



BUILT TO LEAD:

LESSONS IN BUILDING DECARBONIZATION

NEW TECHNOLOGIES & OPPORTUNITIES

LEARN MORE HERE



BUILT TO LEAD: LESSONS IN BUILDING DECARBONIZATION AND RESILIENCE

1. September 24, Built to Lead: [Lessons in Building Decarbonization in Existing Buildings](#)
2. October 30, Built to Lead: [Lessons in Building Decarbonization in New Construction](#)
3. **December 17, Built to Lead: Lessons in New Technologies and Opportunities**
4. February 3, 2026 Built to Lead: Lessons in Deconstruction and Embodied Carbon, @ 10-11:30AM
Location TBD
 - Dennis Carlberg, Chief Sustainability Officer & Associate Vice President for Climate Action, Boston University – *Retrofit of BU's Warren Tower*
 - Irmak Turan, Associate, Climate and Sustainability, Arup – *Circularity and embodied carbon at airports*
 - Caroline Murray, Regional Sustainability Manager, Turner Construction Company – *Deconstruction and reuse of office space*
 - Andrew Thompson, Interim Executive Director, Boston Building Resources – *Material donation and reuse*
5. Built to Lead: Lessons in Resilience, TBD

AGENDA

- 10:00 AM **Kate Dineen, A Better City**—Welcome
- 10:02 AM **Yve Torrie, A Better City**—Introduction
- 10:06 AM **John E. Fernández, MIT**—*AI building envelope evaluation*
- 10:18 AM **Zeyneb Magavi, HEET**—*Thermal energy potential of water sources*
- 10:30 AM **Colin Schless, Turner Construction**—*Hybrid electrification*
- 10:42 AM **John Kastrinos, Haley & Aldrich and Jacob Knowles, BR+A**—*Right sizing of geothermal energy projects*
- 10:54 AM **Q+A**
- 11:30 AM **Event Concludes**

JOHN E. FERNANDEZ, MIT



Data, AI and the City –

Lamarr.AI

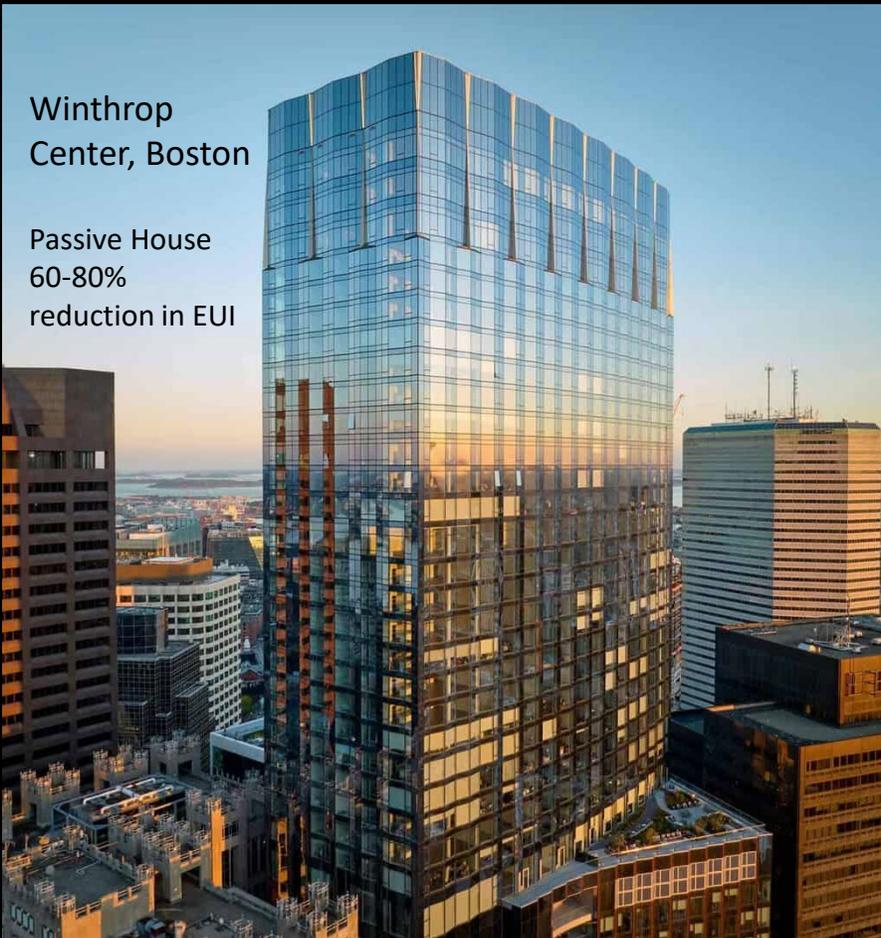


Urban
Metabolism
Group



ENVIRONMENTAL
SOLUTIONS INITIATIVE

Brief bio – sustainability in the built env.



1985: civil engineering, architecture, materials science, computer science, MIT

1989: graduate studies architecture, Princeton University

1989 - 1999: Architect, New York City - continuing practice

1999 - present: Professor of Architecture, Building Technology Program, MIT

2008 - 2012: Director, Sustainable Energy Systems, MIT Portugal Program

2012 - 2013: Director, International Design Center, MIT-SUTD

2015 - present: Director, MIT Environmental Solutions Initiative

2024 – present: CSO of Lamarr.AI

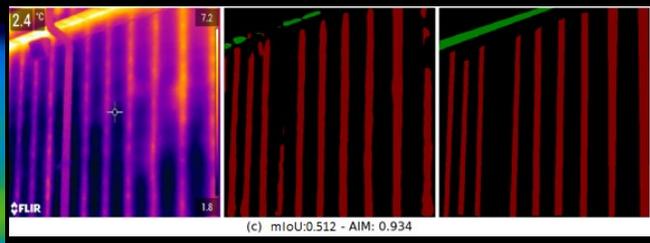
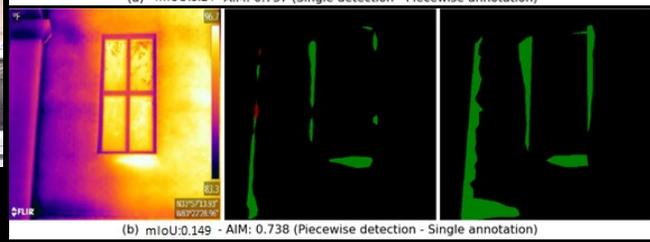
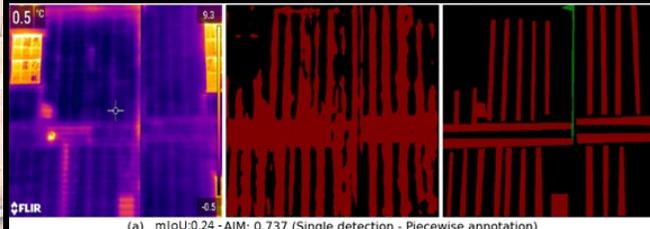
Mitigating emissions in the city



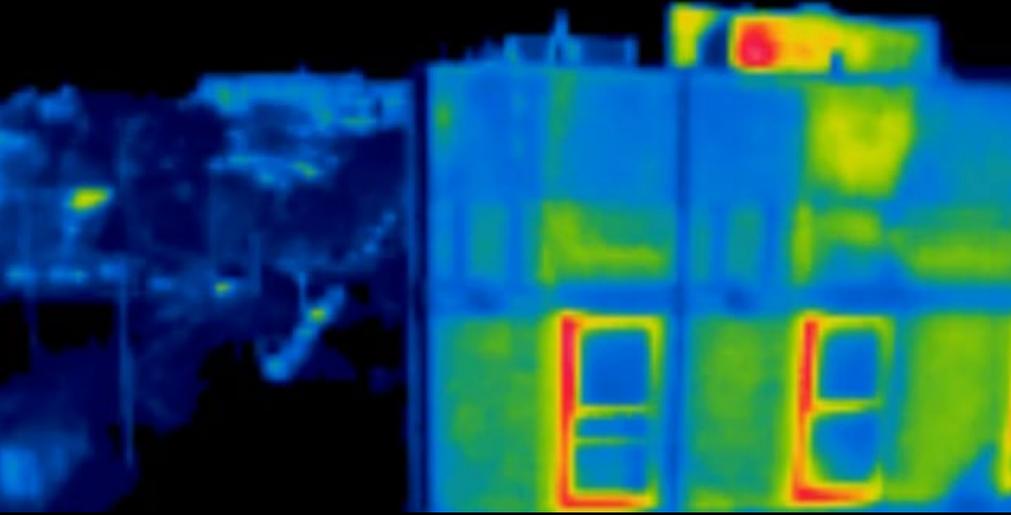
Outdoor Aerial Thermography Inspection



Thermal anomaly detection and classification – thermal bridges, infil/exfil, moisture

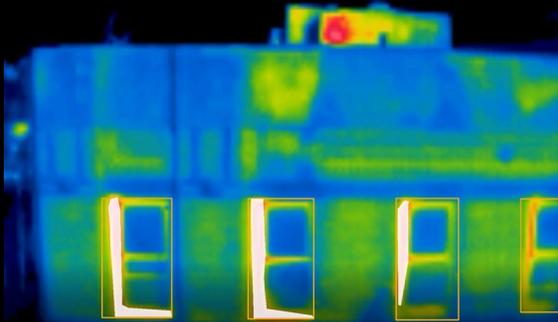


Indoor Thermal Inspection & Personal Interviews

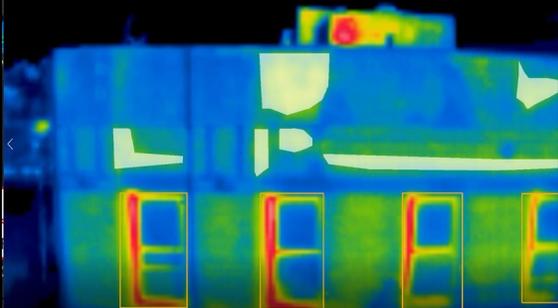


DOE Research Grant – 2018-2023

CD6- BRONX, NYC Aerial Thermography Results

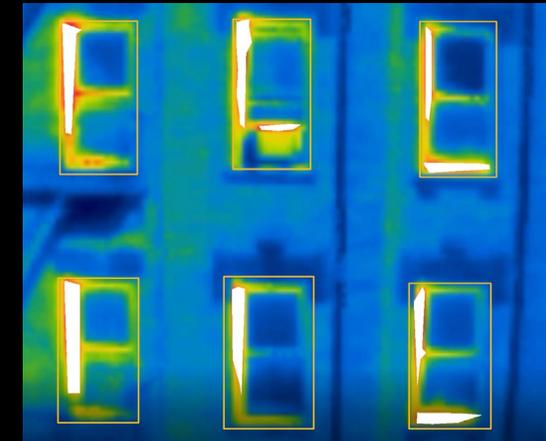
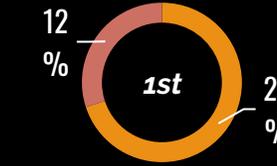
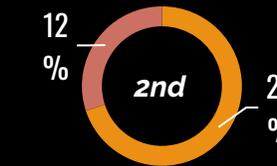
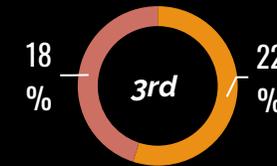
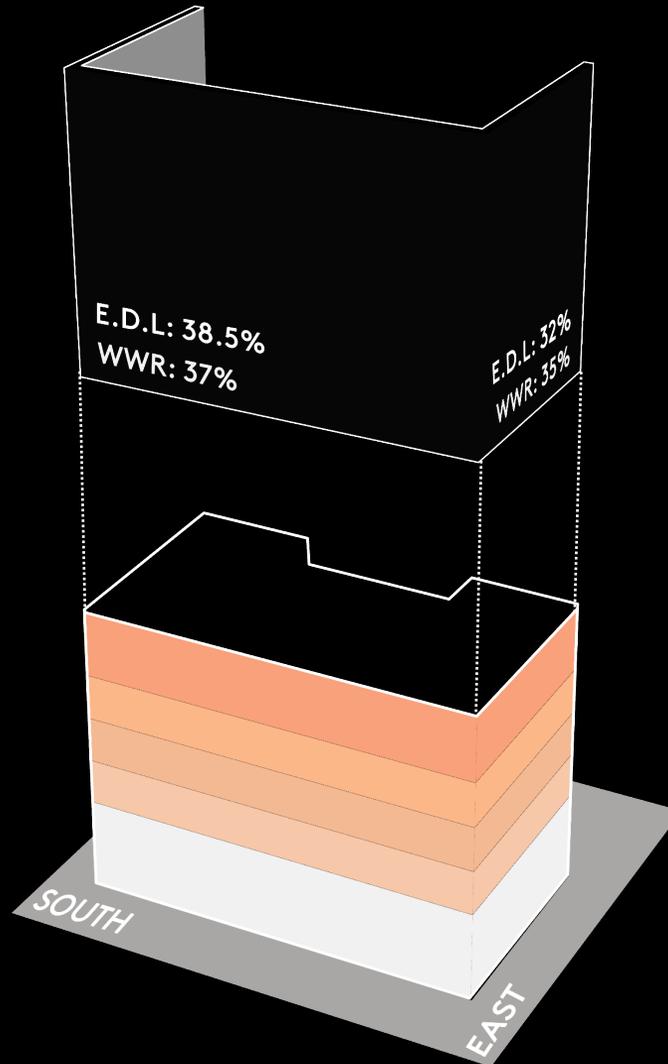
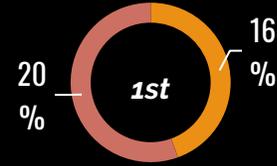
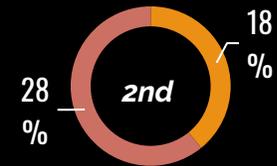
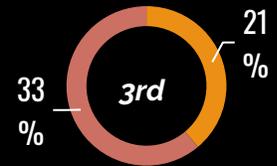
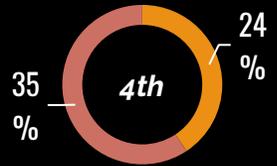


Infiltration/Exfiltration: 98.9%



Thermal Bridge/Missing Insulation: 94.3%

- Infil/Exfil
- Thermal Bridge



Infiltration/Exfiltration: 95.6%



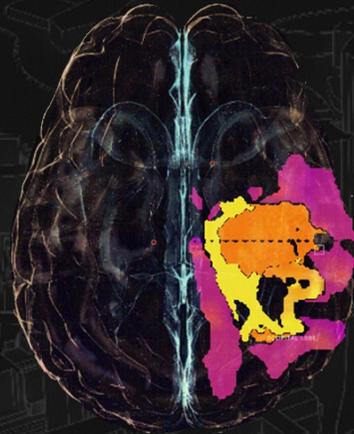
Thermal Bridge/Missing Insulation: 98%

WELCOME TO LAMARR.AI: GIVING YOUR BUILDING AN MRI WITH AUTOMATED DIAGNOSTICS

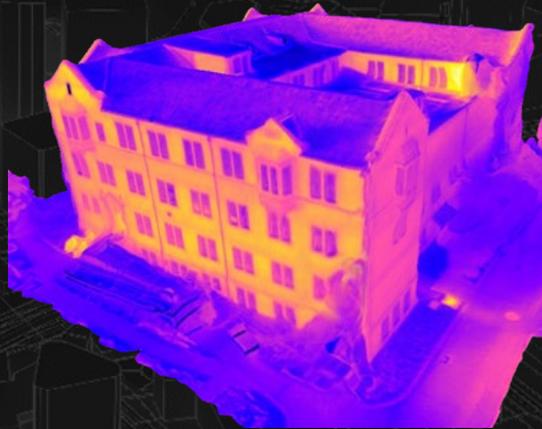
1977



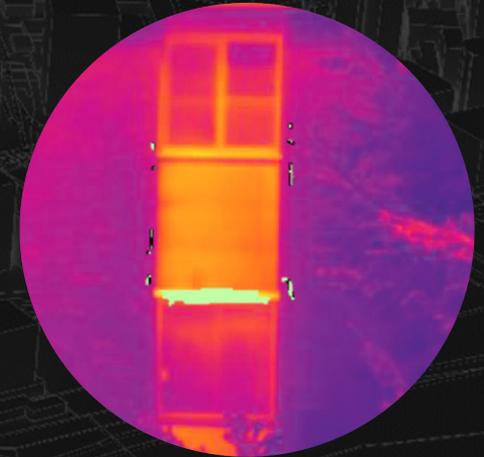
THE FIRST HUMAN IS ANALYZED VIA MRI
MEDICINE CHANGES FOREVER



2023



MRI FOR BUILDINGS BY LAMARR AI
REVOLUTIONIZES BUILT WORLD HEALTH



PATENTED NOVEL AI - AUTOMATES DEFECT CLASSIFICATION + ACCURATE BUILDING ENERGY MODELING



Tier 1:

Detect

Data Collection
Thermal and Visual Image Processing
Anomalies Registration on 3D Model

2-3 Days from Data Collection

Tier 2:

Diagnose

Data Collection
Thermal and Visual Image Processing
Anomalies Registration on 3D Model
Retrofit Work Plans and Cost Estimates

5 Days from Data Collection

Tier 3:

Audit

Data Collection
Thermal and Visual Image Processing
Anomalies Registration on 3D Model
3D Energy Modelling
Retrofit Work Plans & ROI Projections

One Week from Data Collection

SOLUTIONS: BUILT FOR STAKEHOLDERS ACROSS THE REAL-ESTATE AND CONSTRUCTION INDUSTRIES



Compliance & ESG

- Low-cost, efficient method to meet energy & carbon emissions reporting requirements.
- Quickly find out-of-compliance buildings in your portfolio.
- Support compliance with energy and emissions codes such as Boston and Cambridge BEUDO/BERDO, New York City LL97 and similar codes across US and internationally.



Retrofit Planning & ROI Analysis

- Strategically deploy limited budget.
- Extend service life through targeted repair of window/wall systems.
- Align capital planning with NYSERDA and NYS Clean Heat incentives.



Pre-Acquisition Due Diligence

- Accurately assess building health before deal close.
- Rapid analysis to meet your due-diligence time constraints.
- Enable faster transactions in Upstate revitalization projects and Opportunity Zones.

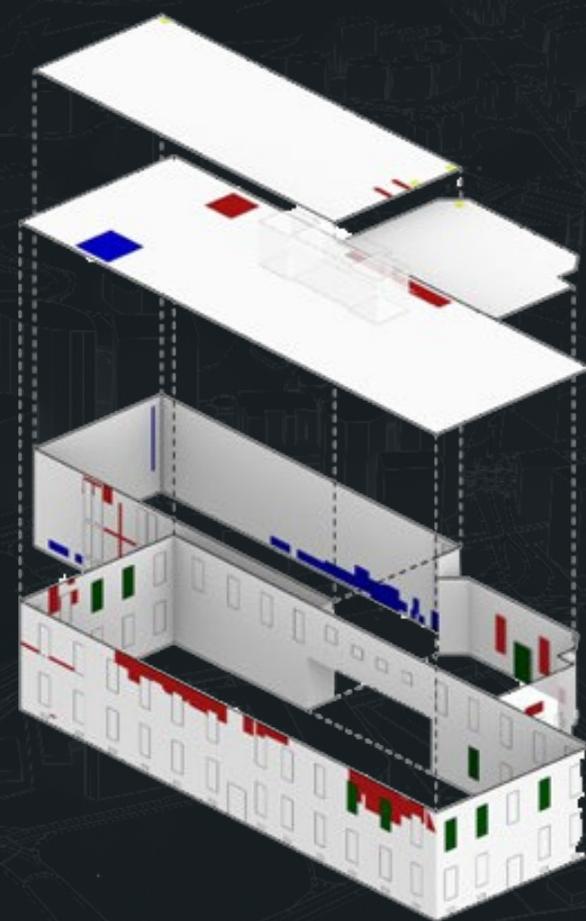
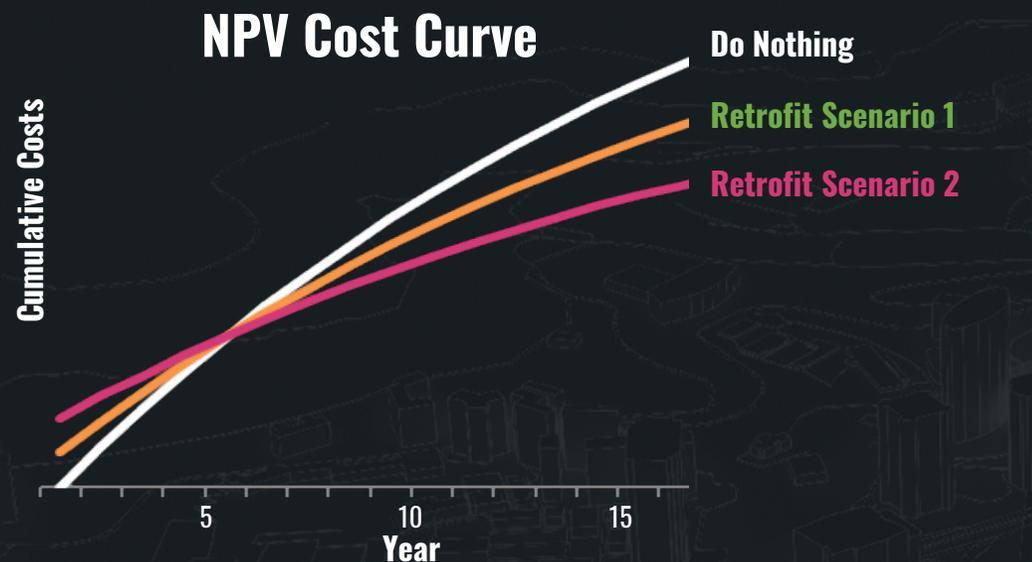


New Construction Quality

- Verify envelope performance before commissioning.
- Quality control on subcontractor work, avoiding costly re-work.
- Ensure warranty compliance and preserve eligibility for future claims.

EXAMPLE CAMPUS 1: UNIVERSITY BUILDING IN THE NORTHEAST [AUDIT]

Translating envelope defects to CapEx planning & decision-making tools



- \$8K** Saved Yearly Utility Costs
- \$36K** Estimated CapEx Forecast
- 4.5** Years to ROI

1 WEEK FROM FLIGHT TO DELIVERY OF REPORT

LEADERSHIP: A CLOSE-KNIT TEAM OF EXPERTS IN BUILDING SCIENCE + AI



DR. TAREK RAKHA
CEO



Director of the GT High Performance Building lab (Regent's Innovator Leave)



DR. NORHAN BAYOMI
CPO



Research Scientist in Building Technology and AI



PROF. JOHN E. FERNÁNDEZ
CSO



Professor of Architecture
Former Head of BT Program
(On Sabbatical)



DR. SENEM VELIPASALAR
CTO



Director of the SU Smart Vision Systems Lab



BEN ROCCI
HEAD OF STRATEGY & BD



Lead AI Product Strategist at Ford



Georgia Tech Scheller College of Business
Ray C. Anderson Center
for Sustainable Business



U.S. DEPARTMENT
of ENERGY



U.S. DEPARTMENT OF ENERGY



Lamarr.AI

Automating Building Exterior Diagnostics for Retrofitting and New Construction

The Building MRI

From drone capture to building portfolio enclosure intelligence: actionable insights for capital and risk foresight.

