Design and Control of Thermal Energy Networks

Moderator: Jacky Kinson / *CDM Smith*

Panel: Stephen Hak / *GEOptimize*

Charlie Marino / *WSP*

Brian Urlaub / *Salas O'Brien*

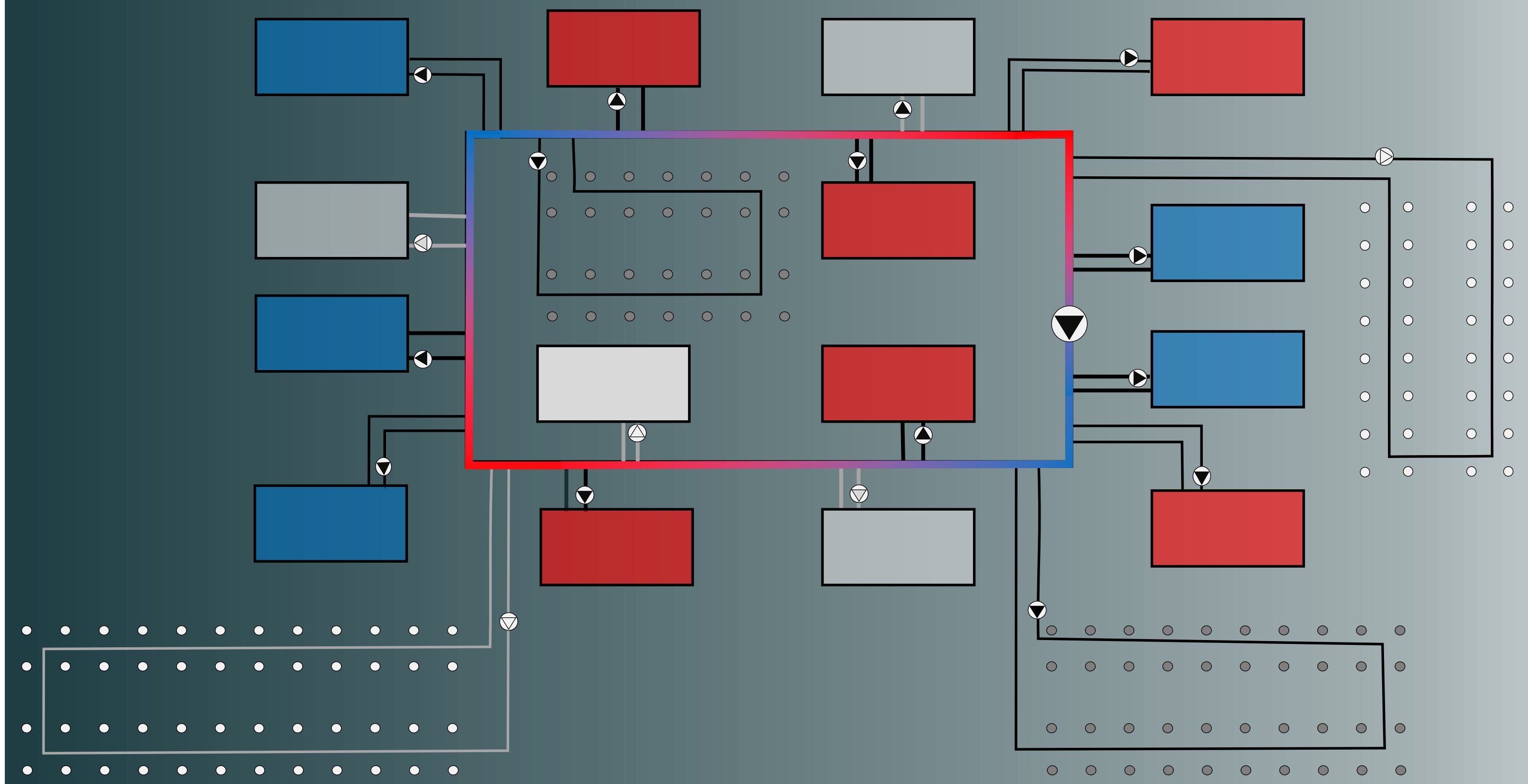
Brendan Hall / *CHA Consulting*

Control of Thermal Energy Networks:

Single-Pipe Ambient Loops

Stephen Hak - Engineer

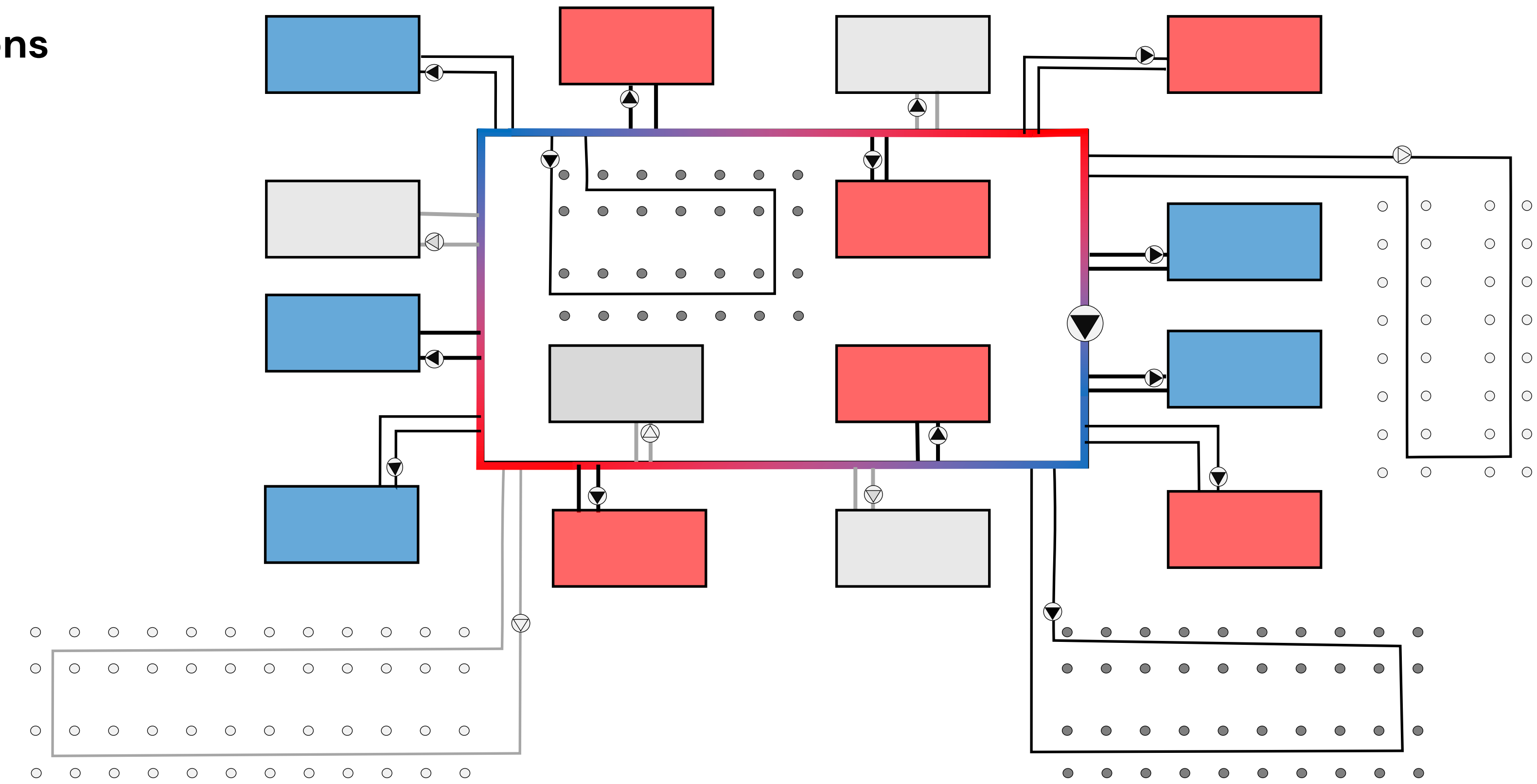
GEOptimize



Single-Pipe Ambient Loop

Main System Components

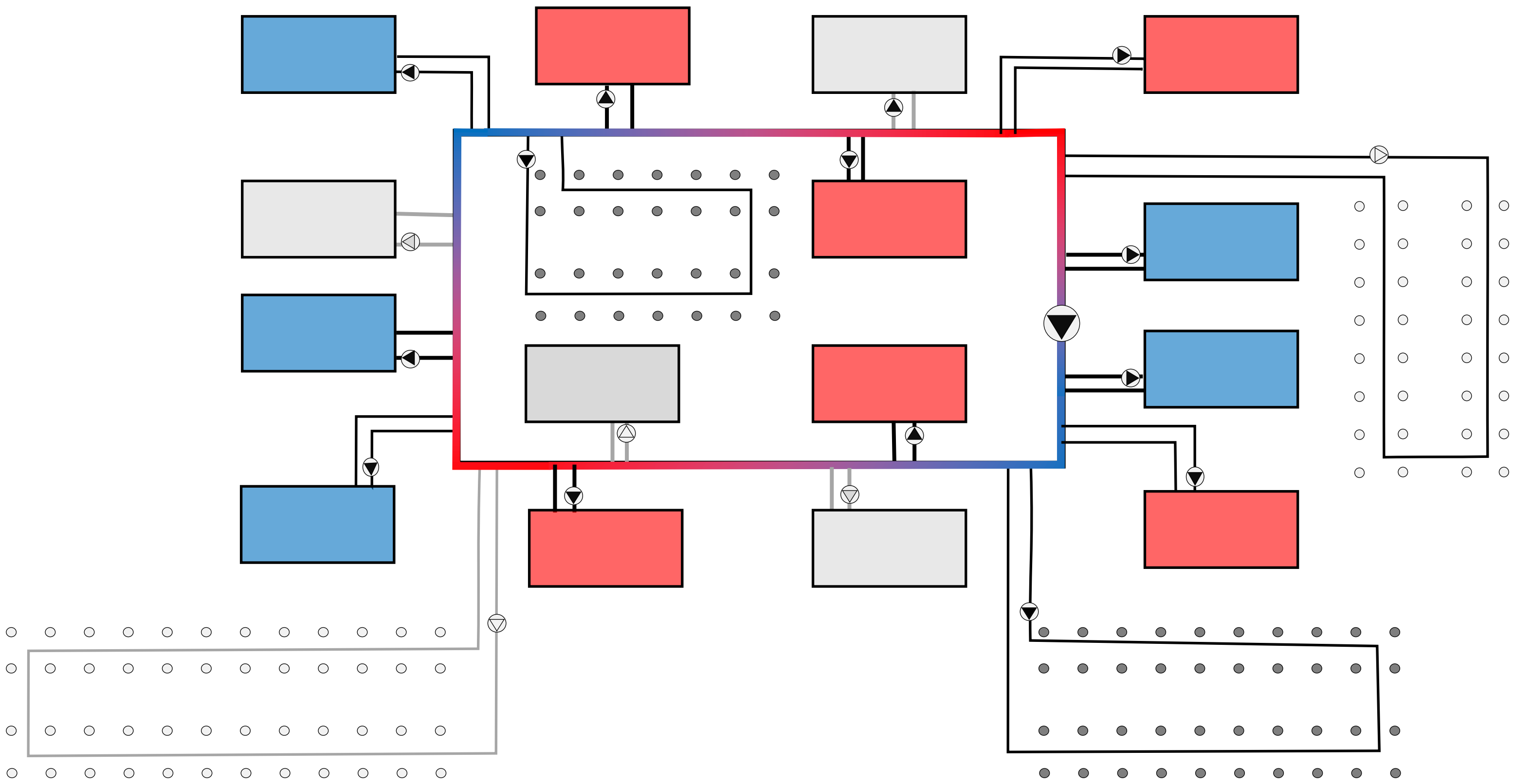
1. **Main Distribution Pipe**
2. **Building Supply/Return Connections**
3. **Energy Sources/Sinks**
   - Ground heat exchanger (GHX)
     - Vertical
     - Horizontal
     - Lake/pond
     - Groundwater
   - Auxiliary energy systems
     - Solar thermal
     - Dry fluid cooler
     - ASHP
     - Wastewater



Single-Pipe Ambient Loop

Main Control Components

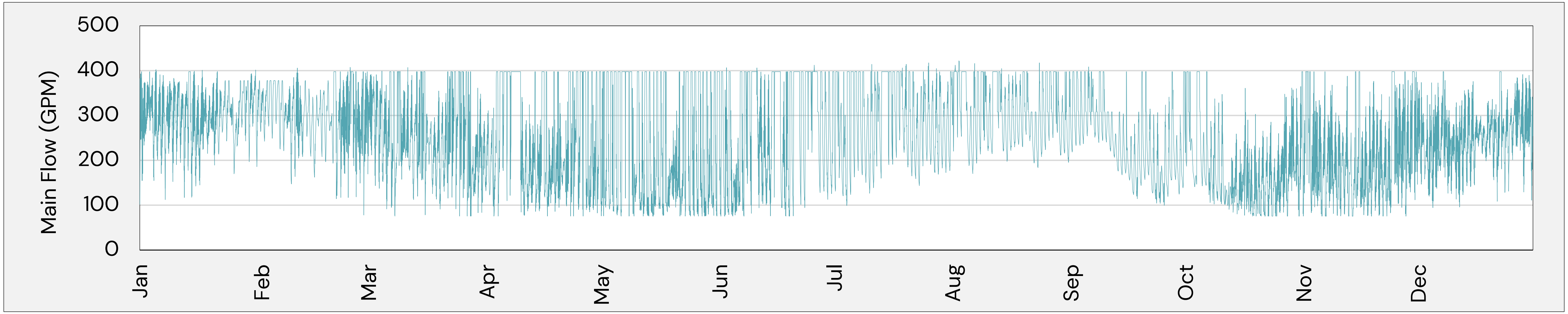
1. **Building Supply/Return Pumps**
2. **Main Distribution Pump**
3. **Energy Source/Sink Pumps**
   - GHX
   - Auxiliary

