BUILDINGENERGY BOSTON

Heating with Ice for Cost Effective Electrification, Resilience and Optimization

Travis Anderson (BPDA)
Laura Corso (WattTime)
Joelle Jahn (JB&B)

Curated by Emily Dillon (Elevated Design)

Northeast Sustainable Energy Association (NESEA) | March 19, 2024

INTRODUCTIONS

Travis Anderson

Senior Infrastructure & Energy Planner

BPDA Smart Utilities

boston planning & development agency

Laura Corso

VP Strategic Growth

WattTime

WattTime

Joelle Jahn

New England Leader

JB&B Deep Carbon Reduction

JB&B DEEP CARBON REDUCTION

AGENDA

Introductions

Policy Landscape (Travis)

State of the Electric Grid (Travis)

Time of Use Carbon & Energy Optimization (Laura)

- Co-optimization – demand / pricing / emissions
- Data management

Grid Interactive Buildings (Joelle)

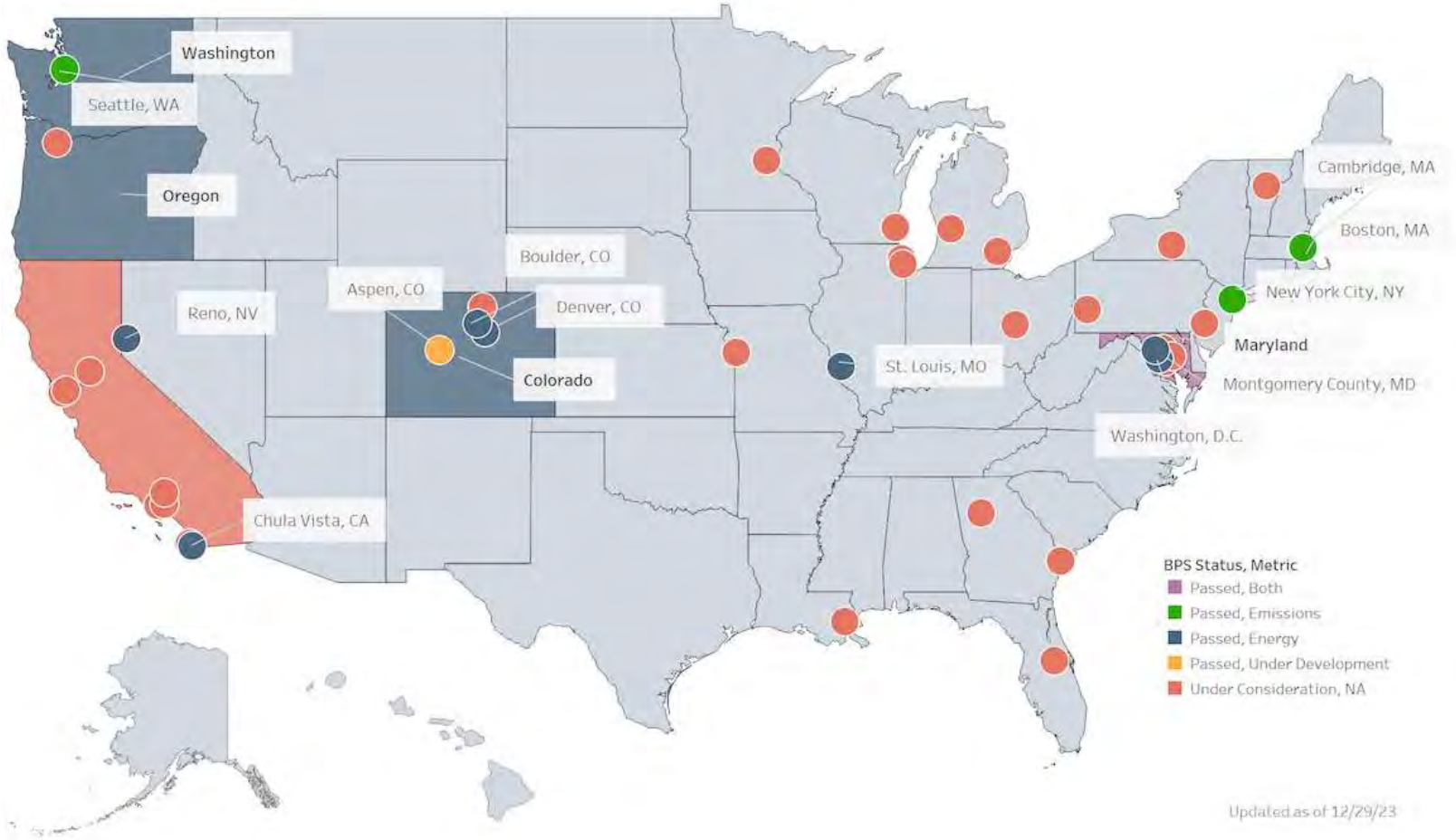
Ice Heating – An Electrification Solution (Joelle)

- Ice Heating Overview
- Case study
- Incentives/Financing

Summary of Benefits (Joelle)

POLICY LANDSCAPE

STATE AND LOCAL BUILDING PERFORMANCE STANDARDS



Credit: Institute for Market Transformation www.imt.org/bps

NET-ZERO POLICY PATHWAYS

NBI recognizes three pathways available to get to the zero levels:

Zero Energy Construction Code. This is an energy code strategy where projects are required to demonstrate that submitted building plans are designed to achieve a zero energy outcome

Zero Energy Outcome Policy. This is a building energy policy requiring buildings to demonstrate net zero energy use based on measured building performance outcome.

Zero Carbon Code or Policy. When considering carbon as the metric, there potentially are two independent facets of the policy:

- *Elimination of building-level combustion*
- *Move from energy cost/site/source metrics to GHG emission metrics*

ALL THINGS POINT TOWARDS ELECTRIFICATION

Net-Zero Pathways - Policy Into Practice

Beyond New England….

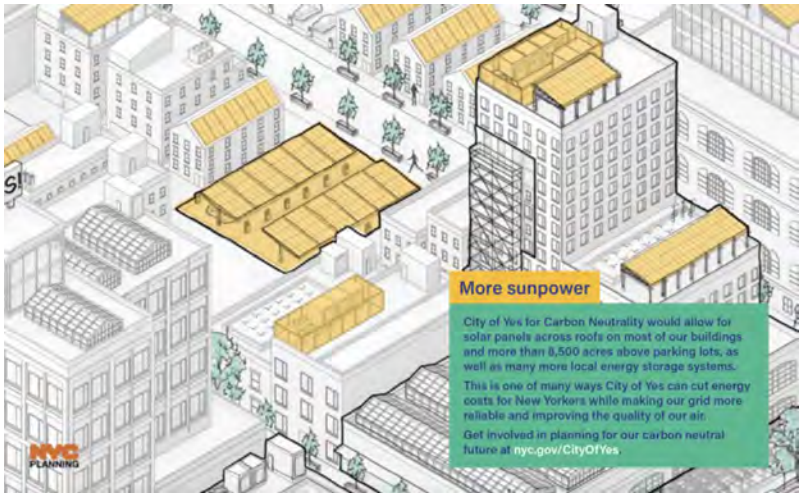
- **California's Title 24 Energy Standard**
  - **California State Building Code**
    - *Lighting Efficiency*
    - *High efficiency Mechanical Systems*
    - *Solar Power installed (roofs up to certain size)*
    - *Envelope and IAQ requirements*
- ***Proposed California Commercial Zero Code***

ALL THINGS POINT TOWARDS ELECTRIFICATION

Net-Zero Pathways - Policy Into Practice

Beyond New England….

- **NYC City of Yes For Carbon Neutrality**
- *Transportation, Waste, Buildings, Renewables*
- **Local Law 97**
- Carbon Emission limits for large existing buildings
- *2024-2029 first compliance period*

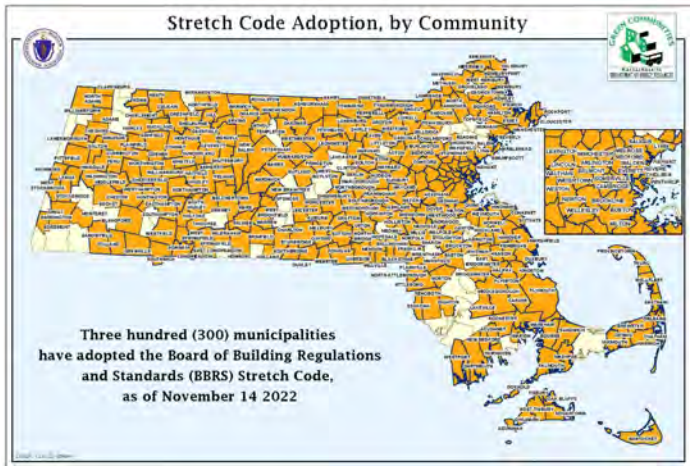


ALL THINGS POINT TOWARDS ELECTRIFICATION

Net-Zero Pathways - Policy Into Practice

Local highlights….

- Municipal Fossil Fuel Free Building Demonstration Program
- **Massachusetts** *Stretch Energy Code and Specialized Opt-in Building Energy Code*
- **Cambridge** BEUDO: *Building Energy Use Disclosure Ordinance*



ALL THINGS POINT TOWARDS ELECTRIFICATION

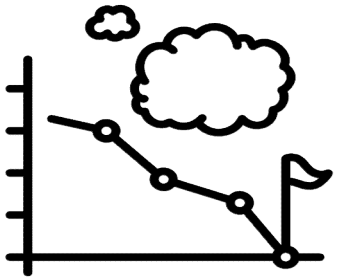
Recent Changes - MA Stretch Energy Code

- **Updated State Building Code** requires very high levels of **energy efficiency** for all new construction.
- **Incentivizes electrification**: Mixed fuel buildings must pre-wire for electrification and install solar where feasible.
- **Passive House certification** required for all new multifamily housing over 12,000 sf.
- BPDA - already seeing increase in **all-electric large residential and commercial office** submissions and >90% operational electrification for labs

ALL THINGS POINT TOWARDS ELECTRIFICATION

Boston's Decarbonization Goals

- The City of Boston aims to achieve **carbon neutrality by 2050**.
- Buildings account for nearly **71% of our community's carbon emissions** and new buildings can be designed to minimize emissions and climate impact.



BUILDING USE	EMISSIONS STANDARD ($kgCO_2e$ / sq. ft. / year)					
	2025-2029	2030-2034	2035-2039	2040-2044	2045-2049	2050-
Assembly	7.8	4.6	3.3	2.1	1.1	0
College / University	10.2	5.3	3.8	2.5	1.2	0
Education	3.9	2.4	1.8	1.2	0.6	0
Food Sales & Service	17.4	10.9	8.0	5.4	2.7	0
Healthcare	15.4	10.0	7.4	4.9	2.4	0
Lodging	5.8	3.7	2.7	1.8	0.9	0
Manufacturing / Industrial	23.9	15.3	10.9	6.7	3.2	0
Multifamily housing	4.1	2.4	1.8	1.1	0.6	0
Office	5.3	3.2	2.4	1.6	0.8	0
Retail	7.1	3.4	2.4	1.5	0.7	0
Services	7.5	4.5	3.3	2.2	1.1	0
Storage	5.4	2.8	1.8	1.0	0.4	0
Technology/Science	19.2	11.1	7.8	5.1	2.5	0

ALL THINGS POINT TOWARDS ELECTRIFICATION

Boston's Decarbonization Goals

Recent Changes - City of Boston - BERDO

- Regulations for the **Building Emissions Reduction and Disclosure Ordinance (BERDO)** have been finalized.
- Requires residential buildings with **15+ units and non-residential buildings >20,000 SF** to meet declining emissions standards and achieve **net zero emissions by 2050**.
- Tracks and enforces emissions reductions ***after* a building is in operation**.
- Sets allowable ***compliance mechanisms*** including renewable energy purchases and Alternative Compliance Payments.

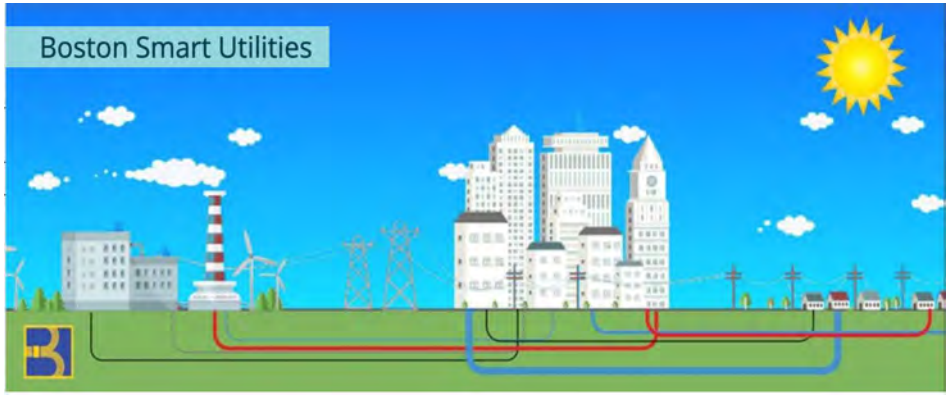
ALL THINGS POINT TOWARDS ELECTRIFICATION

Boston's Decarbonization Goals

Boston Smart Utilities Program and Policy

Benefits:

- Make utilities easier to build, maintain and upgrade
- Reduce energy/water costs for residents/businesses
- Harden infrastructure against flooding and heat waves
- Integrate cutting edge technologies to continue to innovate.

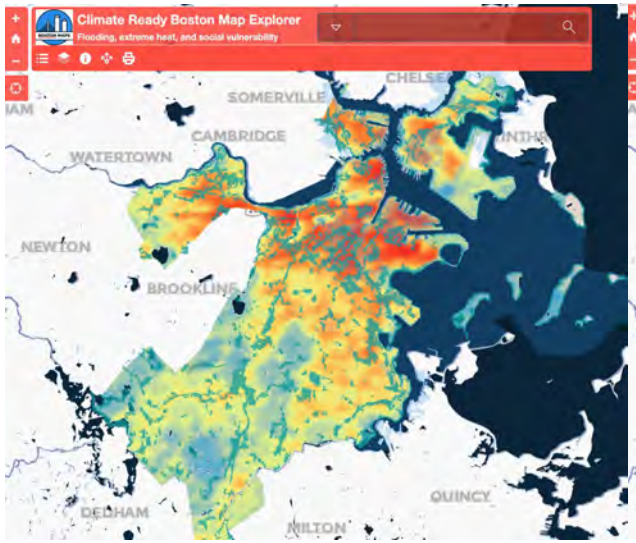


ALL THINGS POINT TOWARDS ELECTRIFICATION

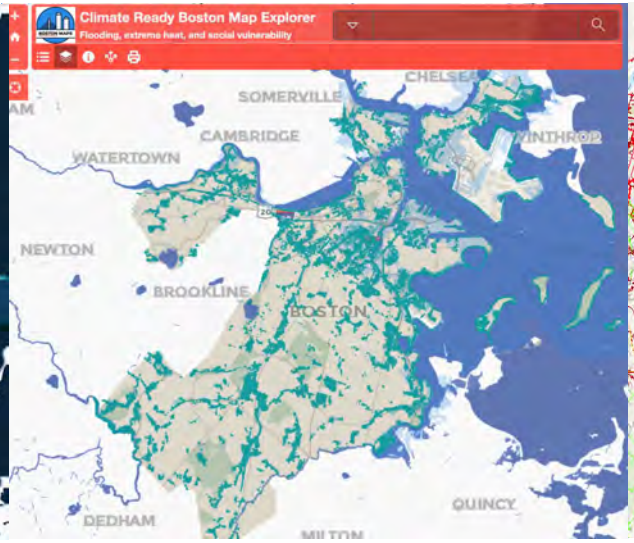
Boston's Decarbonization Goals

Boston Smart Utilities Program and Policy

Heat



Stormwater

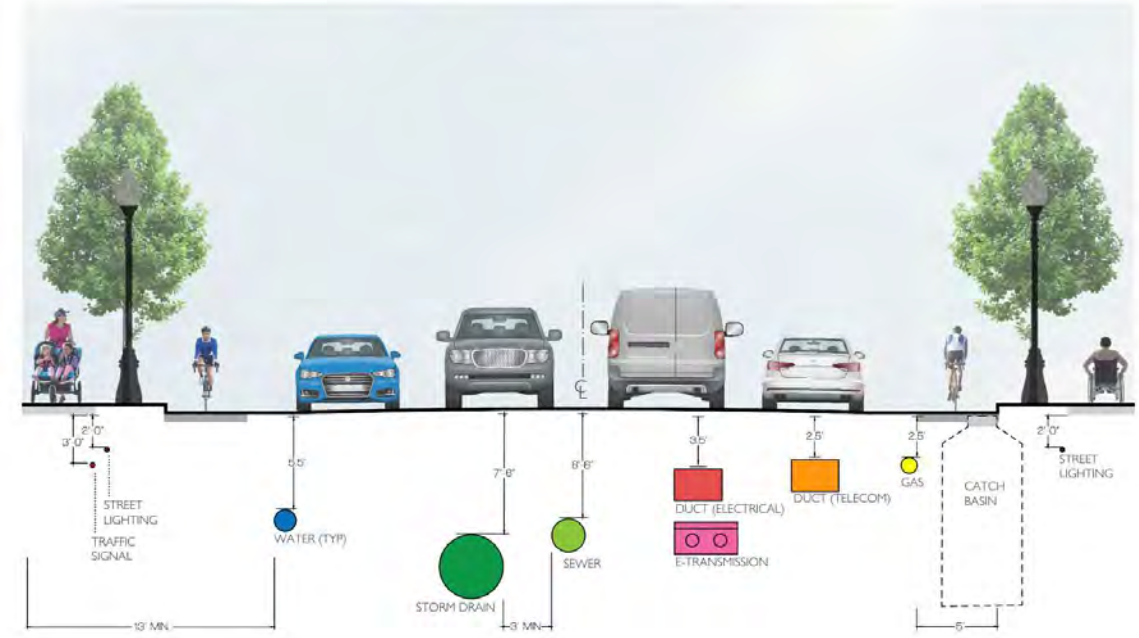


Energy Infrastructure

ALL THINGS POINT TOWARDS ELECTRIFICATION

Boston's Decarbonization Goals

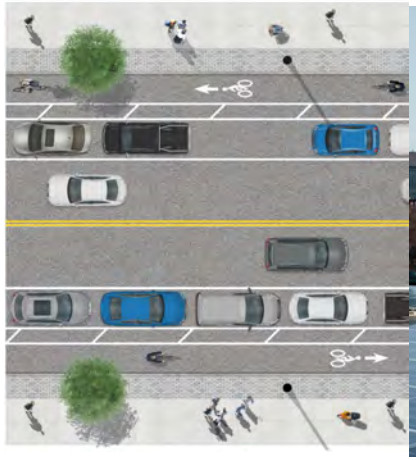
The "Unseen" Right of Way



ALL THINGS POINT TOWARDS ELECTRIFICATION

Boston's Decarbonization Goals

Impacts Above



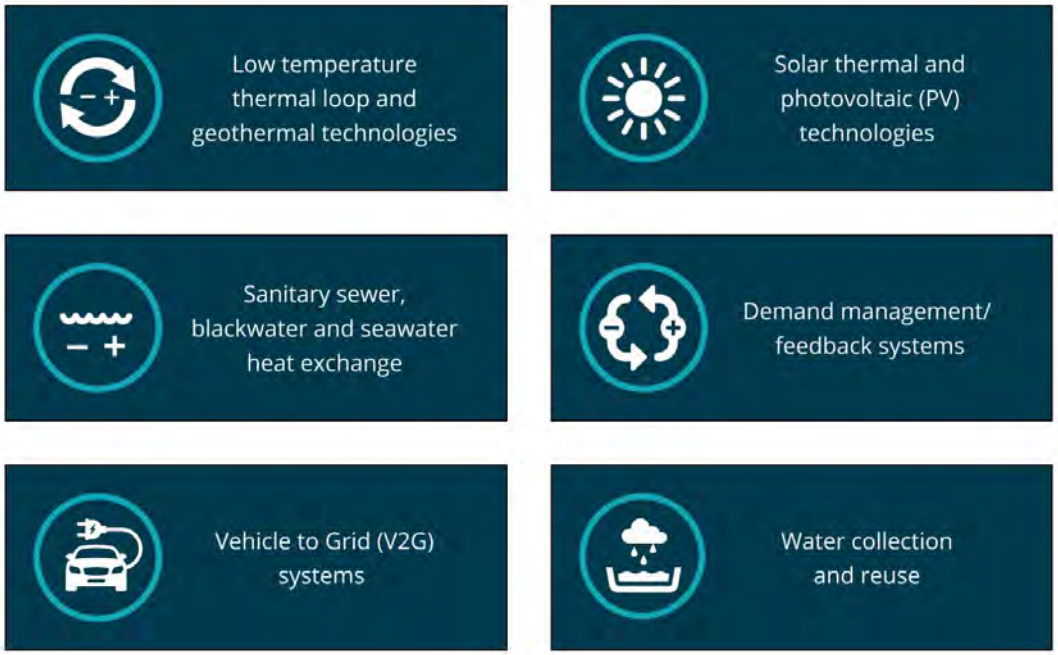


ALL THINGS POINT TOWARDS ELECTRIFICATION

Advanced Energy Feasibility Assessments

Highlights Opportunities for System innovation

- **Integrate cutting edge technologies** to continue to innovate.
- **Respond to Carbon Emission Policies** and goals as a wholistic, system driven approach
- Encourage **Distributed Energy Resouces** and **Districts Systems**



