HVAC Thermal Storage for Enhanced Heating & Cooling

Mike Filler | July 14, 2026

Agenda

- Traditional, Cool Thermal Energy Storage – Shifting Load
- Clean Electricity Investment Tax Credit Overview
- Electrifying Heat in Commercial Buildings - Challenges/Solutions
- Q & A

“Grid-interactive Efficient Buildings”

EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure

CONNECTED

Two-way communication with flexible technologies, the grid, and occupants

SMART

Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

FLEXIBLE

Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use

Source: Department of Energy

Storage is Key to Sustainability and Grid Resiliency

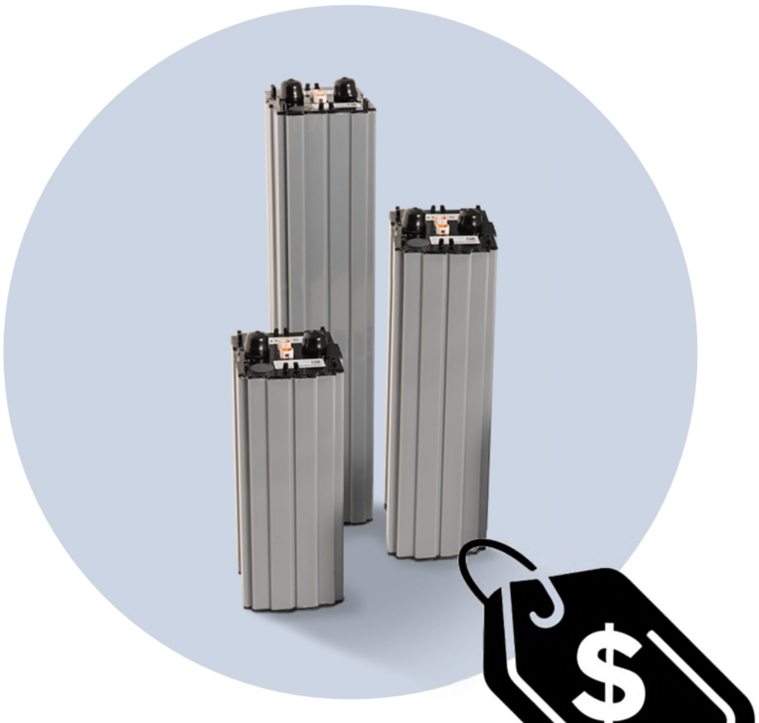
What's missing?