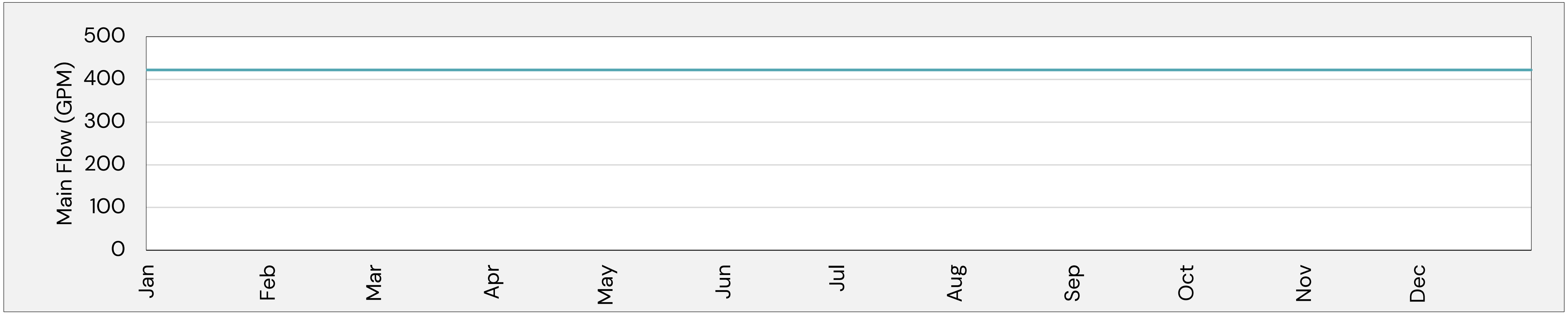


Single-Pipe Ambient Loop

Main Distribution Pump Controls

Constant or Variable Speed





Single-Pipe Ambient Loop

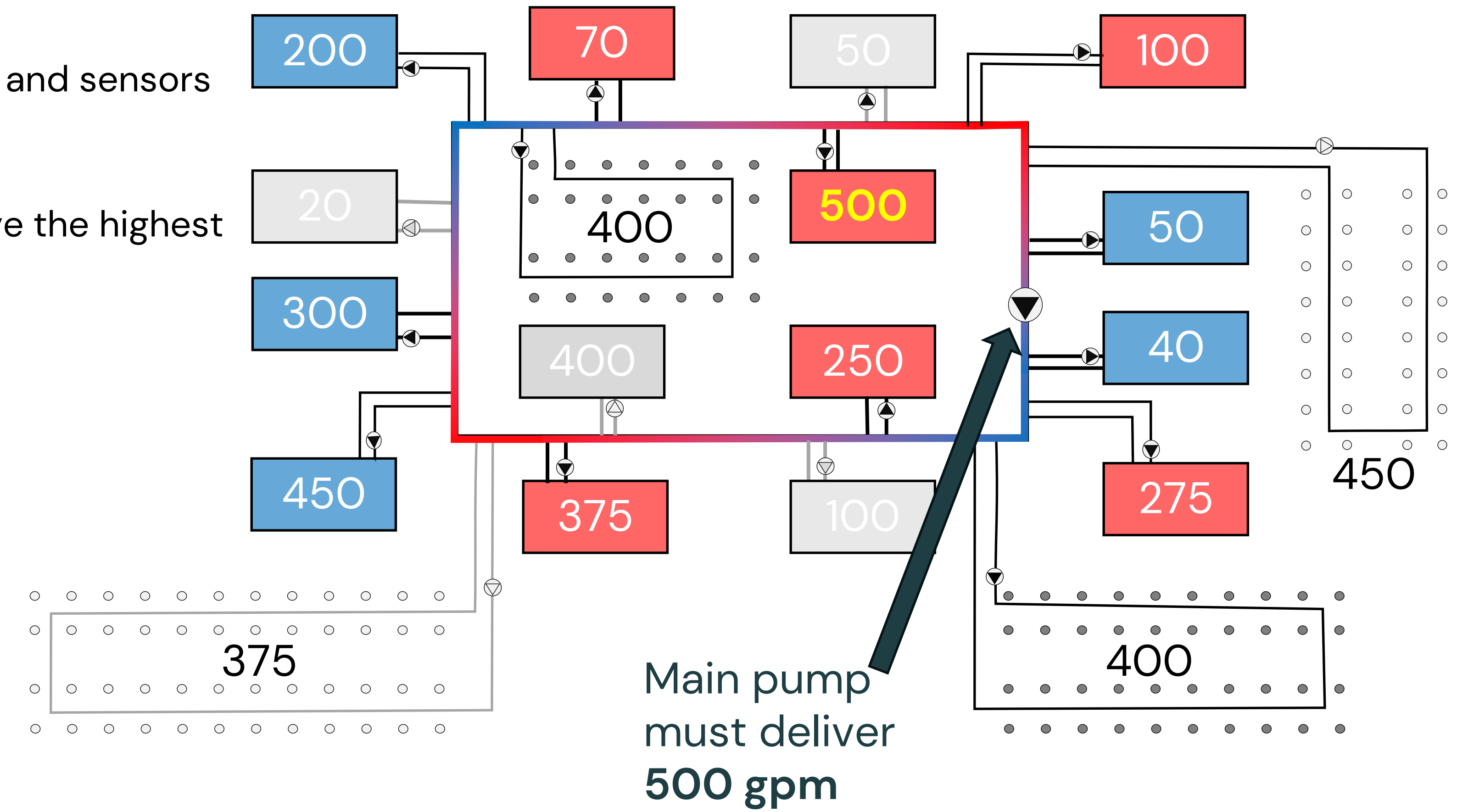
Main Distribution Pump Controls

Variable Speed

- More complex for a decentralized system
- Requires communication between pumps and sensors over large distances

Control Objectives

1. Maintain main distribution flow at or above the highest connected flow requirement



Single-Pipe Ambient Loop

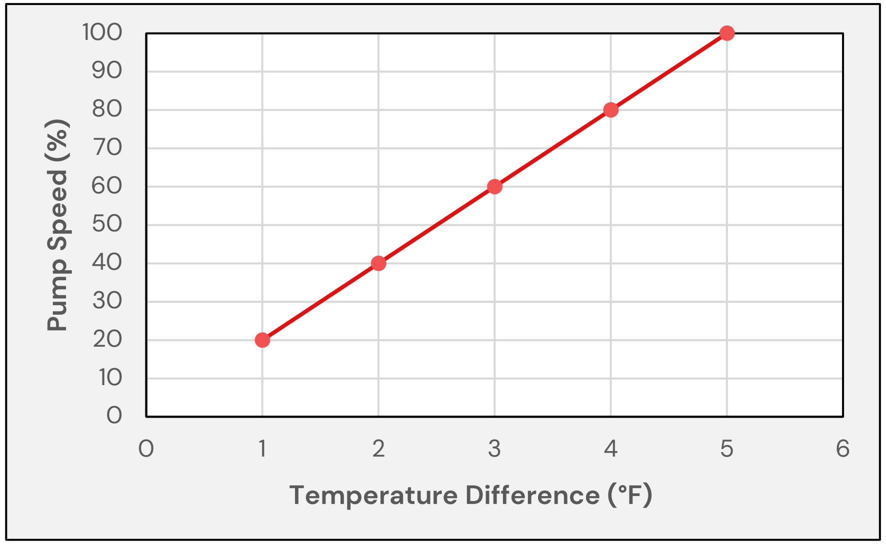
Main Distribution Pump Controls

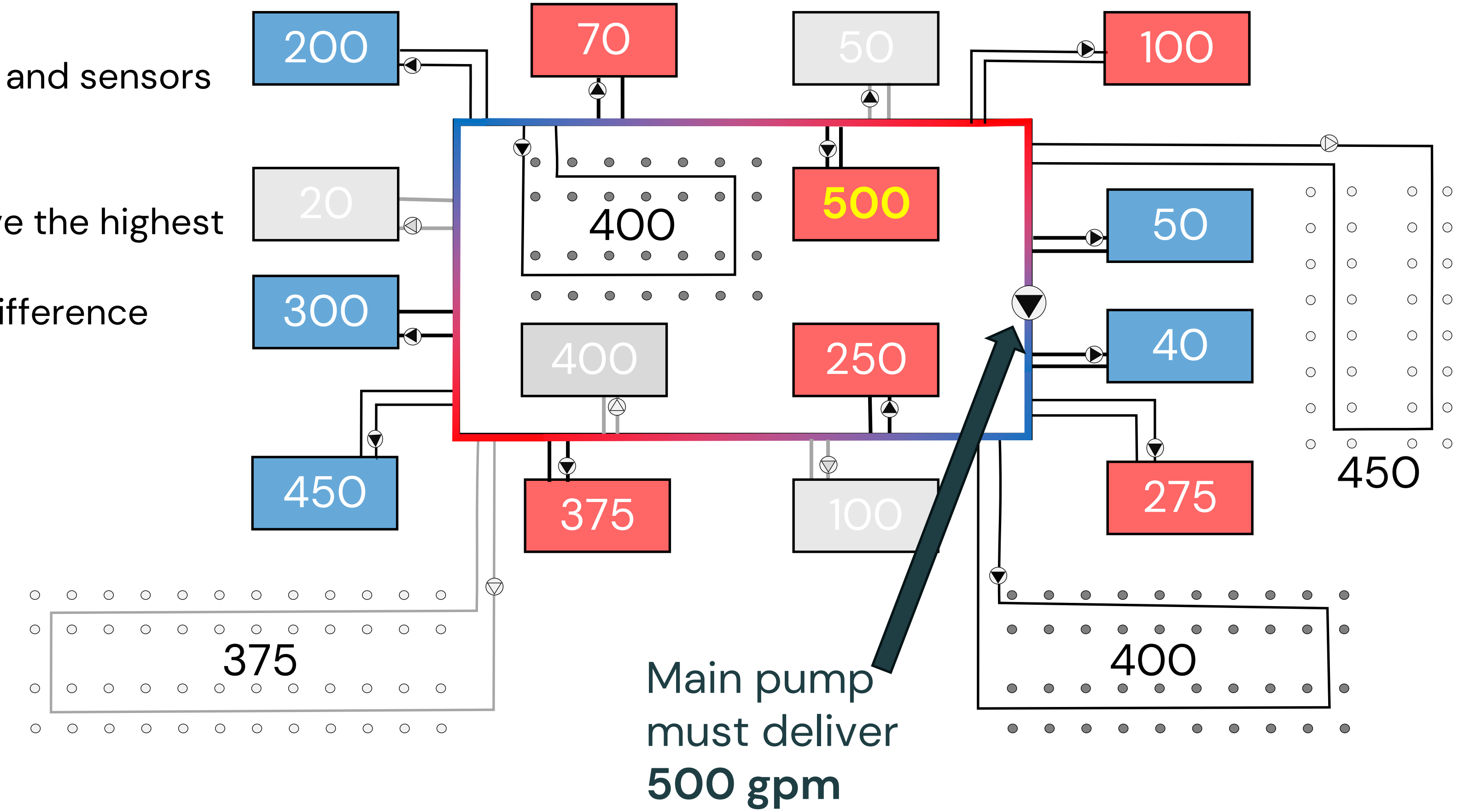
Variable Speed

- More complex for a decentralized system
- Requires communication between pumps and sensors over large distances

Control Objectives

1. Maintain main distribution flow at or above the highest connected flow requirement
2. Minimize the fluid delivery temperature difference





Single-Pipe Ambient Loop

Main Distribution Pump Controls

Example project: Ithaca, NY, USA

- 40 buildings
- 4 groundwater systems

Communication points

- 44 system pumps
- 8 temperature sensors (4 loop sections with sensors at the first and last building)
- Total: 52 communication points

Site size

- Site: 1,000 ft x 800 ft

Single-Pipe Ambient Loop

Main Distribution Pump Controls

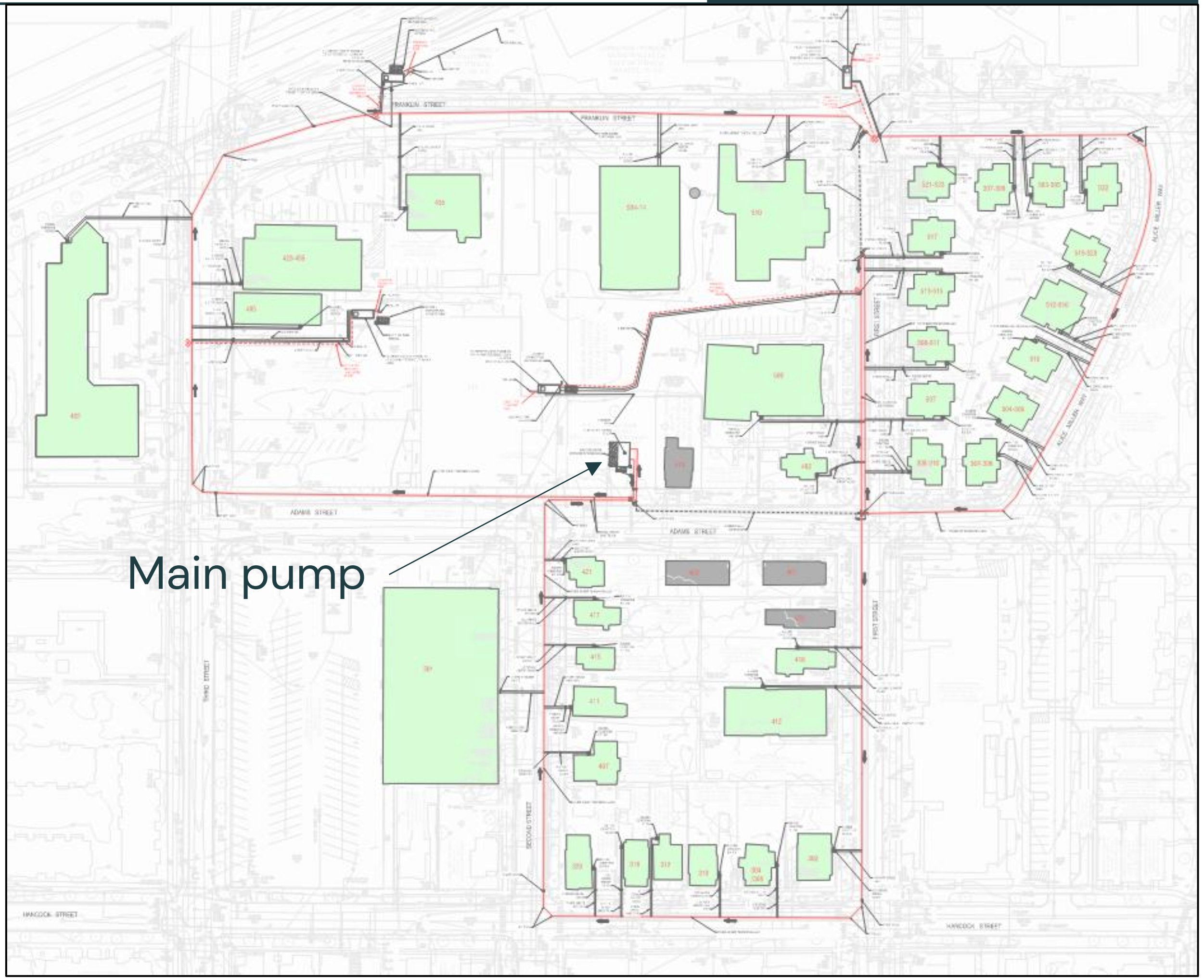
Variable Speed Communication

Wireless

- Use client Wi-Fi at the building
- Dedicated wireless network

Wired

- All 52 communication points routed back to the main pump
- Long wire runs across the site



Single-Pipe Ambient Loop

Main Distribution Pump Controls

Constant Speed

- Simple and reliable – no communication required
- Meets control objectives
- Higher operating cost due to increased pumping energy

