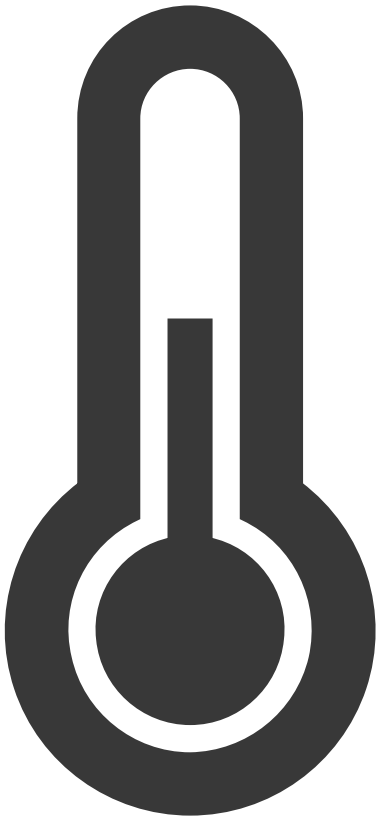
Electrification and decarbonization, chiller heater technologies and trends

Prepared for ASHRAE IA 11/02/2023

Dan Gentry – Applications Engineer

TRANE®

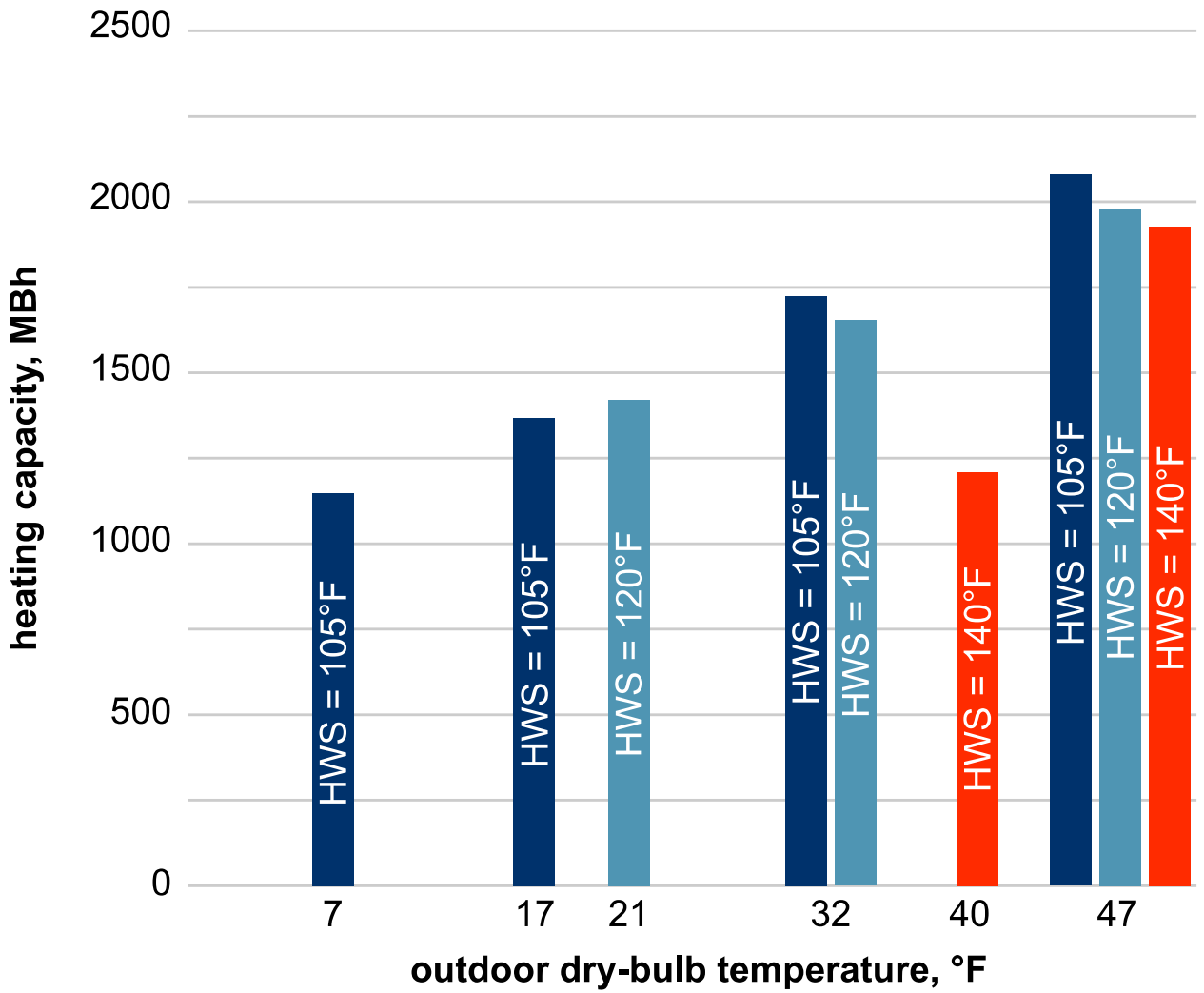
- Best Practices / Trends
- Applied heating products
  - Heat Recovery
  - Heat Pump
  - Air source
  - Water source
- Systems
  - Considerations
  - Examples
- Refrigerants
- Incentives



Low temperature hot water

Best Practices

Hot Water Supply Temperature, OADB, Capacity



- When outdoor air is colder, heat pumps lose efficiency, and heating capacity is lower.
- When hot-water supply temperature is reduced, heat pumps gain efficiency and capacity.

Equipment availability based on HW temperature

105-140F supply HW

- Almost any chiller can be used
- Air source or water source
- Scroll, screw, centrifugal

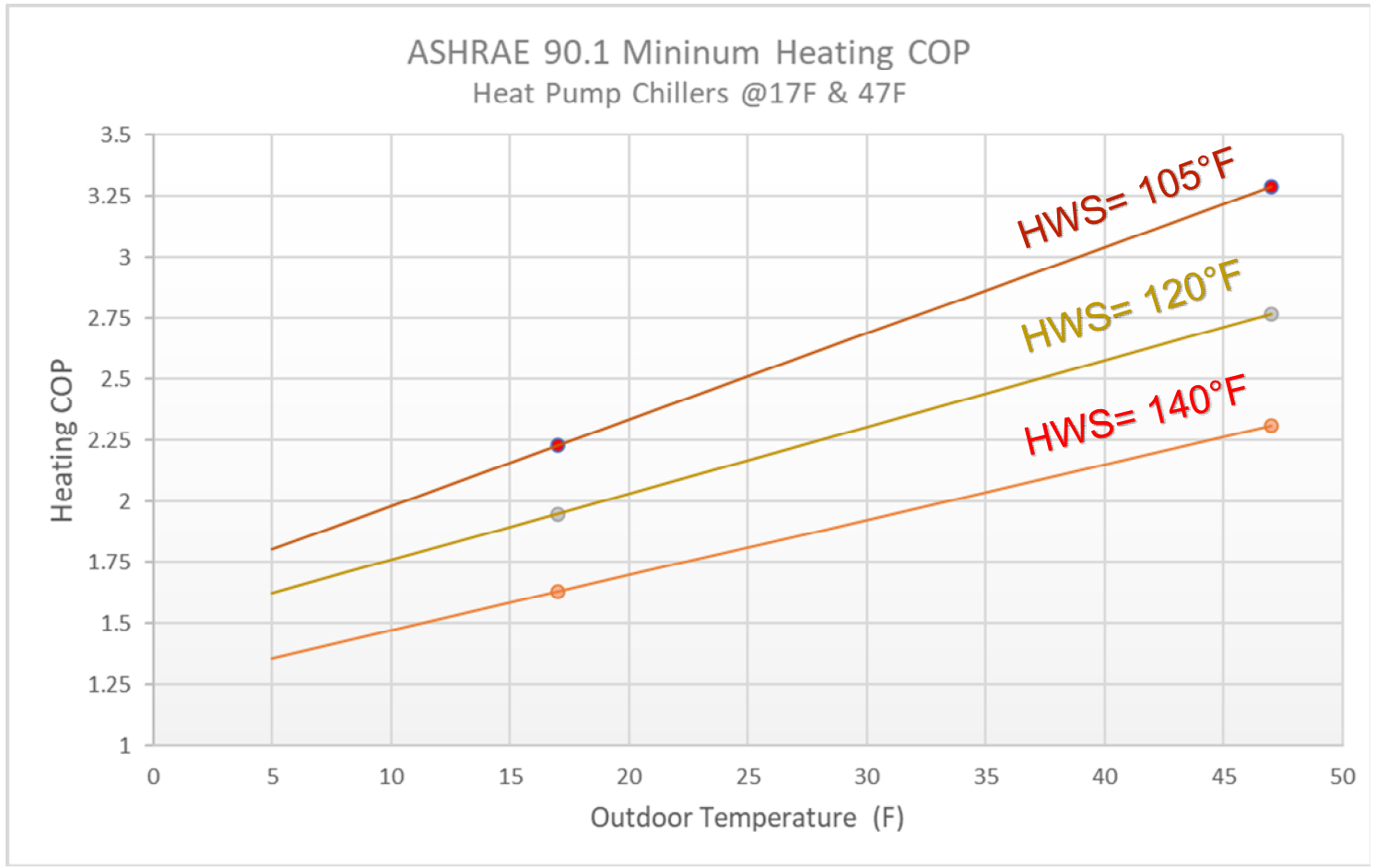
141-165F supply HW

- Fewer options
- No current air source
- Small scroll and screw chillers
- Cascade