[Book a Platform Demo](#)



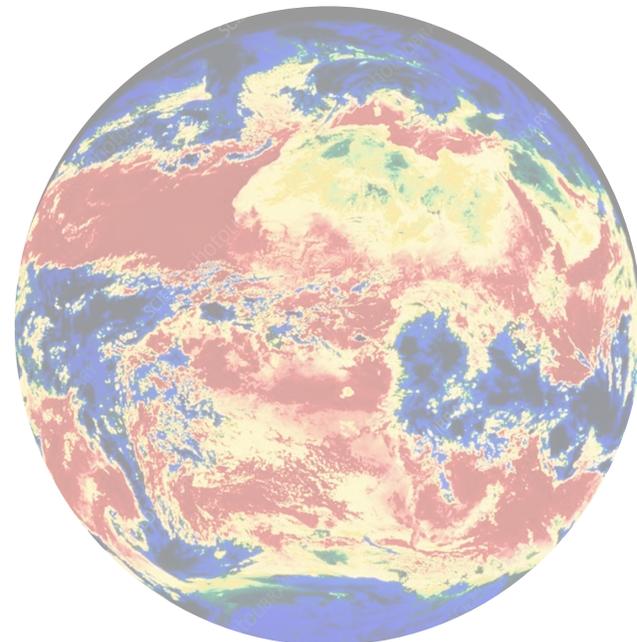
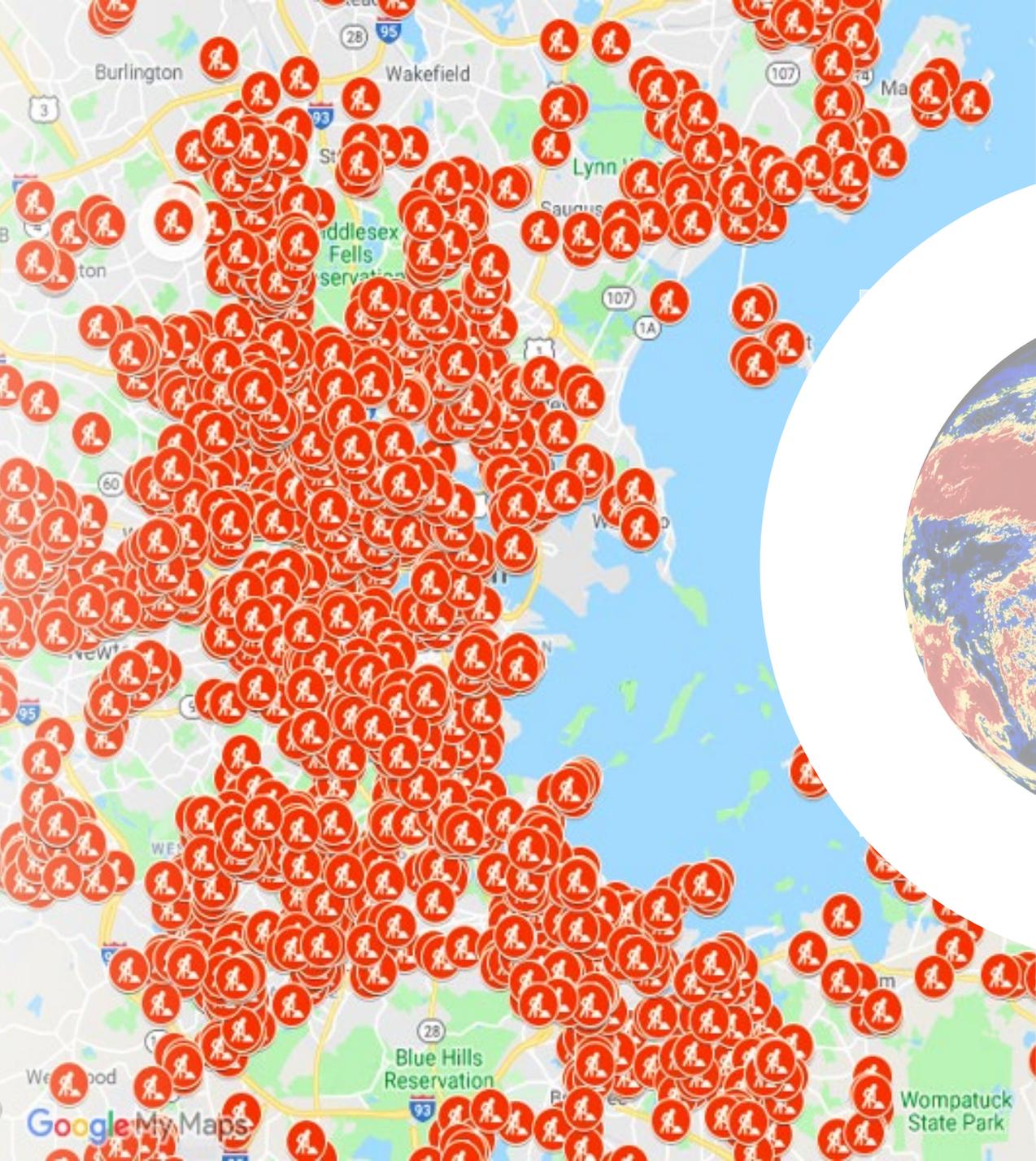
John E. Fernandez, CSO
john@lamarr.ai
www.lamarr.ai

ZEYNEB MAGAVI, HEET





The Thermal Energy Opportunity



Connecting the challenge of 'end of life' infrastructure to climate change to the thermal energy opportunity?

Ambient geothermal energy IS earth's temperature.

Every year our earth absorbs over 10 times the energy all of humanity uses/year.

As Thermal Energy.

Tapping it can multisolve





Engage All Stakeholders



Innovate & Iterate to Align

MOVES AT SPEED OF TRUST



Identify System Levers

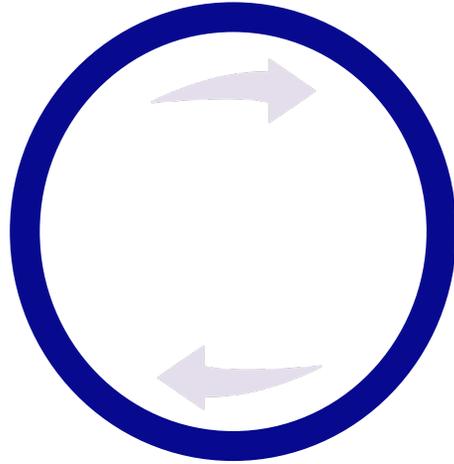
DEMONSTRATED

- ✓ High Safety & Security
- ✓ 100% Combustion-Free
- ✓ Reliable & Resilient
- ✓ Scalable & Adaptable
- ✓ Workforce Transition
- ✓ Ethical Distribution
- ✓ Affordable for consumer
- ✓ Economic for utility
- ✓ Speed & Scale needed
- ✓ Benefits Electric Grid

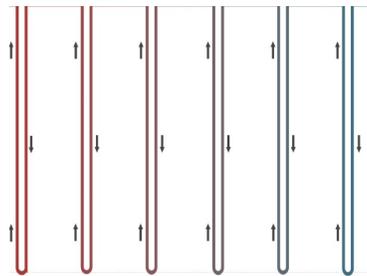




BUILDINGS:
(GEO THERMAL HEAT PUMP)



DISTRIBUTION LOOPS:
(THERMAL ENERGY NETWORK)



THERMAL RESOURCES:
(GEO THERMAL BOREHOLES)

Also ...

WASTEWATER EXCHANGE
INDUSTRIAL WASTE HEAT
LAKES, RIVERS, PONDS
OTHER THERMAL ...

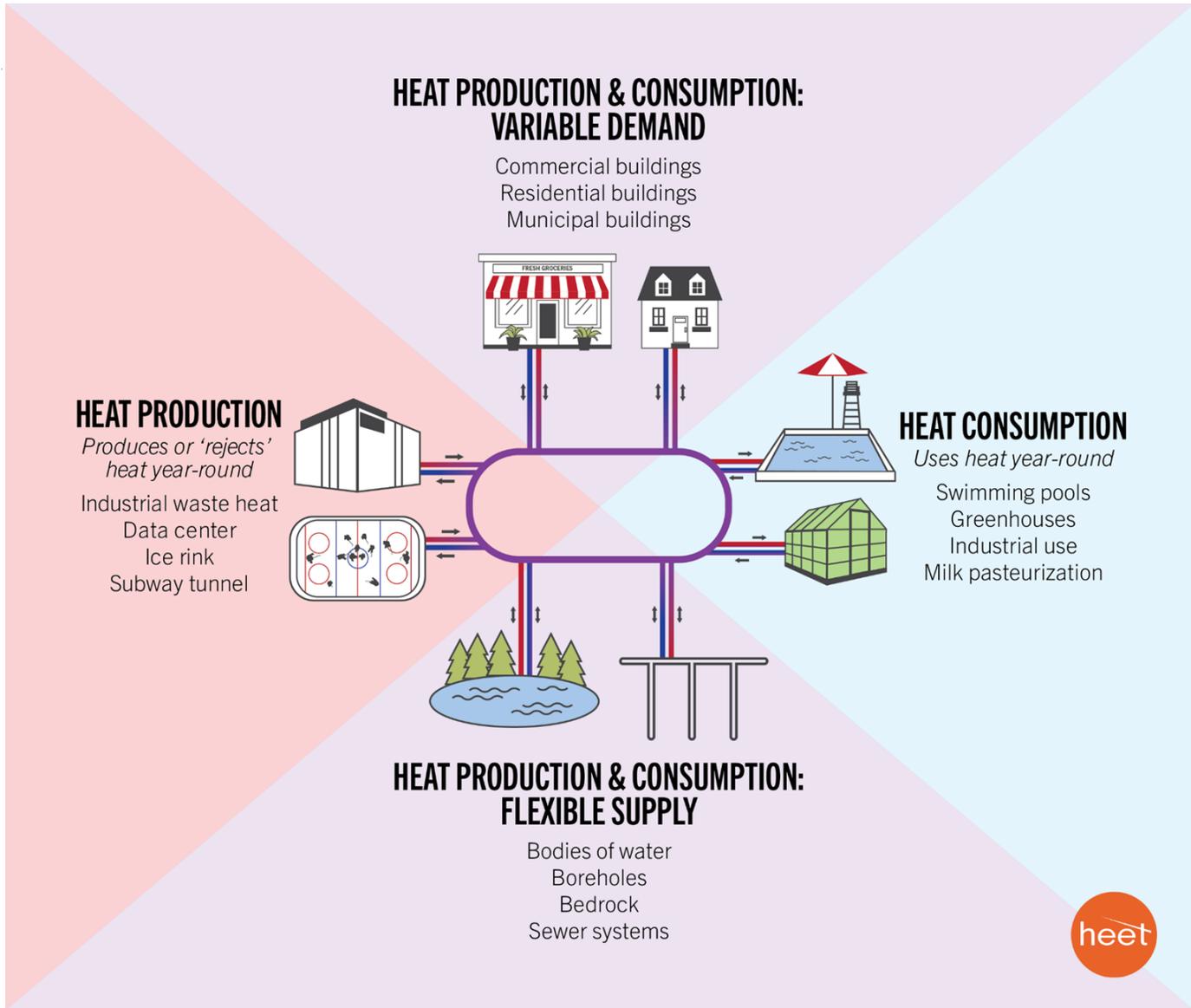
HOW DOES A THERMAL ENERGY NETWORK TAP THERMAL ENERGY ?

Every component of a Geothermal Energy Network contributes efficiencies. Together they are the most efficient heating and cooling.

Each component is OLD TECH.

Together they are NEW TECH





WHAT IS A THERMAL ENERGY RESOURCE ?

A thermal utility should prioritize closest, least cost thermal resources. The defining parameters are illustrated in four quadrants.

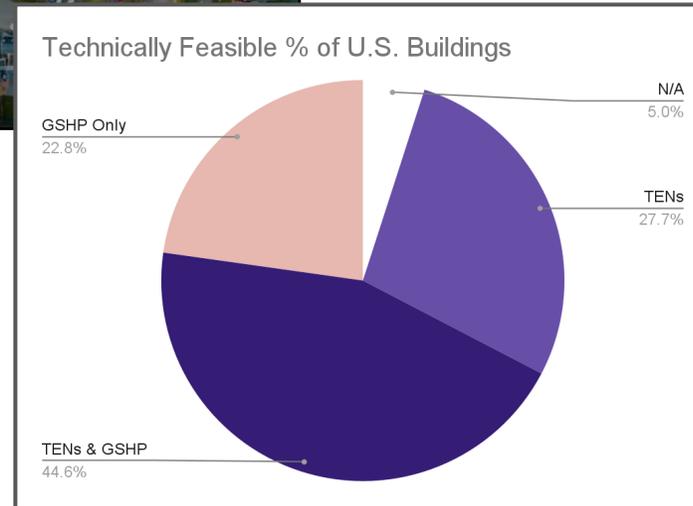
The flexible supply quadrant is the MOST valuable resource.



<https://www.youtube.com/watch?v=mvOoBL-et7U>



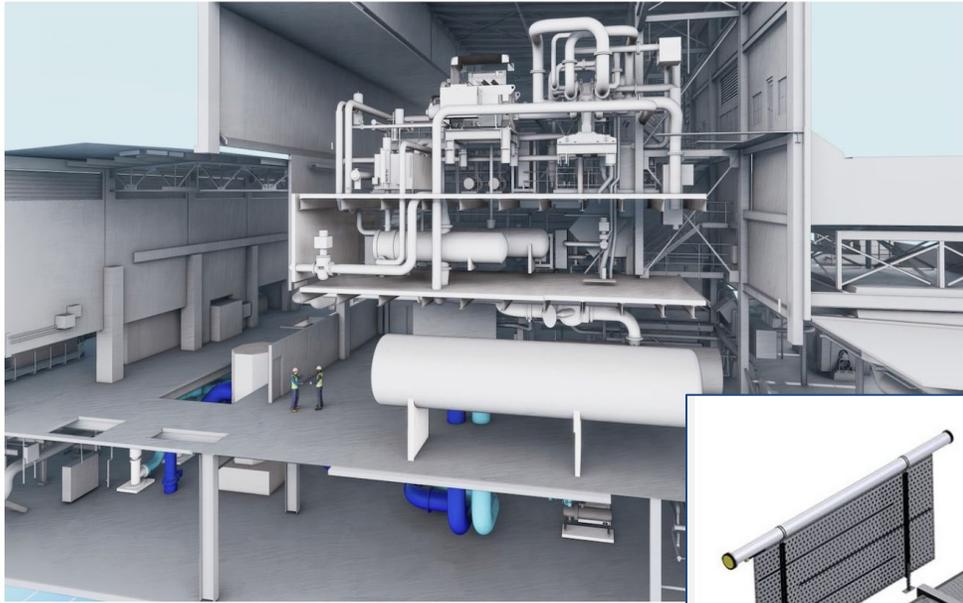
The World Bank Group's International Finance Corporation has initiated in seven countries a program to scale investment in geothermal networks at the 10,000 building scale.



HEET's utility growth model unlocking the financing of geothermal has "awakened a sleeping giant"



Vicinity Energy Commences Construction of Industrial-Scale Heat Pump Complex in Partnership with DCO Energy and Everllence



» Värtan Ropsten – The largest sea water heat pump facility worldwide, with 6 Unitop® 50FY and 180 MW total capacity

Client
 AB Fortum Värme samägt med Stockholms stad
 11577 Stockholm, Sweden

Stockholm's district heating system
 Stockholm, the Royal Capital of Sweden, is situated on 14 islands and is considered as one of the most beautiful cities in the world. Its clean sea

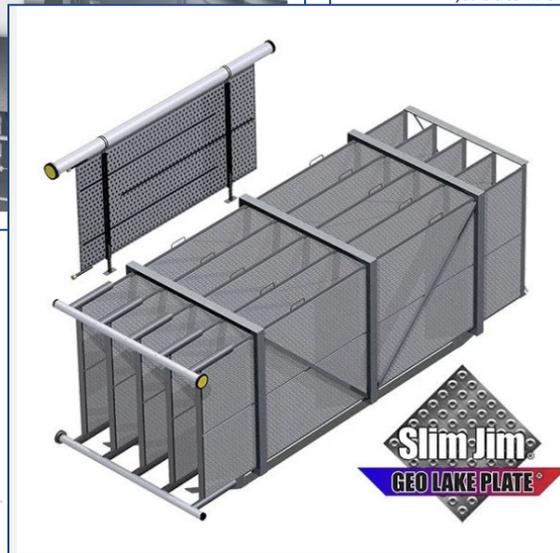
result of stringent environmental requirements. The district heating system is a central part of the total Stockholm energy supply.



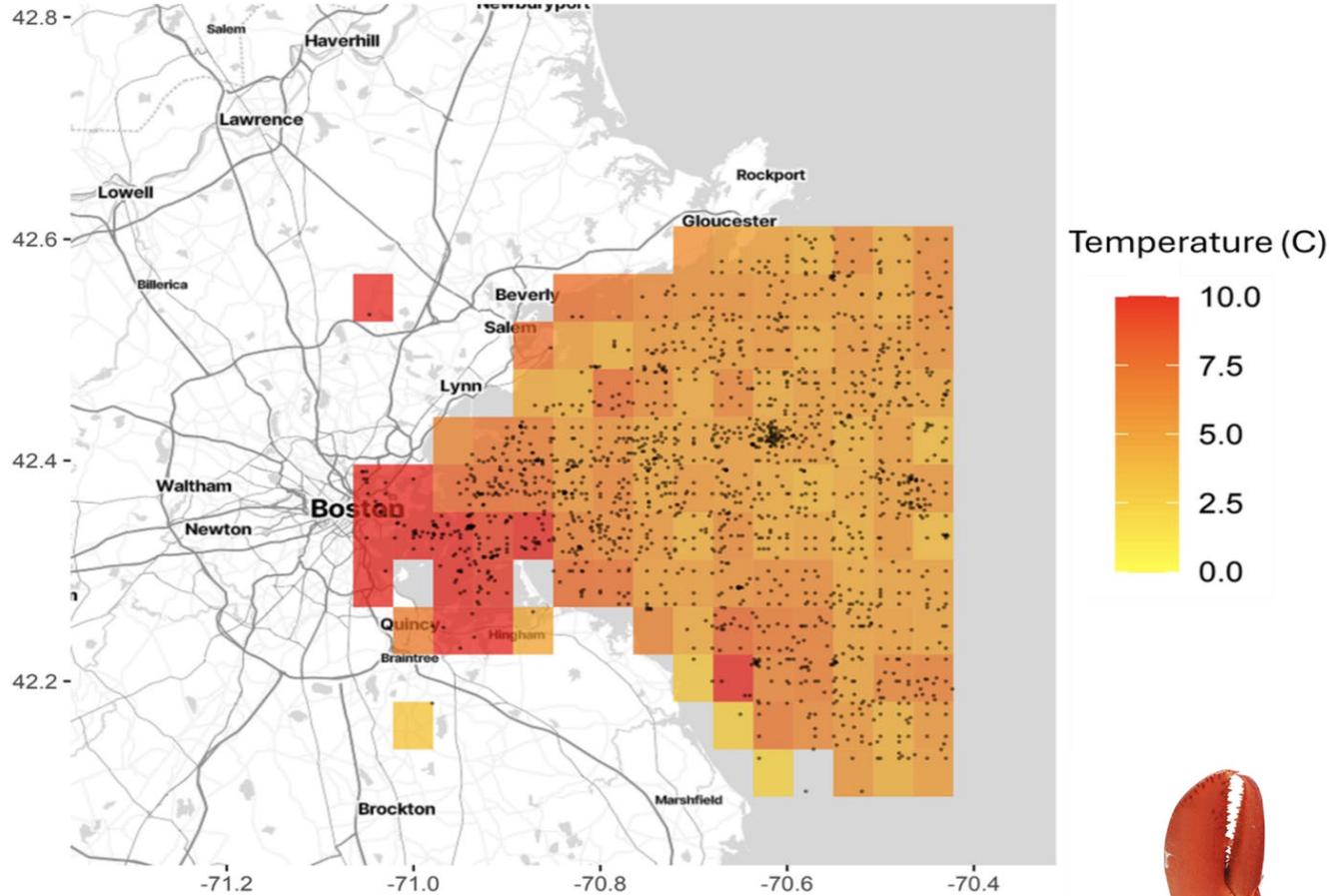
The heat pumps (total 420 MW) are used for base load production along with the bio fuel-fired plants (total 200 MW). Oil-fired plants are used in times of high energy demand only.

Fortums district heating production system is increasing the use of bio fuels and solar energy sources. In addition, for large heat pumps, hydroelectric power is utilized. All these measures add up to nearly 50% of renewable energy used for the production of district heat.

Heat supply for District Heating		
Plant	Network	Heat
Värtan	Central	2,600 GWh



Average Bottom Temperatures (deg C) 1912-2022



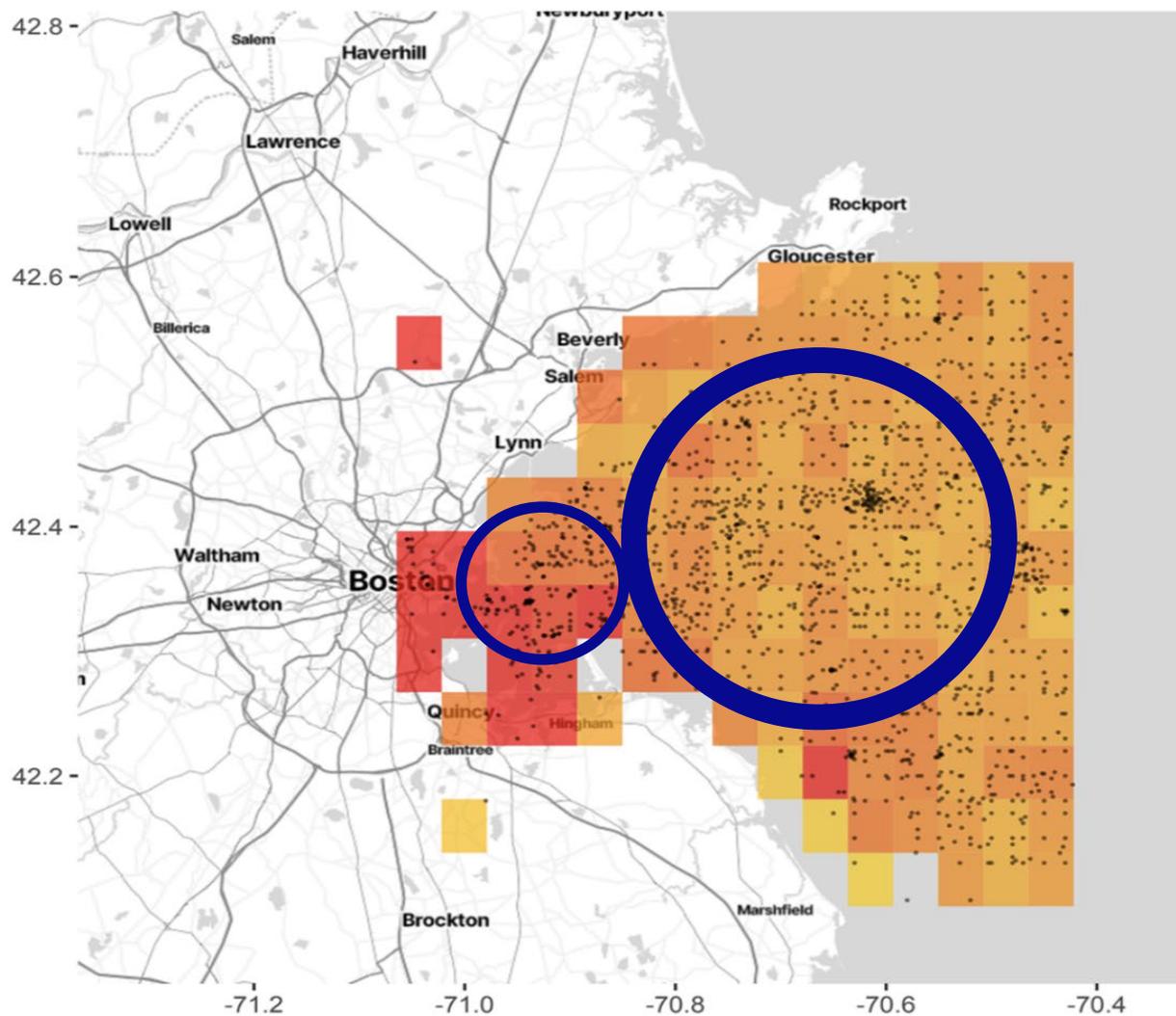
According to NOAA data, Boston Harbor is 3.4 degrees Celsius warmer than in 1912.

That is enough heat for over 1 Million homes annually.

It might even make lobsters think Boston is cool again.



Average Bottom Temperatures (deg C) 1912-2022



HEET is proposing that the quantification and mapping of thermal energy resources allows thermal energy planning, which communicates the scale of the opportunity.

The availability of local energy with no price volatility, total stability, and no global security implications... and also no emissions and significant grid benefits... can be unlocked incrementally.