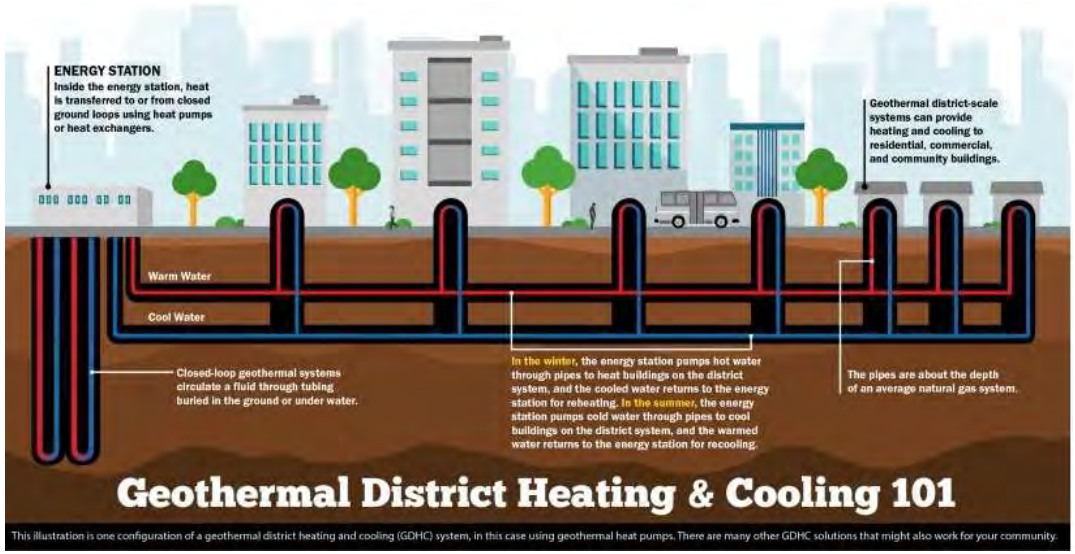
ALL THINGS POINT TOWARDS ELECTRIFICATION

Microgrid / Micro-District Ready Buildings

Developing Strategies

Providing a new model for upfront, **integrated utility planning and design**

Encouraging the deployment of **Smart Utility Technologies across energy, water, telecommunications, and transportation services and infrastructure**.



Boston Housing Authority
Franklin Field Geothermal Network Pilot
National Grid + BHA

STATE OF THE ELECTRIC GRID

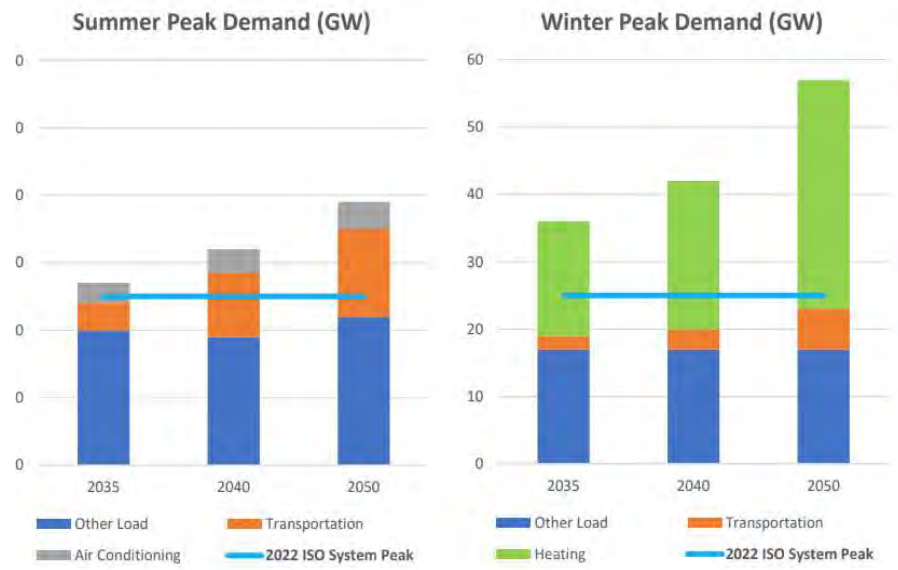
THE MA GRID - PLANS TO KEEP UP

Grid Modernization

The electrification plans result in New England shifting to a Winter Peaking system - **increasing the demand on the grid by 40% by 2035 and 72% by 2040** - an overall increase of 18 GW by 2040 and doubling of New England demand by 2050

Increases in **electric vehicles projected to add 5 GW of summer** and **2 GW of winter peak demand by 2035**

Increases in **zero-carbon heating projected to add 17 GW of winter demand by 2035**

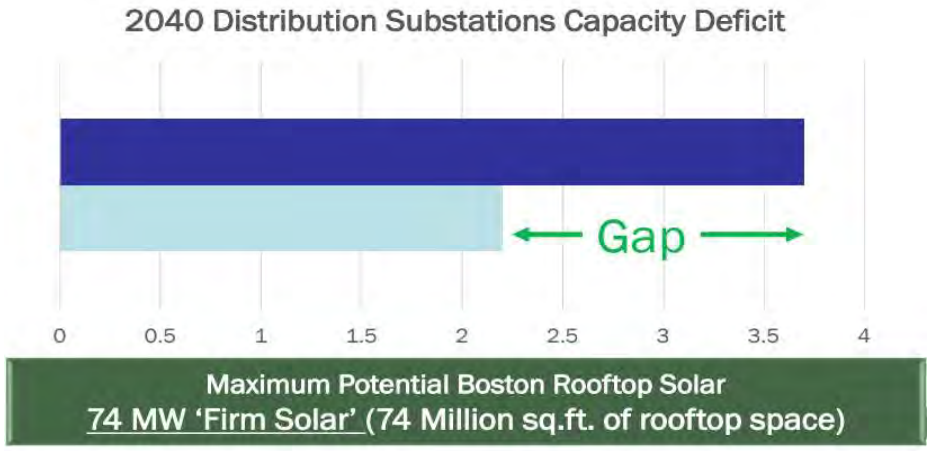


source: Eversource

THE MA GRID - PLANS TO KEEP UP

Grid Modernization

- Boston's current Summer/ Winter peak demand: 1.7/1.2 GW
- 16 Distribution Stations with a firm capacity of 2.2 GW
- **2040 Electrification Demand projected to add 2.5 GW** to the winter load while switching to winter peak
- Total capacity of transmission supply lines into Boston stations: ~3.5 GW



source: Eversource

THE MA GRID - PLANS TO KEEP UP

Grid Modernization

Electric Sector Modernization Plans

Eversource and National Grid

Within **City of Boston Limits** Next 7-15 years

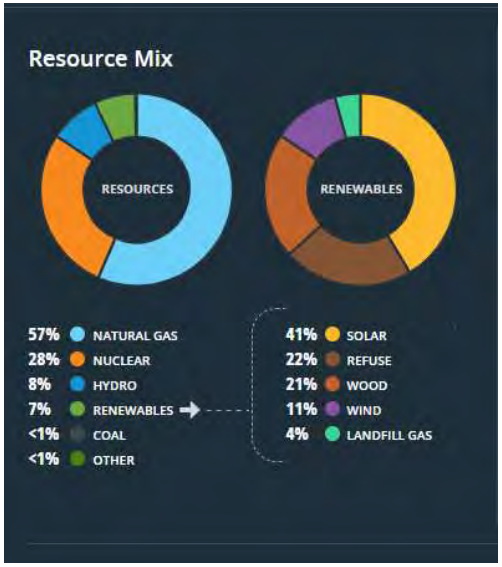
- **6 Substations**
- Distribution Line Upgrades
- Transmission Line Upgrades
- “Smart” Integration
- **Distributed Energy Resource Integration**
- **Resilience + Reliability Goals**

source: Eversource East Hosting Capacity Map

EXPECTED GRID EMISSIONS / GENERATION PROFILE OVER TIME?

Challenges Ahead

- **Increased Overall Load Growth**
- Shift from Summer to Winter peak
  - ***Less "Blue Sky" Renewables available in winter months***
  - ***Storage will play a key role***
- Peak Demand set to increase and may need to be accounted for in project emission factors



source: NE-ISO

Year	Projected Grid Emissions Factor (lb/MWh)
2022	595
2023	580
2024	564
2025	548
2026	533
2027	517
2028	501
2029	486
2030	470
2031	454
2032	439
2033	423
2034	407
2035	392
2036	376
2037	360
2038	345
2039	329

Year	Projected Grid Emissions Factor (lb/MWh)
2040	313
2041	298
2042	282
2043	266
2044	251
2045	235
2046	219
2047	204
2048	188
2049	172
2050	157

Source: These projected Emissions Factors were prepared by Synapse as part of the development process of the BERDO Emissions standards. See complete report here.

Source City of Boston BERDO

BPDA SMART UTILITIES – ADDRESSING GRID CHALLENGES

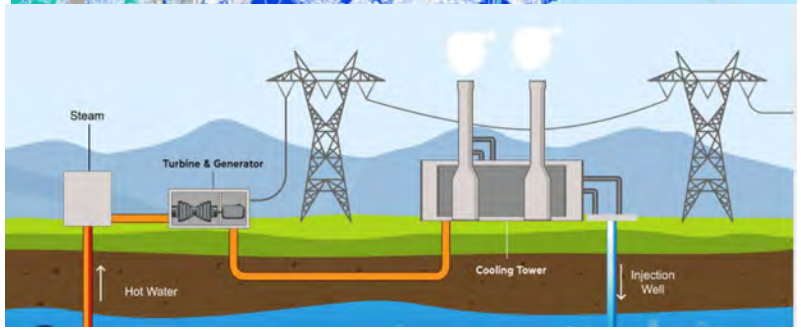
Equitable Electrification

- **Targeted Distributed Energy Resources** in areas of known **Grid Congestion**
- Energy Conservation Measures to Reduce Demand driven by Buildings Codes
- **Baseload Energy Reduction – Thermal Storage, District Opportunities**
- Development Pipeline and Eversource Step Load Forecasting
- Data Driven **Electrification Planning** Across Boston

BPDA SMART UTILITIES – ADDRESSING GRID CHALLENGES

Equitable Electrification

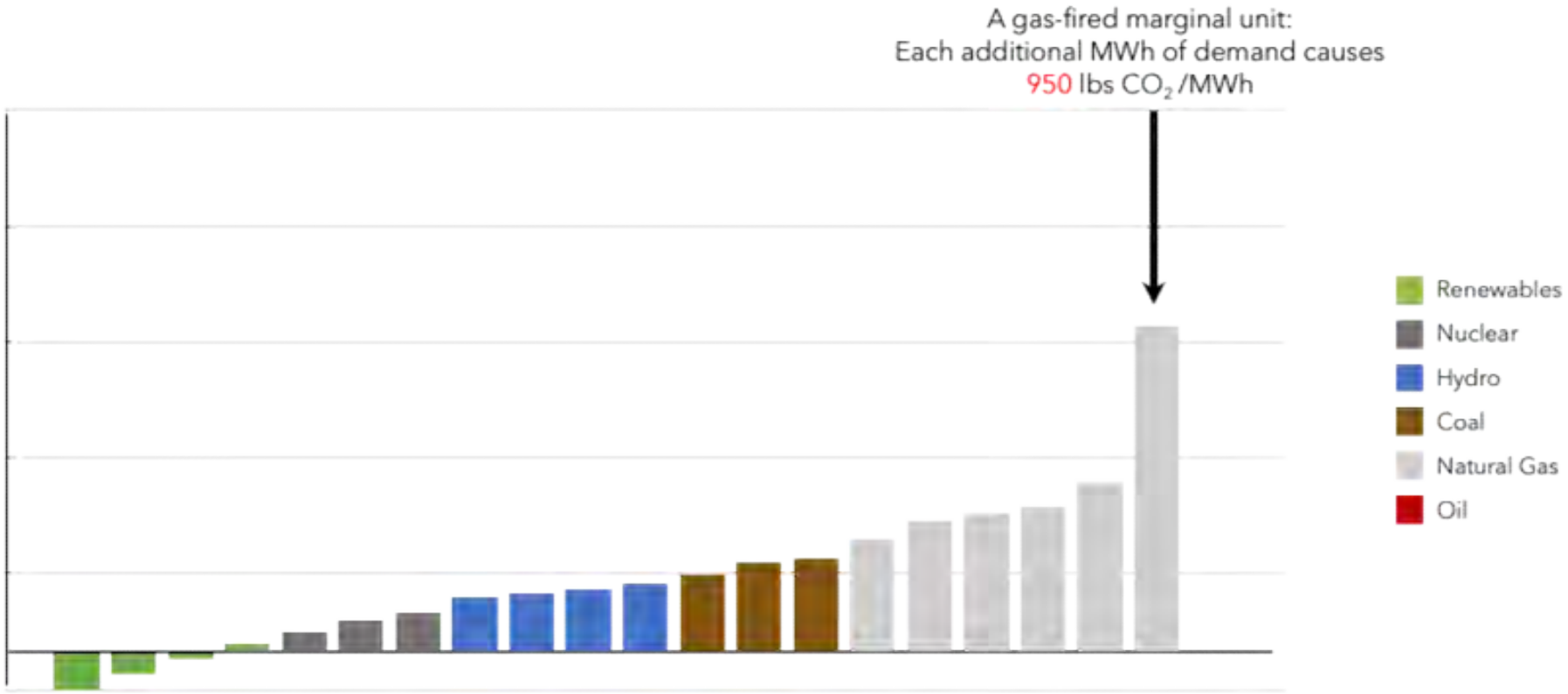
- **Renewable Resources City-wide**
  - Networked Geothermal
  - Enhanced Geothermal and Geopower
  - Sewer Heat Recovery
  - Solar PV
  - Vehicle 2 “X”
- **Strategic Fuel Switching**
- **Fleet Planning and EV adoption strategies**
- **Time of Use**
- **Demand Response**



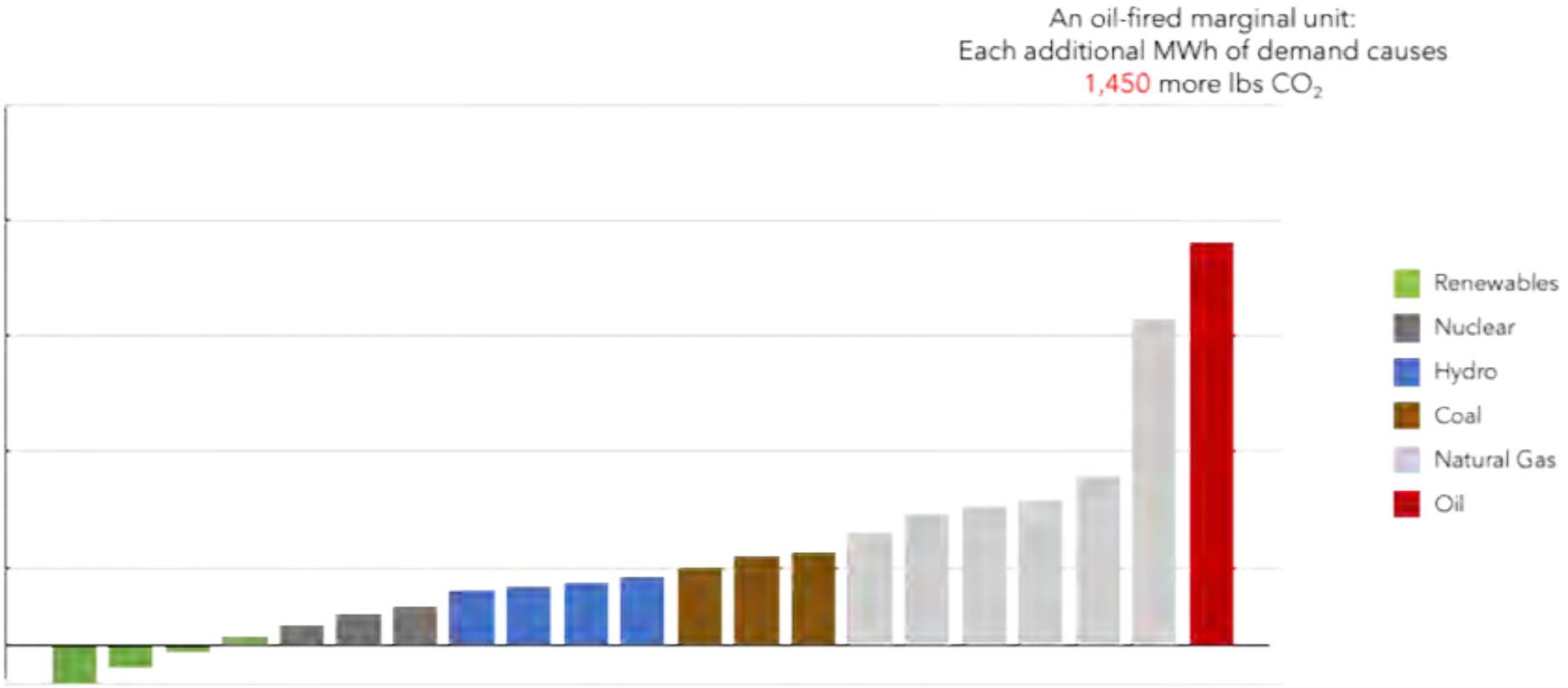
source: above DOER Solar Capacity Map; “Geopower” diagram