Single-Pipe Ambient Loop

Main Distribution Pump Controls

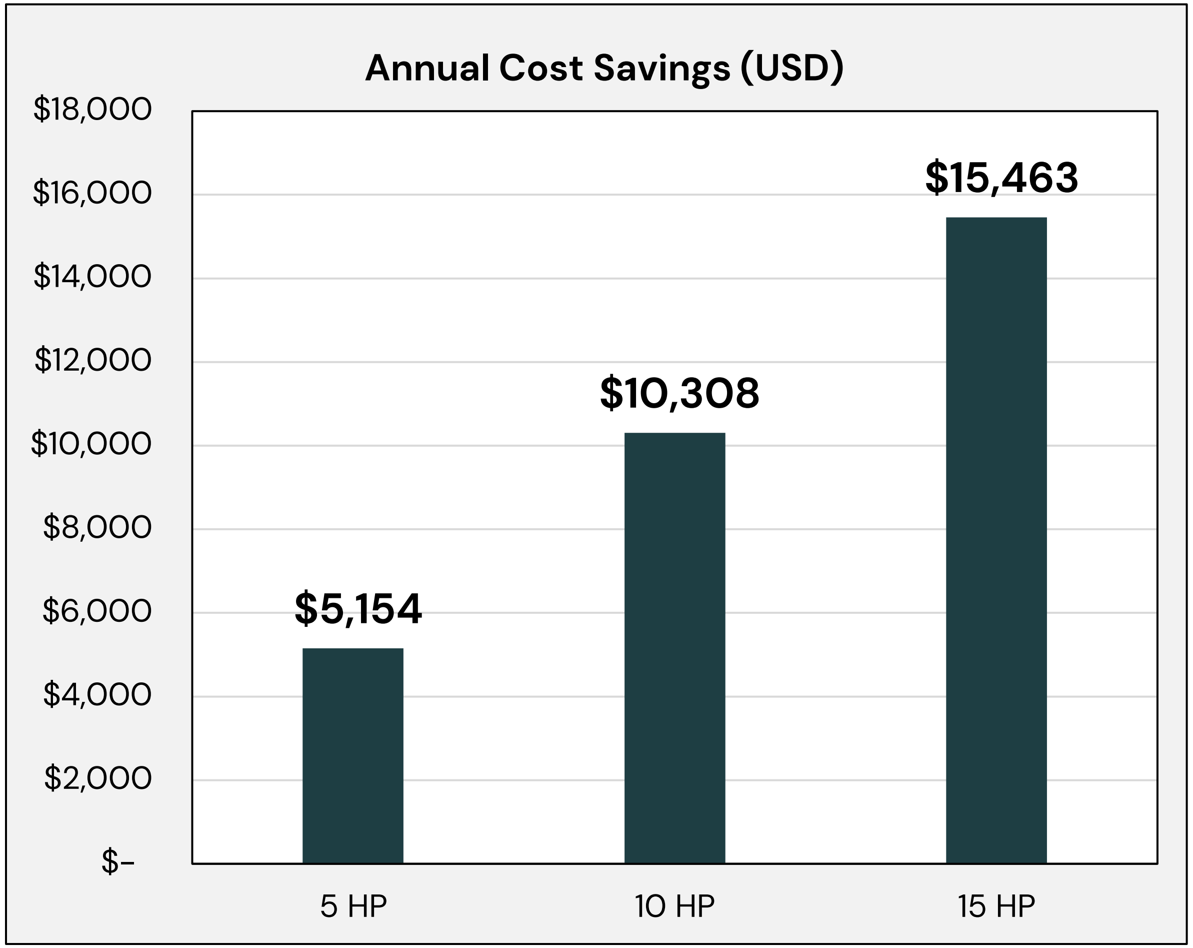
Constant vs Variable Speed

- Do the annual energy savings justify the added control complexity?
- Modeling shows energy savings of about 75–80 % with **variable** speed
- For smaller pumps, the cost savings likely do not justify the variable speed approach

Estimated annual cost savings

(assuming 0.2 $/kWh)

- 5 HP: $ 5,154
- 10 HP: $ 10,308
- 15 HP: $ 15,463



Single-Pipe Ambient Loop

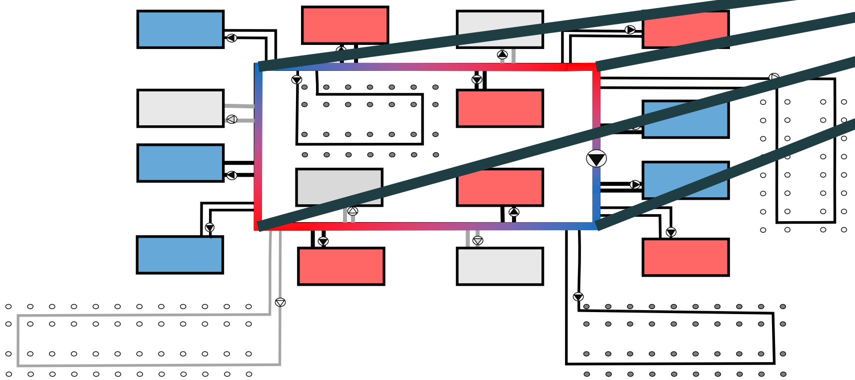
Main Distribution Pump Controls

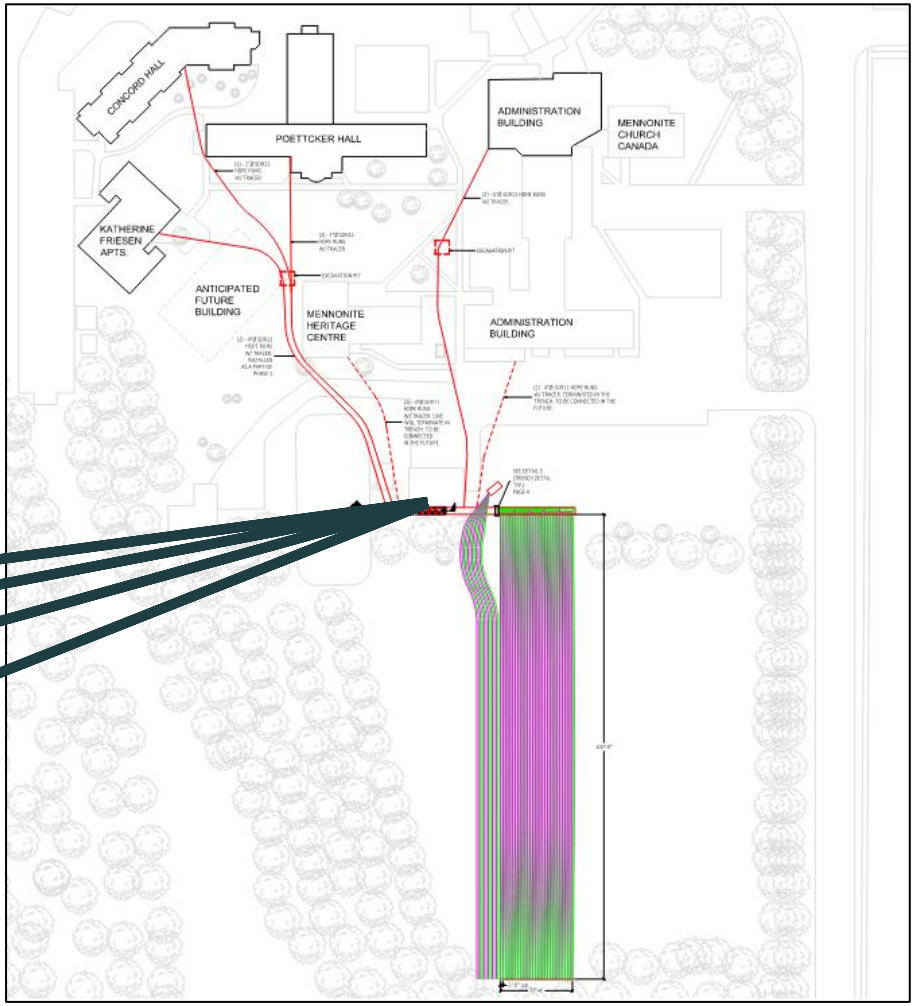
Constant vs Variable Speed

- Constant speed may not be the best strategy for every project

Canadian Mennonite University (Winnipeg, MB, CA)

- 5 buildings total connected in phases
- Main loop and connection points are centrally located



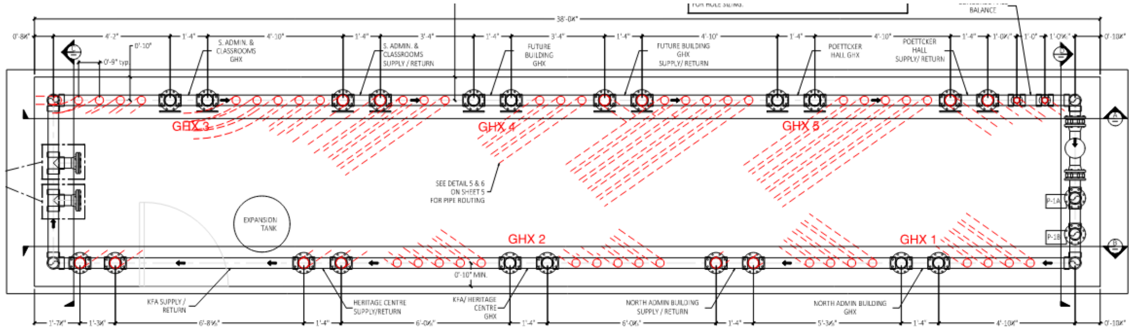


Single-Pipe Ambient Loop

Main Distribution Pump Controls

Canadian Mennonite University (Winnipeg, MB, CA)

- Variable speed strategy selected
- All energy source pumps and the main pump are centrally located in one shipping container
- Communication lines were installed with each building supply/return pipe to communication with the district-side building pumps



Single-Pipe Ambient Loop

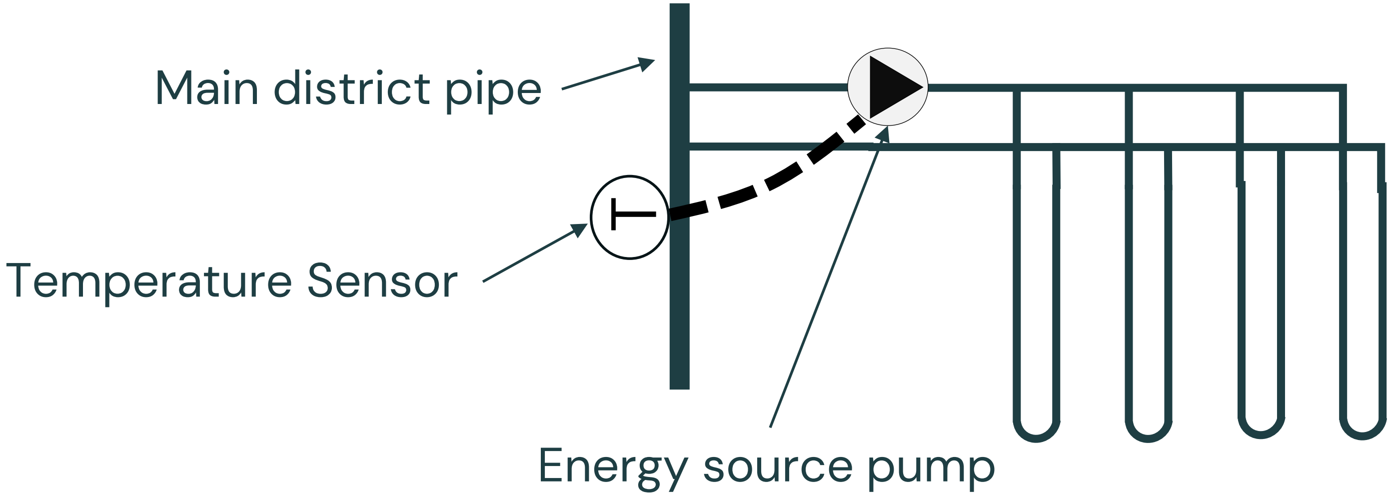
Energy Source/Sink Pump Controls

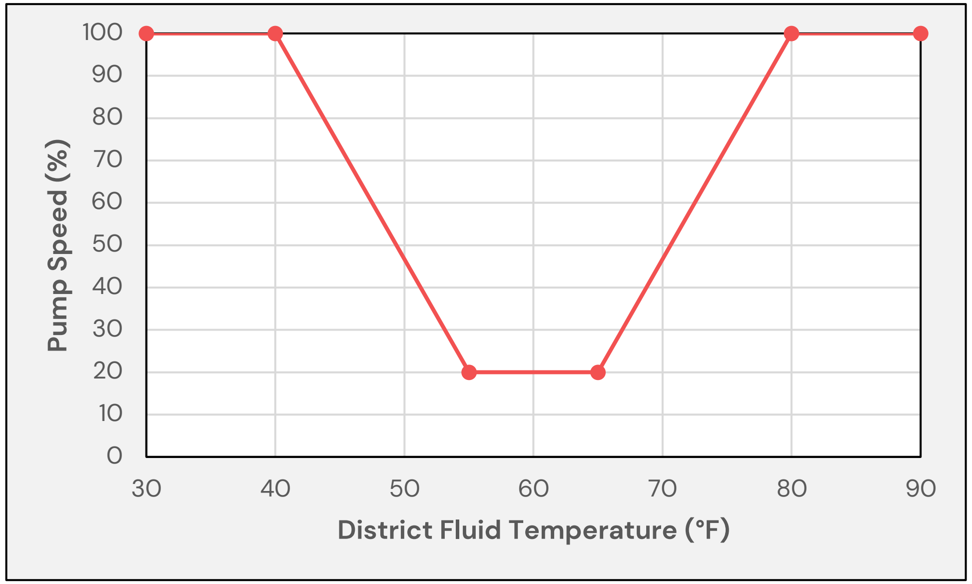
GHX Control Objectives

1. Maintain main loop fluid temperature (30°F–90°F)

Auxiliary Control Objectives

1. Maintain main loop fluid temperature (30°F–90°F)
2. Provide peak heating and/or cooling (setpoint based)
3. Balance annual GHX loads