#ThinkThermalTogether

Zeyneb.Magavi@heet.org

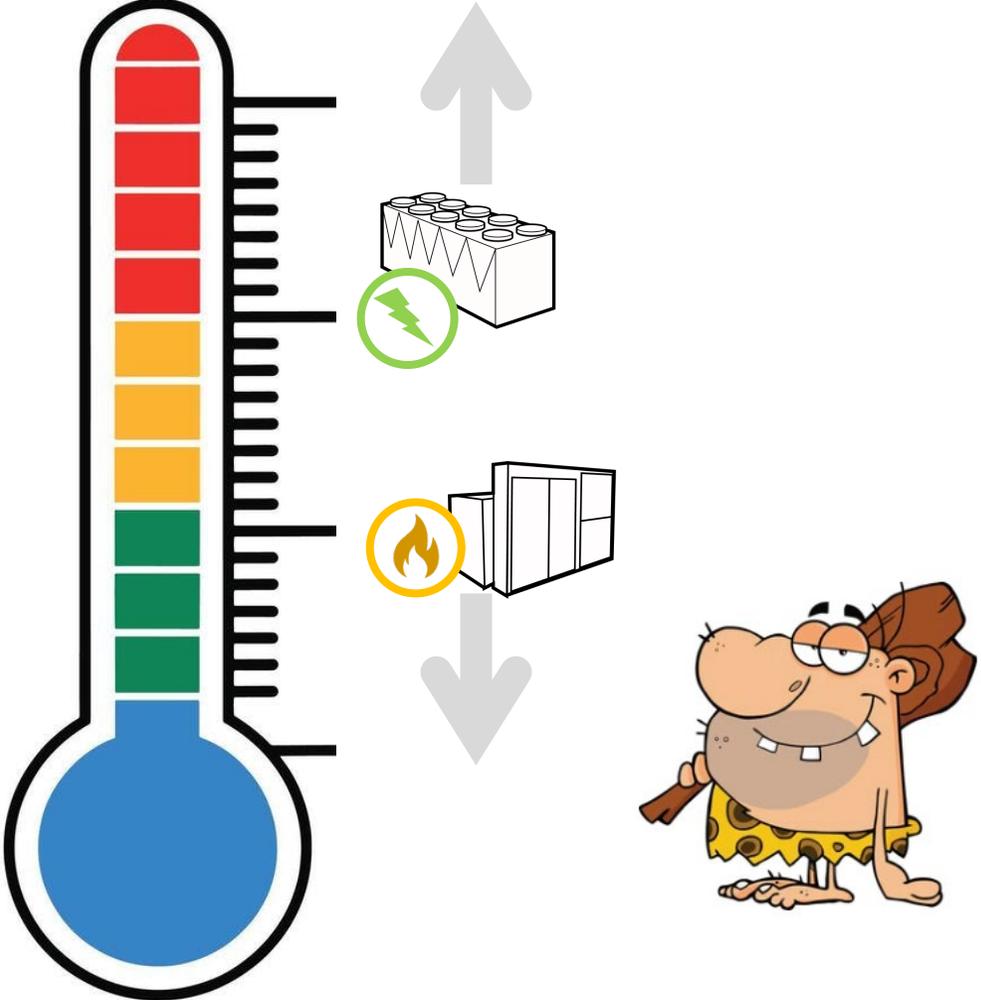


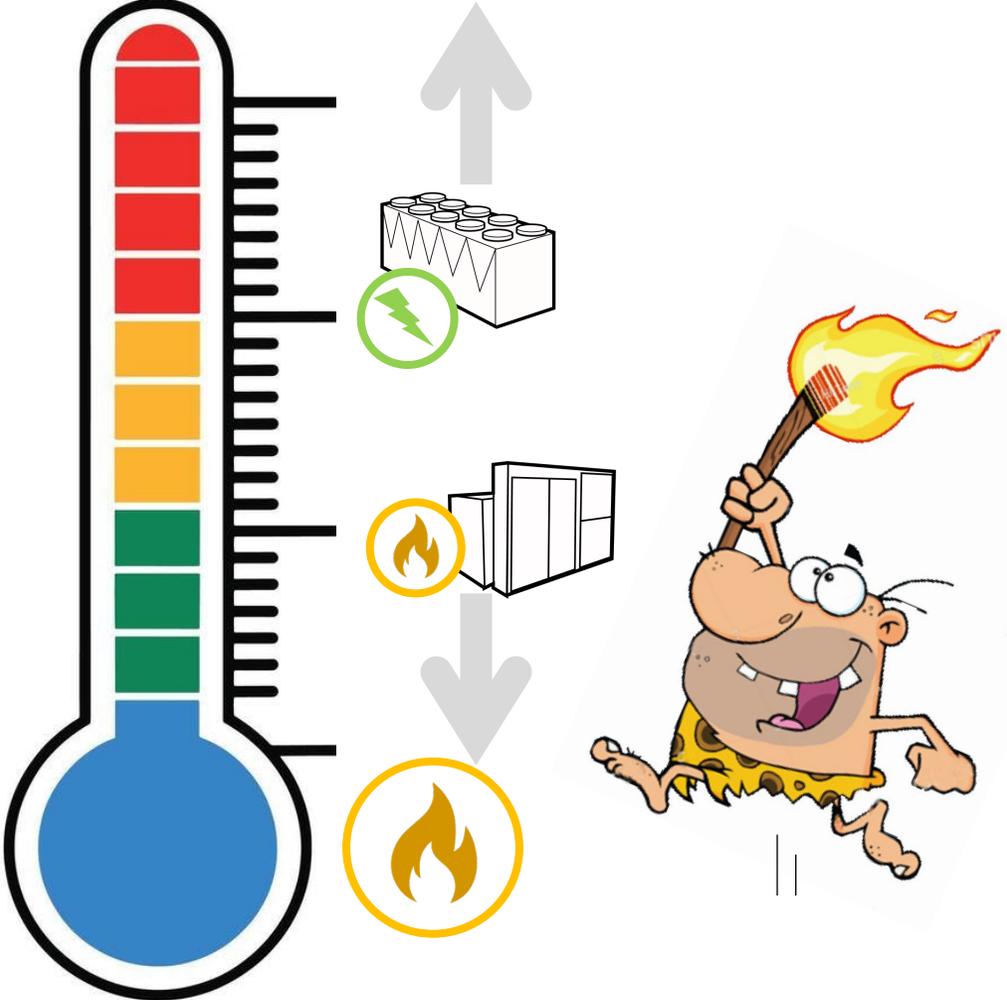
Want Geo Service?

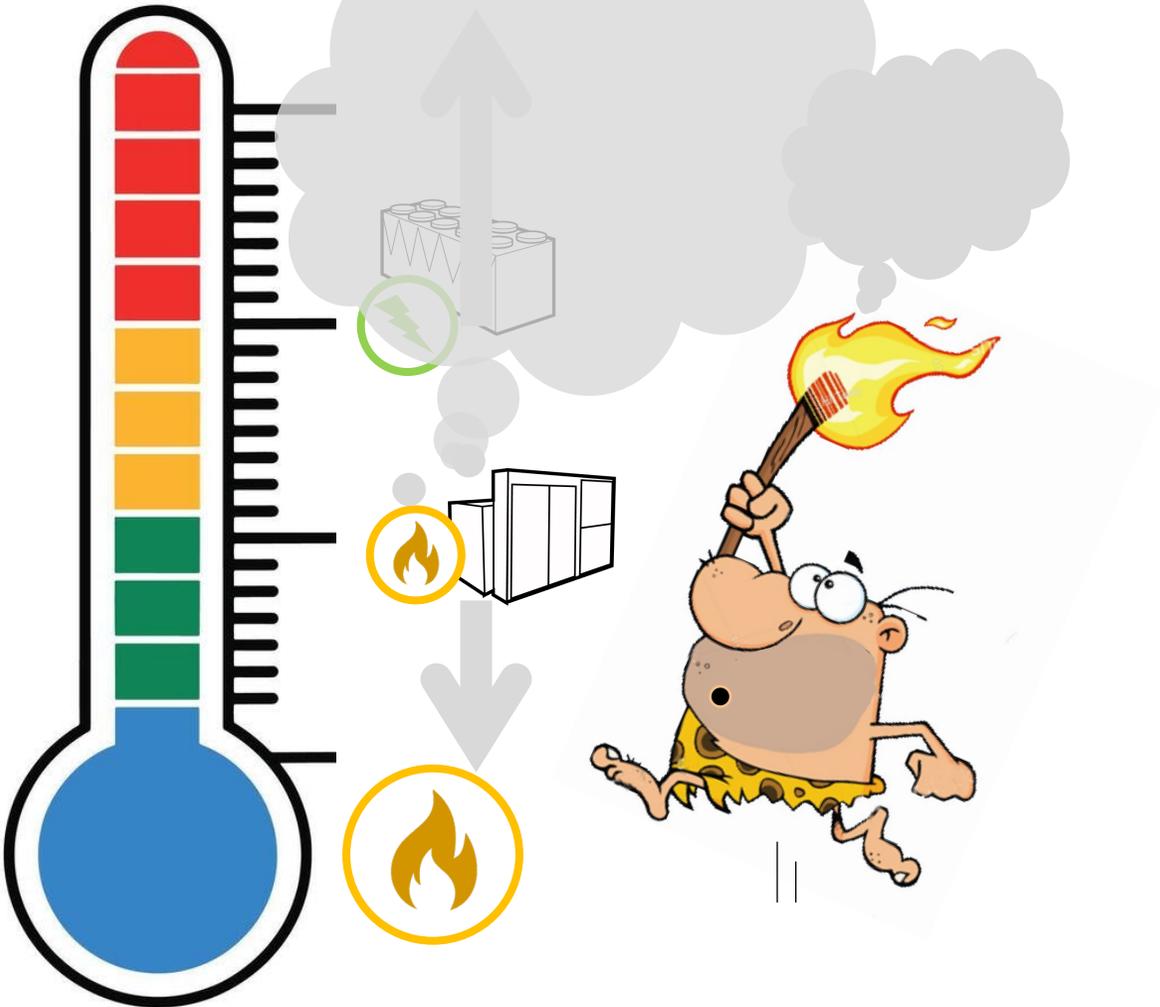
HEET licenses
all materials
for open sharing
& adapting
under
Creative Commons
[CC BY-AS 4.0](https://creativecommons.org/licenses/by-as/4.0/)

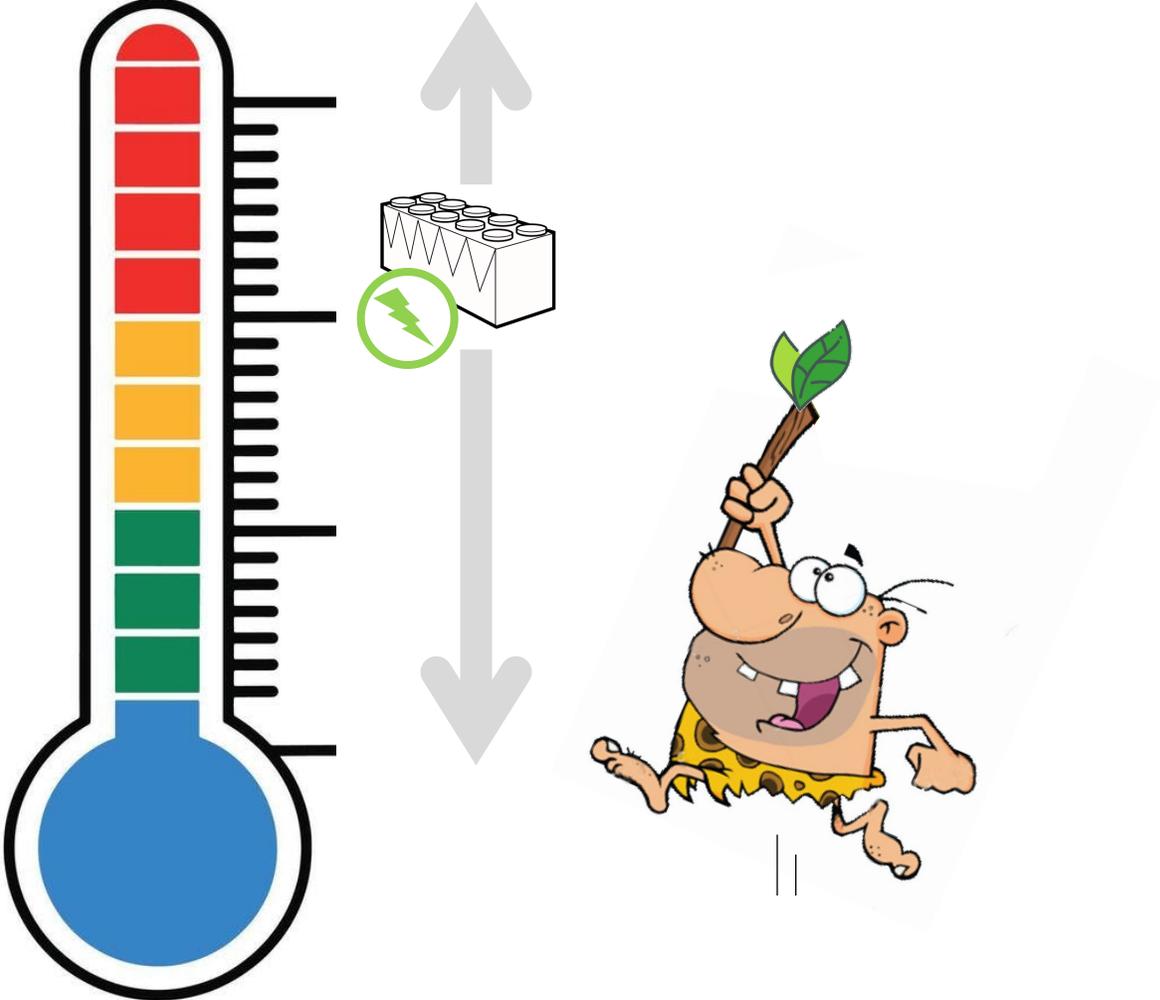
COLIN SCHLESS, TURNER CONSTRUCTION

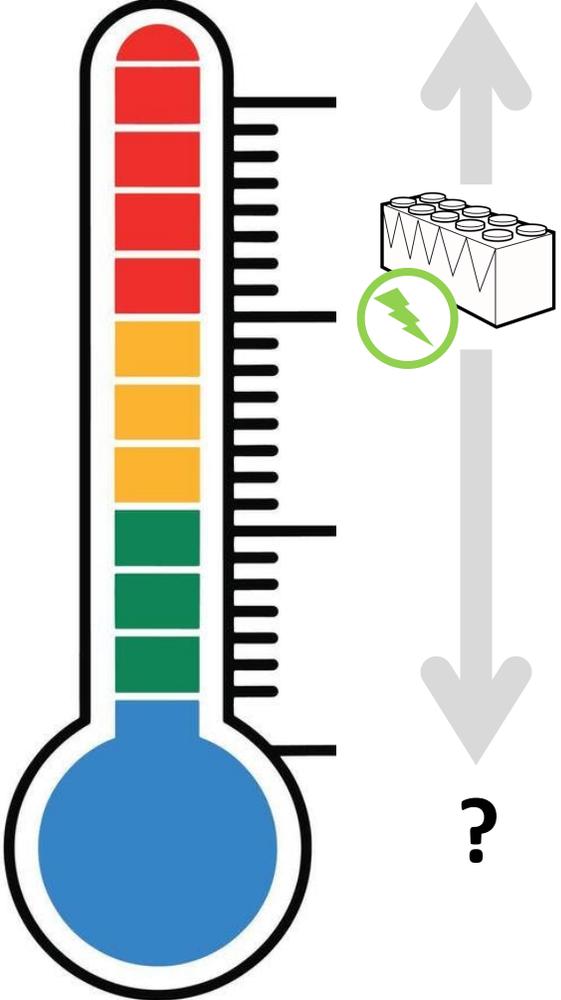


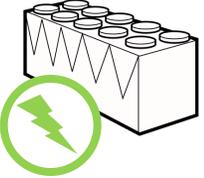
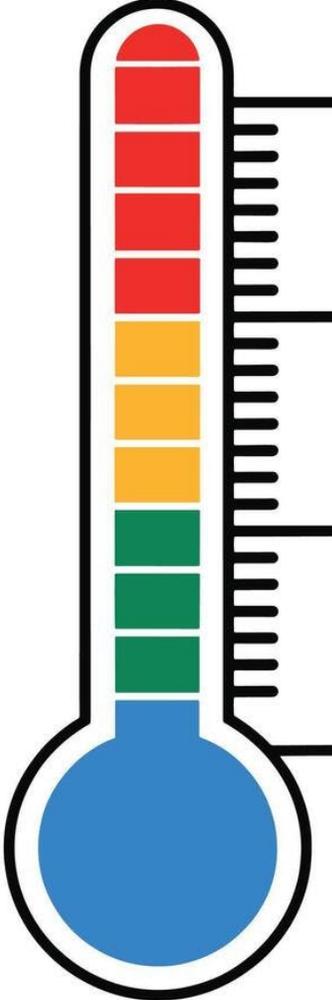




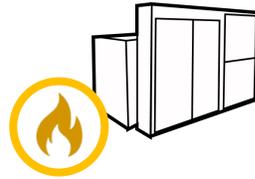








\$4,000/Ton

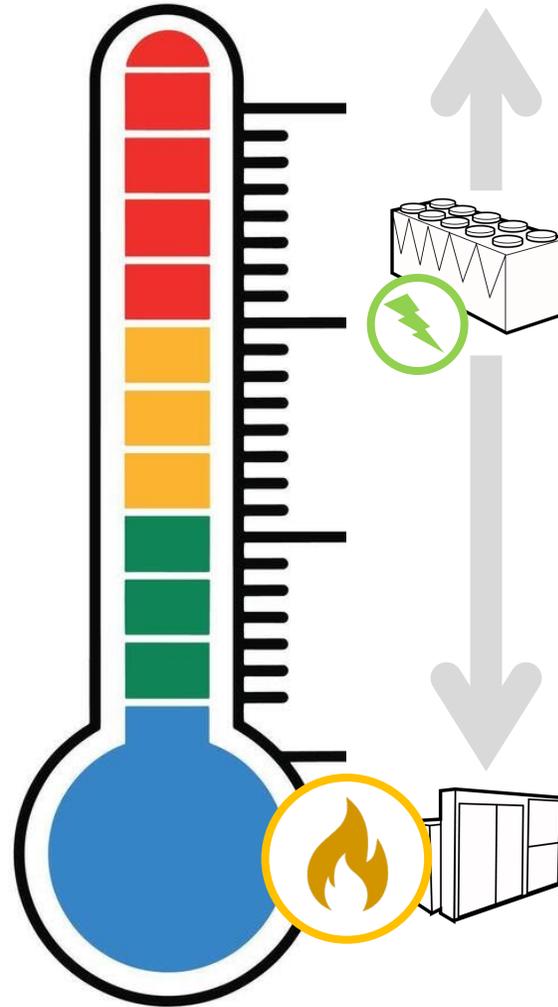


\$1,000/Ton



?





Hybrid Electrification



225 CMR

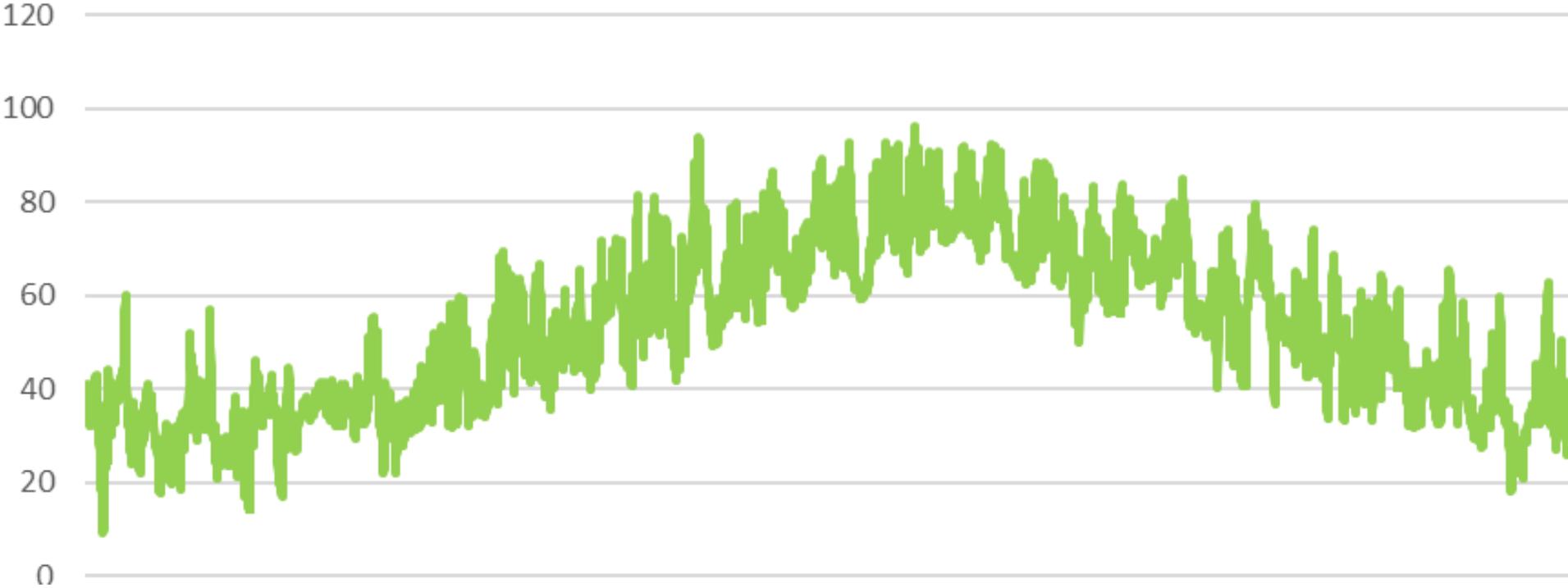
C401.4 *Add Section as follows:*

C401.4 Building electrification. Building projects which utilize Section C407.2.1 shall conform with C401.4.1. Building projects which utilize Section C402.1.5.2 shall conform with C401.4.2 except for buildings using the Relative Performance pathway because average ventilation at full occupancy is greater than 0.5 cfm/sf which shall comply with C401.4.1 rather than C401.4.2. Building projects which utilize Section CC104.1, Part 1 shall conform with C401.4.3.

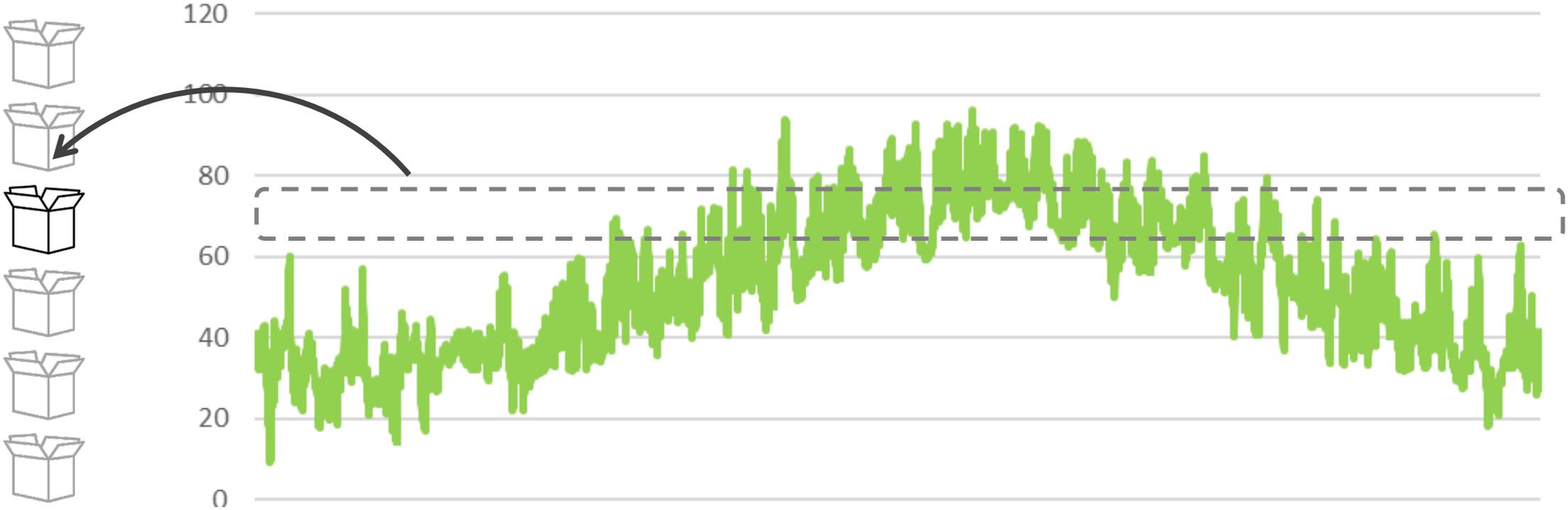
C401.4.1 Partial space heating electrification. Electric air source, *exhaust source*, or ground source heat pump systems shall supply 25% of the building's peak space heating and ventilation air heating load at the ASHRAE 99.6% winter climatic design condition. Heat pumps used for space and ventilation air heating shall comply with C401.4.4.