TIME OF USE CARBON & ENERGY OPTIMIZATION

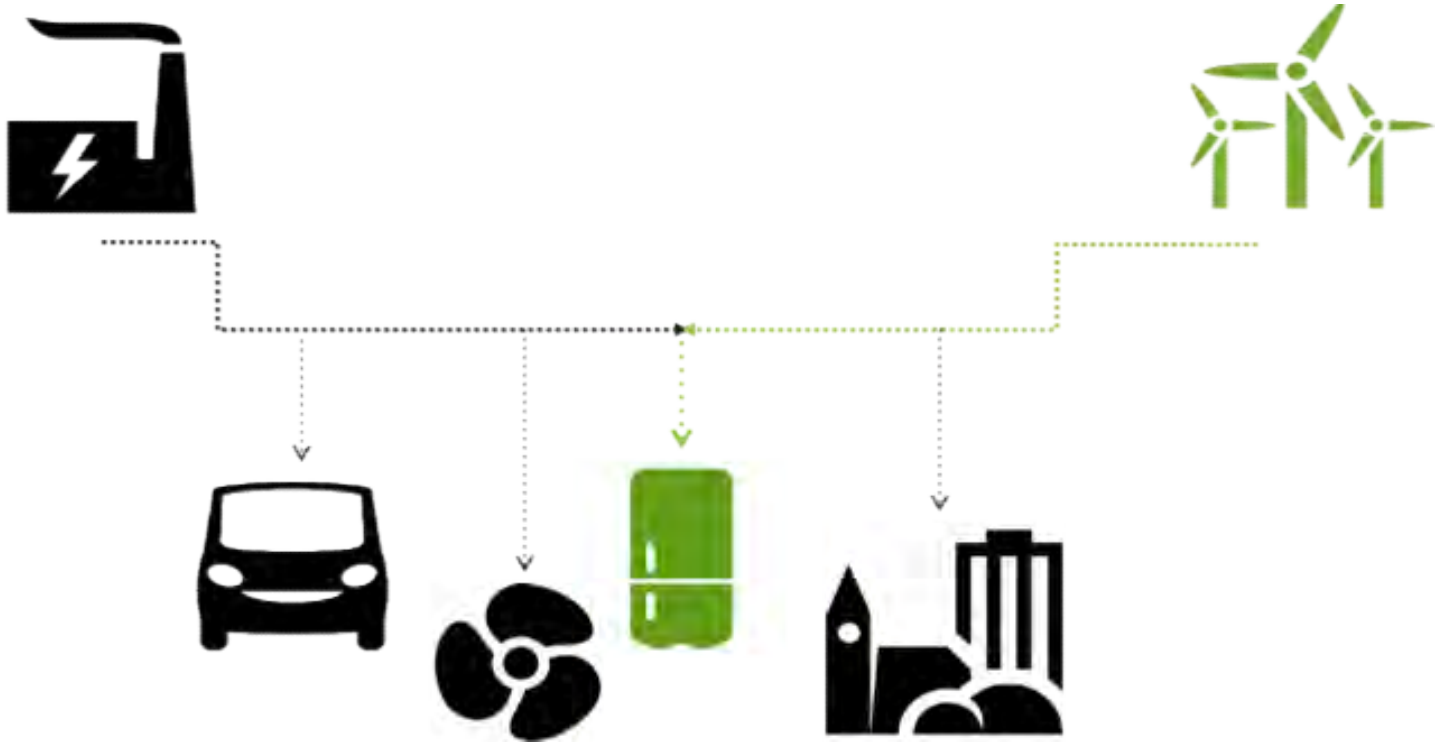
ELECTRIC GRIDS MEET FLUCTUATING DEMAND BY RAMPING THE "MARGINAL" GENERATION RESOURCE



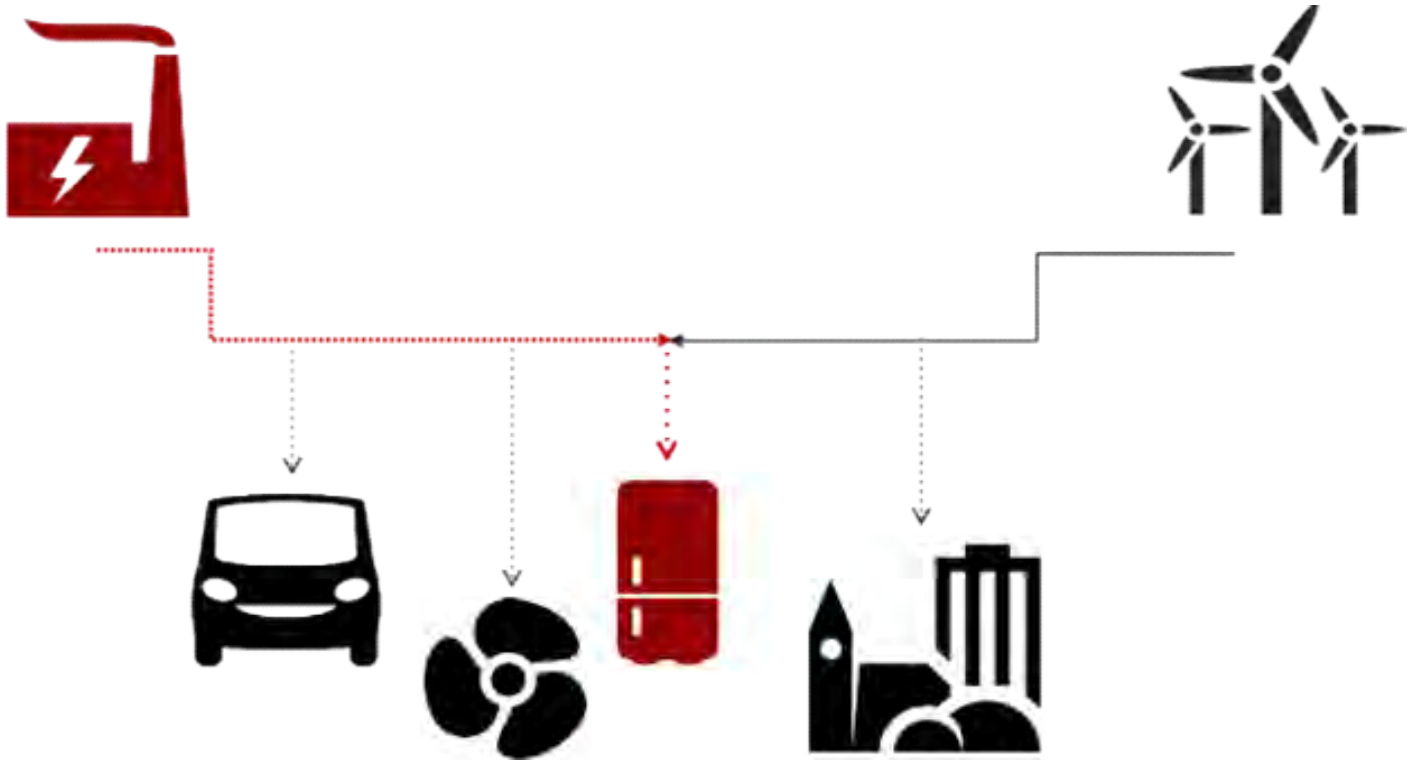
BUT *WHICH* UNIT IS MARGINAL CHANGES THROUGHOUT THE DAY



SOMETIMES INCREASING POWER CAUSES A LOW-EMITTING RESOURCE TO RESPOND…

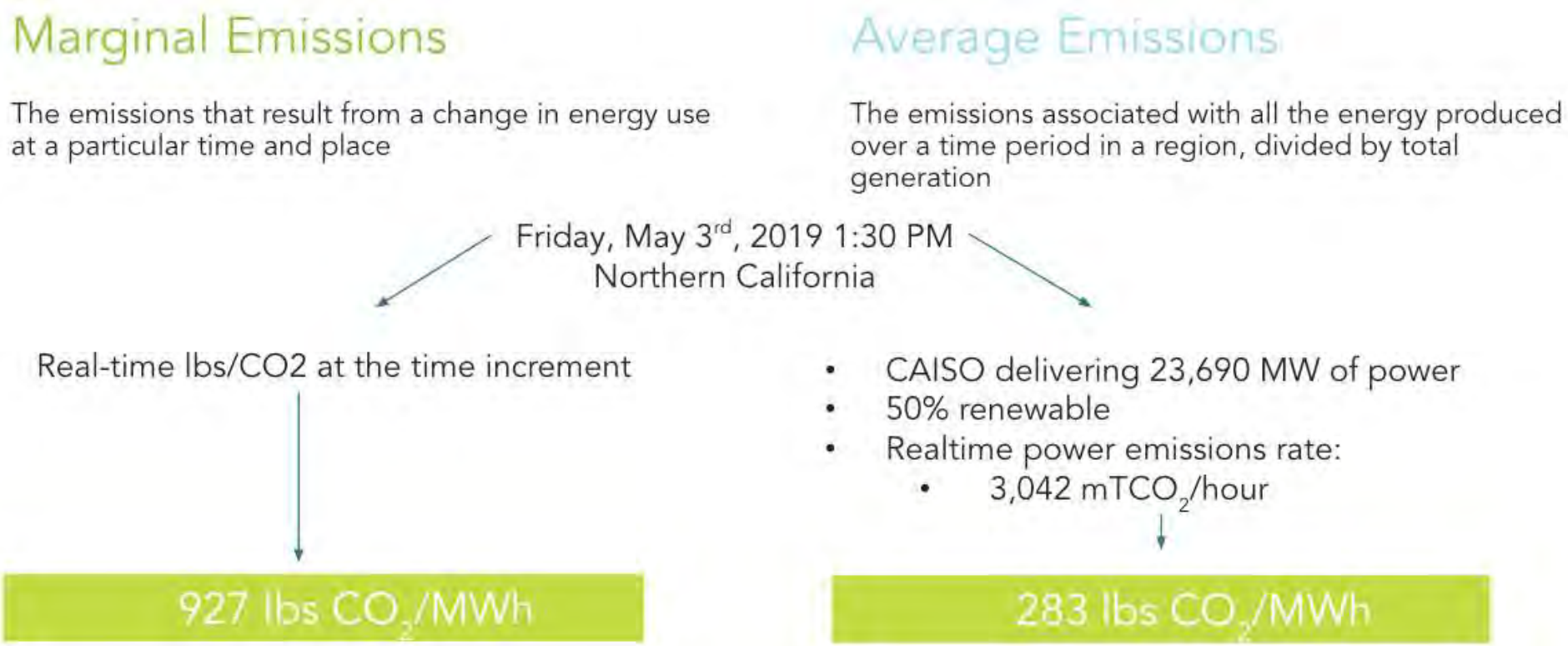


...BUT OTHER TIMES, A HIGH-EMITTING UNIT



MARGINAL VS. AVERAGE

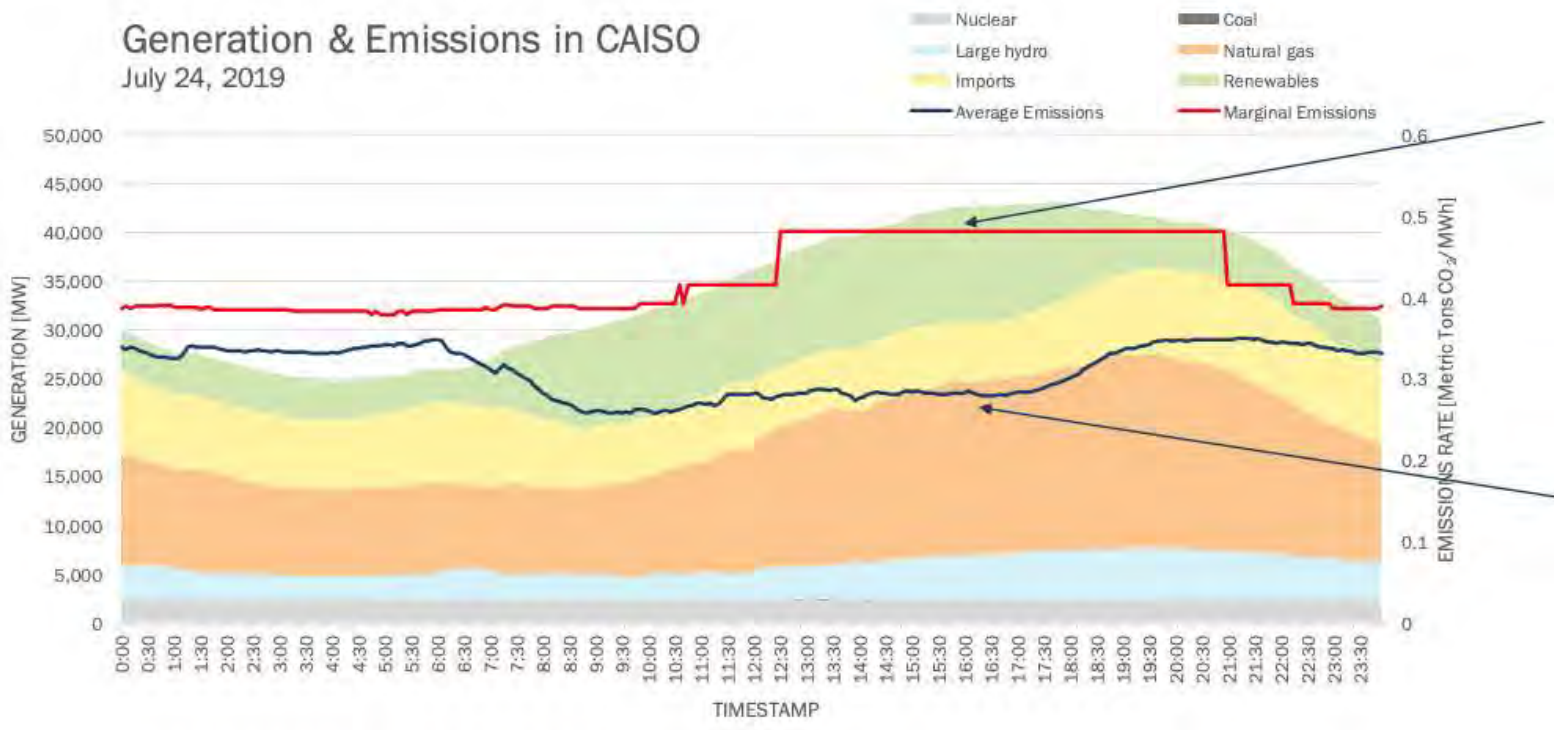
Marginal emissions focuses on impact vs. average emissions focuses on accounting



Average emissions are often the metric used for a company's emissions accounting needs such as with the GHG protocol.

But an average emissions factor may not be representative of the emission impacts of *actual* actions.

AVERAGE AND MARGINAL EMISSION SIGNALS MAY DICTATE COMPLETELY DIFFERENT OPTIMIZATION OUTCOMES



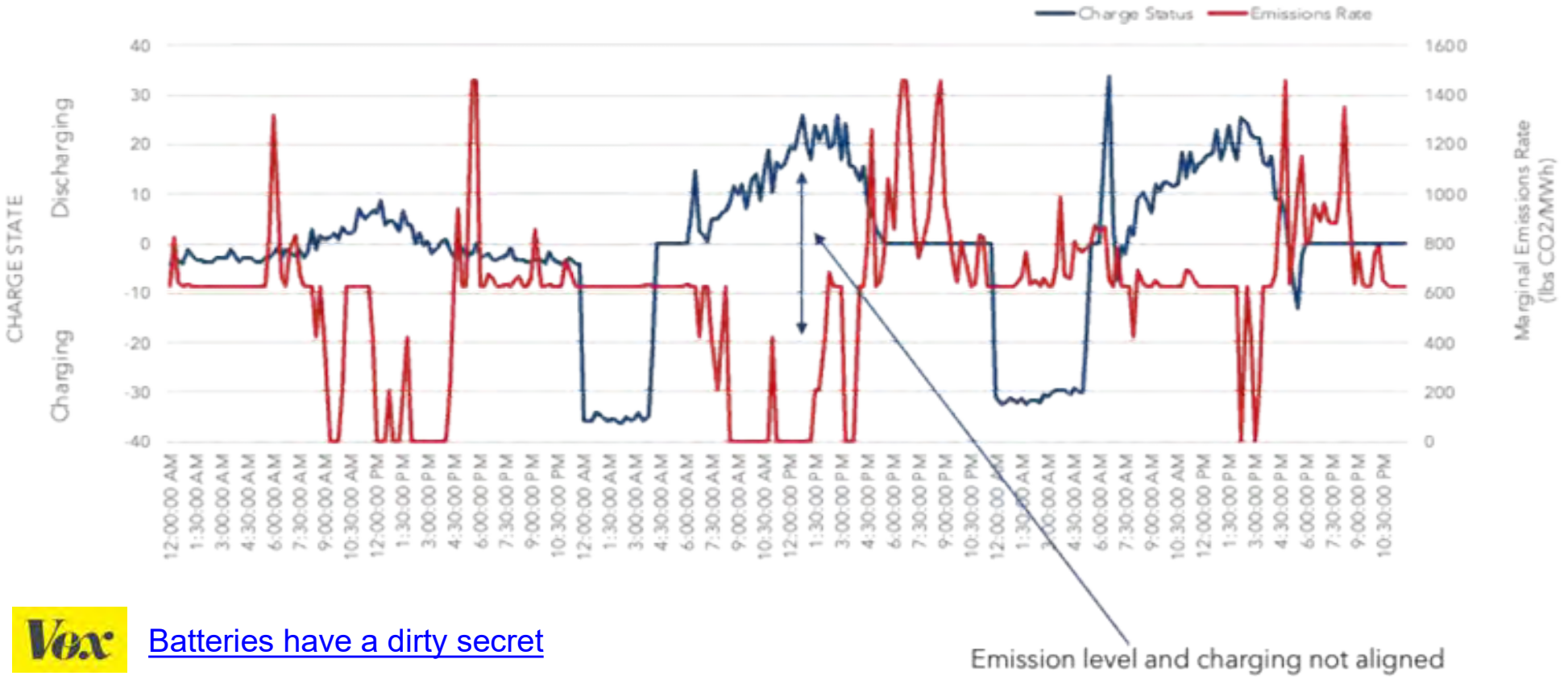
The marginal signal suggests **decreasing** load in the afternoon based on how the grid is responding in real-time

The average signal indicates you could **increase** load in the afternoon.

