

Reflections on Electrifying a 74-Year-Old Building with Thermal Storage and Hydronic Branch Conductors

Sarah Hilden | Applications Engineer | Trane
Juan Manuel Torres | Systems Applications Engineer | Trane

May 2025

WAVES of **INNOVATION**
TOGETHER WE RISE





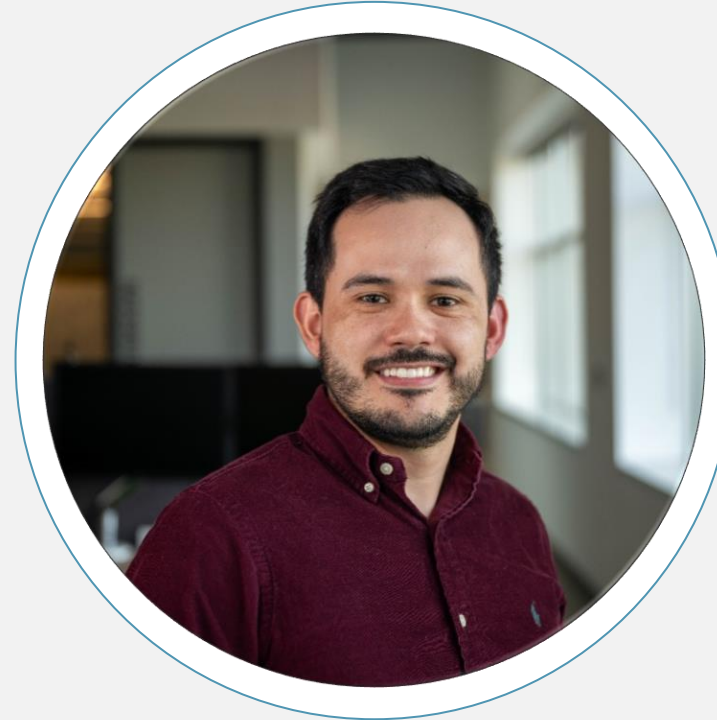
Special Thanks to our Sponsors:



Today's presenters



Sarah Hilden
Applications Engineer



Juan Manuel Torres
Controls Engineer

Today's presenters

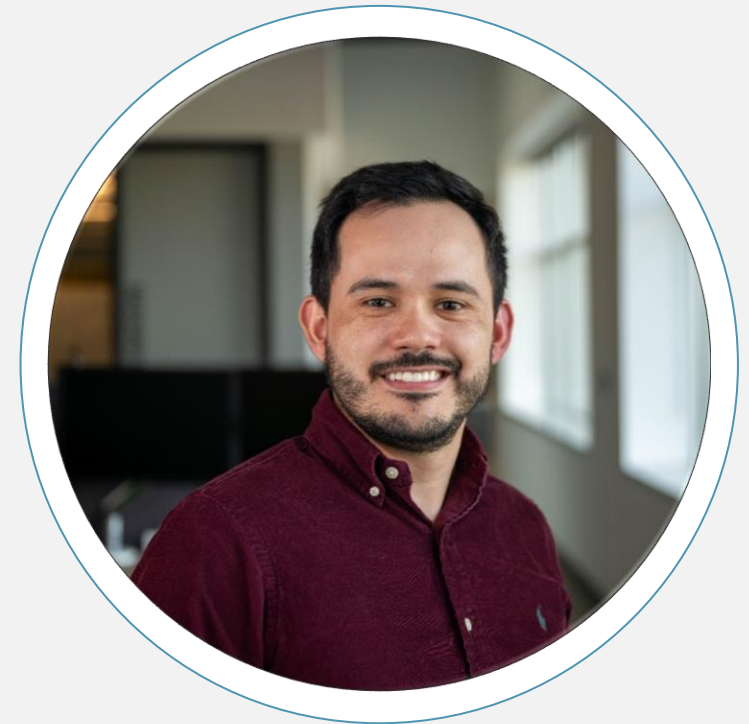
...with special thanks to Rick Heiden



Sarah Hilden
Applications Engineer



Rick Heiden
Systems Development
Engineer



Juan Manuel Torres
Controls Engineer

Agenda



- Emil H. Erickson Building
 - Storage Source Heat Pump System
 - Hydronic Branch Conductor
- Required baseline control
- System insights via performance monitoring
- Case study data
- Potential pitfalls and lessons learned
 - Design, installation and commissioning
- Q & A

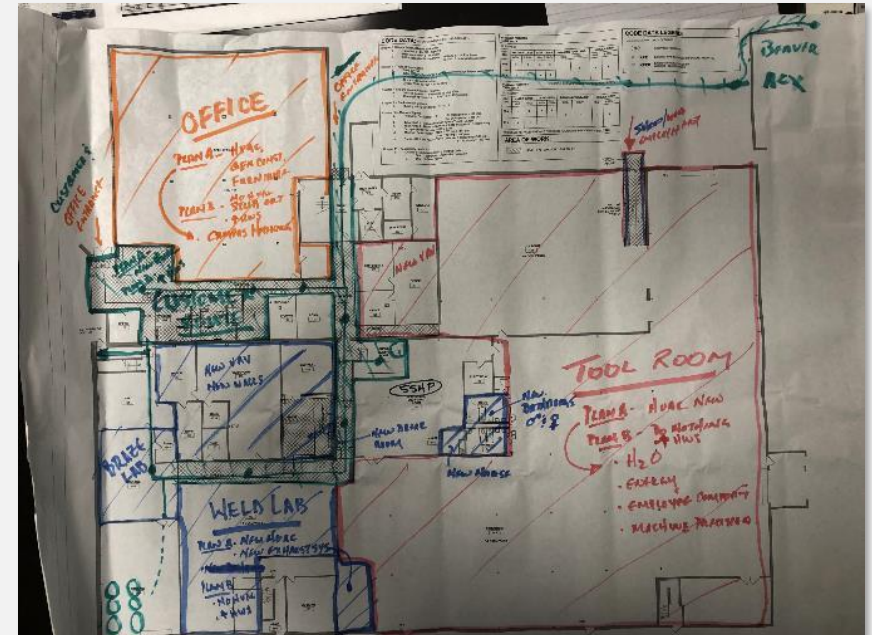


Emil Erickson Training Facility Building

Trane “Building 13”



- 79,338 ft²
- La Crosse, WI
 - ASHRAE climate zone 5A)
- **Built in 1951**
- Latest expansion in 1982
- Renovation and refresh
 - VAV Reheat terminals updated to 4-row HW coils
 - Mechanical pressure independent control valves (PICV)
 - Vertical air turnover units (changeover)



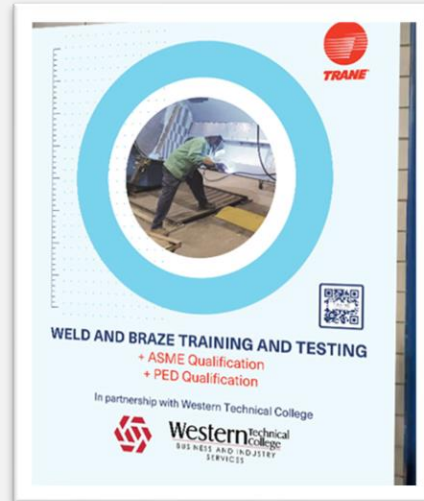
A new beginning

Aside from the plant and educational spaces.....



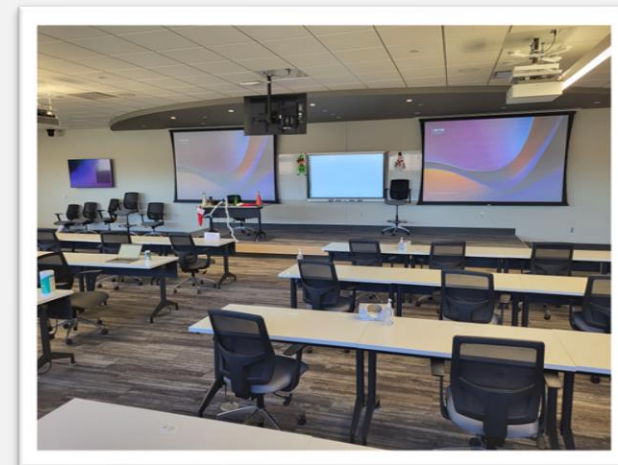
Weld Training

- **Strong Partnership**
 - Over 25 years with Western Technical College (WTC)
- **Job Opportunities**
 - Trane-specific procedures and techniques
 - Safety focus
- **Industry Certifications**
 - ASME and PED qualifications
- **Ongoing Skill Development**
 - Over 20 specific 1-week advanced classes



Graduate Training Program

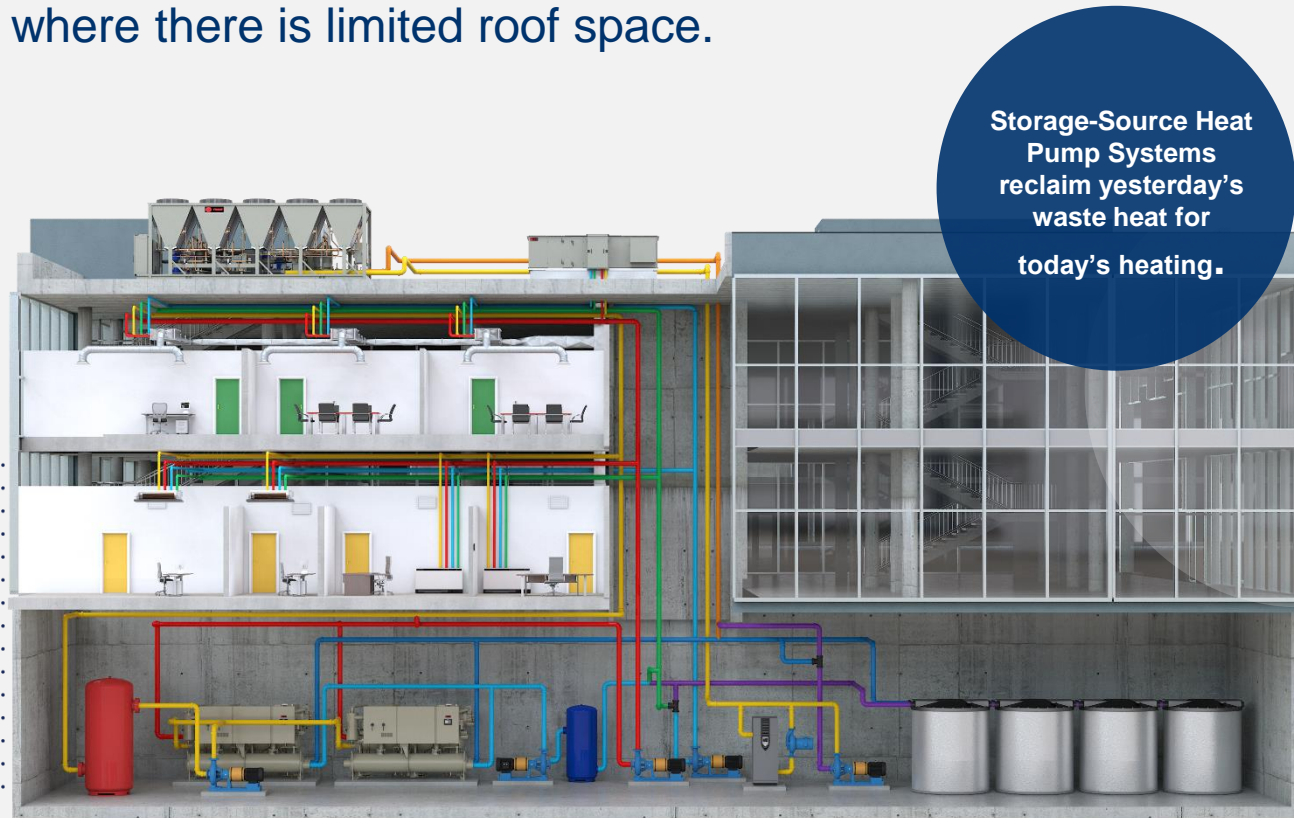
- **Est. 1926 by Reuben Trane**
 - Created to sell revolutionary convector radiators
- **HVAC Bootcamp**
 - 20-week program
 - Equip grads with extensive HVAC knowledge, emphasizing ethics and professional standards








Thermal Battery™ Storage-Source Heat Pump System

SSHP

An innovative way to make all-electric heat pump heating possible even in cold climates and dense urban environments where there is limited roof space.

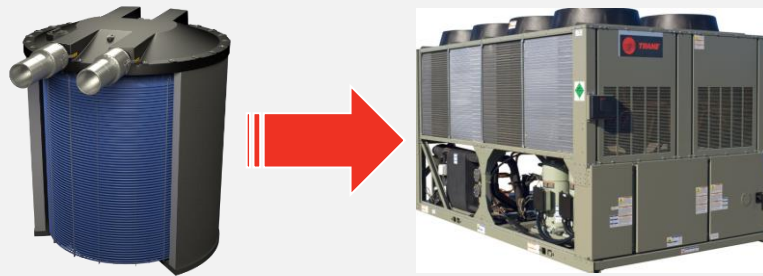


BENEFITS

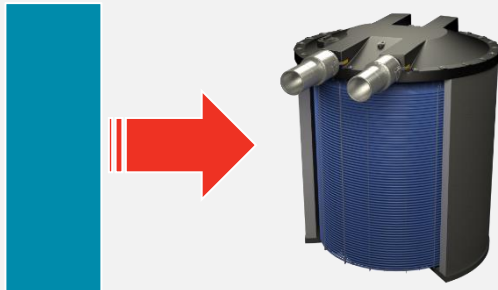
-  **Energy efficient**
-  **Reliable operation**
-  **Save roof space**
-  **Higher supply water temperatures**
-  **Lowens costs**



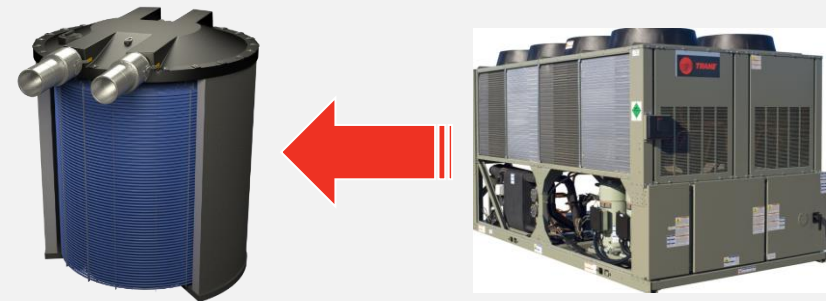
We can use TES for more than just cooling



- Build Ice – remove heat from tanks
- Melt Ice – put building heat into tanks



- Build ice – to heat the building
- Melt ice – to store heat for later



Thermal Battery ice storage tanks

Basic building block is the all-welded model 1190

- Non-corroding modular construction
- Multiple Sizes to fit every project
- Re-deployable
- Repeatable cataloged performance
- Designed to easily fit into chilled water systems
- Ten-year total freeze limited warranty!
- Simple to maintain