Storage for dispatch ability

TES can increase use of renewables by up to 50%*

* Source: ASHRAE RE-1607.2018

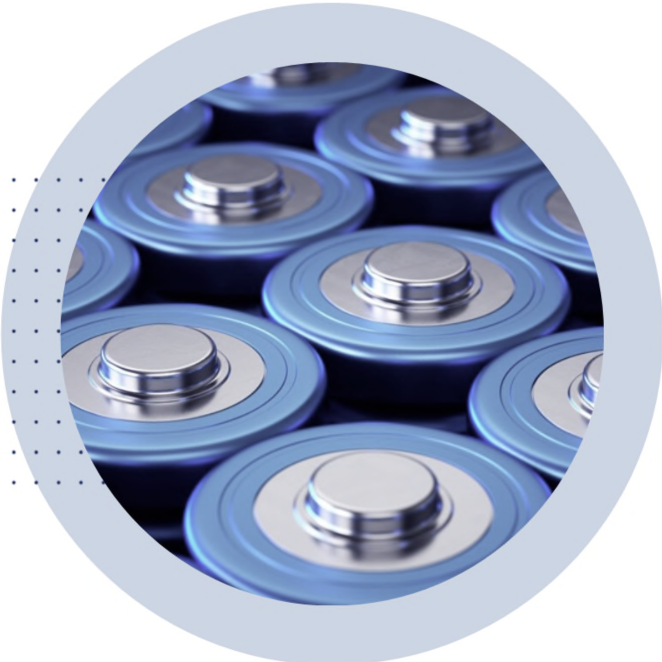
We Will Need Both Types of Batteries

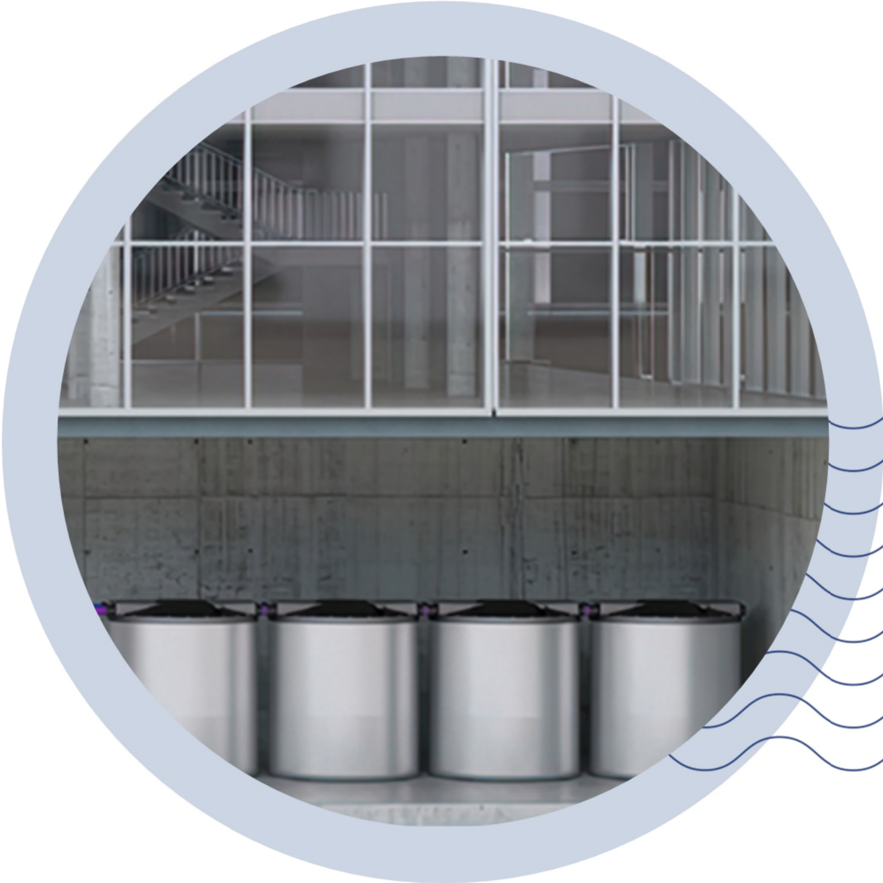


Electric Batteries

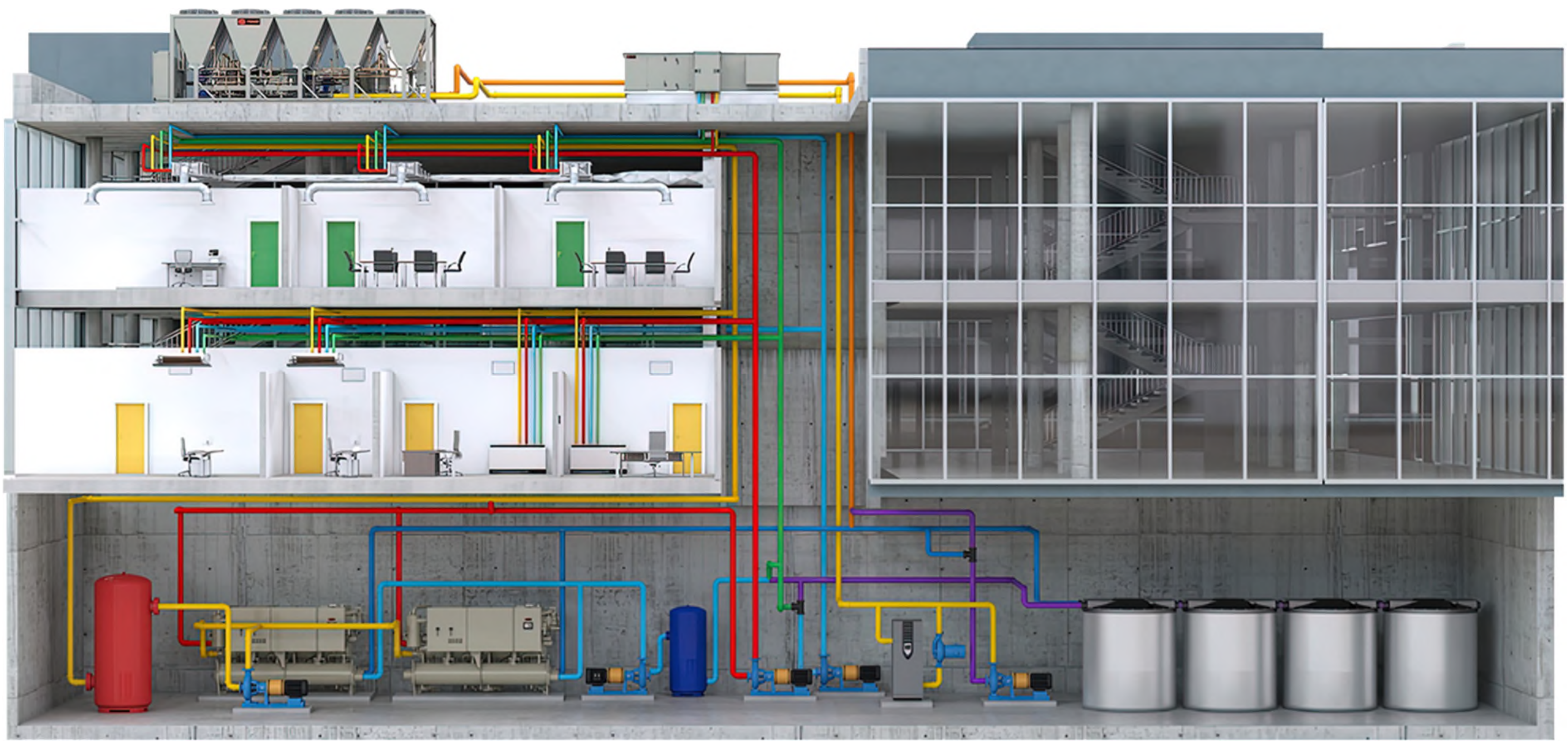
Thermal Batteries:
More Affordable

Imagine a bank of batteries



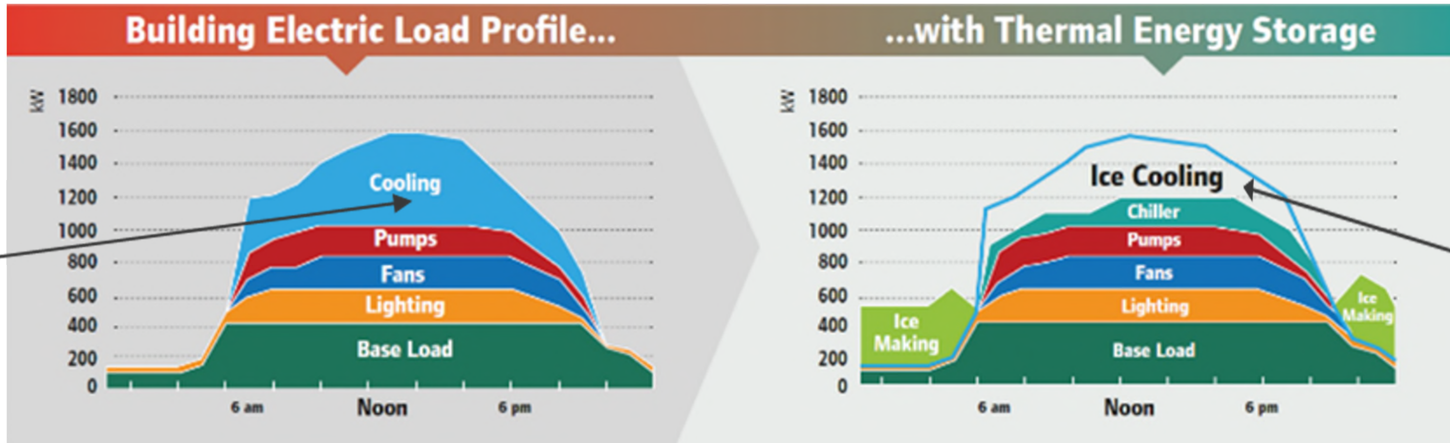


...with the ability to cool or heat your whole building



Shift Demand by Cooling with Thermal Storage

Air-conditioning can account for over 40% of the summer peak-day load



Reduced need for peaking plants & other redundant grid infrastructure

Thermal storage meets grid challenges

- Addressing **critical** utility/grid peaks
- Avoid **expensive** and **high-emission** peaker plants
- Supporting **advanced grid services** and **demand response**

Chilled Water Storage vs. Ice Storage

40F supply/60F return…20 Btu/lb or 46 kJ/kG

144 Btu/lb or 334 kJ/kG

Ice Storage in Commercial Buildings

What is it?

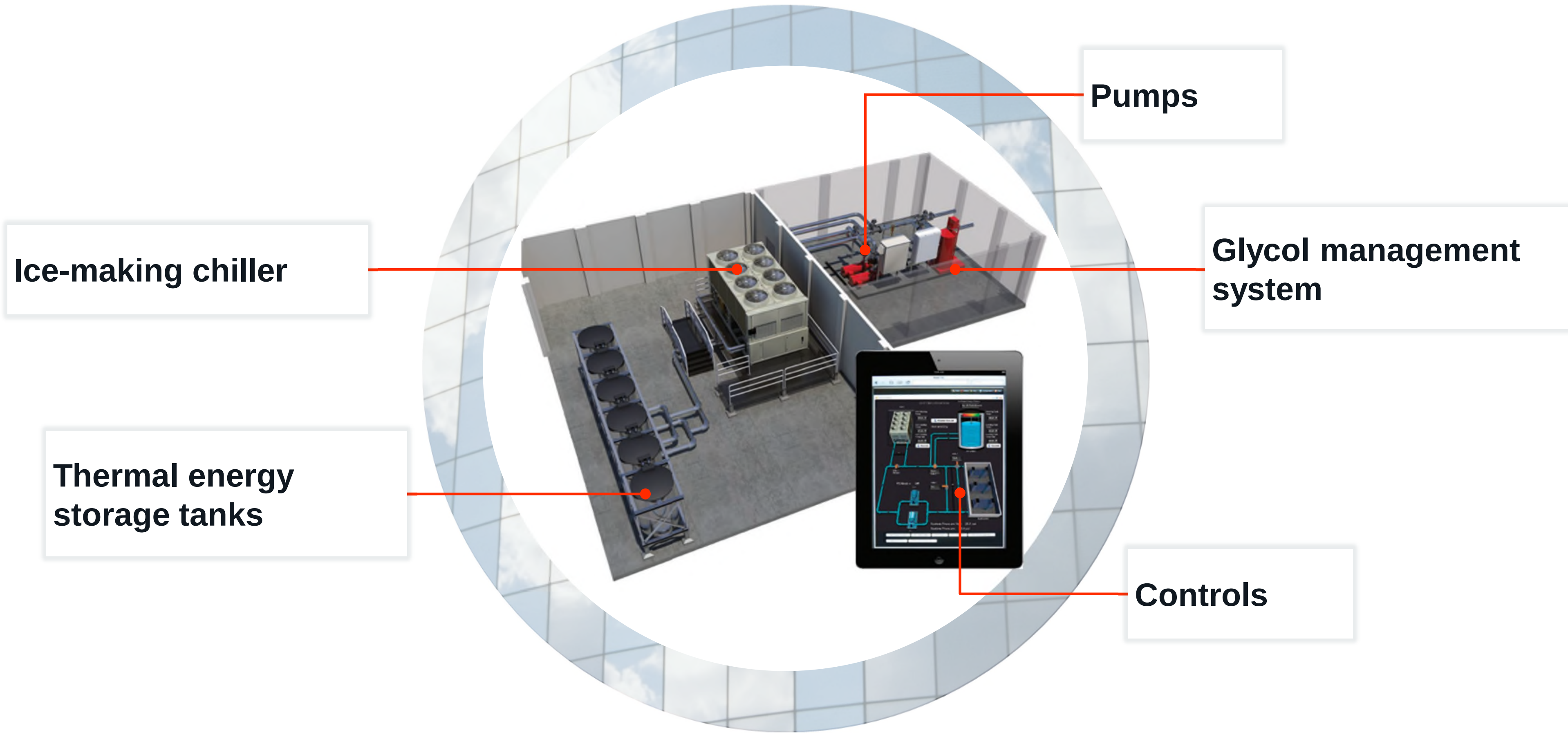
- A chiller plant enhanced with thermal energy storage.

What does it do?

- Chiller plant operates like a battery, charging energy storage tanks (filled with water) when excess or inexpensive energy is available.
- And discharging when demand or cost is high, or when the utility asks for the discharge to occur.

Key Features

Ice-Enhanced Chiller Plant



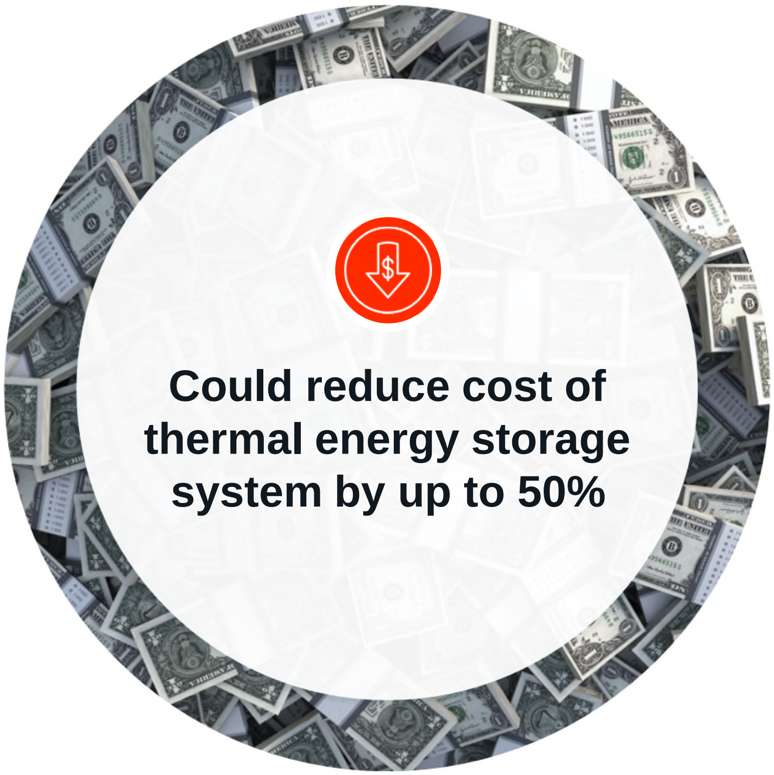
Modular Ice Storage Tanks

How does it work?

At the heart of the system is the ice storage tank

- Contains water; changes water to ice or ice to water depending on application
- Just one tank has the capacity to cool six homes

Financial Incentives



The Inflation Reduction Act of 2022 included the first federal incentive for thermal energy storage

- Federal tax credits
- Federal tax deductions
- Additionally, local utilities may offer their own rebates and incentives, enabling building owners to “double dip” into financial support that slashes the cost of their thermal energy projects

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Clean Electricity Investment Tax Credit (ITC)

Section 48E of the US Tax Code

- Long-standing **investment tax credit** for **private** and **non-taxable** entities
- Historically for qualified "energy property,"
  incl: solar, geothermal heat pumps, combined heat and power, and more

Key details about the ITC:

- **Tax credits** of **up to 50% of the cost** for energy property projects
- Expanded to addt'l technologies, incl. **thermal energy storage property** – defined as property comprising a system which:
  (I) is directly connected to a **heating, ventilation, or air conditioning system,**
  (II) removes heat from, or adds heat to, a **storage medium for subsequent use**, and
  (III) provides energy for the heating/cooling of the interior of a **residential/commercial building**
- New Rules added in 2025 from One Big Beautiful Bill Act
- Timeframe base credit rates apply**:**
  –**Thermal energy storage: Available through 2032 with phase down thereafter**

Section 48E Investment Tax Credit (ITC)	
Base Rate	**6%**
Increased Credit Amount*	**5X multiplier**
Meets Domestic Content Requirements**	**2% or 10%**
Meets Energy Communities Requirements***	**2% or 10%**
Total Potential Credit Value	**Up to 50% with Bonuses**

*Increase Credit Amount: must be less than 284 tons **(OR)** meet prevailing wage and apprenticeship requirements. **Domestic Content: i.e., materials/components made in the USA

***Energy Communities: See most recent map at https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d

2025 Final Guidance from IRS

TreasReg 1.48E-2(g)6(ii) Thermal energy storage property—

…However, consistent with §1.48-14(d), if thermal energy storage property, such as a heat pump system, includes equipment, such as a heat pump, **that also serves a purpose in an HVAC system** that is installed in connection with the thermal energy storage property, the taxpayer's qualified investment with respect to the thermal energy storage property includes the total cost of the thermal energy storage property and HVAC system less the cost of an HVAC system without thermal storage capacity that would meet the same functional heating or cooling needs as the heat pump system with a storage medium, other than time shifting of heating or cooling. See §1.48-14(h) for application of the **Incremental Cost Rule**.