Doing so would also mean an actual **increase in emissions** since the marginal emissions are high

BATTERIES CONTROLLED FOR PRICE ALONE TEND TO INCREASE EMISSIONS

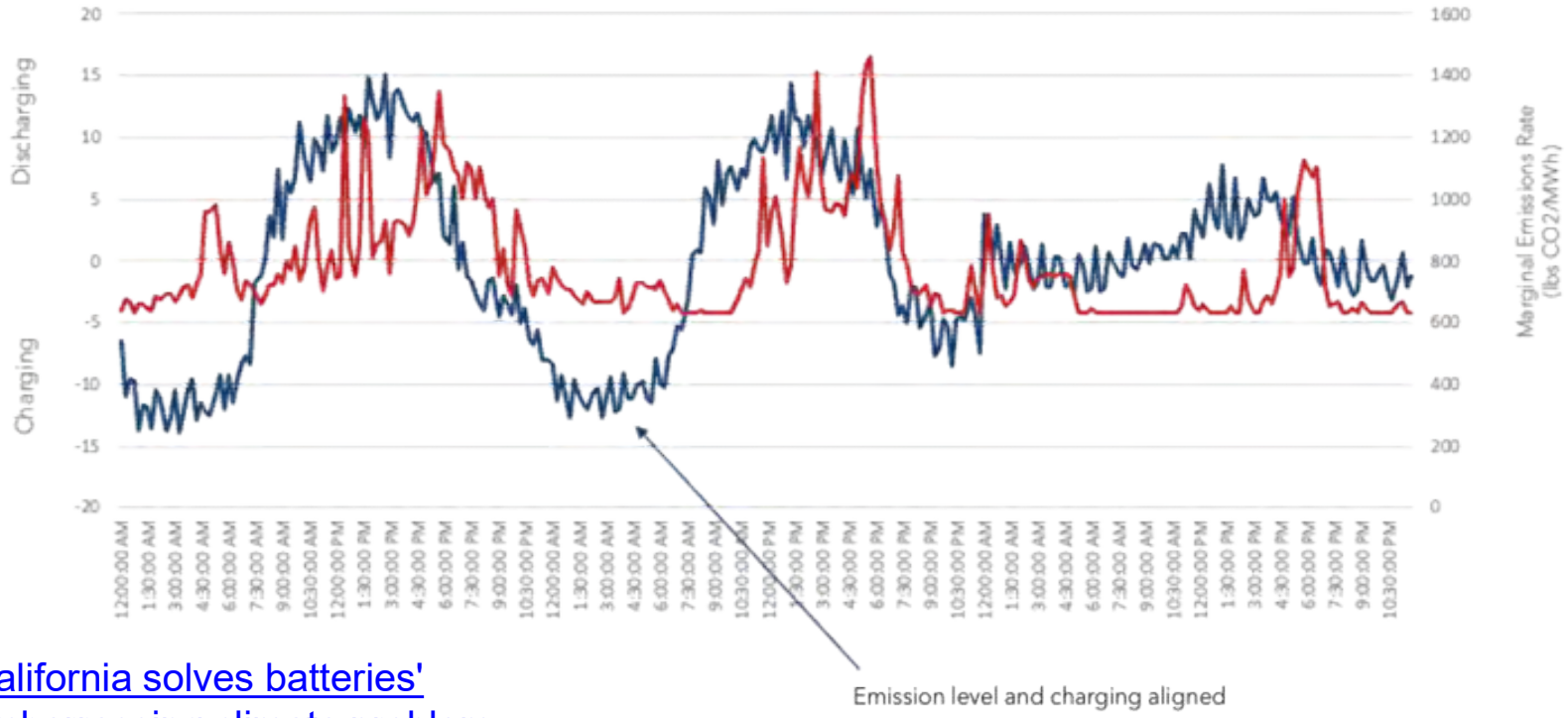
California storage devices had *increased* pollution because they were controlled to charge at the "wrong" times



Vox [Batteries have a dirty secret]

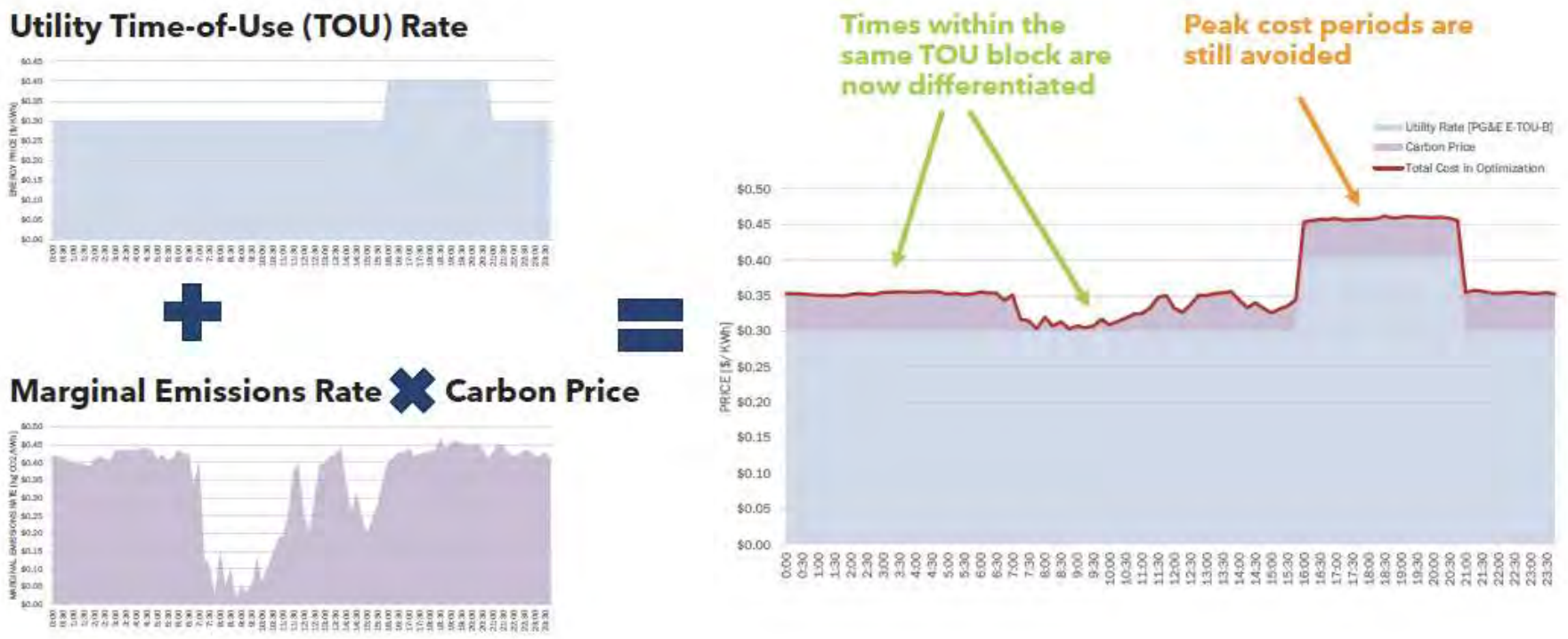
CALIFORNIA PUC NOW INTEGRATES EMISSIONS INTO OPTIMIZATION STRATEGIES

Incentives are now directly aligned with decarbonization goals

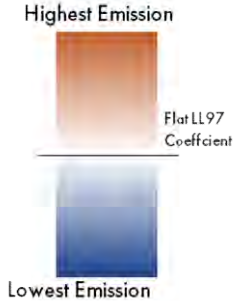


Vox [California solves batteries' embarrassing climate problem]

DECARBONIZATION CAN EASILY COINCIDE WITH TOU COST OPTIMIZATION



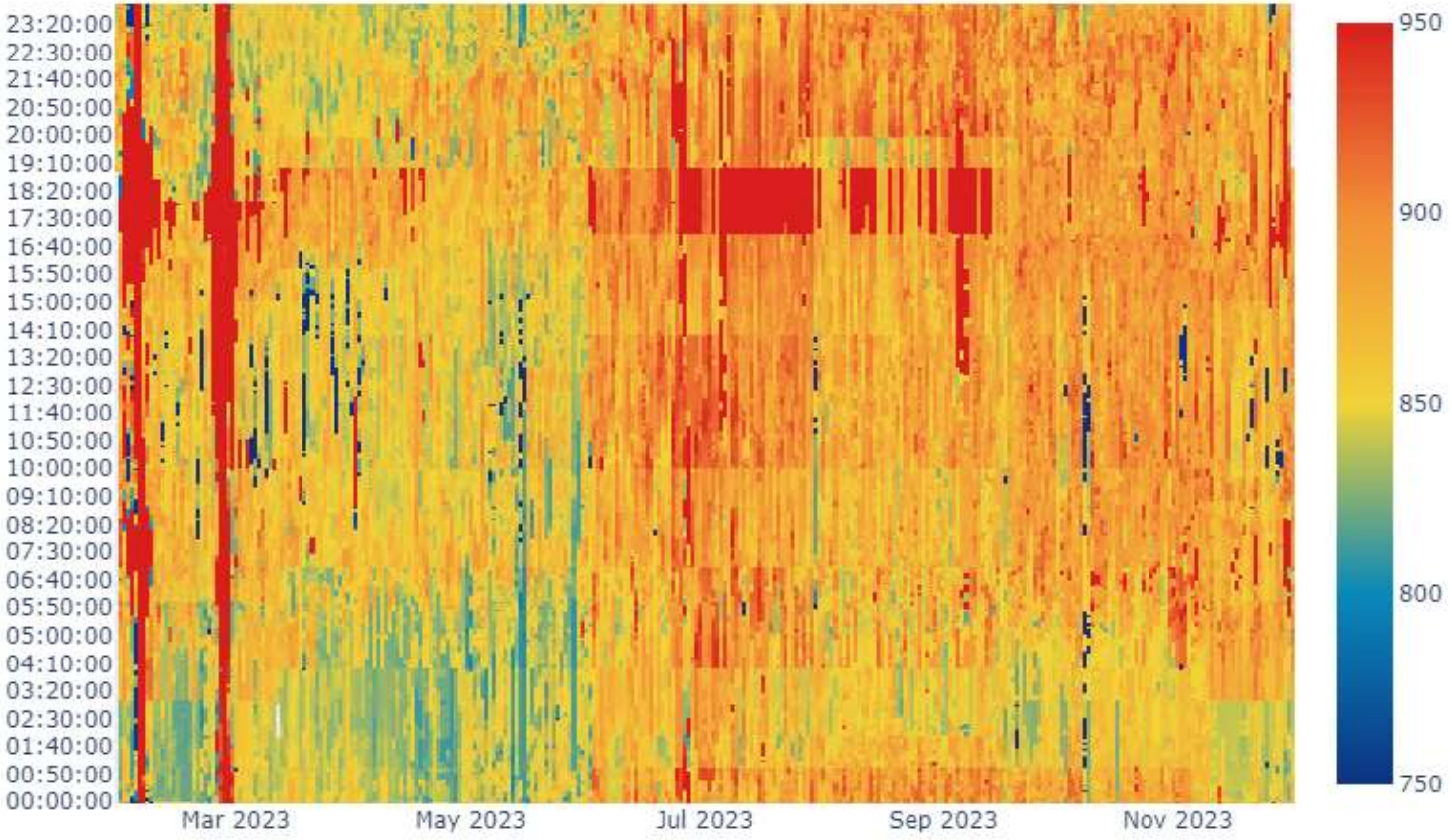
NYC TIME OF USE EMISSIONS COEFFICIENT INFORMED BY MARGINAL EMISSIONS



2023 Time-of-Use Coefficient (TOUn), tCO2e/kWh

Hour \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Hour of Day Subtotal
12AM	0.00018	0.00029	0.00022	0.00020	0.00011	0.00018	0.00023	0.00017	0.00014	0.00010	0.00020	0.00018	0.00018
1AM	0.00016	0.00026	0.00020	0.00019	0.00010	0.00014	0.00019	0.00013	0.00010	0.00007	0.00018	0.00017	0.00016
2AM	0.00015	0.00025	0.00019	0.00018	0.00008	0.00012	0.00017	0.00011	0.00009	0.00004	0.00019	0.00015	0.00014
3AM	0.00015	0.00026	0.00021	0.00019	0.00010	0.00012	0.00016	0.00012	0.00011	0.00004	0.00017	0.00014	0.00015
4AM	0.00016	0.00028	0.00024	0.00022	0.00013	0.00013	0.00019	0.00015	0.00013	0.00006	0.00020	0.00015	0.00017
5AM	0.00018	0.00029	0.00034	0.00032	0.00021	0.00015	0.00022	0.00017	0.00020	0.00014	0.00025	0.00019	0.00022
6AM	0.00023	0.00038	0.00043	0.00035	0.00020	0.00021	0.00022	0.00017	0.00024	0.00022	0.00028	0.00025	0.00026
7AM	0.00027	0.00046	0.00037	0.00031	0.00019	0.00023	0.00025	0.00020	0.00021	0.00020	0.00029	0.00028	0.00027
8AM	0.00029	0.00038	0.00033	0.00031	0.00019	0.00027	0.00032	0.00020	0.00022	0.00019	0.00024	0.00026	0.00027
9AM	0.00029	0.00036	0.00032	0.00031	0.00014	0.00027	0.00032	0.00023	0.00021	0.00017	0.00022	0.00025	0.00026
10AM	0.00031	0.00041	0.00031	0.00030	0.00014	0.00029	0.00036	0.00024	0.00029	0.00020	0.00025	0.00027	0.00028
11AM	0.00029	0.00039	0.00027	0.00029	0.00013	0.00030	0.00039	0.00026	0.00026	0.00017	0.00023	0.00027	0.00027
12PM	0.00027	0.00036	0.00023	0.00030	0.00015	0.00031	0.00042	0.00027	0.00028	0.00019	0.00023	0.00026	0.00027
1PM	0.00025	0.00034	0.00025	0.00029	0.00014	0.00032	0.00042	0.00032	0.00030	0.00018	0.00024	0.00026	0.00027
2PM	0.00024	0.00034	0.00025	0.00029	0.00017	0.00032	0.00042	0.00033	0.00029	0.00019	0.00024	0.00028	0.00028
3PM	0.00026	0.00037	0.00032	0.00030	0.00020	0.00036	0.00048	0.00036	0.00032	0.00023	0.00028	0.00030	0.00031
4PM	0.00031	0.00038	0.00029	0.00032	0.00022	0.00037	0.00048	0.00038	0.00036	0.00026	0.00032	0.00032	0.00033
5PM	0.00038	0.00049	0.00038	0.00041	0.00028	0.00032	0.00049	0.00038	0.00037	0.00031	0.00043	0.00039	0.00038
6PM	0.00035	0.00049	0.00043	0.00044	0.00034	0.00032	0.00048	0.00034	0.00033	0.00027	0.00036	0.00036	0.00038
7PM	0.00032	0.00048	0.00041	0.00045	0.00035	0.00032	0.00043	0.00036	0.00031	0.00022	0.00029	0.00031	0.00036
8PM	0.00030	0.00044	0.00042	0.00036	0.00027	0.00031	0.00040	0.00029	0.00026	0.00015	0.00031	0.00030	0.00032
9PM	0.00026	0.00043	0.00033	0.00032	0.00021	0.00027	0.00034	0.00025	0.00023	0.00013	0.00025	0.00029	0.00027
10PM	0.00022	0.00036	0.00024	0.00023	0.00015	0.00023	0.00029	0.00022	0.00020	0.00010	0.00023	0.00022	0.00022
11PM	0.00022	0.00032	0.00023	0.00022	0.00015	0.00022	0.00025	0.00020	0.00018	0.00011	0.00020	0.00020	0.00021
Monthly Subtotal	0.00025	0.00037	0.00030	0.00029	0.00018	0.00025	0.00033	0.00024	0.00023	0.00016	0.00025	0.00025	

ISONE NEMA MARGINAL EMISSIONS



ELECTRIFICATION HOLDS SIGNIFICANT OPPORTUNITY TO REDUCE EMISSIONS

- **Timing** of energy use directly affects actual emissions impact
- **Marginal** emissions reflect impact, average emissions reflect accounting
- Flexible building technology (i.e., ice heating managed with BMS) are ideal applications to **co-optimize** energy use at ideal times
- **As grids evolve** and renewables increase, **opportunities grow** for energy optimization

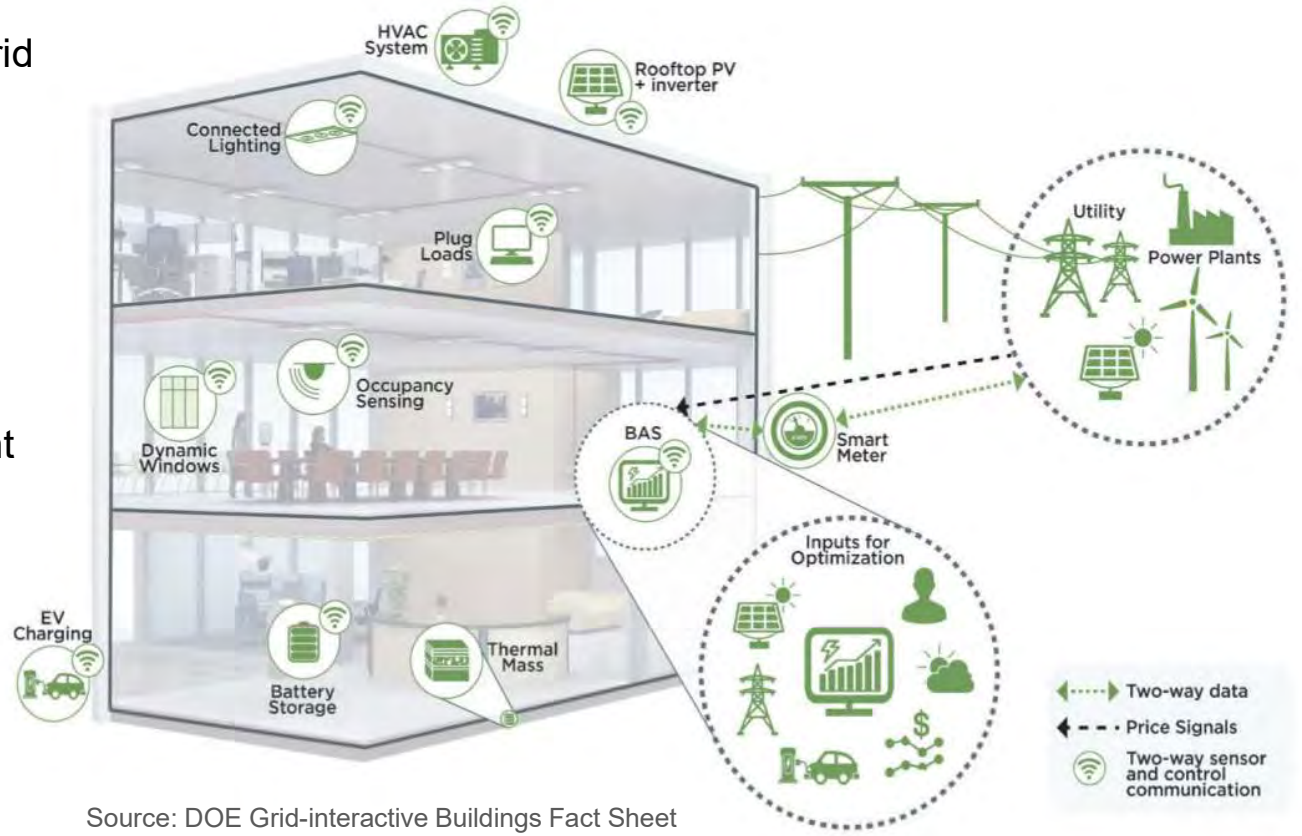
GRID INTERACTIVE BUILDINGS

WHAT IS A GRID INTERACTIVE BUILDING?