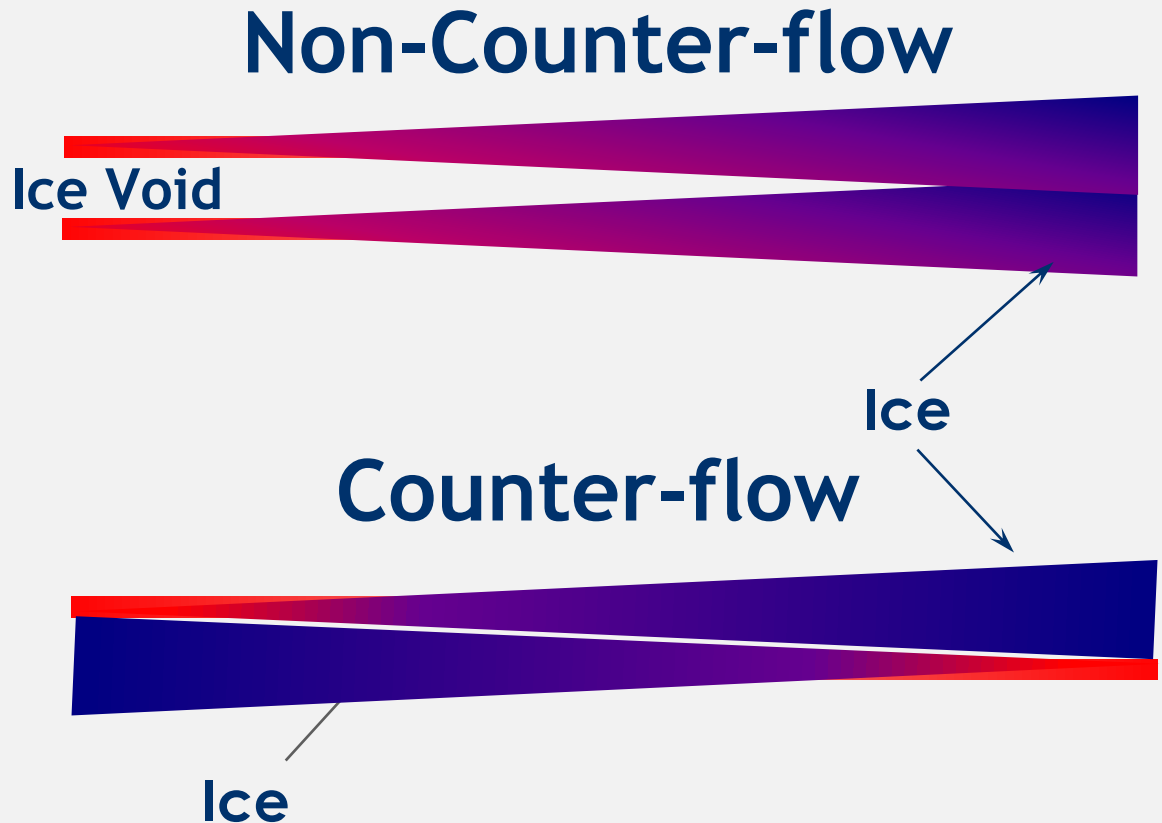


Ice Bank® counter-flow heat exchanger

Efficient Freeze and Melt



- Over 2.5 miles of 5/8" translucent polyethylene tubing for easy maintenance
- Max 1/2" ice build freezes tank solid with highest ice making temperatures on the market
- Counter-flow design for:
 - Efficient Ice Build
 - Reliable Ice Melt
- Internal isolated expansion chamber simplifies installation



ASCEND[®] air-to-water heat pump

Model ACX (140 to 230 tons cooling, 1500 to 2500 MBh heating)



R454B

A perfect fit to
meet your
sustainability
and efficiency
targets



FEATURES

Built on Trane's Ascend chiller platform and Trane controls knowledge and expertise to provide consistent quality and reliability.

- **Support of electrification of heat**
- **ASHRAE[®] 90.1-2019 Compliant**
- **Ease of installation**
- **Simplified service**
- **Options:** Integrated pump packages & sound-reduction packages, Drain pan

Recent feature adds

- Defrost delay request for BAS
- Ice making option

Series R[®] water-to-water heat pump (heat pump chiller)

Model RTWD (80 to 250 tons)



**R513A
R515B**

**Efficiency and
design you
can rely on.**



FEATURES

Water-cooled units can be controlled to provide either heating or cooling as the primary function.

- **Reliability**
- **High Lift Versatility**
- **Precision Temperature Control**
- **Options:** sound-reduction package

44/54°F Evap | 130/140°F Condenser | 250 T Nominal

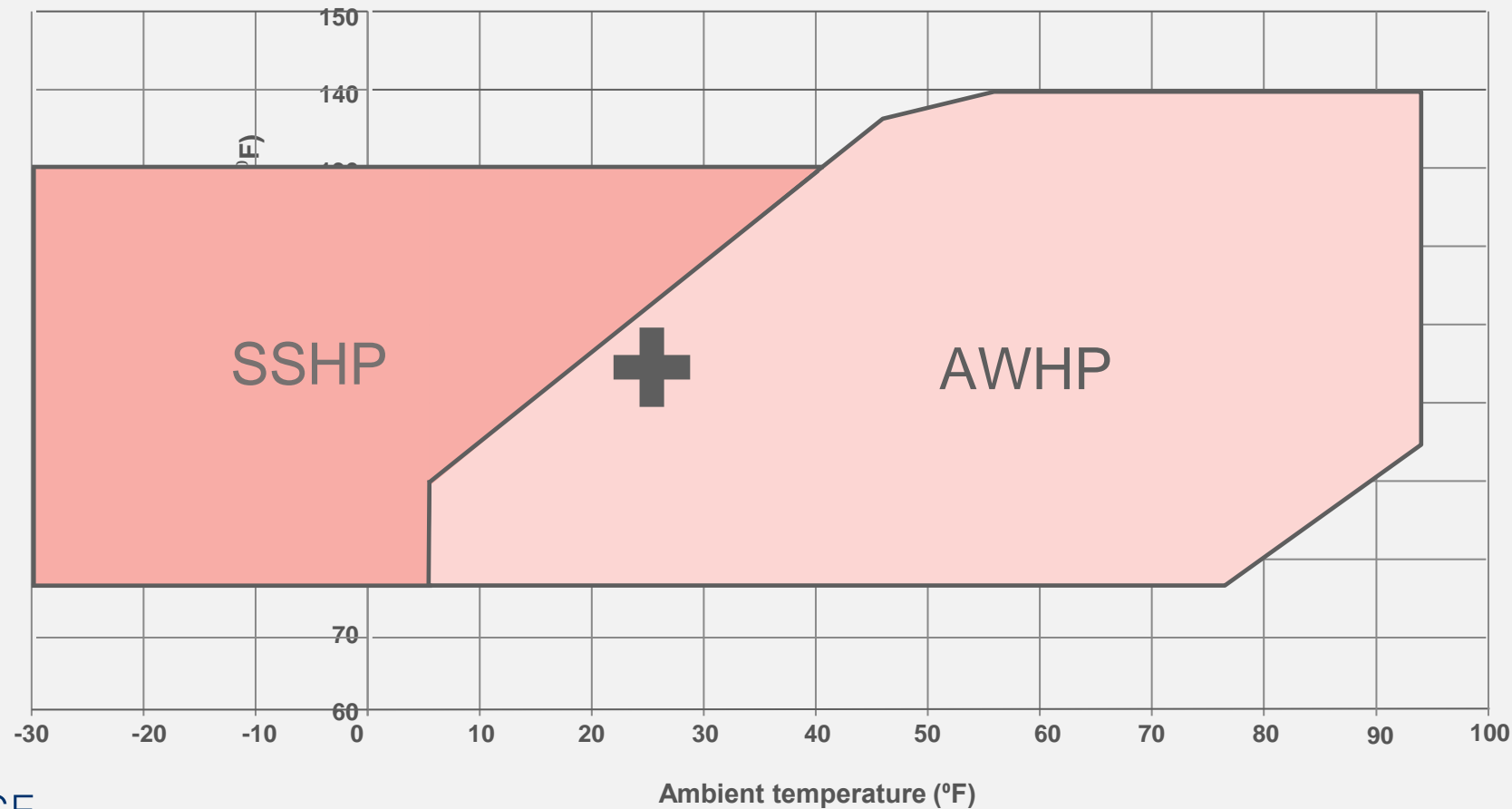
	Cooling Capacity Tons	Heating capacity MBh	Heating + Cooling COP
R-513A	151	2684	5.175
R-515B	115	1946	5.883

Storage Source Heat Pump

System overview



AWHP Operating Map

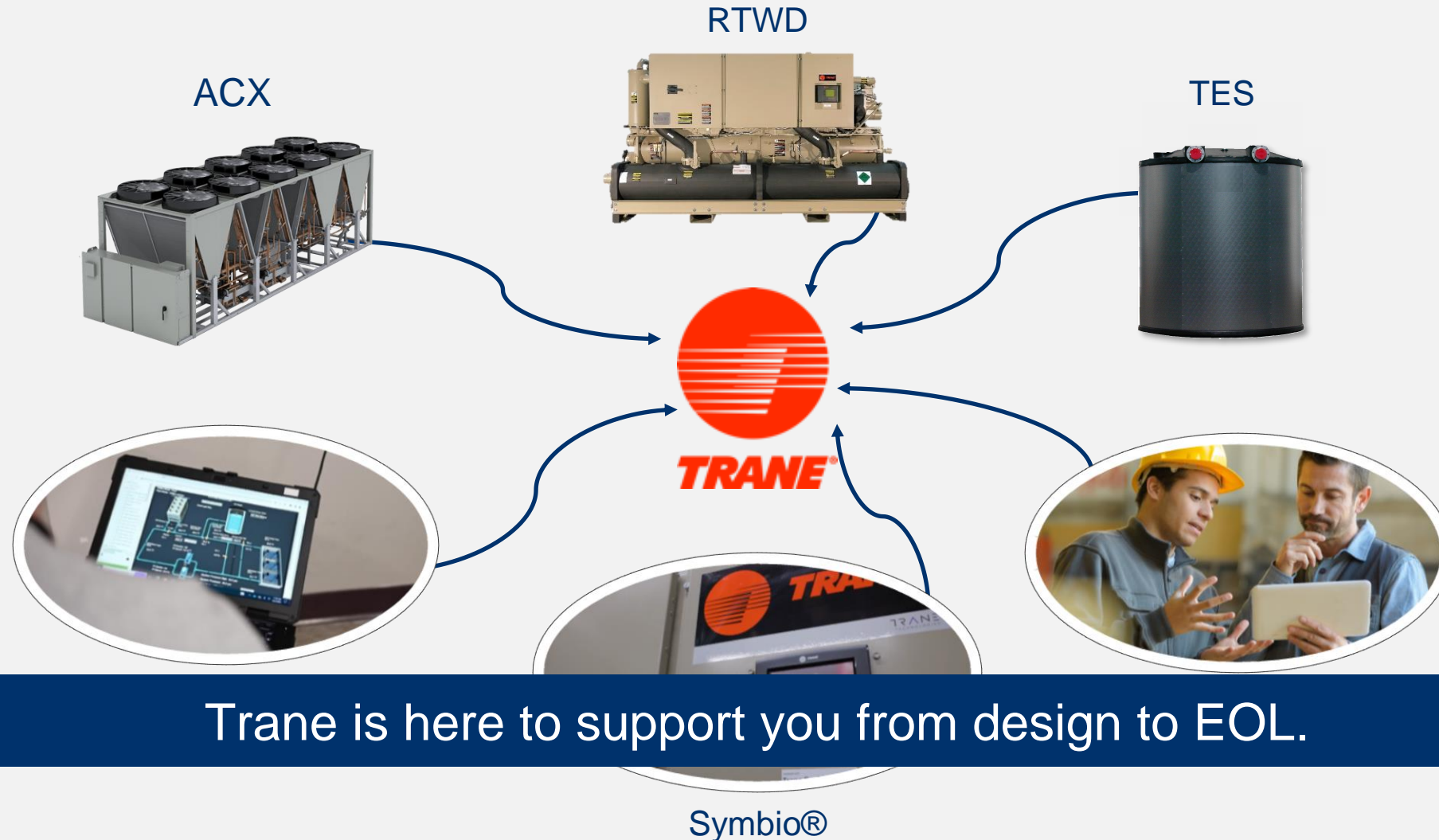


**SSHP Extends Op Map
Vs. Traditional AWHP**

**Extra Thermal Storage
-OR-
Trickle Heater
-OR-
Auxiliary Heat
-OR-
Any Combination Above**

All roads lead to Trane

Single source of equipment and integrated control options



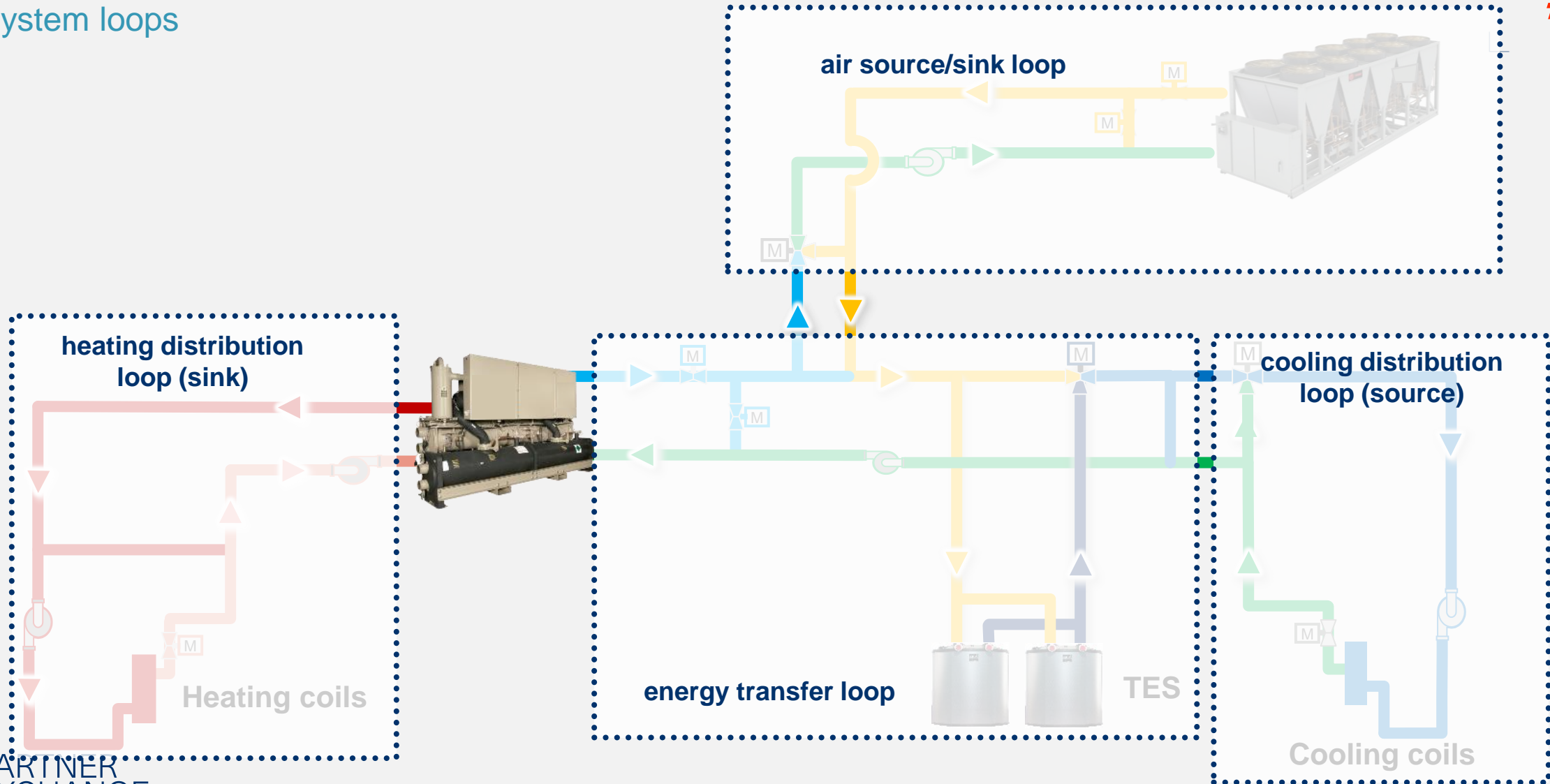
When should I suggest SSHP?

Listen for....