C401.4.1.1 Heat pump primary operation. The heat pumps shall be controlled to prioritize their primary operation, prior to operation of supplemental fossil-fuel equipment, during non-emergency conditions.

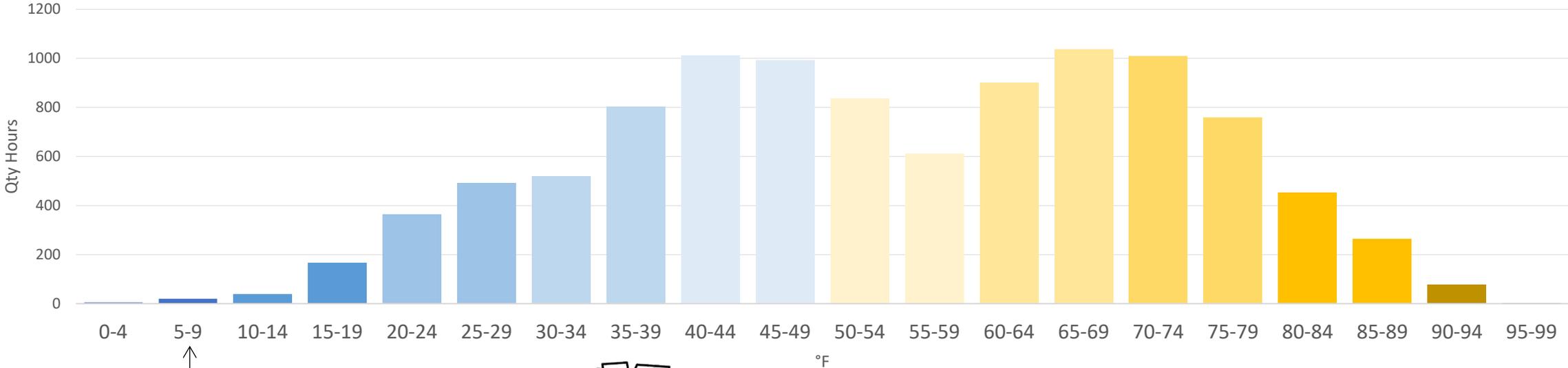
Dry Bulb Temperature (°F)



Dry Bulb Temperature (°F)

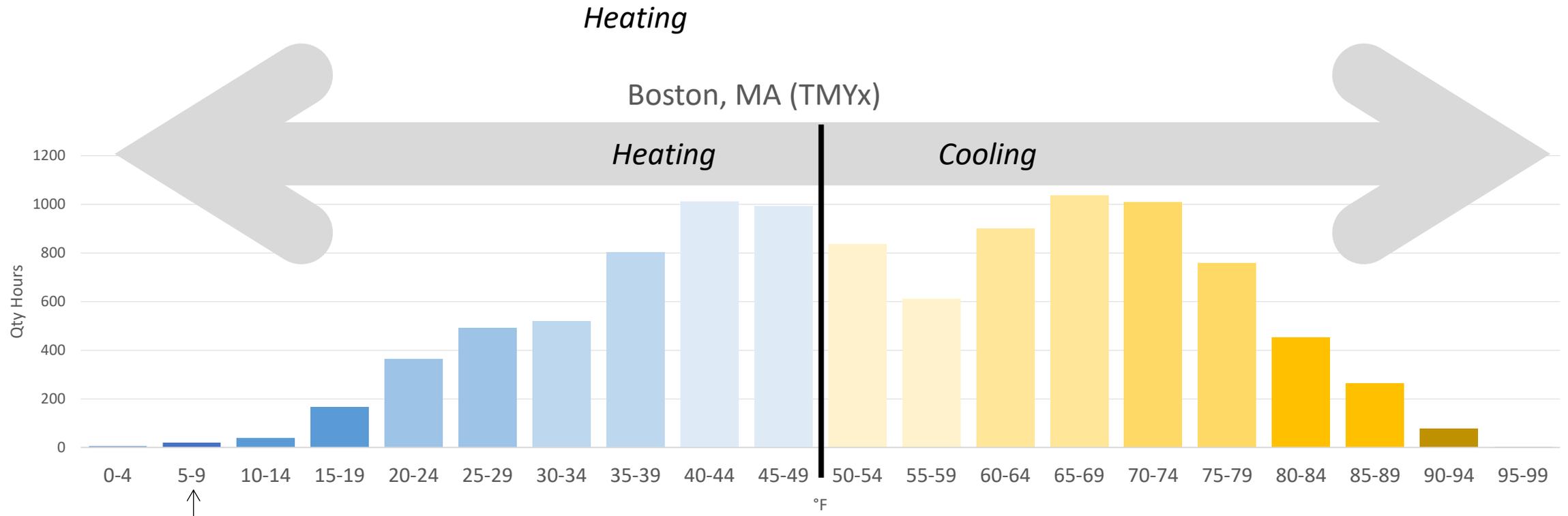


Boston, MA (TMYx)

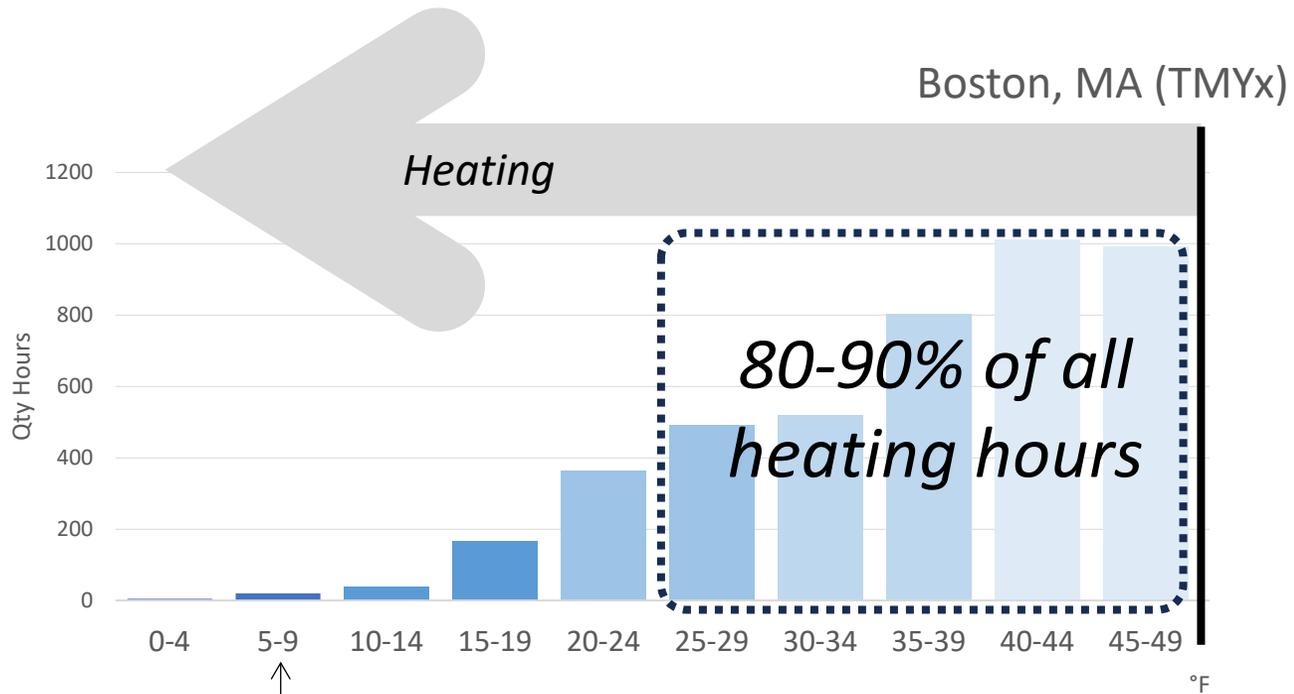


↑
ASHRAE 99.6% Design Temp
= 8.4°F

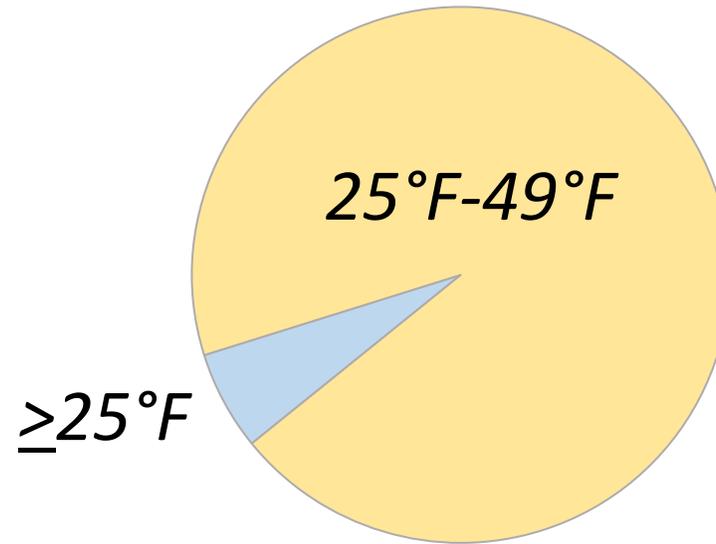


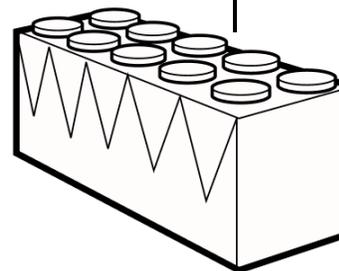
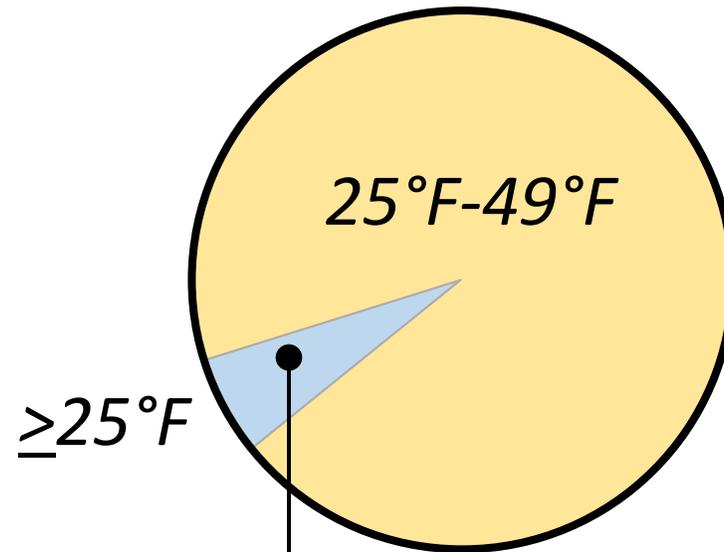
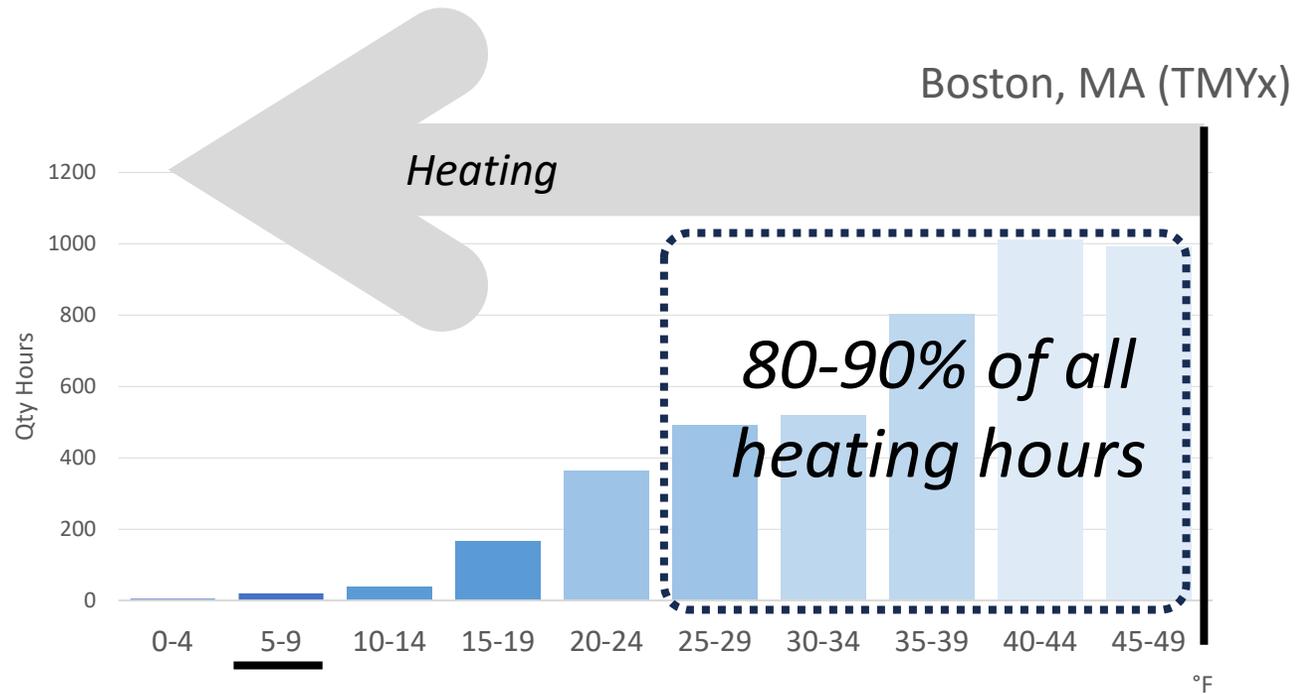


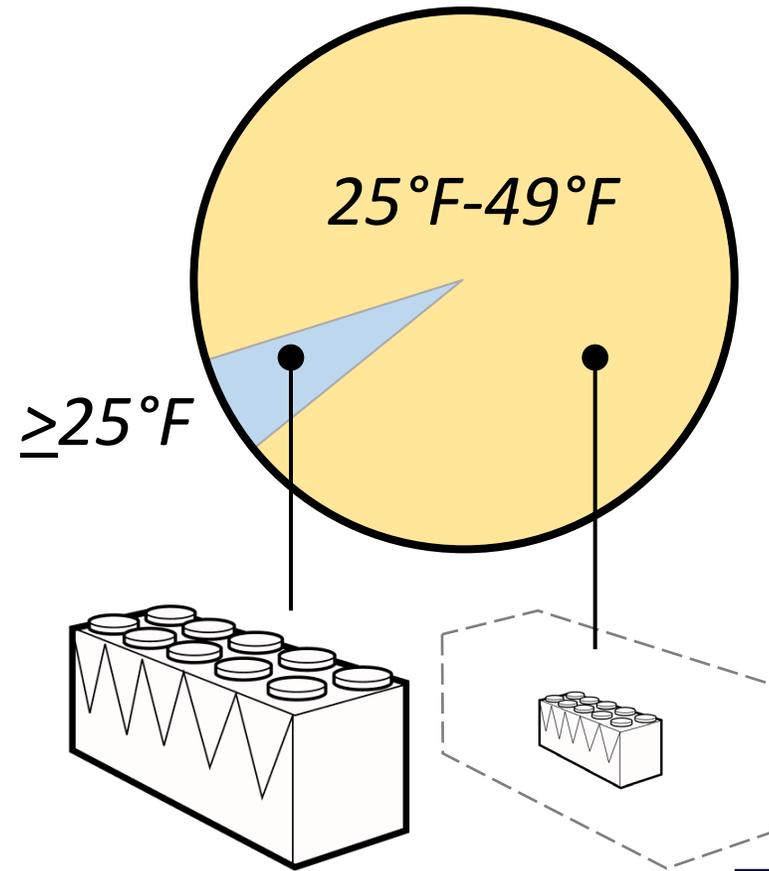
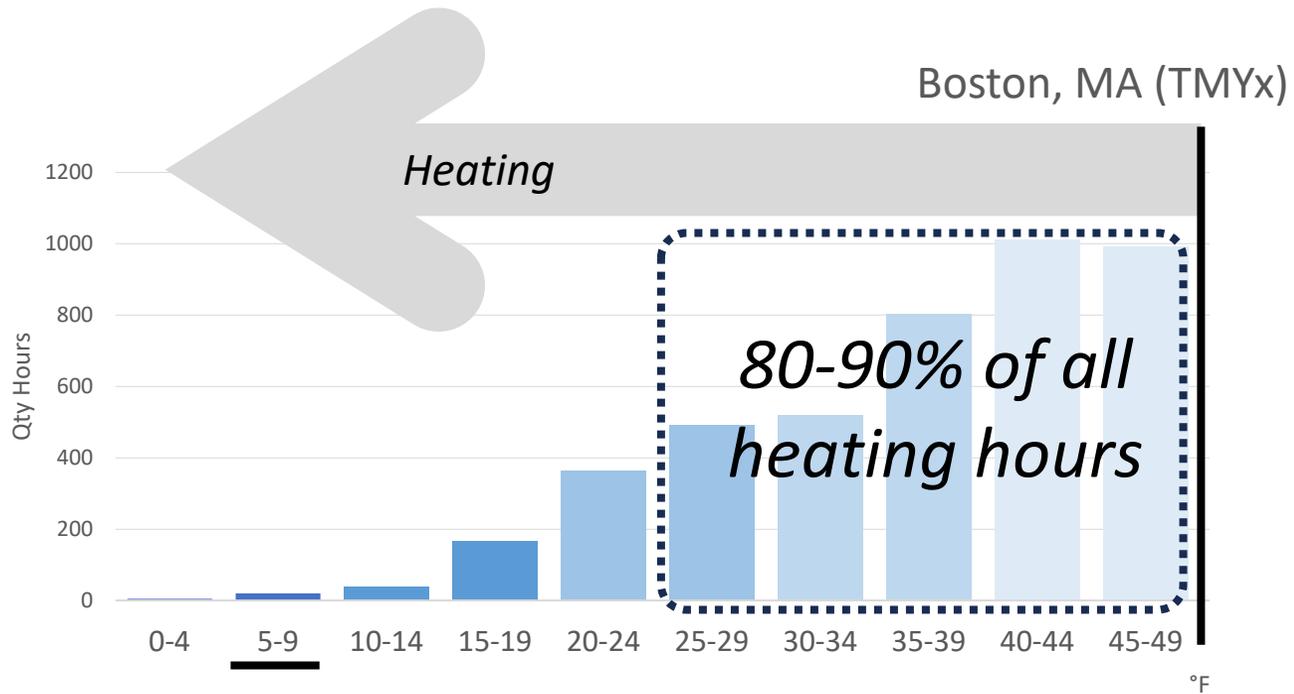
ASHRAE 99.6% Design Temp
= 8.4°F

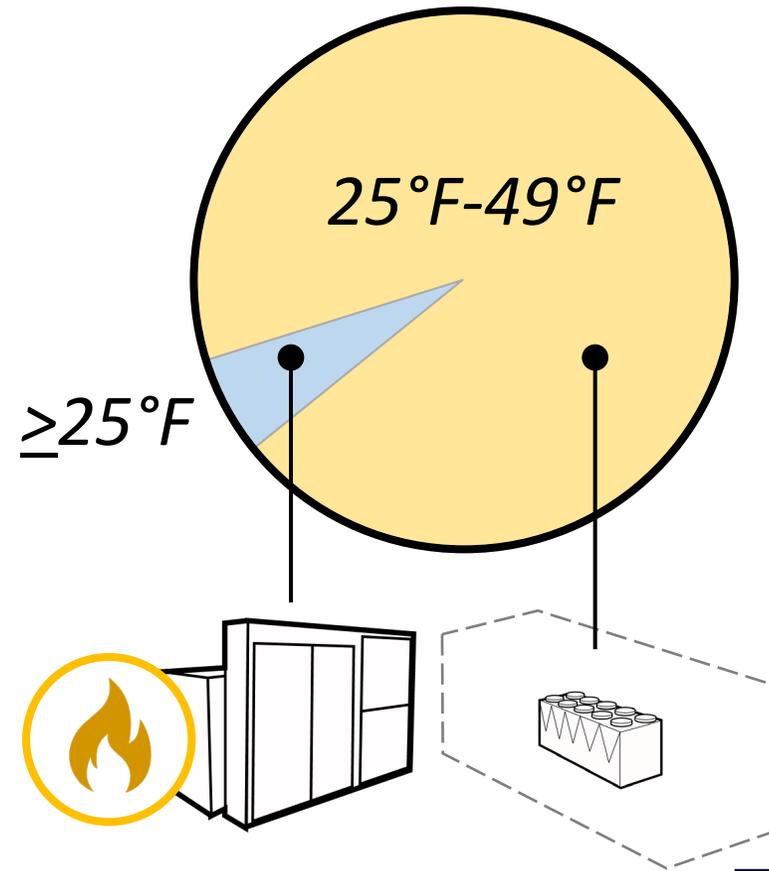
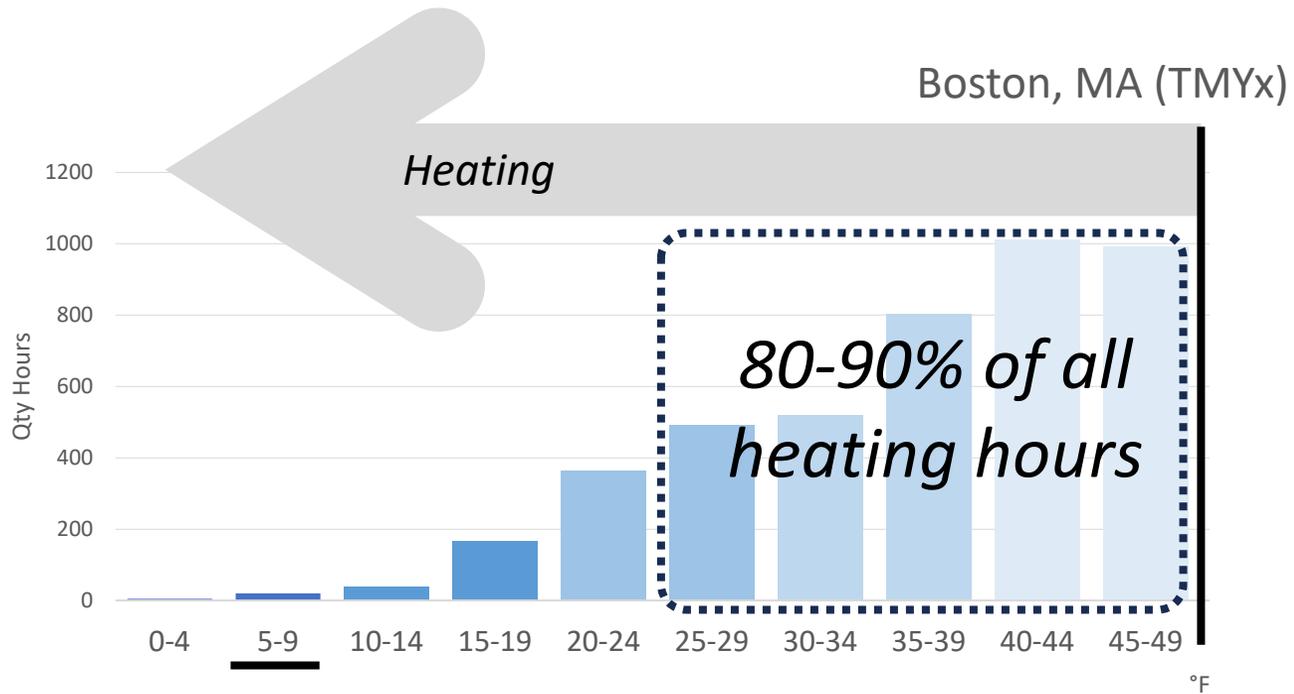