Over 165F supply HW

- Limited options
- Small scroll
- Large centrifugal
- Booster
- Cascade

Hot Water Supply Temperature, Outdoor Air and COP

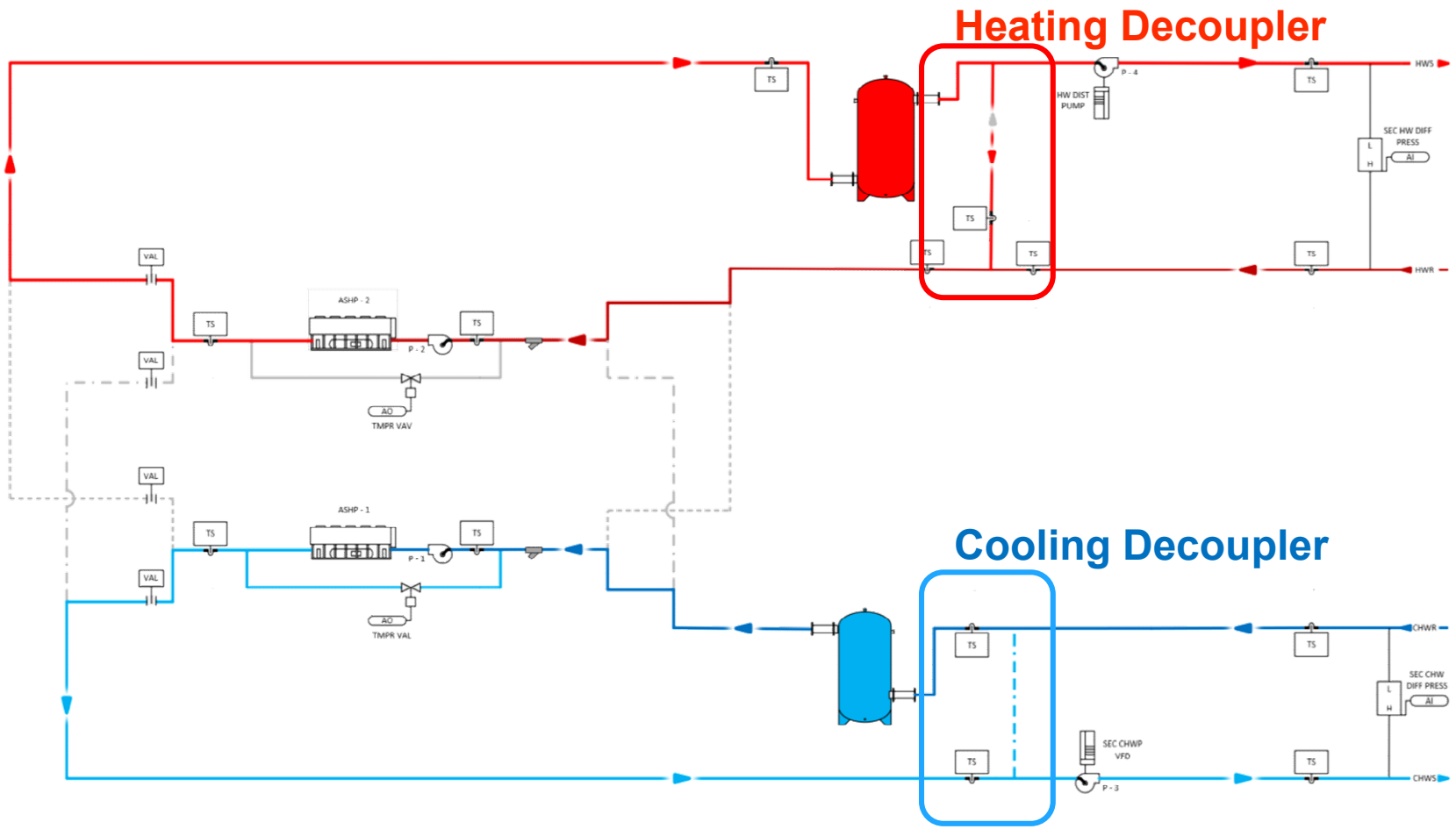


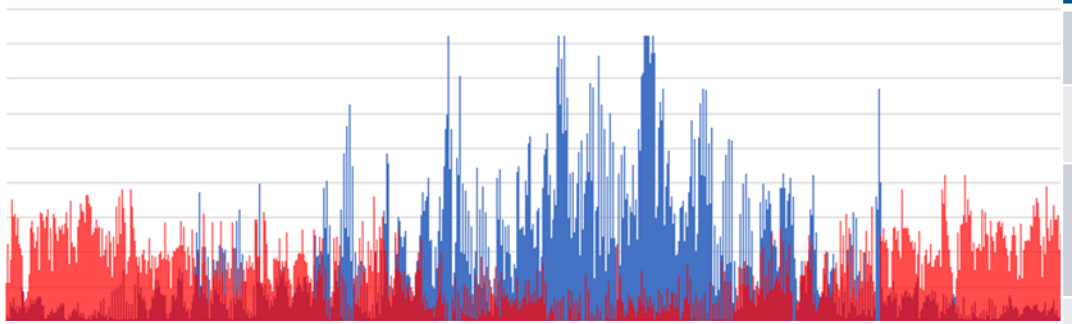
1%

1% penalty per
1°F above 105°F

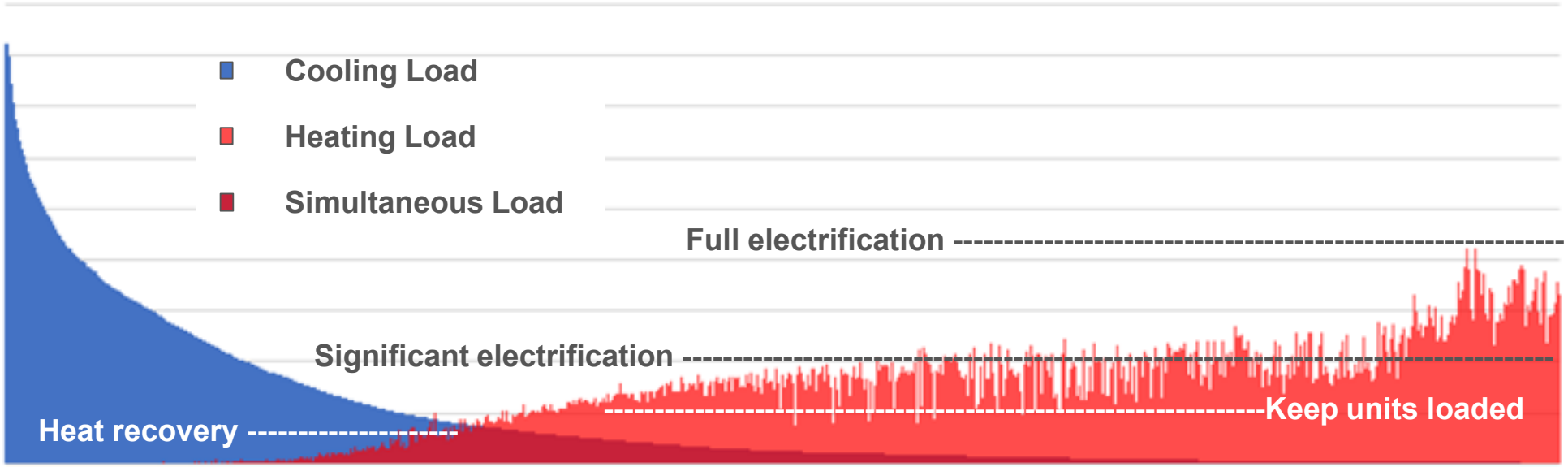
140°F hot water requires 35% more peak power and annual heating energy than 105°F

Four-Pipe Distribution



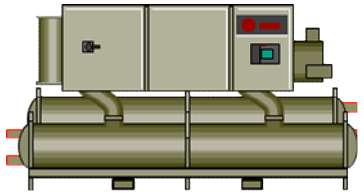


Goal	Unit sizing guidance basis
Heat recovery	Simultaneous heating & cooling
Full electrification	Peak heating loads
Significant electrification	Peak heating load minus augmented heating unit capacity (e.g. boilers)
Keep units loaded	System reliability and simplicity

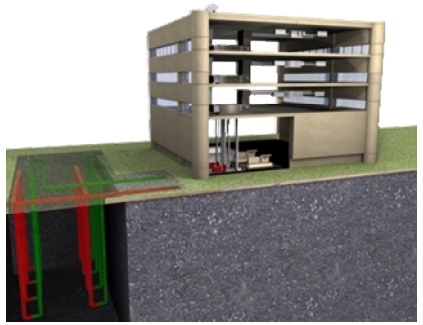


Electrified systems – heat sources

Ambient Air



Cooling Load
(Heat Recovery)