Storage Source Heat Pump – system overview

System loops



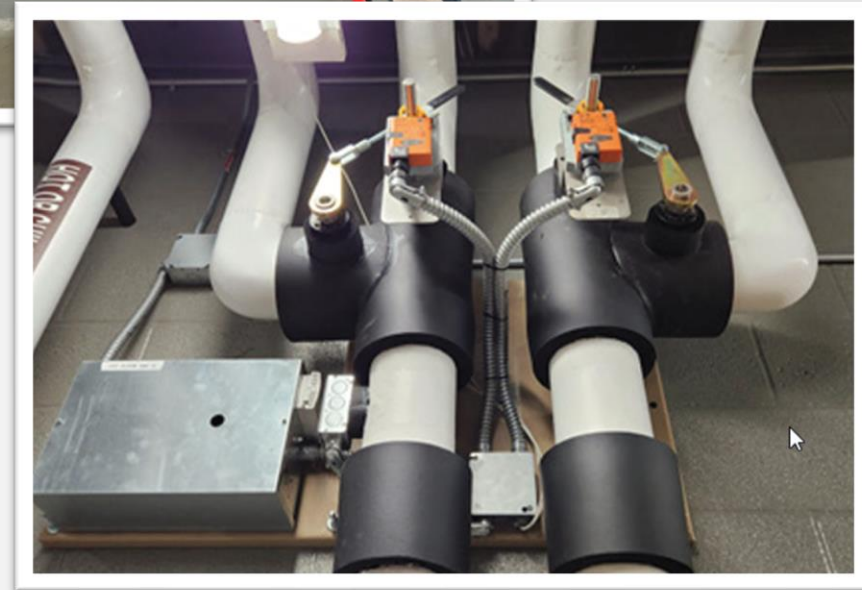
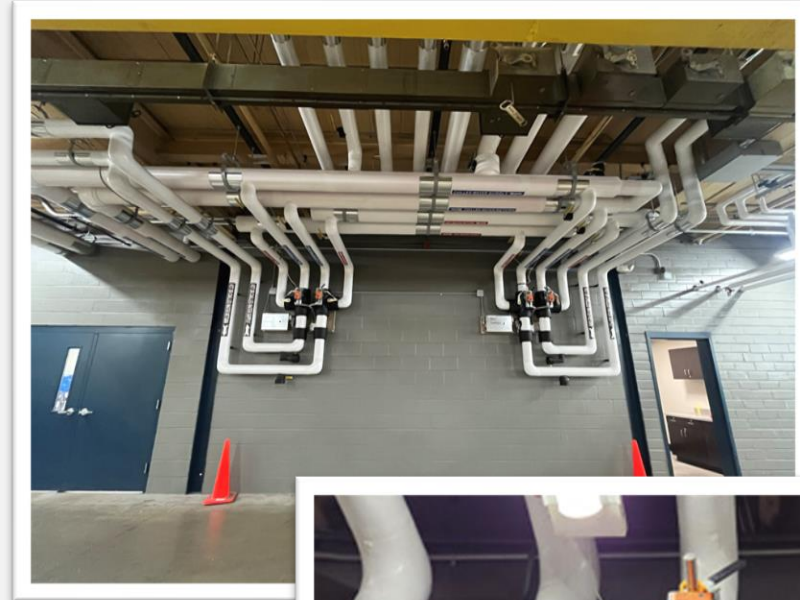
Hydronic Branch Conductor



Installation

Enhance the benefits of your chiller-heater system with the Conductor.

- **Simplify projects** for four-pipe heating and cooling in buildings with lower-temperature hot water
- Repurposes high-capacity cold-water piping and a single dual-purpose coil for both heating and cooling distribution to **save you money**
- Takes the hydronic heat pump systems to the next level with milder hot water temperatures and decreased zone fighting to **further enhance sustainability**
- Provides precise zoned heating and cooling to **improve comfort**



Hydronic Branch Conductor



New systems

Central four-pipe hydronic distribution provides **simultaneous cooling and heat pump heating capability** year-round

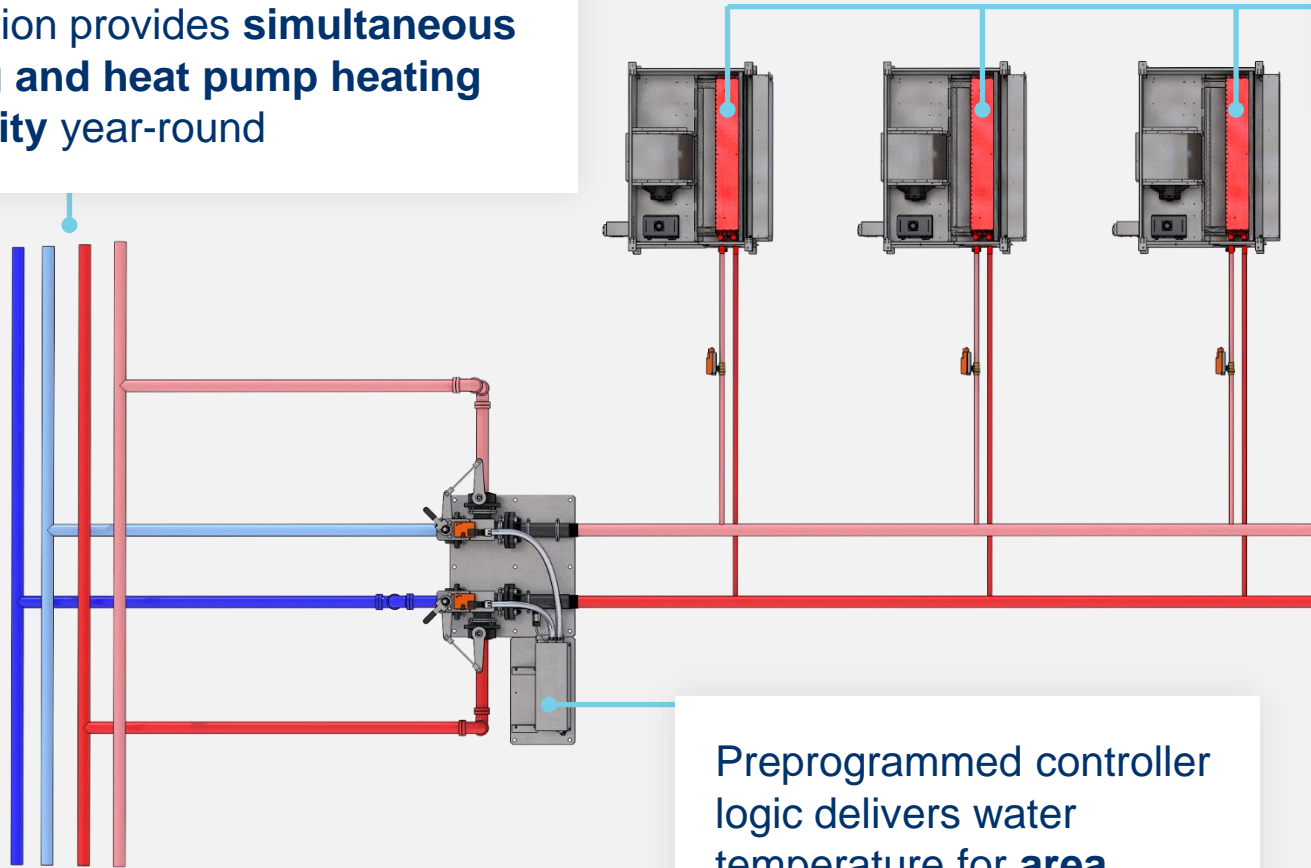
Independent **zone** control with single, dual-purpose coil

Utilization of the existing chilled water piping and coil for heating is **perfect for retrofit opportunities**

Heating with 105°F results in **reduced energy costs**: Heat pump efficiency improved by 35% per ASHRAE 90.1

Uses same branch piping for cooling and heating for **reduced installation costs**

Preprogrammed controller logic delivers water temperature for **area** heating or cooling



SSHP Modes of operation

It's not as complicated as you think!



Cooling Only

- AWHP Cooling
- TES Cooling/Discharge
- AWHP + TES Discharge

Heating Only

- Chiller-Heater + TES Dispatch (freezing)

Heating and Cooling

- Cooling only + Heating only
 - Heat surplus or deficit

TES Charging (Ice making)

- AWHP in ice making mode

TES Heat Collection (melting)

- AWHP heating
- Trickle Heater



Cooling only – Summer peak

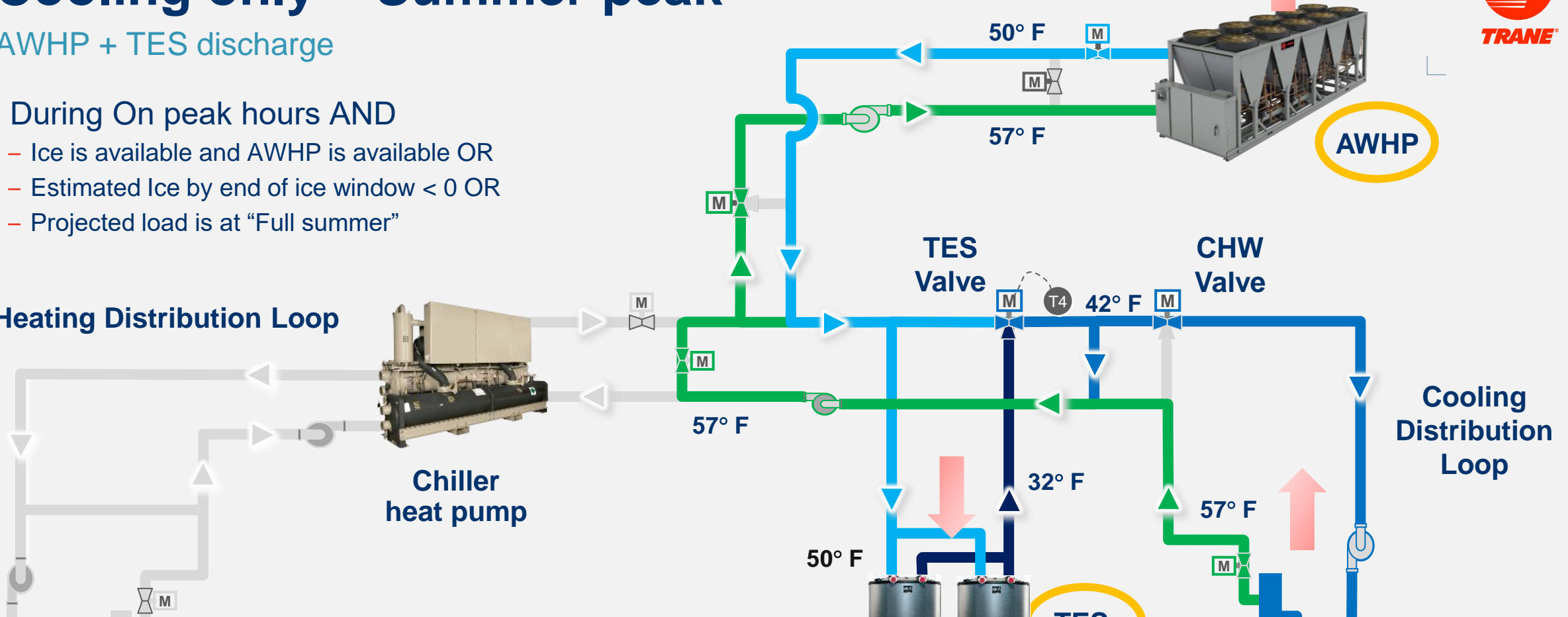
AWHP + TES discharge

- During On peak hours AND
 - Ice is available and AWHP is available OR
 - Estimated Ice by end of ice window < 0 OR
 - Projected load is at “Full summer”

Heating Distribution Loop



Chiller
heat pump



The less we use the AWHP, the more BTUs we can **recover** into the ice tanks for later use.



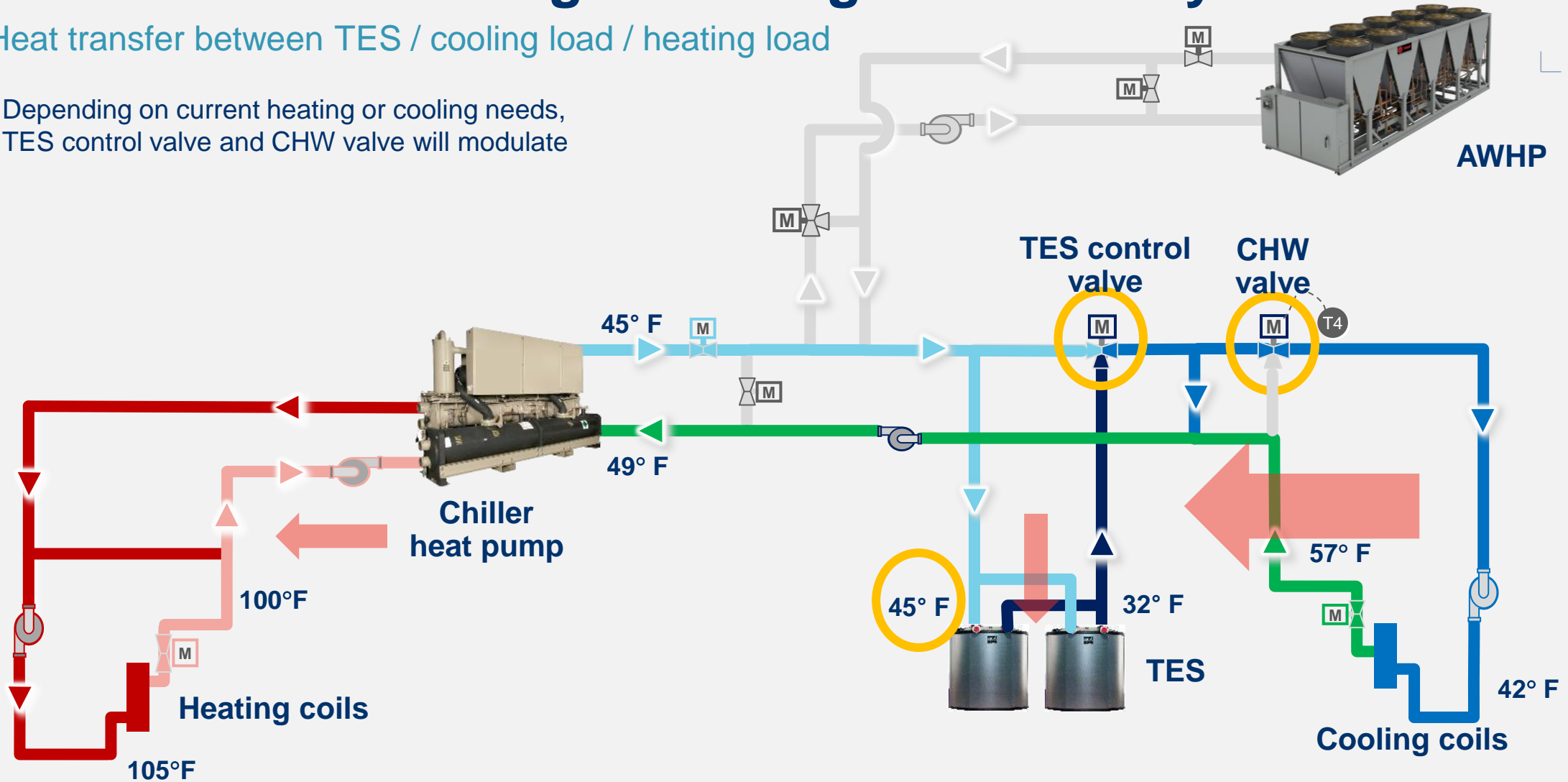
- At all times to satisfy a heating load
- Only one source of heating: Chiller heat pump
- Auxiliary sources recommended.



