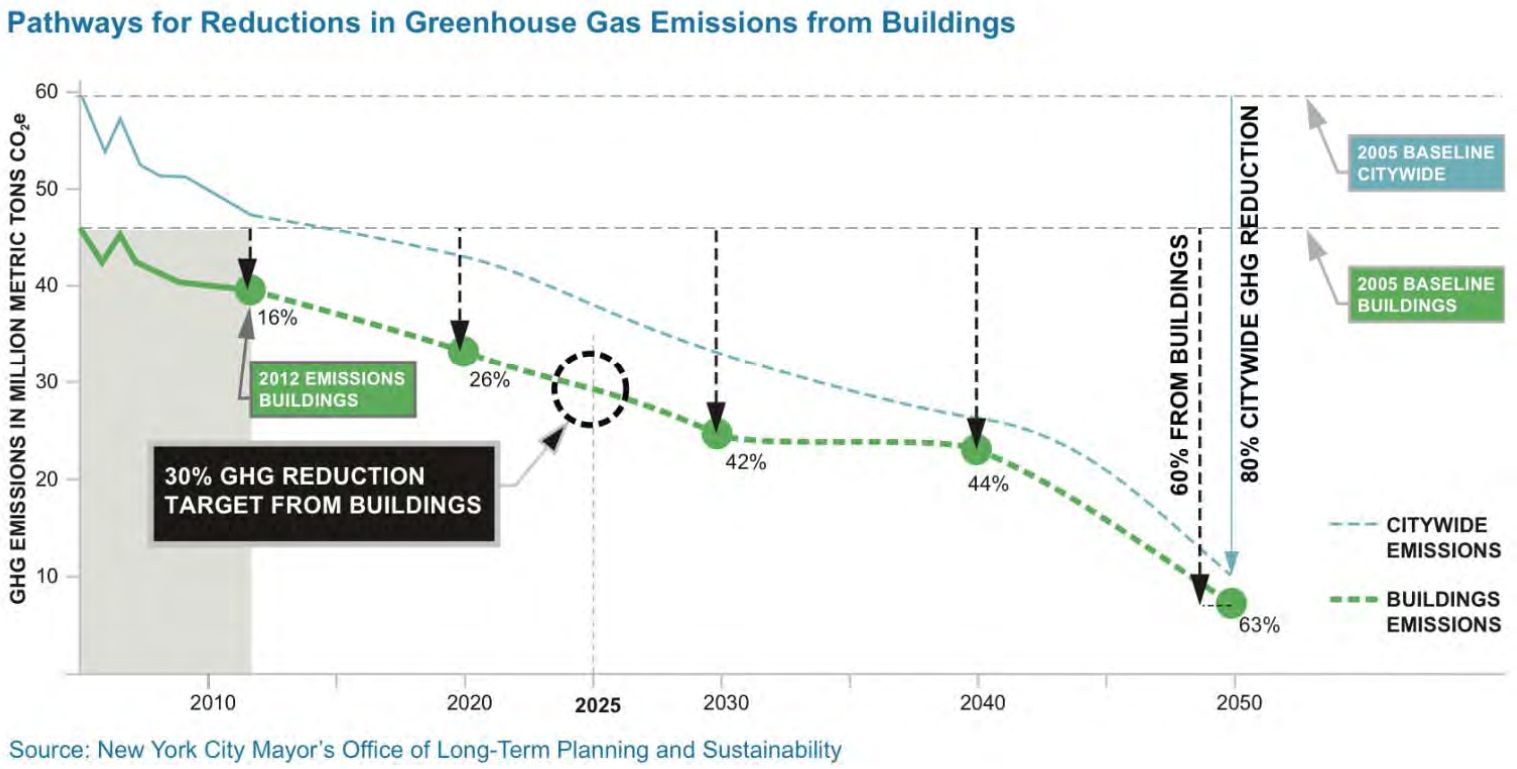
Gina Bocra, AIA, LEED Fellow

NYC Buildings

NYC BUILDING ENERGY POLICIES

Local Law 66 of 2014 (80x50)

Set the goal for the city of New York to reduce greenhouse gases by eighty percent by 2050.



Source: New York City Mayor's Office of Long-Term Planning and Sustainability

NYC Buildings

NYC Building Energy Policies

Base Legislation in NYC

Photo by G. Bocra

- **Local Law 85 of 2009** – requires the NYC Energy Conservation Code
- **Local Law 84 of 2009** - requires annual energy and water benchmarking for buildings 25K SQ. FT. and greater
- **Local Law 87 of 2009** - requires energy audits and retro-commissioning in buildings 50K SQ FT and greater (every 10 years)
- **Local Law 31 of 2016** - sets aggressive energy targets for City-funded capital projects

NYC Building Energy Policies

Recent policy changes

Photo by G. Bocra

- **Local Law 32 of 2018** - mandates a much more stringent energy code in 2019, 2022, and 2025
- **Intro 1253** - mandates GHG limits for buildings 25,000 Sq. Ft. and greater beginning in 2022

NYC's Local Law 32 of 2018

2019 and 2022- NYC must adopt the NYStretch Energy Code

- NYStretch Energy Code is about 4-5% more stringent than NY State's 2019 Energy Code is expected to be (based on 90.1-2016)
- Includes an envelope backstop for projects following the performance path that are 25,000 SQ. FT. and greater

2025- NYC must adopt an absolute limit for energy consumption in buildings (EUI targets or some other metric)

- Applies to all buildings 25,000 SQ. FT. and greater

https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=3066695&GUID=CBC9F654-EC3E-4CC8-BA14-CEED2C744414&Options=ID|Text|&Search=energy

NYC Buildings

NYC's Intro. 1253 of 2018

Building GHG limits- Establishes absolute limits for GHG emissions from buildings 25K SQ. FT. and greater

- Bill establishes limits, penalties and fines, beginning in 2022
- This law is co-sponsored by over half of the members of City Council, and is expected to become law in April.

https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=3761078&GUID=B938F26C-E9B9-4B9F-B981-1BB2BB52A486&Options=ID|Text|&Search=energy