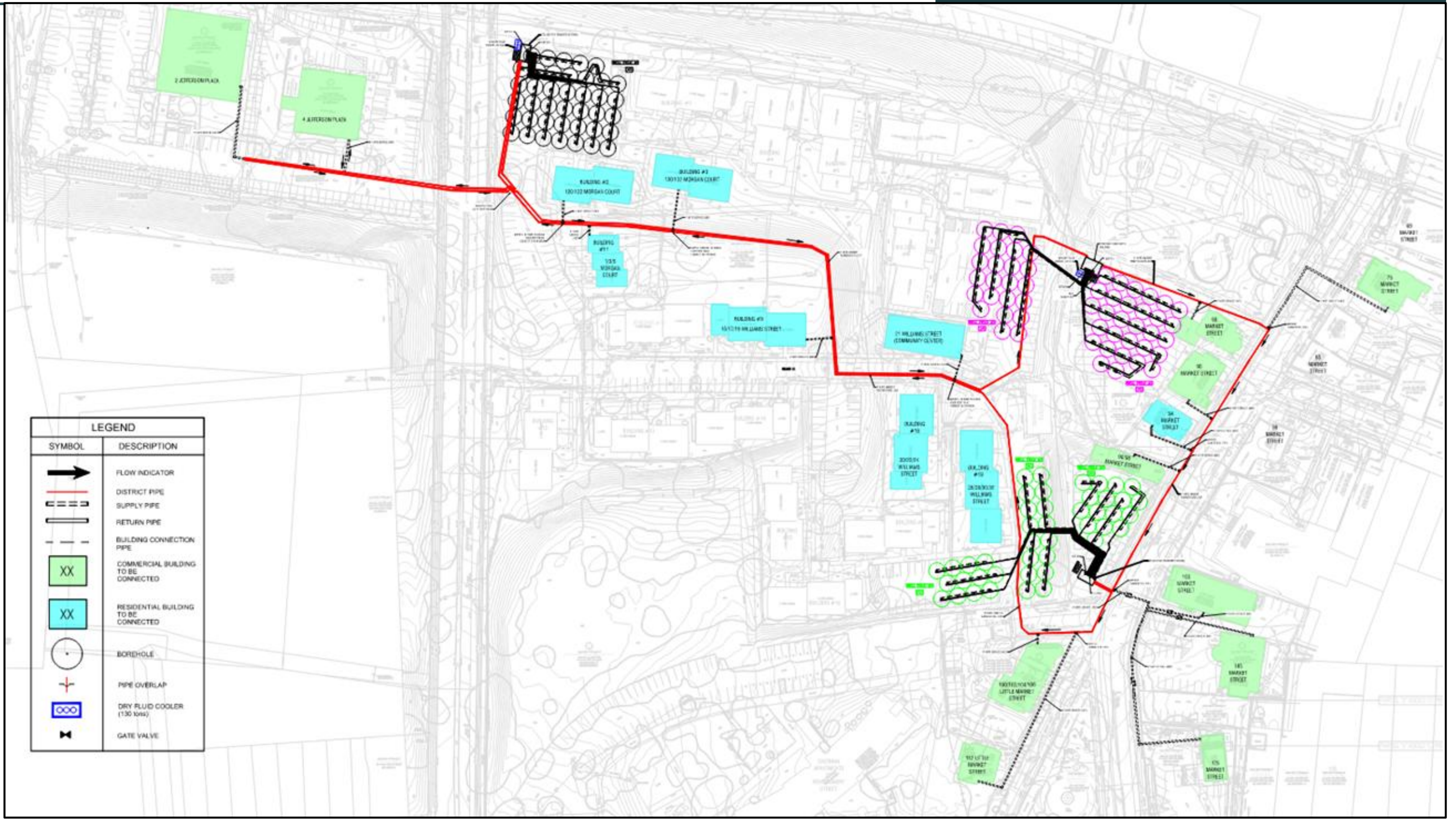


Single-Pipe Ambient Loop

Energy Source/Sink Pump Controls

Example project: Poughkeepsie, NY, USA

- 19 buildings
- 3 vertical GHXs
- 2 dry fluid coolers for GHX balancing

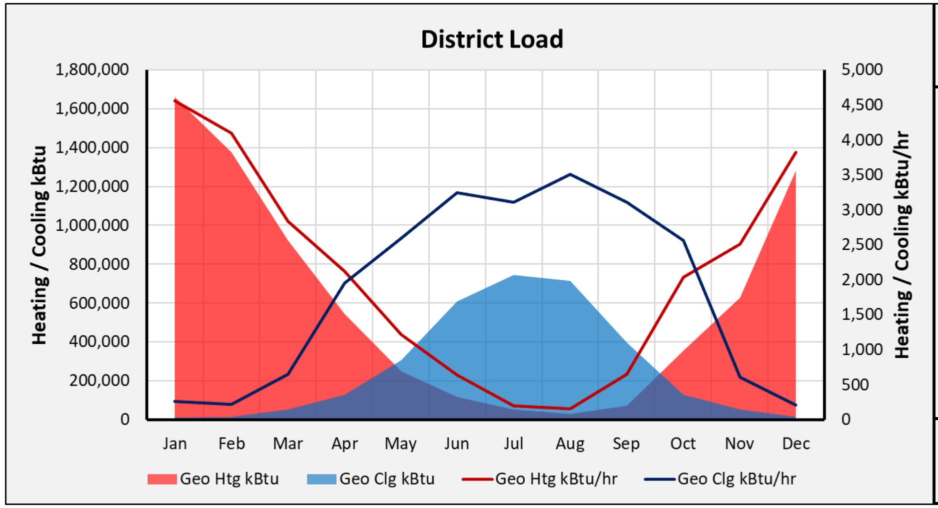


Single-Pipe Ambient Loop

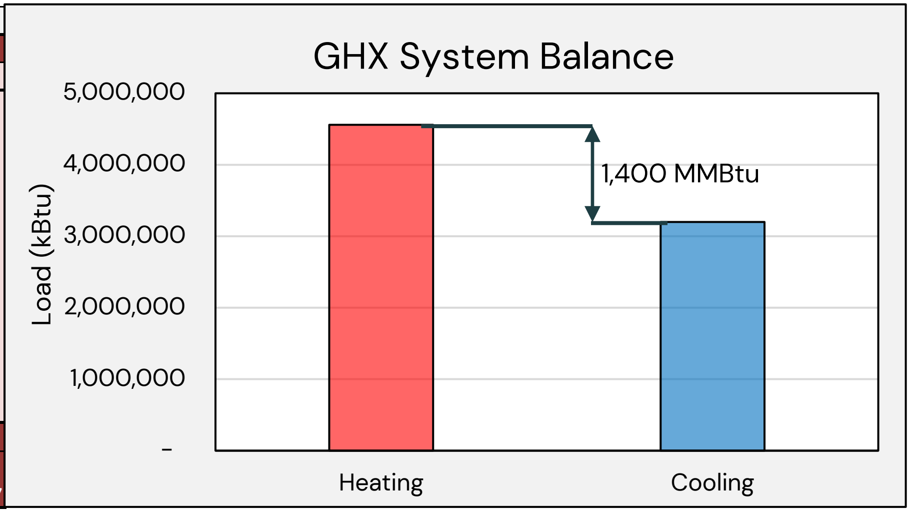
Energy Source/Sink Pump Controls

Example project: Poughkeepsie, NY, USA

- System is heating dominant
- GHX sized to meet the full annual heating and cooling
- Minimal groundwater movement in shale → GHX acts as a thermal battery
- Auxiliary equipment is required to maintain long-term GHX heating capacity



District Load	Geo Cooling		Geo Heating	
	kBtu	kBtu/hr	kBtu	kBtu/hr
Jan	11,625	263	1,659,348	4,559
Feb	13,833	221	1,377,543	4,096
Mar	50,541	652	921,409	2,835
Apr	126,012	1,957	543,049	2,119
May	305,234	2,596	248,600	1,215
Jun	606,395	3,244	115,951	633
Jul	745,419	3,112	52,024	194
Aug	713,178	3,509	27,525	155
Sep	395,154	3,106	69,859	652
Oct	127,667	2,561	356,328	2,032
Nov	51,996	609	628,054	2,510
Dec	15,450	210	1,282,279	3,827
	3,162,503	3,509	7,281,970	4,559
	Tons	292	Tons	380
	EFLH	901	EFLH	1,597



Single-Pipe Ambient Loop

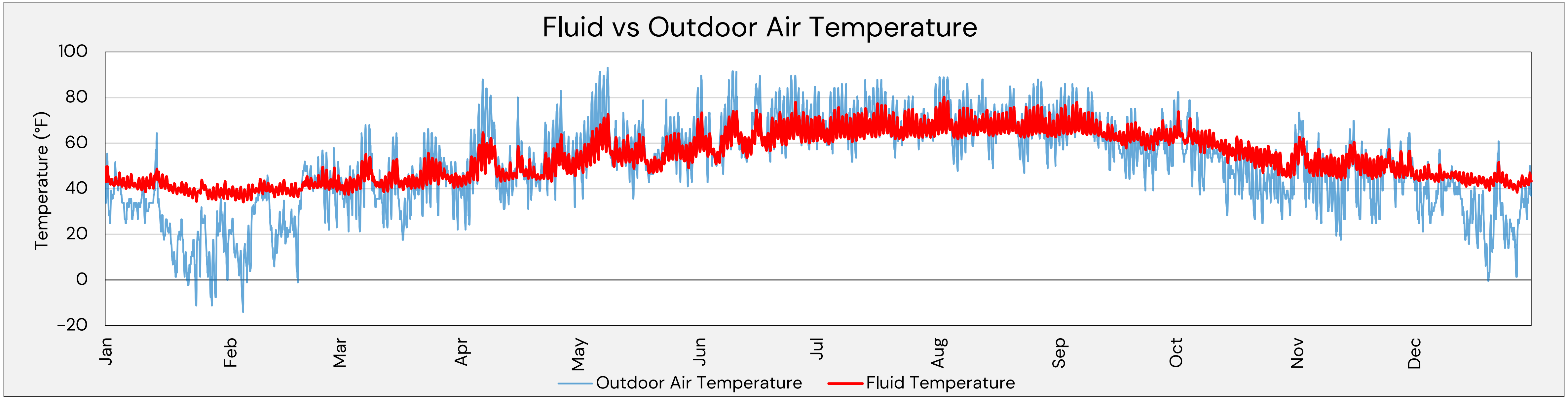
Energy Source/Sink Pump Controls

DFC Control Objective

1. Provide enough heat energy over the year to balance the GHX (~1,400 MMBtu)

DFC control

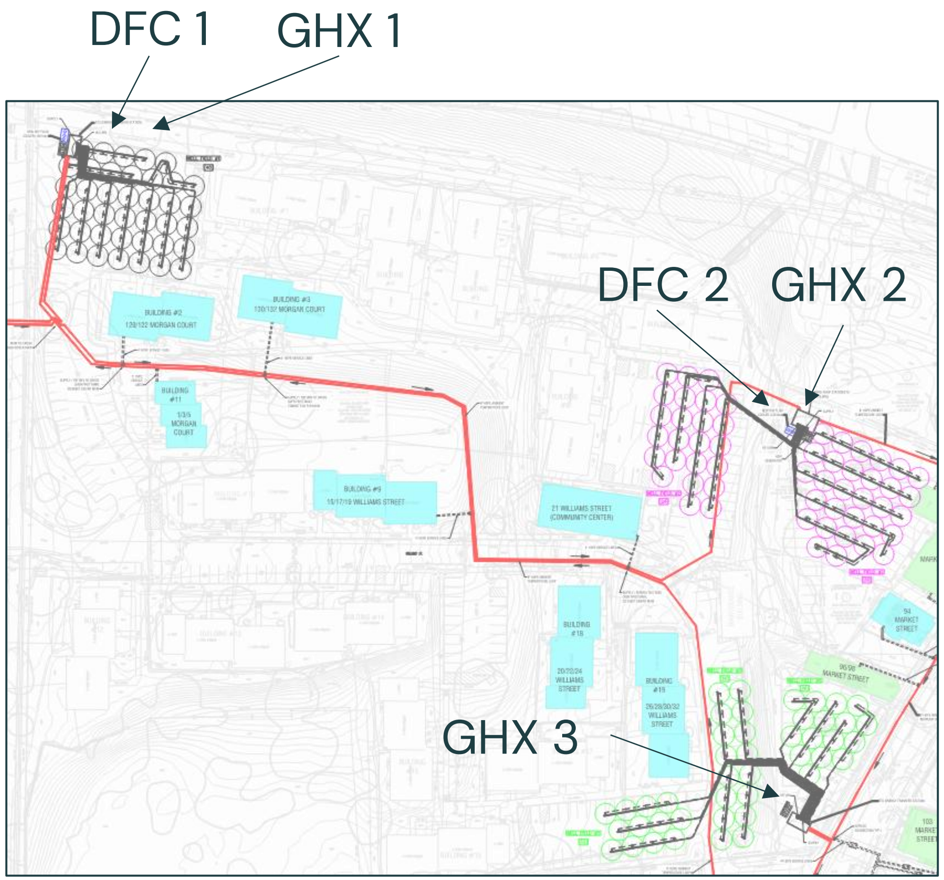
- Based on the temperature difference between outdoor air and main loop fluid temperature (ΔT = 5–10°F)
- Monitor annual energy transferred
- Activate GHX pump when DFC is activated to ensure energy is transferred to the GHX



Single-Pipe Ambient Loop

Energy Source/Sink Pump Controls

How can we balance the GHX that is not in proximity to the DFC?

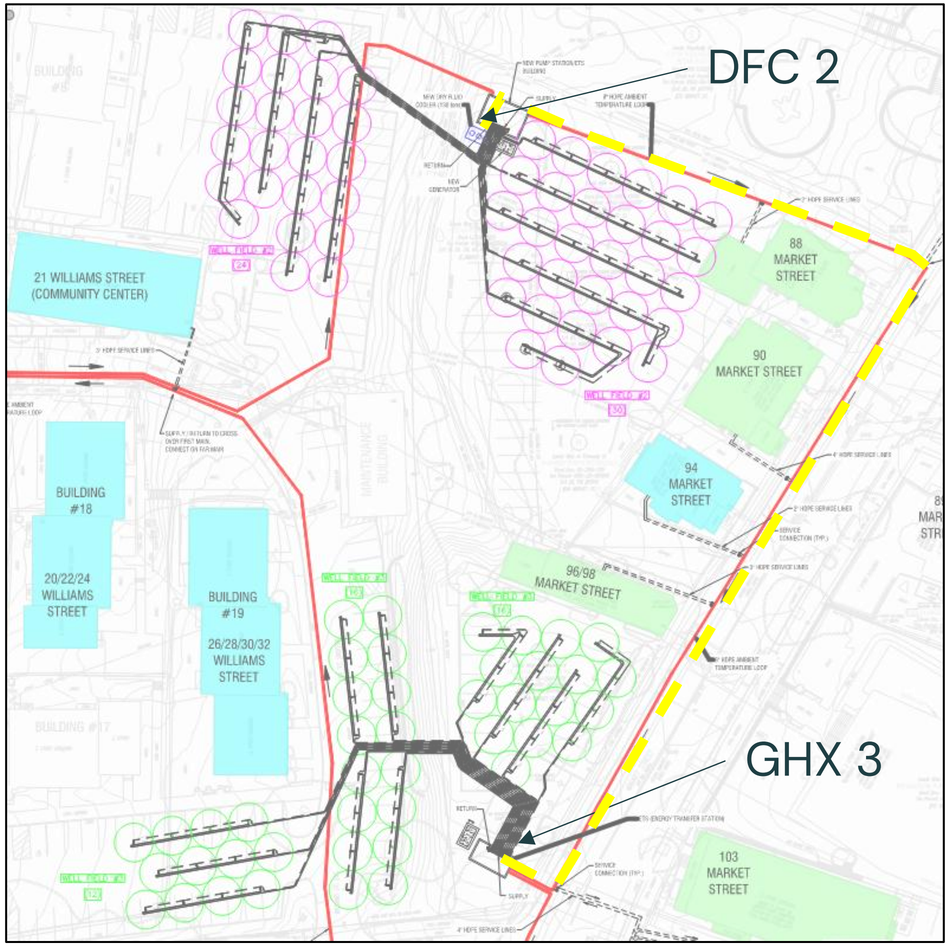


Single-Pipe Ambient Loop

Energy Source/Sink Pump Controls

GHX balance with DFC (DFC and GHX are not in the same location)

- Wired or wireless connection required from DFC 2 to GHX 3
- GHX 3 activated when DFC 2 is operating



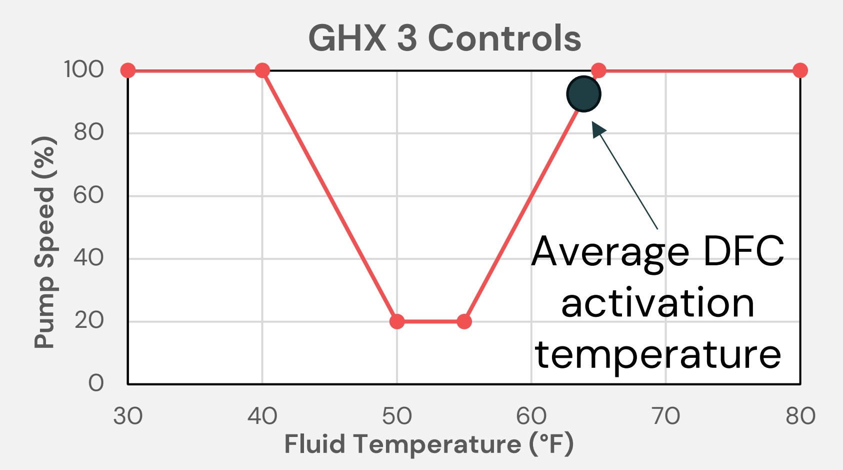
Single-Pipe Ambient Loop

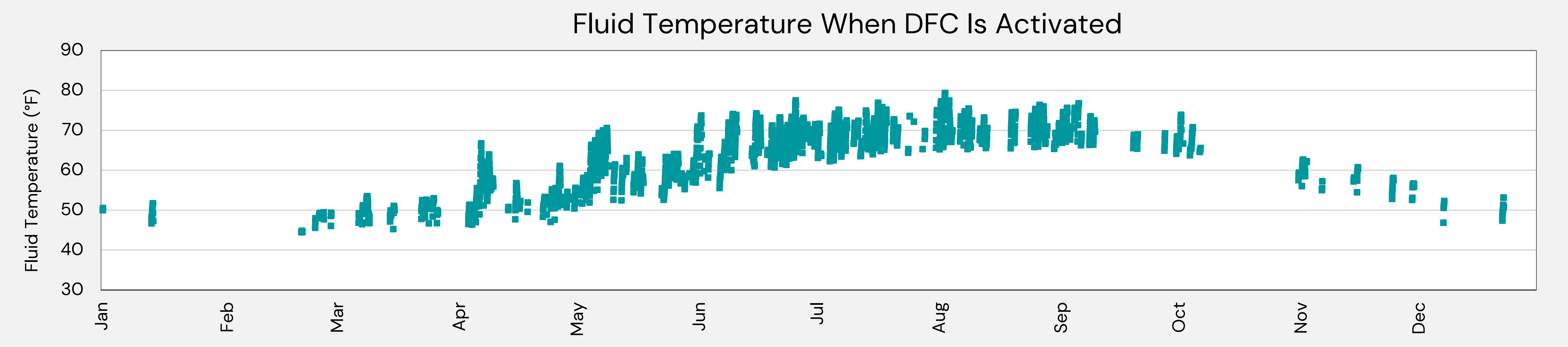
Energy Source/Sink Pump Controls

GHX balance with DFC (DFC and GHX are not in the same location)

