Decarbonizing with Heat Pumps

(in a low-GWP, A2L World)

Part 1: Hydronic Distribution Systems

Presented by: David Butcher and Mark LaFrance

March 20, 2025

Hosted by:

Delivering Real Success®

We are: HVAC Manufacturer's Representatives & a Building Automation contractor

AHUs (catalogued – modular – full custom), ERVs, Chillers, ASHP & WSHP Chillers, Fans, Lab exhaust, Lab energy recovery, pre-fab plants, terminal equipment, humidification, air purification, etc.

Specialized in VRV/VRF, ASHPs, VRV driven ERVs and AHUs, VRV controls

Largest Daikin VRV rep in North America!

Building automation, energy and emissions monitoring and reporting, fault detection systems, and lab energy recovery controls

David Butcher

HTS New England

Boston University– Mechanical Engineering

Core role at HTS is supporting Contractors with HVAC equipment applications

Likes running, biking, and air conditioners

Mark LaFrance

HTS New England

University of New Hampshire - Mechanical Engineer

Core role at HTS is supporting Consulting Engineers with HVAC equipment applications

Likes long walks at HVAC trade shows, and cars

Decarbonizing with Heat Pumps (in a low-GWP A2L World)

Part 1: Hydronic Distribution Systems

- **Low-GWP:** lower global warming potential (driven by EPA)
- **A2L:** Per ASHRAE 34: Low flammability
- **Hydronic:** For application in hot water heating systems

Come see us tomorrow at 10:30a for **Part 2: Distributed Refrigerant Systems**!

HTS

DXS

Agenda

- Part 1 – Lessons learned from hydronic heat pumps prior to today
- Part 2 – New advancements in unitary high-lift machines, high-temp boosters, and alternative heat sources
- Part 3 – System-level and equipment-level optimizations
- Part 4 – How hydronic compares to other options
- Part 5 – The future

Agenda

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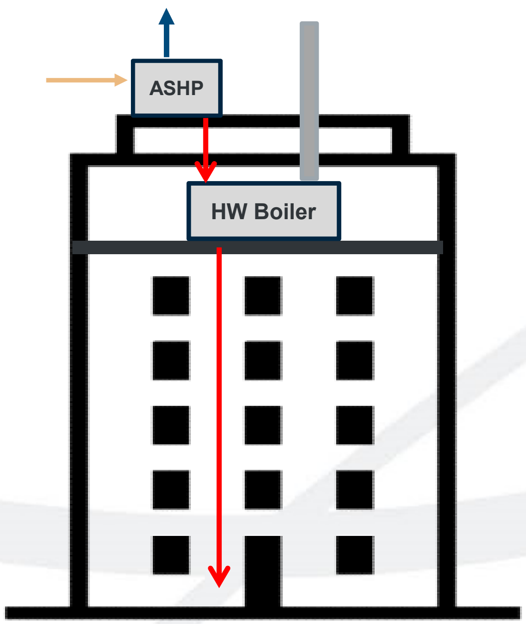
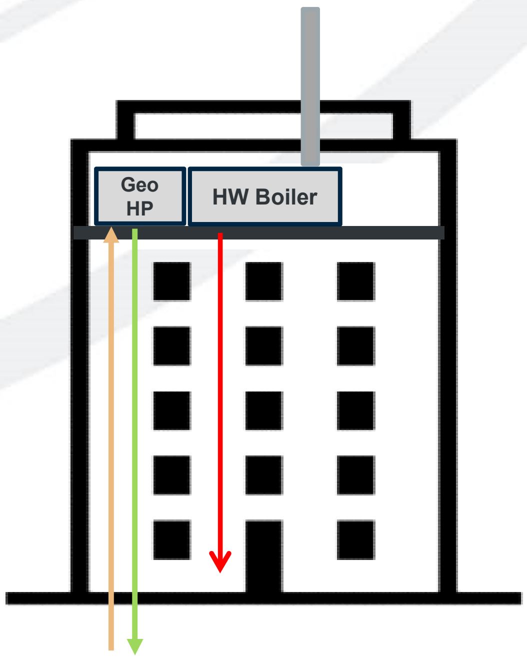
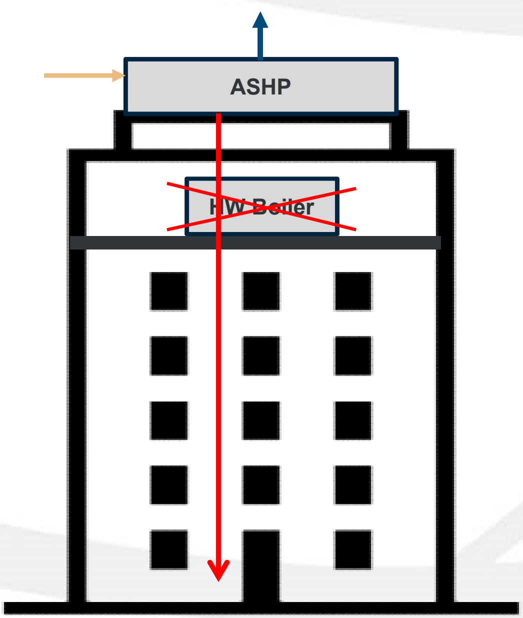
- Part 5 – The future

How are we electrifying hydronic systems?



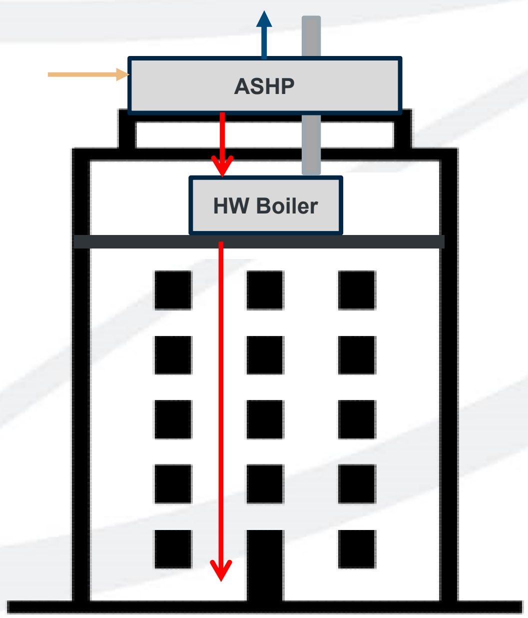


Electrification Options



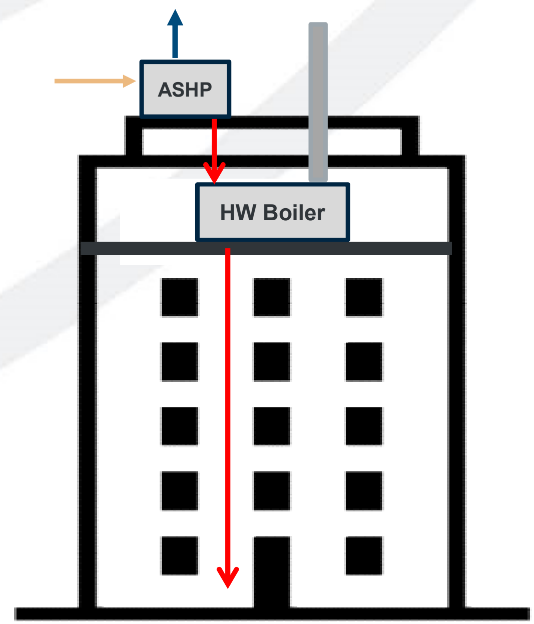
Heat pump sized for 100%
of building load on a 0F day
<u>without</u> backup

- or -



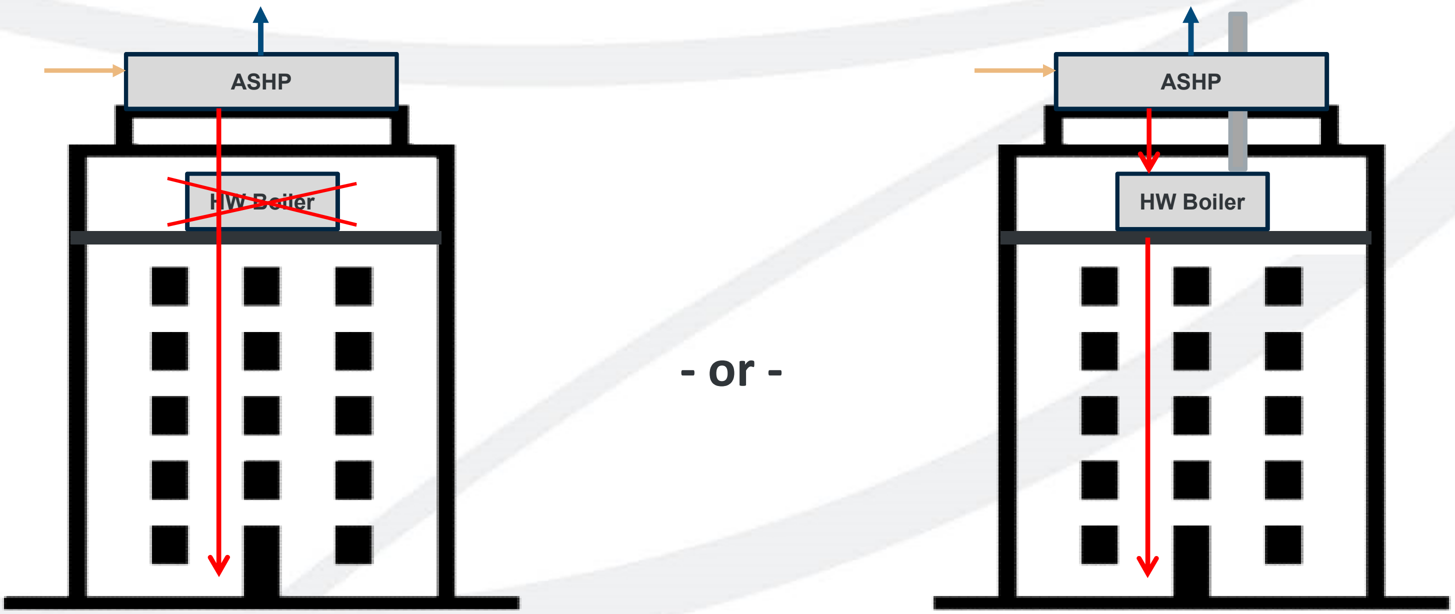
Heat pump sized for 100%
of building load on a 0F day
<u>with</u> backup

- or -



Heat pump sized for 33% of
building load on a 0F day

Electrification Options – Backup Heat

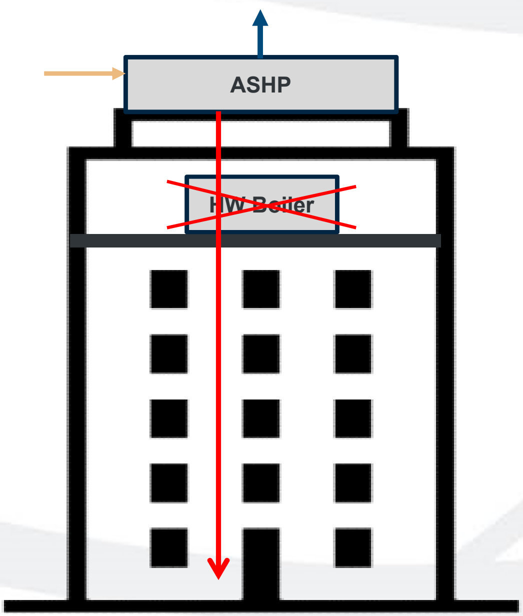


Heat pump sized for 100% of building load on a 0F day ***without*** ***backup***

Heat pump sized for 100% of building load on a 0F day ***with*** ***backup***

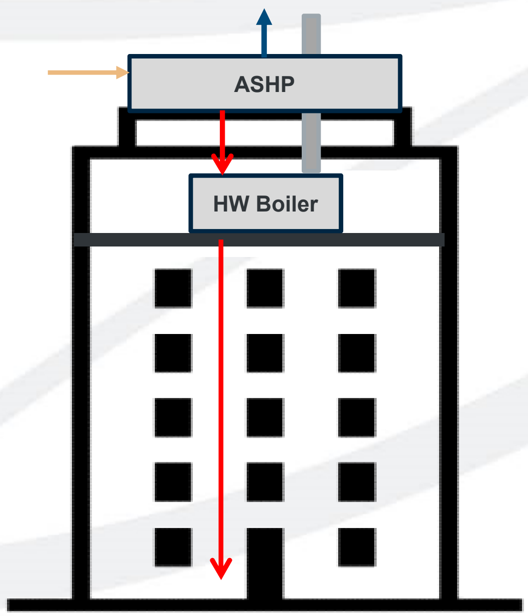
Boilers are relatively inexpensive. Keeping boilers increases reliability, creates flexibility in sizing, and creates opportunity to run them when grid emissions are high.