Simultaneous heating & cooling – A mild day

Heat transfer between TES / cooling load / heating load

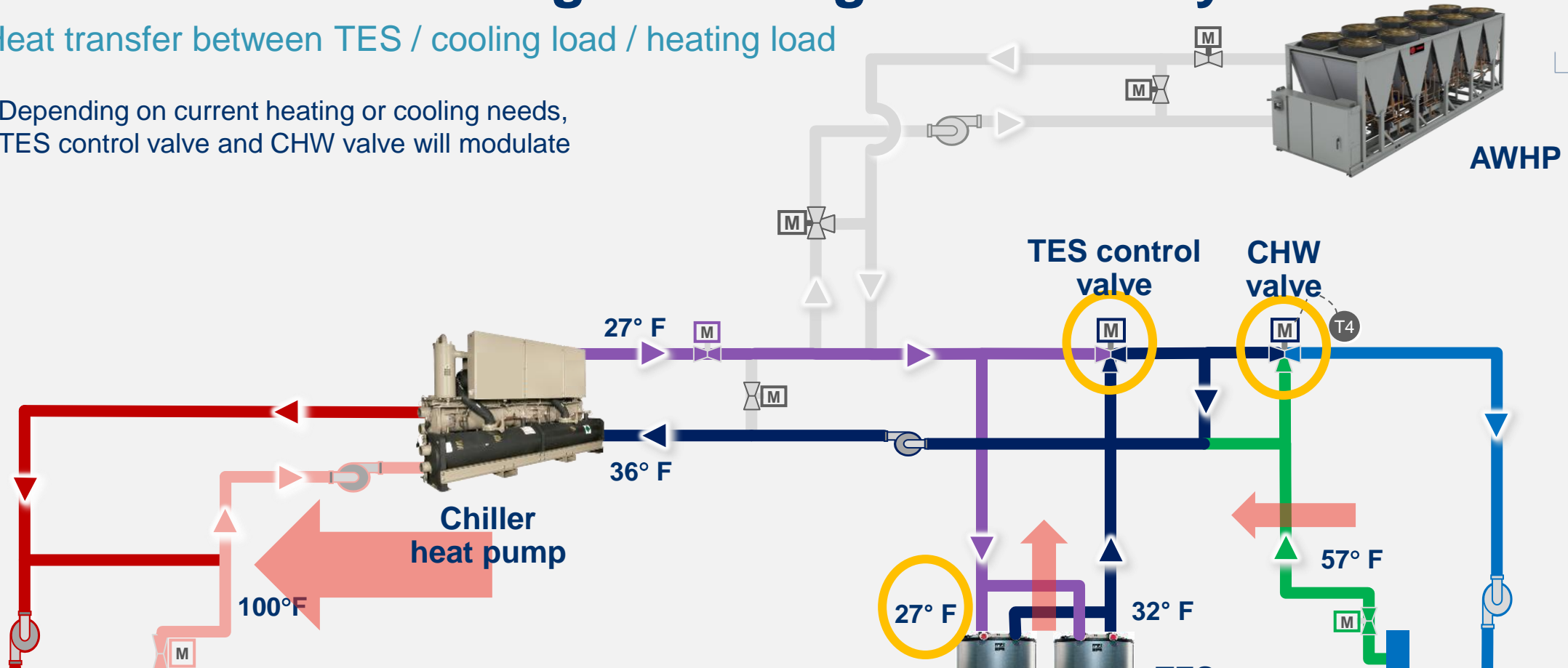
- Depending on current heating or cooling needs, TES control valve and CHW valve will modulate



Simultaneous heating & cooling – A cold day

Heat transfer between TES / cooling load / heating load

- Depending on current heating or cooling needs, TES control valve and CHW valve will modulate



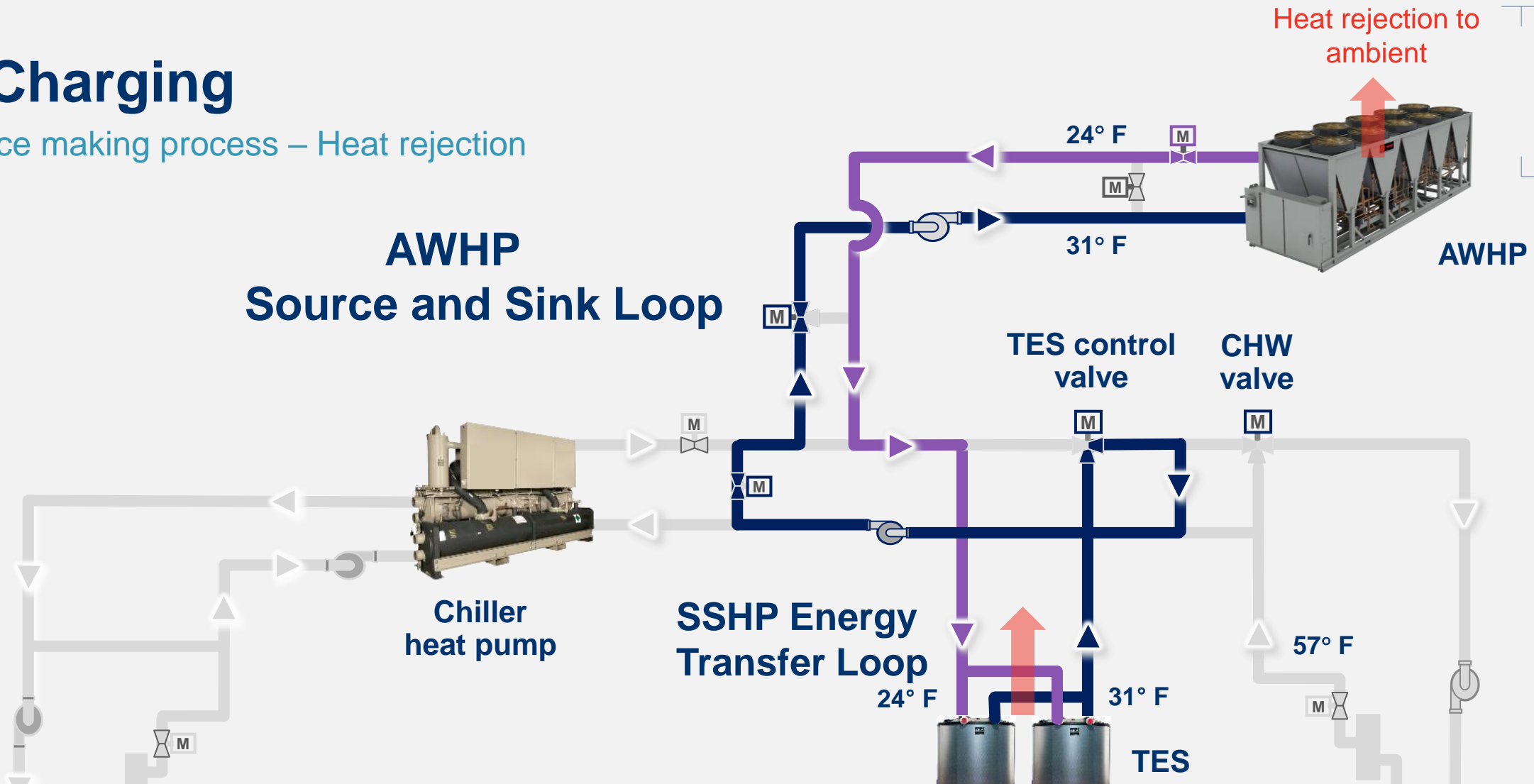
Whenever we have simultaneous loads, the plant enables instantaneous and asynchronous heat recovery!

Charging

Ice making process – Heat rejection



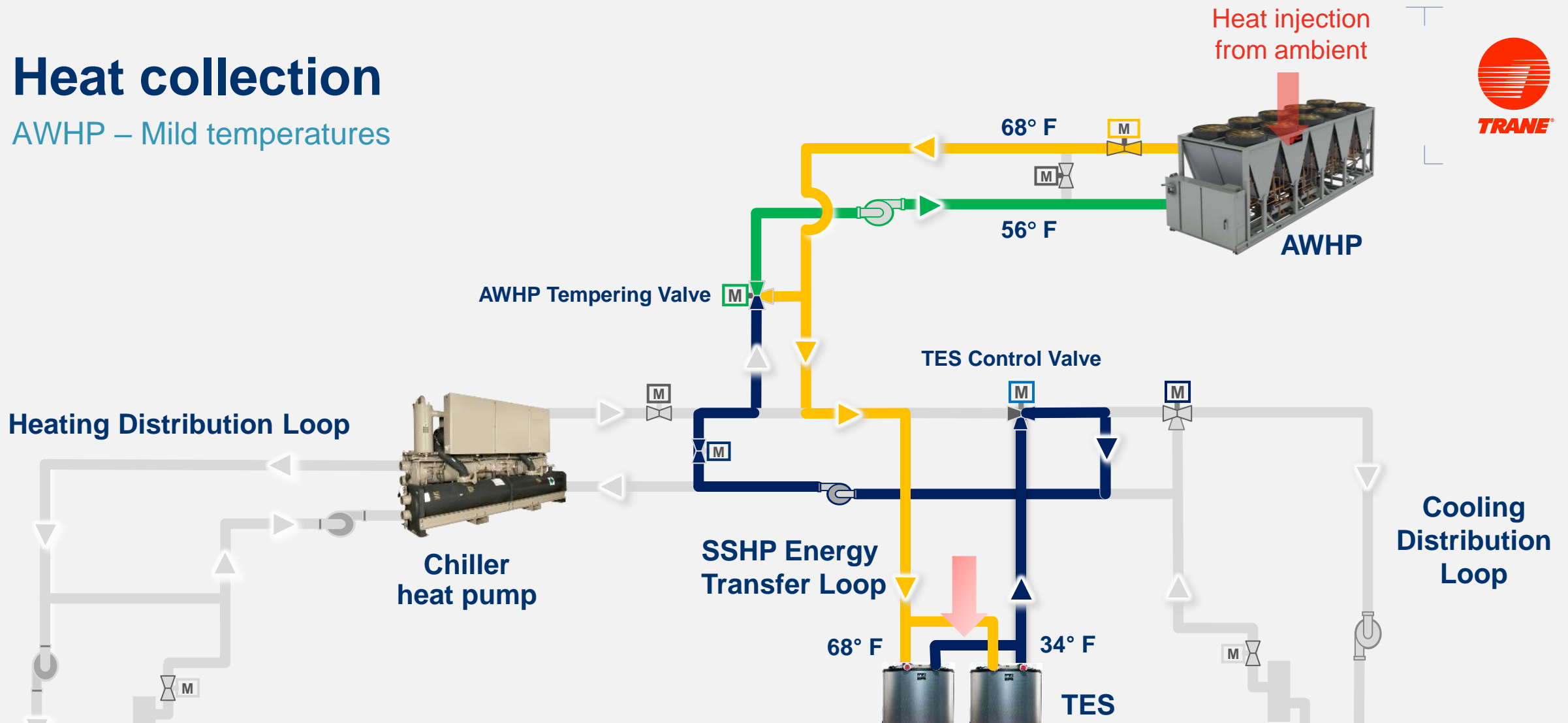
AWHP Source and Sink Loop



Make ice to meet the daily target

Heat collection

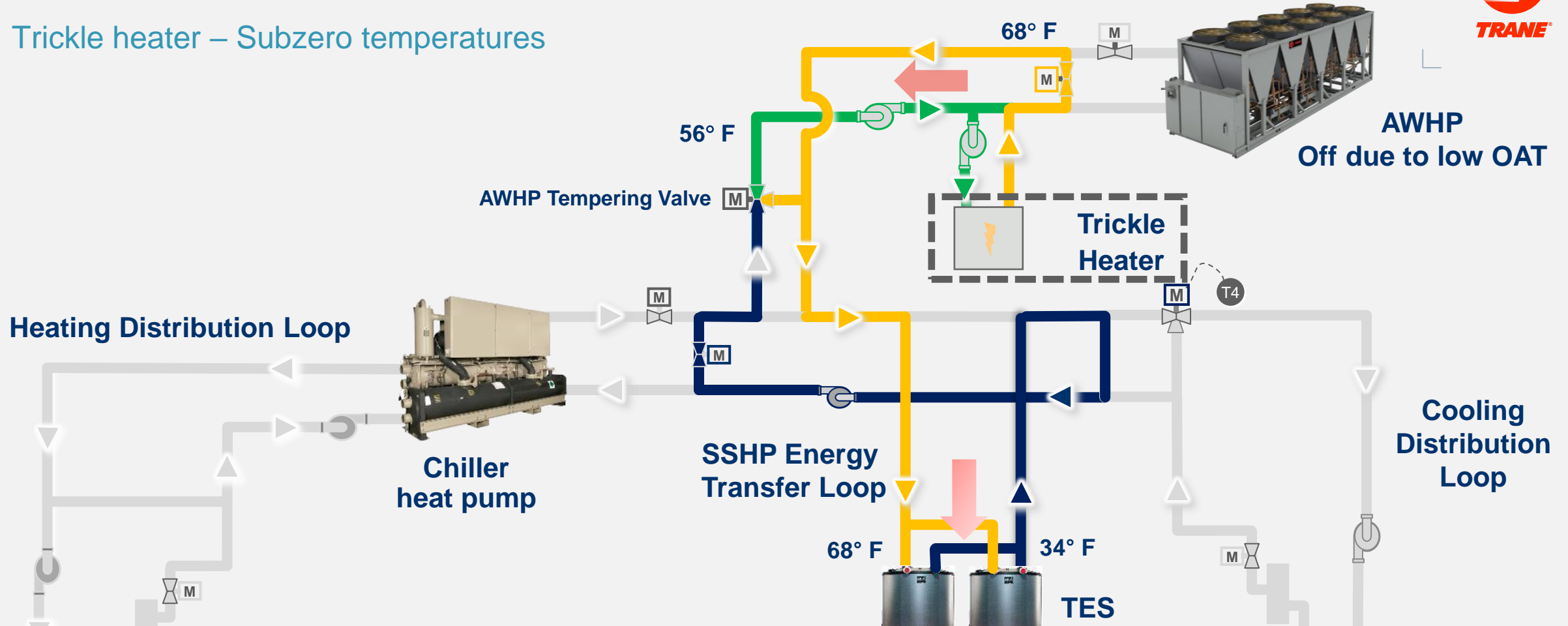
AWHP – Mild temperatures



Melt ice to meet the daily target

Heat collection

Trickle heater – Subzero temperatures



Rare operation only some hours per year!

Some important control features!

Ice level management - How much ice/water do we need for a given day?

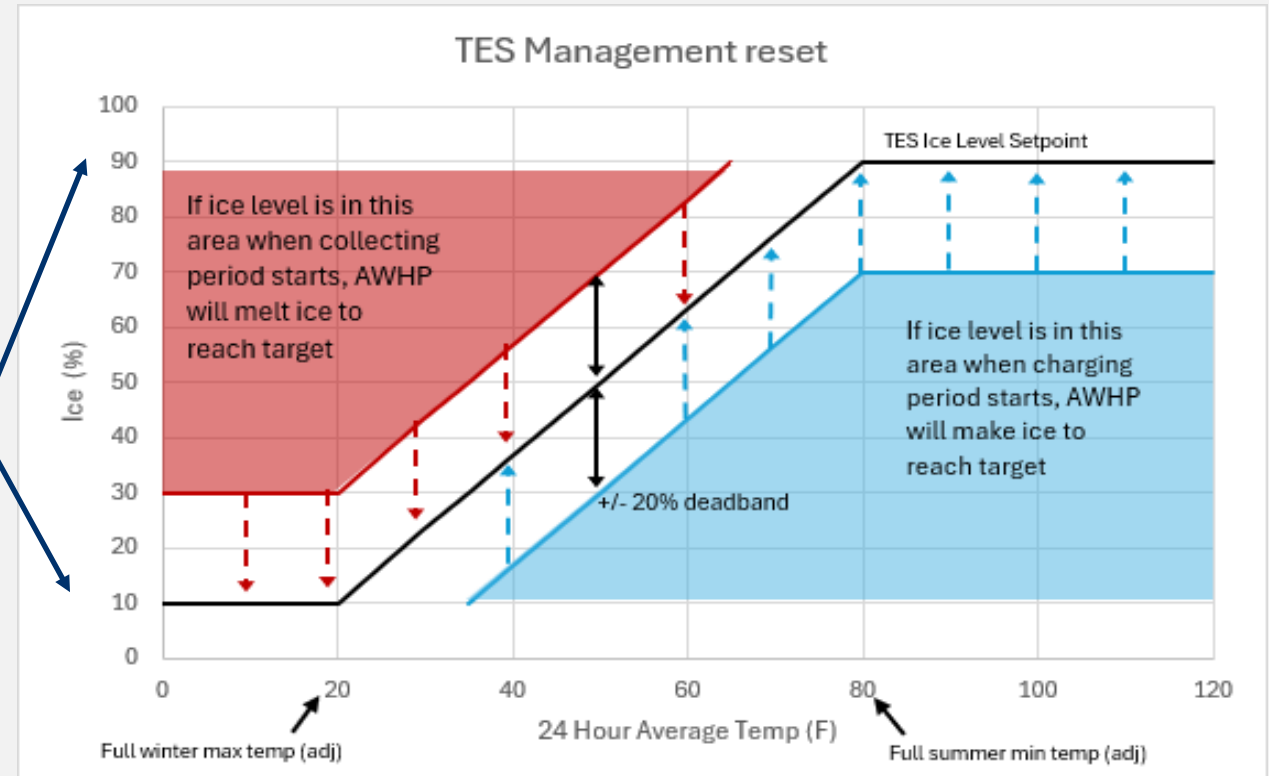


- Ice level Management

- Calculations using OAT temperature in a 24-hr period
- Make/Melt ice whenever it is most efficient (nights / days)