ASHRAE 99.6% Design Temp
= 8.4°F

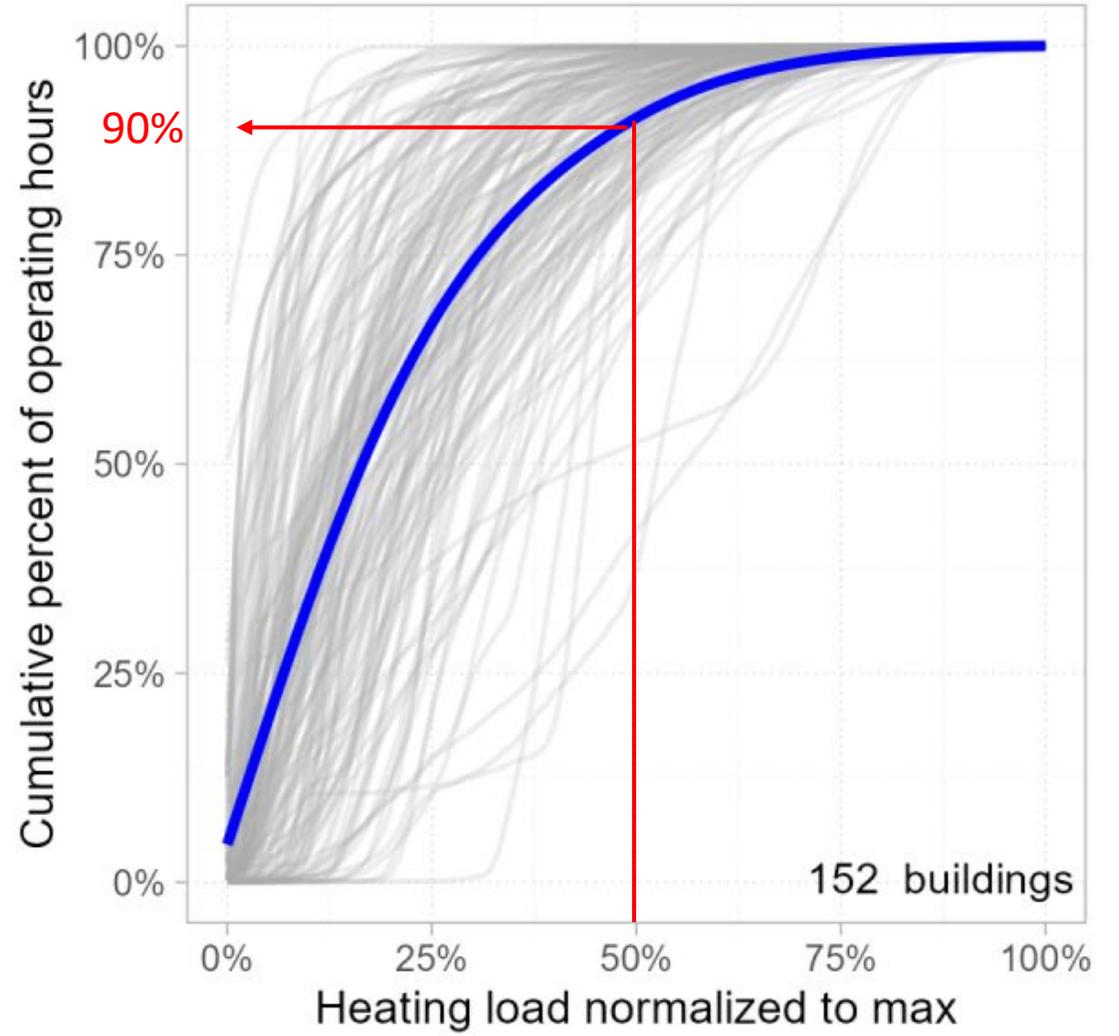
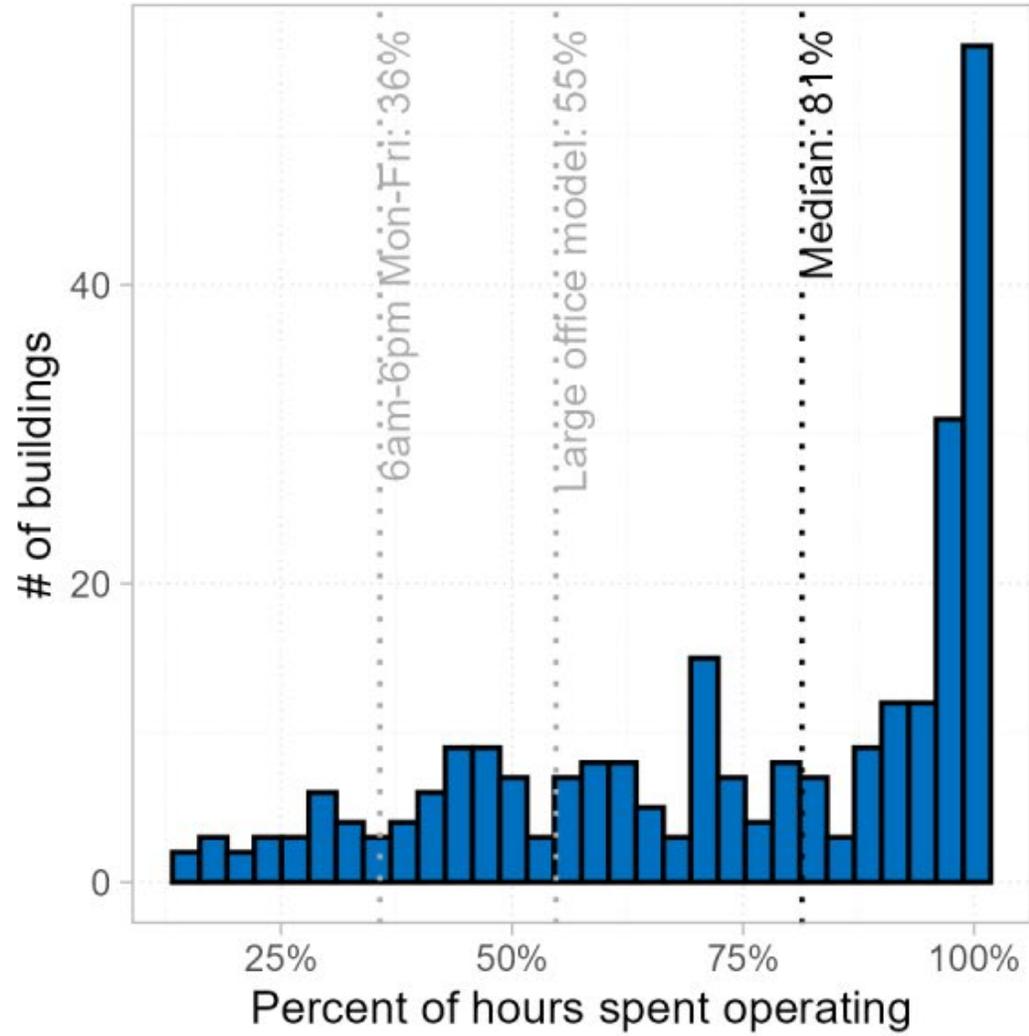




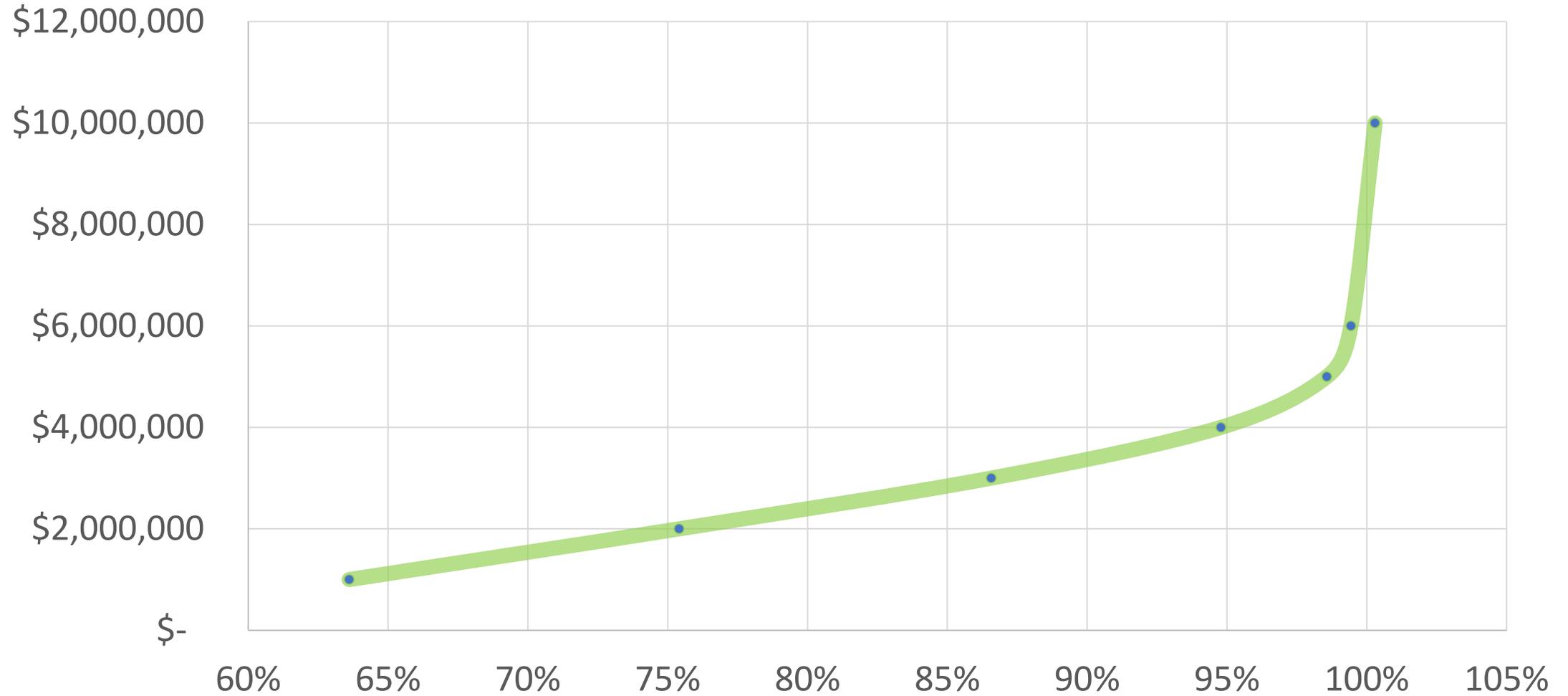




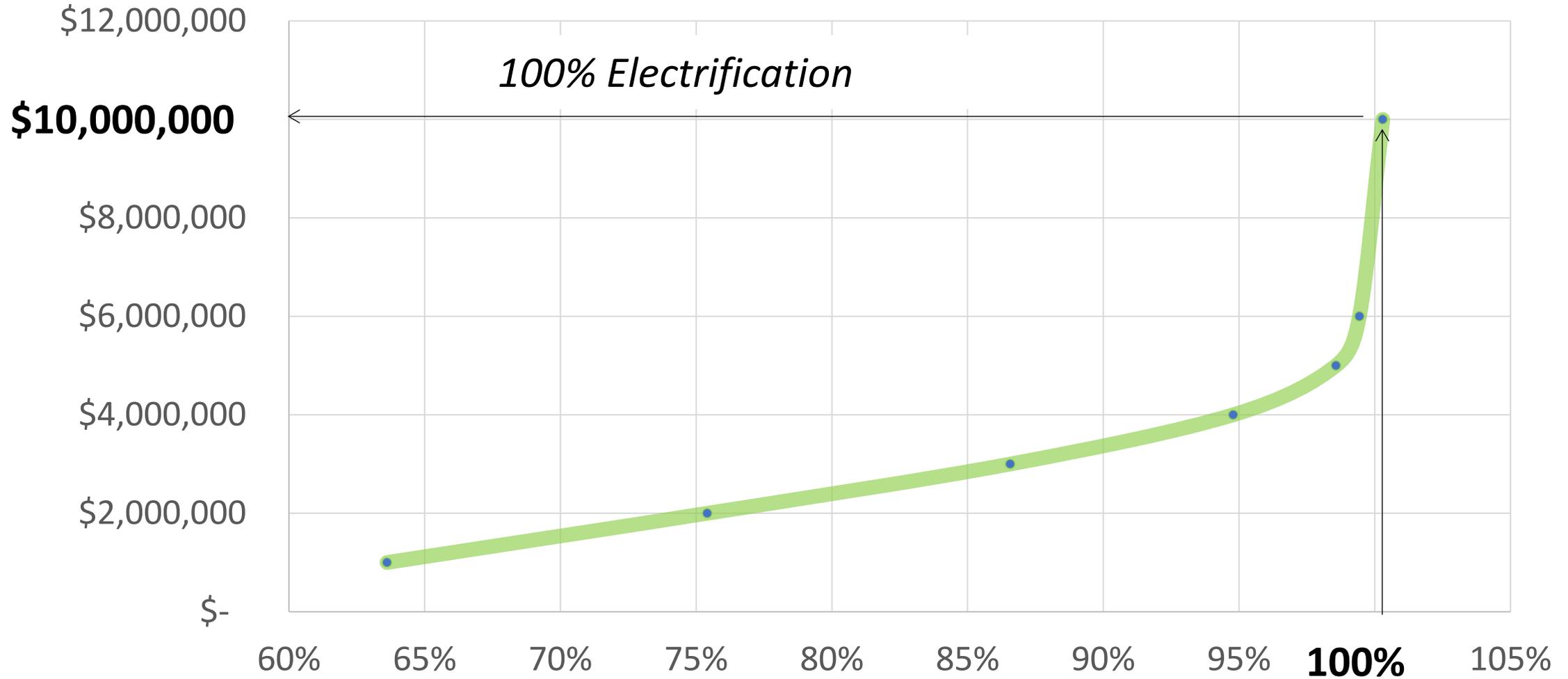
Measured data from hydronic heating systems in 259 commercial buildings



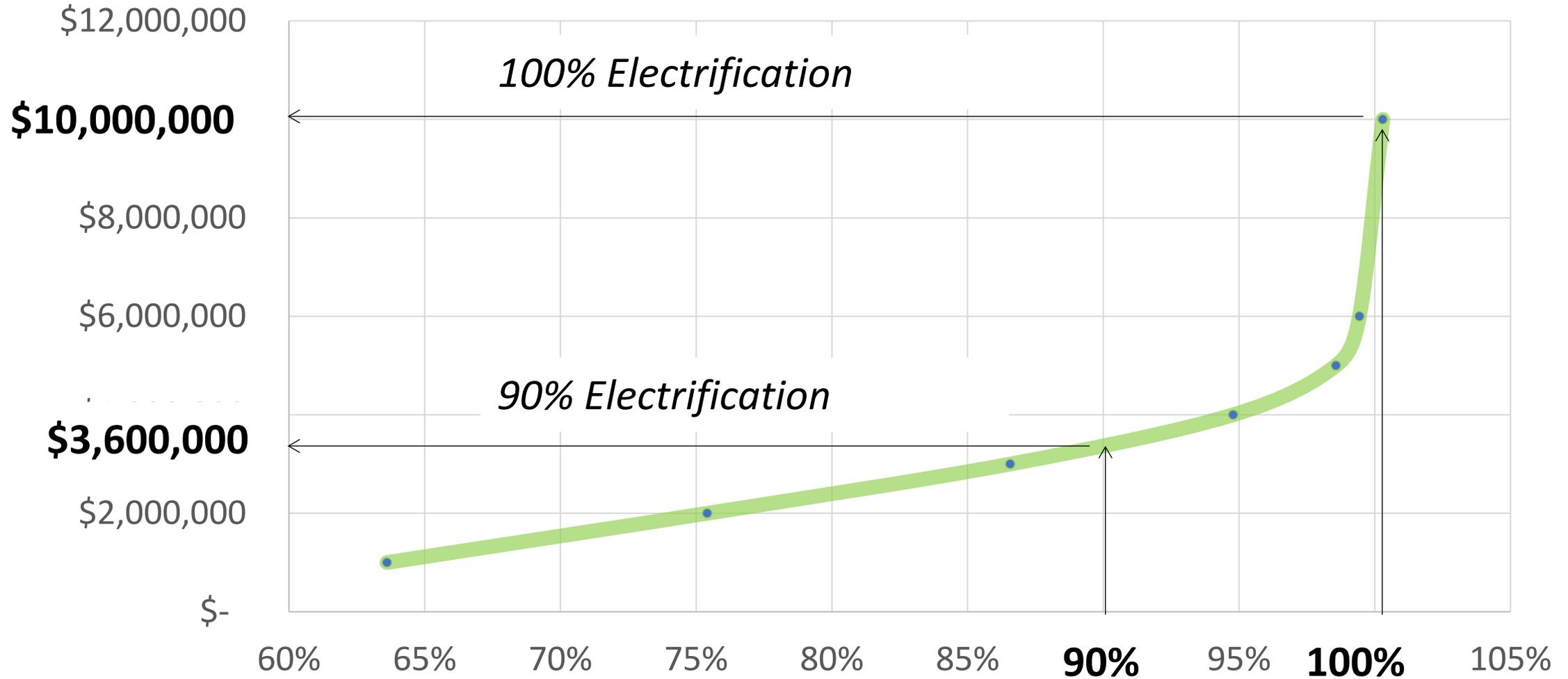
Heat Pump Cost vs. % Emission Reduction



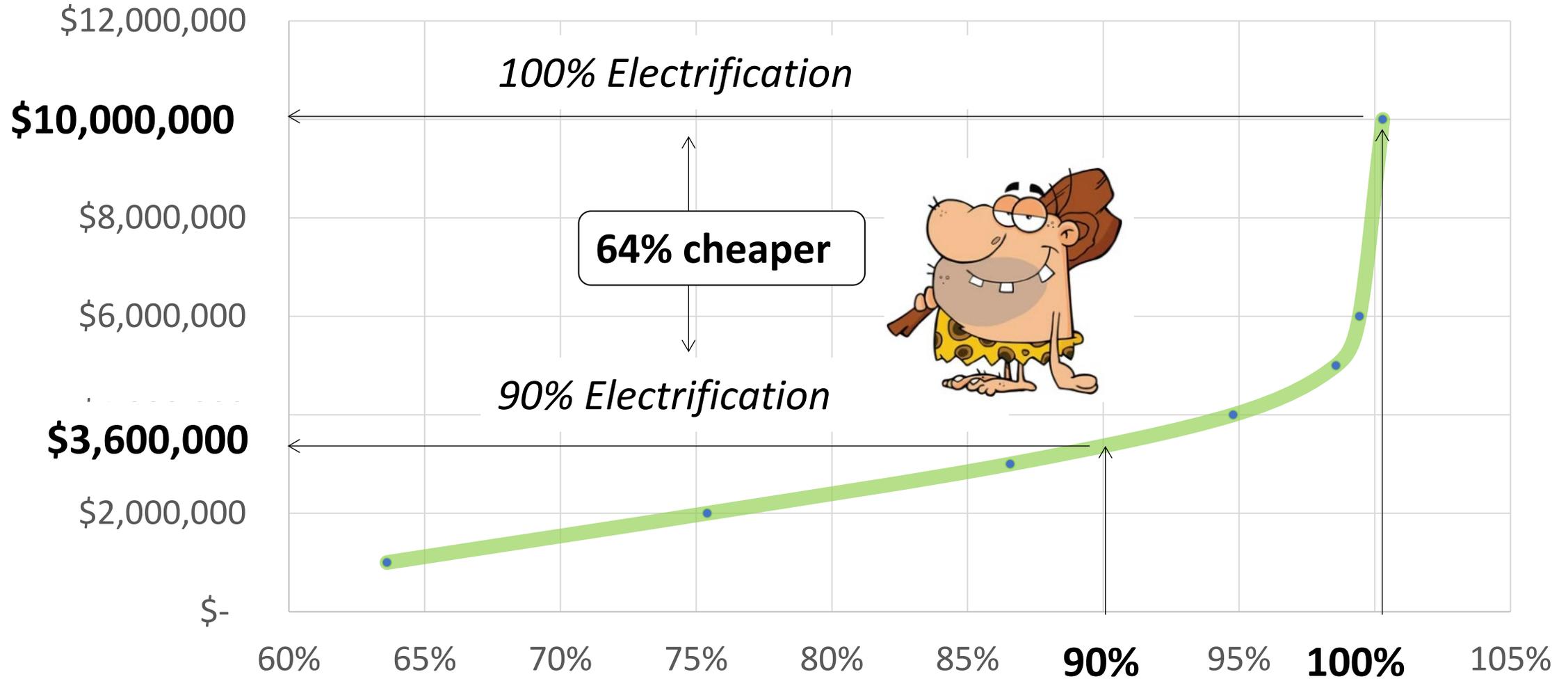
Heat Pump Cost vs. % Emission Reduction



Heat Pump Cost vs. % Emission Reduction



Heat Pump Cost vs. % Emission Reduction





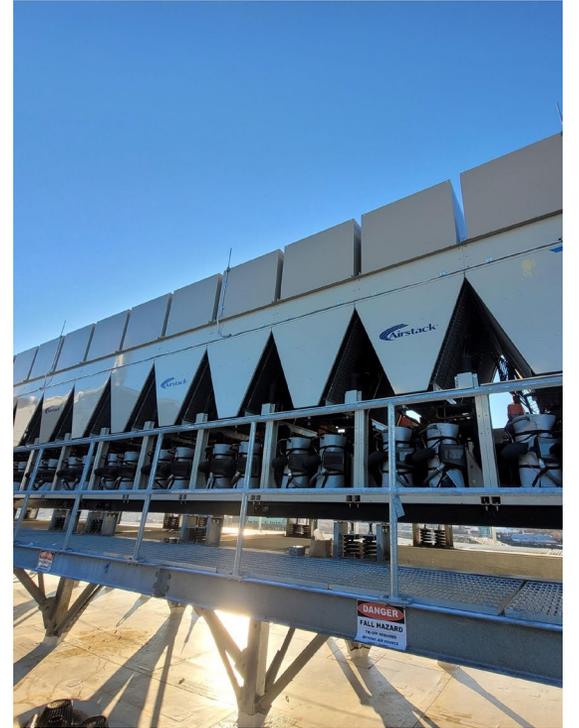
MGH Ragon
323,000 gsf



Comm Pier
705,000 gsf



L5
707,000 gsf

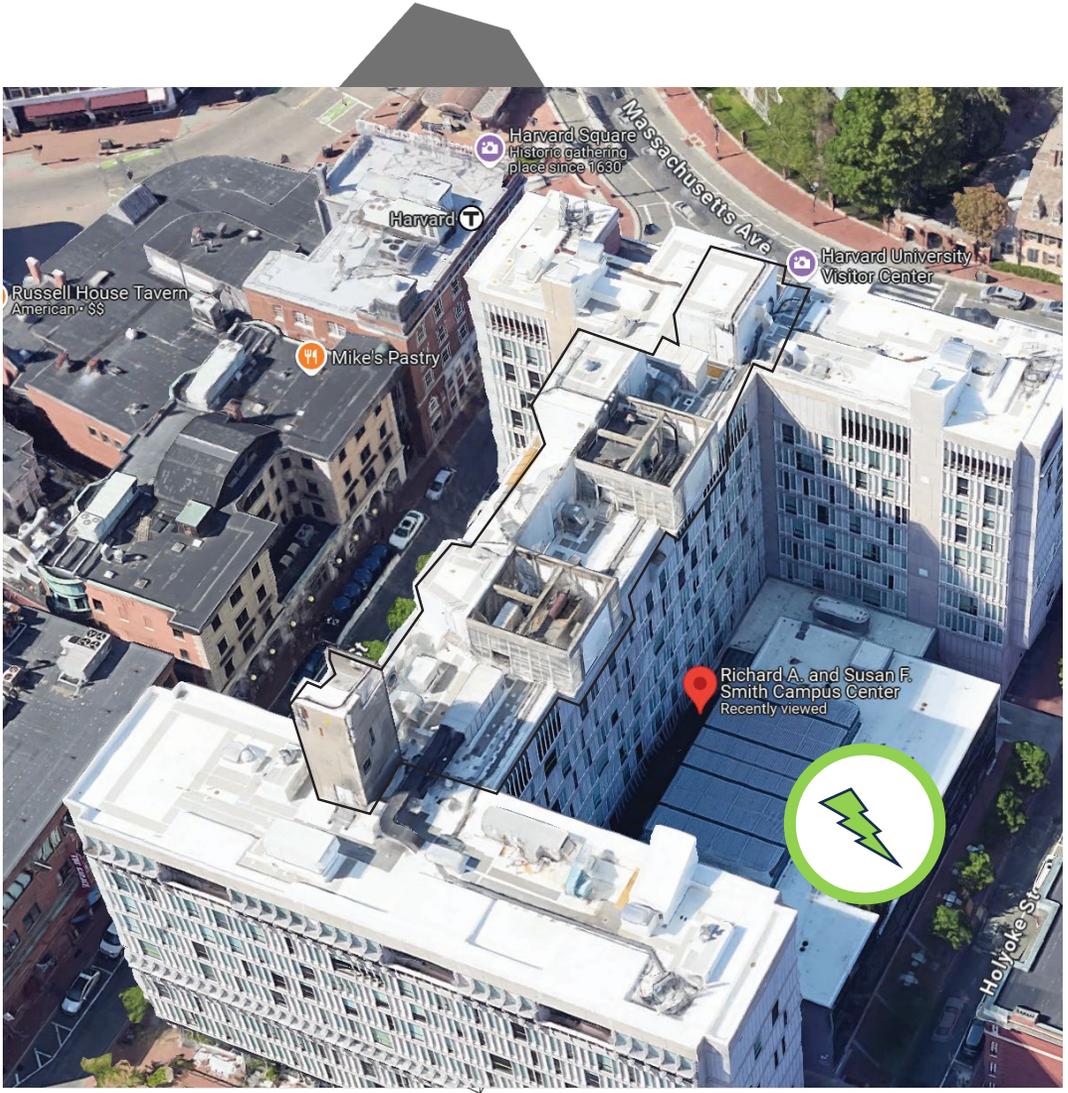


Harvard ERC
440,000 gsf



Program

360,000 GSF Classroom + Admin Building
New England

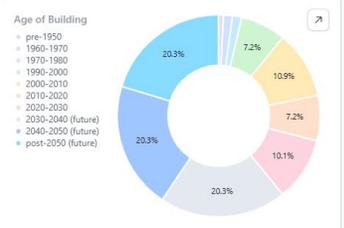
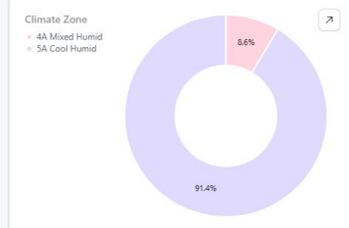
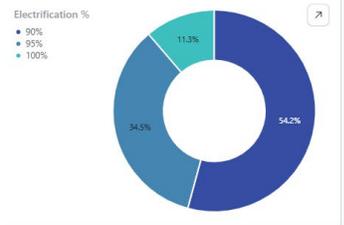
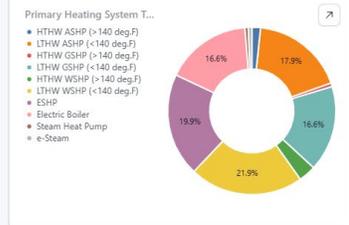
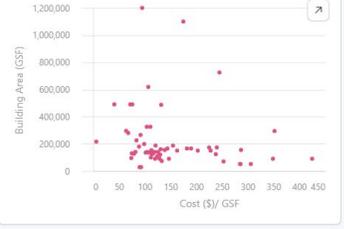