Electrification Options



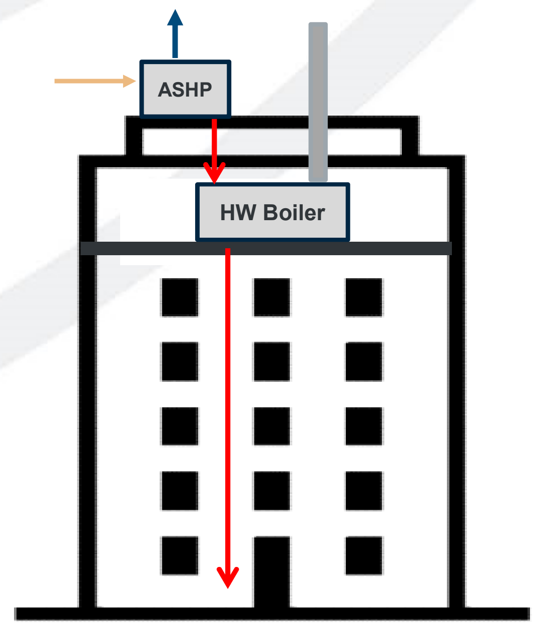
Heat pump sized for 100% of building load on a 0F day *<u>without</u> backup*

- or -



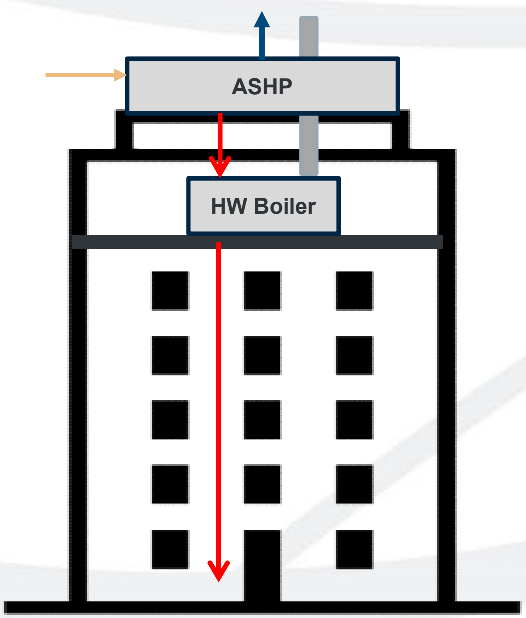
Heat pump sized for 100% of building load on a 0F day *<u>with</u> backup*

- or -



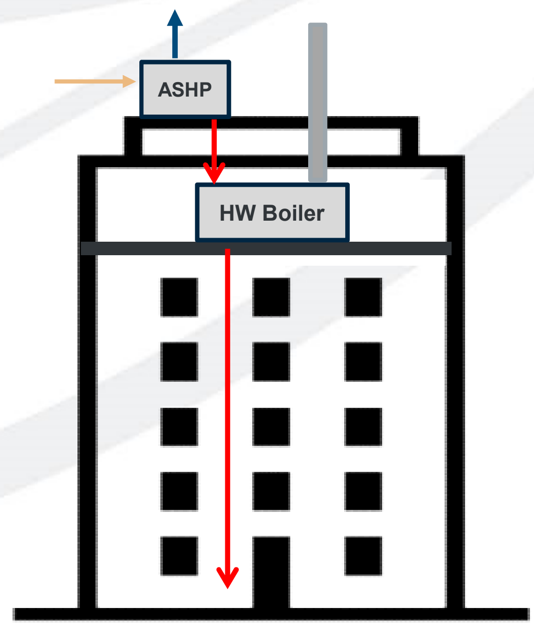
Heat pump sized for 33% of building load on a 0F day

Electrification Options – How Much Heat Pump?



Heat pump sized for 100% of building load on a 0F day ***with* backup**

- or -

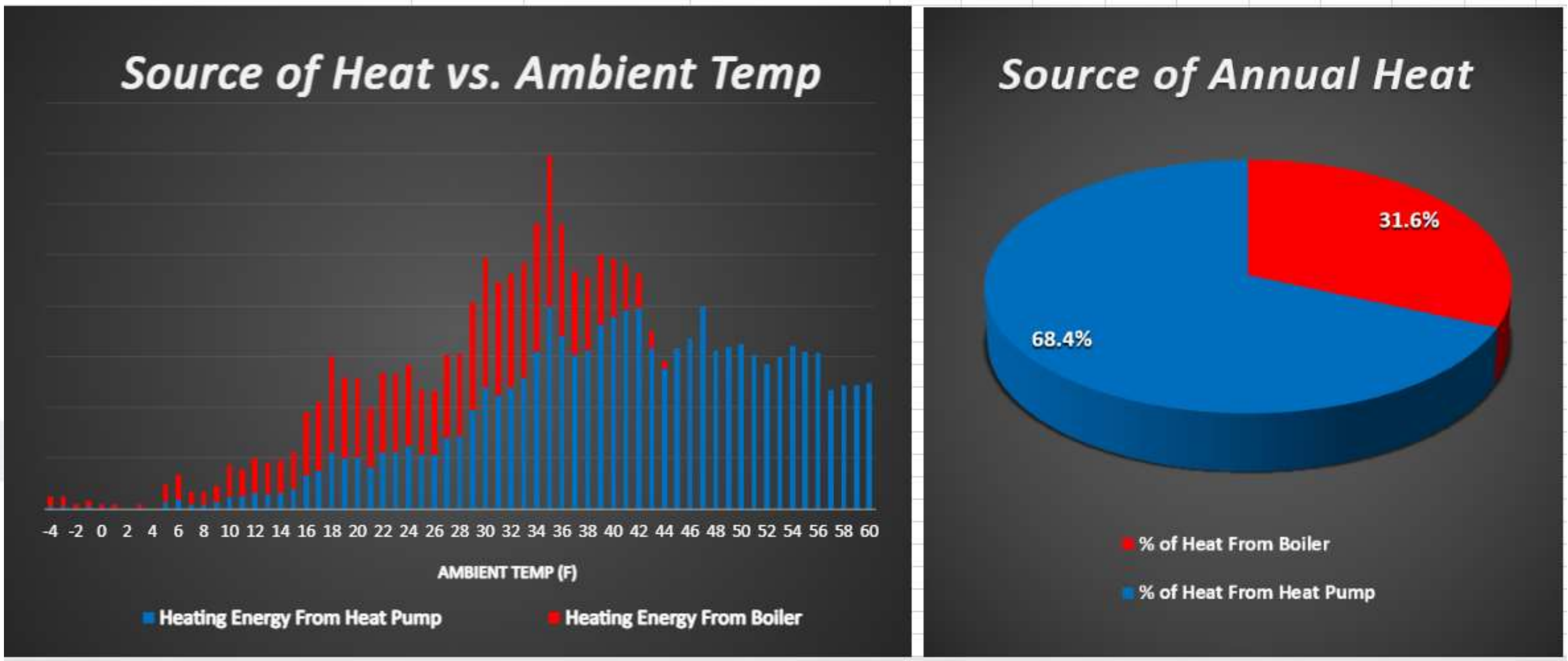


Heat pump sized for 33% of building load on a 0F day

Building Heating – Air-to-Water Heat Pumps

What if we cover *part* of the load with ASHP's?

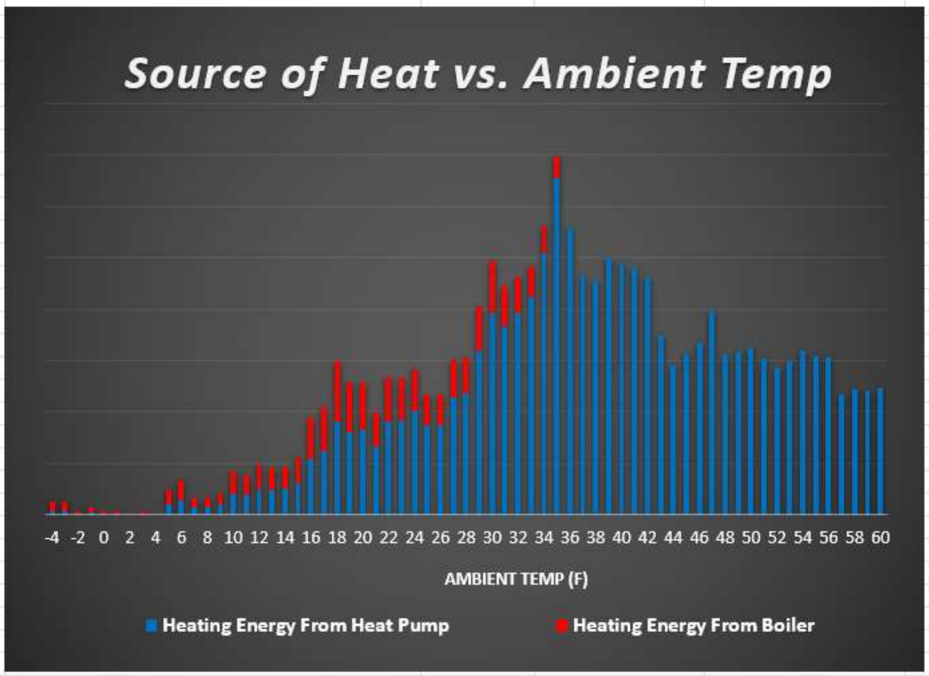
% of Total Load Provided By Heat Pump at 0F	% Decarb
20%	68.4%

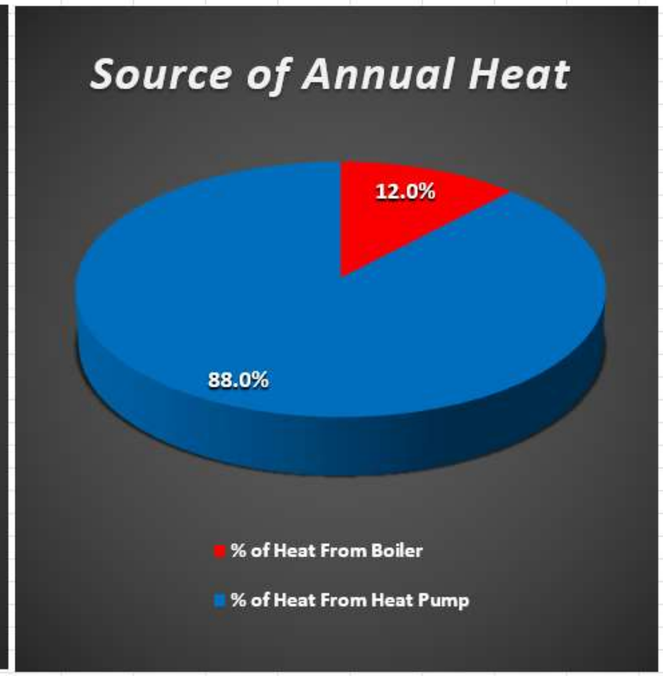


Building Heating – Air-to-Water Heat Pumps

What if we cover *part* of the load with ASHP's?