- Adjust GHX 3 control set points, so the pump is more likely to operate when the DFC is operating

Minimum (°F)	Maximum (°F)	Average (°F)
45	79	63



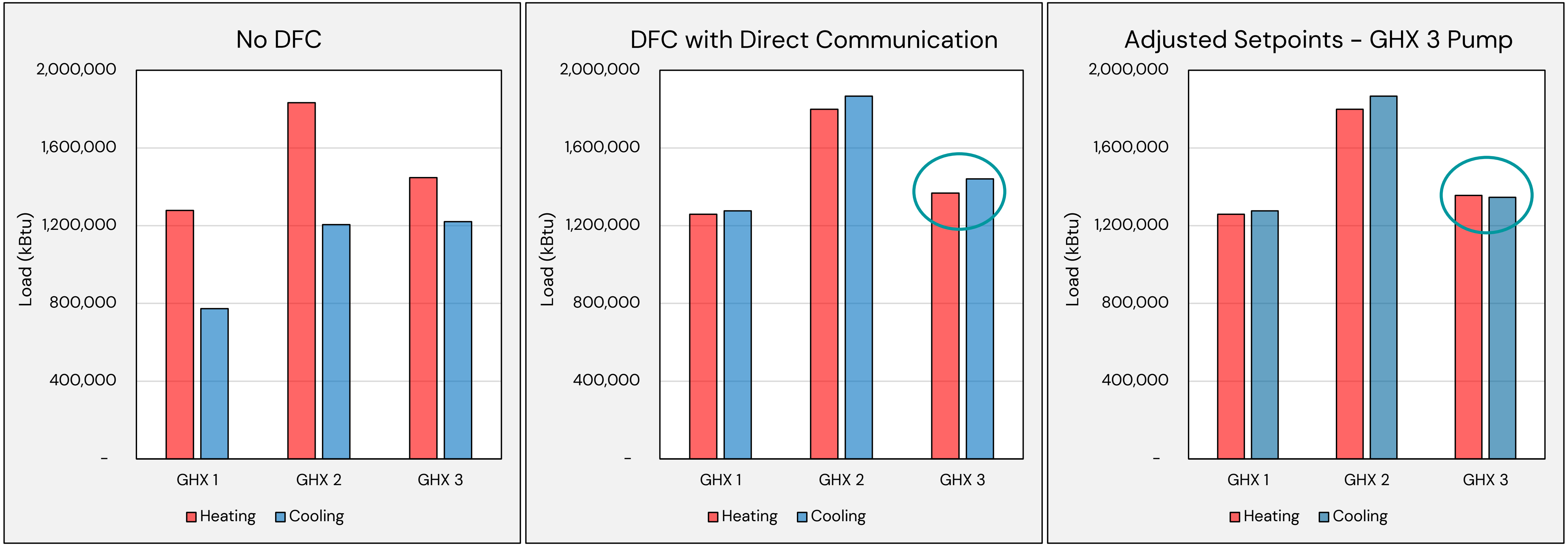


Single-Pipe Ambient Loop

Energy Source/Sink Pump Controls

GHX Balance

- Modeling shows that GHX 3 can be balanced without direct communication with the DFCs



Single-Pipe Ambient Loop

Summary

1. Decentralized single-pipe TENs can create control barriers due to distances between system components
   - Wired or wireless communication over large distances can increase cost and potential failure points
2. Control strategies can be used to mitigate these issues
   - Constant speed main pump
   - Adjust GHX set points to increase load balancing opportunity from the DFCs without communication
3. Modeling is a critical tool for optimizing the design and control of TENs
   - Assess different control strategies and their trade-offs

Thank You

Stephen Hak

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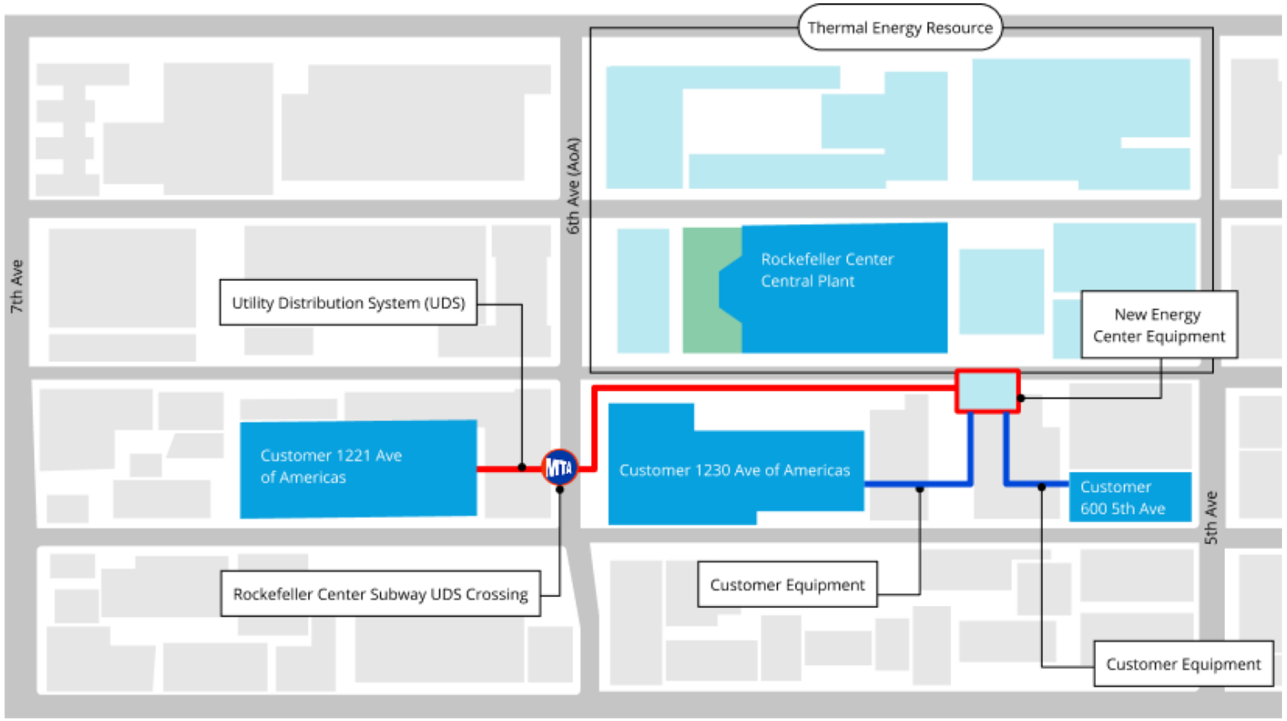
UTEN PILOT CONTROLS OVERVIEW

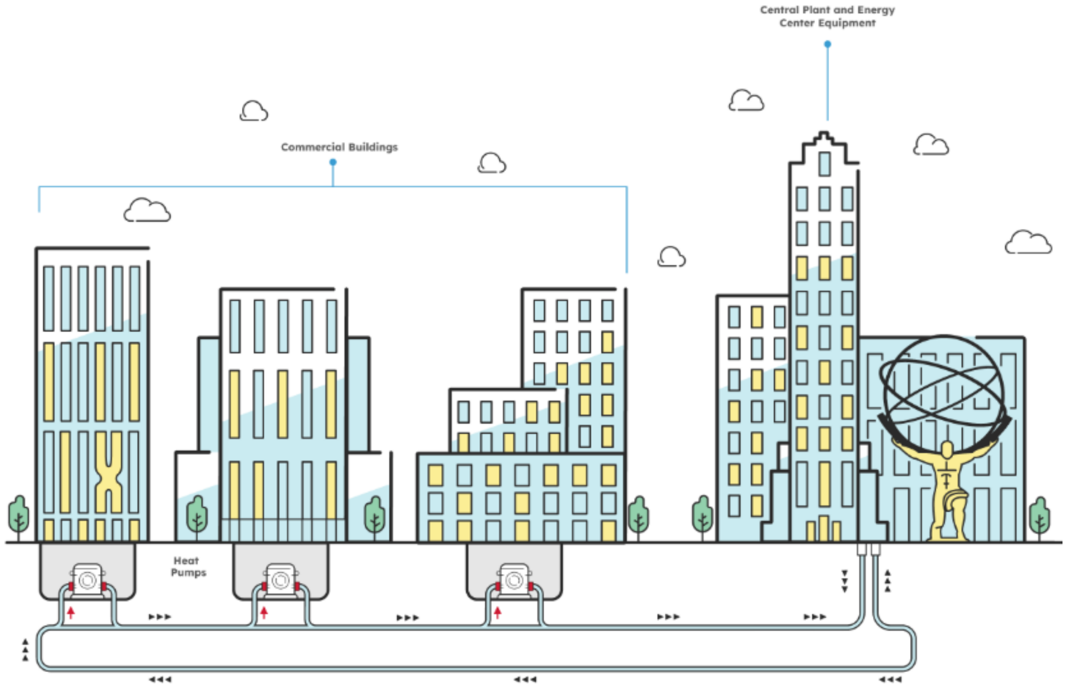
NY-GEO 2026

Presented by Charlie Marino | March 2026

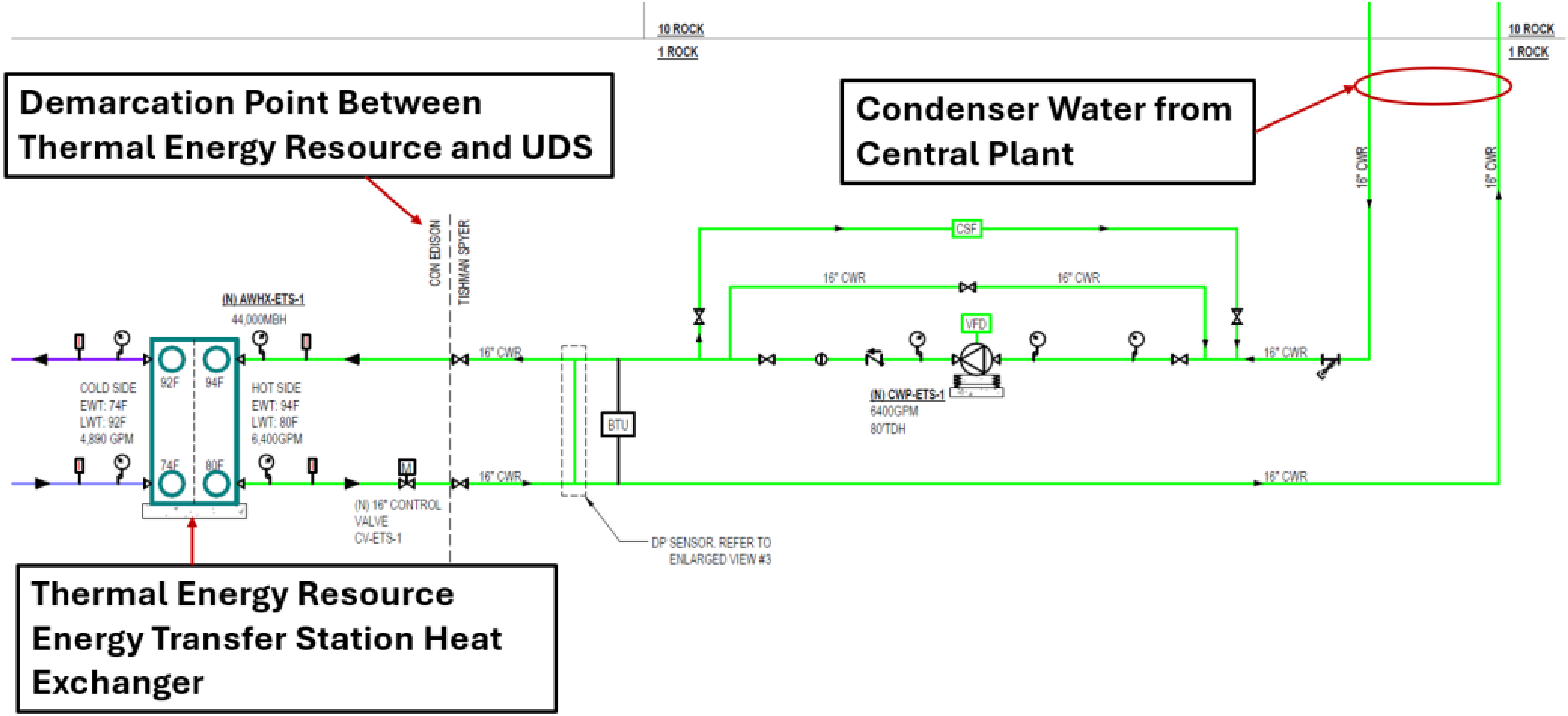
Rock Center UTEN
Project Overview

- Waste heat from the central chilled water plant
- Ultra-low hot temperature UTEN loop for winter season operation only
- 3 large commercial office buildings equipped with water-source heat pumps (WSHPs)
- Serving existing hydronic loops for perimeter space heating
- Serving new large centralized air handling units designed with low temperature hot water coils