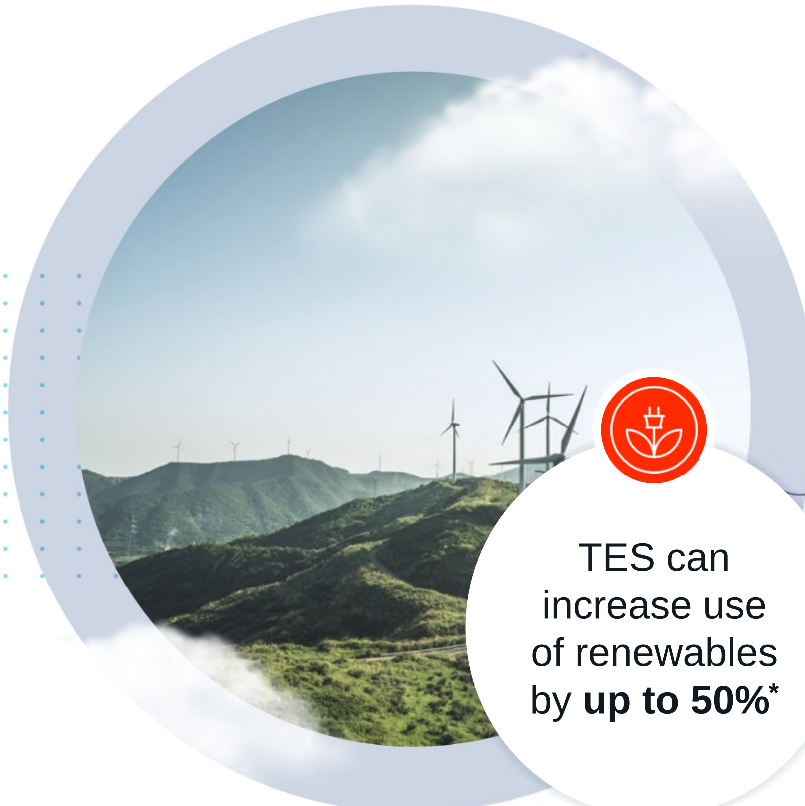
A thermal energy storage property will be deemed to have the purpose of substantially altering the time profile of when heat added to or removed from the thermal storage medium can be used to heat or cool the interior of a residential or commercial building if that thermal energy storage property is capable of storing energy that is sufficient to provide heating or cooling of the interior of a residential or commercial building for a **minimum of one hour**.

Local Utility Incentive Examples

- Austin Energy: $350.00 *per peak kW reduced*
- AEP Texas: $350.00 *per peak kW reduced*
- Duke Energy Florida: $300.00 *per peak kW reduced*
- Arizona Public Service Company: *$30 per Ton-Hour*
- *More incentives can be found at* [UtilityGenius]

More Flexibility, Less Money

- Provides demand flexibility and can reduce reliance on grid during peak hours (thus reducing costs)
- Enables renewable energy and decarbonization
- Offers reliable redundancy and assurance
- Incentivized by utility programs, federal tax incentives and local funding programs



TES can increase use of renewables by **up to 50%***

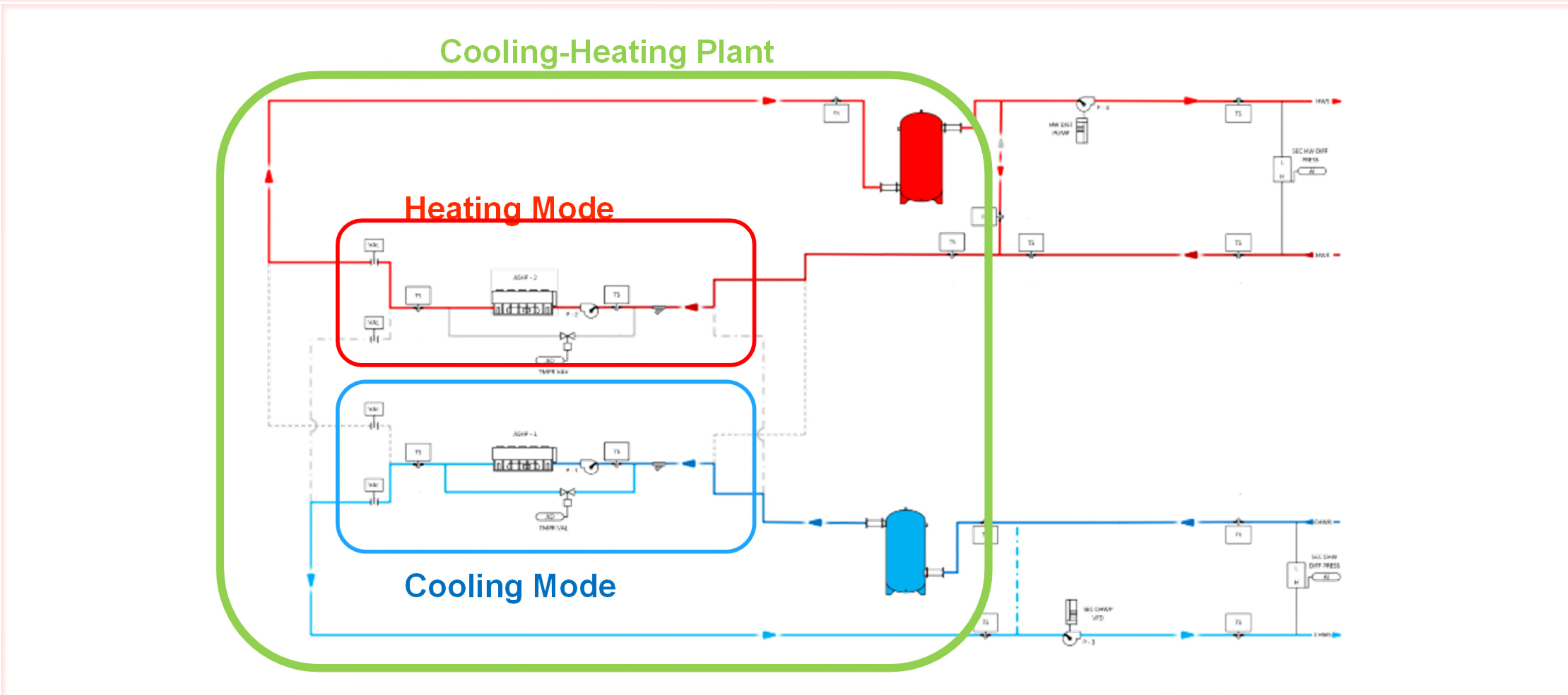
* Source: ASHRAE RE-1607.2018

Heat Pump Terminology

Air-Water Heat Pump (AWHP)

Chiller-Heater or
Heat Pump Chiller
(non-reversing)

Four Pipe, Simultaneous Heating and Cooling



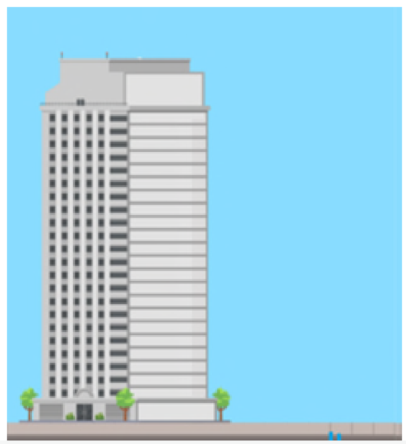
Hydronic Heating for HVAC: Closed Water System
Source Requirements for Hot Water Supply and Return
<u>Heat Pumps</u>

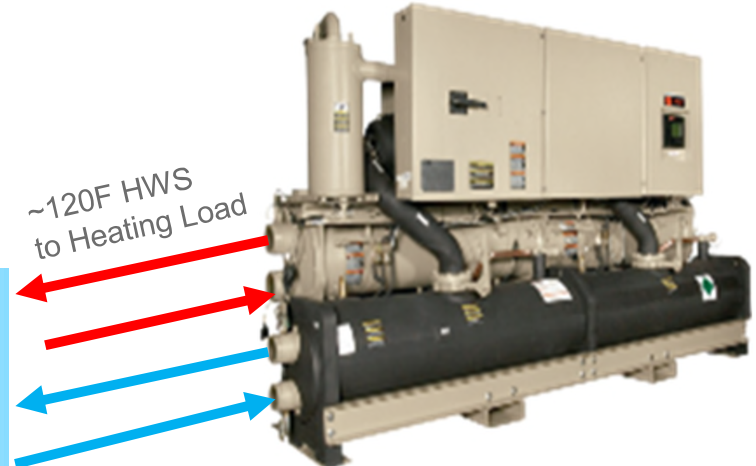
What is the source of heat
making the hot water?

Source Heat

Water Source: Extract Heat from Water Loop

- A Building (Chilled Water Loop)
- The Earth (Ground Loop)
- Thermal Storage(Ice Tanks)





Hydronic Heating for HVAC: Closed Water System
Source Requirements for Hot Water Supply and Return

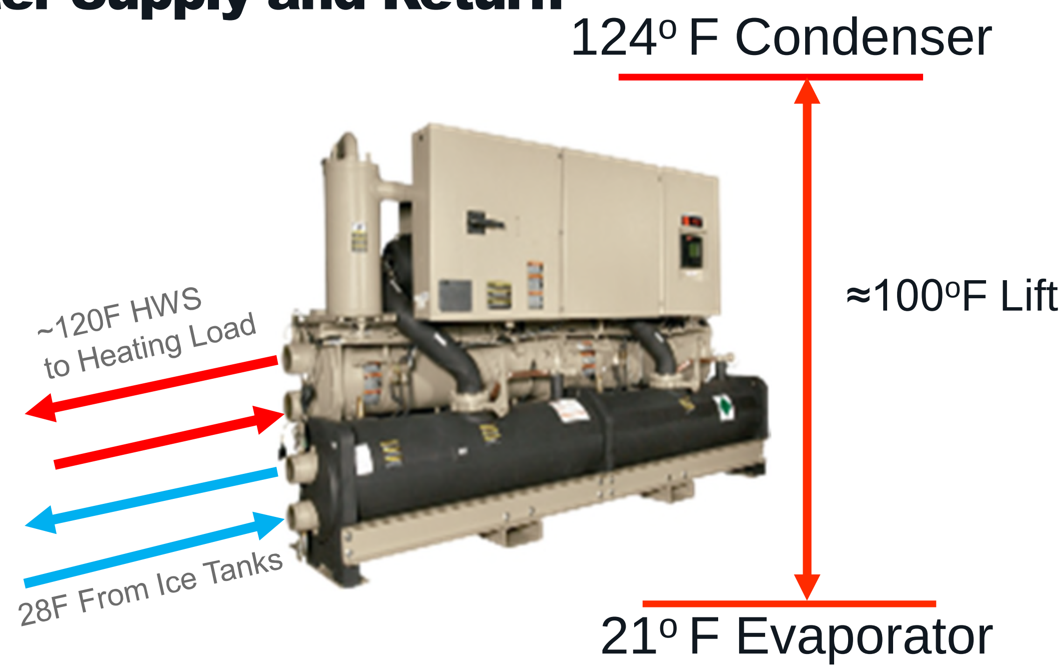
Water Source Heat Pumps

Heat source is water loop

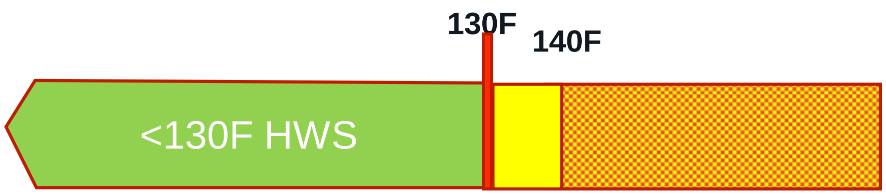
Example: Extract Heat From Thermal Storage Tank