% of Total Load Provided By Heat Pump at 0F	% Decarb
33%	88.0%

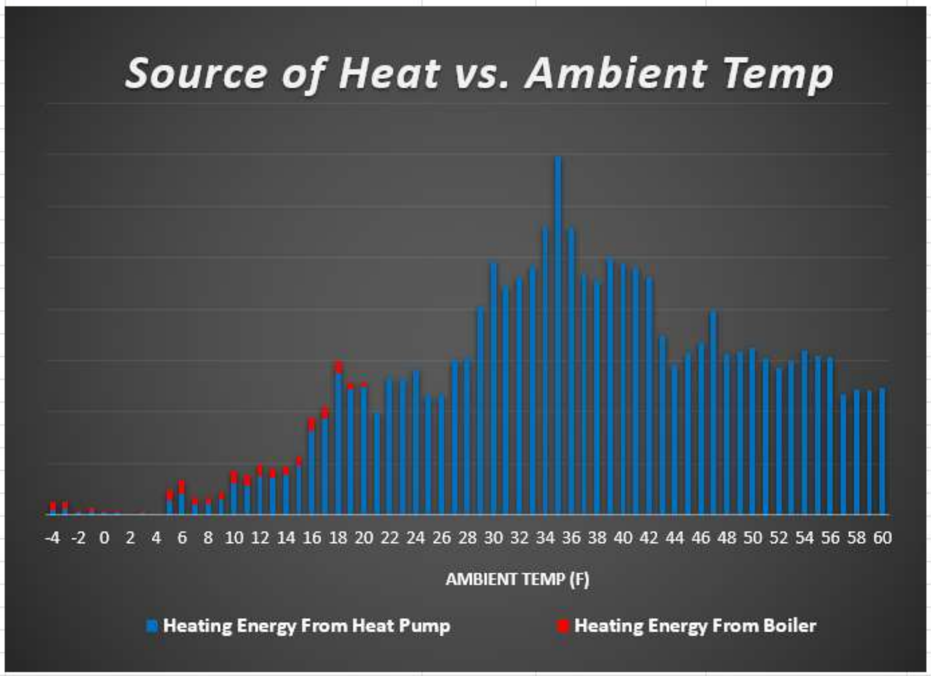


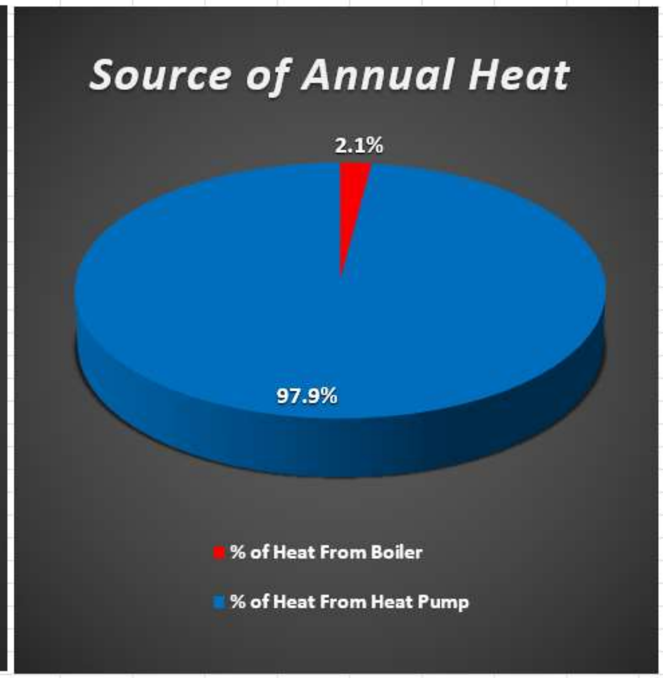


Building Heating – Air-to-Water Heat Pumps

What if we cover *part* of the load with ASHP's?

% of Total Load Provided By Heat Pump at 0F	% Decarb
50%	97.9%





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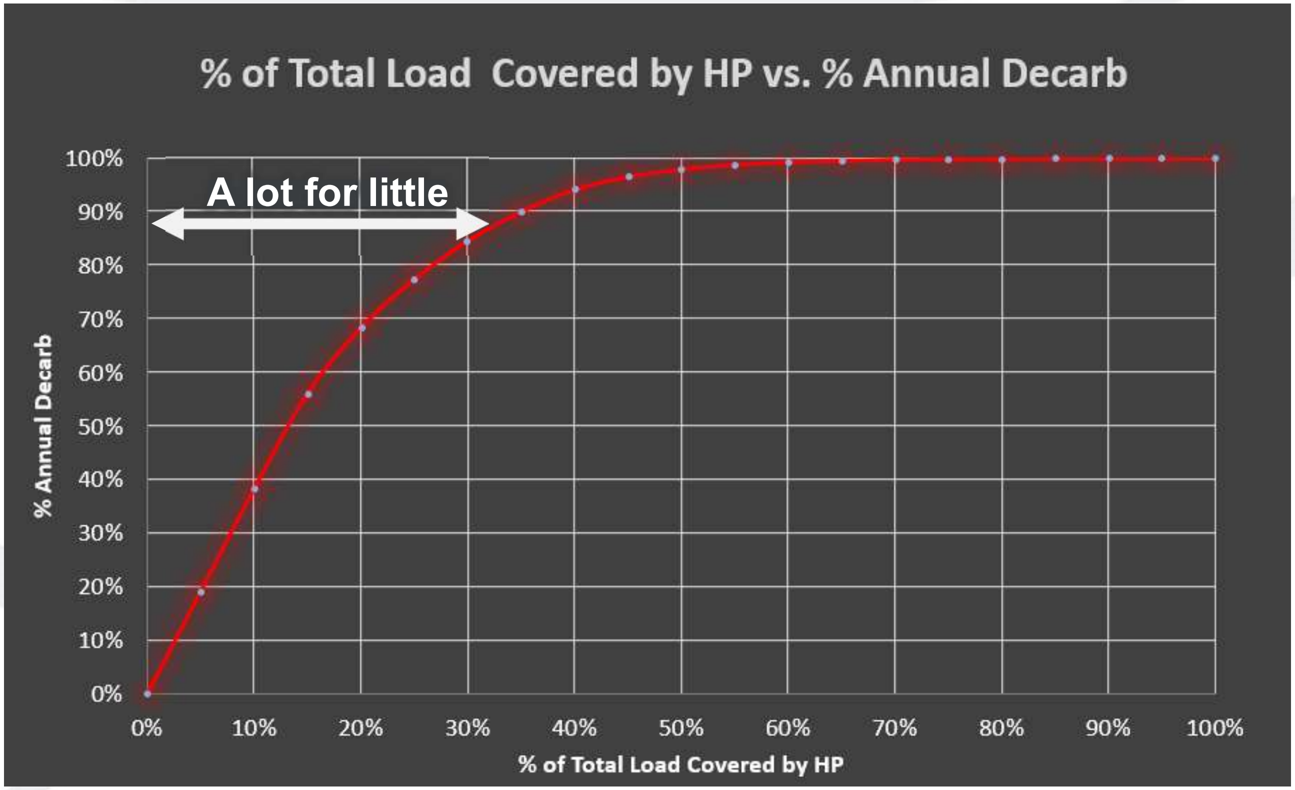
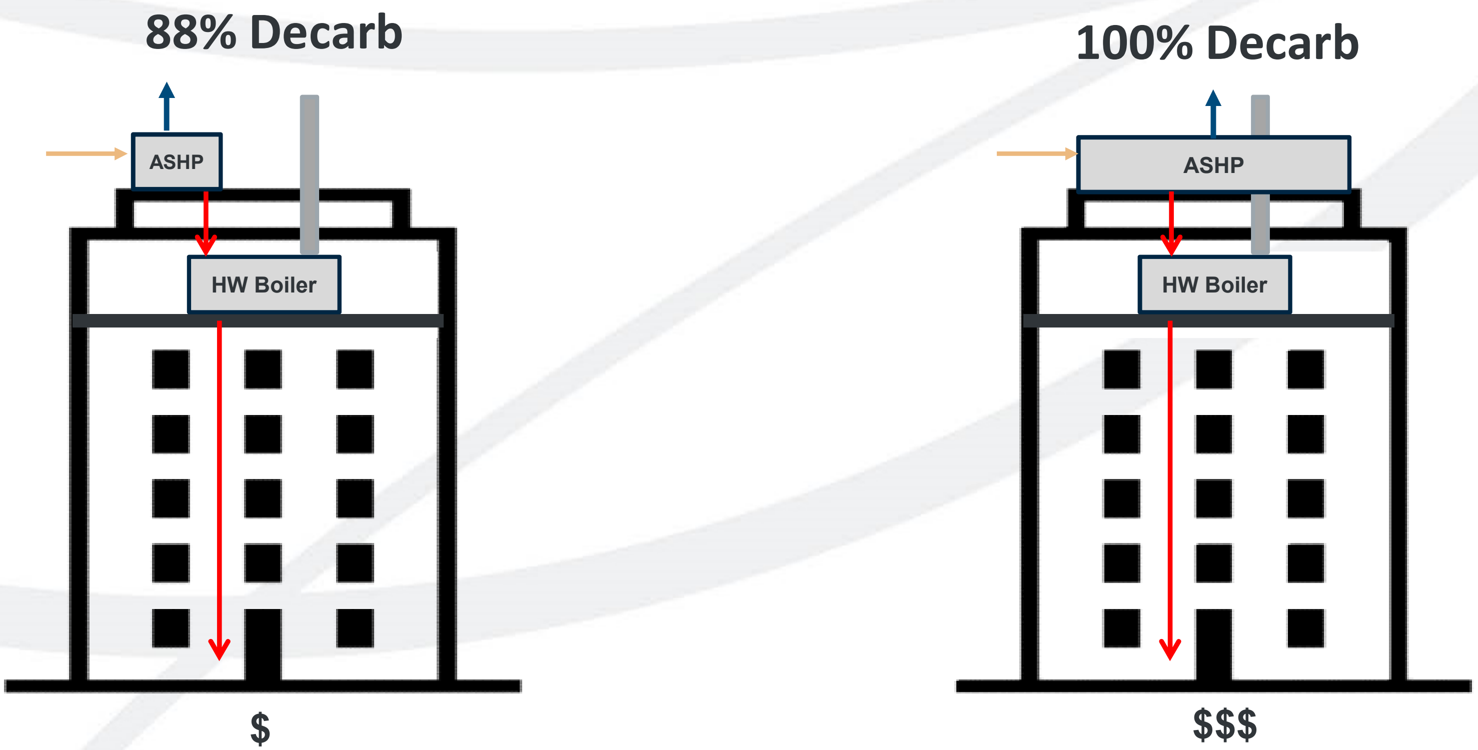
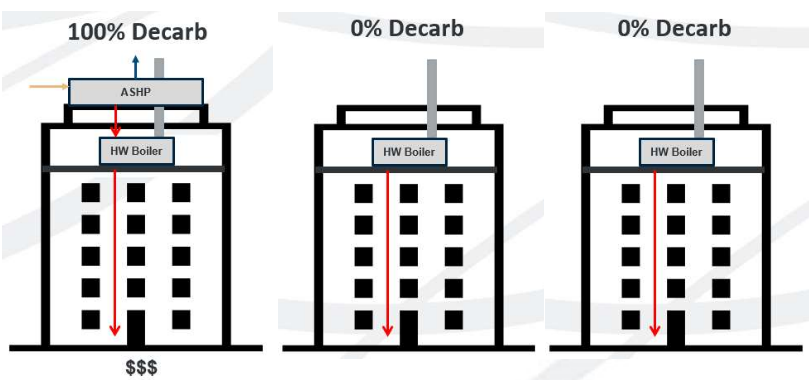