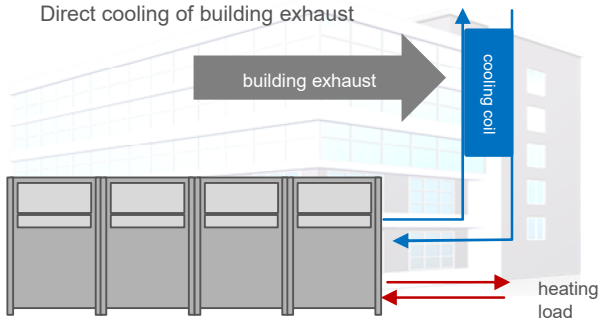


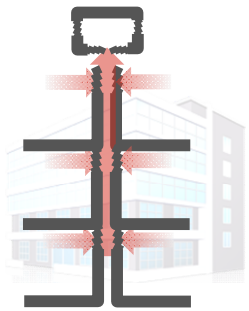
Geothermal
loop

Lake,
river, pond

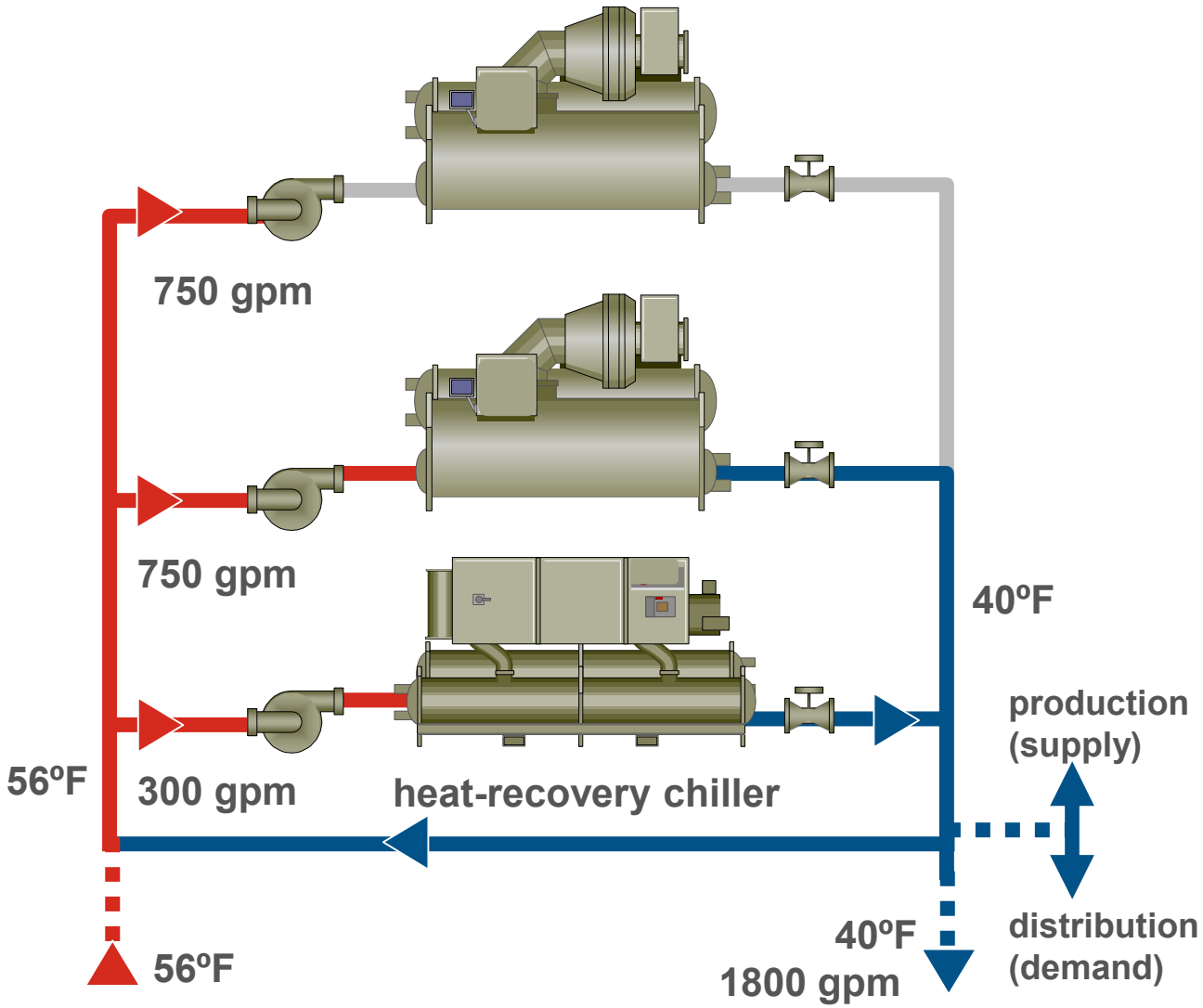
Storm and
sewer

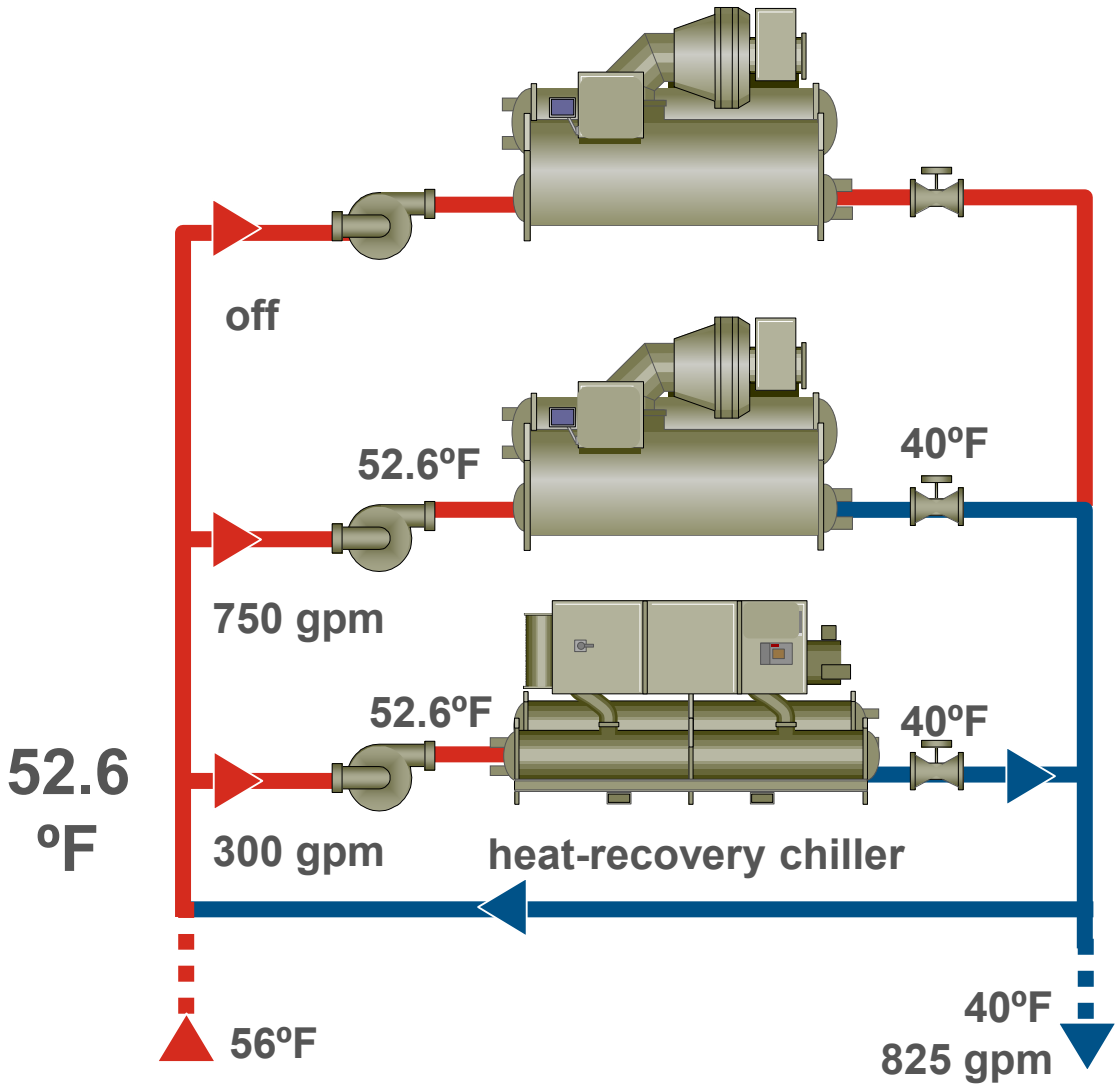
Thermal energy
storage battery
“Storage Source
Heat Pump”





Exhaust
air coil

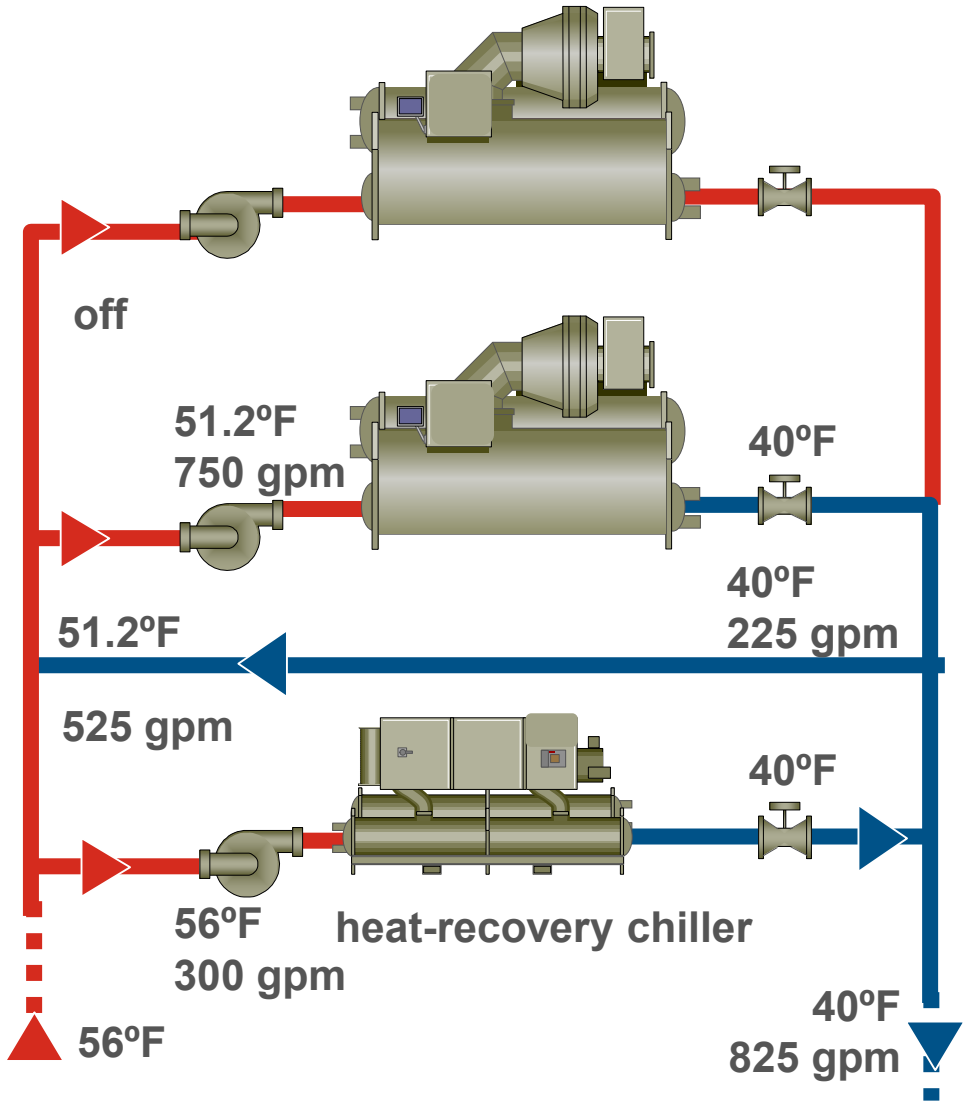

750 gpm
750 gpm
40ºF
56ºF
300 gpm
heat-recovery chiller
production
(supply)
56ºF
40ºF
1800 gpm
distribution
(demand)



All operating units loaded to equal percentages

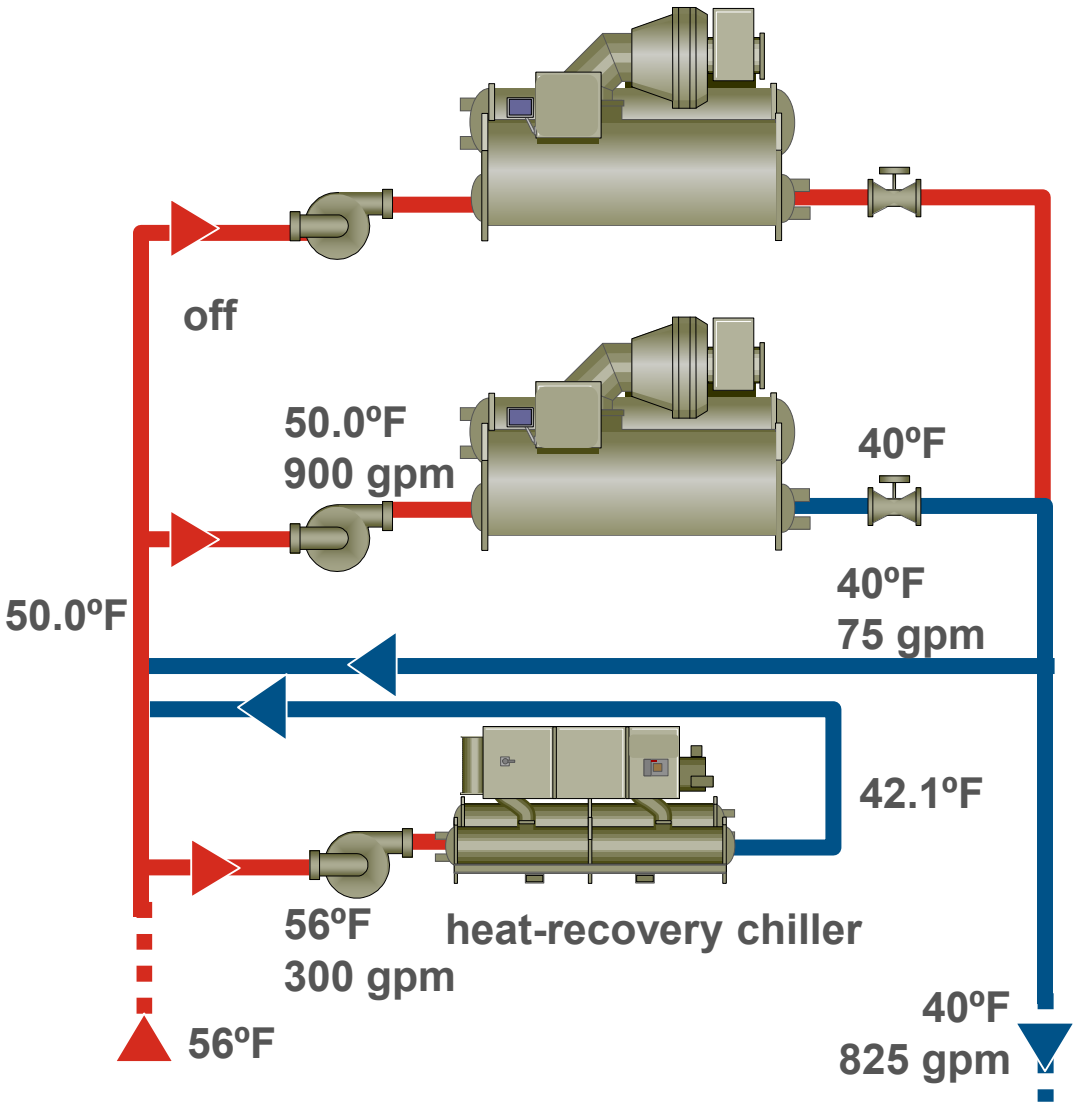
	Cooling (tons)	Heating (MBh)
Building Loads	550	2,600
Heat recovery chiller	157.5	2,360
Cooling chiller	392.5	0
Heat purchased		240