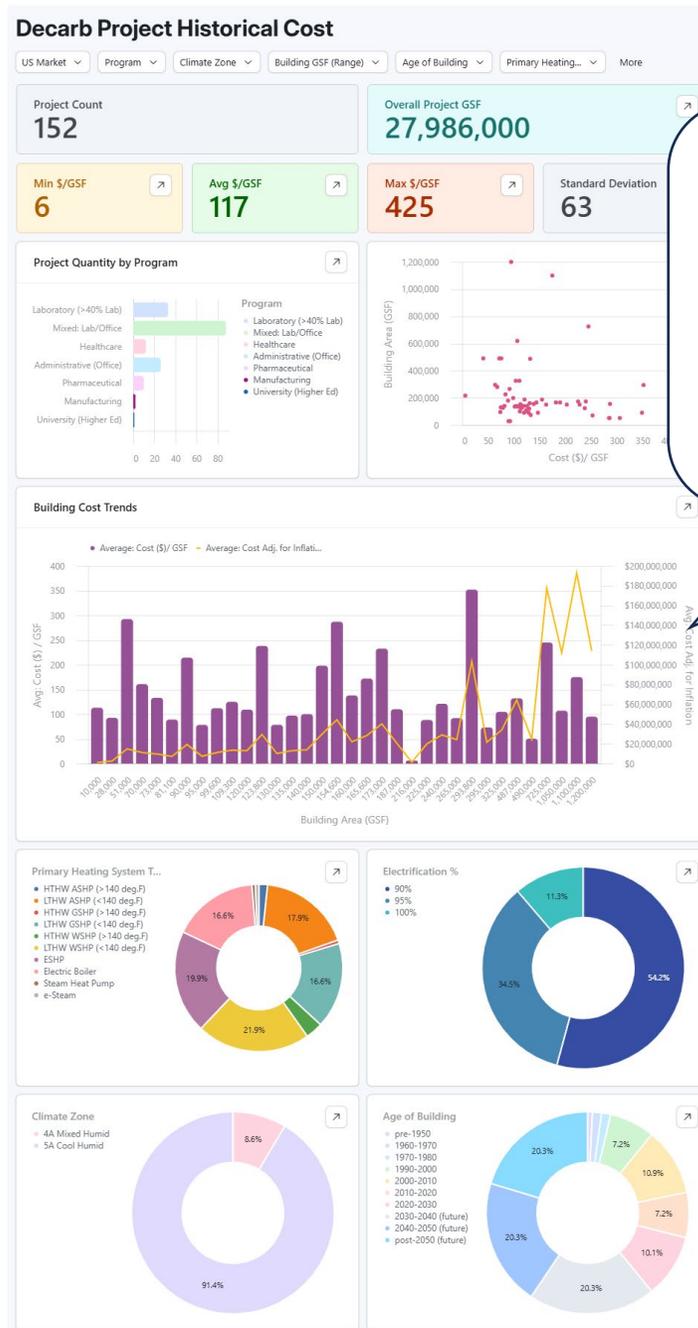
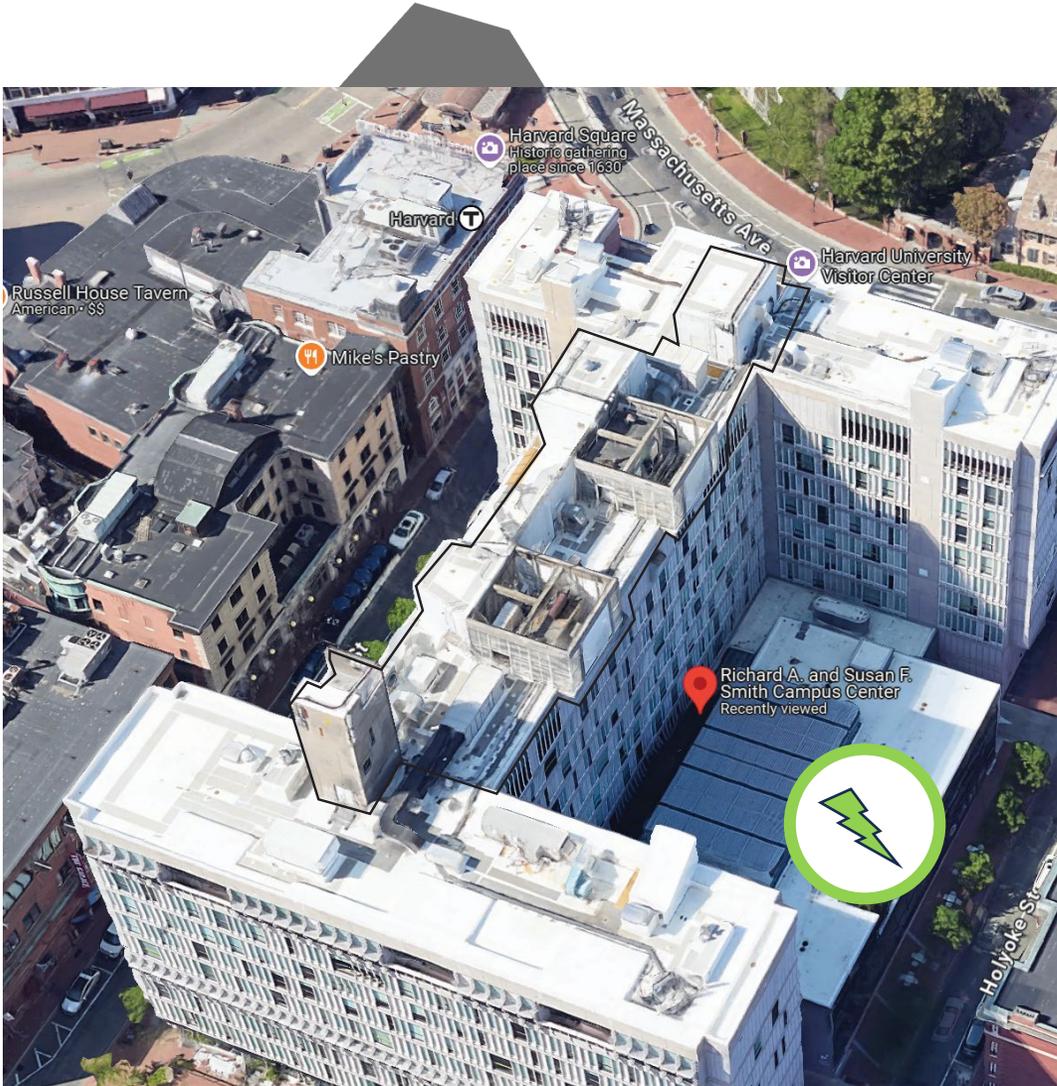
Decarb Project Historical Cost

US Market | Program | Climate Zone | Building GSF (Range) | Age of Building | Primary Heating... | More

Project Count: **152** | Overall Project GSF: **27,986,000**

Min \$/GSF: **6** | Avg \$/GSF: **117** | Max \$/GSF: **425** | Standard Deviation: **63**





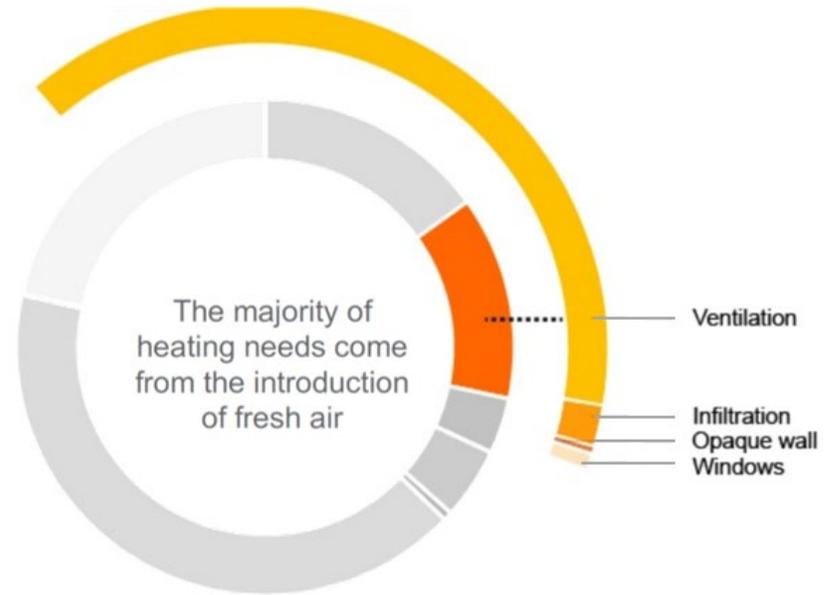
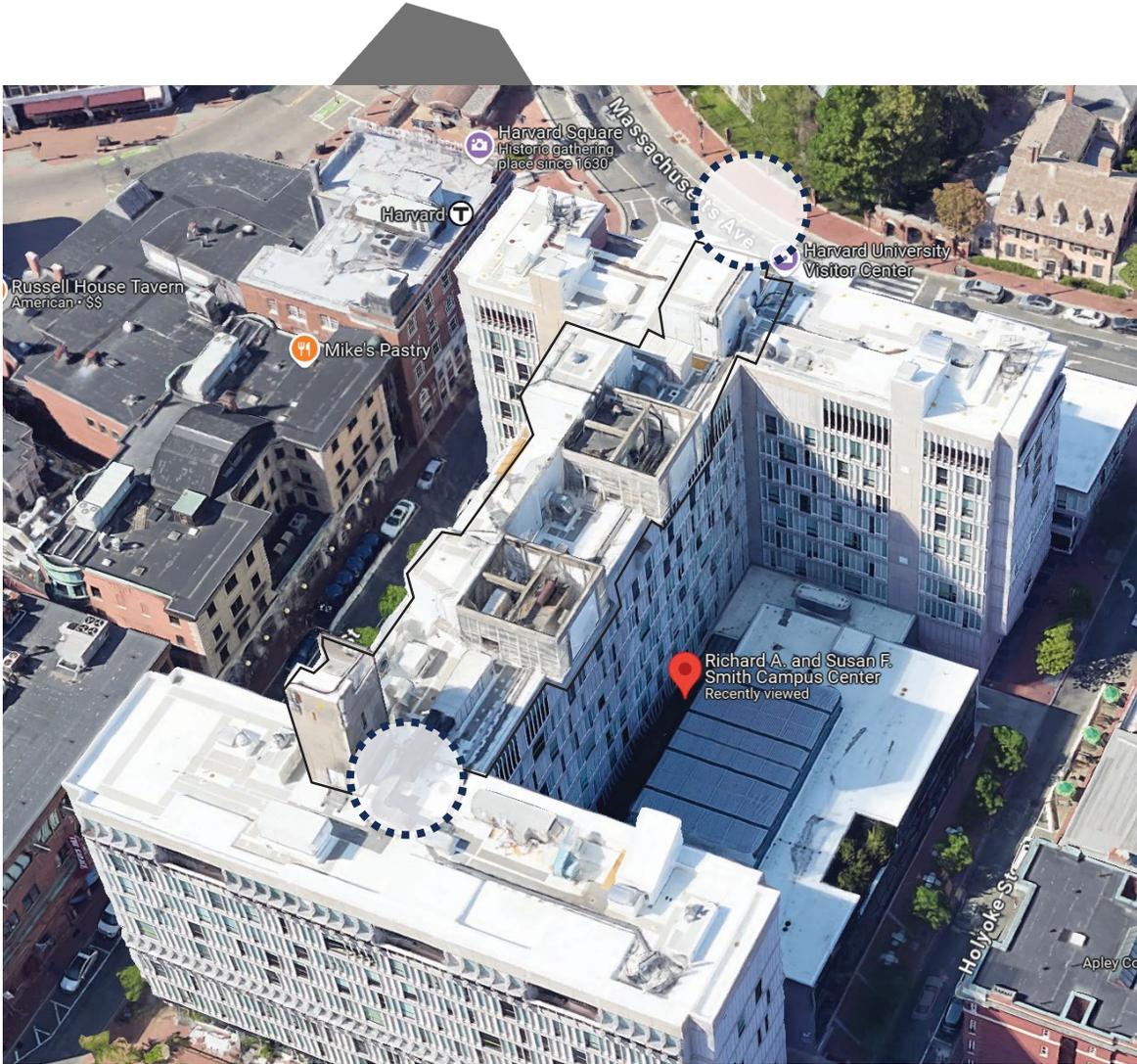
Decarbonization of Classroom + Admin Building
360,000 GSF

\$40/SF = \$14,400,000

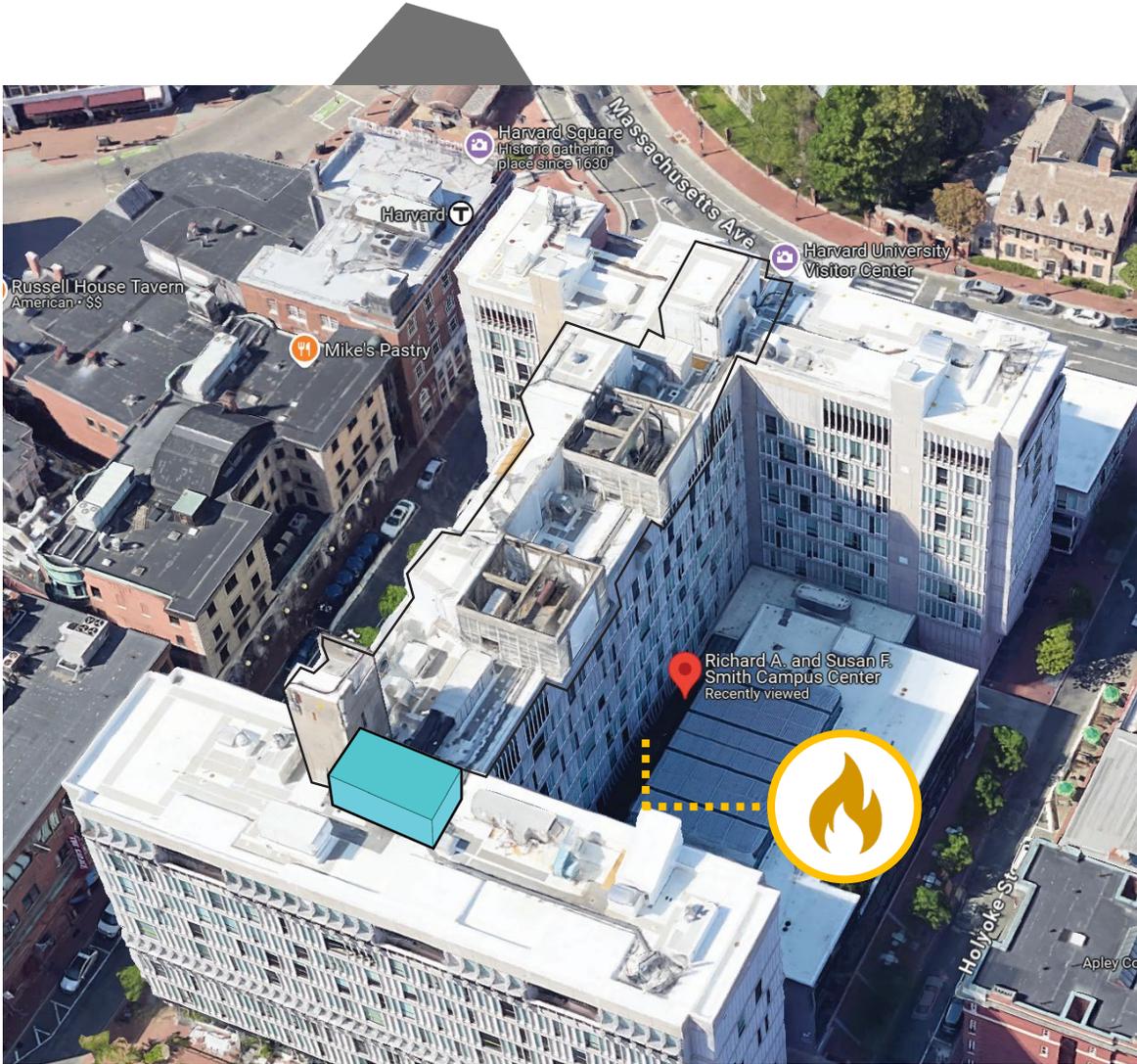


Scope of Work

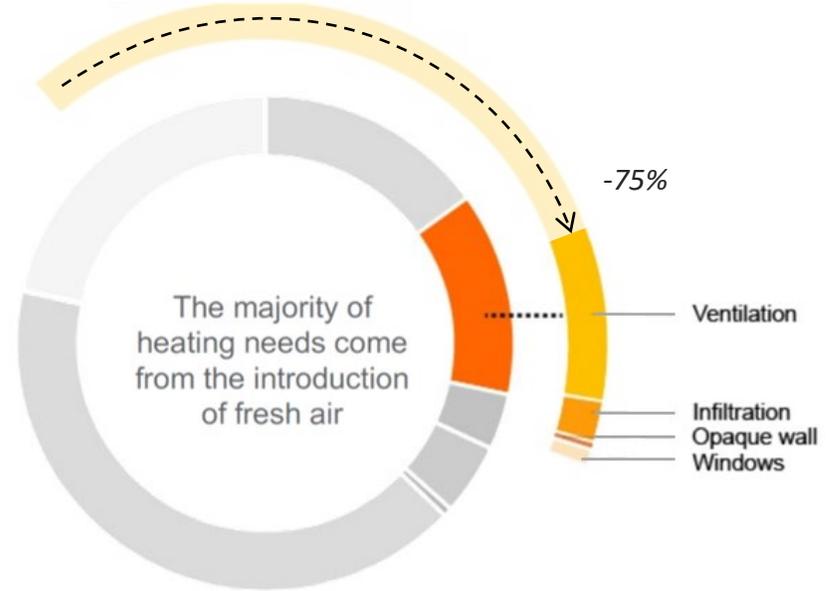
- 360,000 GSF Classroom + Admin Building
- New AHUs
- New Generator
- \$44/cfm = \$860,000



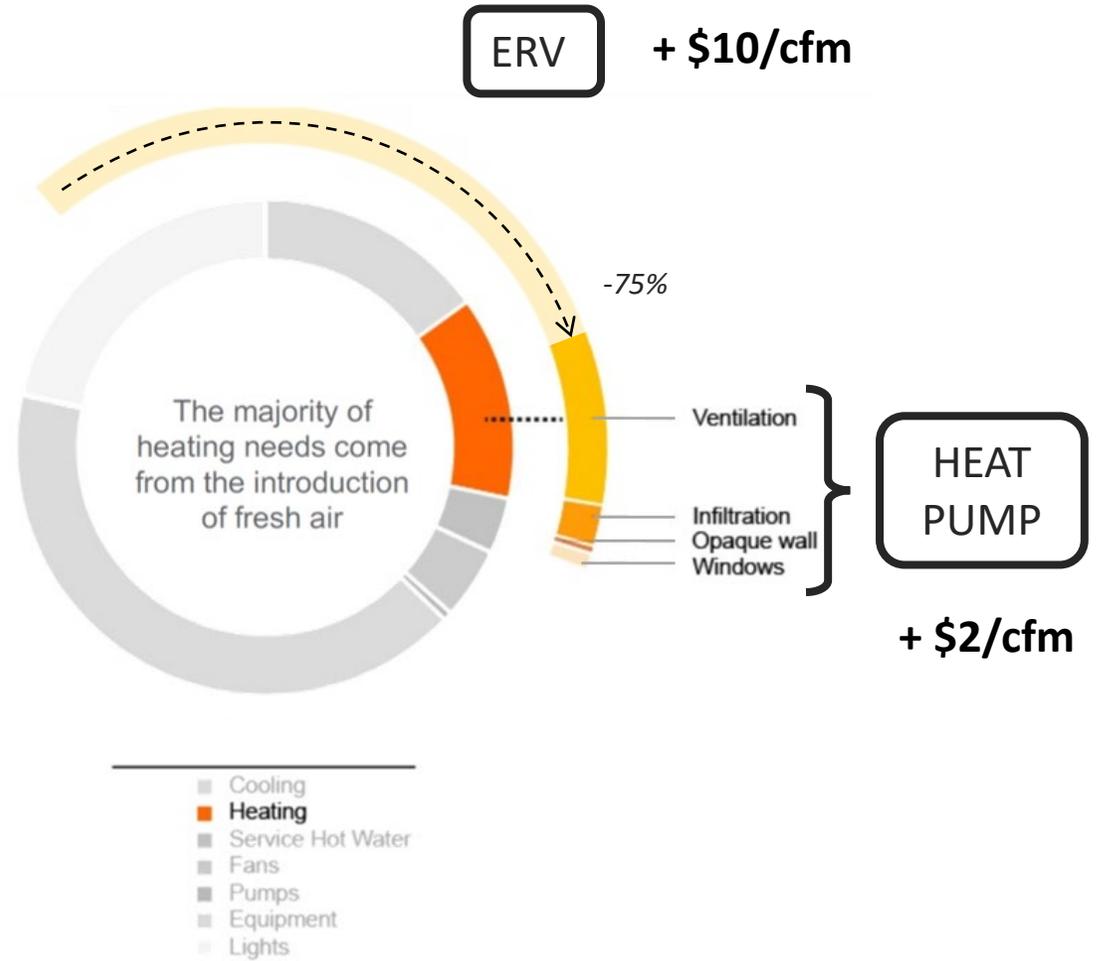
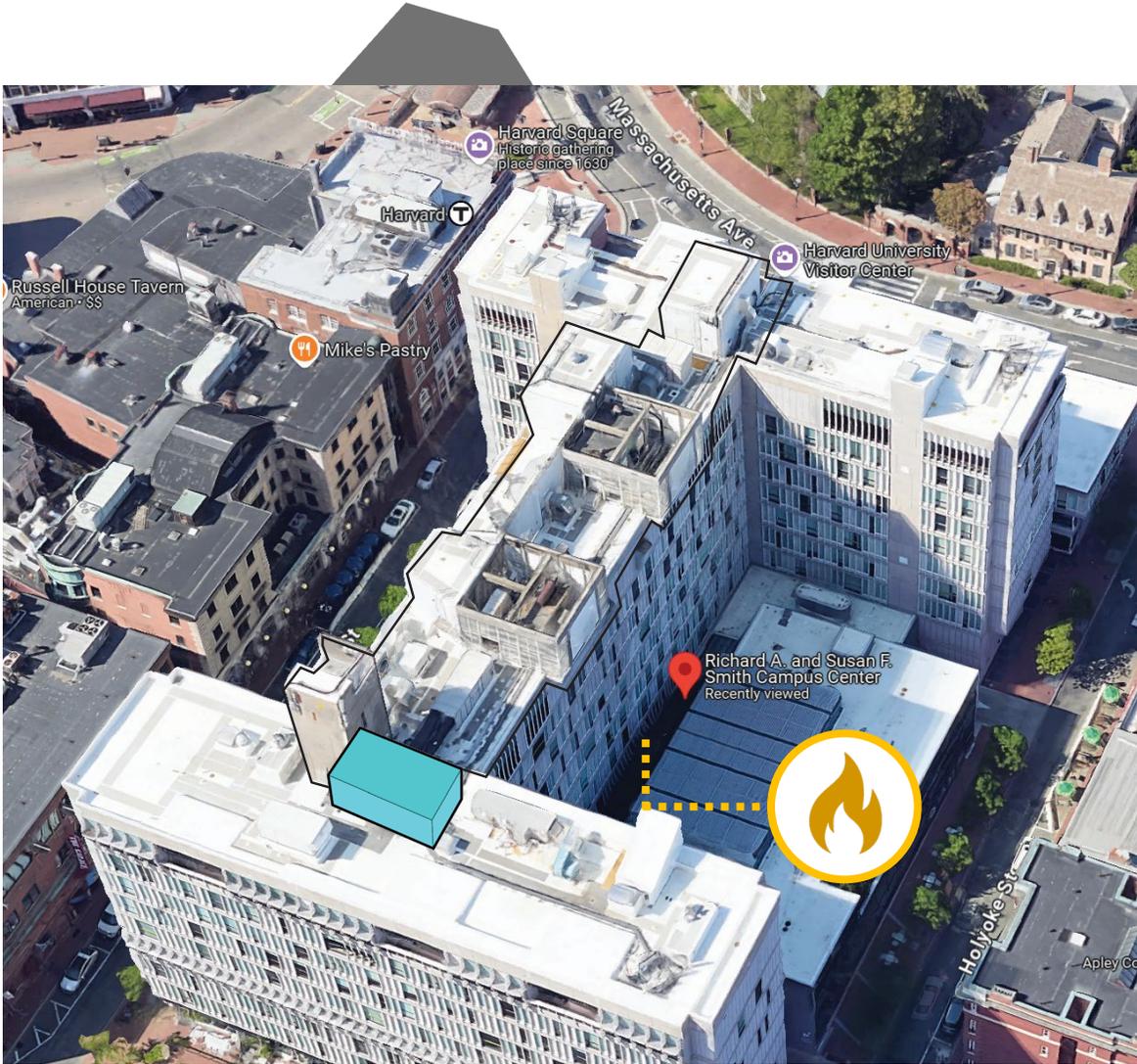
- Cooling
- Heating**
- Service Hot Water
- Fans
- Pumps
- Equipment
- Lights