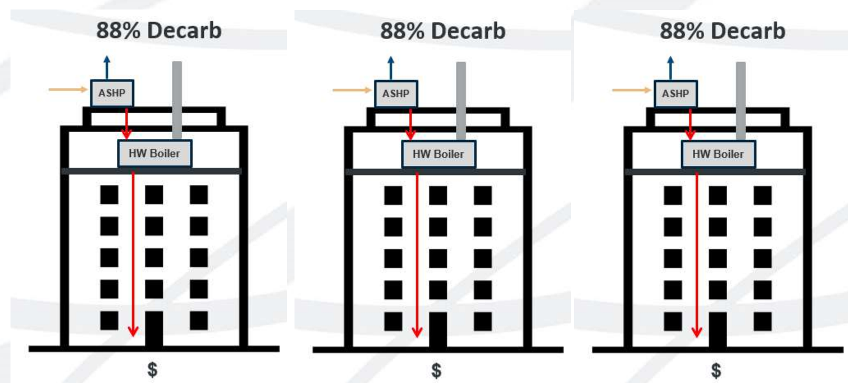
Capital Equipment vs. Value



Capital Equipment vs. Value



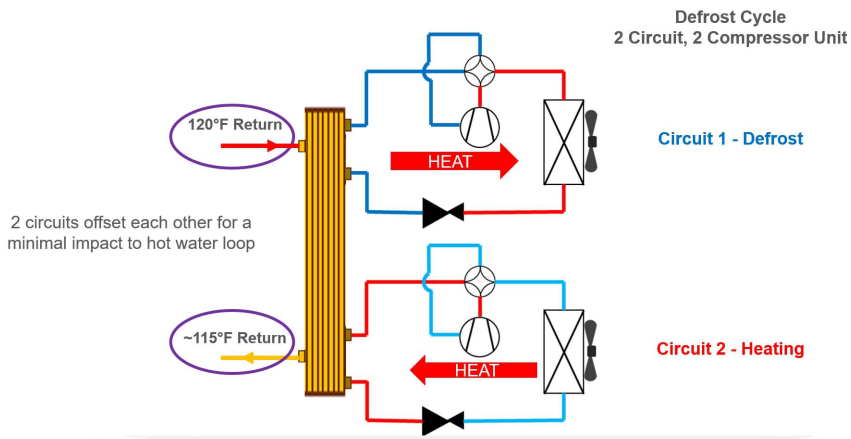
33% Total Decarb

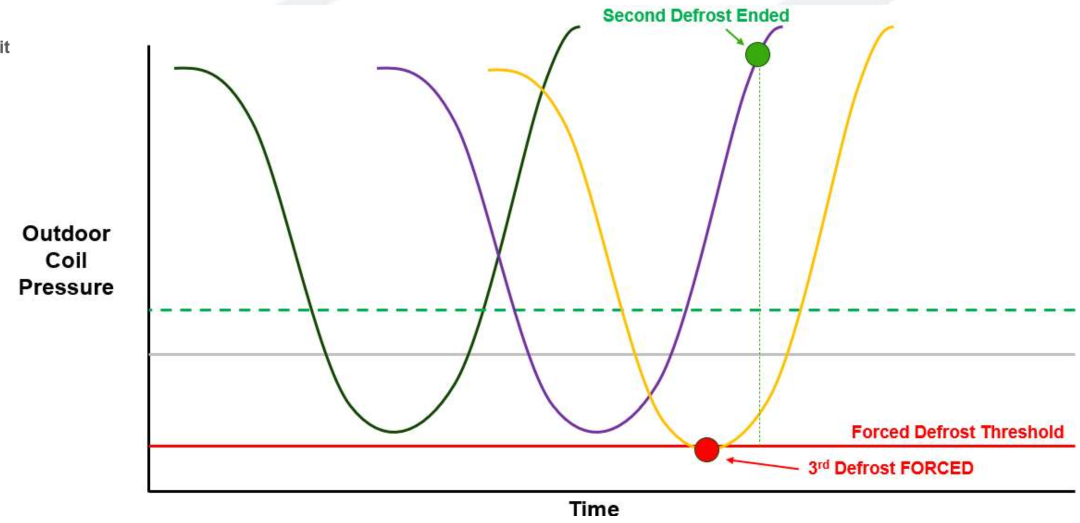


88% Total Decarb

Smart Defrost

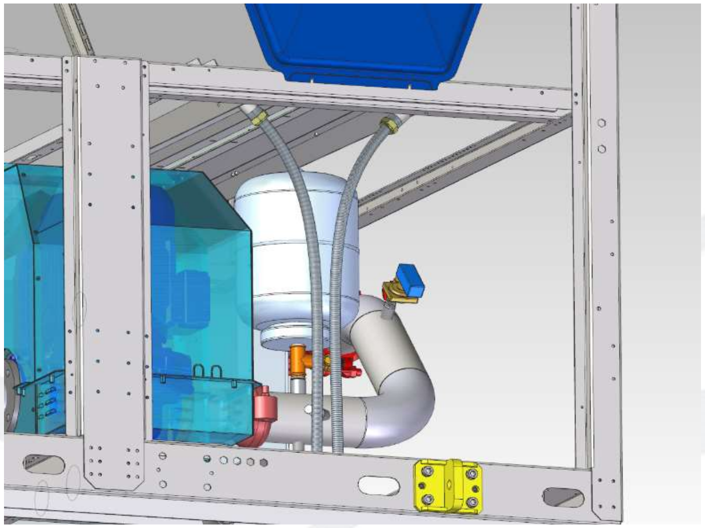
- Only one circuit defrosts at a time
- Intelligent sequencing of defrost across chiller plant

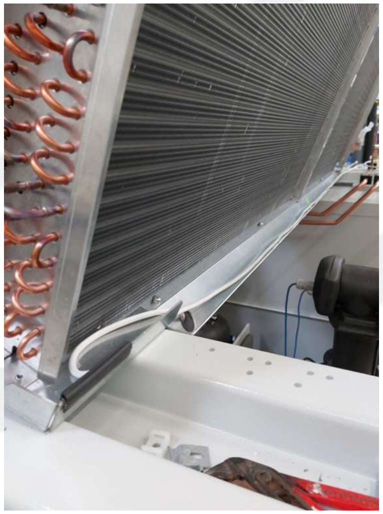




Condensate Management

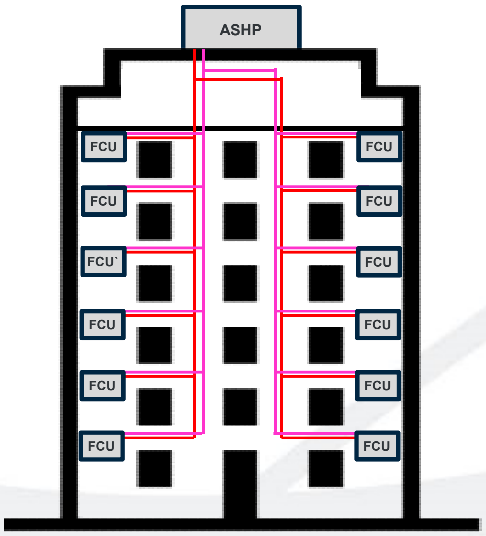
- Consider where condensate will flow
- Decrease impact of frosting on coil performance
- Can your roof support a small ice rink?

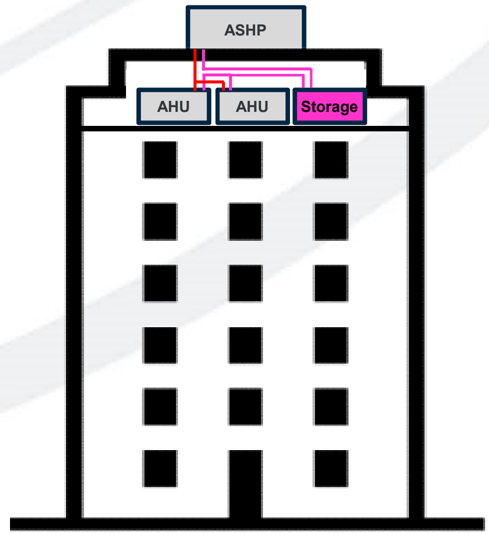




System Volume

- **What is system volume?**





System Volume

When in defrost, we reverse the cycle to cooling mode.

What happens to the loop temperature?

Unit output	0 ton
Load demand	100 ton
Starting temp	120 F
Max. time (6 minutes)	360 seconds
Volume (3.7 gal / ton)	370 gal
Final temp	81 F

Unit output	0 ton
Load demand	100 ton
Starting temp	120 F
Max. time (6 minutes)	360 seconds
Volume (6.5 gal / ton)	650 gal
Final temp	98 F

Unit output	0 ton
Load demand	100 ton
Starting temp	120 F
Max. time (6 minutes)	360 seconds
Volume (13.0 gal / ton)	1300 gal
Final temp	109 F

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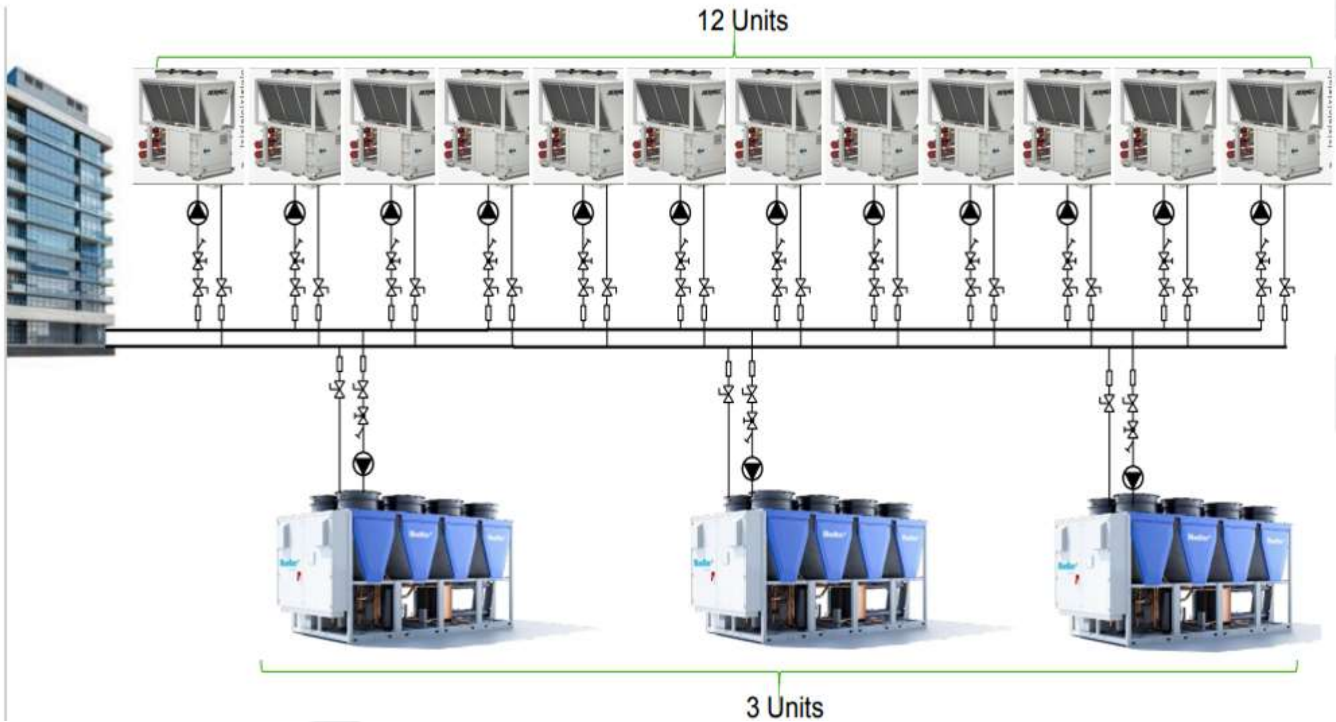
Modular vs. Unitary Air-to-Water Heat Pumps

300-ton cooling plant

vs.