Adjustable limits

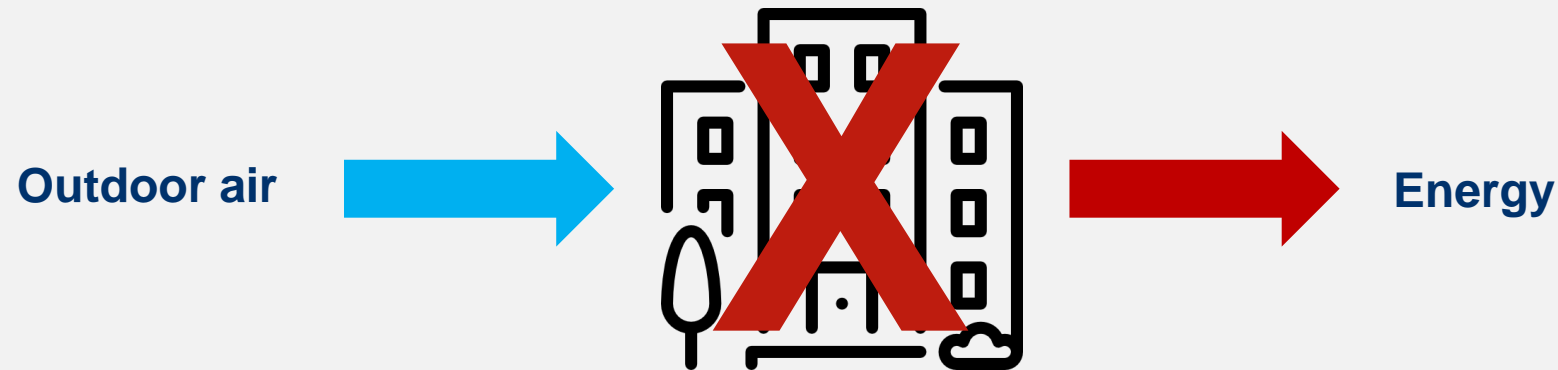


Some important control features!

Air side economizer control – Not always enabled!



- Air side economizer – Disable when:
 - Ice level more than 20% above setpoint
 - 24-hour average OAT below full winter maximum temperature
 - Any time during heat collection mode



Don't throw away heat that you will need later!

System monitoring

Leads to system optimization



Instrumentation

Energy
Metering

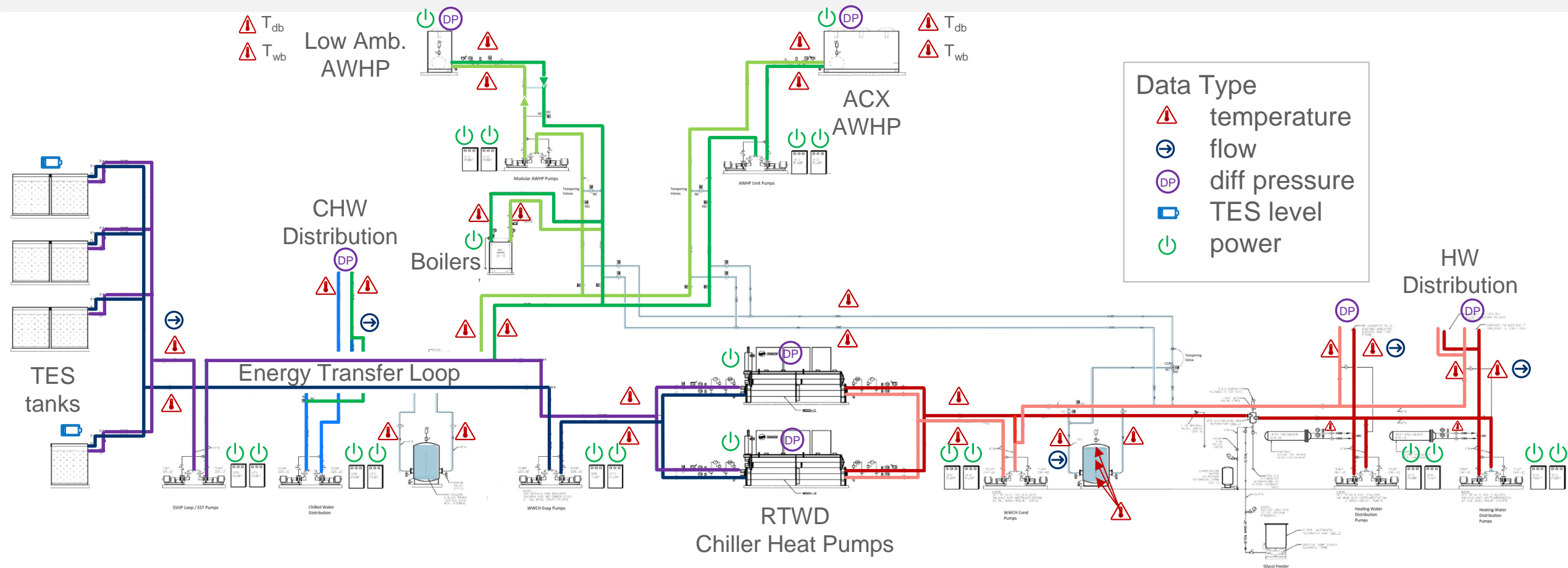
Ice Bank
Targets

Commissioning

Data Analytics

Instrumentation

We have 'extras'



System controls and monitoring



Tracer® SC+

- BAS integrates SSHP control
- Optimal control sequences
- Manages thermal storage target based on ambient temperature and schedules
- Synchrony™ for system data

Trane Ensemble® for facility management

Trane® Connect™ for system insights/optimization

Tests and Evaluations

- Low temperature heating
- Heating and cooling load profile
- Heating COP of equipment and system
- System control algorithm
- TES control optimization
- Low outdoor ambient operation
- Freeze protection evaluation
- Sensorless pump control evaluation
- Defrost performance evaluation
- Pump pressure optimization with mechanical PICV

Case studies

Continue to evolve



Heating Supply Fluid Temperature

Boiler temperatures
are a thing of the past

Sub zero heating performance

SSHP enables
electrified heating at
low ambient

Improved Seasonal COP Heating

compared to other
electrified solutions

Forecast IceBank

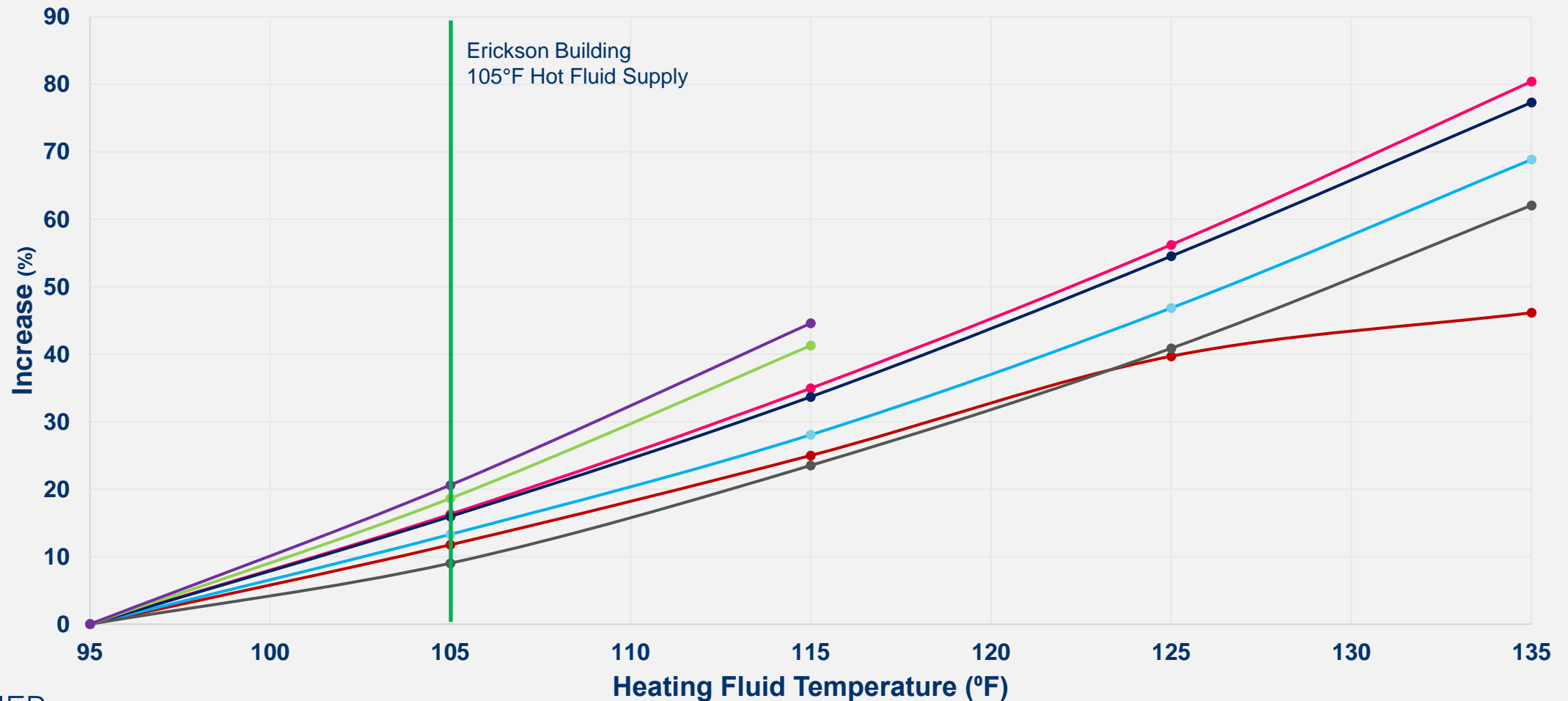
energy storage
levels

Lower than historical heating fluid temperatures

It works – even in cold climates – and saves energy



Heating Energy/Emissions Increase



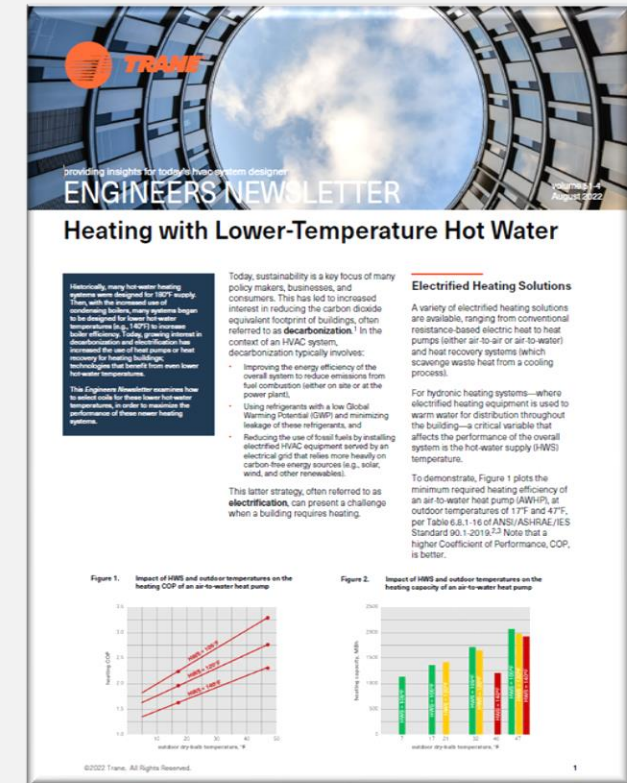
Hot water supply temperature



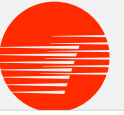
What is needed by the zone equipment?

- Most equipment can be selected for space heating with 100°F to 110°F hot water

Equipment	Minimum Hot Water Supply Temperature
DOAS Air Handler	>80°F
Central Air Handler/VAV	95-105°F
Single Zone VAV AHU	100-105°F
VAV boxes (4row)	95-105°F
Fan Coil Units w/ Changeover coil	100-115°F

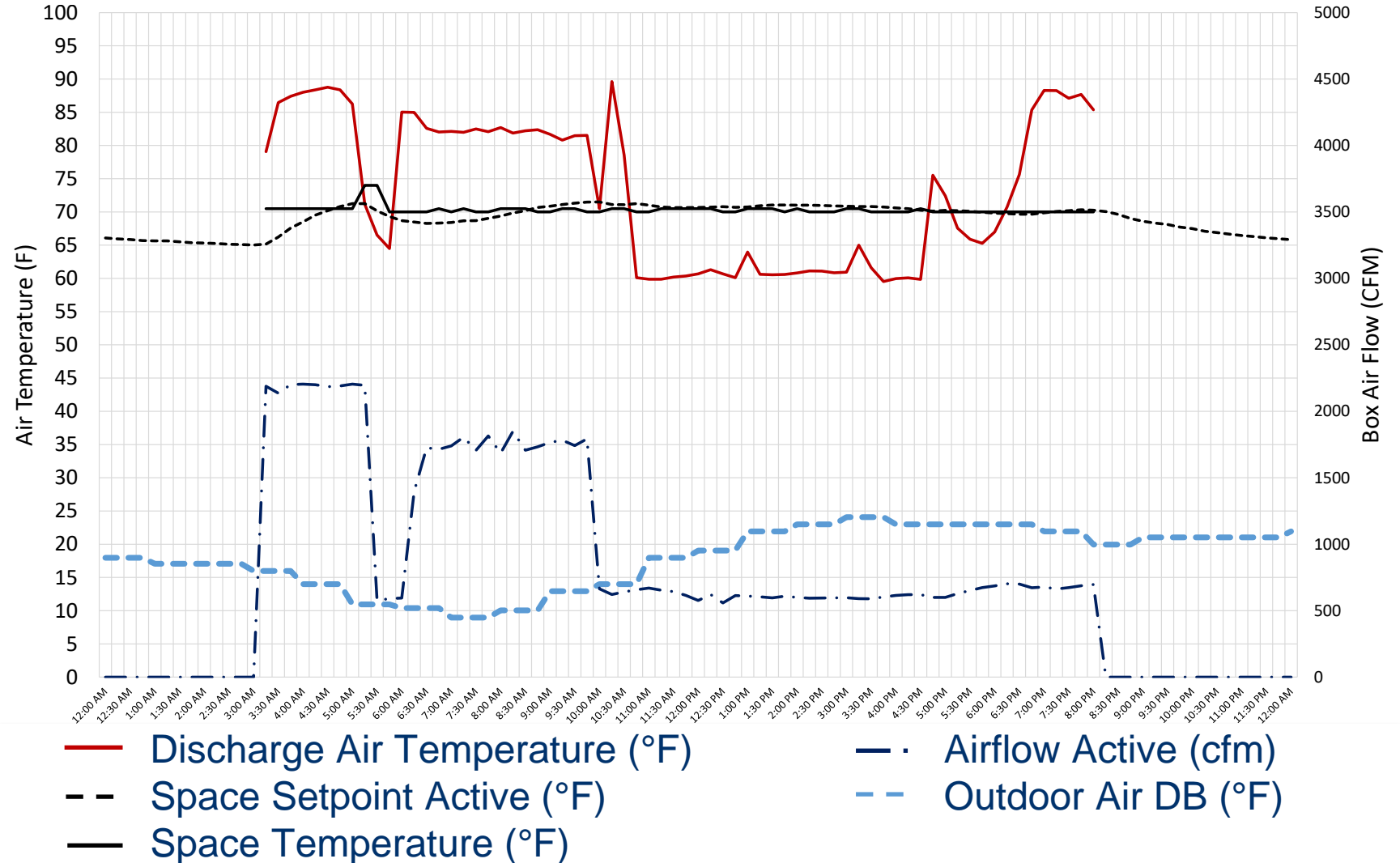


Multiple zone VAV | Heating with 105°F hot fluid supply



- 12-6am Unoccupied
- 3-5:30am Predictive Morning Warm Up
- 6am Occupied
- 6-6:15am Stage 1 Heat
- 6:15-10:30a Stage 2 Heat
- 10:30am-8pm Stage 1 Heat
- 8pm Unoccupied