Not optimal



Units on load side of bypass loaded preferentially

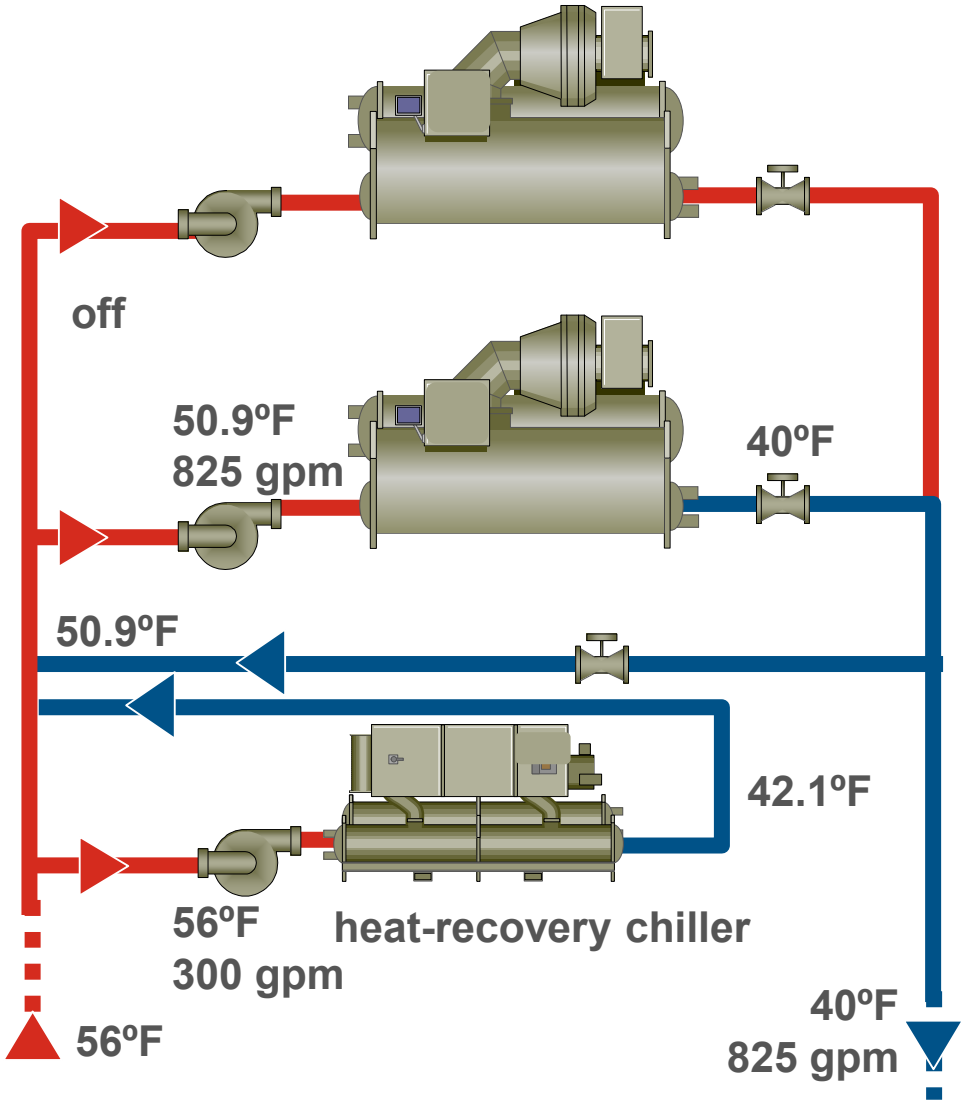
	Cooling (tons)	Heating (MBh)
Building Loads	550	2,600
Heat recovery chiller	200	3,000
Cooling chiller	350	0
Heat purchased		0
Heat that must be rejected from HR chiller	0	400



Unit loaded to exactly to satisfy heating load

	Cooling (tons)	Heating (MBh)
Building Loads	550	2,600
Heat recovery chiller	174	2,600
Cooling chiller	376	0
Heat purchased		0
Heat that must be rejected from HR chiller		0

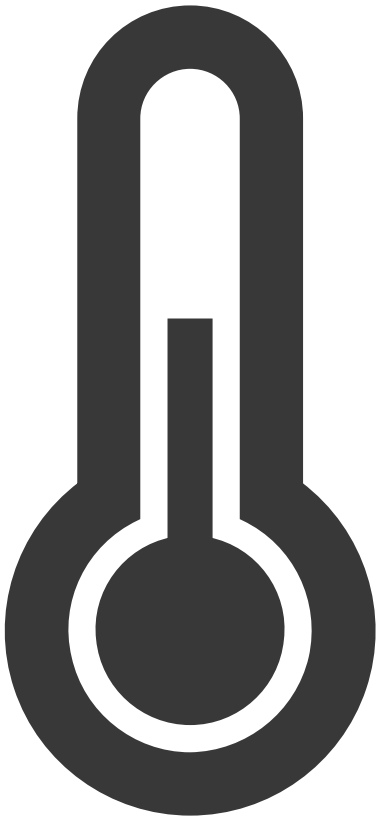
Simple and Reliable



Unit loaded to exactly to satisfy heating load

	Cooling (tons)	Heating (MBh)
Building Loads	550	2,600
Heat recovery chiller	174	2,600
Cooling chiller	376	0
Heat purchased		0
Heat that must be rejected from the HR chiller		0

Simple and Reliable



High temperature hot water

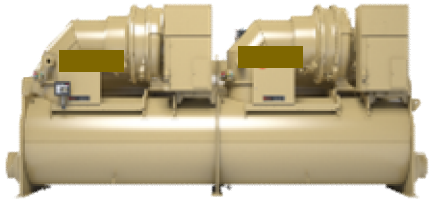
Best Practices

- Today, water sourced equipment
- Mind the delta T
- Pre-heat
- Remember we are moving heat, where is it coming from?