(1) 300-ton machine (2-4 compressors) - or - (10) 30-ton modules (20 compressors)

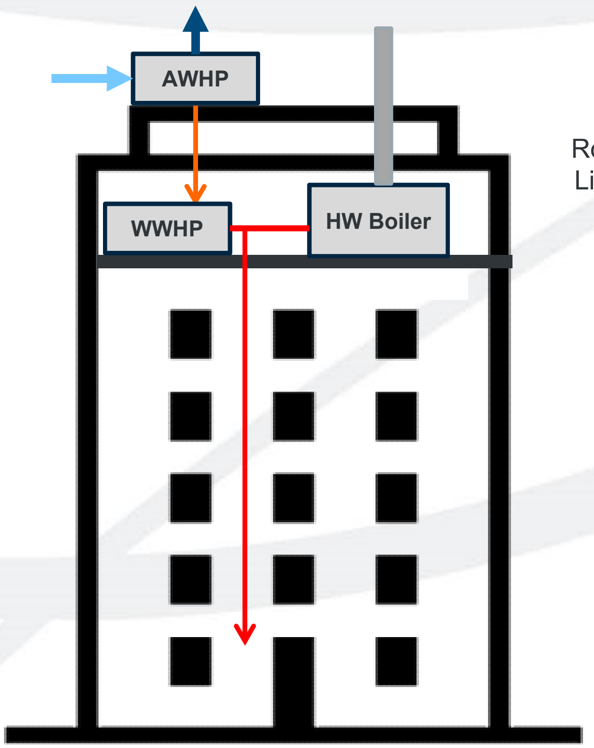
Modular vs. Unitary Air-to-Water Heat Pumps

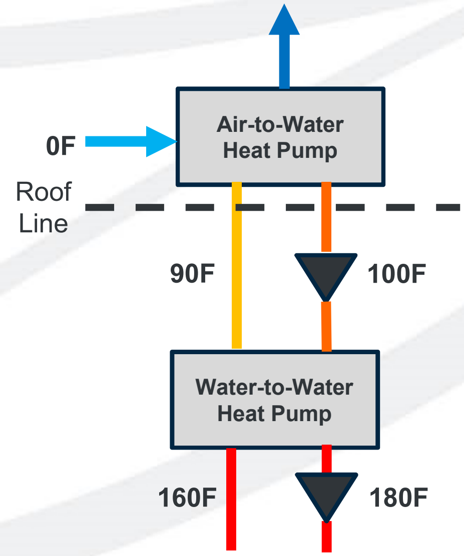


- 24 compressors vs. 12 compressors
- 24 circuits vs. 6 circuits
- 9 more balancing valves
- 18 more isolation valves
- 9 more electrical connections / controllers

High-Temp Hot Water (180F)

How do I get 180F HW with an ASHP?

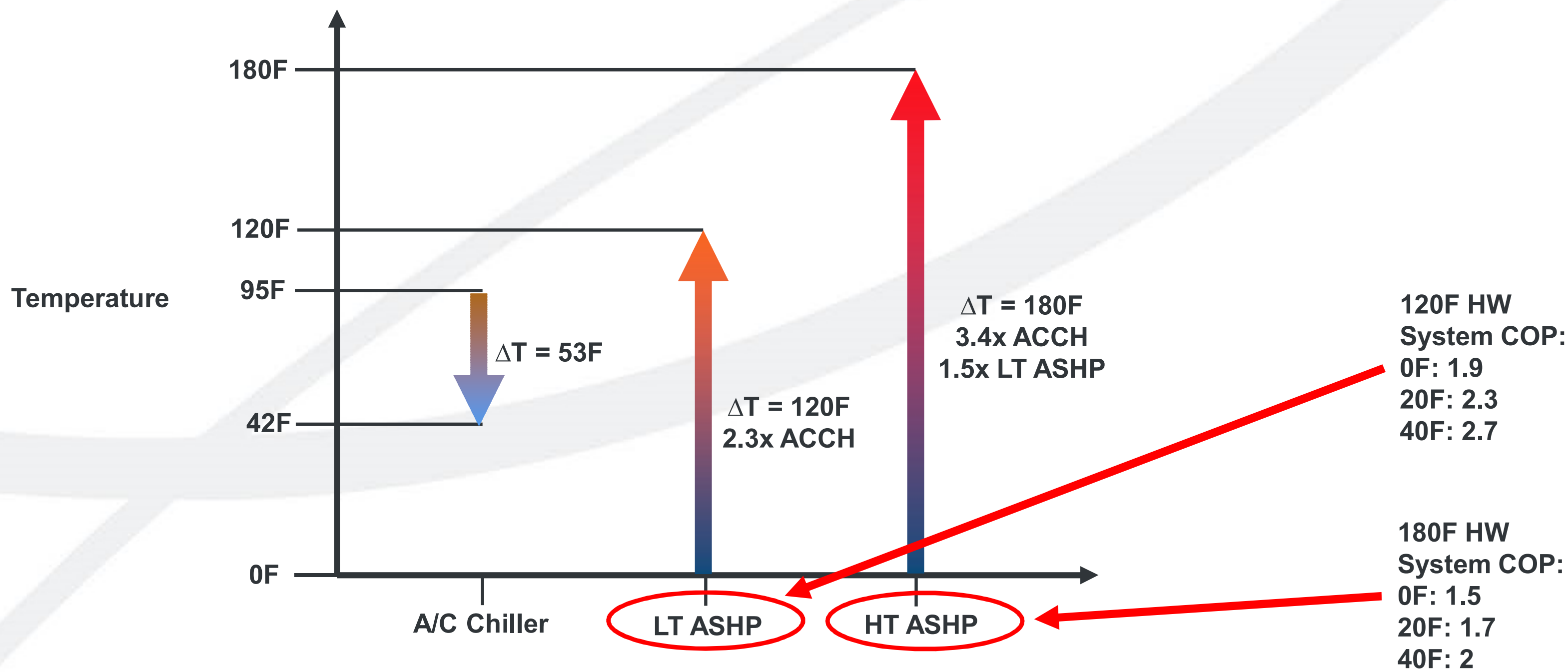




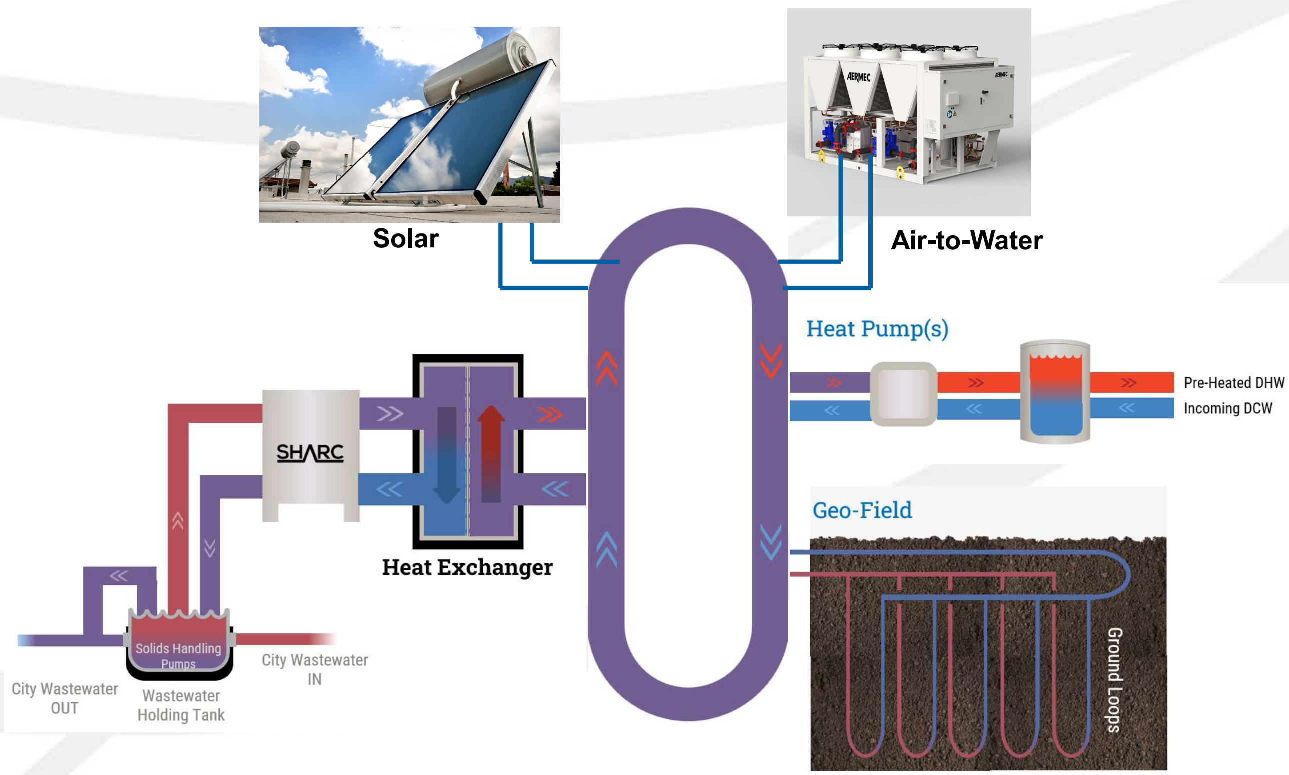
High-Temp Hot Water (180F)

Does it make sense to make 180F HW with an ASHP?

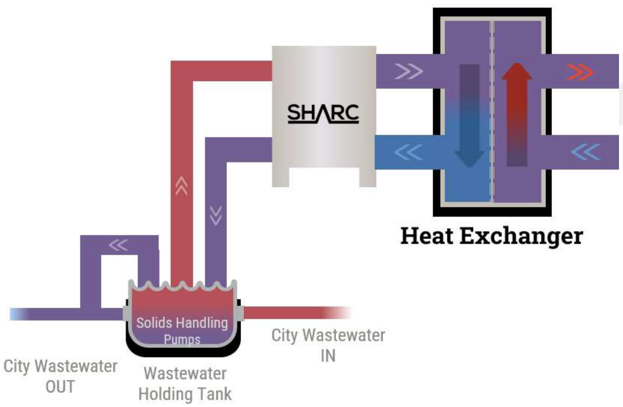
There are caveats. We can't cheat physics.