This example, makes ~124ºF Hot Water

COP=3.2… 320% efficient



Range of Hot Water Supply Temperature for Water Source Heat Pump

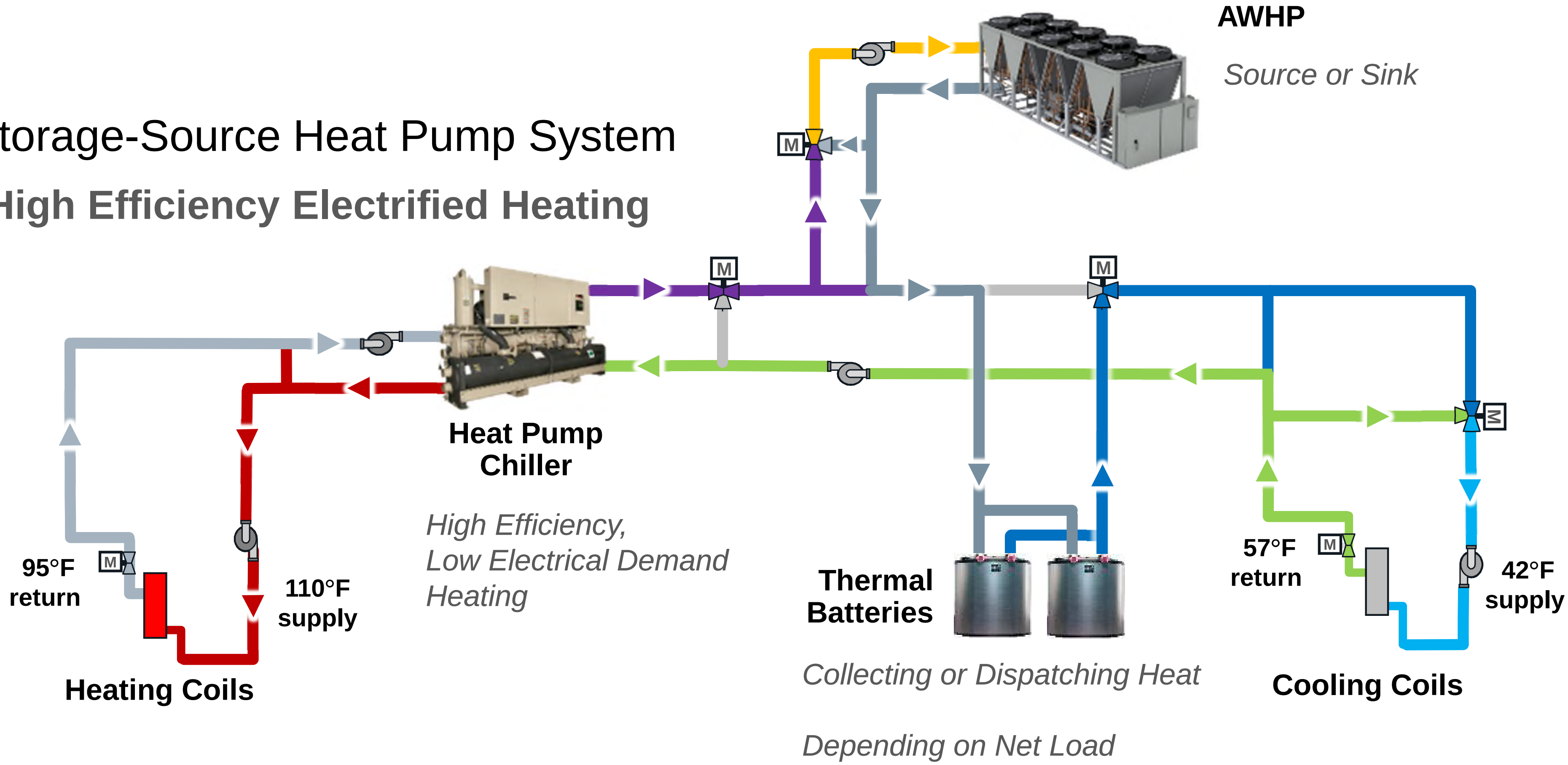


Solving Electrification of Heat Challenges with Thermal Batteries

Heating with Recovered Cooling Plus Supplemental Charging Sources

Storage-Source Heat Pump System

High Efficiency Electrified Heating



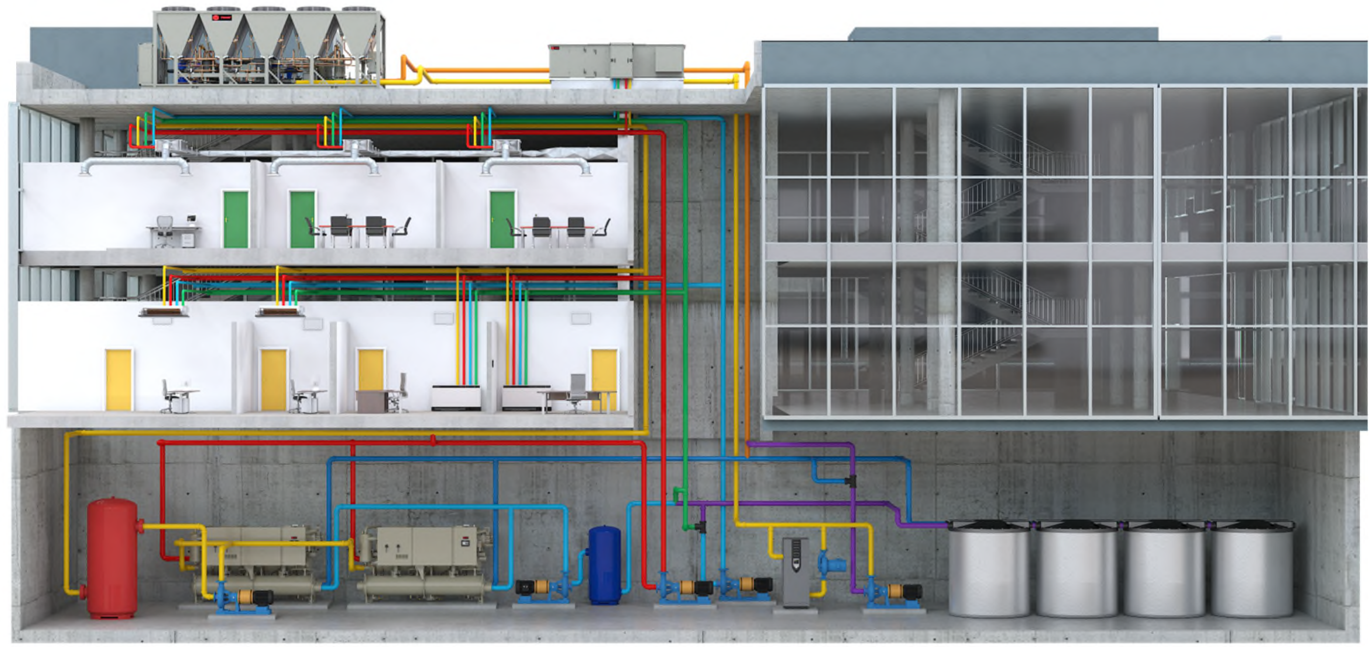
Ice Energy Storage Tanks

H 8’-6” D 7’6” Dia.
1655 Gal of Water = 13,786 lbs.
13,786 lbs. x 144 Btu’s/lb. ~2,000,000 Btu’s

2,000,000 Btu’s =
~14 gallons of fuel oil
~20 therms of natural gas
~2000 lbs. steam
~160 ton-hrs.

Chiller Heater Systems are Airside Flexible

- Applied to all airside systems
  - Multiple zone VAV systems
  - Fan coil systems
  - Central air handling systems
  - Single zone VAV systems
  - Sensible cooling systems
  - Any combination
- Benefits of this flexibility
  - Air economizer
  - Downsize capacity with whole building diversity
  - One integrated backup heating system
  - DOAS can heat 0F to 60F air directly



Heating with Heat Pumps is a $CO2_e$ Winner, and Energy Costs are Comparable to Fossil Fuels ………..

but there are five (5)challenges…

1. Thermal Balancing - Loads are NOT equal and synchronized

- Heating loads peak in the morning
- Cooling loads peak in the afternoon

2. Space needed for heat pumps outdoors

- Large heat pumps require substantial amounts of outdoor space, to collect the heating energy from the outside ambient air and, in urban areas, this is roof space.