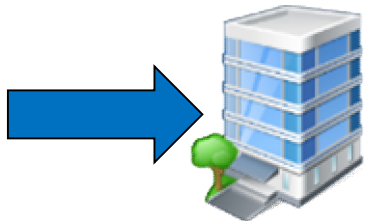
Applied Heating Units

Brief overview of technology

Water-cooled and water-source units

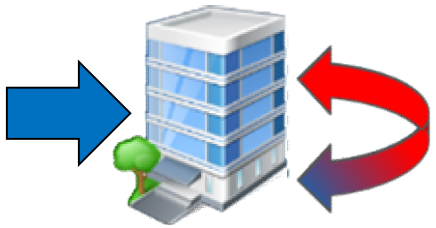


Chiller



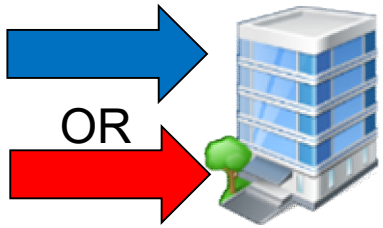
Cooling only

Chiller + Heat Recovery



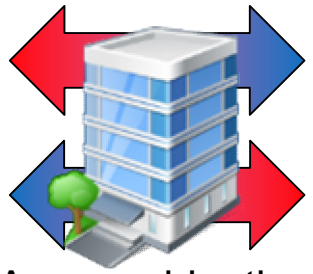
Heating while Cooling

Heat Pump



Heating or Cooling

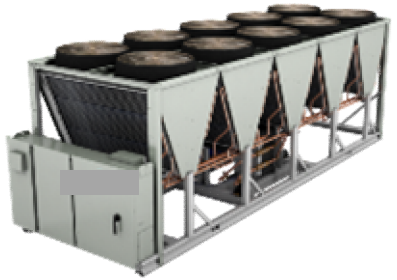
Multi-pipe



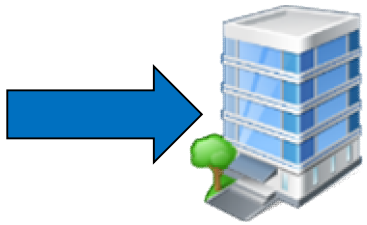
Any combination

Air-cooled and air-source units



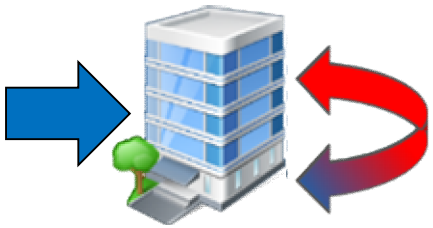



Chiller



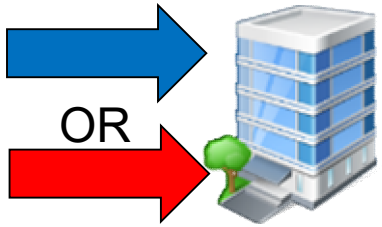
Cooling only

Chiller + Heat Recovery



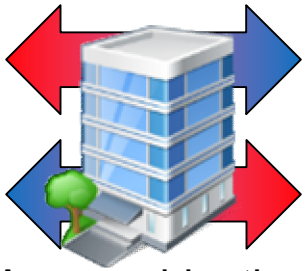
Heating while Cooling

Heat Pump



Heating or Cooling

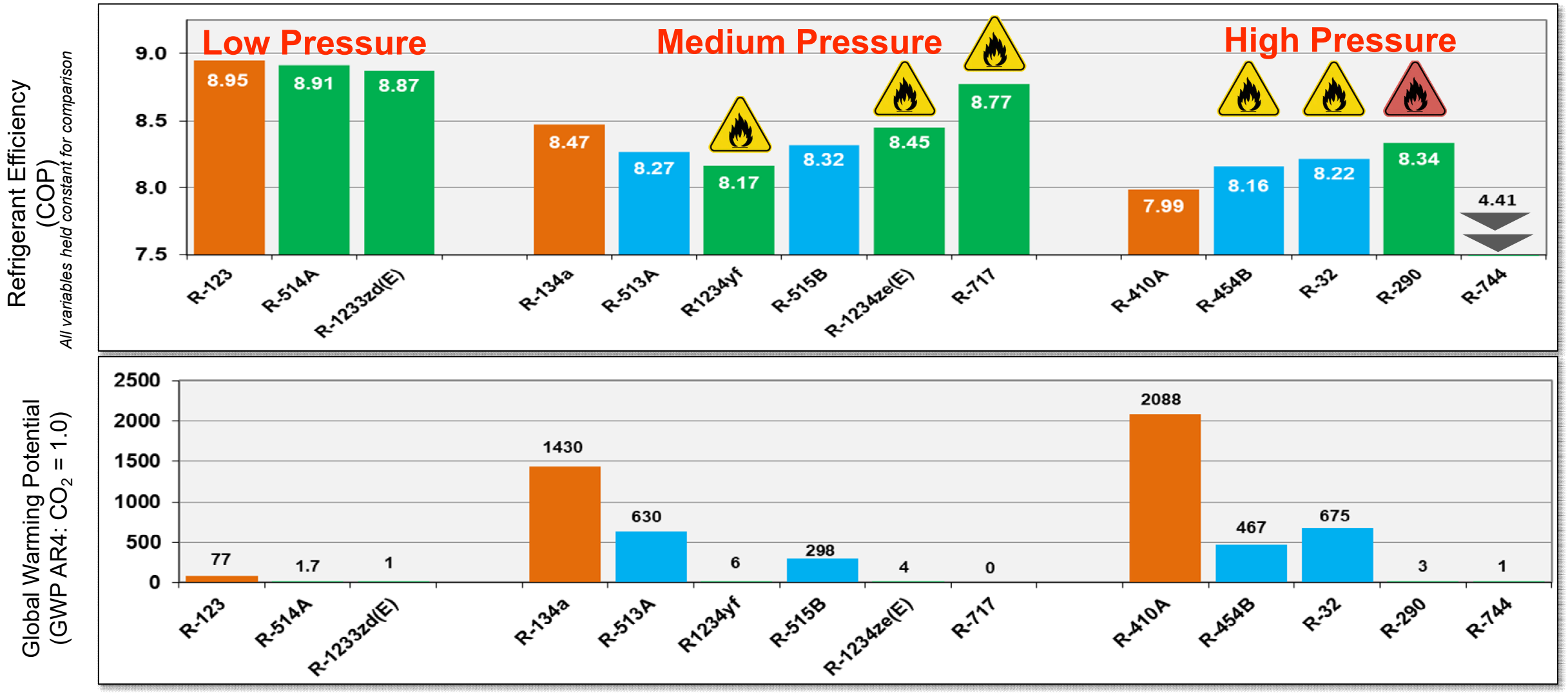
Multi-pipe



Any combination

Efficiency and GWP Comparison

Baseline | Lower GWP | Ultra-Low GWP



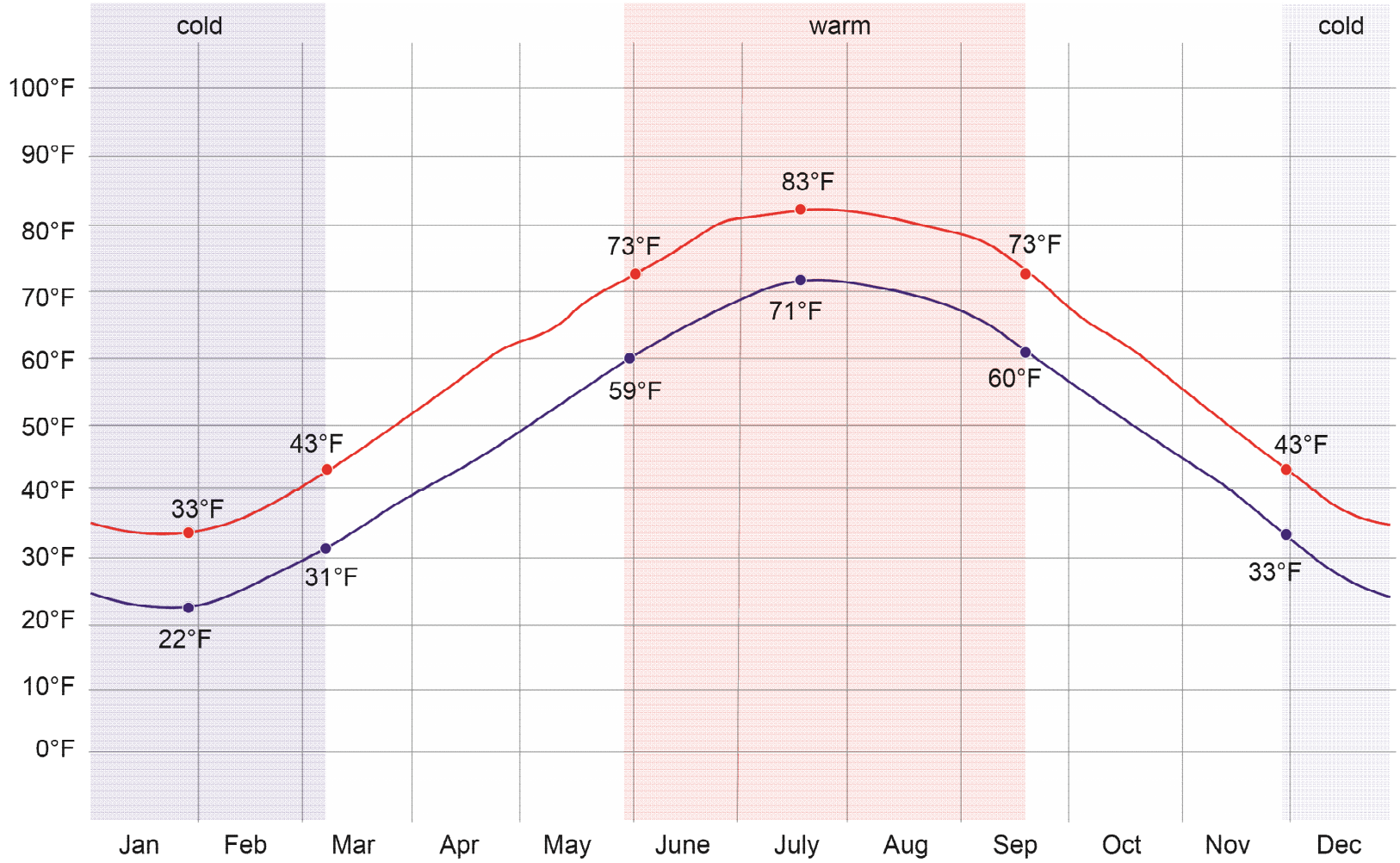
Industry Choices Offer Options & Trade-offs; New Options Evolving

New Construction to mild retrofit

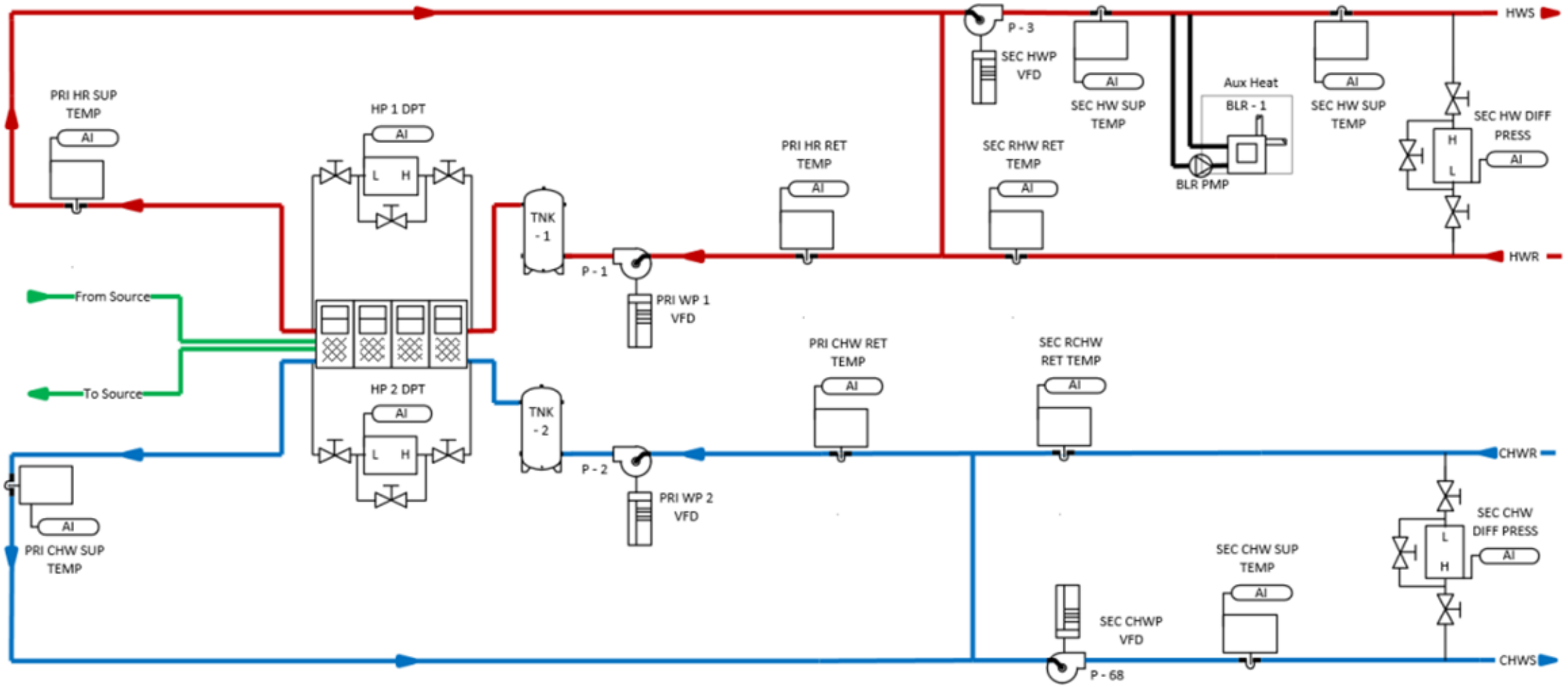
Low temperature hot water

System 1
Cold Climate Electrification with Backup Heating

Average high and low temperatures in Chicago

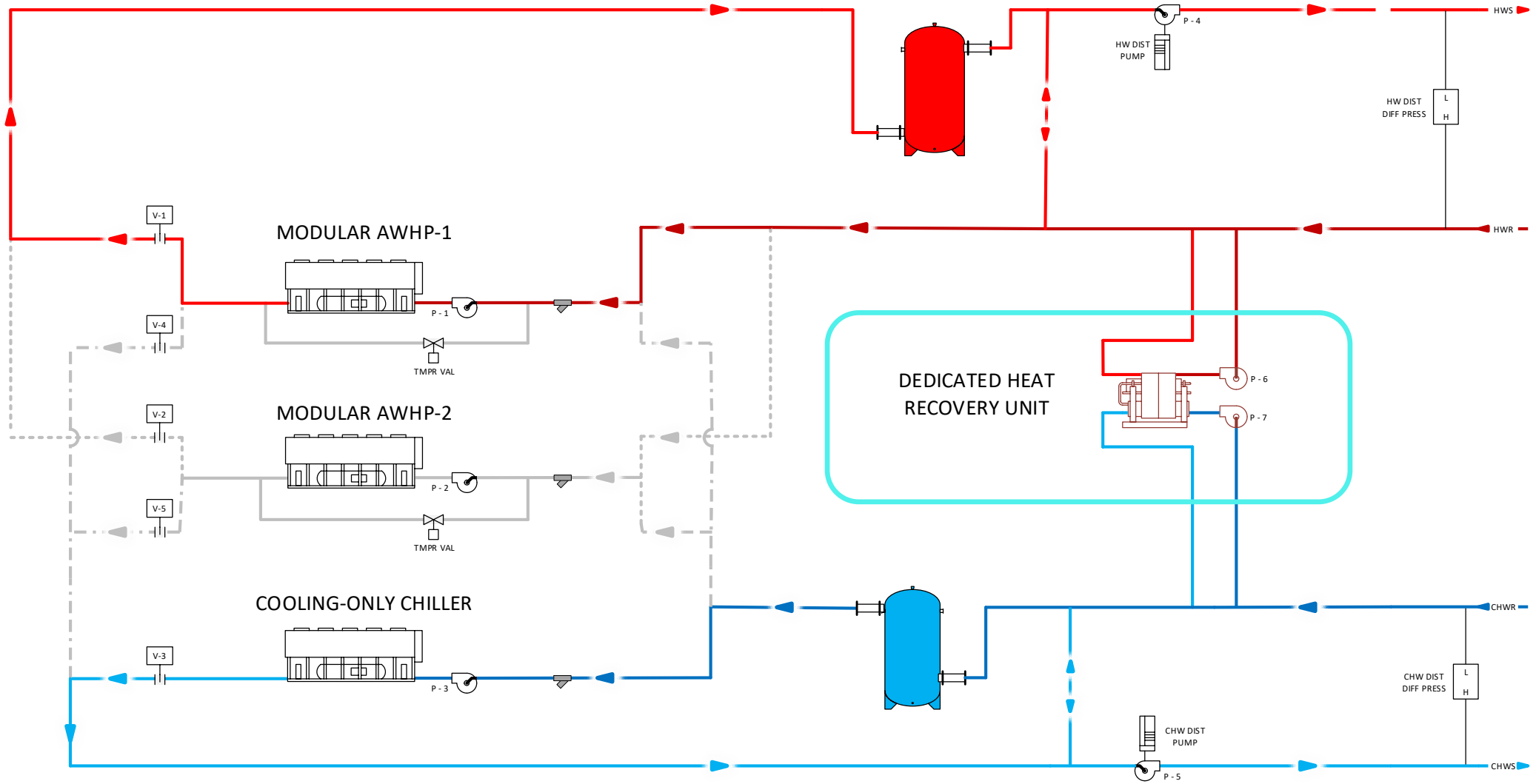


Hydronic Central Geothermal with Modular Chiller(s)