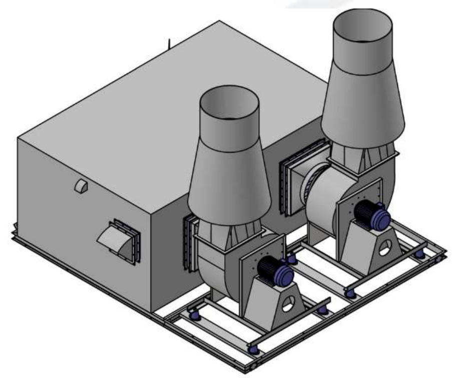
Alternative Heat Sources



Alternative Heat Sources

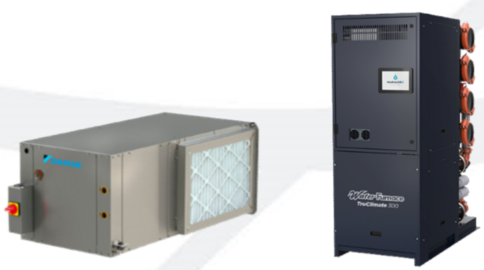


Wastewater Heat Recovery



Exhaust Air Thermal Reclaim

Solar



Year-Round Cooling Loads

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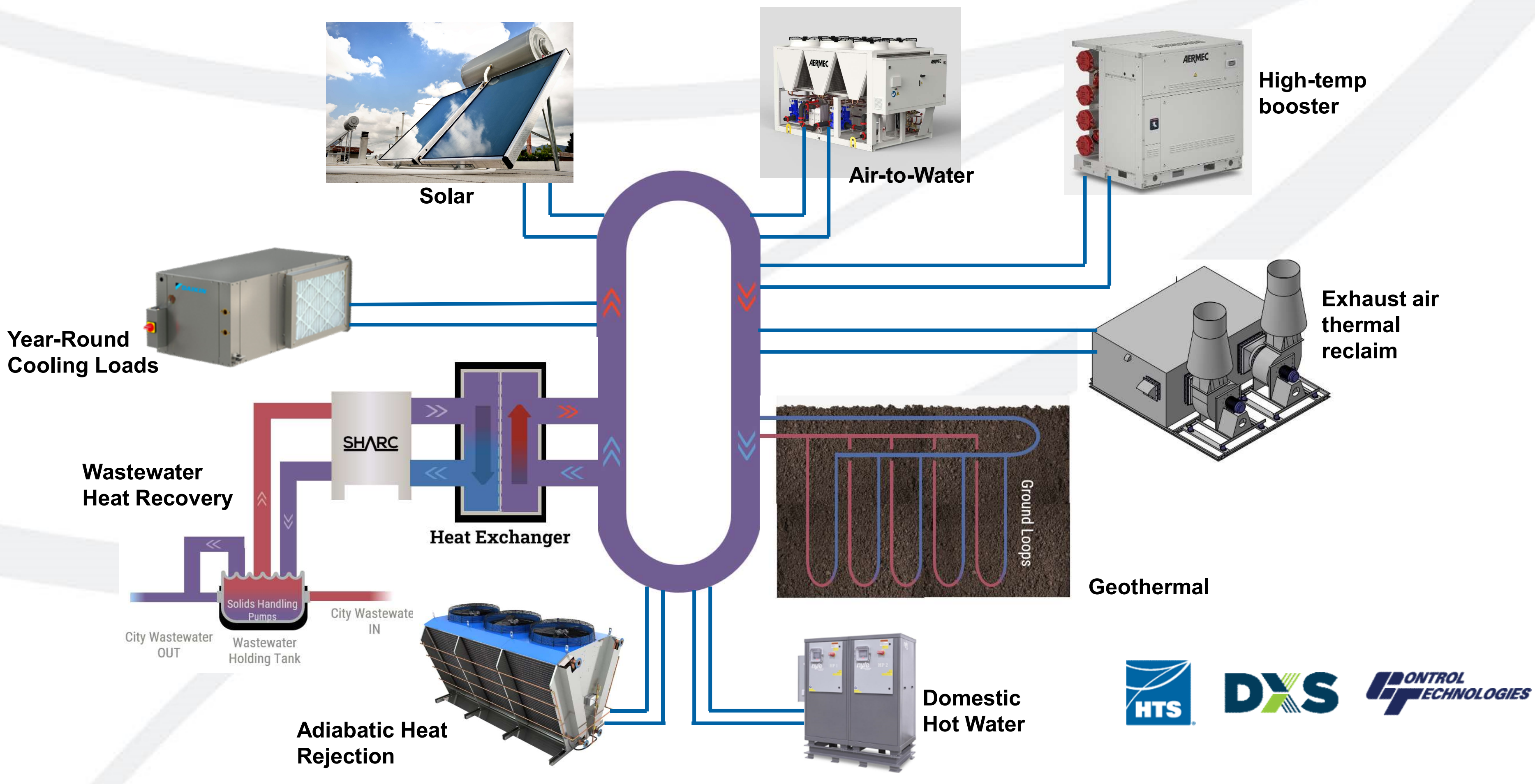
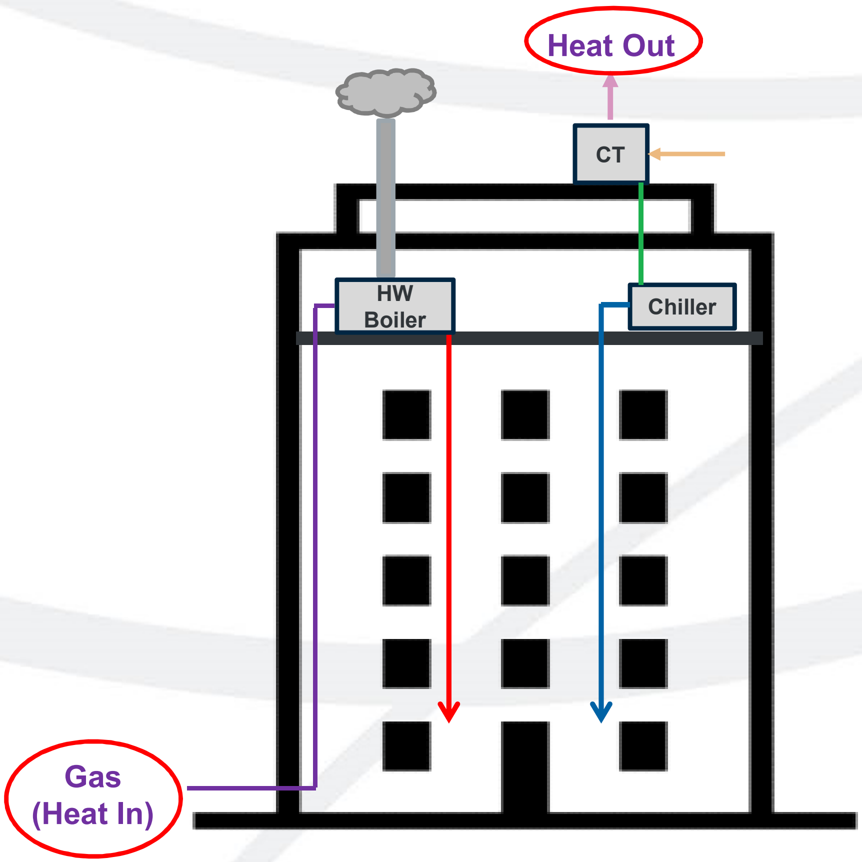
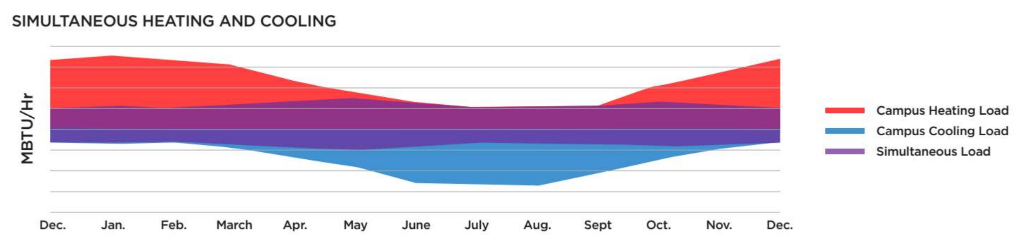
Thermal Networking

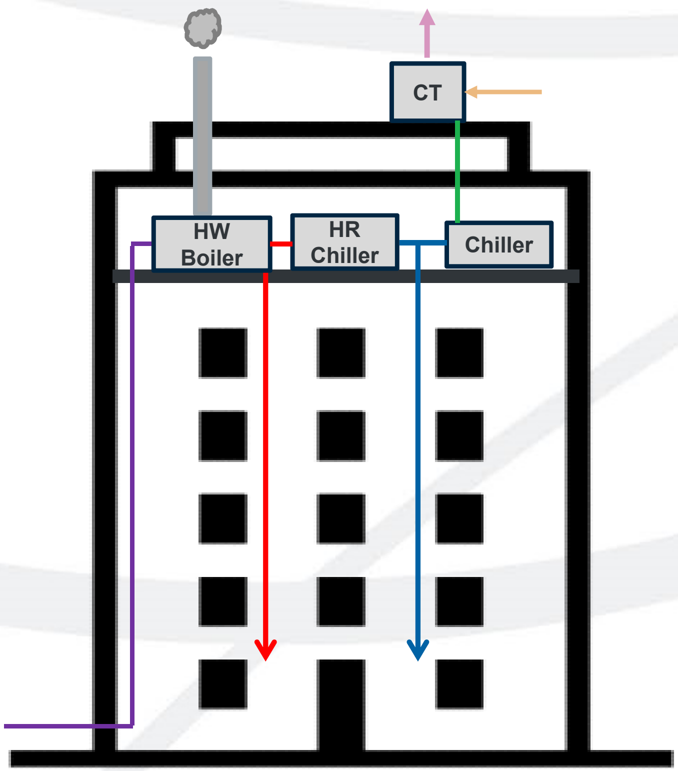


Reducing Demand From Central Heating Systems





Reducing Demand From Central Heating Systems



Air-to-Water Heat Pumps with Heat Recovery

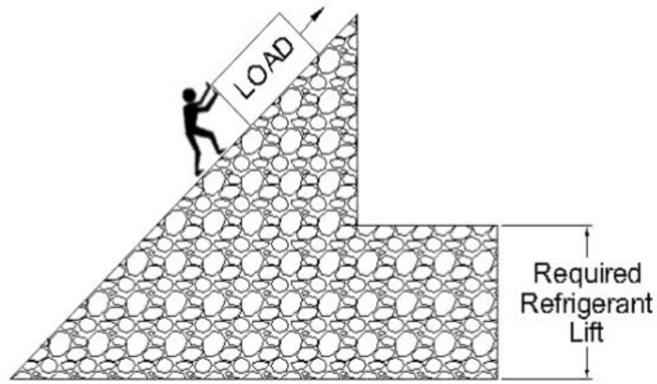
- Now available with inverter compressor technology to achieve new high levels of efficiency
- Operation to -15F ambient
- Fluid temps up to ~130F above ambient

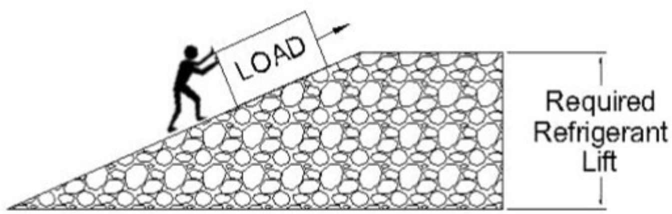
44°F Cooling

120°F Heating

Simultaneous Heating & Cooling

Temperature Reset





Only do as much lift as needed

At 40F ambient:

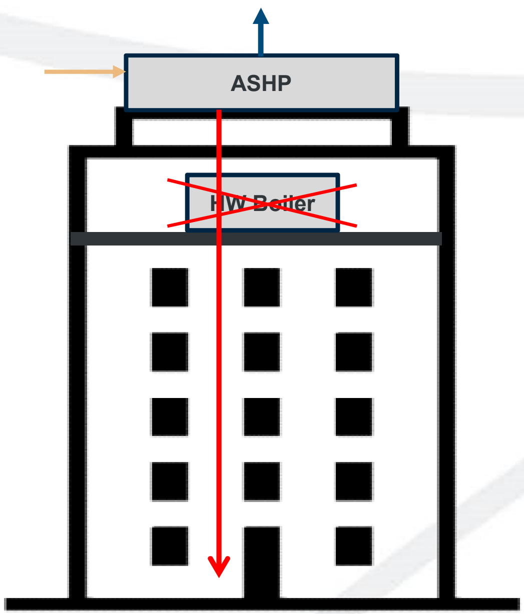
140F HW: COP = 1.93
130F HW: COP = 2.16
120F HW: COP = 2.42
110F HW: COP = 2.72
100F HW: COP = 3.06

20% Energy Savings (140F to 120F)

21% Energy Savings (120F to 100F)

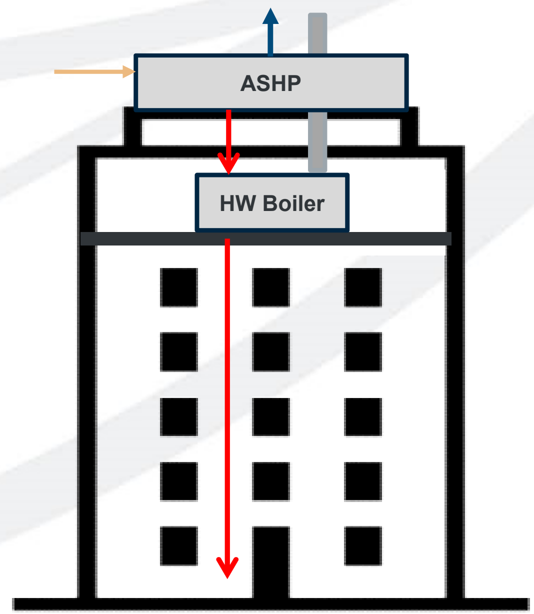
37% Energy Savings (140F to 100F)