Responds to condition of electric grid

Many examples:

1. Turning things off
2. Ability to Setback loads using BMS and control sequences
3. Shift loads to energy/thermal storage to operate independent from electric grid



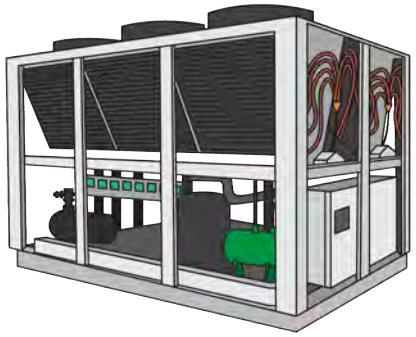
Source: DOE Grid-interactive Buildings Fact Sheet

GRID INTERACTIVE BUILDINGS: THE NEXT GENERATION OF ELECTRIFICATION

1st Generation

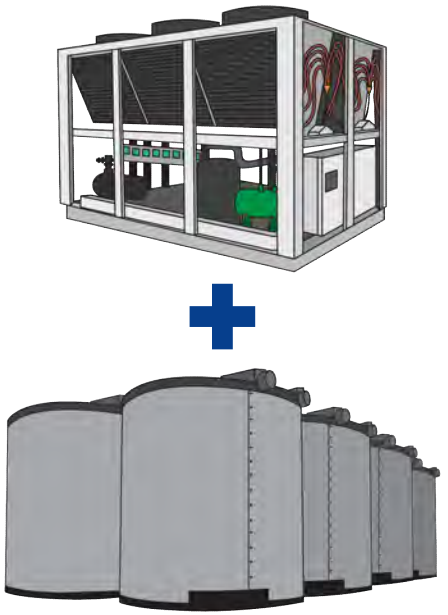
Electric Resistance

2nd Generation



Heat Pumps

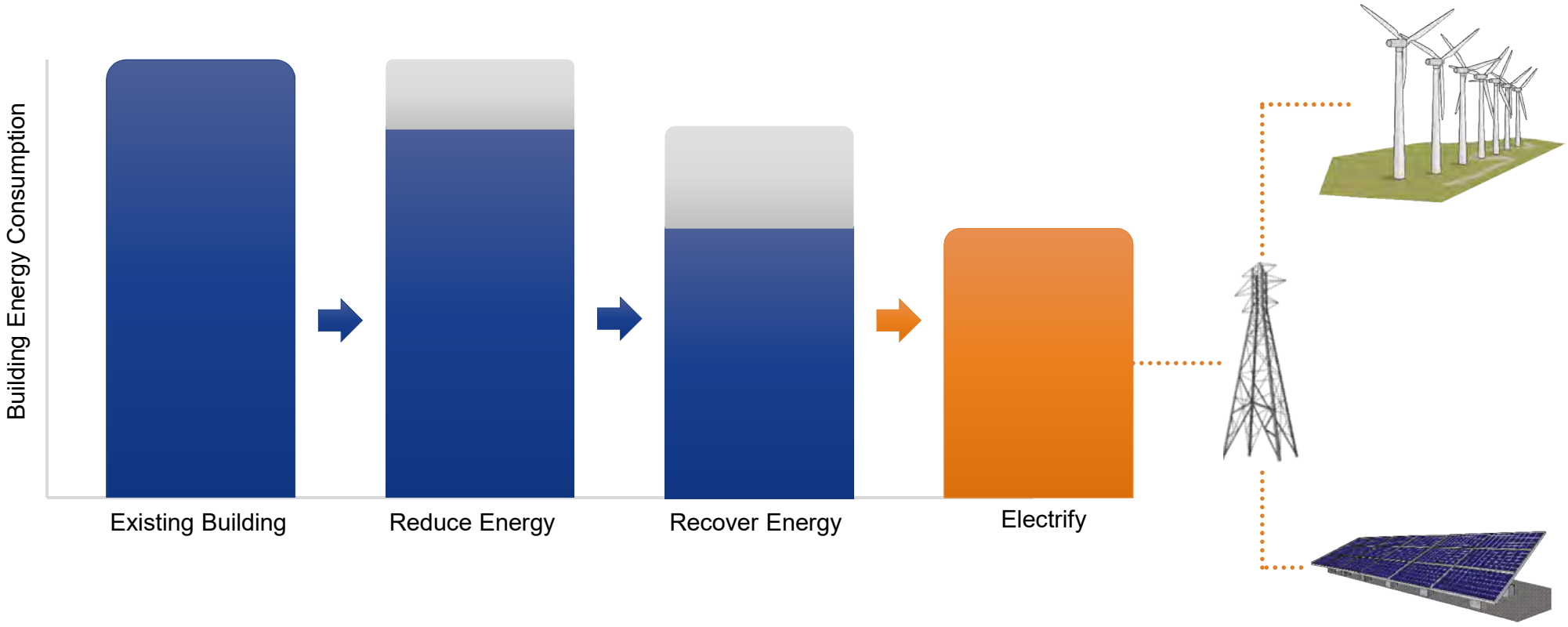
Next Generation



Heat Pumps + Energy Storage

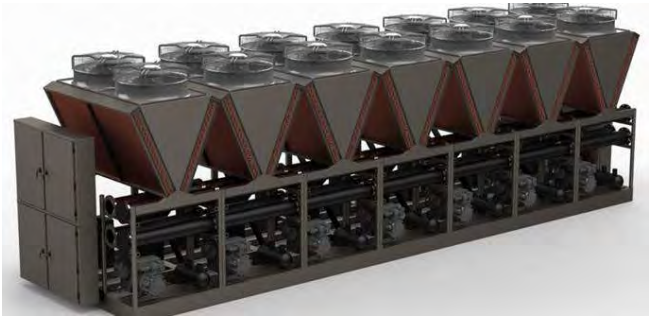
ICE HEATING
– AN ELECTRIFICATION SOLUTION

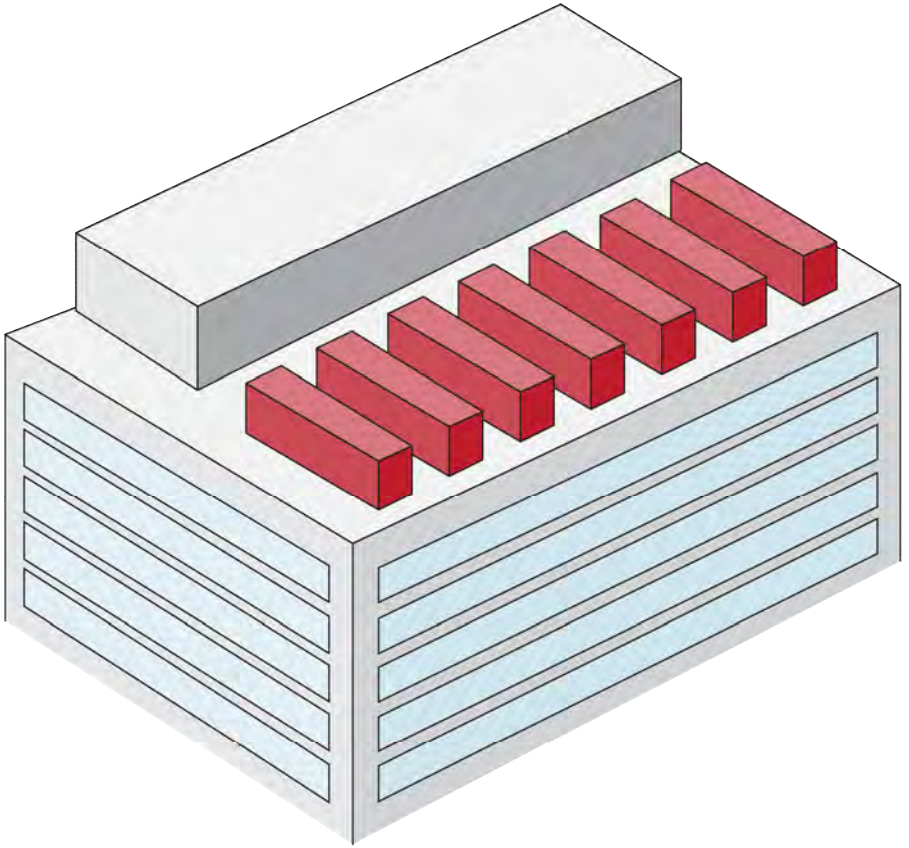
ELECTRIFYING IS A 3 STEP PROCESS



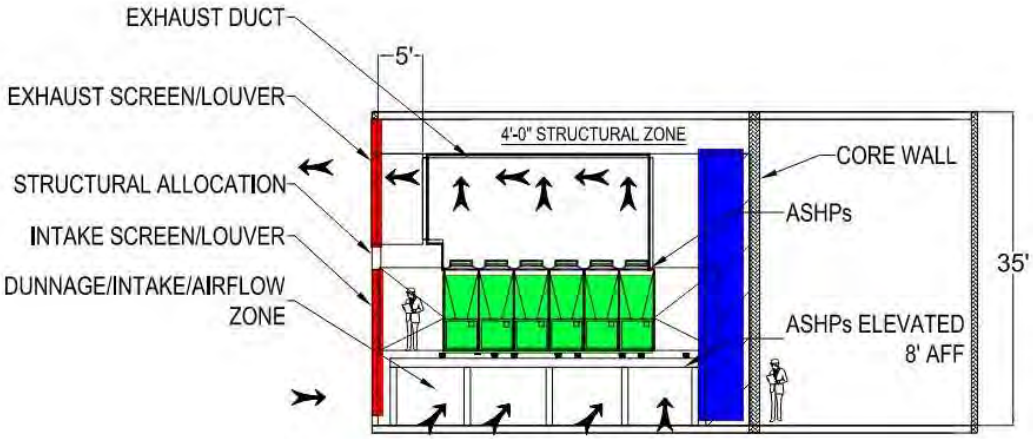
AIR-SOURCE HEAT PUMPS ARE HARD TO INTEGRATE

- Space-intensive
- Need to “breathe”
- High cost
- Increase in electrical demand (Winter peak)

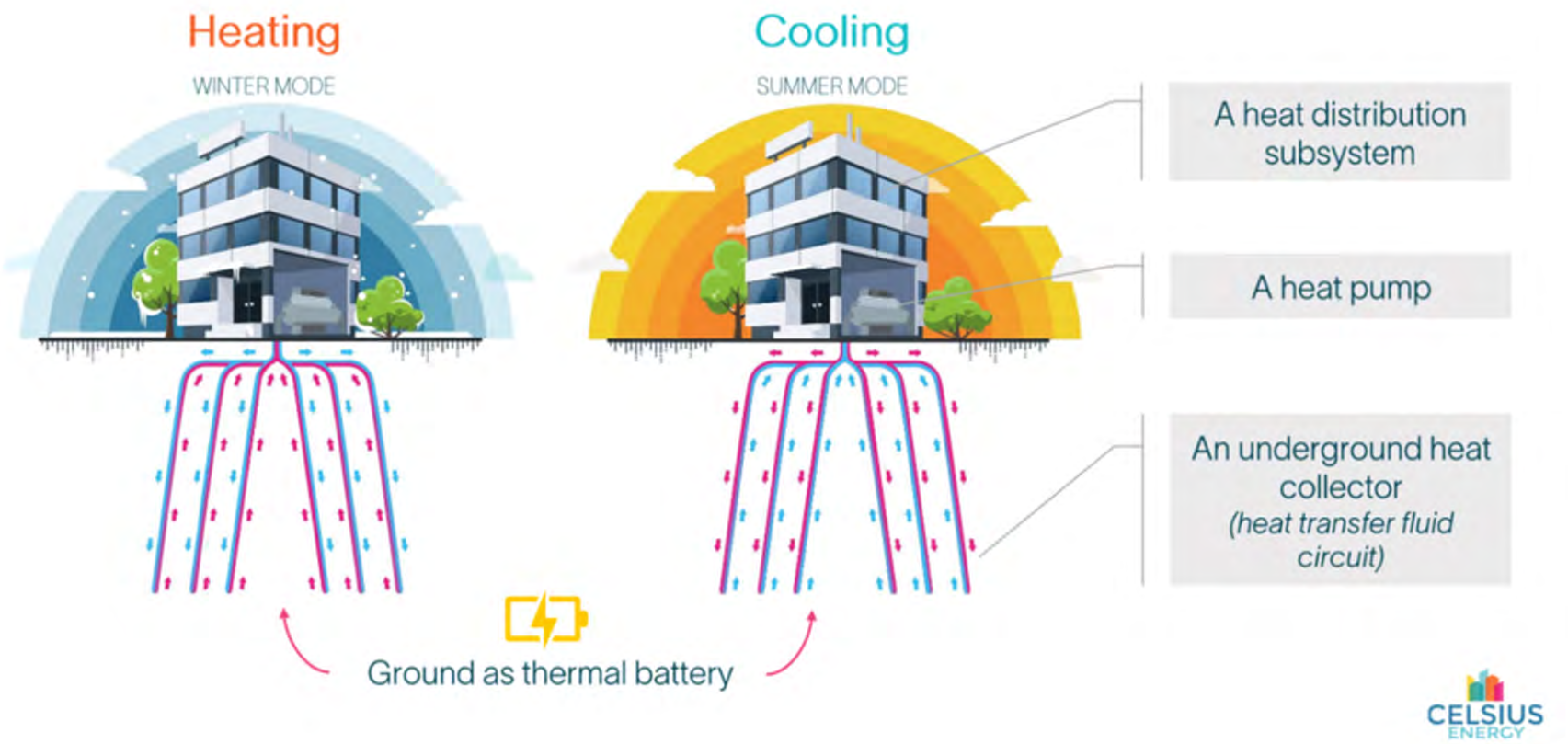




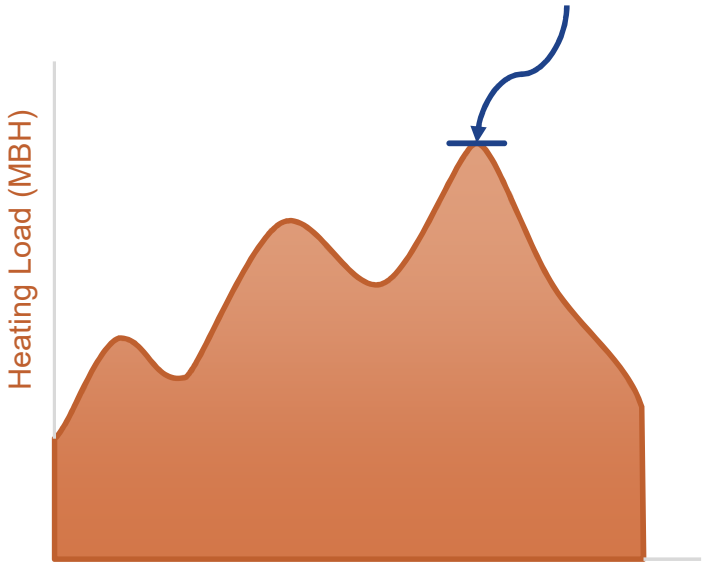
INDOORS: TAKES FULL FLOOR – 35’ FLOOR HEIGHT