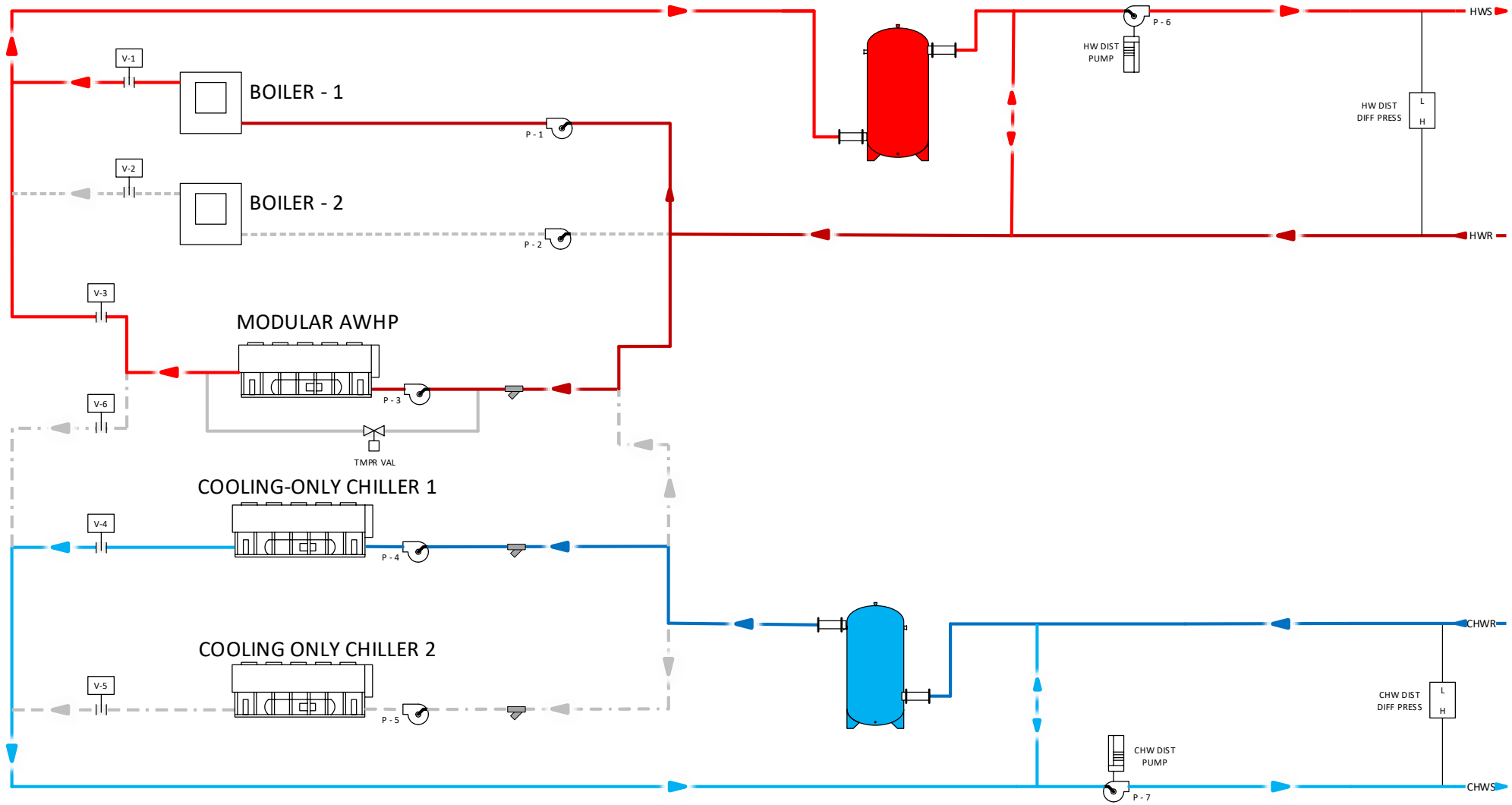


NOTE: Not all components are depicted in this diagram

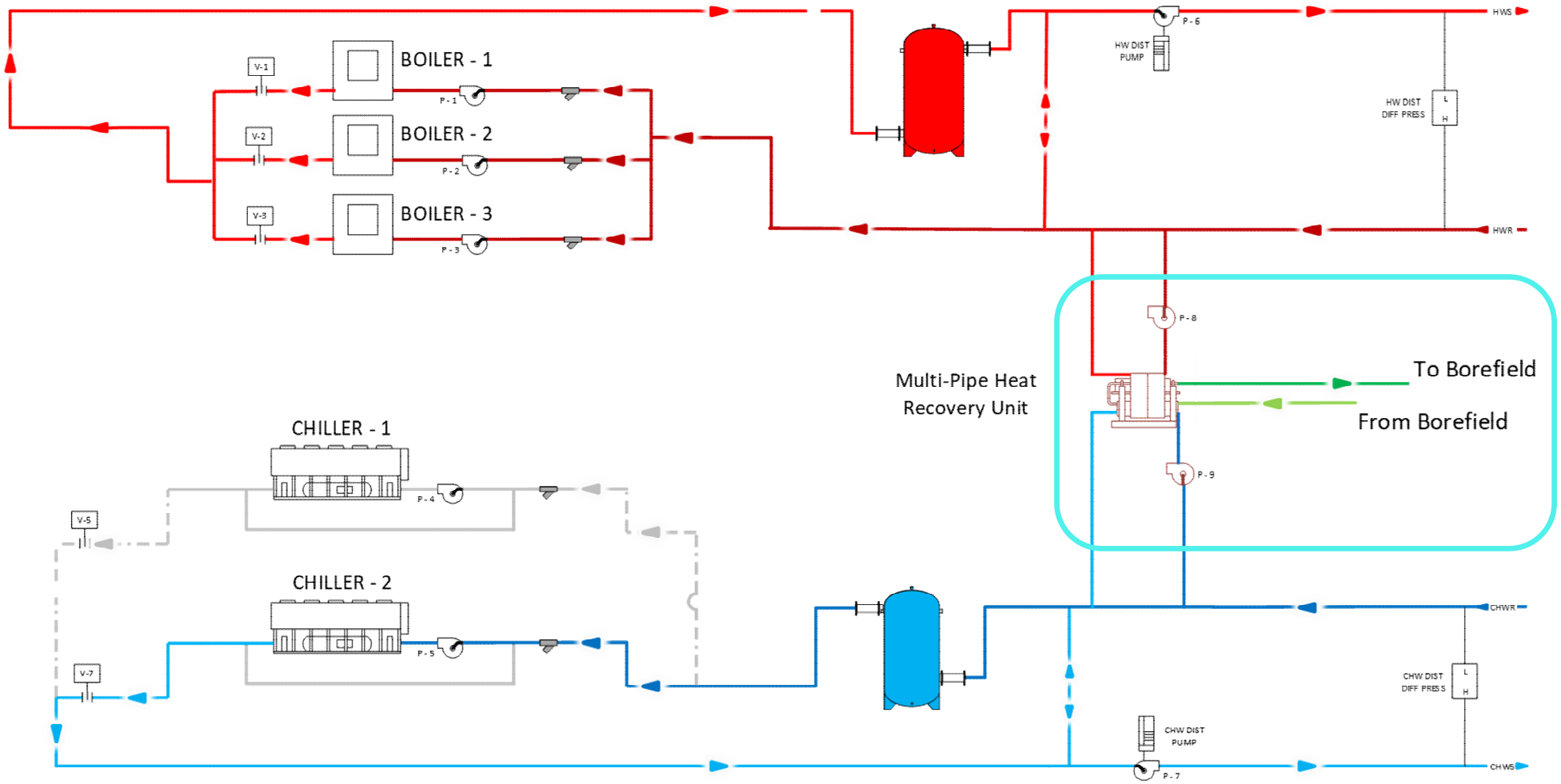
Heat Recovery, Full Electrification



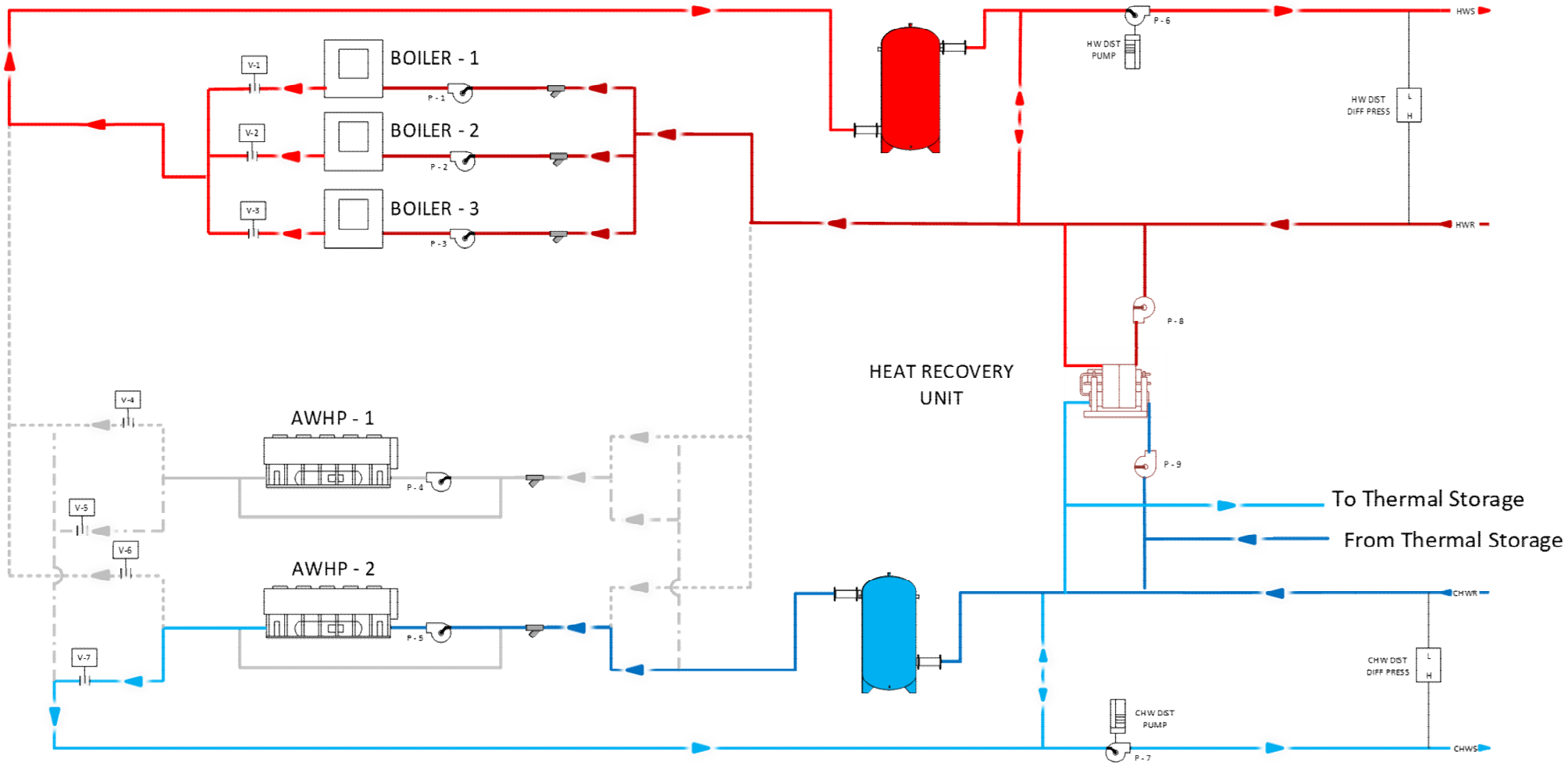
Significant Electrification or Backup Heating