3. Colder climates hamper AWHP Performance

- Requires even more space for more heat pumps as capacity and efficiency diminish when temperatures drop

4. Heat Pump electrical demand

- At design heating conditions, COPs are low and electric demand is very high

5. Heat Pumps are more expensive than gas boilers

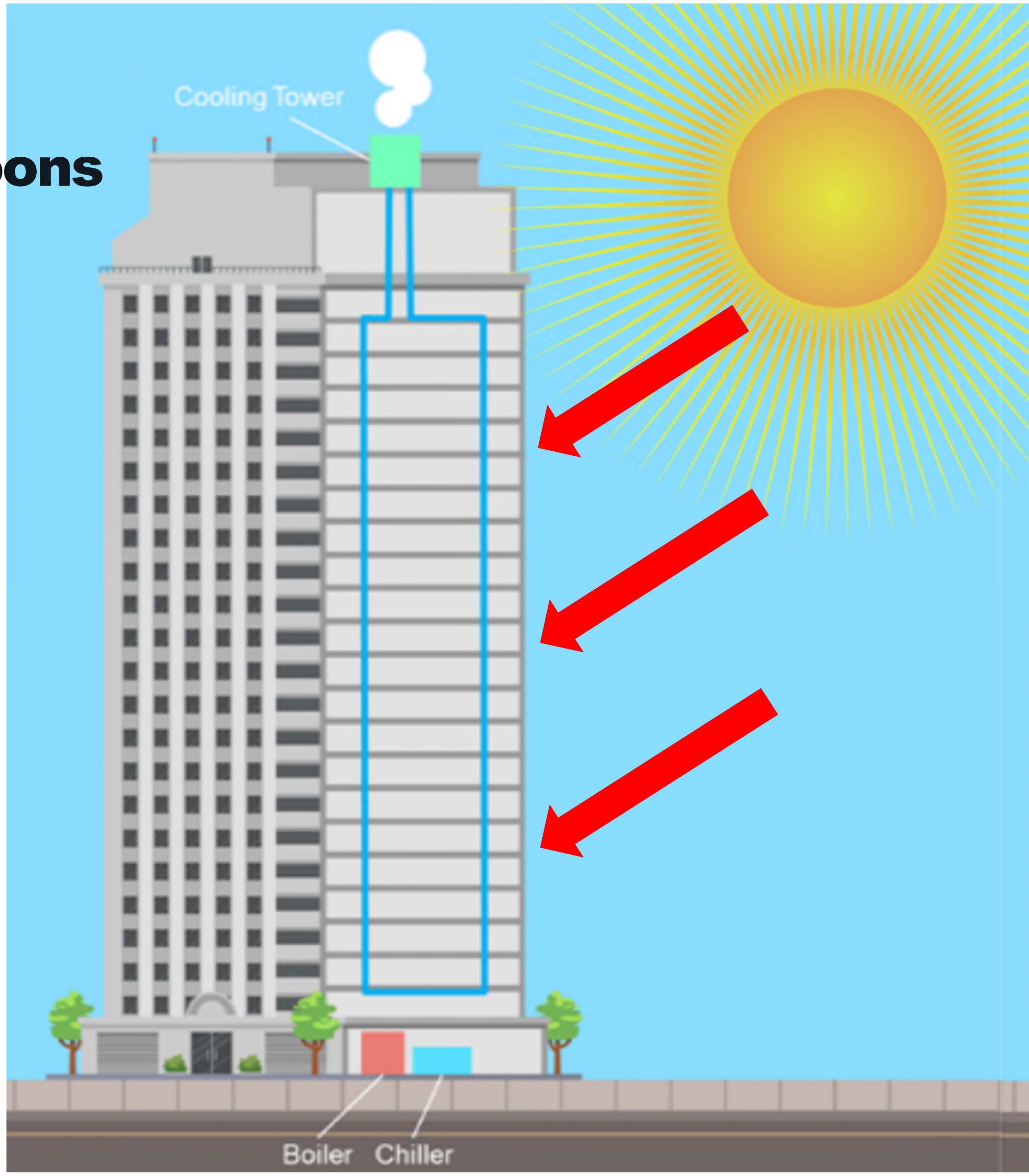
- Capital costs are considerably higher than gas boilers

Challenge 1
Thermal Balancing - Winter afternoons

<u>Thermal Balancing - Loads are NOT equal and synchronized</u>

- Heating loads peak in the morning
- Cooling loads peak in the afternoon

Existing buildings routinely “Free Cool” energy away in the winter with cooling towers, wasting it to the atmosphere.



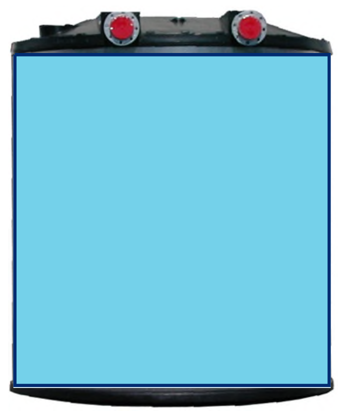
Challenge 1: Thermal Balancing – Winter Afternoons

Winter Afternoon

Instead of wasting the heat by “Free Cooling”, the thermal storage tank collects and stores energy to be used the next day.

(melt ice to cool the space)

Melting ice stores energy for tomorrow’s heating needs



Thermal Energy Storage Tank

Winter Morning

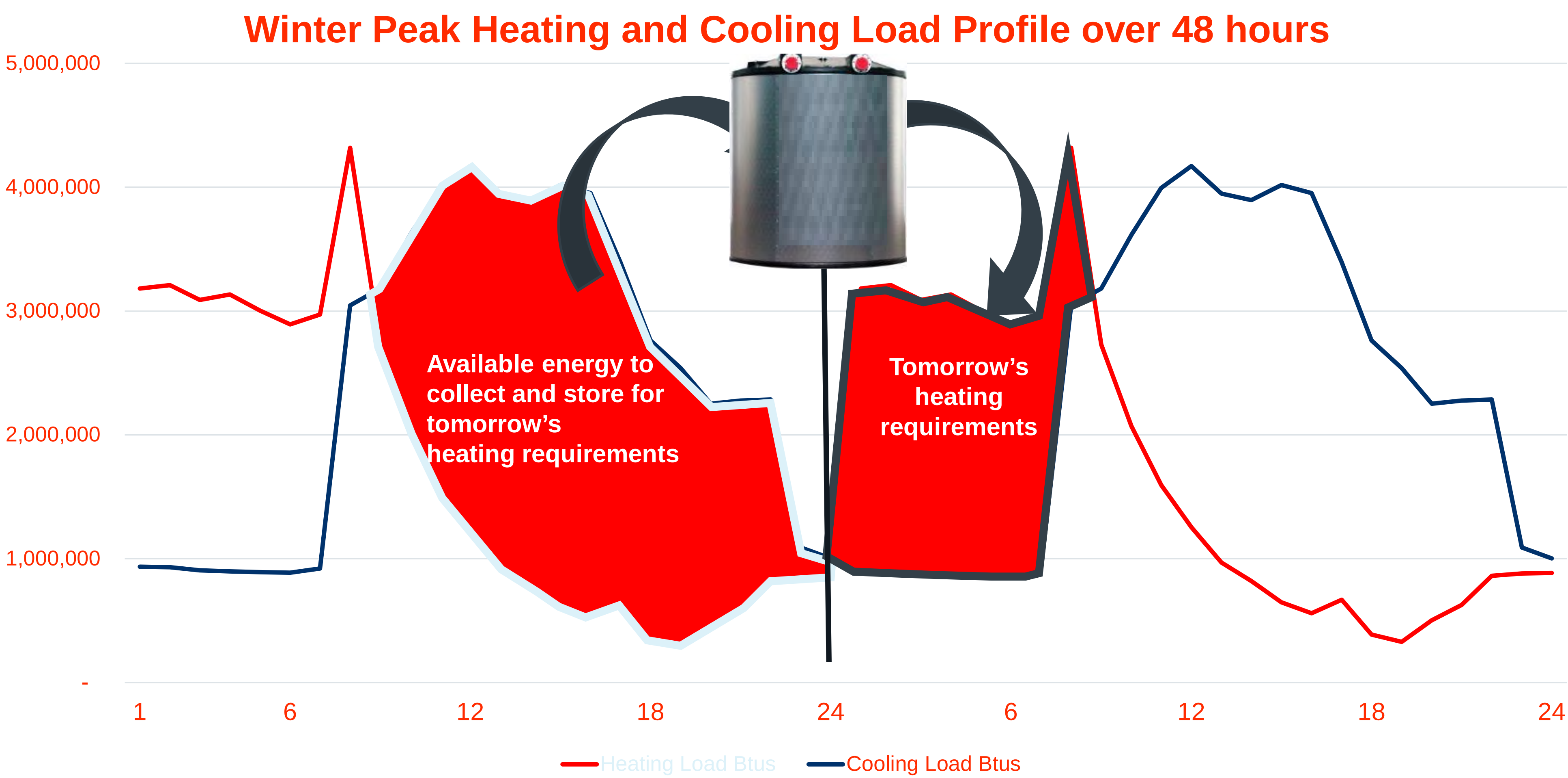
The next day the stored energy is used by a chiller-heater to heat the building.

(ice is made, building is heated)

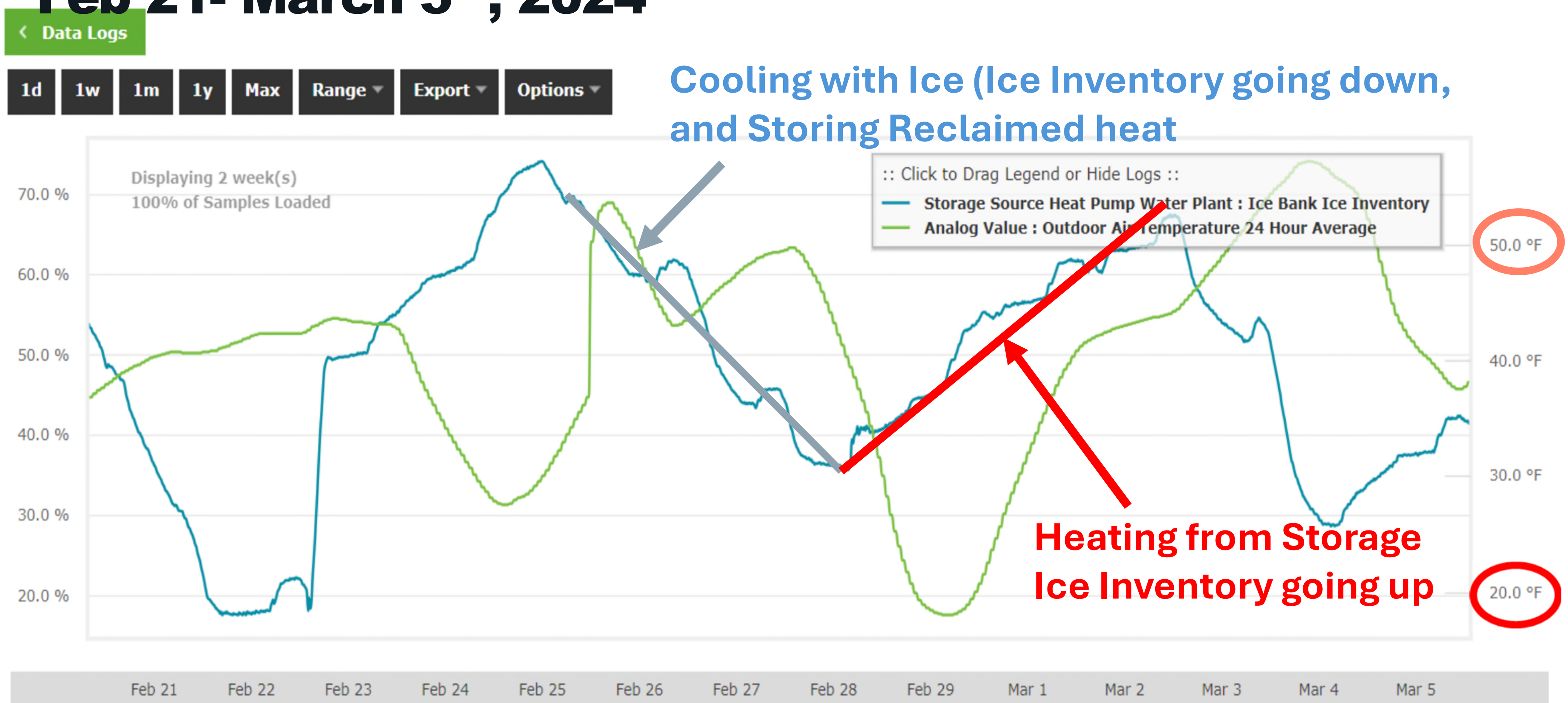
A chiller-heater removes energy from water (making Ice) and condenser heats the building