GROUND-SOURCE HEAT PUMPS HAVE LIMITED CAPACITY



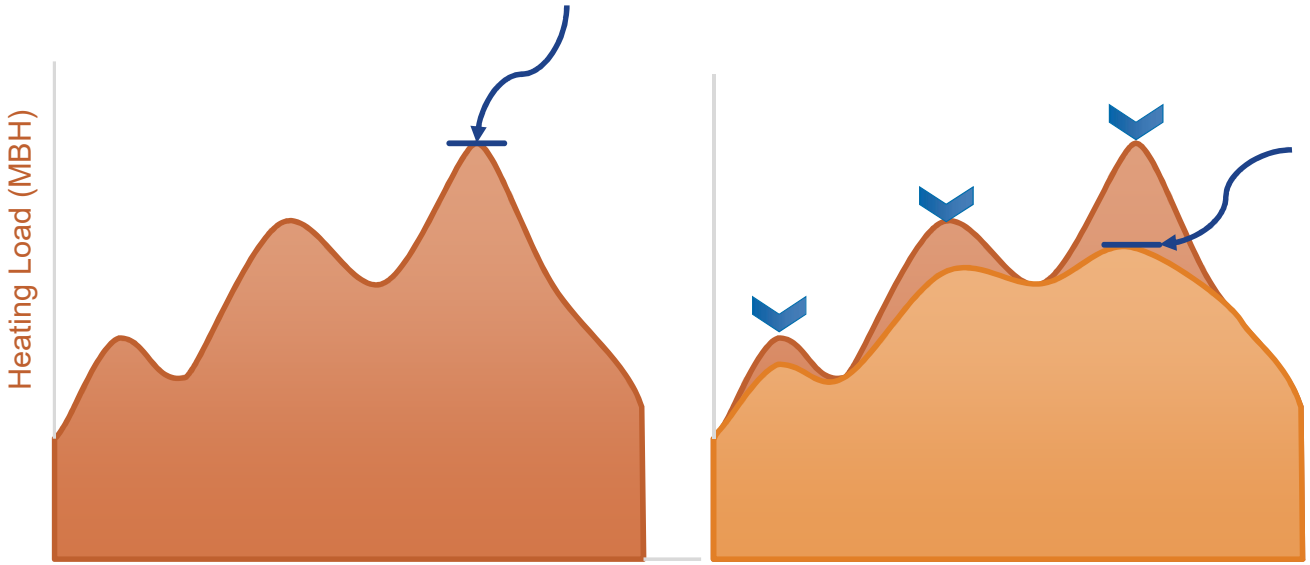
CAPACITY OPTIMIZATION



Peak Demand

Dictates equipment sizing

CAPACITY OPTIMIZATION



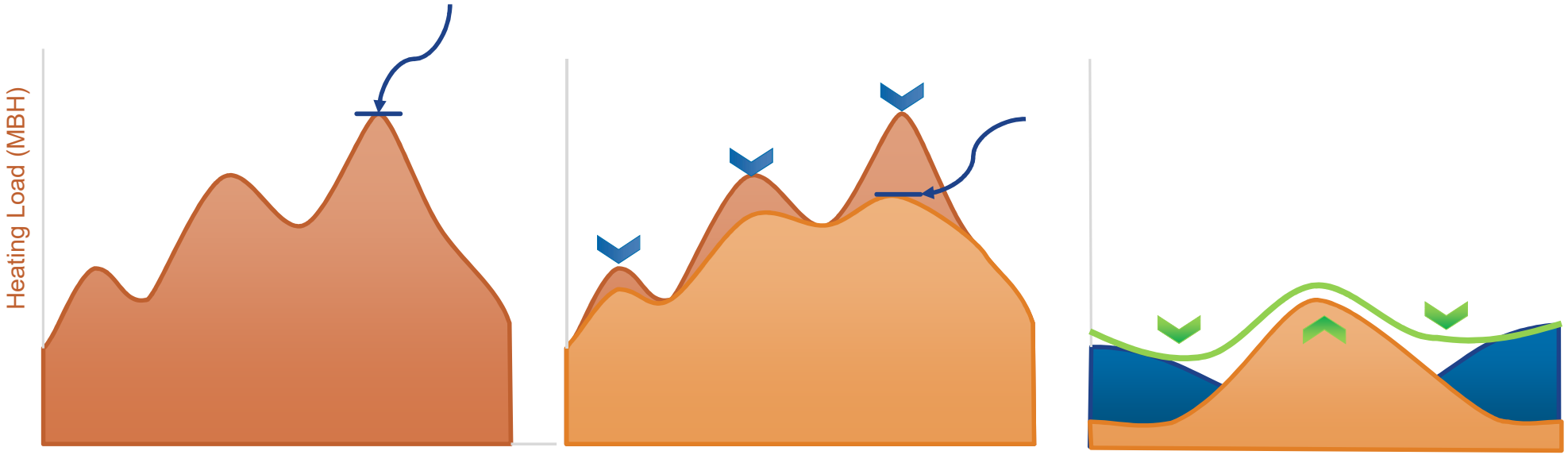
Peak Demand

Dictates equipment sizing

Reduce Peaks

Right-size equipment

CAPACITY OPTIMIZATION



Peak Demand

Dictates equipment sizing

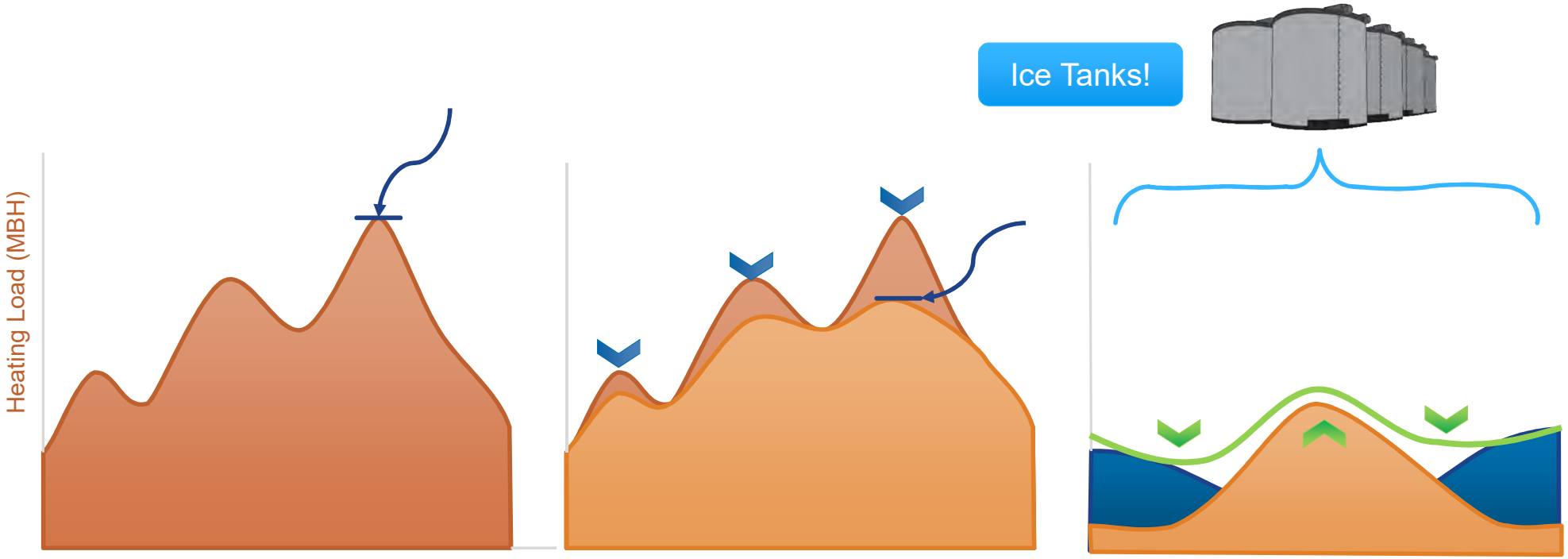
Reduce Peaks

Right-size equipment

Shifting Load

Maximize utilization

CAPACITY OPTIMIZATION



Peak Demand

Dictates equipment sizing

Reduce Peaks

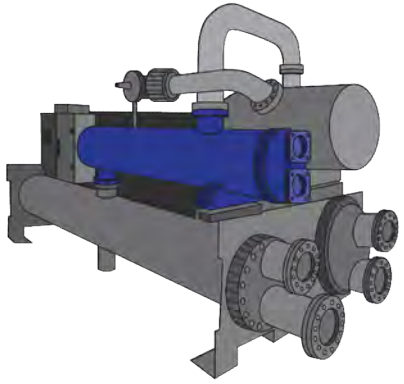
Right-size equipment

Shifting Load

Maximize utilization

ICE TANKS: TYPICAL ARRANGEMENT

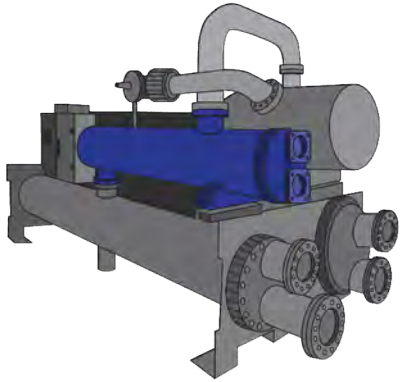
Chiller

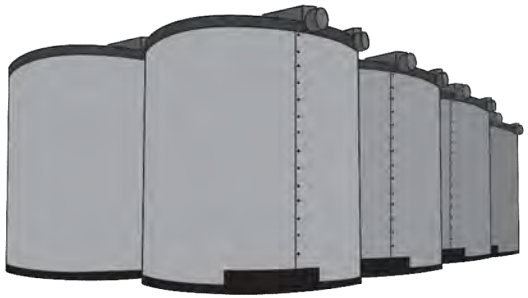


ICE TANKS: TYPICAL ARRANGEMENT

Chiller

Energy Storage Tank

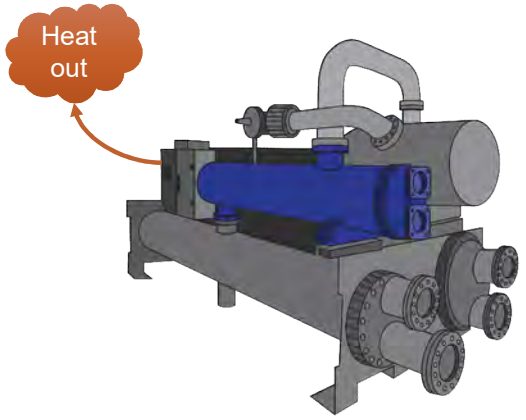


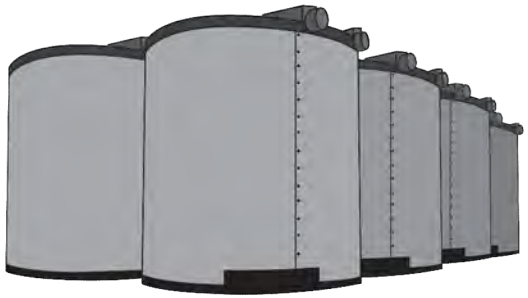


ICE TANKS: TYPICAL ARRANGEMENT

Chiller

Energy Storage Tank





A chiller extracts heat from ice tanks

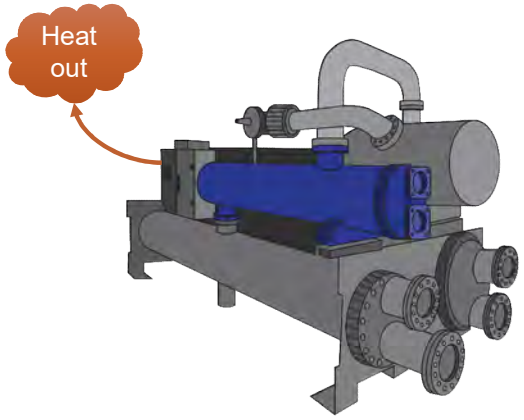
Ice is essentially liquid water with the heat removed from it

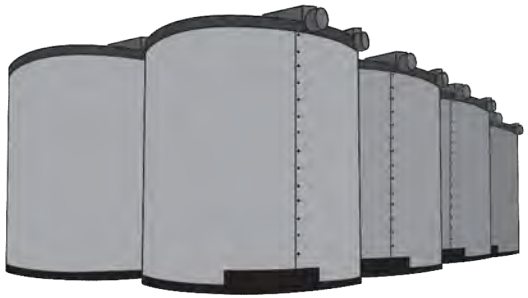
ICE TANKS: TYPICAL ARRANGEMENT

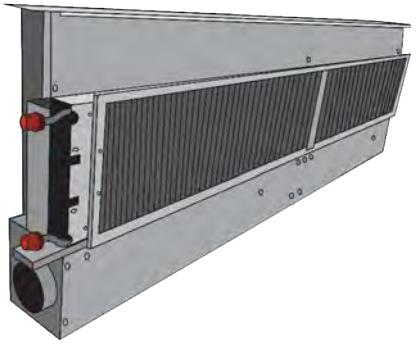
Chiller

Energy Storage Tank

Cooling Load







A chiller extracts heat from ice tanks

Ice is essentially liquid water with the heat removed from it

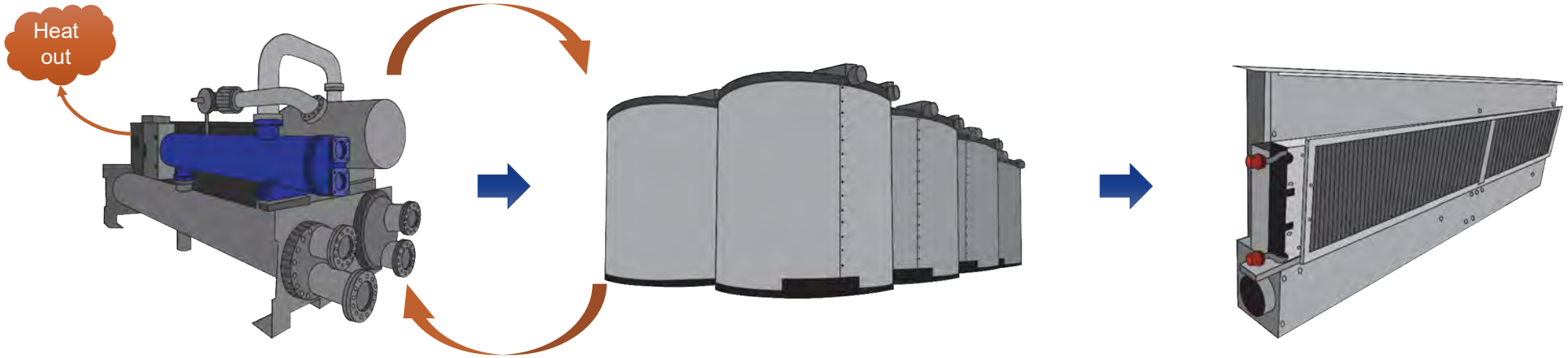
The ice tanks becomes a **source of cold** for the building

ICE TANKS: TYPICAL ARRANGEMENT

Chiller

Energy Storage Tank

Cooling Load



A chiller extracts heat from ice tanks

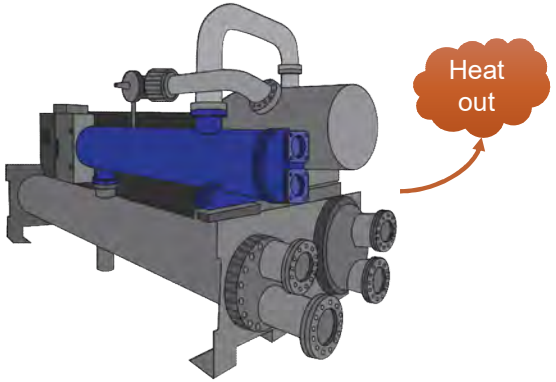
Ice is essentially liquid water with the heat removed from it

The ice tanks becomes a **source of cold** for the building

ICE HEATING ARRANGEMENT

Energy Storage Tank

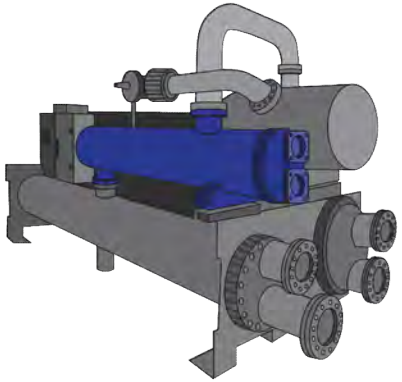
Chiller / Heat Pump



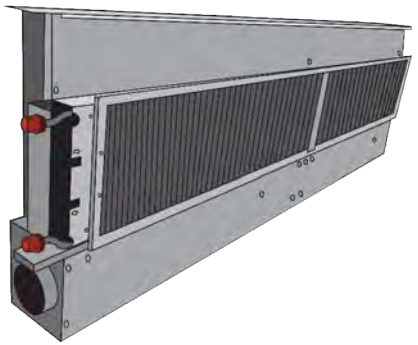
ICE HEATING ARRANGEMENT

Energy Storage Tank

Chiller / Heat Pump



Heating Load

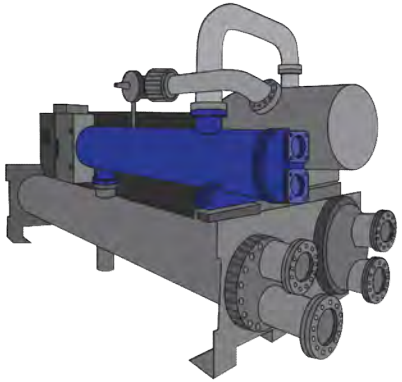


ICE HEATING ARRANGEMENT

Energy Storage Tank

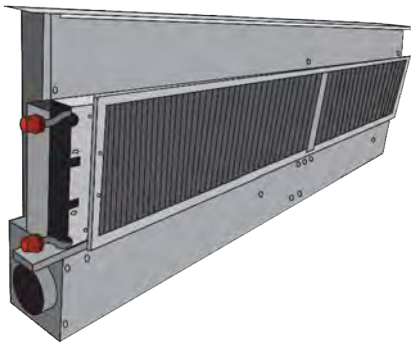
Ice is essentially liquid water with the heat removed from it