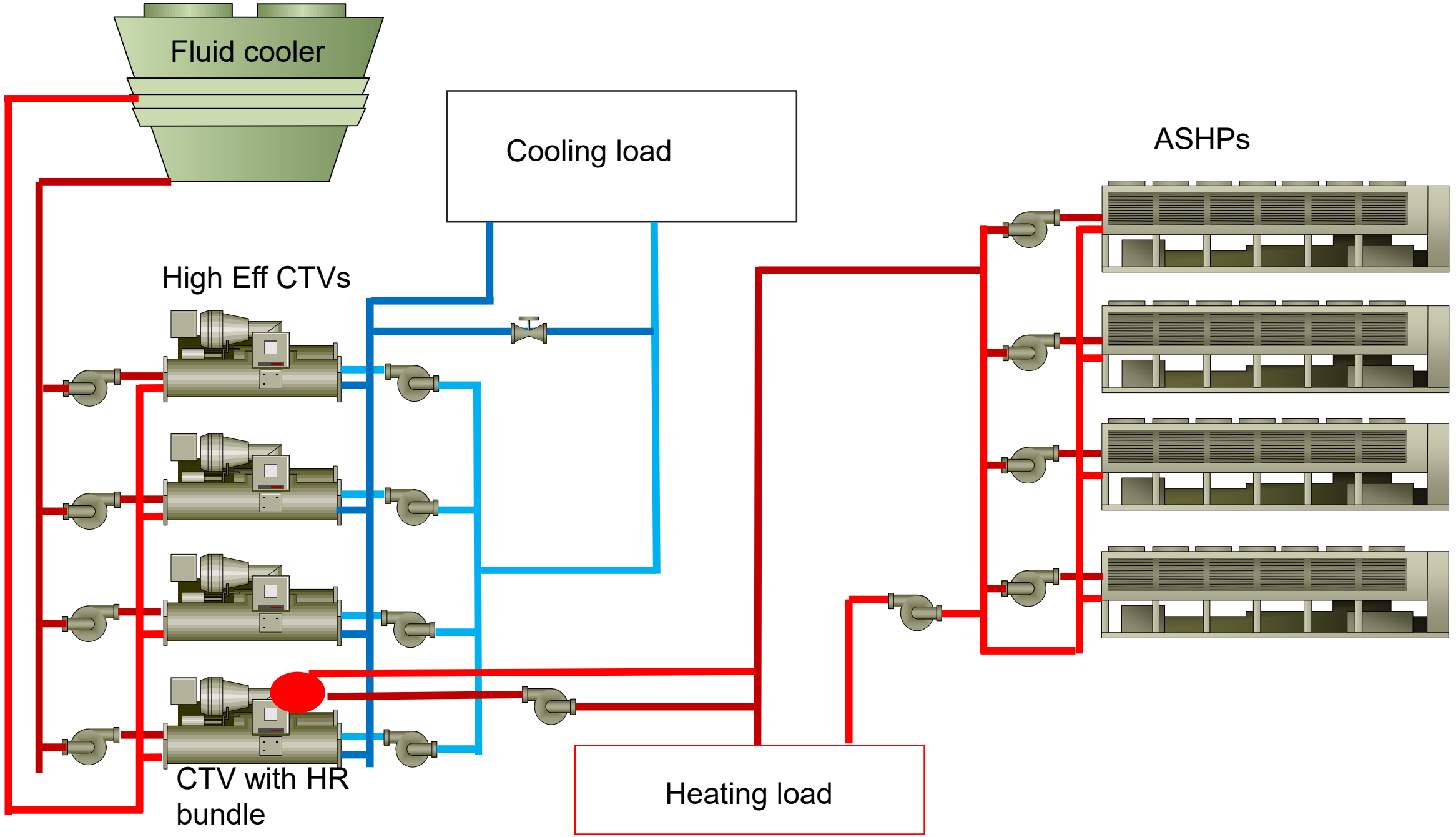
Electrification: Geothermal

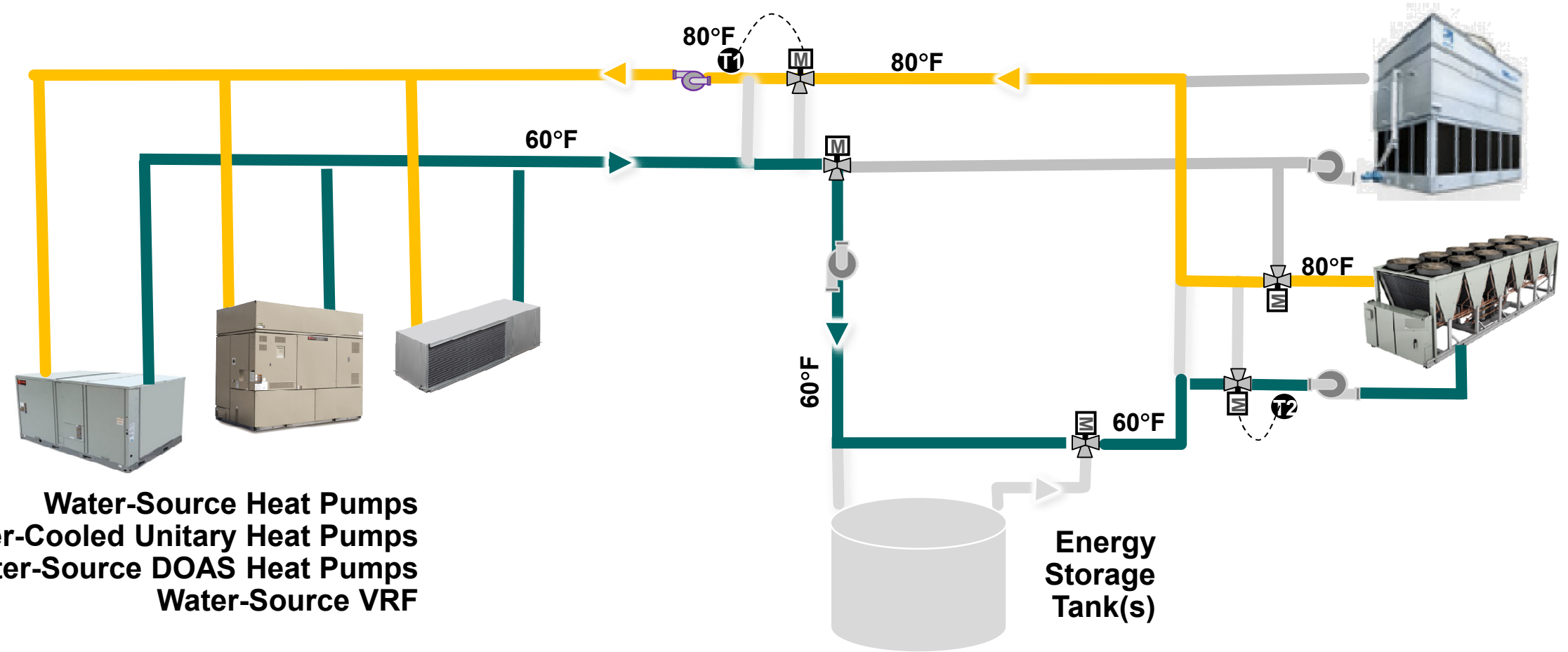


Electrification: Thermal Energy Storage



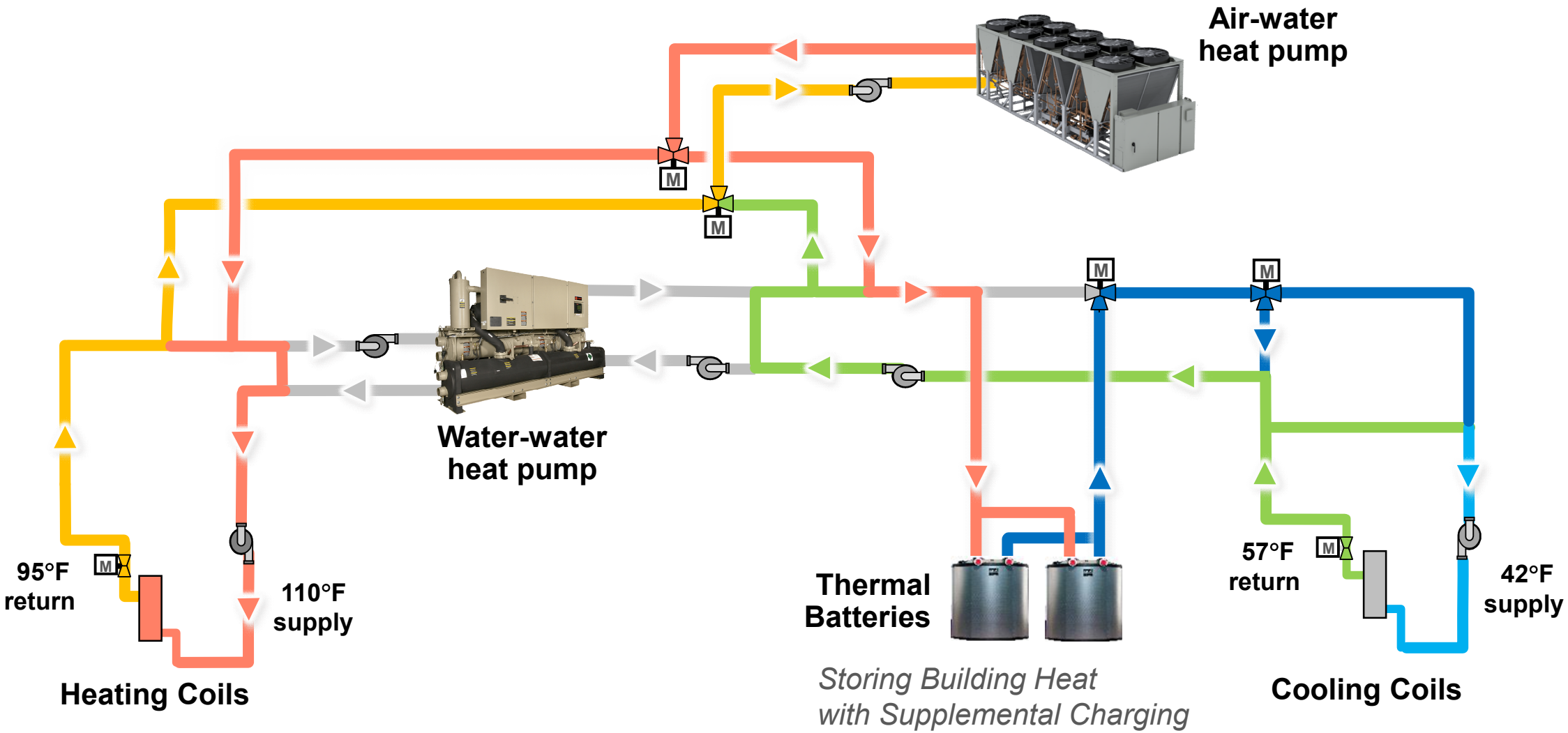
MacCracken, M. “Electrification, Heat Pumps and Thermal Energy Storage, ASHRAE Journal, July 2020,


Fluid cooler
Cooling load
ASHPs
High Eff CTVs
CTV with HR bundle
Heating load


80°F
80°F
60°F
80°F
60°F
60°F
Water-Source Heat Pumps
Water-Cooled Unitary Heat Pumps
Water-Source DOAS Heat Pumps
Water-Source VRF
Energy
Storage
Tank(s)