Collect and store today's waste energy for tomorrow's heating needs which improves efficiency & lowers carbon emissions

Challenge 1: Thermal Balancing – Winter Afternoons



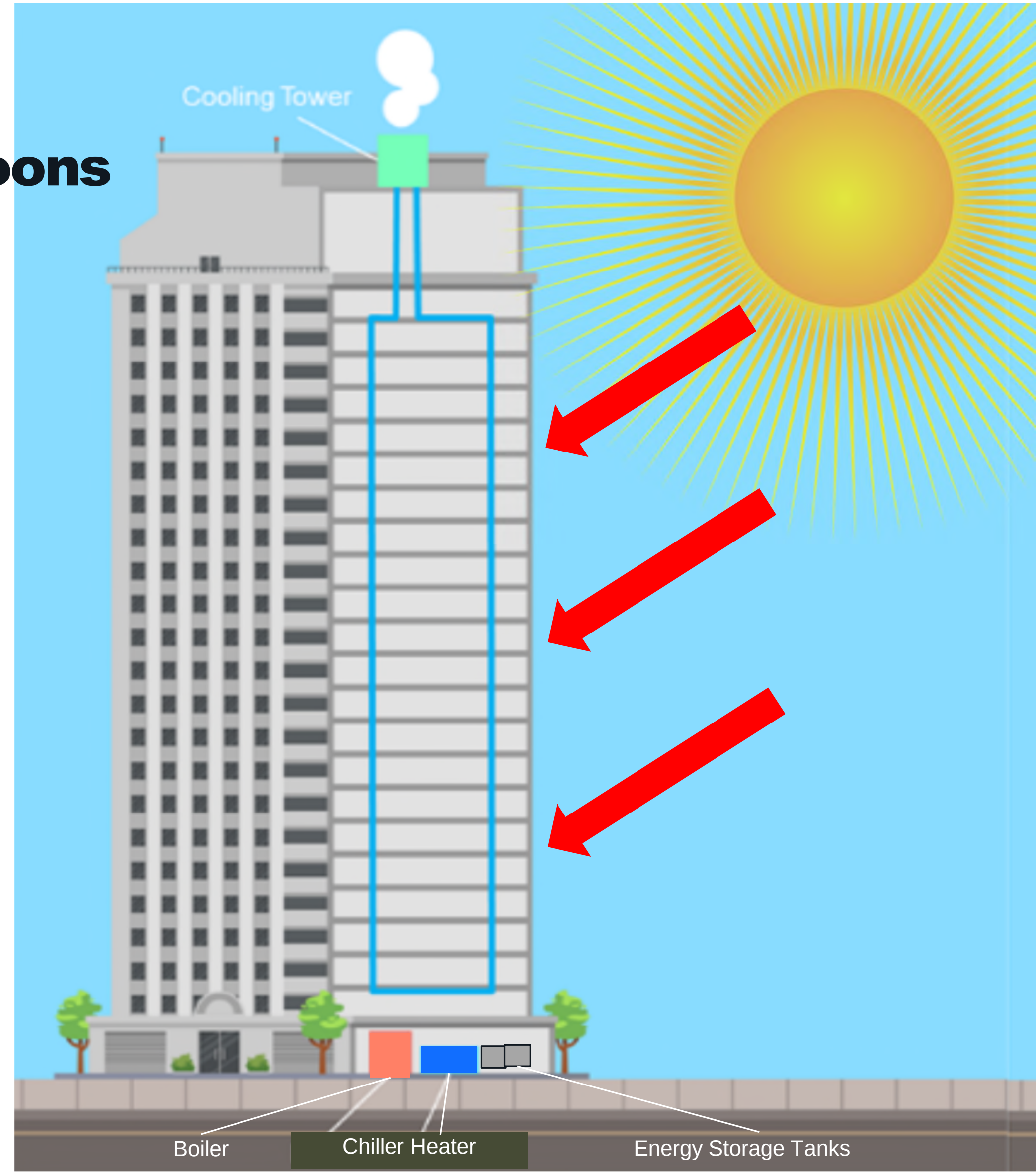
Ice Inventory vs 24 hr. Average Ambient Temp Feb 21- March 5th, 2024



Challenge 1:
Thermal Balancing - Winter afternoons

With Thermal Energy Storage, "curtain walls" essentially becomes huge solar collectors, for harvesting heat to "charge" the Storage for tomorrow's heating requirements

It's counter intuitive,
but there is a lot of stored heat
in a tank of cold water.



Is there much waste heat on a winter day?

- A New York City building uses their 44 Thermal Storage Tanks to cool the building every winter day (because their experience says “using ice is cheaper than “free” cooling”).

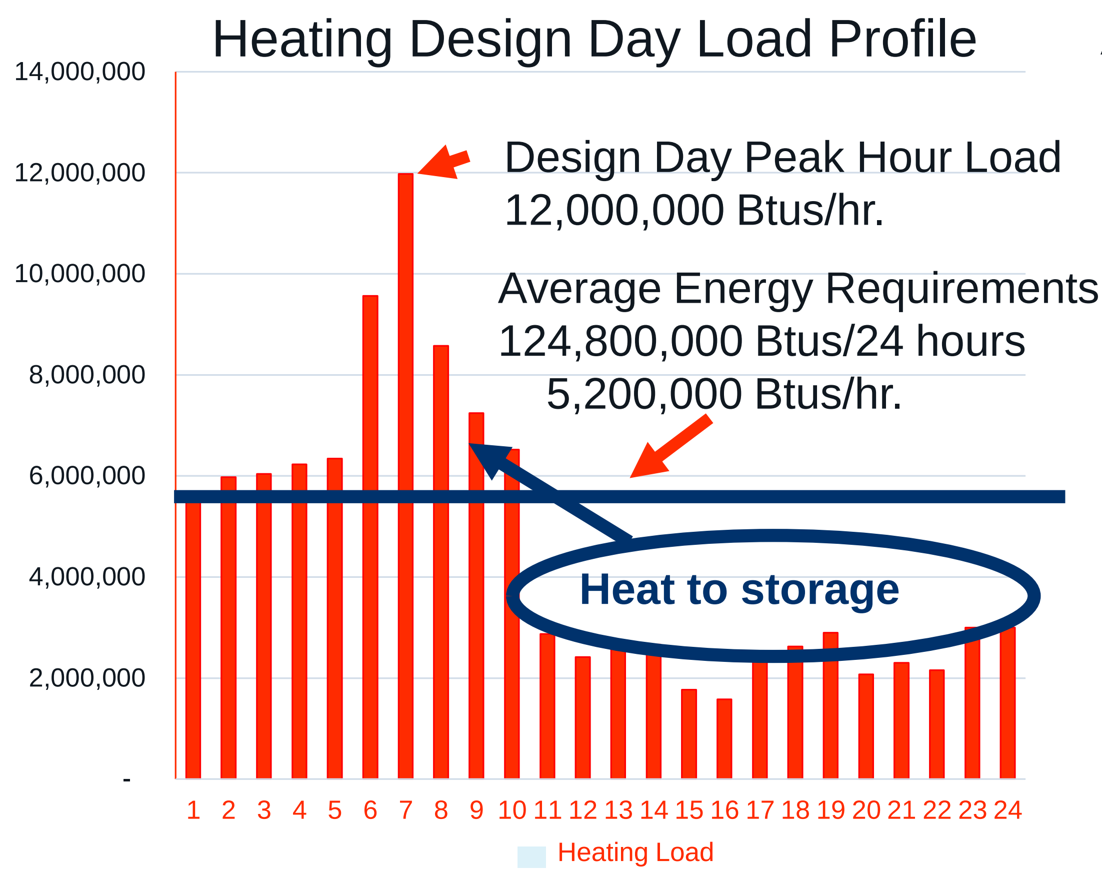
- The site engineer says he uses all the ice every day in the winter.

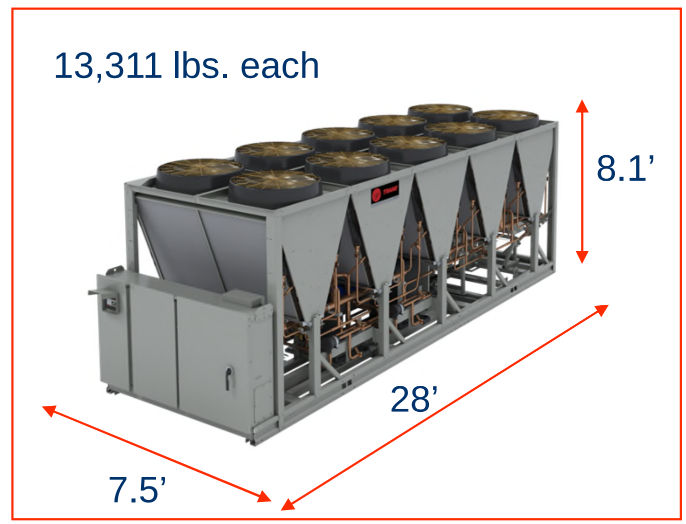
- That water in the tanks is equivalent to 88 million Btus of energy that could be used to heat the building the following day.