Large VAV Box – Student Lounge | November 8th OA Temperature 8-24°F



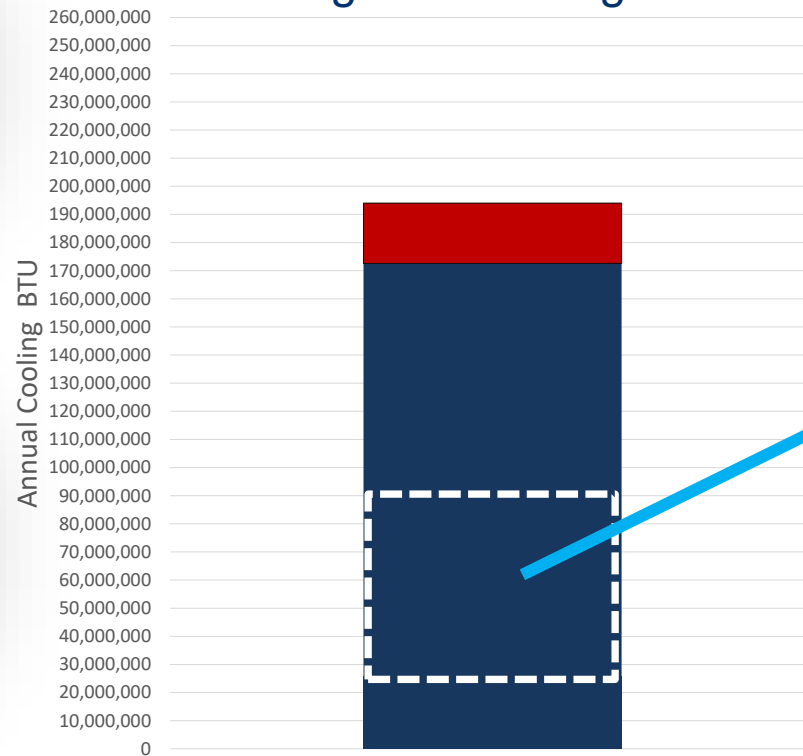
Multiple zone VAV system

Heating with 105°F HWS for SSHP

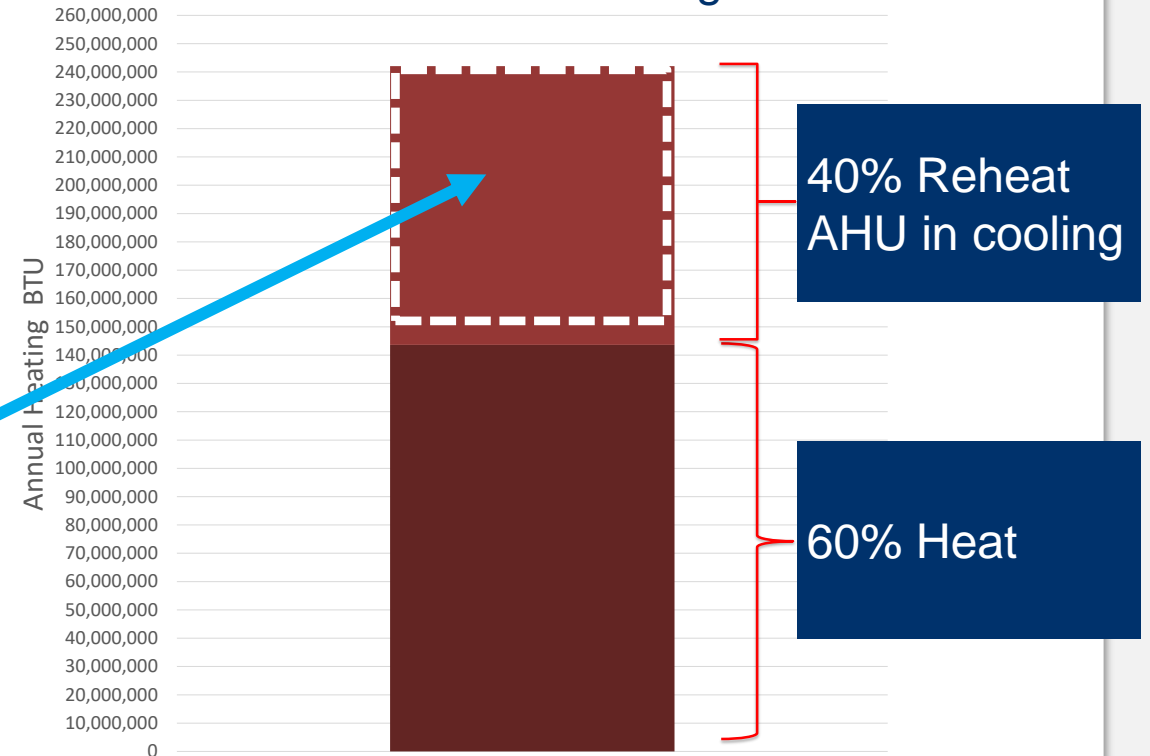


SSHP Annual Heating and Cooling Provided for VAV system

Annual Logged AHU Heating and Cooling



Annual Logged VAV Boxes Heating
4-row VAV Box Heating Coils



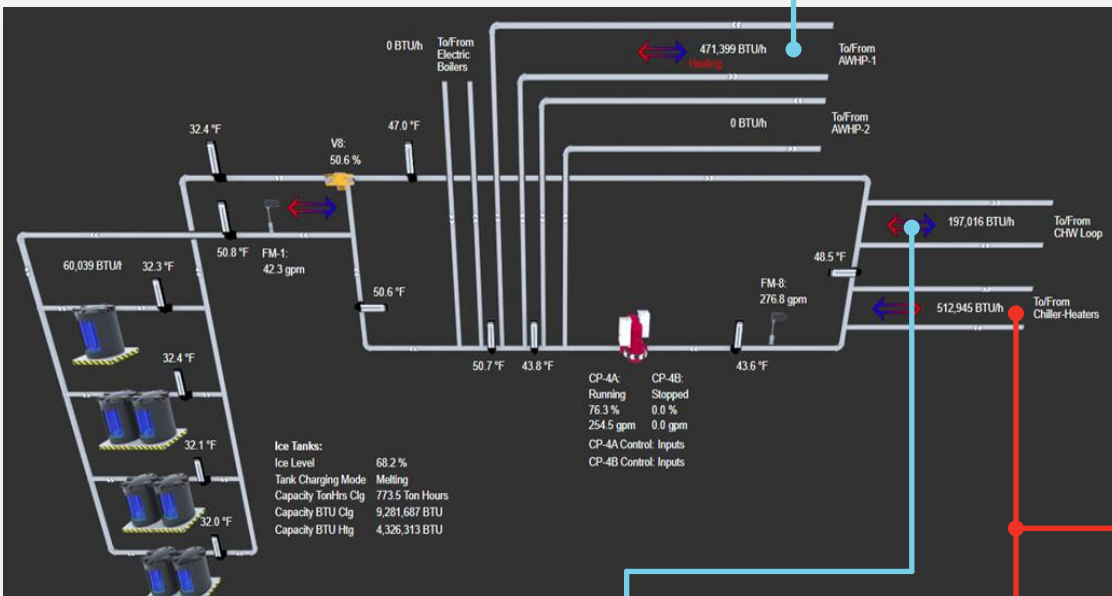
90% of reheat is recovered

66 MMBTU Cooling -> 88.8 MMBTU Reheat

SSHP performance at 0°F ambient



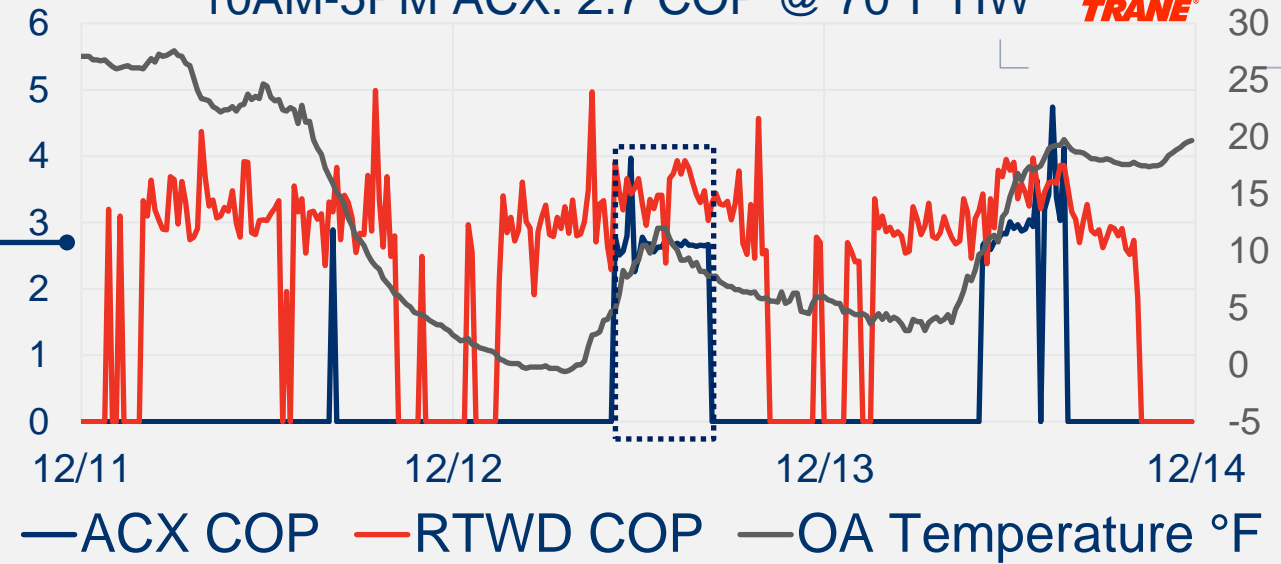
Collected heat from
ACX at 2.7 COP



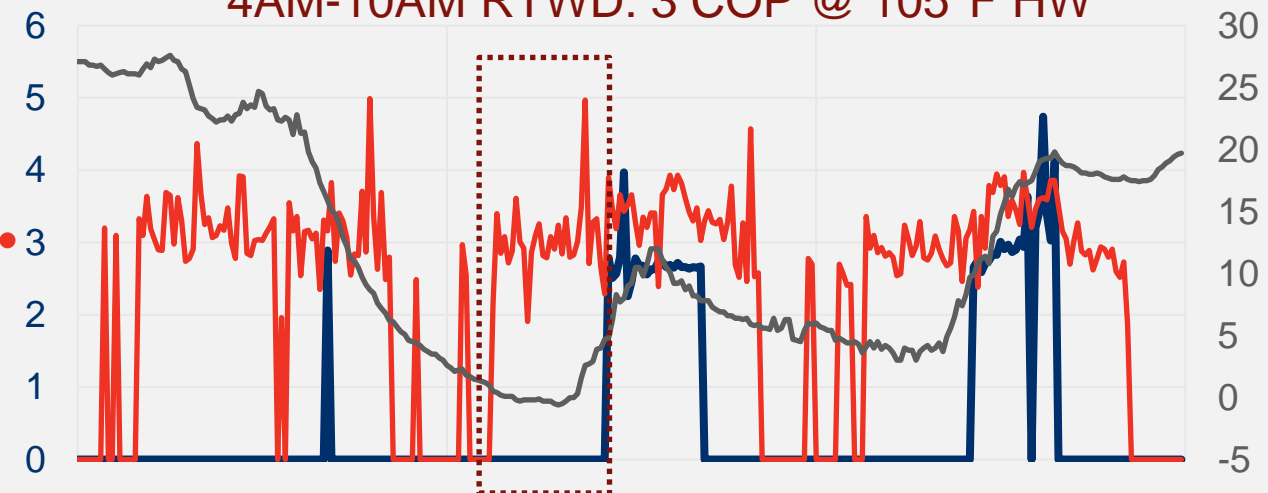
Reclaimed heat
from cooling

**3.0 Heating COP
@ 0°F OAT**

10AM-5PM ACX: 2.7 COP @ 70°F HW

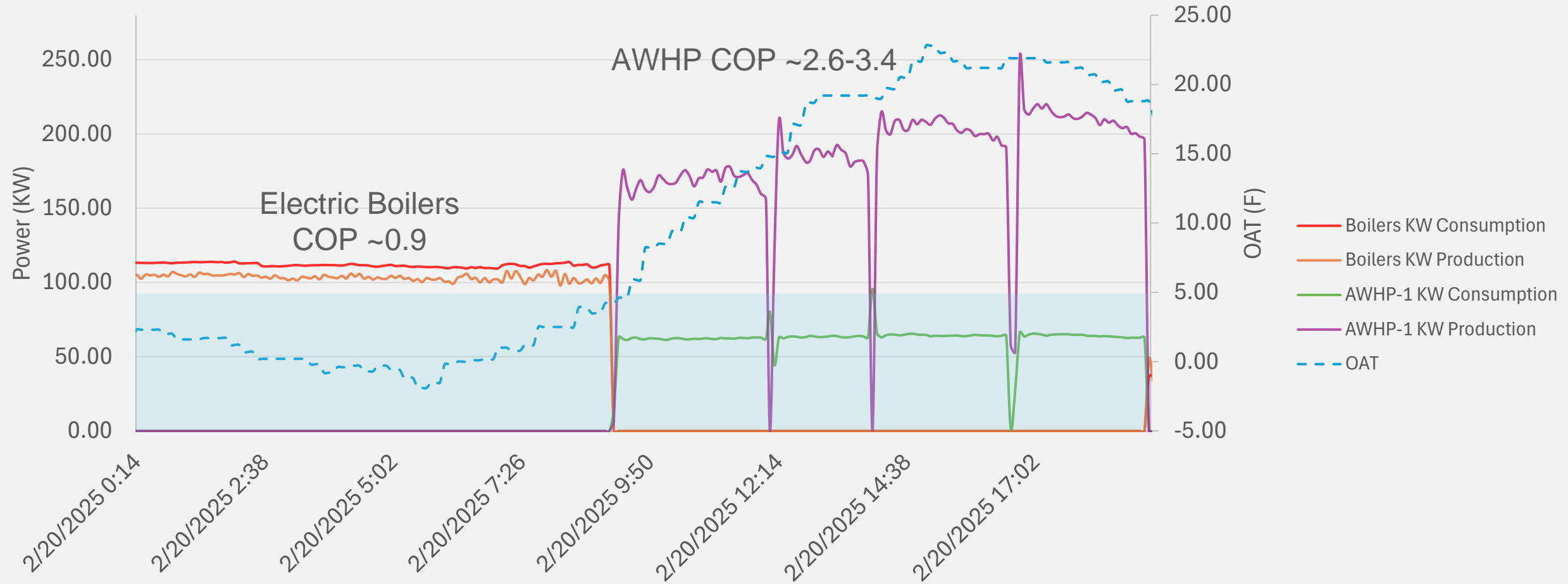


4AM-10AM RTWD: 3 COP @ 105°F HW



Seasonal heating COP

Heat collection efficiency

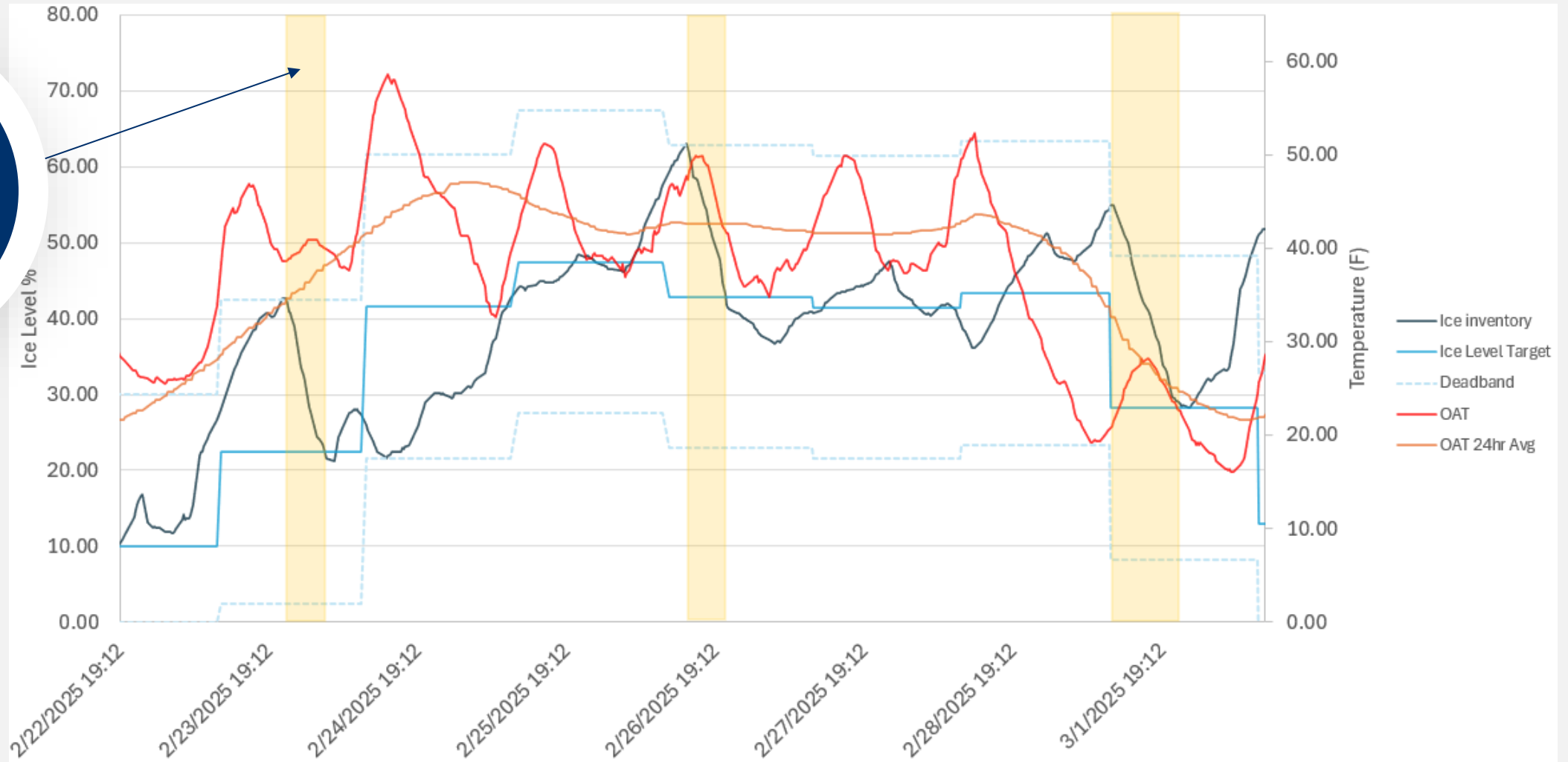


Ice level management operation

How does the plant determine the right amount of ice?



Just 3 heat collection periods in 8 days

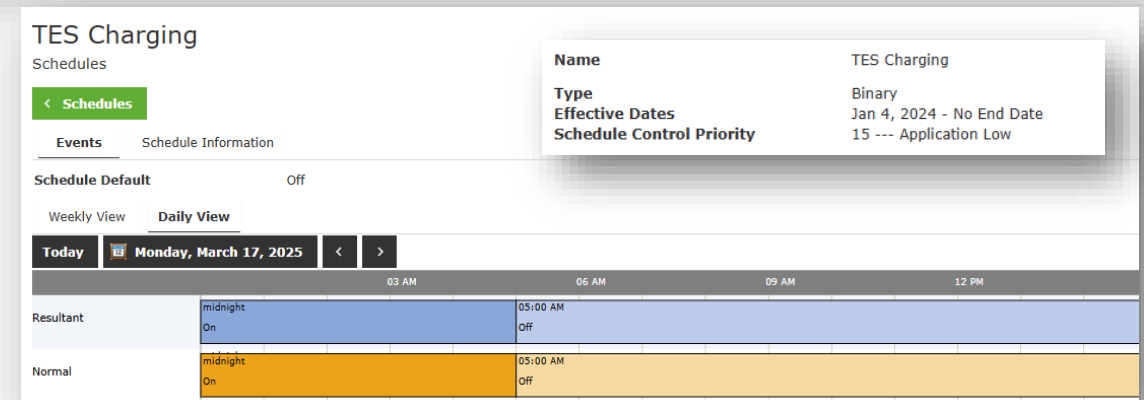
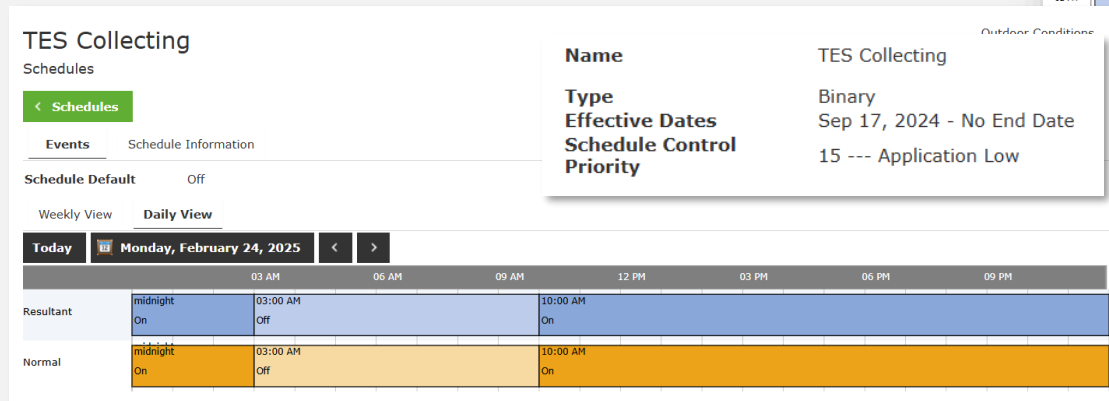
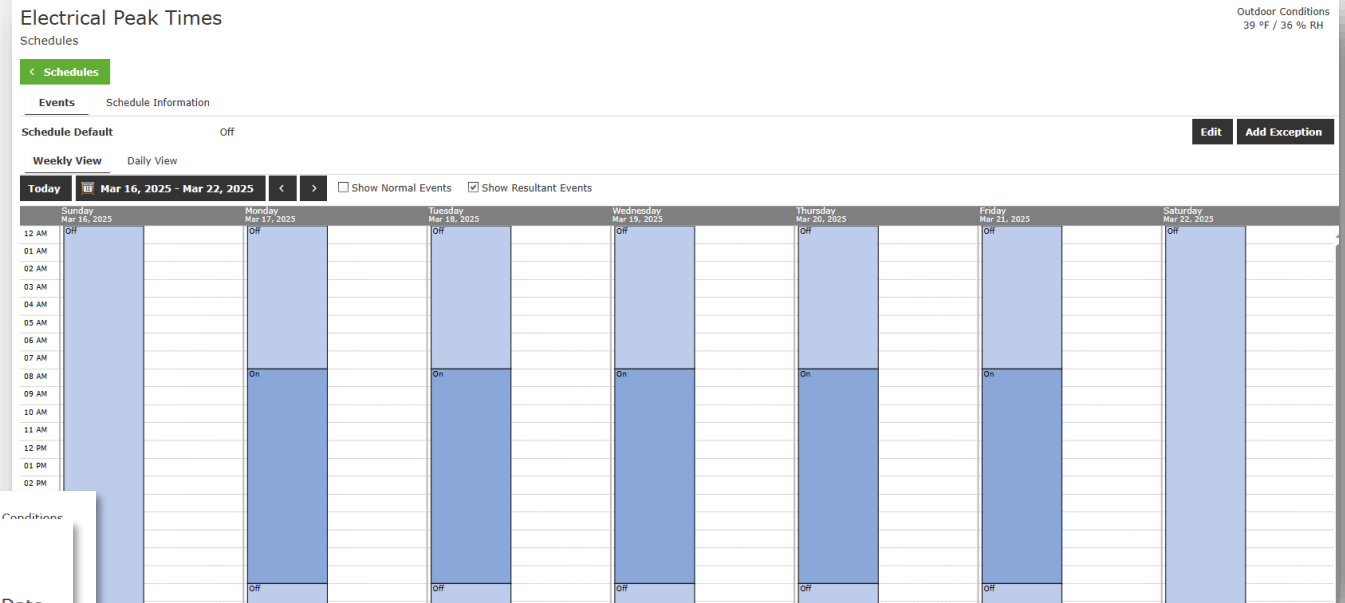


Schedules

Simple graphical view and configuration



- Schedules to determine:
 - Electrical Peak Times
 - Heat Collection Window
 - Charging Window



Pitfalls and lessons learned



Decoupler piping

Specifications matter...and must be communicated



Best Practices