Flexibility of Heat Source



Heat pump sized for 100%
of building load on a 0F day
without *backup*

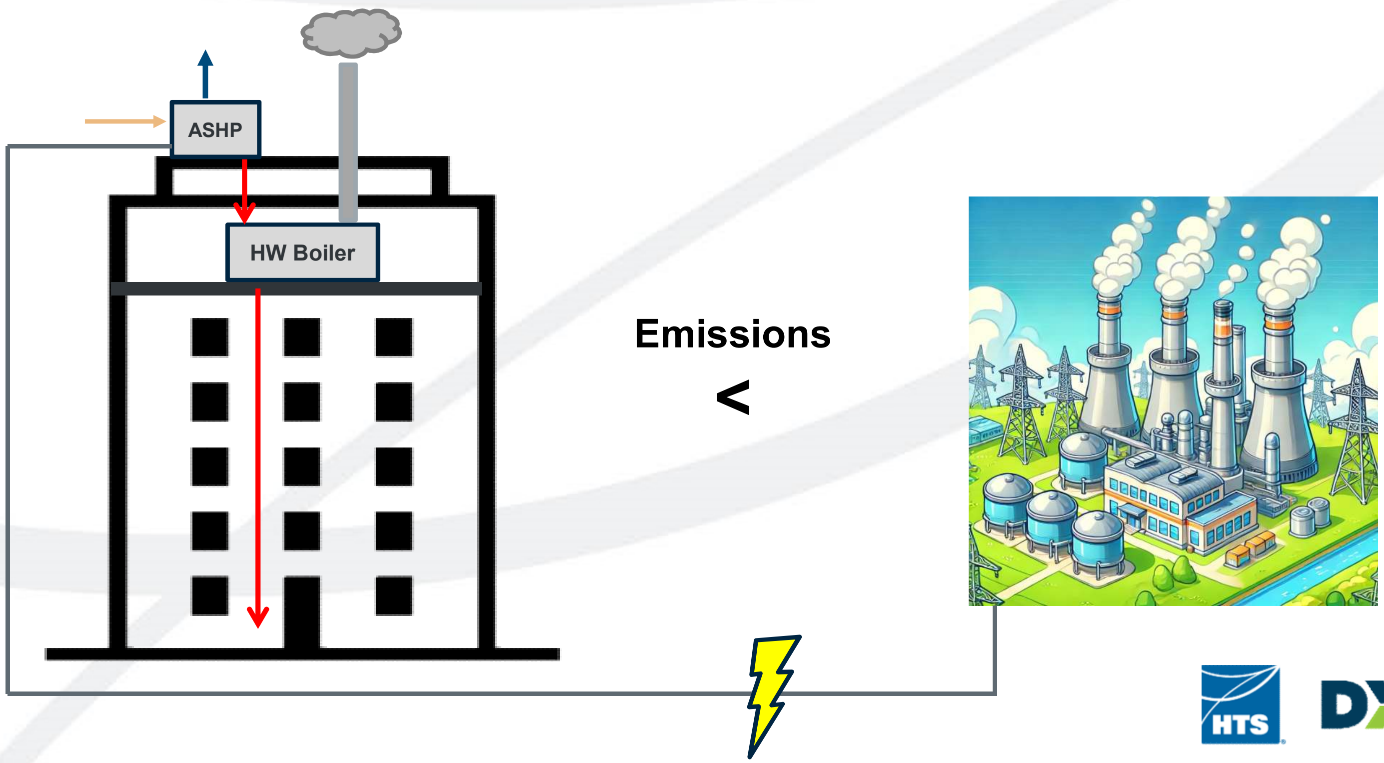
- or -



Heat pump sized for 100%
of building load on a 0F day
with *backup*

Flexibility of Heat Source

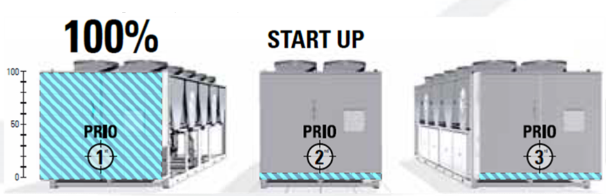
What if fossil-fuel-sourced power generation emissions exceed the emissions of running a boiler at the building?



Equipment-Level Optimization

BALANCED

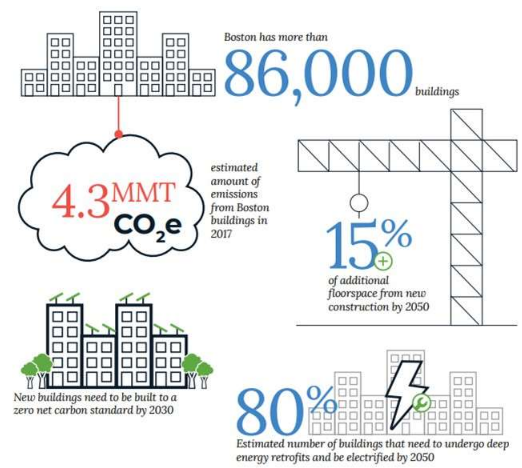
SATURATED



OPTIMIZED

Heat pumps are the heart - controls are the brain

- Building controls more important than ever
- Fault detection and energy monitoring are critical to maintaining building efficiency
- Reporting is not a want but a need



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Internal Notes

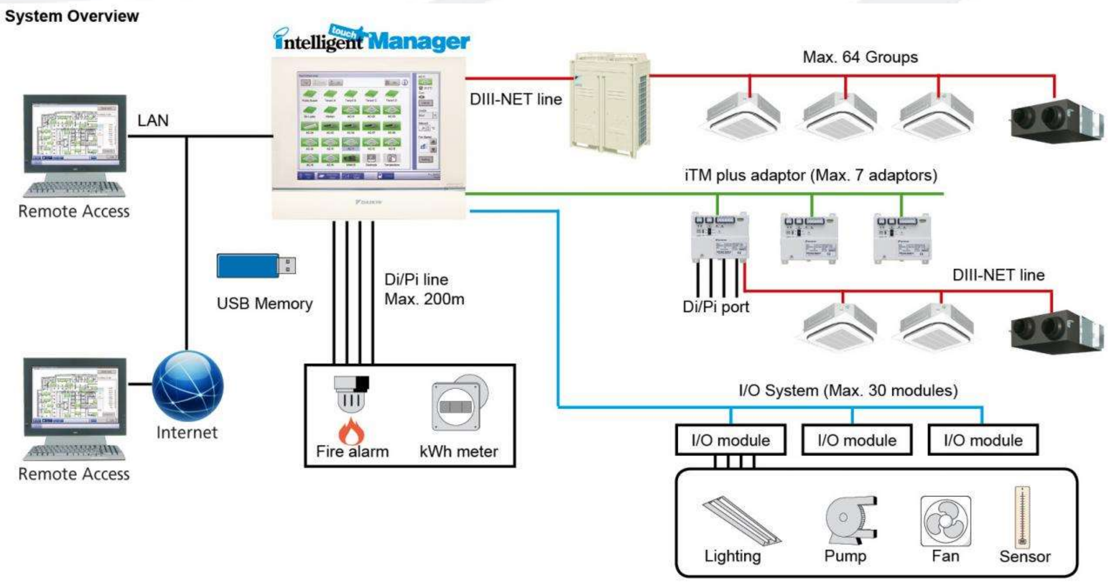
Part 4 – How hydronic compares to other options

Message:

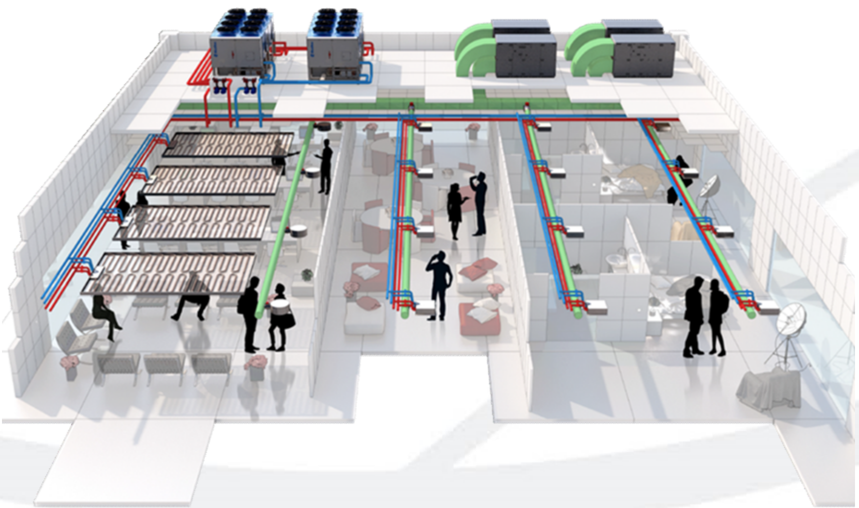
- **Hydronic vs. VRF**
  - Maybe we also mention that on jobs where RTU's would be used, the easy button is ASHP RTU's (and mention catalog option 3-68 tons and semi-custom/custom options to 120+ tons)
  - Unknown of VRF future. Replacing items and controls integration. Re-using existing pipes? Next phase-down? How to expand VRF in the future – will there be enough capacity, and if not, not easy to add. Are there enough spare ports? Who can do this work and integrate controls years down the road? Is service locked into that supplier? Is it like a proprietary control system where you can't get out of it even if you dislike what you get?

What we can learn from VRF

- Truly packaged systems for <200 ton systems
- Simplified hydronic packages
- Simplified controls
- Contractor training



Hydronic - System Design Flexibility

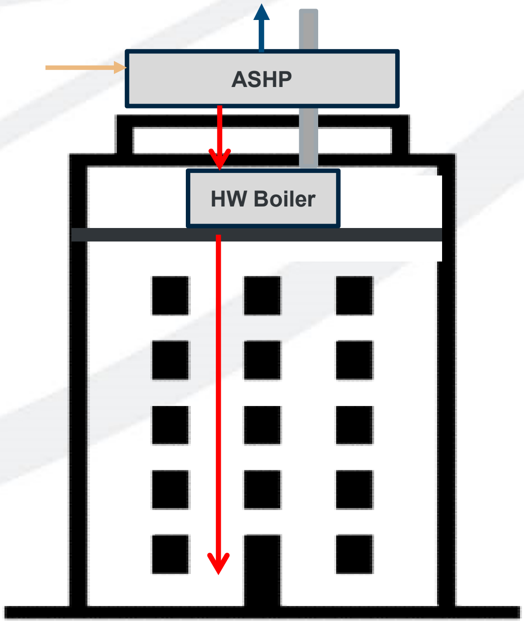


- Unlimited end device options
- High-COP convectors
- Simplify building use type conversions
- Contractor training

HTS DXS CONTROL TECHNOLOGIES

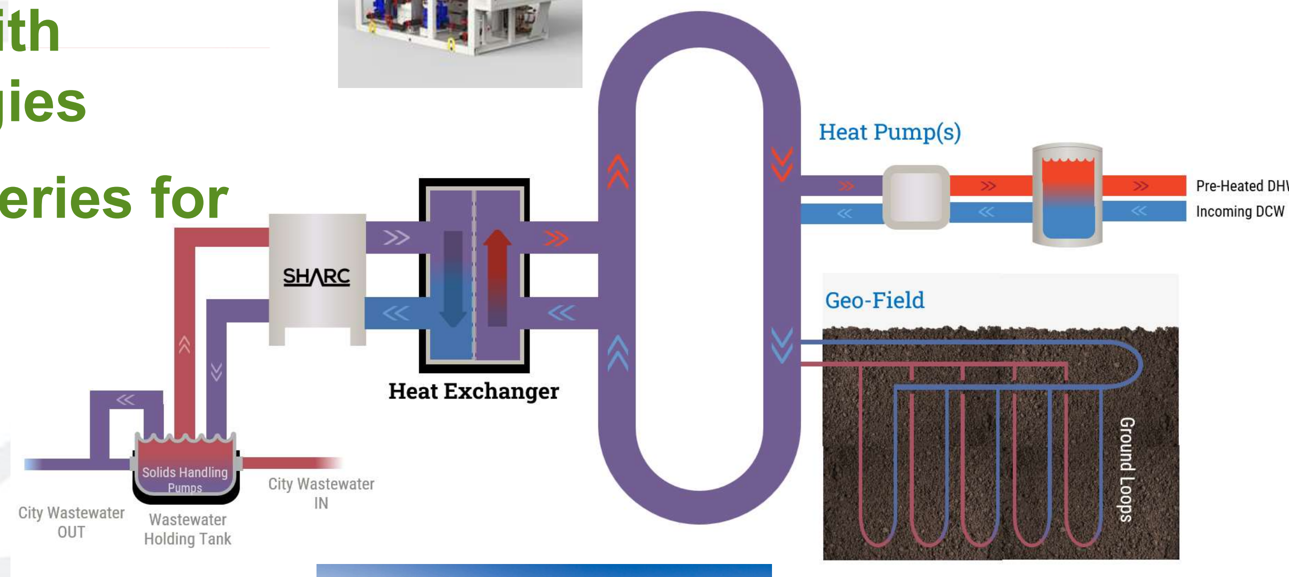
Hydronic - Easier Backup Integration

- Retain existing NG boilers
- Integrate with new electric boilers
- Utilizes the same terminal systems
- Easy hookup for temporary rental systems.