Challenge 2: Space for Heat Pumps Outdoors

As few as 5

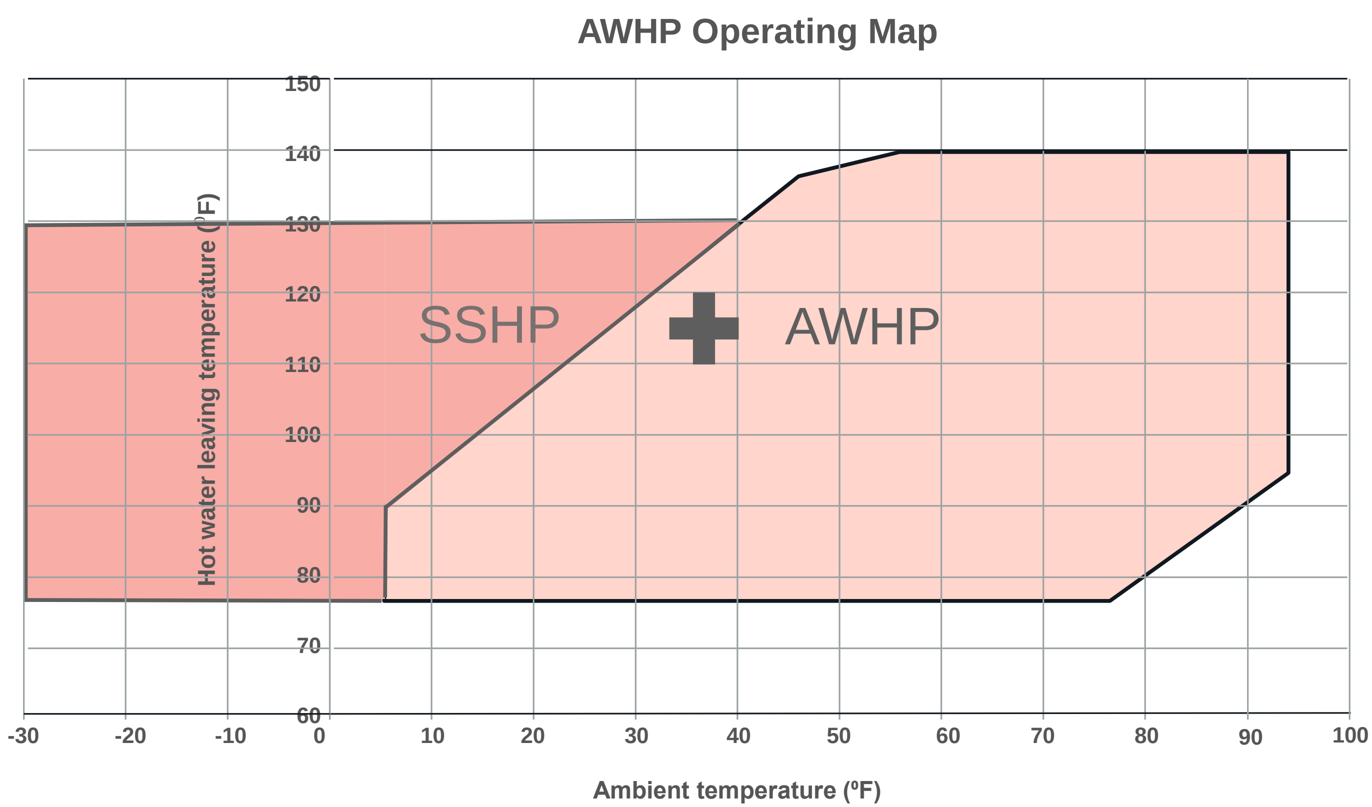
AWHP – 1,295,000 btu/hr requires ~~10~~ units – maybe more to accommodate defrost cycle





* Depending on building type and climate.

Challenge 3: Colder Climates Hamper AWHP Performance



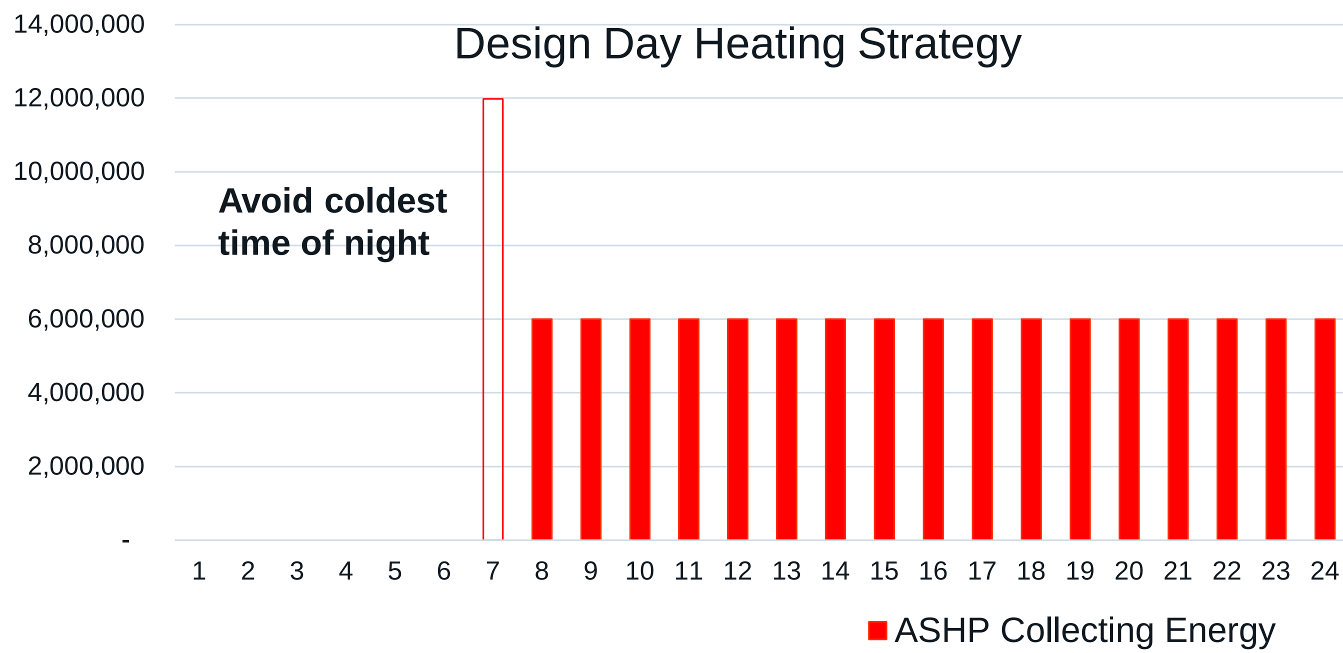
AWHPs have operational limits at low ambient temperature

- Capacity and hot water temperature drop dramatically
- WWHP + thermal storage extends the operating map for cold climates

Challenge 3: Colder Climates Hamper AWHP Performance

AWHPs have operational limits at low ambient temperature

- Capacity and hot water temperature drop dramatically
- Storage extends the map
- **Storage enables the avoidance of running AWHP during extreme nightly temperatures**



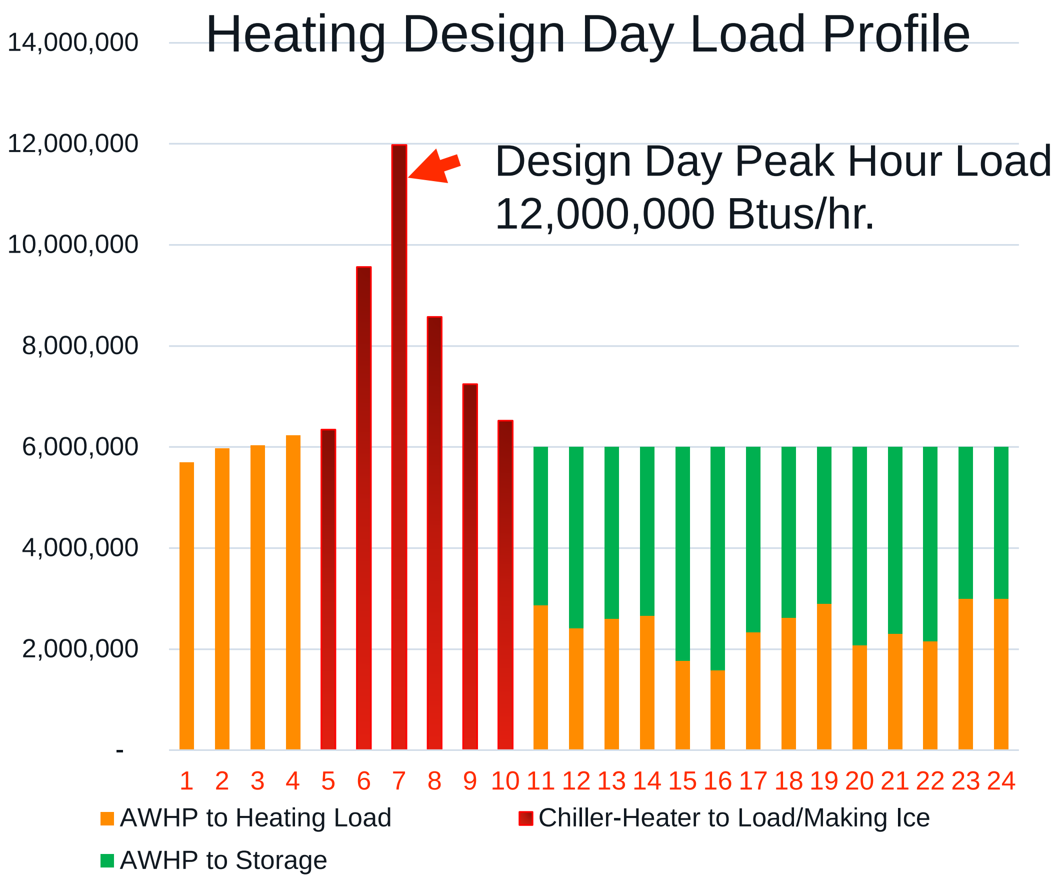
Challenge 3: Colder Climates Hamper AWHP Performance

- Storage enables the avoidance of running AWHP during extreme nightly temperatures.
- Storage enables the running AWHP during low-carbon times.
- Storage enables the avoidance of running AWHP during utility peak periods reducing energy cost.

The addition of storage gives buildings the **flexibility** of load shifting.
DOE's Grid-Interactive Efficient Building Program* (GEB) states this is key to a low-carbon future.

* Source. U.S. DOE. A National Roadmap for Grid-Interactive Efficient Buildings. May 17, 2021

Challenge 4: Winter Peak Electrical Demand



AWHP @ 0F Ambient temp to 115F = 1.8 COP
12,000,000 Btu/1.8/3414 = 1952 kW

Chiller-Heater making ice to 115 F Liquid = 3.23 COP
12,000,000 Btu/3.23/3414 = 1088 kW

863 kW Winter On-Peak Demand Reduction SSHP vs. Heat Pump only

* Depending on building type and climate.