- Tees are in straight pipe
 - At least 5 pipe diameters upstream of fittings/devices
- Tees are at right angle
 - Guard against ghost flow
- Tee separation
 - 2-10 pipe diameters

BEFORE



AFTER



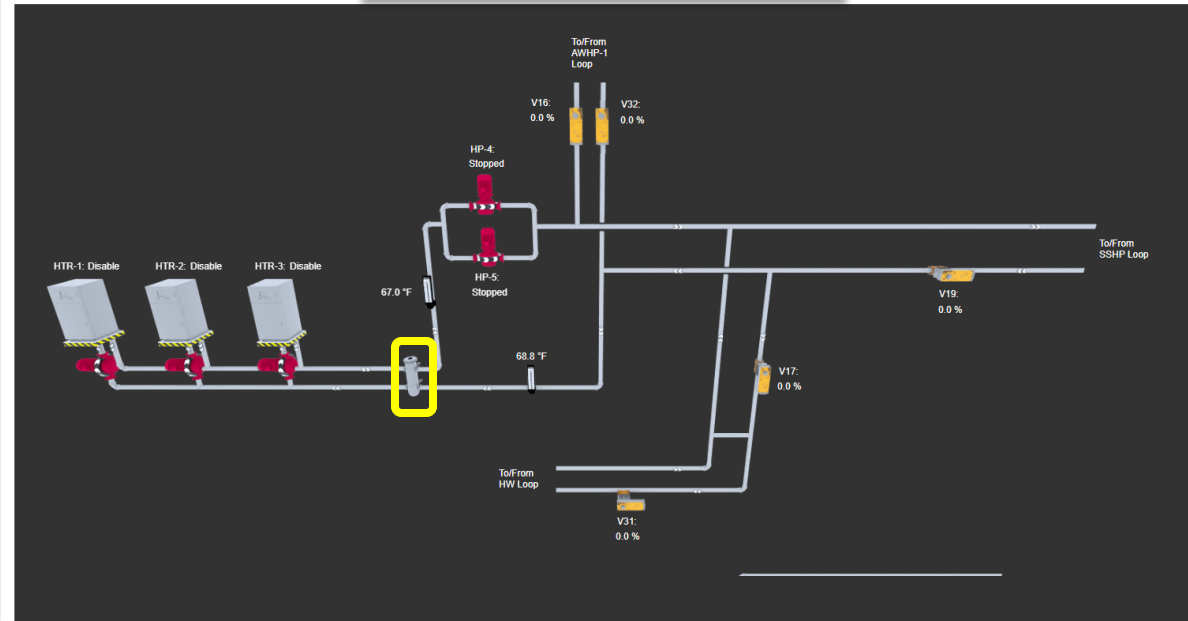
Document specifications
to reduce unnecessary rework costs.

Trickle heater pressure rating



Boiler-Wtr-Loop-Comp
Graphics (Custom)

Outdoor Conditions
38 °F / 40 % RH



- Direct heating scenario
 - At Trane and in a customer site
- Issue:
 - Electric boiler rated for 30psi
 - Distribution system pressure 45 psi
- What happened?
 - PRV opens when pumping direct to distribution
 - Hydraulic separator inadequate
- Solution:
 - Replace hydraulic separator with heat exchanger

Auxiliary heating sequences

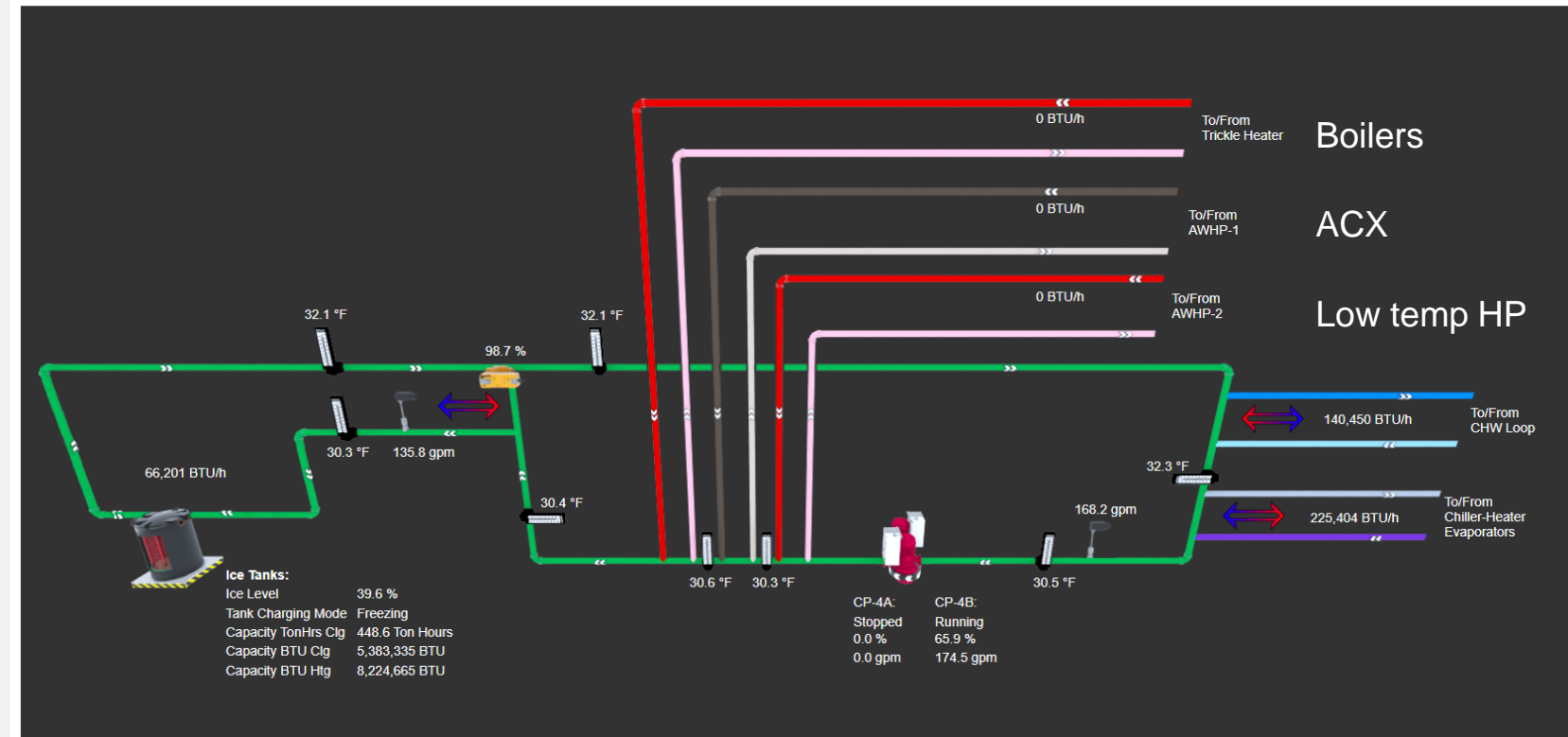
Not defined soon enough



- Emergency sequences are **critical** to system operation
 - Define early
 - Implement
 - Validate
 - Modify
- Plan for all situations
 - Especially the unexpected

SSHP-Wtr-Loop-Edu
Graphics (Custom)

Outdoor Conditions
38 °F / 40 % RH



Other lessons



Commission early

- With the right stakeholders



Test sequences individually

- Allot time for validation



Early operator engagement

- Curate training material
- Control technicians
- Installers
- Project managers
- Facility managers



Operation before optimization

- Validate sequences



Integrated design team coordination for successful implementation.