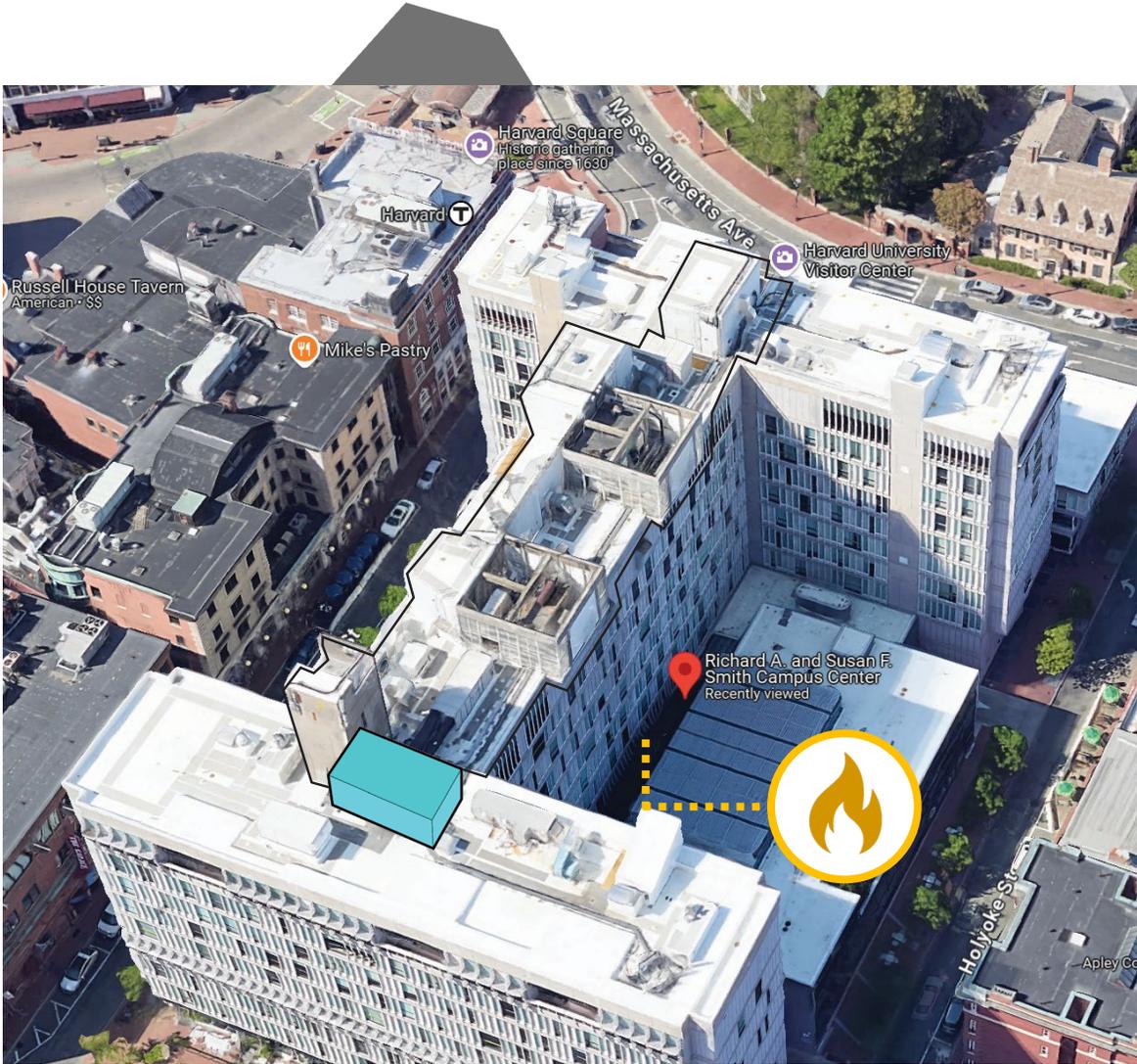


ERV + \$10/cfm



- Cooling
- Heating
- Service Hot Water
- Fans
- Pumps
- Equipment
- Lights





DECARB AIR-HANDLING UNIT REPLACEMENT

\$44/CFM (\$860,000)

+

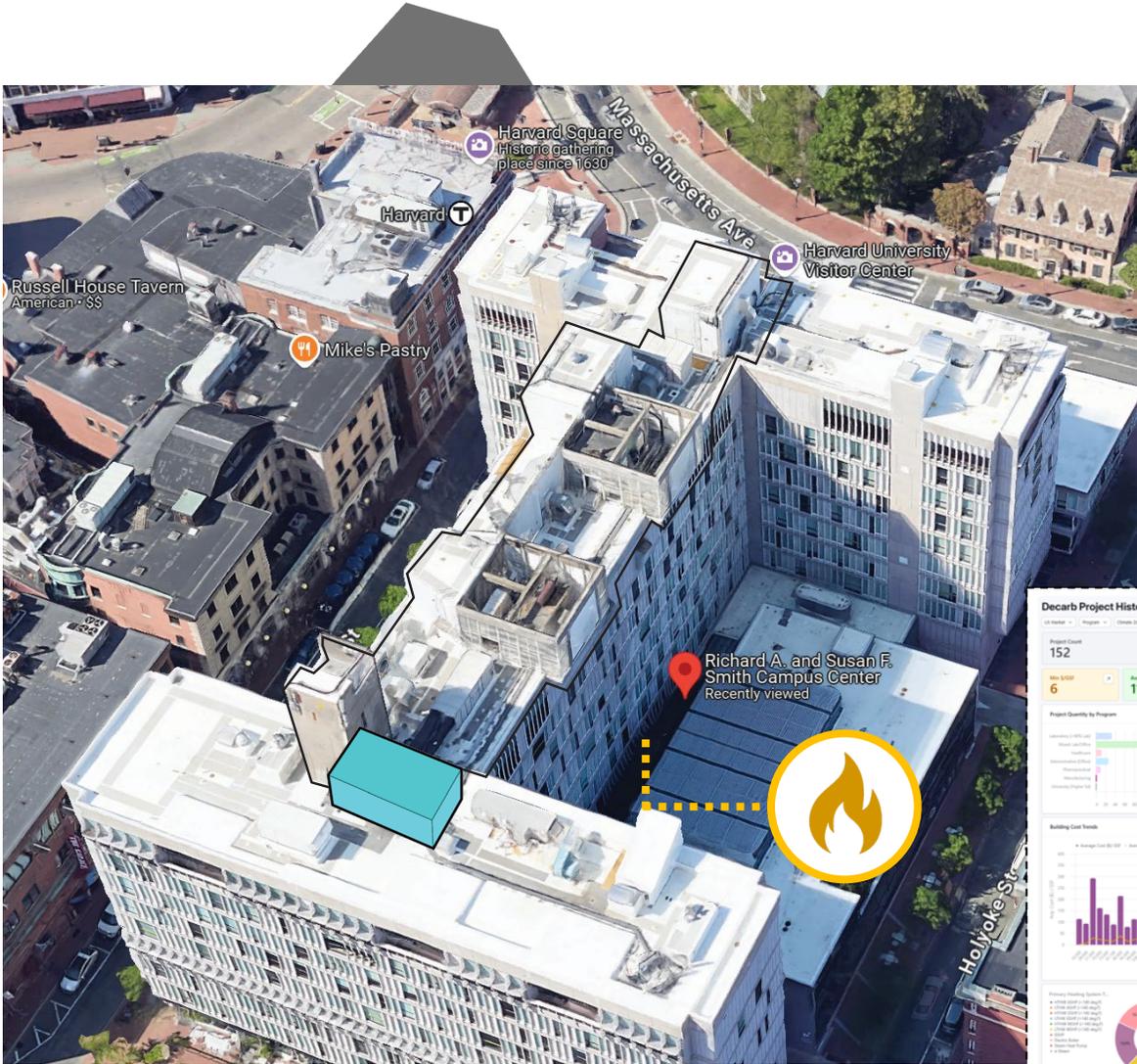
\$10/CFM (\$200,000 – ERV)

\$2/CFM (\$40,000 - REMOTE CONDENSING UNITS)

\$56/CFM (27% *EQUIPMENT COST PREMIUM*)

\$10/CFM+\$2/CFM = \$12 /cfm premium)

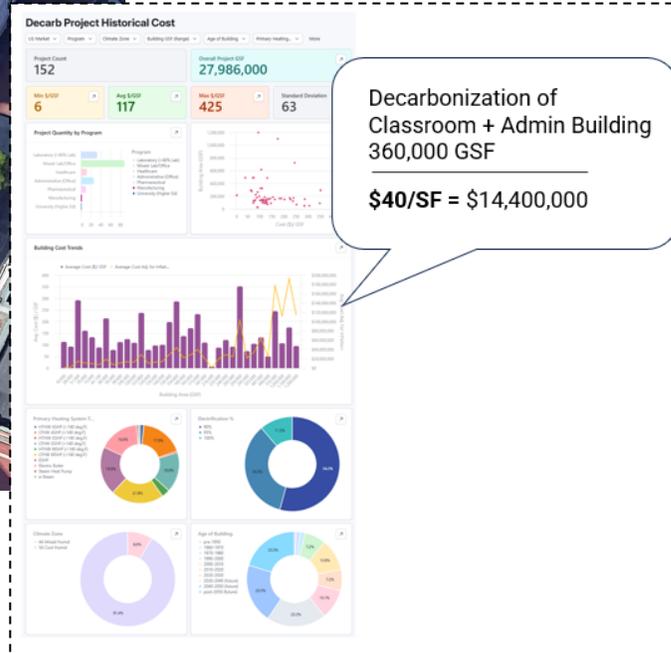
\$240,000 add



DECARB AIR-HANDLING UNIT REPLACEMENT

VS. **\$240,000** (\$0.66/sf decarb premium)
\$14,400,000 (\$40/sf)

98% COST REDUCTION



90% CO2 reduction

Colin Schless | Director, Client Decarbonization Services
Turner Construction Company | 2 Seaport Lane, 2nd Floor,
Boston, MA 02210
mobile 978.501.2623 | cschless@tcco.com

Turner

JOHN KASTRINOS, HALEY & ALDRICH

JACOB KNOWLES, BR+A





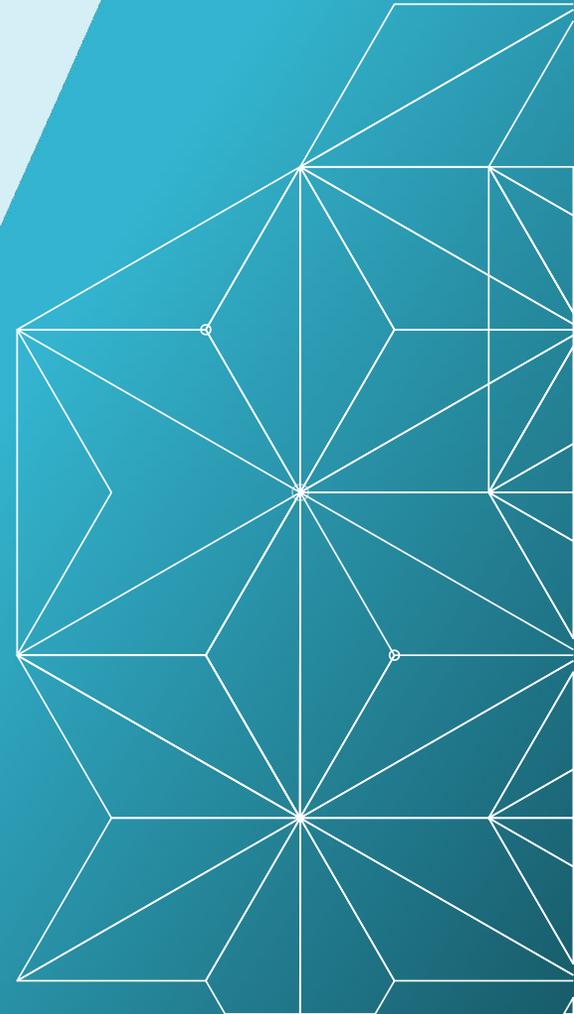
Optimal Sizing Approaches for Geothermal Borefields

Jacob Knowles

BR+A Consulting Engineers, Inc.

John R. Kastrinos, P.G. (PA)

Haley & Aldrich, Inc.



Agenda

1

Case Studies – Project Goals that Drive Design

2

Case Studies – Load Reduction Strategies and Electrification Technologies

3

Load Profiles – Effect on Borefield Design

4

Questions

Moderna World Headquarters
Cambridge, MA



Boston University, Duan Family Center
for Data Science
Boston, MA

GEOHERMAL GOAL SETTING

MODERNA HQ

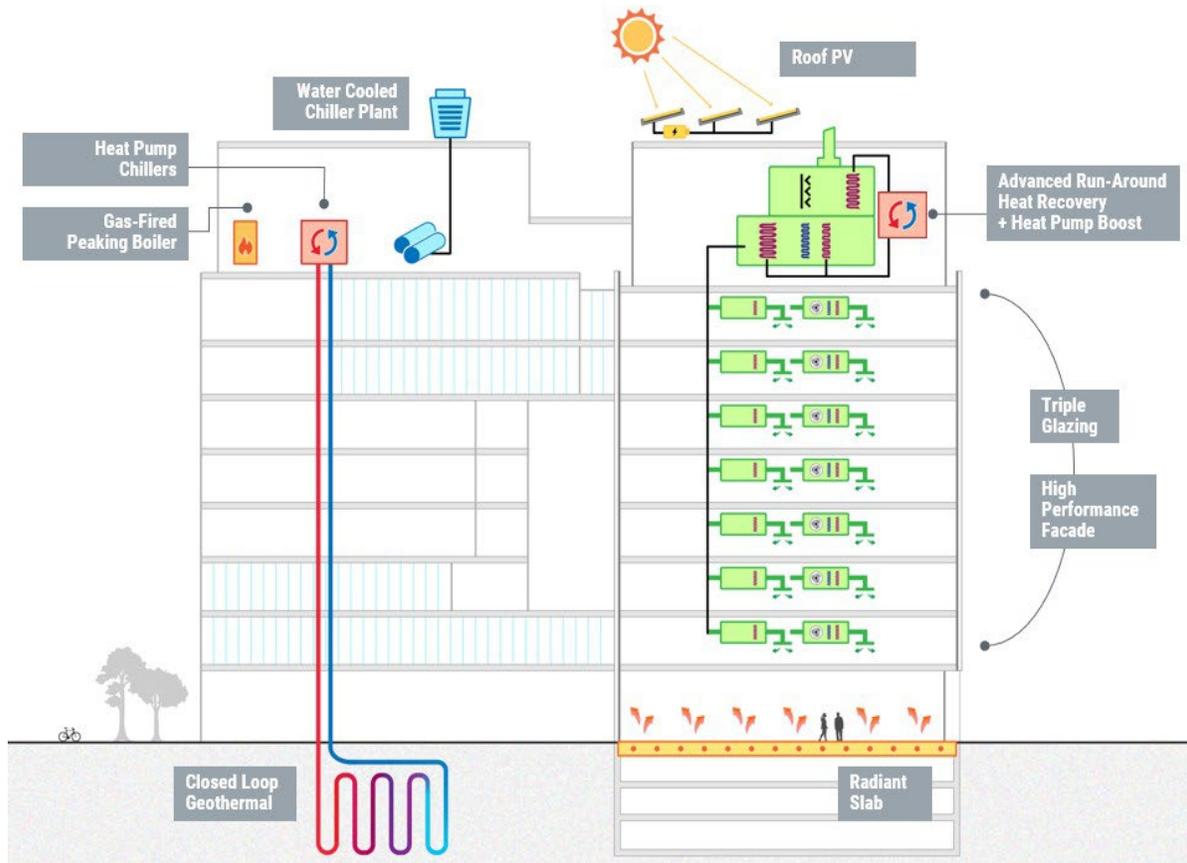
- Lowest fossil fuel use for developer lab in cold climate
 - >90% fossil fuel reduction

BU DATA SCIENCE

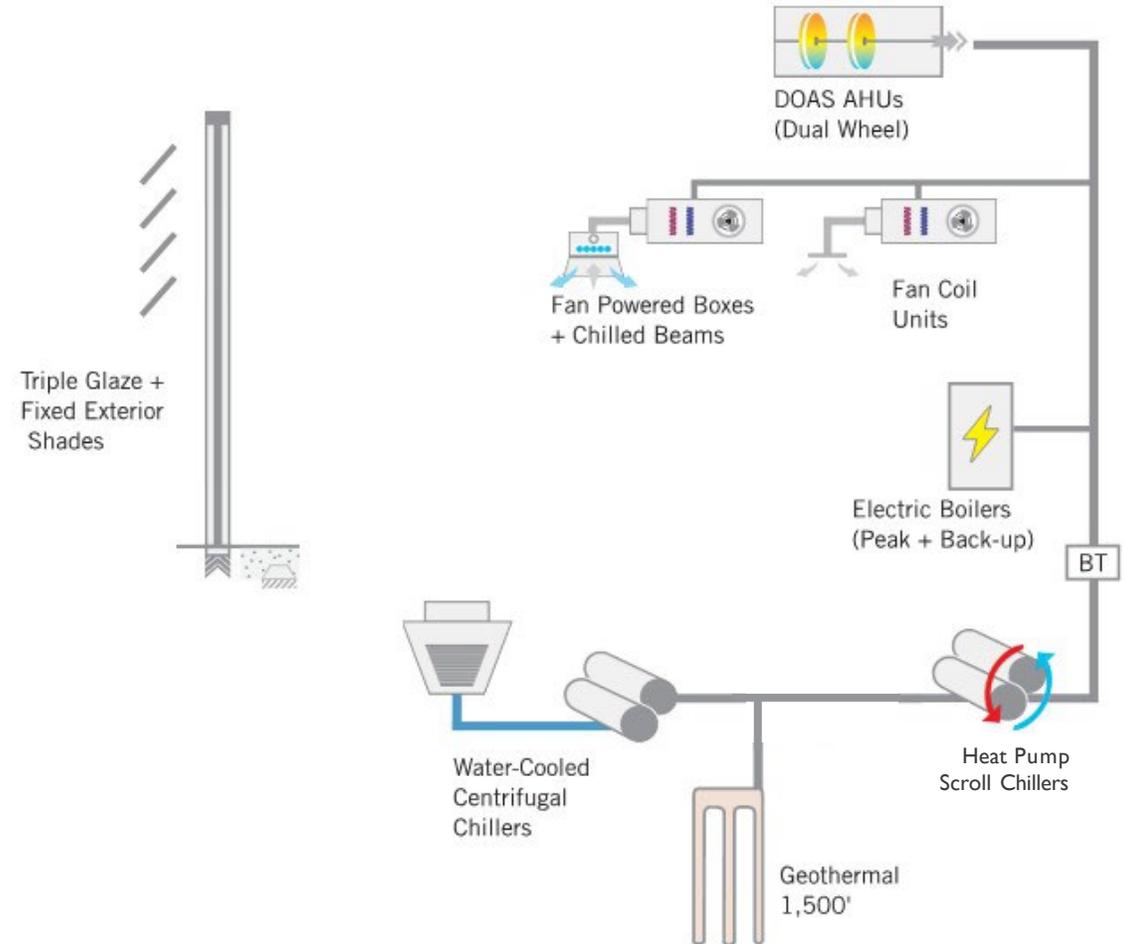
- Fully electric
 - 100% fossil fuel reduction