Solving Decarbonization Challenges with Thermal Batteries

Heating and Cooling with Supplemental Charging – when Ample Green Power

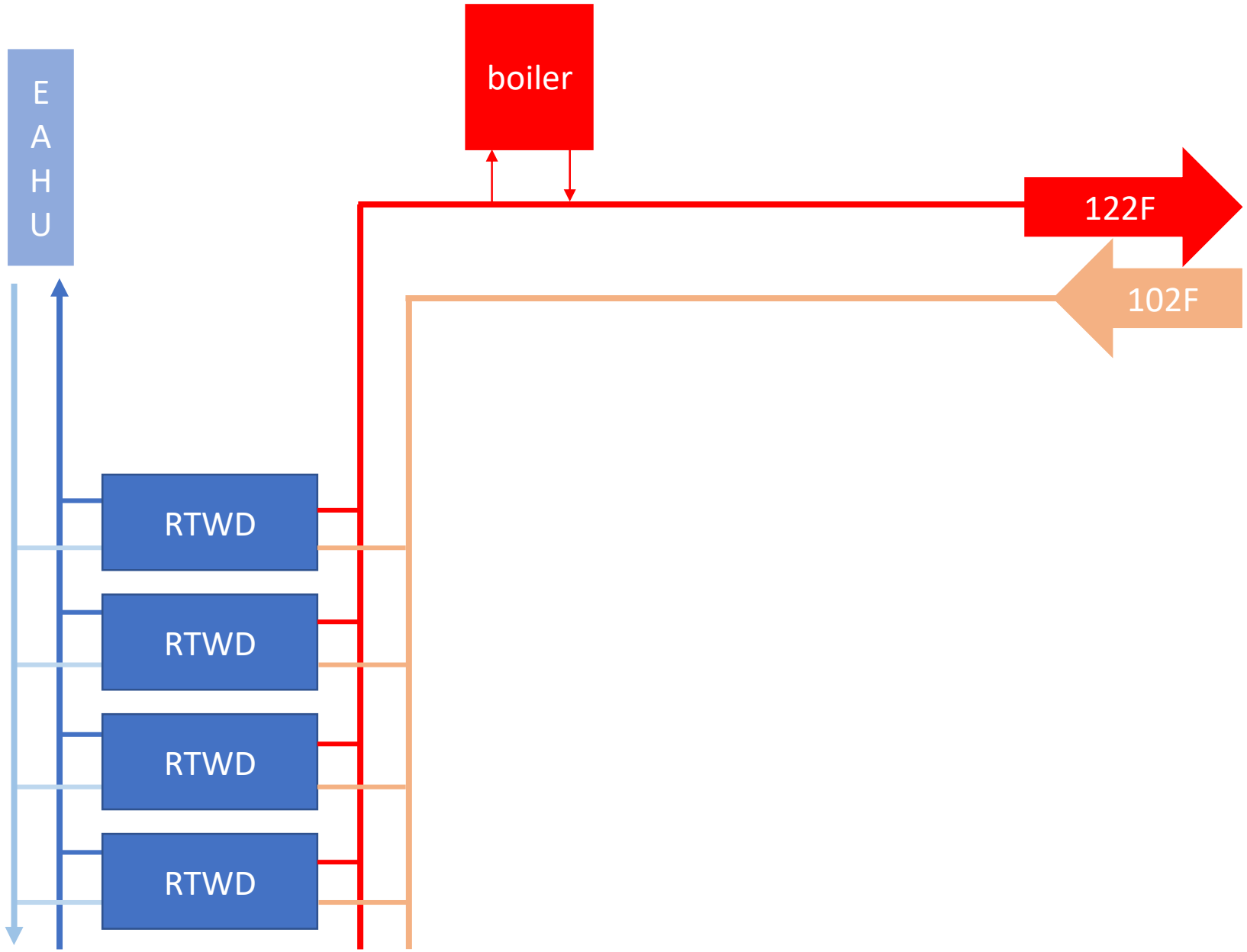


Existing Building

High temperature hot water

Cascade

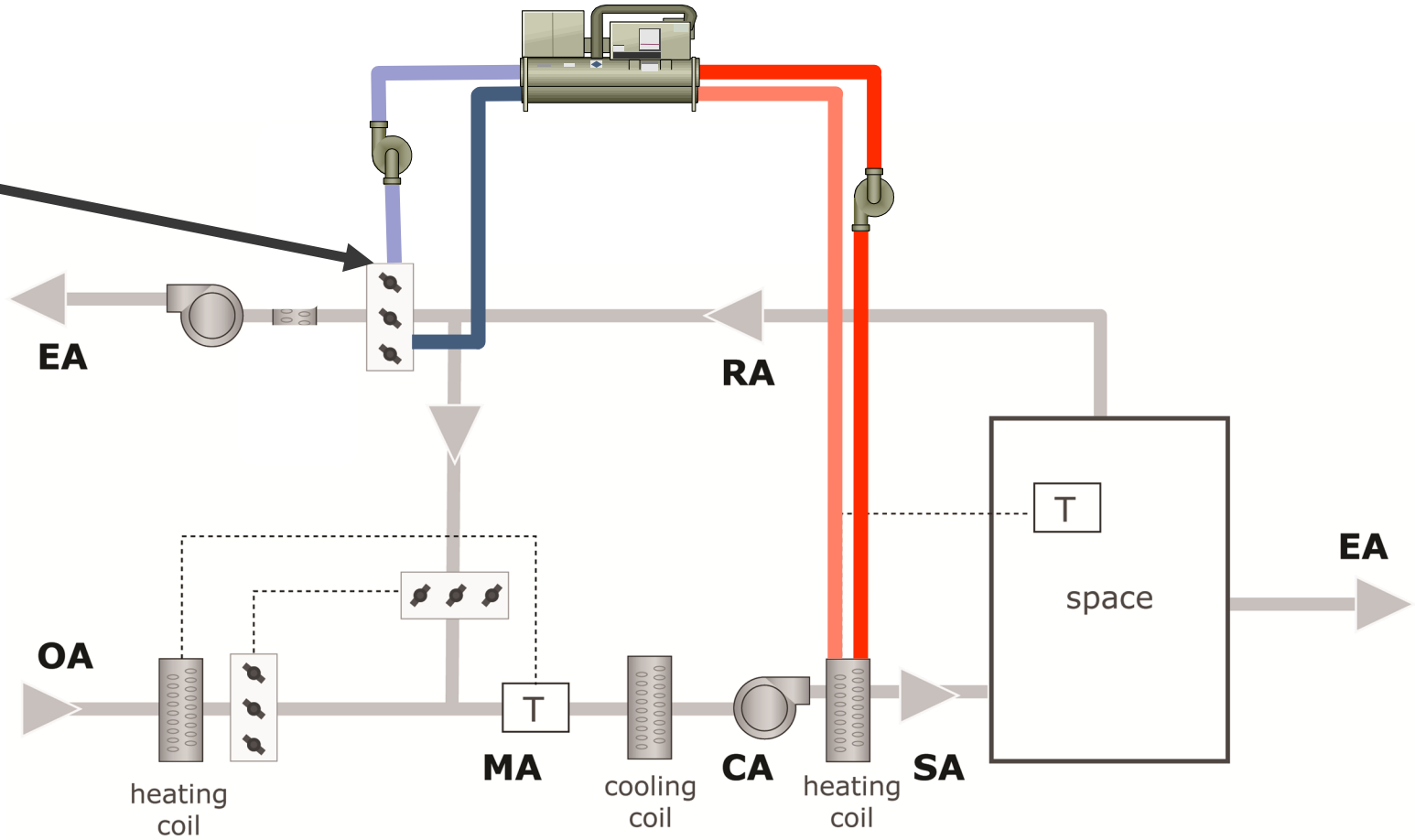
- I want to replace my boiler with a heat pump

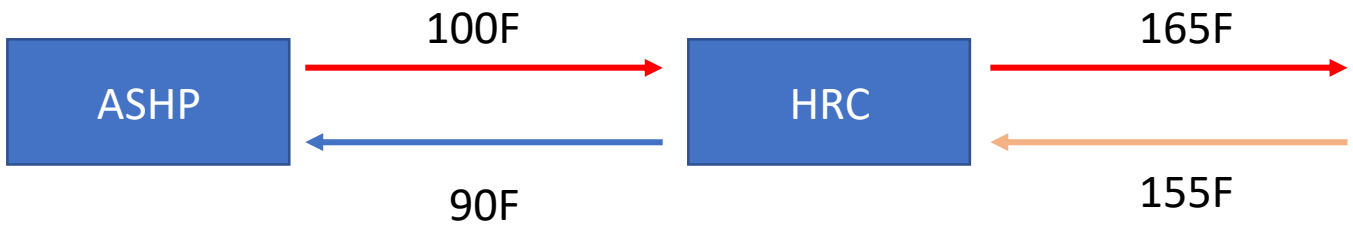

E
A
H
U
boiler
122F
102F
RTWD
RTWD
RTWD
RTWD

Heat Sources

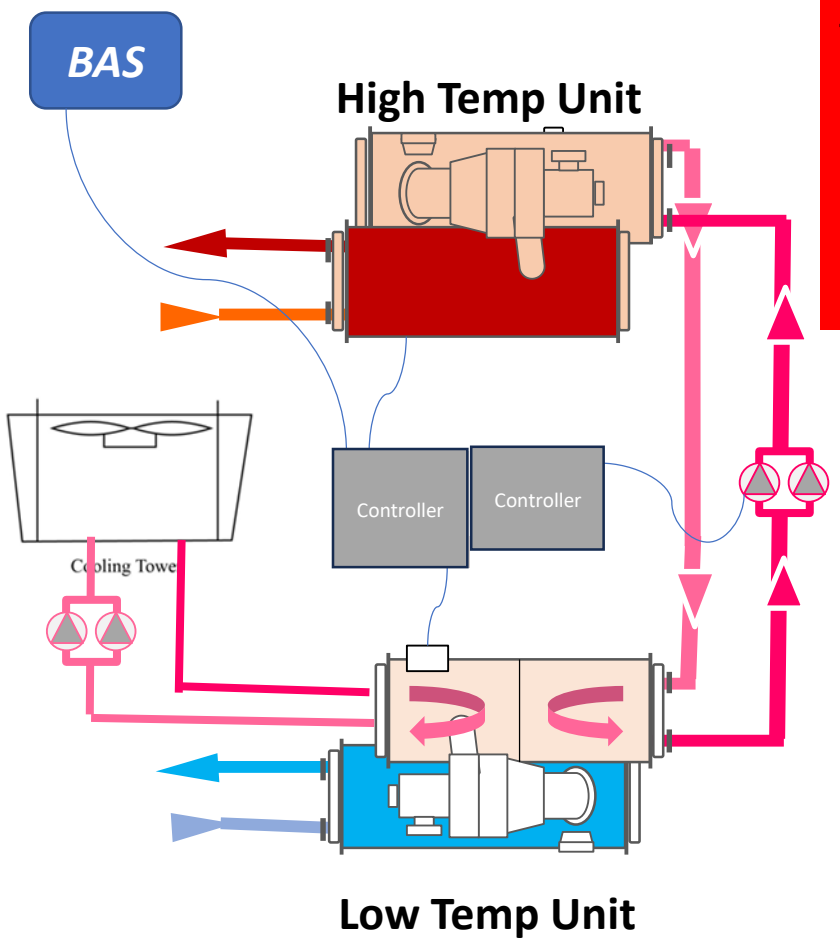
Airstreams

- Outdoor air
- Exhaust air
- Load-shedding economizer




ASHP
100F
90F
HRC
165F
155F

Cascade Heat Pump



High Temp Unit- CVHH Based Product

- 180F Leaving Hot Water Capable
- R514A for very high temp (180F)
- R1233zd(E) for high temp (155F) and high load
- Capacity Range: 22,000 to 35,000 MBH

Low Temp Unit- Any WC Chiller

- Standard chiller such as CVHH
- Configuration flexibility
  - HTRC unit for uneven loading
- Can be an existing unit in your facility

Trane Cascade Advantage

- Better Turndown (Down to 25% of Full Load or better)
- Operates under uneven cooling and heating loads
- High reliability and standard parts
- System design flexibility
- Best cooling efficiency
- Easy integration with BAS
- Pairing with an existing cooling chiller
- High Temp unit can be used for chilled water unit in summer
- Low GWP
  - GWP = 1 for R1233zd(E)
  - GWP= 2 for R514A

Into the future

- High temp
- High lift
- Low ambient

Small Building Application
VRF with DOAS or ERV

- Cold climate capability (≥ -22ºF)
  - Operation during defrost limits impact to occupant comfort
  - Auxiliary fuel option
- High efficiency

Small Building Application
Rooftop Unit (RTU) Heat Pump

- Similar footprint and accessibility to gas/electric RTUs
- No cold climate capability
  - 100% defrost
    (dual or auxiliary fuel required)

Operating condition	COP / Efficiency
High ambient heating	3.6
Low ambient heating	2.3
Dual fuel backup (natural gas)	0.81 (81% efficiency)
Auxiliary backup (electric resistance)	1

Pertinent Rebates, Tax Incentives & Funding or the Commercial Market

$30.5B+

To **boost U.S. production to support building electrification** (incl. energy storage & heat pumps)

$1B+

In grants for **local gov'ts to modernize commercial &** residential buildings to meet energy codes

Tax Incentives

To expand **tax deductions** for **Energy Efficiency** & **Inv. Tax Credits for Electrification** (incl. thermal storage & heat pumps)

$30B

To transition states & electric utilities to clean electricity

$3.42B

To decarbonize federal buildings through construction or retrofit

$50M+

To reduce air pollutants in schools

Many of these programs aren't created yet; Impacts to be determined

TRANE TECHNOLOGIES

QUESTIONS