Fully electrified heating in cold climates is possible

Final thoughts!



Learning
laboratory

Involve cx
with
operator
early

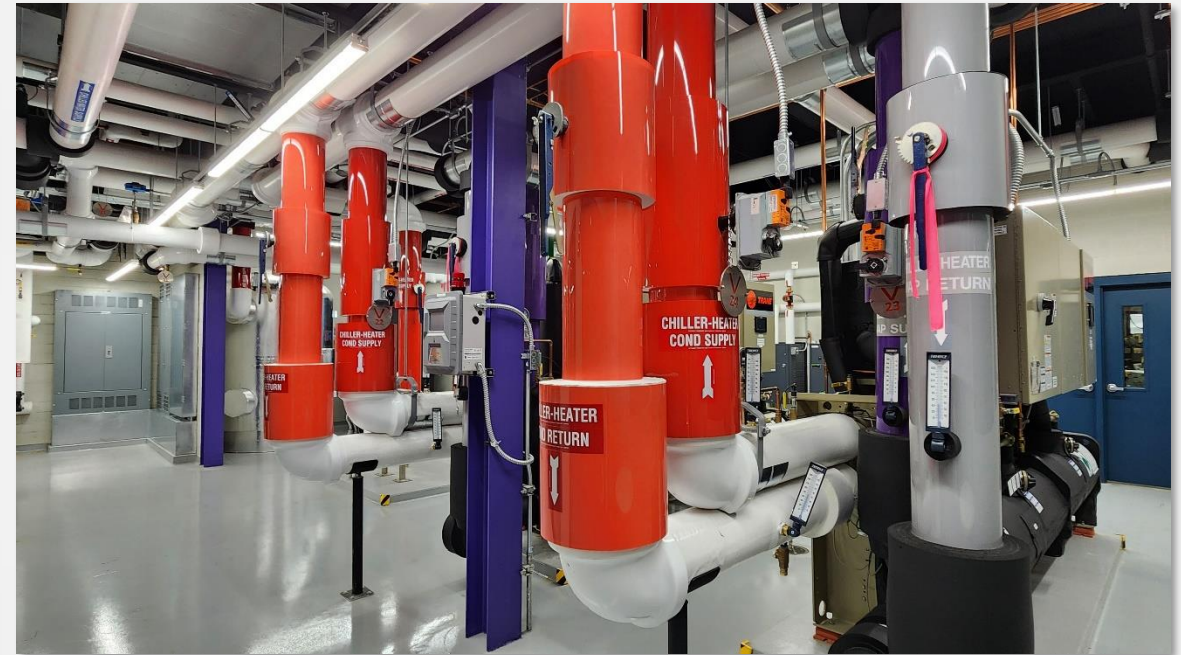
Stakeholder
coordination

**Proof of
concept
The SSHP
works as
expected**

Sequences
validated in
a real, live
building!

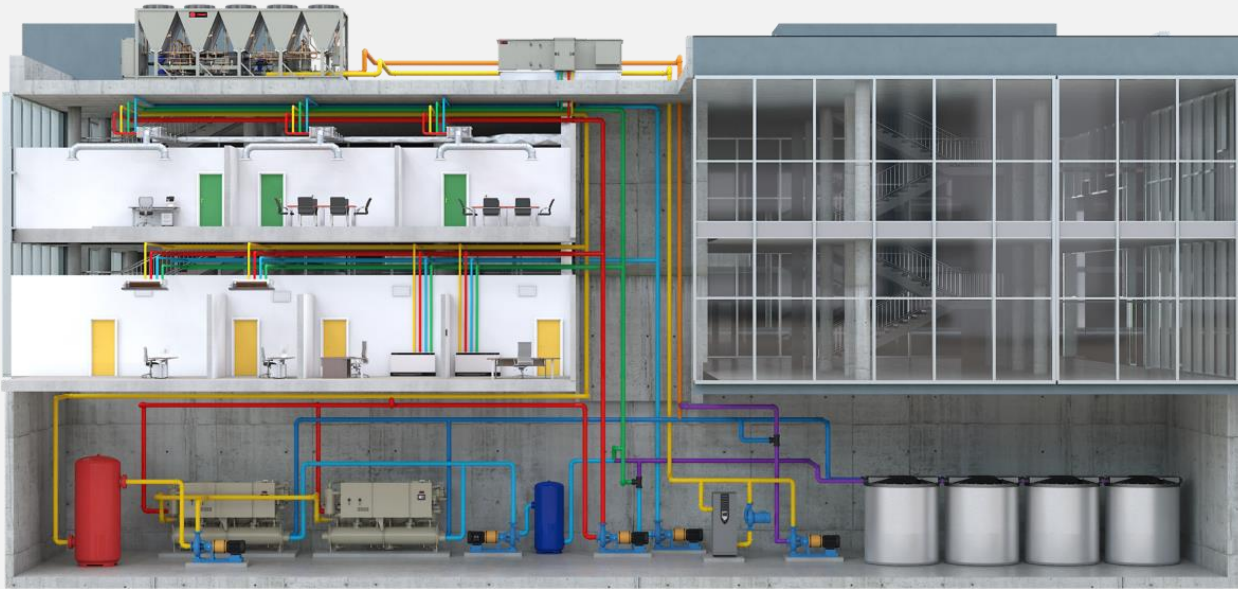
Active
involvement
with operators,
installers, GC
through entire
process

Enhanced
performance



Engineering resources

Want to learn more?



SSHP Resources

- Electrification of Cooling and Heating with Thermal Energy Storage Engineers Newsletter Live program (APP-CMC083-EN)
- Electrified Heating System Control Strategies Engineers Newsletter Live program (APP-CMC088-EN)
- Thermal Battery™ Storage-Source Heat Pump application guide (APP-APG022*-EN)
- Thermal Battery™ Storage-Source Heat Pump Systems: Harnessing the Flexibility of Electrified Ice Heating (SYS-SLB036-EN)



Additional Resources

- Heating with Lower-Temperature Hot Water Engineers Newsletter (ADM-APN084-EN)
- Heating with Compressors application manual (SYS-APM005*-EN)
- Comprehensive Chiller-Heater System application guide (SYS-APG003*-EN)
- Hydronic Heating Systems Air Conditioning Clinic (TRG-TRC021-EN)
- Retrofitting Hydronic Heating Systems Engineers Newsletter Live program (APP-CMC091-EN)

Engineering resources

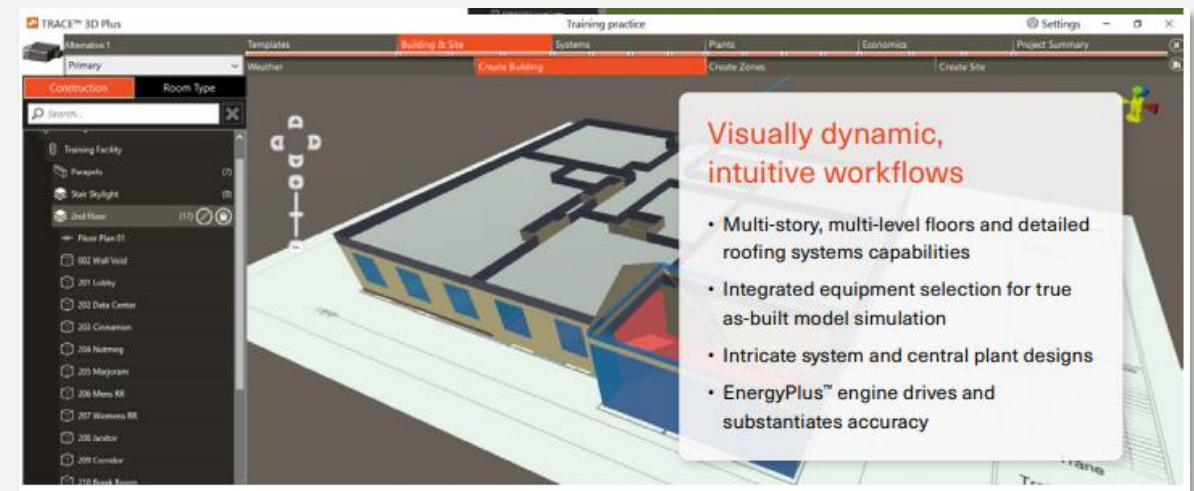
Leverage Trane's expertise and resources from conceptual design to seamless system control.



- Design Tools:
 - Trane System Designer:
 - System Performance and Sizing
 - Comparative energy analysis
- TRACE® 3D Plus Building Performance
 - Capable of full and partial thermal storage for cooling-only
 - SSHP coming later this year
- Design Day with Trane
 - In person
- Come see our system!

The screenshot shows the 'Building Inputs' form in the Trane System Designer software. The form is organized into sections: Project Name (University Of Michigan), Project Location (Region: North America, Country: United States, State: Michigan (MI), City: Flint (5A)), Altitude (ft) (768), CO2e Emission Rate (lb/MWh) (1013.4), Building Type (Building Type (baseline loads): School, Building System Type: MZVAV Air Economizing), and Building Loads (Peak Cooling Load (Tons): 169, Peak Heating Load (MBh): 1586). There are buttons for 'Reset All Inputs', 'Next step: Plant Inputs >', and '< Help'.

Building Inputs		
Project Name University Of Michigan		
Project Location:		
Region	North America	
Country	United States	
State	Michigan (MI)	
City	Flint (5A)	
Altitude (ft)	Default	Override
	768	
CO2e Emission Rate (lb/MWh)	1013.4	
Building Type:		
Building Type (baseline loads)	School	
Building System Type	MZVAV Air Economizing	
	Custom Profile > (later)	
Building Loads:		
Peak Cooling Load (Tons)	Default	Override
	169	
Peak Heating Load (MBh)	1586	

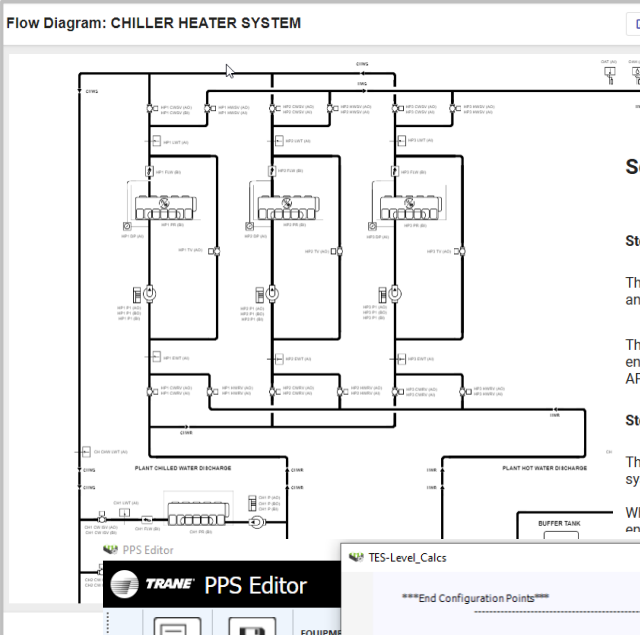


Engineering resources

Leverage Trane's expertise and resources from conceptual design to seamless system control.



- System Control Tools:
 - Trane Design Assist:
 - Generate control drawings
 - (Piping layout, Sequences of operation, wiring details, spec language,...)
 - “Pre-Packaged Solutions” programs:
 - All the required standard programs and code available in a single location.



Flow Diagram: CHILLER HEATER SYSTEM

Sequence of Operation: CHILLER HEATER SYSTEM

Storage Source Heat Pump (SSHP) System General Description:

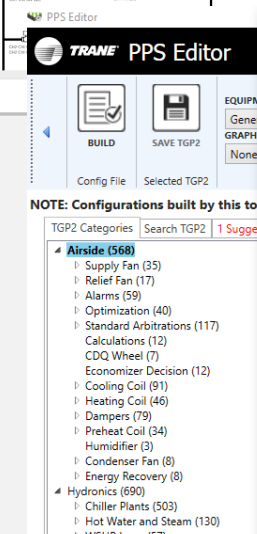
The storage source heat pump (SSHP) control system shall monitor and control the system's ice tanks, air to water and any other equipment as shown on the water plant piping diagrams, in the water plant points list and as detailed in the SSHP system description.

The SSHP system is a high efficiency hydronic system that consists of multiple pieces of heating and cooling equipment in the building and producing hot water and chilled water to serve the building loads. For detailed terminology see APG022*-EN)

Storage Source Heat Pump (SSHP) System Enable/Disable:

The SSHP plant shall be enabled/disabled by the SSHP plant controller as requested by the Building Automation System. The system shall start and stop the water pumps and cooling/heating equipment based upon system cooling and heating demands.

When the SSHP plant is enabled and there is a call for cooling and/or heating as determined by the BAS, the system shall enable the required equipment.



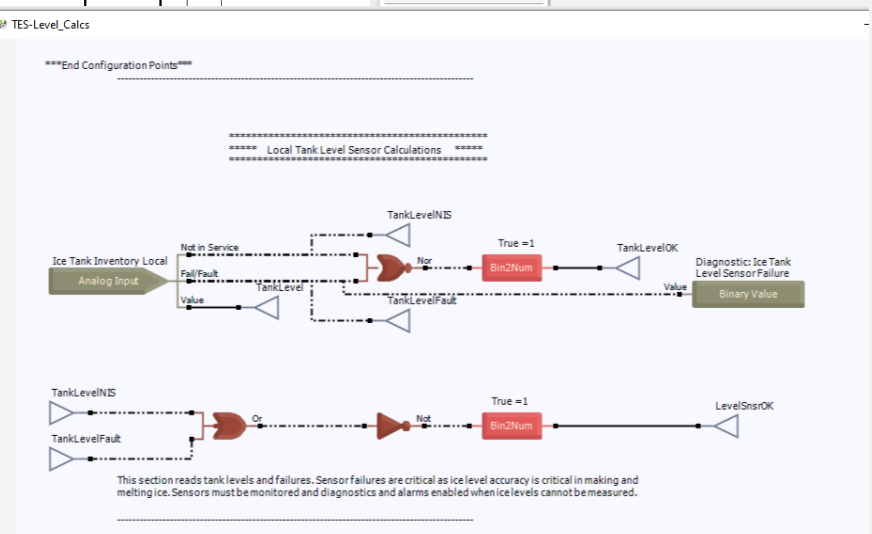
TRANE PPS Editor

Build, Save TGP2, Config File, Selected TGP2

NOTE: Configurations built by this tool

TGP2 Categories: Search TGP2, Suggest

- Airside (568)
 - Supply Fan (35)
 - Relief Fan (17)
 - Alarms (59)
 - Optimization (40)
 - Standard Arbitrations (117)
 - Calculations (12)
 - CDQ Wheel (7)
 - Economizer Decision (12)
 - Cooling Coil (91)
 - Heating Coil (46)
 - Dampers (79)
 - Preheat Coil (34)
 - Humidifier (3)
 - Condenser Fan (8)
 - Energy Recovery (8)
- Hydronics (690)
 - Chiller Plants (503)
 - Hot Water and Steam (130)
 - WSHP Loop (57)



TES-Level_Calcs

End Configuration Points

Local Tank Level Sensor Calculations

Ice Tank Inventory Local: Not in Service, Fail/Fault, Value, TankLevel, TankLevelFault, TankLevelNIS, TankLevelOK, Diagnostic: Ice Tank Level Sensor Failure, Binary Value

TankLevelNIS, TankLevelFault, Or, Not, True = 1, LevelSensorOK

This section reads tank levels and failures. Sensor failures are critical as ice level accuracy is critical in making and melting ice. Sensors must be monitored and diagnostics and alarms enabled when ice levels cannot be measured.



Breakout Workshops

Thank you!

If you would like to receive PDH credit for this session, please be sure to provide your feedback in the applicable session survey.
(Also available via the event App!)

**Surveys close 6/4/25*





2025 PARTNER 2025 EXCHANGE

35th Anniversary

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