LOAD REDUCTION STRATEGIES

MODERNA HQ



BU DATA SCIENCE



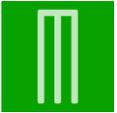
ELECTRIFICATION TECHNOLOGIES

MODERNA HQ

HEATING
EQUIPMENT



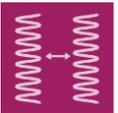
GAS BOILER



GROUND-SOURCE
HEAT PUMP



HEAT RECOVERY
CHILLER



EXHAUST-SOURCE
HEAT PUMP

BU DATA SCIENCE

HEATING
EQUIPMENT



ELEC BOILER



GROUND-SOURCE
HEAT PUMP



HEAT RECOVERY
CHILLER

ELECTRIFICATION TECHNOLOGIES

HEATING EQUIPMENT



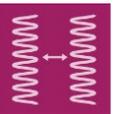
GAS BOILER



GROUND-SOURCE HEAT PUMP



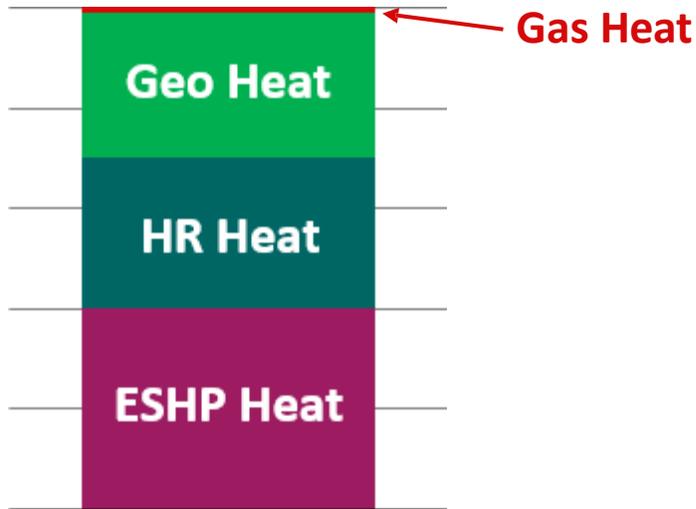
HEAT RECOVERY CHILLER



EXHAUST-SOURCE HEAT PUMP

MODERNA HQ

BUILDING HEATING ENERGY USE BY EQUIPMENT TYPE



BU DATA SCIENCE

BUILDING HEATING ENERGY USE BY EQUIPMENT TYPE

HEATING EQUIPMENT



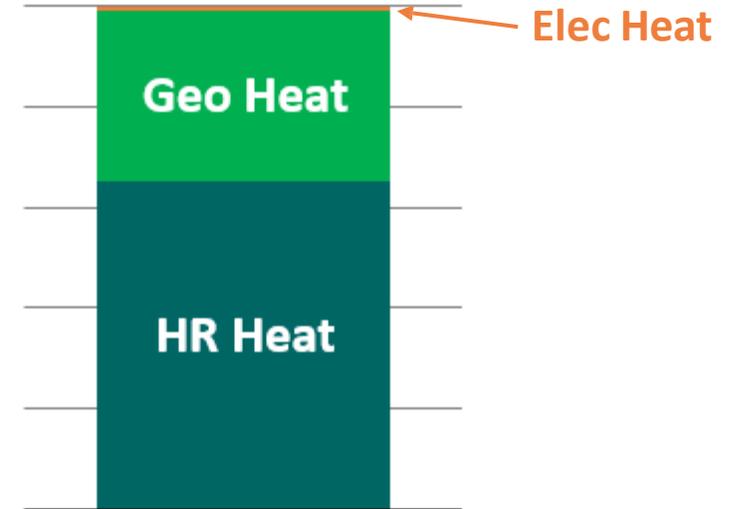
ELEC BOILER



GROUND-SOURCE HEAT PUMP



HEAT RECOVERY CHILLER



LOAD PROFILES

MODERNA HQ

HEATING EQUIPMENT



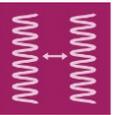
GAS BOILER



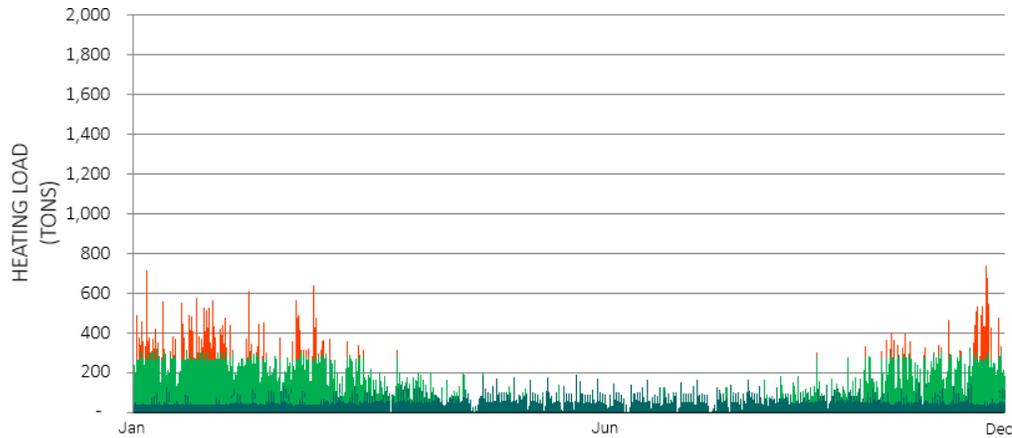
GROUND-SOURCE HEAT PUMP



HEAT RECOVERY CHILLER



EXHAUST-SOURCE HEAT PUMP



BU DATA SCIENCE

HEATING EQUIPMENT



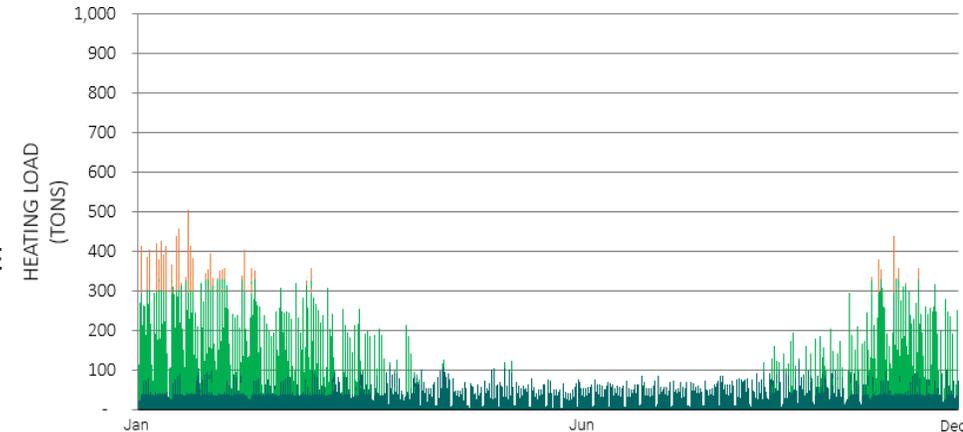
ELEC BOILER



GROUND-SOURCE HEAT PUMP

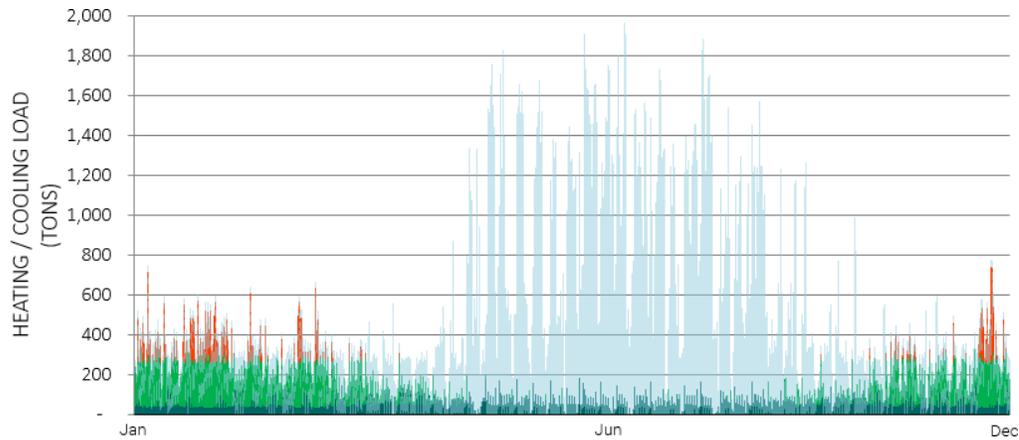


HEAT RECOVERY CHILLER

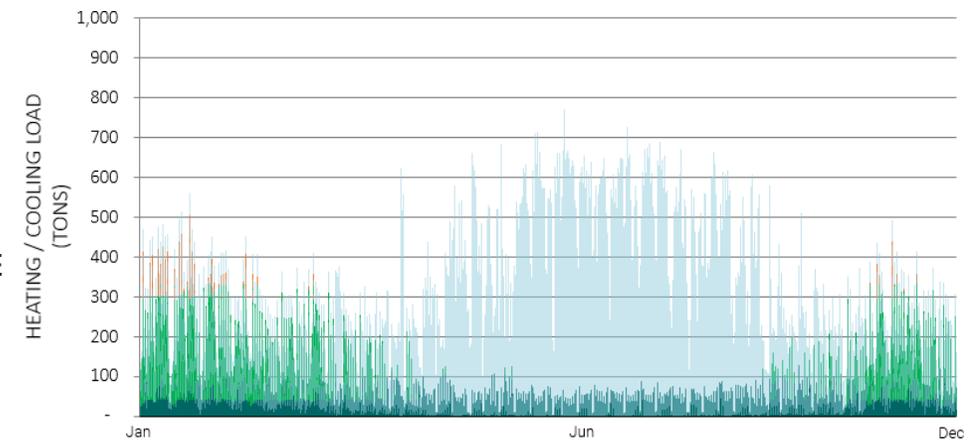


LOAD PROFILES

MODERNA HQ



BU DATA SCIENCE



HEATING EQUIPMENT



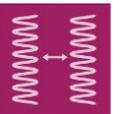
GAS BOILER



GROUND-SOURCE HEAT PUMP



HEAT RECOVERY CHILLER



EXHAUST-SOURCE HEAT PUMP

HEATING EQUIPMENT



ELEC BOILER



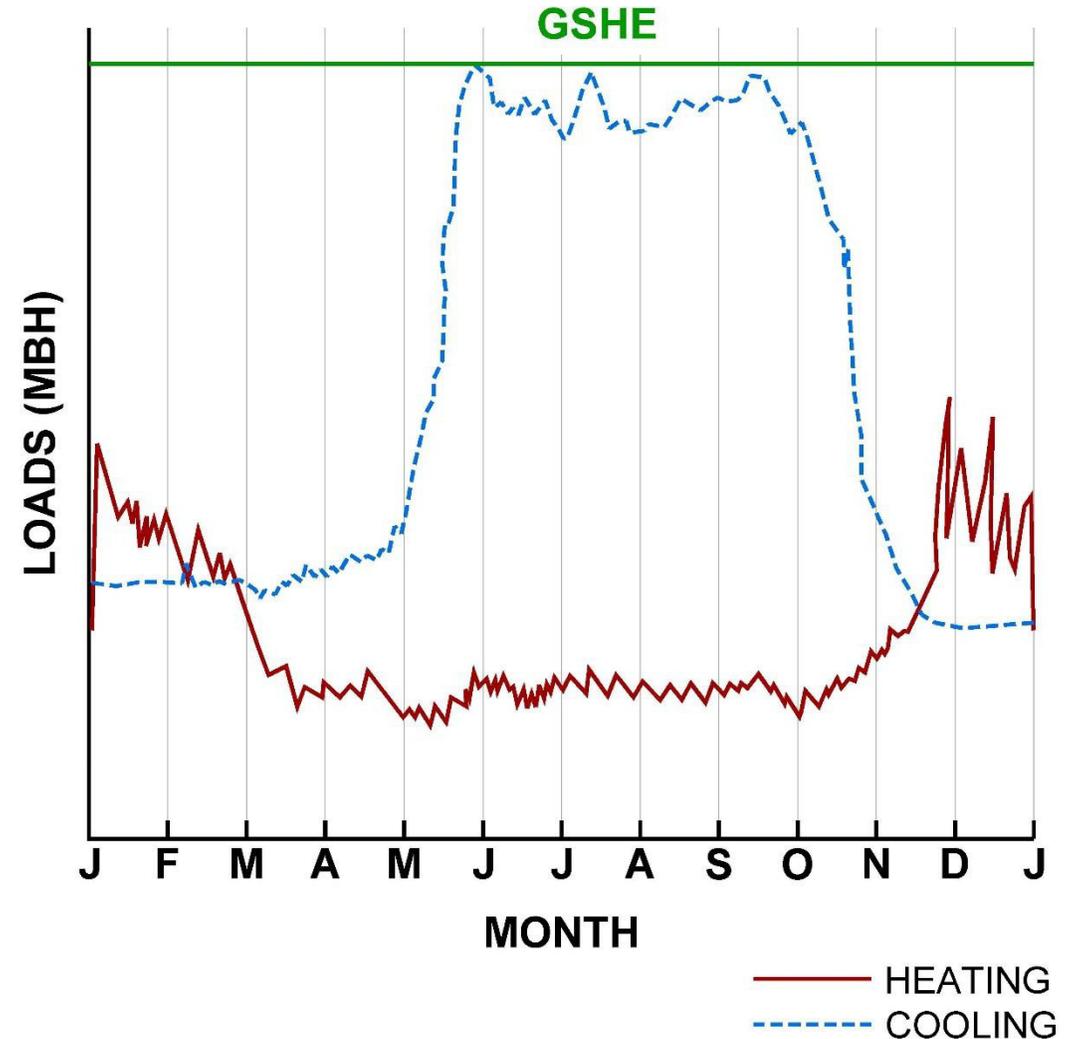
GROUND-SOURCE HEAT PUMP



HEAT RECOVERY CHILLER

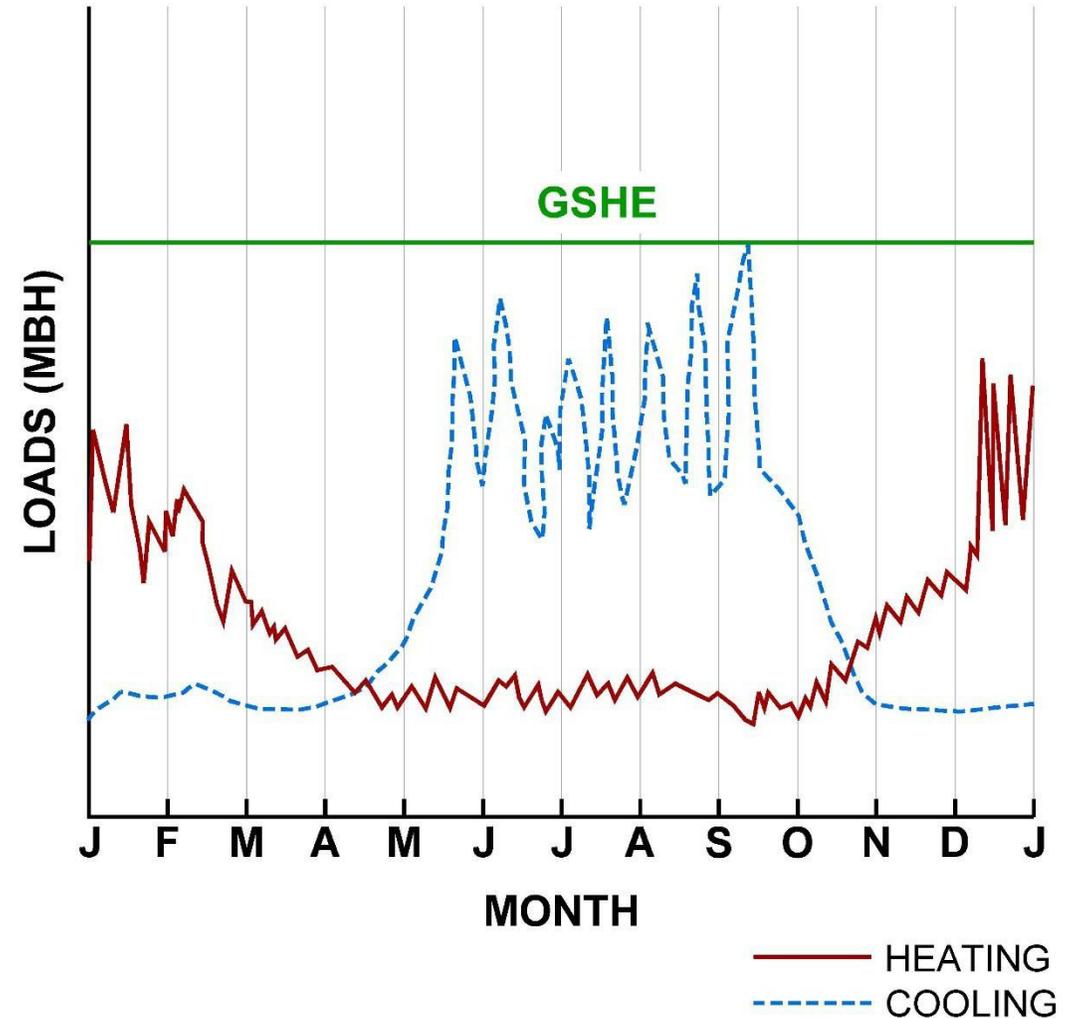
Load Profiles – Type 1

- Imbalanced load (cooling-dominated)
- Ground-Source Heat Exchange (GSHE) (geothermal) covers 100% of the load
- Significantly over-sized (low thermal exchange [tons] per borehole) to compensate for load imbalance



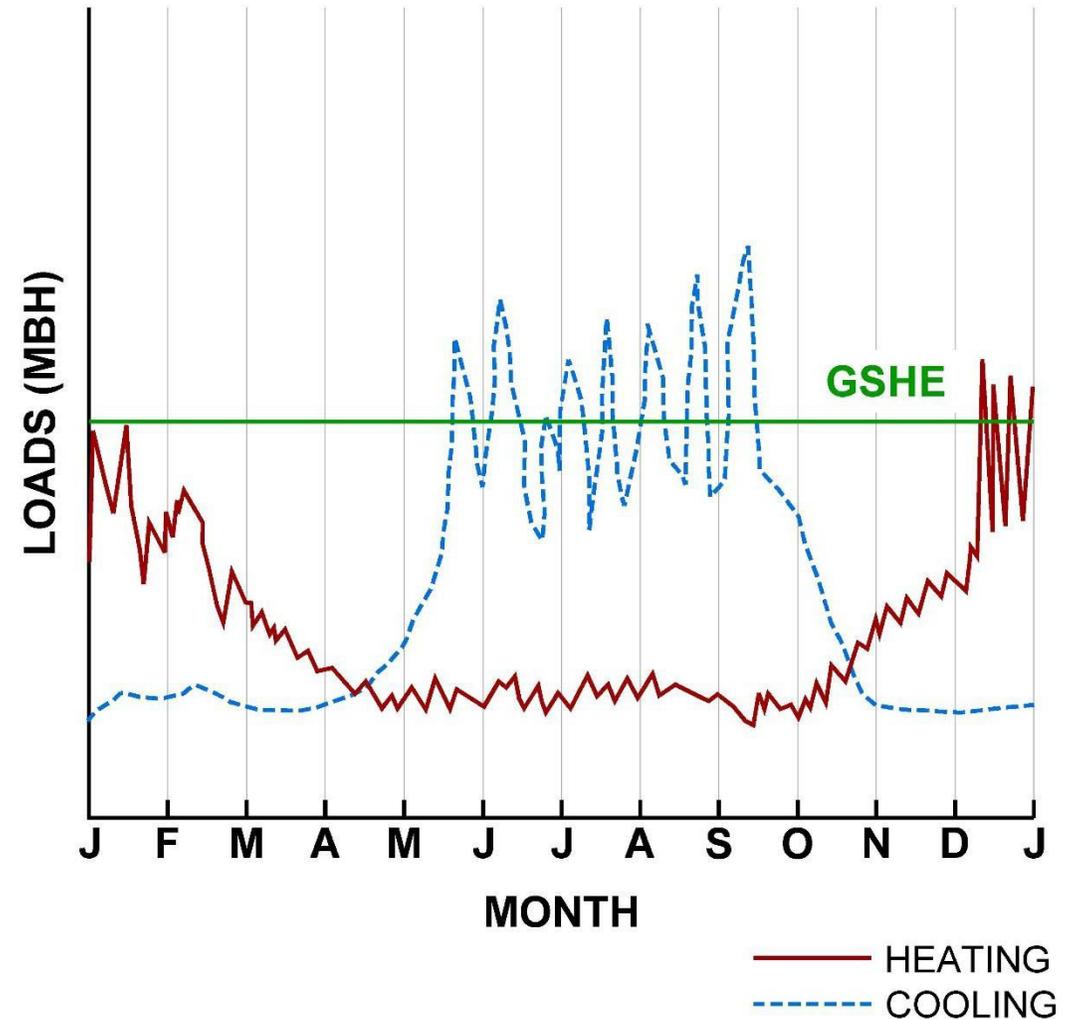
Load Profiles – Type 2

- Balanced load
- GSHE covers 100% of the load
- Over-sized (low to moderate thermal exchange per borehole) as borefield covers short-duration peak loads



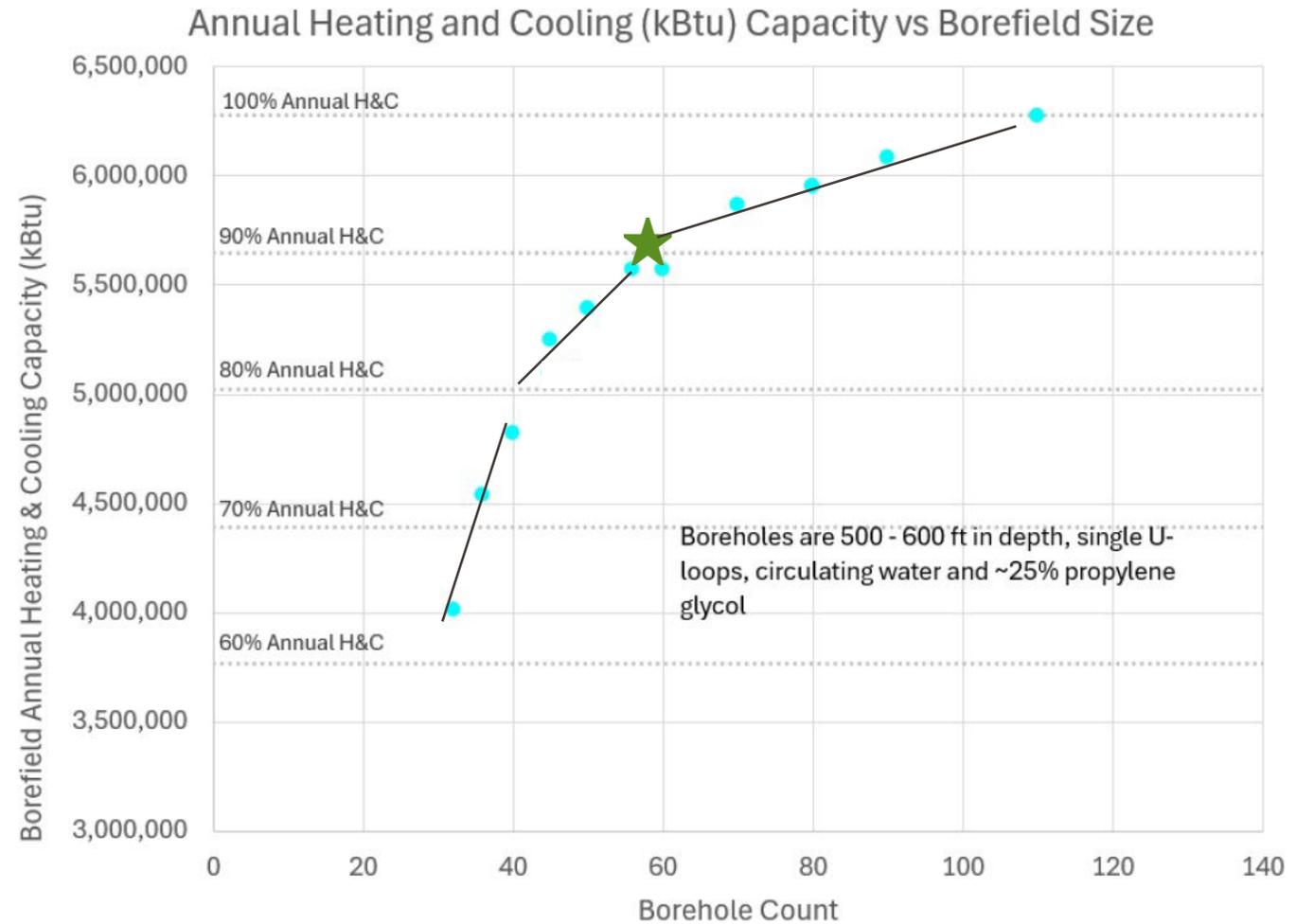
Load Profiles – Type 3 (Hybrid)

- Balanced Load
- GSHE covers 80% to 90% or more of the annual load
- Supplemental equipment covers short-term peak loads
- Thermal exchange per borehole is generally consistent with expectations (ton/borehole rules of thumb)



Example

- Diminishing returns in thermal exchange with increasing borehole count



Thank you.....

Questions ?

To contact us



Jacob Knowles
BR+A



John R. Kastrinos
Haley & Aldrich



A wide-angle photograph of a city skyline, likely New York City, featuring several prominent skyscrapers and a bridge in the foreground. The bridge has a white metal railing and stone pillars. The sky is a clear, light blue. A blue rectangular box with the white text 'Q&A' is centered in the middle of the image.

Q&A

SAVE THE DATE

Built to Lead: Lessons in Deconstruction and Embodied Carbon

February 3, 2026 @ 10-11:30AM, Location TBD

- **Dennis Carlberg**, Chief Sustainability Officer & Associate Vice President for Climate Action, Boston University – *Retrofit of BU's Warren Towers*
- **Irmak Turan**, Associate, Climate and Sustainability, Arup – *Circularity and embodied carbon at airports*
- **Caroline Murray**, Regional Sustainability Manager, Turner Construction Company – *Deconstruction and reuse of office space*
- **Andrew Thompson**, Interim Executive Director, Boston Building Resources – *Material donation and reuse*