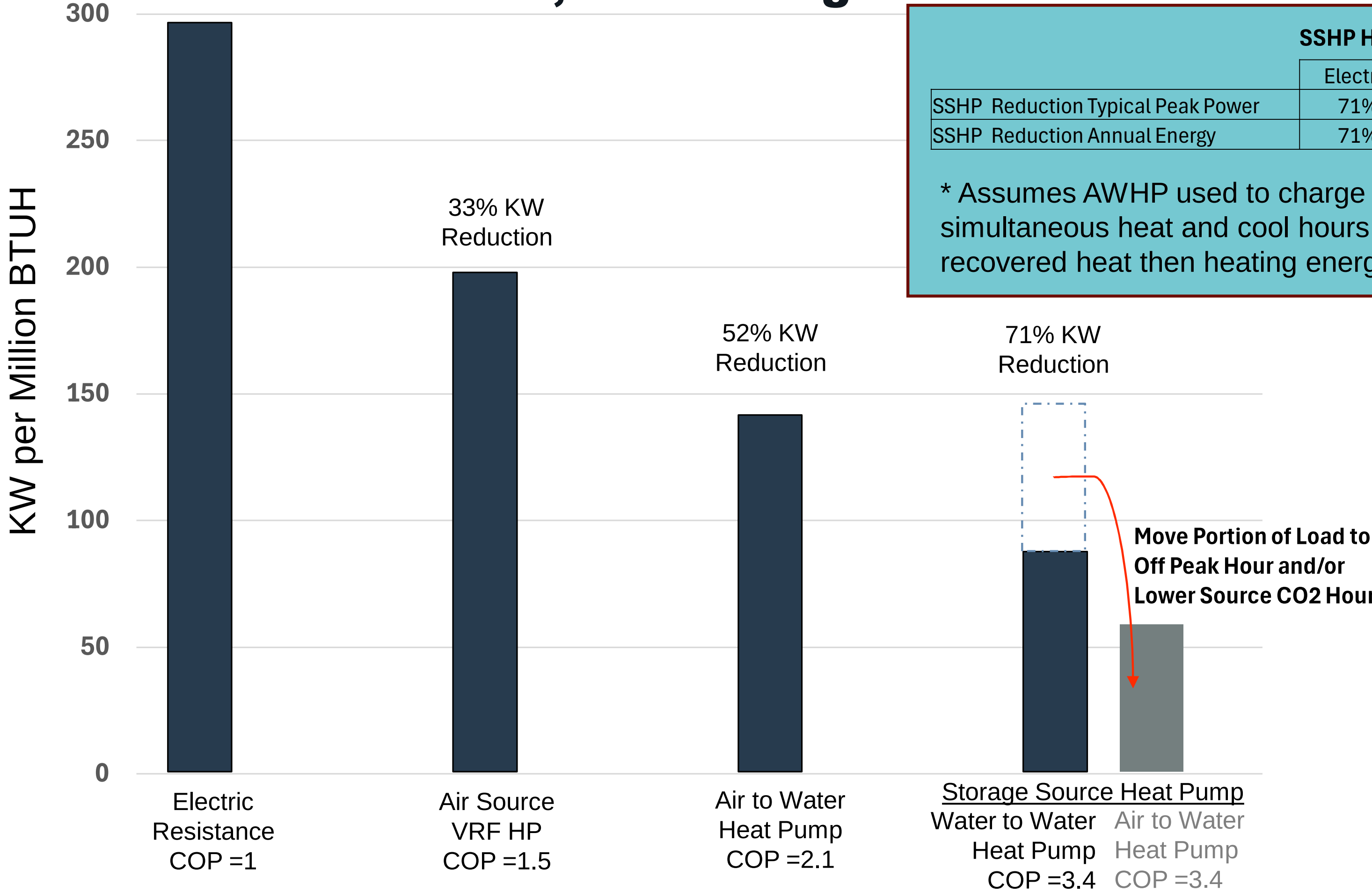
Comparison of KW Used for Heat Generation

Using Annualized COP for Boston, MA Building Model

SSHP Heat Generation Benefits vs

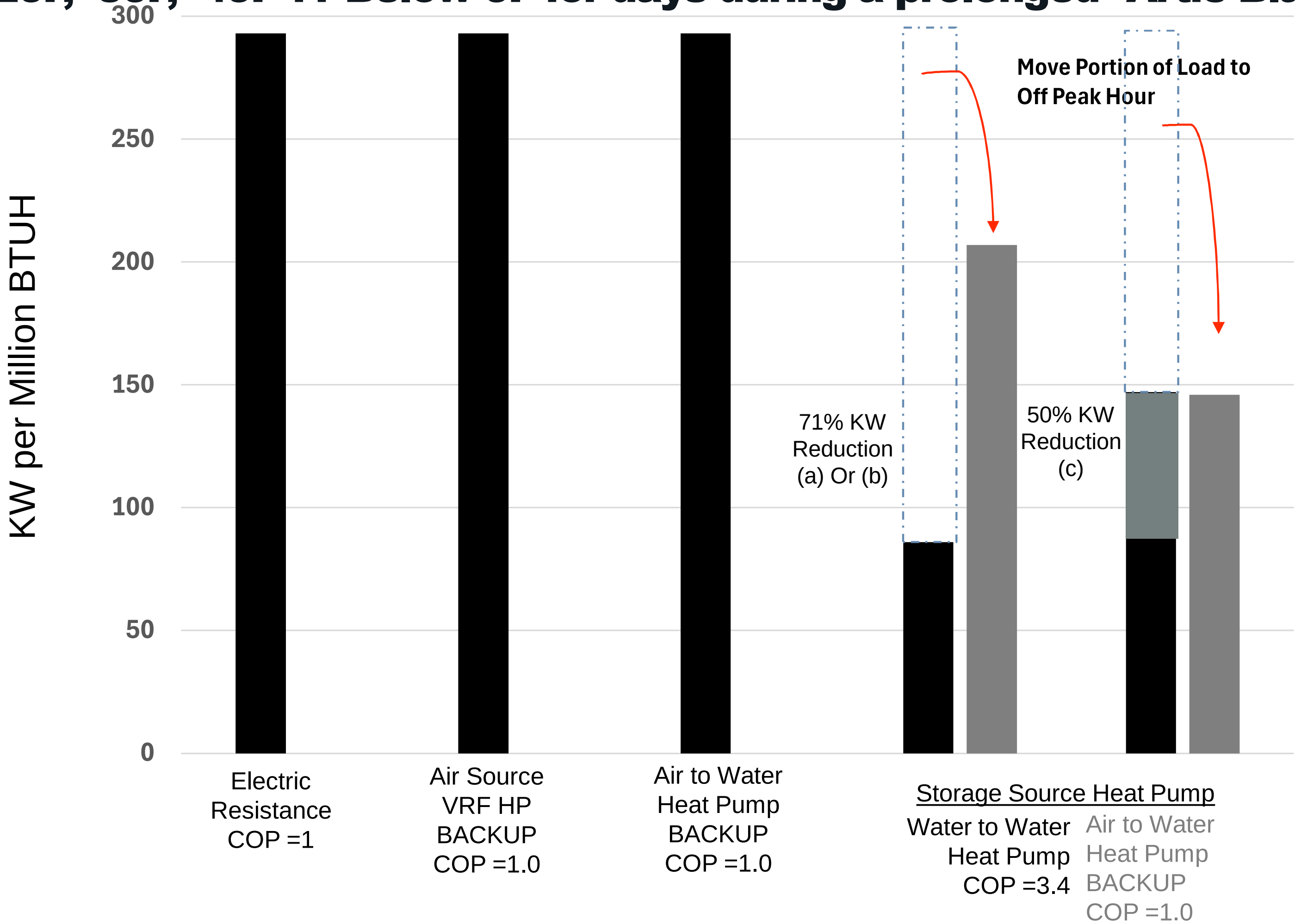
	Electric	VRF	AWHP
SSHP Reduction Typical Peak Power	71%	56%	38%
SSHP Reduction Annual Energy	71%	56%	0% *

* Assumes AWHP used to charge tank If significant simultaneous heat and cool hours or a source of recovered heat then heating energy can be reduced



Comparison of KW Used for Heat Generation

-20F, -30F, -40F ?? Below 0F for days during a prolonged "Artic Blast"



a) If advantageous to utility to shift load as away from certain peak hours of day, 71% reduction for those hours can be accomplished, it will increase size of trickle heater to increase charging rate for less hours

b) If advantageous to utility to shift all 71% of the loads until outdoor ambient is above 0F when everyone else's heat pumps will work, this will increase the size number tanks to days requested

c) Normal Operation the trickle heater will run all hours needed to maintain load but will even the load for the 24hrs, reduce peaks

Challenge 5: Heat Pumps are more expensive than boilers

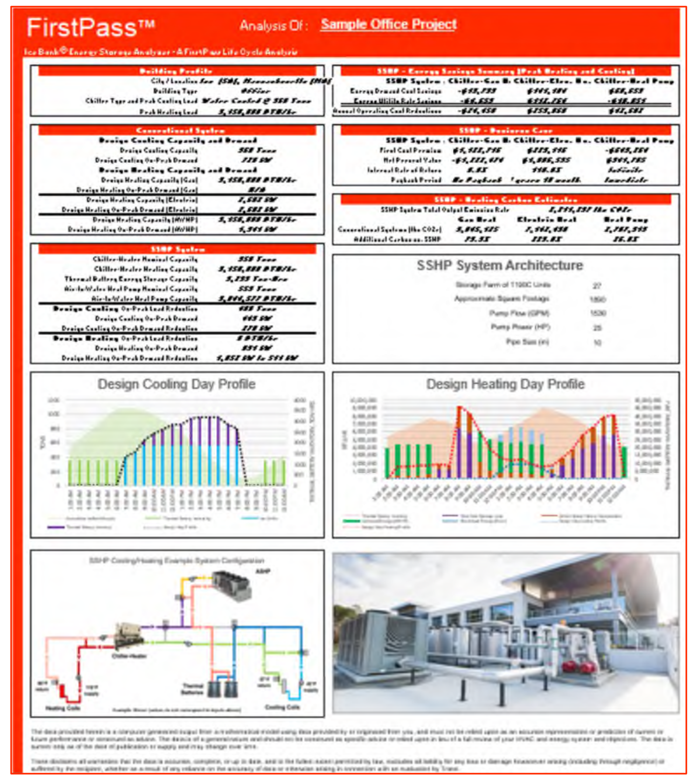
Thermal Storage for Chiller Plant

- In new construction, the cost of thermal storage is the same, or similar, to a conventional applied chilled water system

Storage-Source Heat Pump System (SSHP)

- Number of AWHP units is cut by 50% or more, so only half as much instantaneous capacity as the gas alternative
- Cost for storage is already covered by the reductions in chiller plant size
- Chiller-heater and thermal storage meet peak heating and cooling loads

Simple model available to understand equipment sizes, initial costs, and operational savings of energy storage cooling and heating system



Key Ideas Regarding System Operation

- **Outdoor air** is the near-limitless source of building cooling and heating using the **AWHP.** Cooling towers can provide supplemental heat rejection as needed.
- **Thermal storage** balances the net heat flow of all equipment and loads.
- **AWHP** is able to "**cool charge**" (freeze water) or "**heat charge**" (melt ice) the thermal storage when conditions are favorable.
- Thermal storage will directly cool the building (melt ice) to **shift the electrical load** and **limit electrical demand** in cooling season or to store building heat during heating season.
- **Chiller Heater** units will be used for thermal battery source **building heating** (freezing water) during **any** outdoor conditions (**including below 0F**).
- Key benefits are:
  - **Cold ambient electrified heating**
  - Hot water supply (**~120F**) when **cold**
  - **Time independent heat recovery**
  - **AWHP downsizing**
  - Enables **demand management**

Q + A

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