Hydronic - True Heat Recovery and Storage

- True building level HR
- Easy integration with evolving technologies
- Utilize thermal batteries for grid stabilization



Refrigerant Leakage – Hydronic vs. VRF

Table 9 Typical Annual Refrigerant Leakage Rates by Equipment Type

	Equipment Type	Typical Annual Leakage Rate of Refrigerant Mass Charge Per Year
1	Supermarket refrigeration	30%
3	Commercial condensing units	15%
4	Water chillers	5%
5	Hermetic units with no field installed refrigerant piping	1%
6	Rooftop unit air conditioner	6%
7	Residential heat pump and air conditioner	2%
8	Variable refrigerant flow air conditioner	10%
9	Other refrigeration	2%
10	Other air conditioning	2%

Source: ASHRAE 228: Standard Method of Evaluating Zero Net Energy and Zero Net Carbon Building Performance

- VRF has 2-4x refrigerant charge
- More circuits, more fittings, more leakage
- Consider GWP of entire building

Refrigerant GWP			
HOTEL	**A Hydronic - DCV**	**B VRF - CAV**	**Hydronic System benefit**
Refrigerant charge	66 lbs	357 lbs	81% less charge
Refrigerant leakage, annual	3.3 lbs	35.7 lbs	91% less leakage

Hydronic – Ability for Thermal Networking

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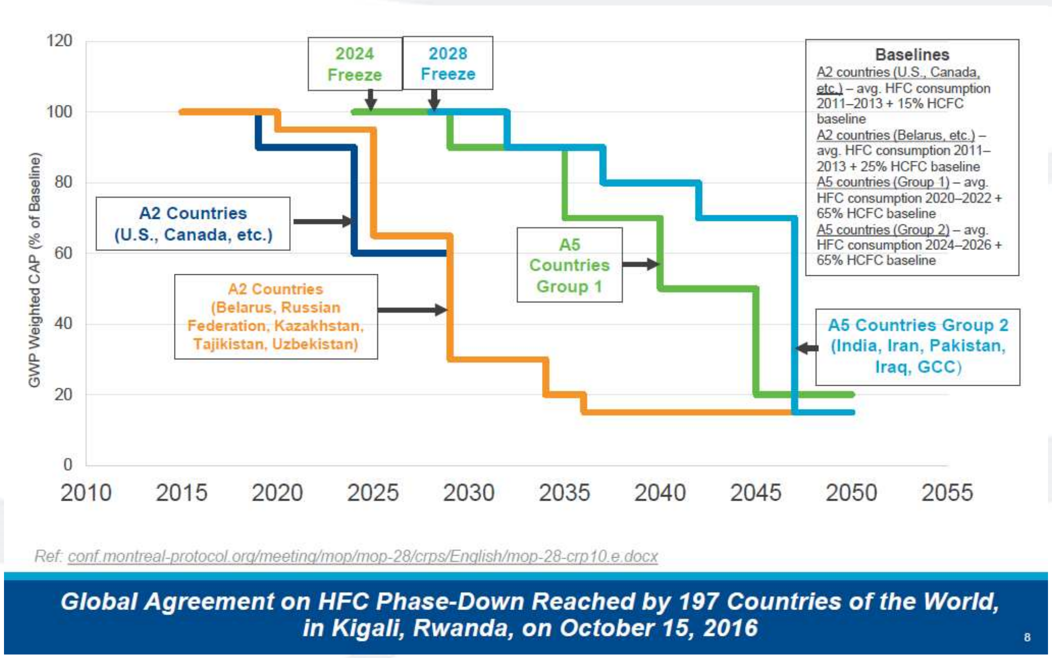
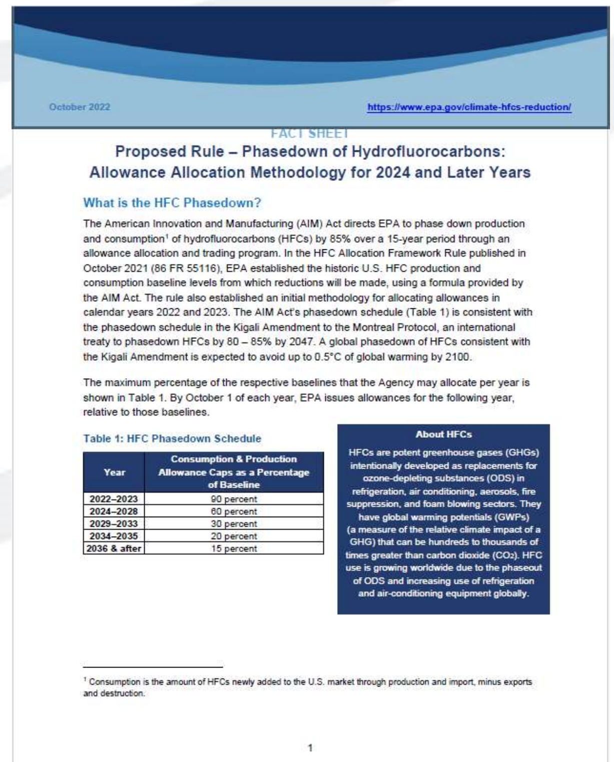
- **Part 5 – The future**

Beyond A2L





October 2022 https://www.epa.gov/climate-hfcs-reduction/

FACT SHEET

Proposed Rule – Phasedown of Hydrofluorocarbons: Allowance Allocation Methodology for 2024 and Later Years

What is the HFC Phasedown?

The American Innovation and Manufacturing (AIM) Act directs EPA to phase down production and consumption[1] of hydrofluorocarbons (HFCs) by 85% over a 15-year period through an allowance allocation and trading program. In the HFC Allocation Framework Rule published in October 2021 (86 FR 55116), EPA established the historic U.S. HFC production and consumption baseline levels from which reductions will be made, using a formula provided by the AIM Act. The rule also established an initial methodology for allocating allowances in calendar years 2022 and 2023. The AIM Act's phasedown schedule (Table 1) is consistent with the phasedown schedule in the Kigali Amendment to the Montreal Protocol, an international treaty to phasedown HFCs by 80 – 85% by 2047. A global phasedown of HFCs consistent with the Kigali Amendment is expected to avoid up to 0.5°C of global warming by 2100.

The maximum percentage of the respective baselines that the Agency may allocate per year is shown in Table 1. By October 1 of each year, EPA issues allowances for the following year, relative to those baselines.

Table 1: HFC Phasedown Schedule

Year	Consumption & Production Allowance Caps as a Percentage of Baseline
2022–2023	90 percent
2024–2028	60 percent
2029–2033	30 percent
2034–2035	20 percent
2036 & after	15 percent

About HFCs

HFCs are potent greenhouse gases (GHGs) intentionally developed as replacements for ozone-depleting substances (ODS) in refrigeration, air conditioning, aerosols, fire suppression, and foam blowing sectors. They have global warming potentials (GWPs) (a measure of the relative climate impact of a GHG) that can be hundreds to thousands of times greater than carbon dioxide (CO_2). HFC use is growing worldwide due to the phaseout of ODS and increasing use of refrigeration and air-conditioning equipment globally.

[1] Consumption is the amount of HFCs newly added to the U.S. market through production and import, minus exports and destruction.

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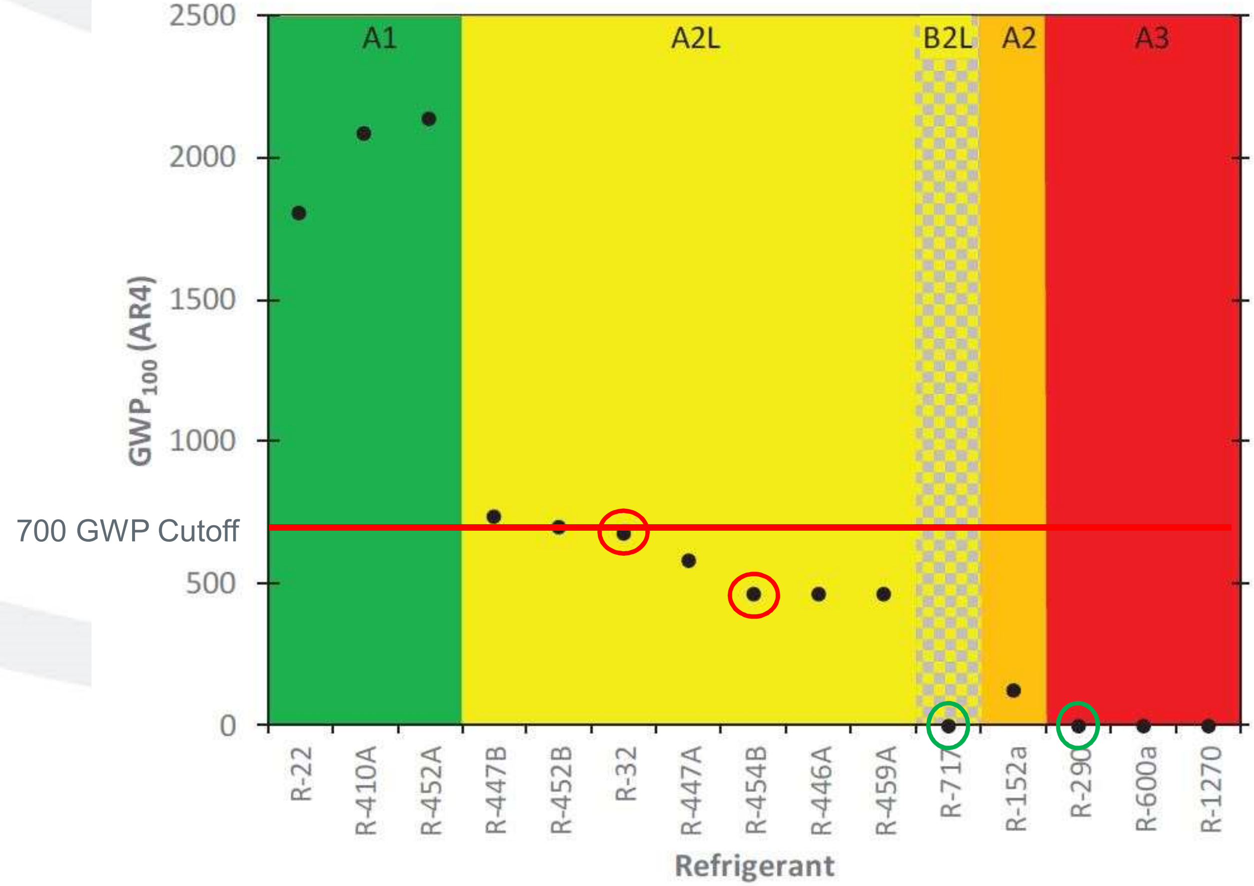
Beyond A2L



- Consider other issues like PFAS and Acid Rain
- Push to natural refrigerants
- Propane, CO_2, Ammonia

R290 = Propane

- GWP = 0
- Similar envelope to current A2L's
- Easily integrate into existing hydronic systems

What does this mean for distributed air and refrigerant?

- Think about 10->20->50 year plan
- Assess procurement risks
- Look to places ahead of us

?

Summary

- We have come a long way in the past 5-10 years
- Think big but don't lose track of the task at hand
- Don't brute-force decarbonization
- Weigh pros and cons of distributed hydronic vs refrigerant vs air
- Buildings last more than a lifetime…

Questions? Fill out the form for a chance to win a drone!

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