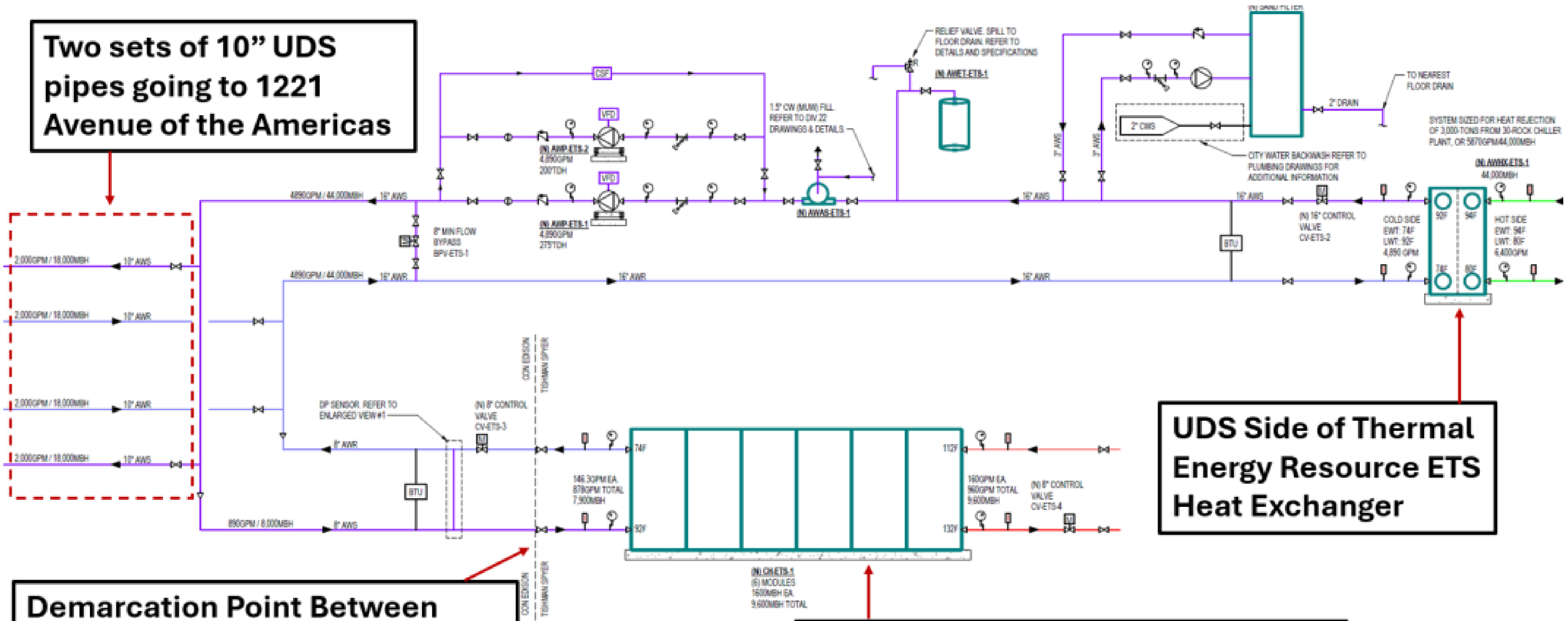
Rock Center UTEN



Thermal Source – Energy Transfer Station

Rock Center UTEN

Two sets of 10" UDS pipes going to 1221 Avenue of the Americas



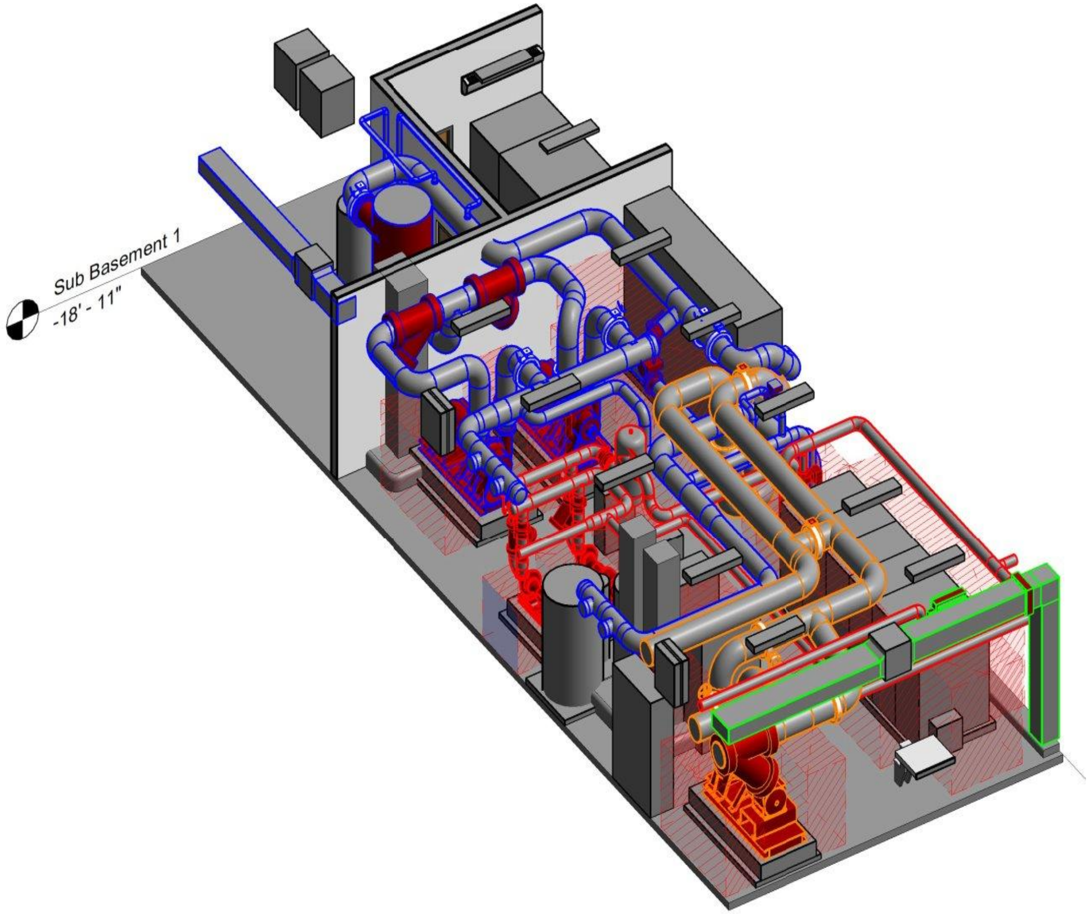
UDS Side of Thermal Energy Resource ETS Heat Exchanger

Demarcation Point Between UDS and 600 5th Ave and 1230 Avenue of the Americas

Heat Pump for 600 5th Ave and 1230 Avenue of the Americas

Utility Distribution System

Rock Center UTEN



Rockefeller Center Energy Center

Rock Center UTEN
Controls Overview

- **SCADA-CENTRIC SYSTEM CONTROL**
  - Responsible for real-time system visibility, alarms, and operational oversight.
- **UTILITY-SIDE OPERATIONAL AUTHORITY**
  - Energy Center, UDS, and utility-side ETS equipment (located in Customer buildings)
- **FAIL-SAFE AND RESILIENCY LOGIC**
  - Strategies for Equipment failure, Communication loss, or Emergency / backup operation
- **BMS–SCADA INTEGRATION**
  - Customer Building Management Systems (BMS) exchange defined data points with Con Edison SCADA using approved protocols.
- **CYBERSECURITY AND NETWORK COMPLIANCE**
  - Compliance with Con Edison network and cybersecurity requirements.

Controls Overview

Key control and monitoring points across the UTEN System.

Energy Transfer Stations (ETS)

- Heat exchanger inlet / outlet temperatures (utility & customer side)
- Flow rates through ETS
- BTU meters at each ETS
- Control valve command and position feedback
- Isolation valve status
- Differential pressure across heat exchangers

Utility Distribution System (UDS)

- Loop supply and return temperatures
- Loop pressure and differential pressure
- Thermal energy flow (BTU in / BTU out)
- UDS electricity consumption
- Hours outside design temperature range
- Heat transfer medium composition
- Leak detection indicators

Mechanical Equipment

- Pump VFD status, speed, and alarms
- Heat pump start/stop counts
- Runtime hours
- Electrical energy consumption (kWh)
- Fault and bypass status
- Supply / return temperatures

wsp

CONTROLS OVERVIEW

Performance Metrics

- **DPS Matter 24-00515**
  - Established a uniform, PSC-approved performance metrics framework for (UTEN) pilots.
  - “Technical Performance” metrics include:
    - Thermal delivery,
    - Efficiency,
    - Operating conditions
  - Project metrics tables capture (58) technical metrics related to each asset category:
    - Customer-Side
    - Thermal Energy Resource
    - Utility Distribution System (UDS)

NEW YORK STATE | Department of Public Service

Three Empire State Plaza, Albany, NY 12223-1350
www.dps.ny.gov

September 9, 2024

VIA ELECTRONIC FILING
Hon. Michelle L. Phillips
Secretary to the Commission
New York State Public Service Commission
Agency Building 3
Albany NY 12223-1350
E-mail: secretary@dps.ny.gov

Re: Matter 24-00515 - In the Matter of Utility Thermal Energy Network Performance Metrics.

Dear Secretary Phillips:

As required by the Commission’s Order Providing Guidance on Development of Utility Thermal Energy Networks (Guidance Order),[1] Staff of the Department of Public Service (Staff) must convene one or more technical conference(s) to discuss utility thermal energy network (UTEN) performance metrics categorized as follows: (1) technical; (2) financial; (3) customer/societal; and (4) safety/reliability. This letter presents the revised draft performance metrics, including the associated data points to assess the metrics, developed based on discussions held to date, for stakeholder consideration.[2] **Staff requests that stakeholders state their agreement or disagreement with justification, on the proposed metrics and data points by September 20, 2024, in Matter Number 24-00515.** A final technical conference will be held on September 30, 2024, to review and discuss stakeholder submissions.

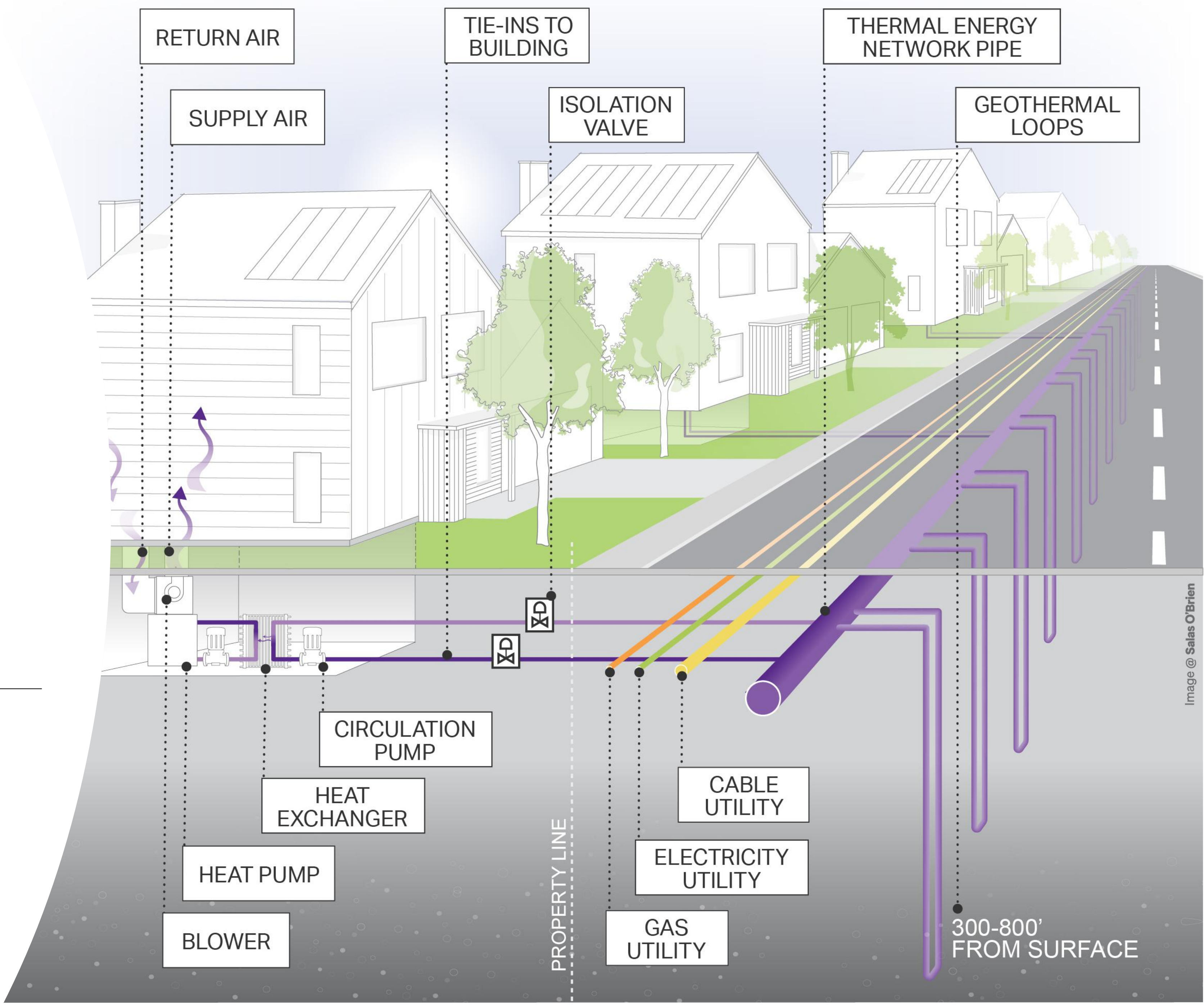
For purposes of background, the technical conferences held to date have provided an opportunity for discussion of potential UTEN performance metrics, using the list of metrics proposed by one or more Utility in their pilot project proposals as well as some additional possible metrics compiled as Appendix B in the Guidance Order, as a starting point. Staff has filed the presentations given at each technical conference in Matter 24-00515 and interested stakeholders have had the opportunity to submit comments in response to the technical conferences and materials presented during the conferences. As outlined in the Guidance Order, identifying standardized metrics is of paramount importance as it will provide the necessary data to assist the Commission in

[1] Case 22-M-0429, Proceeding on Motion of the Commission to Implement the Requirements of the Utility Thermal Energy Network and Jobs Act, Order Providing Guidance on Development of Utility Thermal Energy Networks (issued September 14, 2023) (Guidance Order).
[2] Technical conferences held to date in-person and via Webex and phone occurred on March 19, 2024, April 25, 2024, and May 7, 2024.

THANK YOU

TEN Demarcation

- Infrastructure vs. Building systems



PRESENTED BY
Brian Urlaub
Principal
Brian.Urlaub@salasobrien.com

Demarcation of Infrastructure systems

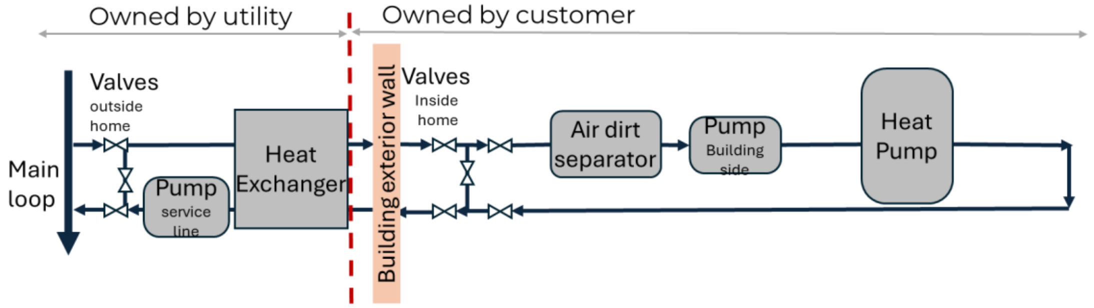
- **Ownership:**
  - Who owns what and where does ownership transfer
  - The infrastructure fluid is the largest risk issue
  - If controls are required (BTU, Flow, Temp, Pumps) inside the building that are part of the infrastructure, how does that get connected to the owner system?
  - Maintenance/Service access agreements
  - Building pump energy gets paid by consumer, but pump may be owned by infrastructure owner.