Chiller / Heat Pump



A chiller extracts heat from ice tanks

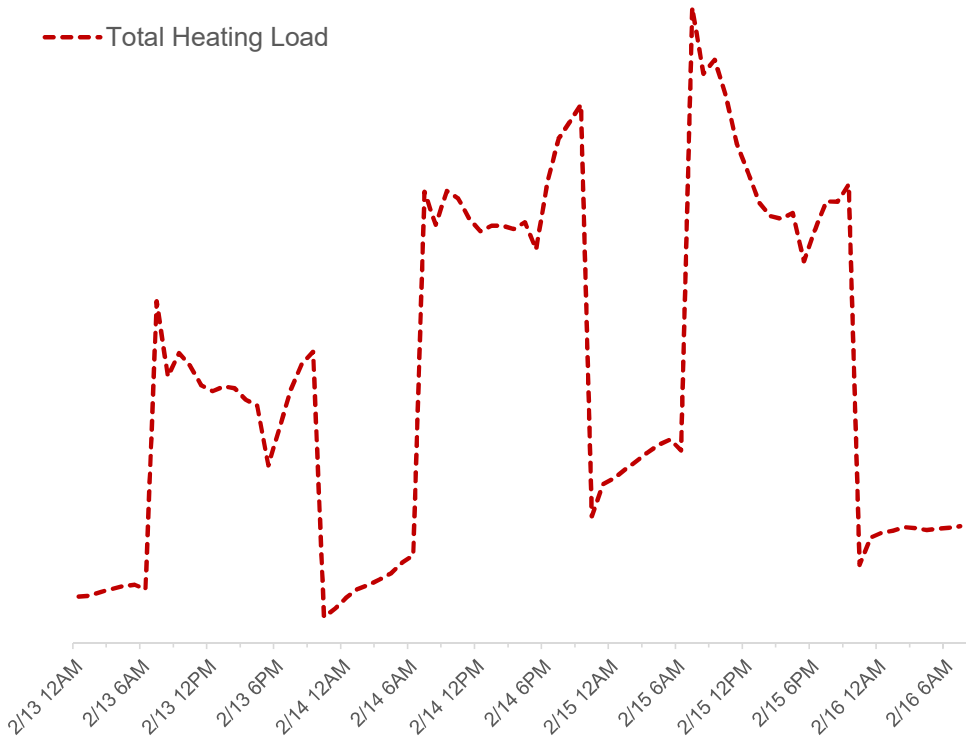
Heating Load



The ice tanks become a **source of heat** for the building

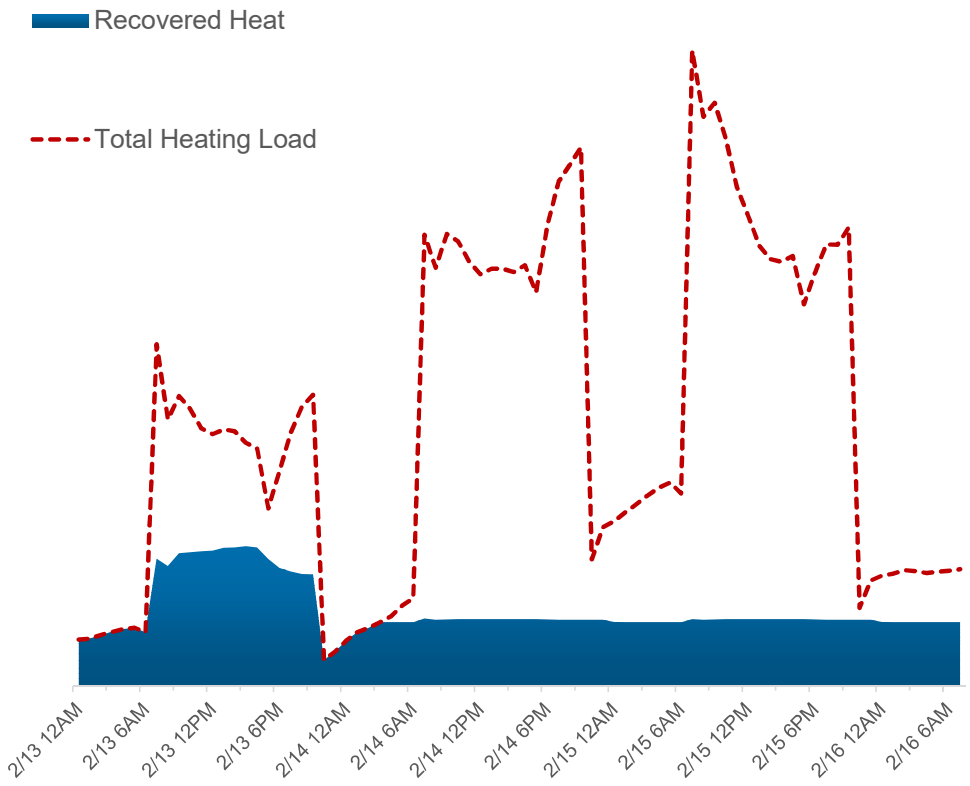
STARTING CONDITION: HEATING LOAD

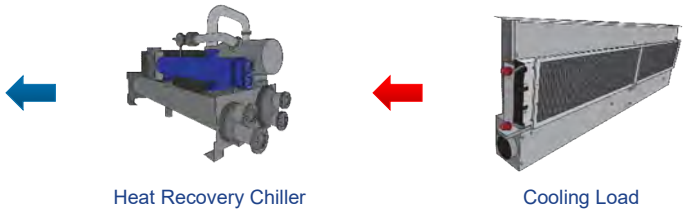
THERMAL LAYERING



LAYER 1: RECOVERED HEAT FROM COOLING LOAD

THERMAL LAYERING



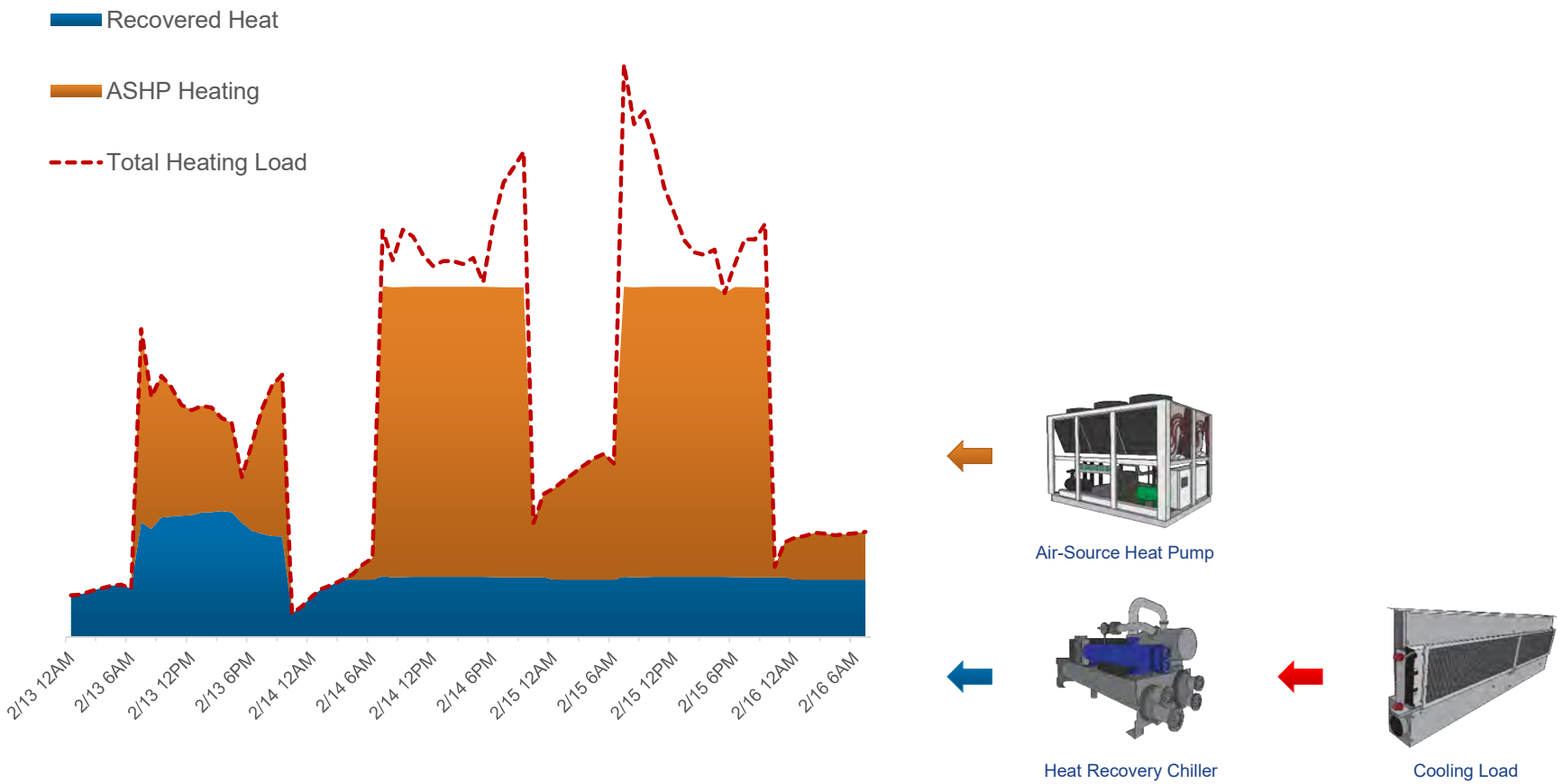


Heat Recovery Chiller

Cooling Load

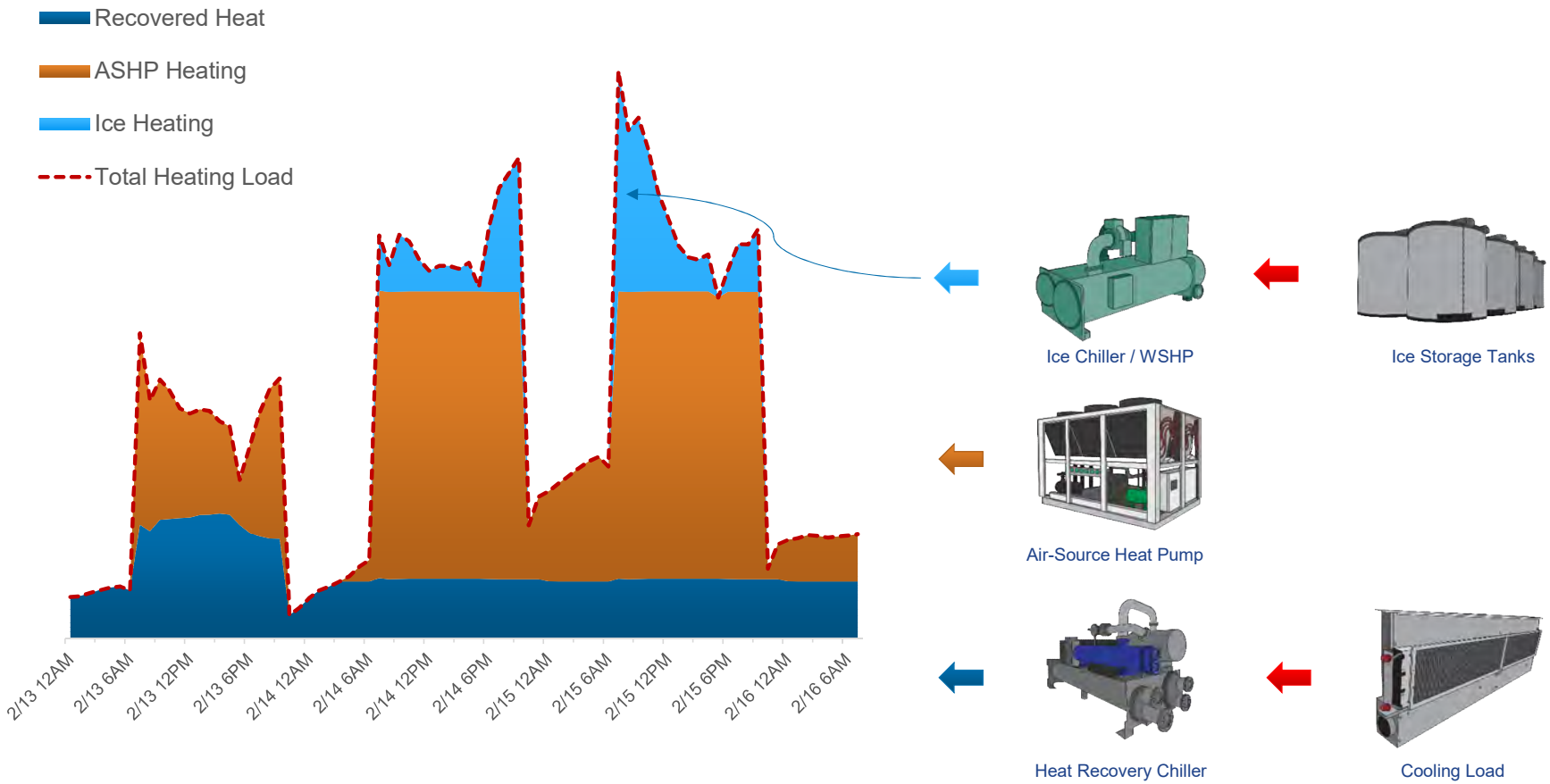
LAYER 2: AIR-SOURCE HEAT PUMPS

THERMAL LAYERING



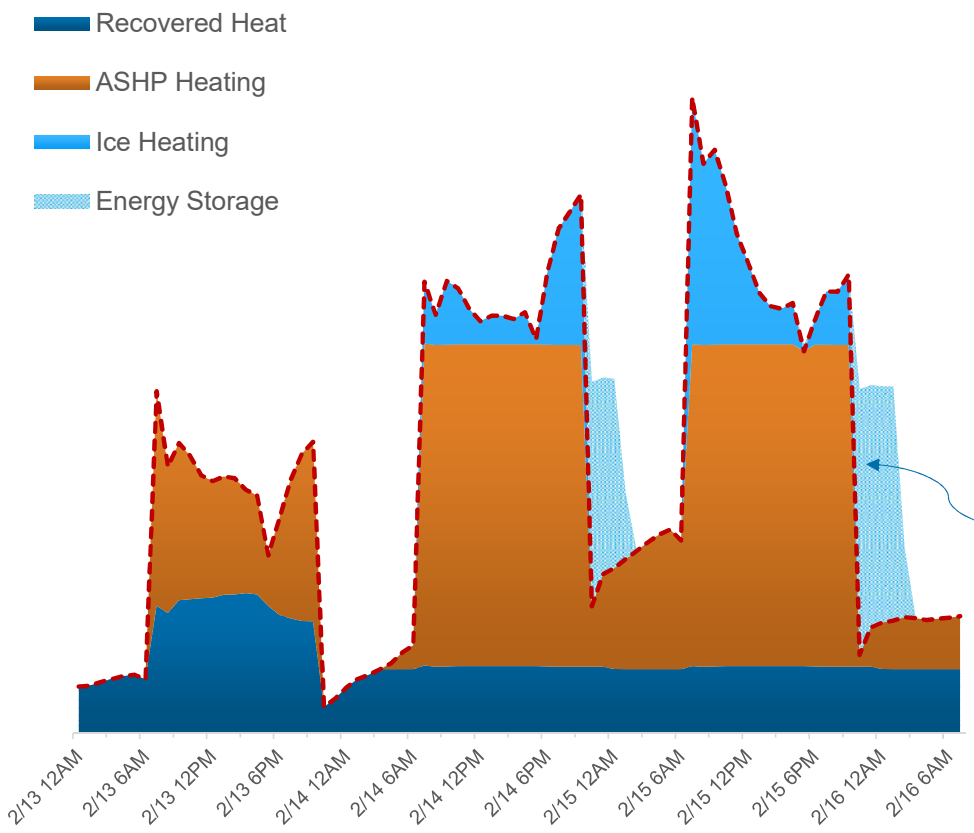
LAYER 3: ICE HEATING

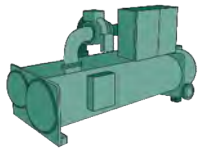
THERMAL LAYERING



LAYER 4: ICE MELTING

THERMAL LAYERING





Ice Chiller / WSHP

Ice Storage Tanks

Air-Source Heat Pump

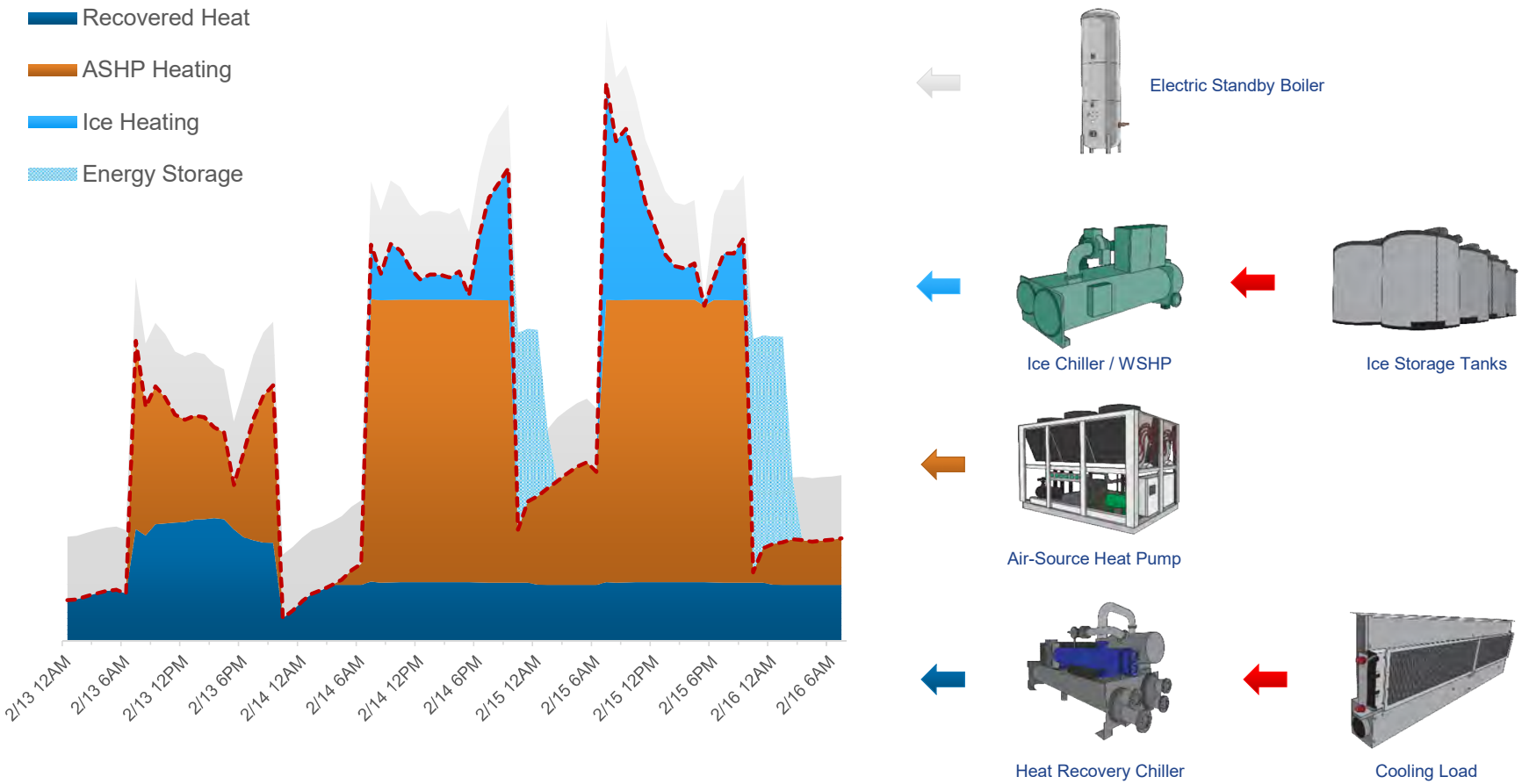
ASHP produces heat and **"melts ice"**

Heat Recovery Chiller

Cooling Load

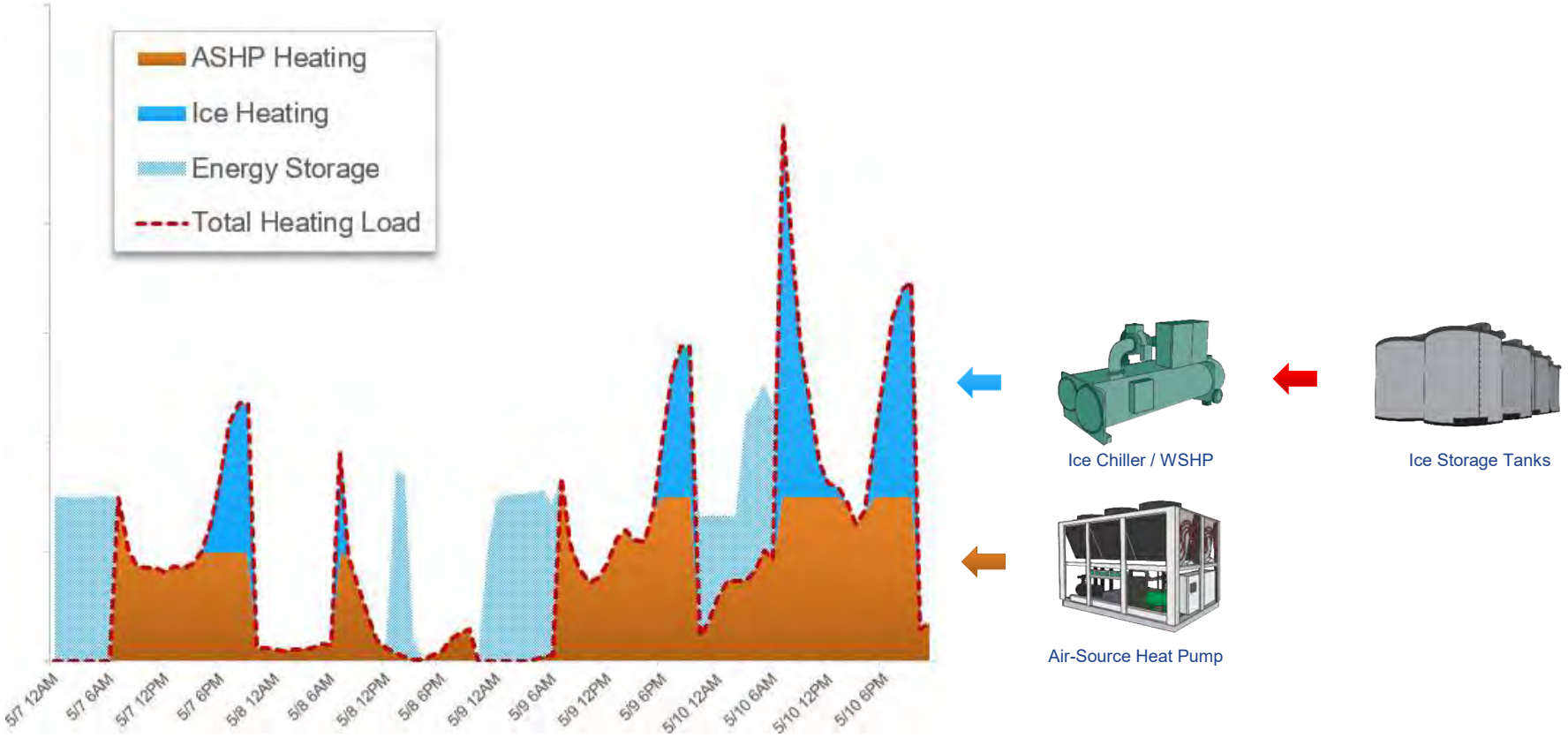
STANDBY LAYER: ELECTRIC BOILER

THERMAL LAYERING



SHOULDER SEASONS BENEFITS

“FREE COOLING”, ENERGY & CARBON SAVINGS



55 WATER STREET

COMMERCIAL OFFICE, NEW YORK (NY)

- Reconfigured **existing summertime ice tanks** for ice heating
- Added new **right sized ton ice chiller** for wintertime load
- **New WSHPs** to boost temperature required for heating load
- Using **existing steam as supplement** peak heating

INCENTIVES

- IRA Incentives can be used for up to **40% of the design & equipment costs**
  - Investment Tax Credit (48, 48 E & 48(h)) – up to 40% of design & equipment costs
  - Production Tax Credit (45 & 45Y) – up to $0.027/kWh

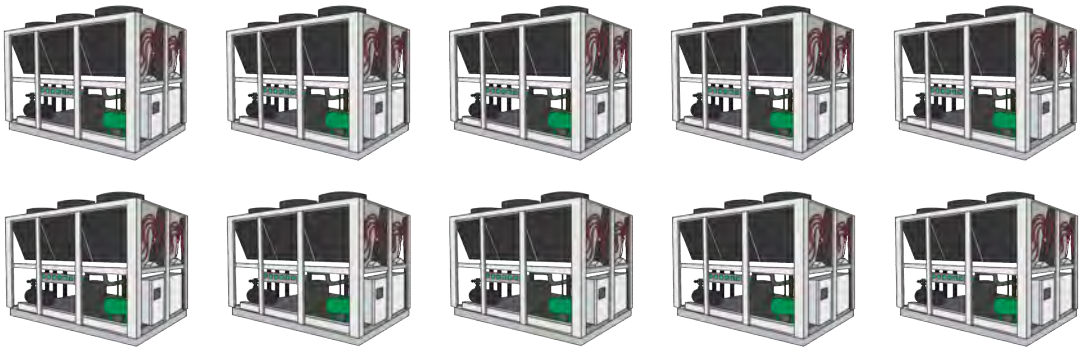
WHY WOULD WE DO THIS?

1. **Equipment Sizing Reduction**
2. Electric Peak Demand Reduction