Utility vs Customer Line of Demarcation for Residential Homes

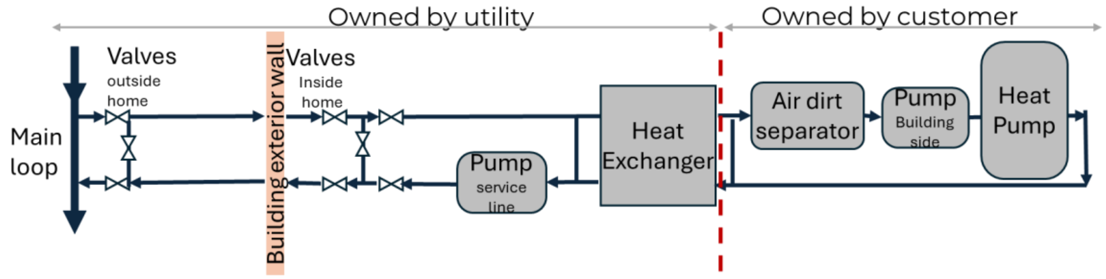
Parameter	Behind HX Outside Home	Behind HX Inside Home	Behind the Valve
Installation cost	$$$$	$$$	$
Maintenance cost	$$$$$	$$	$
Extra service line pump	Required	Required	NA
Extra heat exchanger	Required	Required	NA
System Efficiency Loss	-2%	-2%	NA
Reduces risk of malfunction in home equipment affecting loop	Yes	No	No
Utility requires regular access to homes for maintenance	No	Yes	No
Requires extra space in home basement	No	Yes	No

Slide Courtesy of HEET

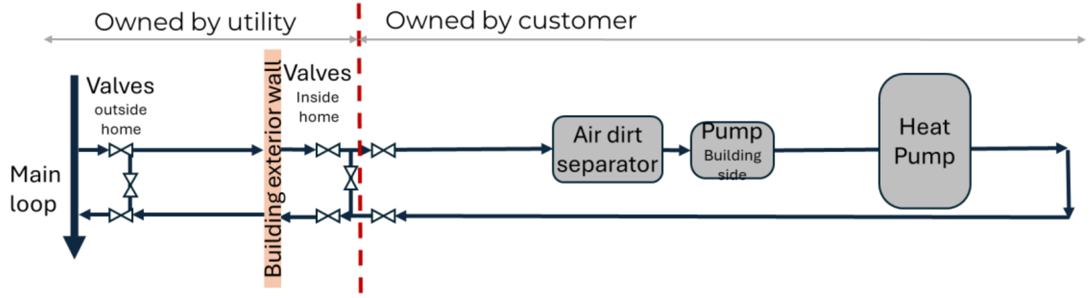
A) Behind Heat Exchanger – Outside Home



B) Behind Heat Exchanger – Inside Home



C) Behind the Valve – Inside Home

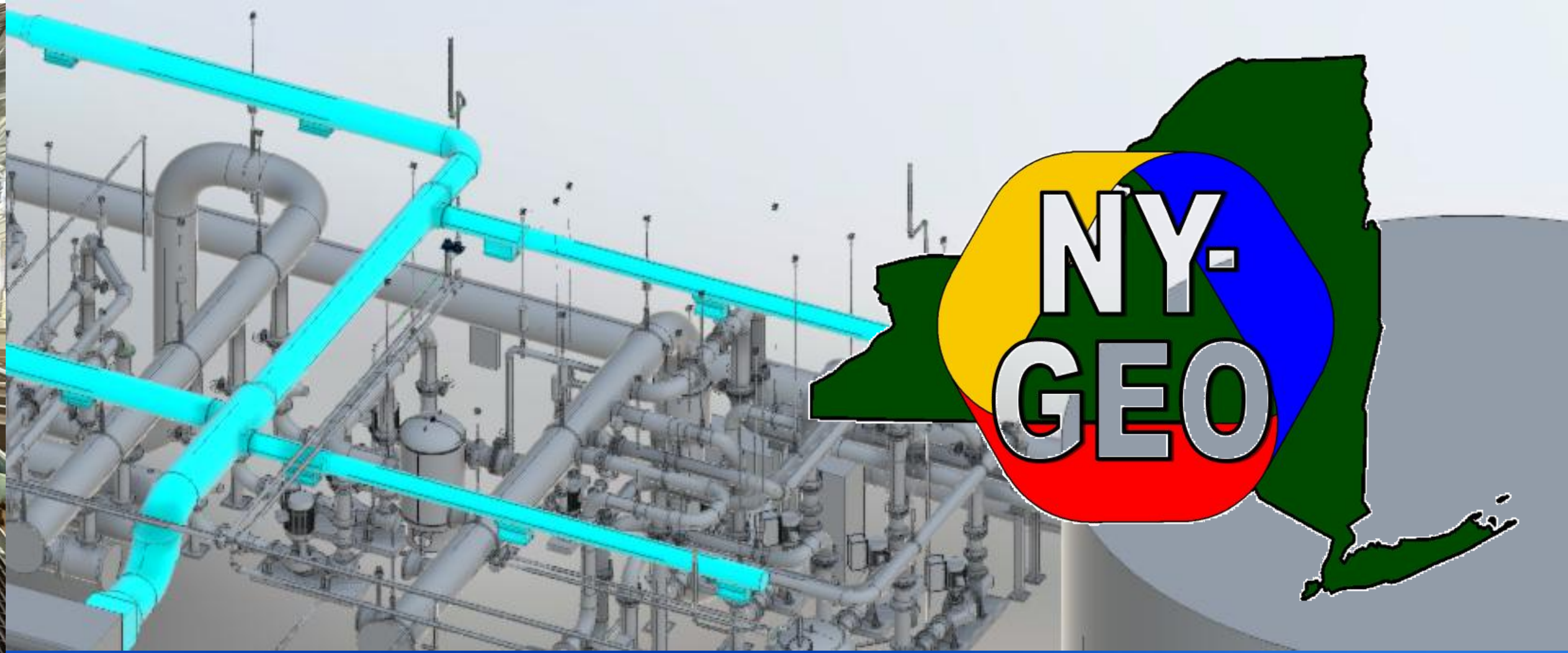


Salas O'Brien

Brian Urlaub

Brian.Urlaub@salasobrien.com

Thank You for your Participation!



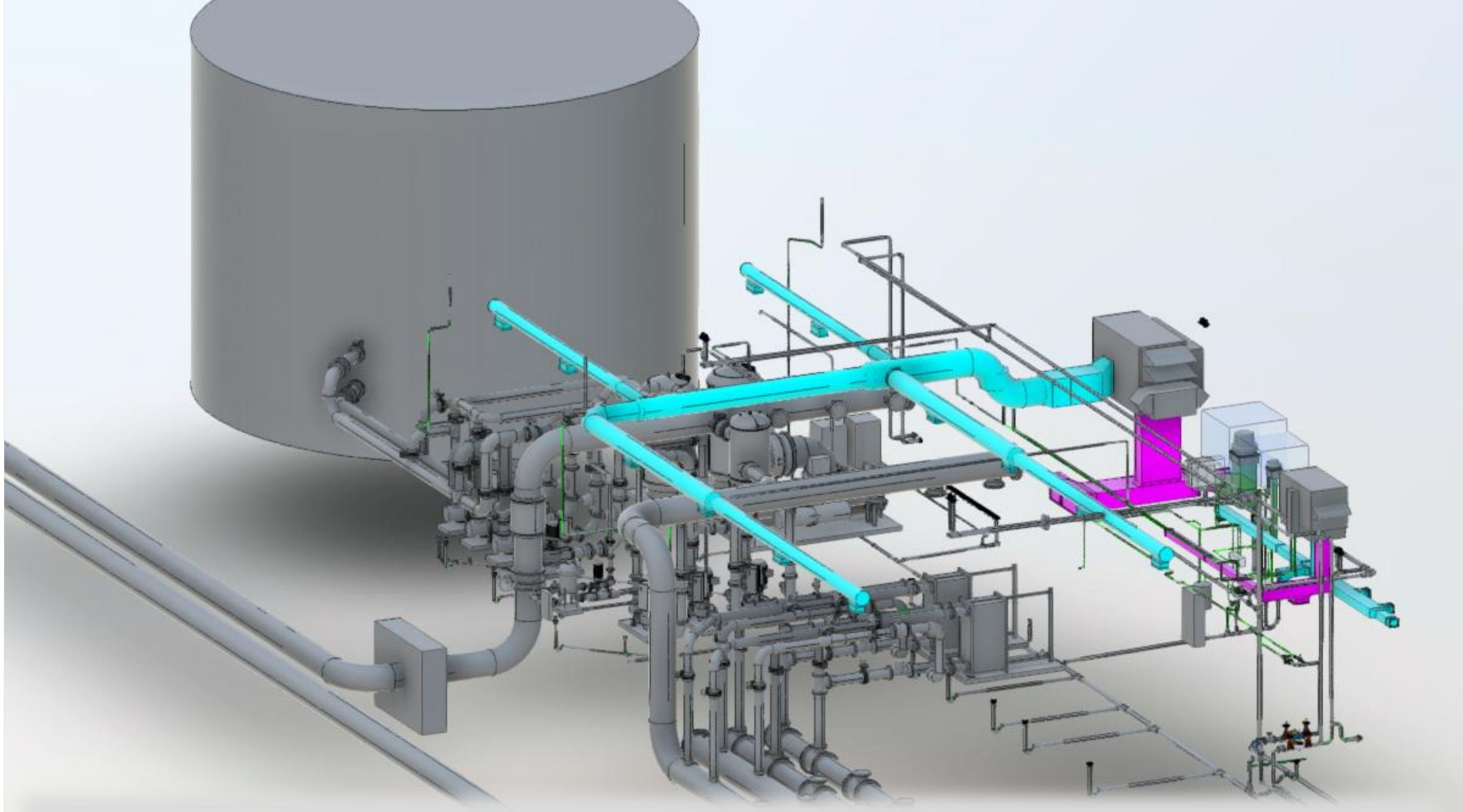
Design and Control of Thermal Energy Networks

Brendan Hall, PE, CGD

March 24, 2026

Renewable Thermal Energy Solutions

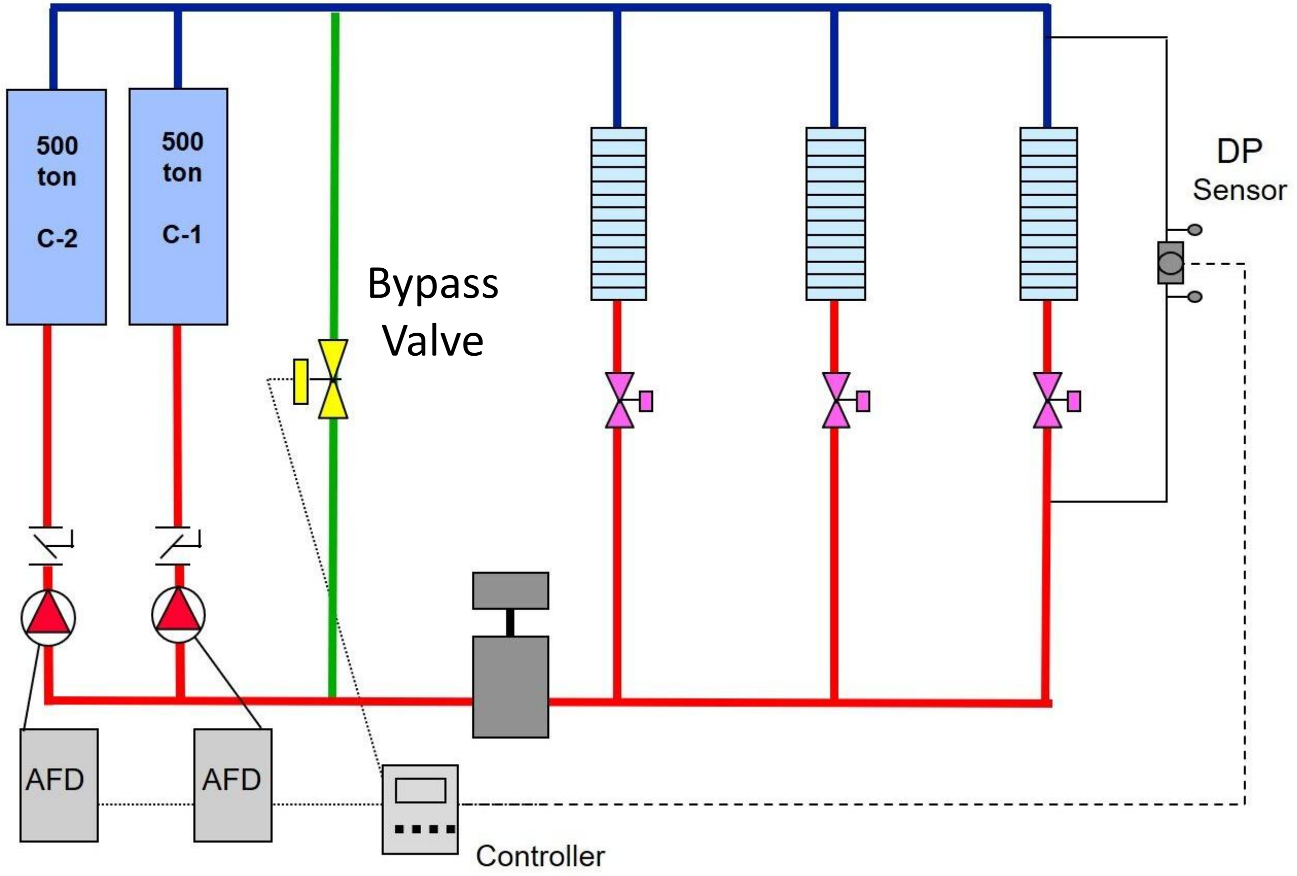
CHA's renewable thermal energy solutions (RTES) team delivers **innovative electrification, geothermal, and thermal energy network solutions** for campuses, utilities, and municipalities. We provide comprehensive design, engineering, and implementation services that enable sustainable, cost-effective heating and cooling at scale.



- Electrification
- Heat pump retrofits
- Geothermal design
- District/campus energy
- Thermal energy networks
- Thermal energy storage

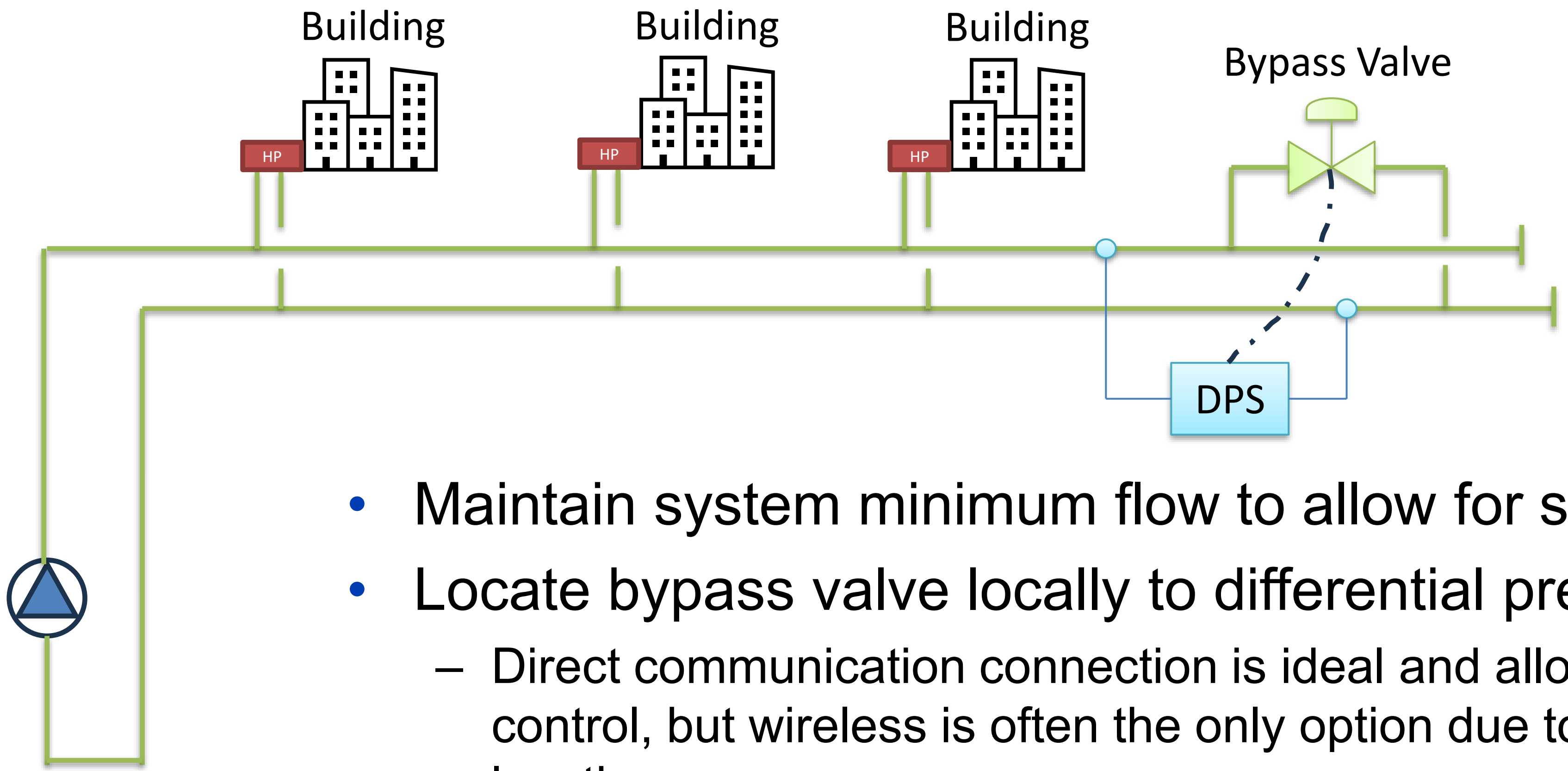
CHA

Pumping Strategies



- Many building level control strategies are challenging in district scale pipe systems.
- For a 2 pipe system:
  - Variable Speed Pumping
  - Differential Pressure control
  - Bypass control of minimum flow.

Bypass Valve / Minimum Flow



- Maintain system minimum flow to allow for system visibility.
- Locate bypass valve locally to differential pressure sensor.
  - Direct communication connection is ideal and allows for tighter control, but wireless is often the only option due to distance or location.
  - If wireless, operation is not reliant on communications connectivity.

Pressure Monitoring and Control

Campus System

Single Owner

- Measuer pressure at a remote building
- Relay through campus BMS.
- Mange flow based on system load.
- Monitor flow rate.

Utility System

Third Party Customers

- Avoiding critical control infrastructure in customer buildings.
- Option 1 –
  - Control flow by dP at plant, monitor at remote building connections and bypass.
  - dP reset based on system temperatures to reduce over pumping
- Option 2
  - Run conduit parallel to piping to allow for sensor station(s) along the path. dP sensors installed in manholes or vaults.
  - Manage flow directly through dP measurements.

Hydraulic Separation

- Used to connect resources in 1-pipe loops.
- Principle borrowed from monoflow and primary/secondary systems. Developed by Bell & Gossett in the 1950s
- Loops are hydraulically separated.
- Pressure drop between tees must be negligible, general rule is 3-4x the diameter of the common pipe.

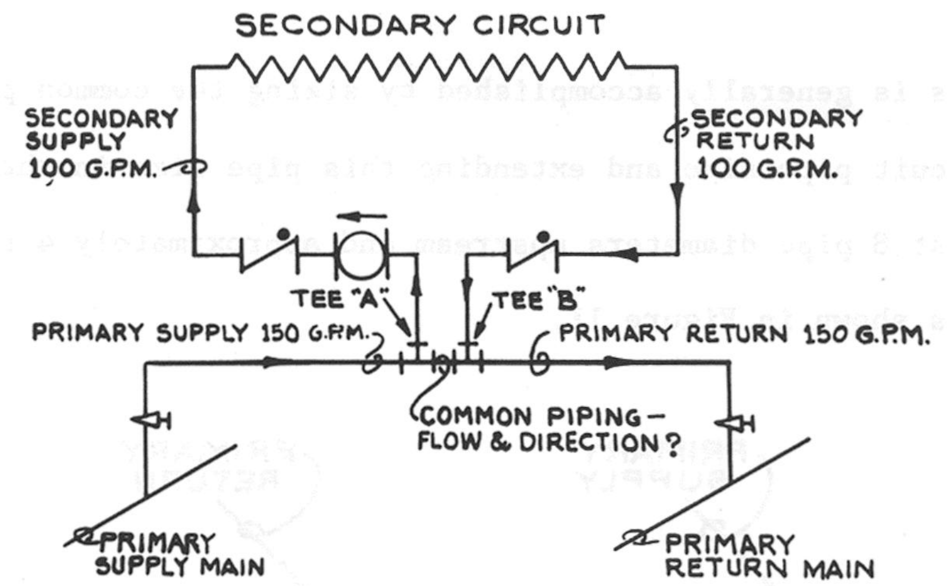
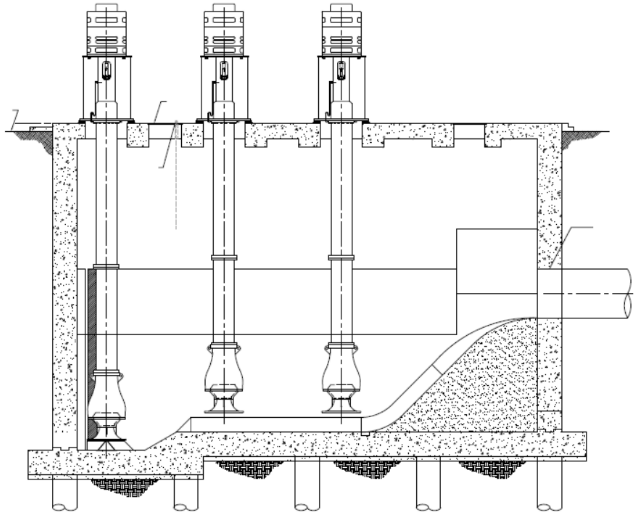


Figure 12 – P-S ILLUSTRATION, PRIMARY FLOW GREATER THAN SECONDARY FLOW

[Primary Secondary Piping](https://www.youtube.com/watch?v=U5nDztGOYDg)
https://www.youtube.com/watch?v=U5nDztGOYDg

Connecting open loop to closed loop

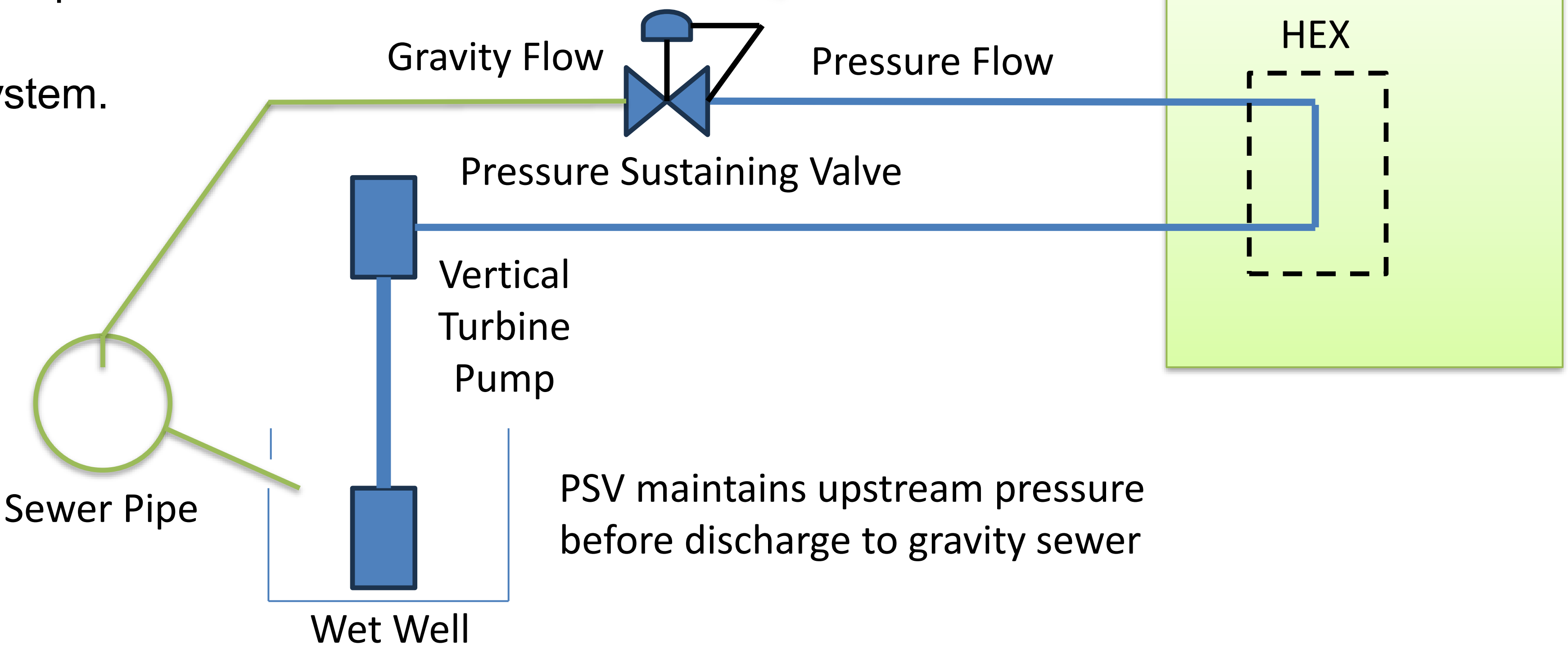
- Wastewater, Storm Water or Groundwater are unpressurized gravity systems.
- Require a wet well, pump station, means of returning water to the source
- Requires space, proximity to the resource, power, similar to sewage pump stations.



Trench Wet Well with Vertical Turbine Pumps

Pressure Sustaining Valves

- Provides backpressure to the flow, creating a region of fully filled pipe and pressurized flow needed to run heat exchangers.
- Allow pump to run in a stable portion of the curve.
- Manage air in the piping system.
- Maintain heat exchanger performance.



Thermal Storage / Buffer Tanks

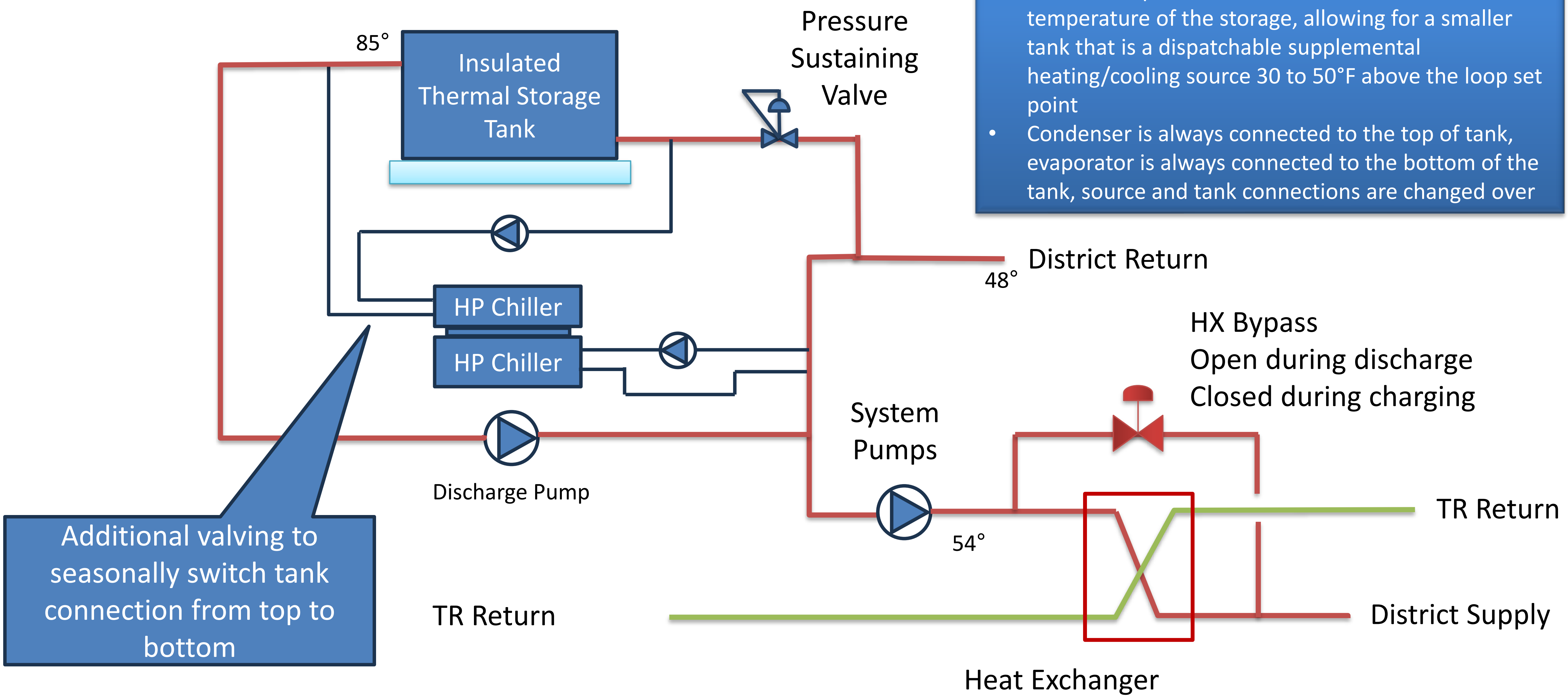
- Pressurized vs Atmospheric
  - Pressurized
    - Can be placed inline with the piping system with few modifications.
    - ASME rated, which limits the size due to cost.
  - Atmospheric
    - Much Larger Volume
    - Becomes point of constant pressure in the system, much like an expansion tank
    - Careful isolation with a HX or interaction with pressurized side using a pressure sustaining valve.

1000 gal

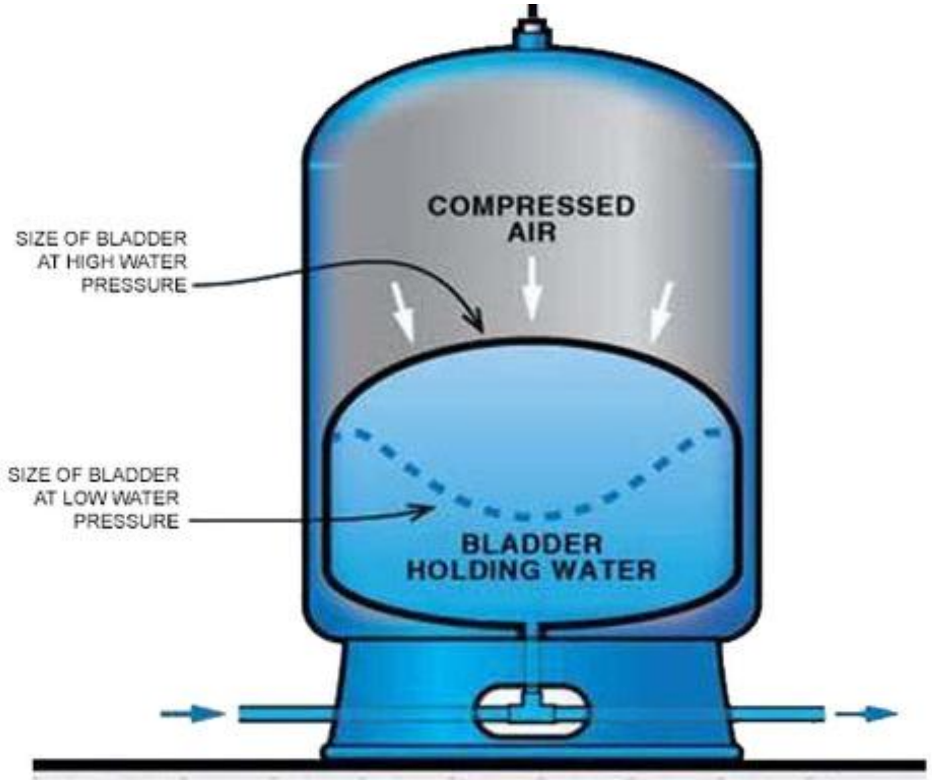
1,000,000 gal

Thermal Tank Storage

- A Heat Pump Chiller is used to increase the temperature of the storage, allowing for a smaller tank that is a dispatchable supplemental heating/cooling source 30 to 50°F above the loop set point
- Condenser is always connected to the top of tank, evaporator is always connected to the bottom of the tank, source and tank connections are changed over



Expansion Tanks in HDPE Systems



- HDPE piping expands much more than traditional steel piping systems.
- HDPE piping expands and contracts quicker than water or glycol.
- Limiting case for expansion tank sizing becomes the winter time, opposite of boiler systems.
- Similar to geothermal borefields, but effect is larger with large HDPE distribution systems.

Design and Control of Thermal Energy Networks

Moderator: Jacky Kinson / *CDM Smith*

Panel: Stephen Hak / *GEOptimize*
Charlie Marino / *WSP*
Brian Urlaub / *Salas O'Brien*
Brendan Hall / *CHA Consulting*