3. Grid Interactive Benefits

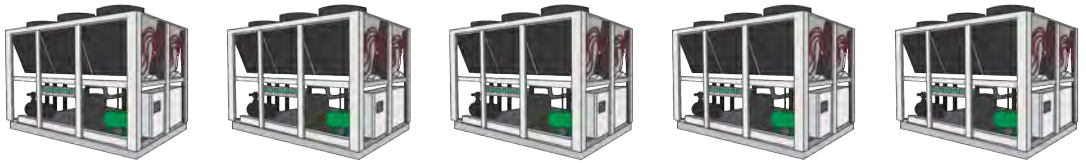
KEY BENEFIT: SPACE AND COST SAVINGS

Space and capital cost savings: 40%-50% reduction in ASHP capacity

Typical Design

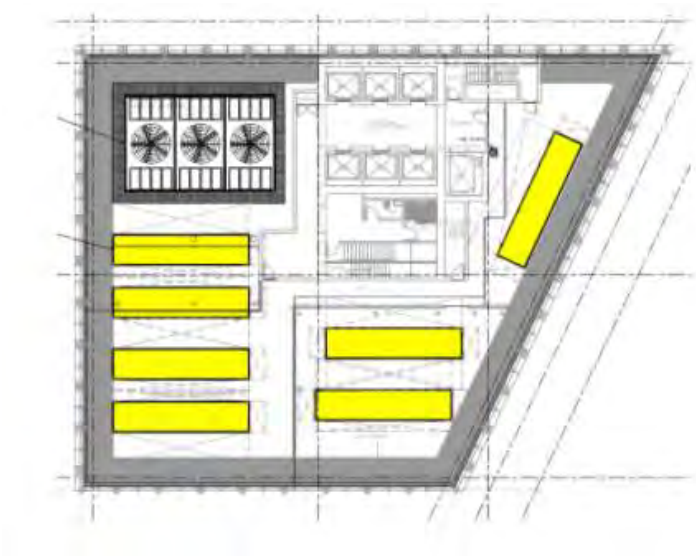


With Ice Heating

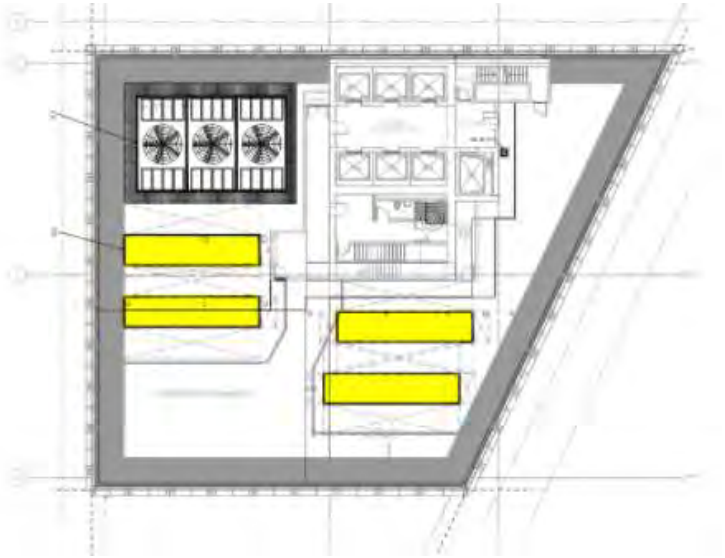


CASE STUDY: 500K SF OFFICE BUILDING (NYC)

- Example project: 40% reduction



Basis of Design
7 ASHPs



Ice Heating
4 ASHPs

WHY WOULD WE DO THIS?

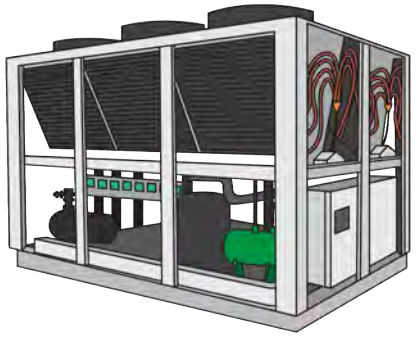
1. Equipment Sizing Reduction
2. **Electric Peak Demand Reduction**
3. Grid Interactive Benefits

GRID INTERACTIVE BUILDINGS: THE NEXT GENERATION OF ELECTRIFICATION

1st Generation

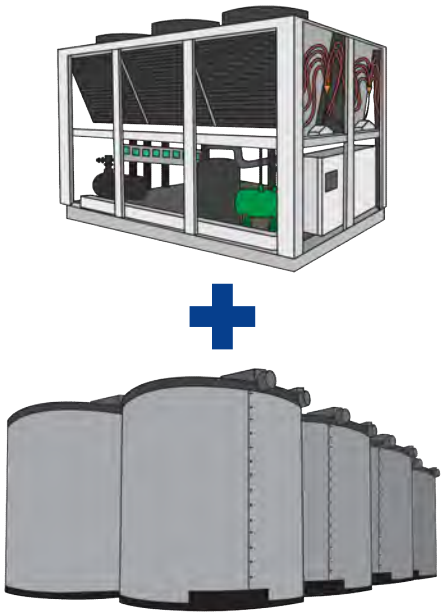
Electric Resistance

2nd Generation



Heat Pumps

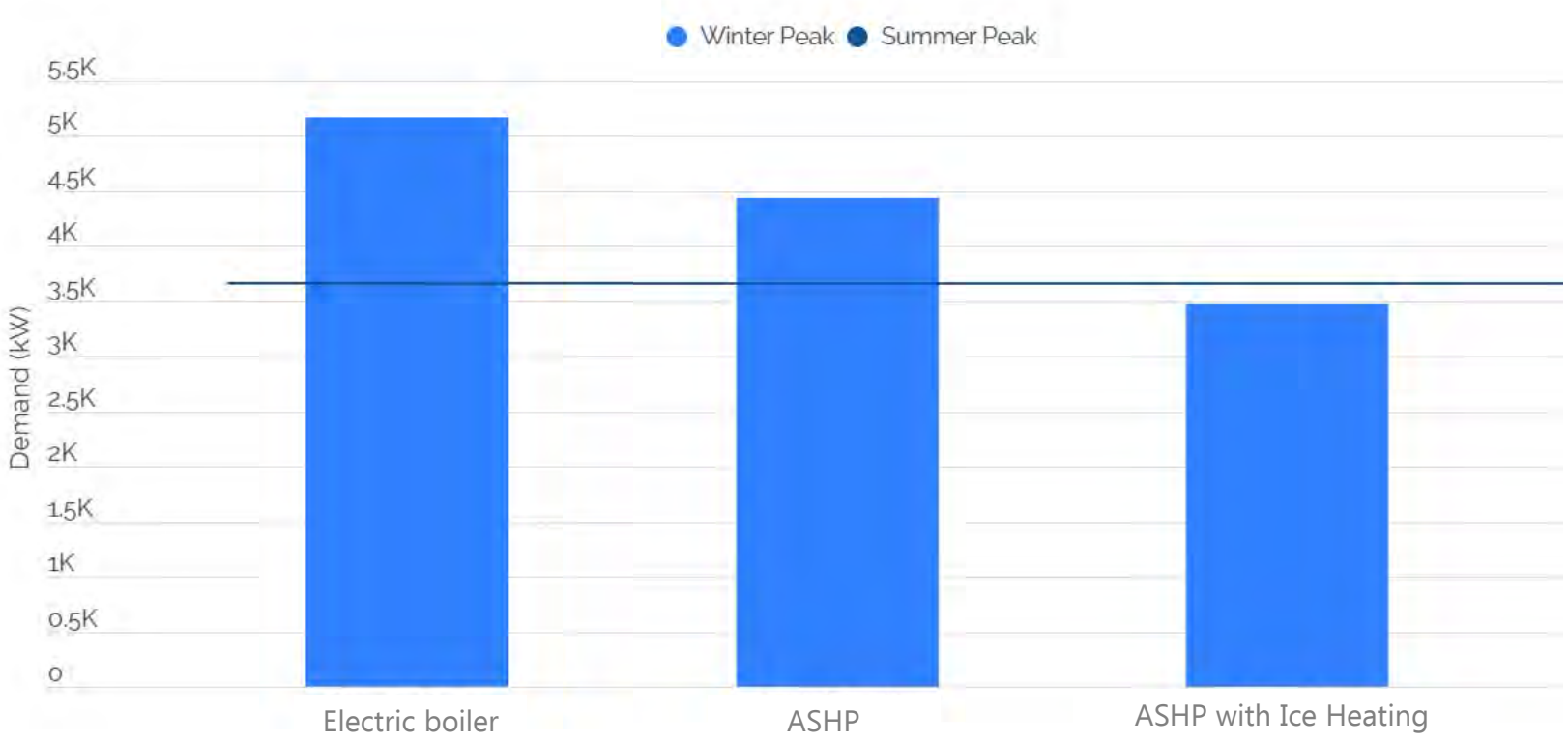
Next Generation



Heat Pumps + Energy Storage

KEY BENEFIT: PEAK LOAD REDUCTION

- ASHP with Ice Heating **does not require upsizing electrical capacity** for wintertime peak



WHY WOULD WE DO THIS?

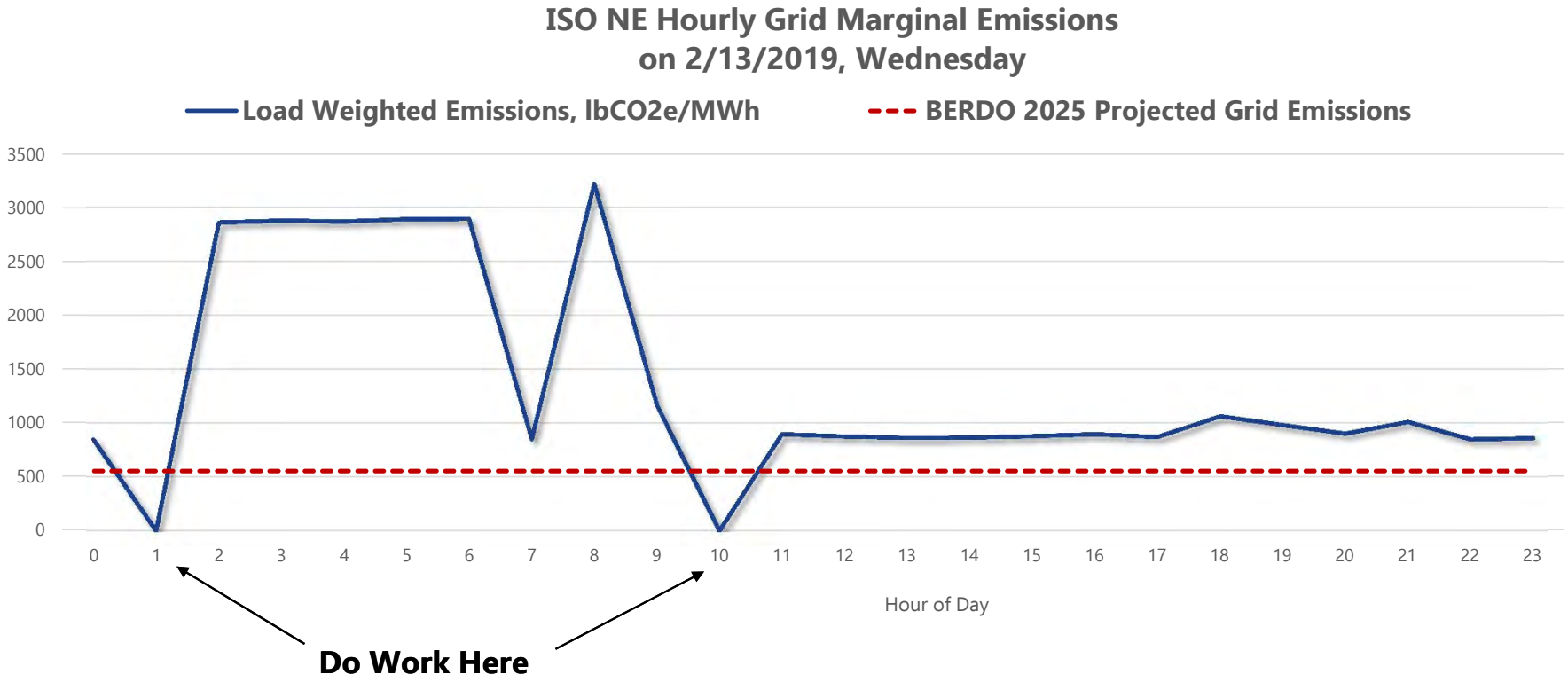
1. Equipment Sizing Reduction
2. Electric Peak Demand Reduction
3. **Grid Interactive Benefits**

KEY BENEFIT: CARBON EMISSIONS REDUCTION

THE VALUE OF TIME OF USE (TOU)

Time-of-use carbon coefficients unlock the value of energy storage.

Carbon Trading allows monetization of carbon savings.



QUESTIONS?

Travis Anderson
E: Travis.Anderson@boston.gov

Laura Corso
E: Travis.Anderson@boston.gov

Joelle Jahn
E: jahnj@jbb.com

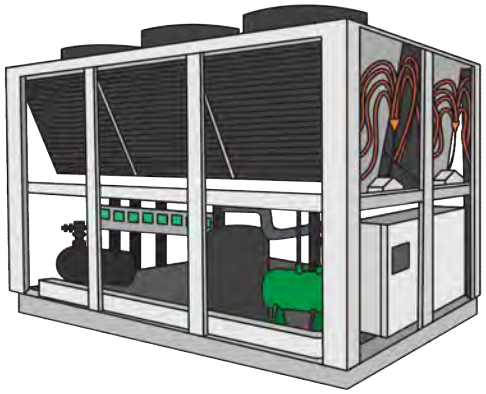
boston planning & development agency

WattTime

JB&B DEEP CARBON REDUCTION

ELECTRIC HEAT SOURCES

Electric Resistance Boilers



Air-Source Heat Pumps (ASHP)

Ground-Source Heat Pumps (GSHP)