Geothermal for High-Rise Buildings: Design Considerations

Moderator: Colin Rojas / *Con Edison*

Speakers: Brian Urlaub / *Salas O'Brien*

Jason Eitel / *EJS New York*

Sam Gerber / *CDM Smith*

Geothermal for High-Rise Buildings: Design Considerations

Brian Urlaub / *Salas O'Brien*

Designing Tall Buildings in Cold Climates

Presented by:

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Learning Objectives

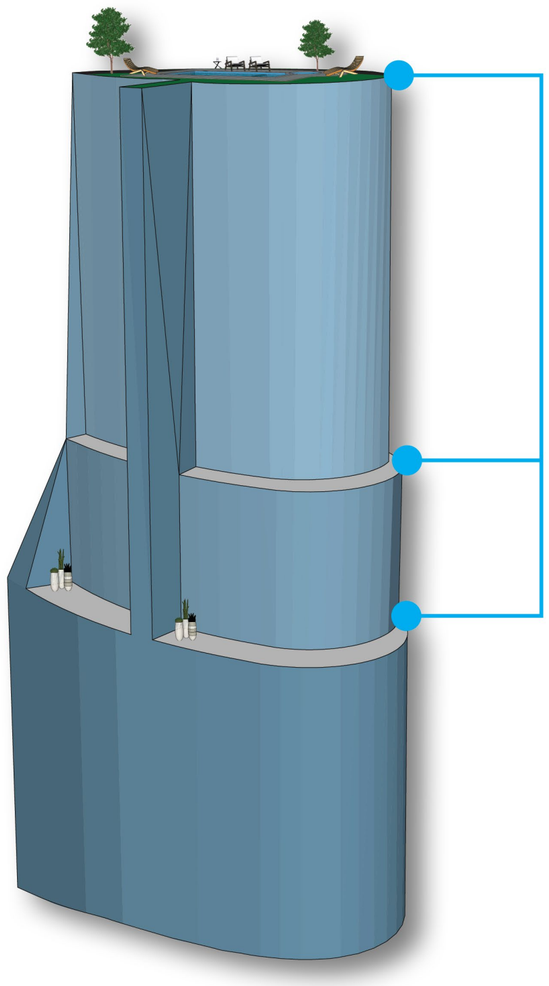
1. Be able to identify the special challenges with heating/cooling tall buildings.
2. How the thermal load profile impacts decisions regarding the HVAC system design.
3. How ventilation/outside air requirements change the load profile and impact sizing of a geothermal system.
4. How a limited building footprint and limited roof space factors into equipment sizing and hybrid design.

Steps and Decisions during design

- Thermal Load Profile
  - Can be stand alone building or a group of buildings
- Finding and selecting the thermal assets
  - Looking at all the potential thermal assets and breaking down by cost matrix for best options
- Determine the best distribution system (1-pipe, 2-pipe, 4-pipe)
  - This can be for stand alone and district systems
  - Develop a cost matrix with energy use/pump power
- Determine the best heat pump technology to use
  - Could be a mix of types of heat pumps (DHW vs. HVAC, or Centrifugal and Scroll Heat Pumps) (Lift and Efficiency is key)
  - Determine cost/ton as well as total efficiency

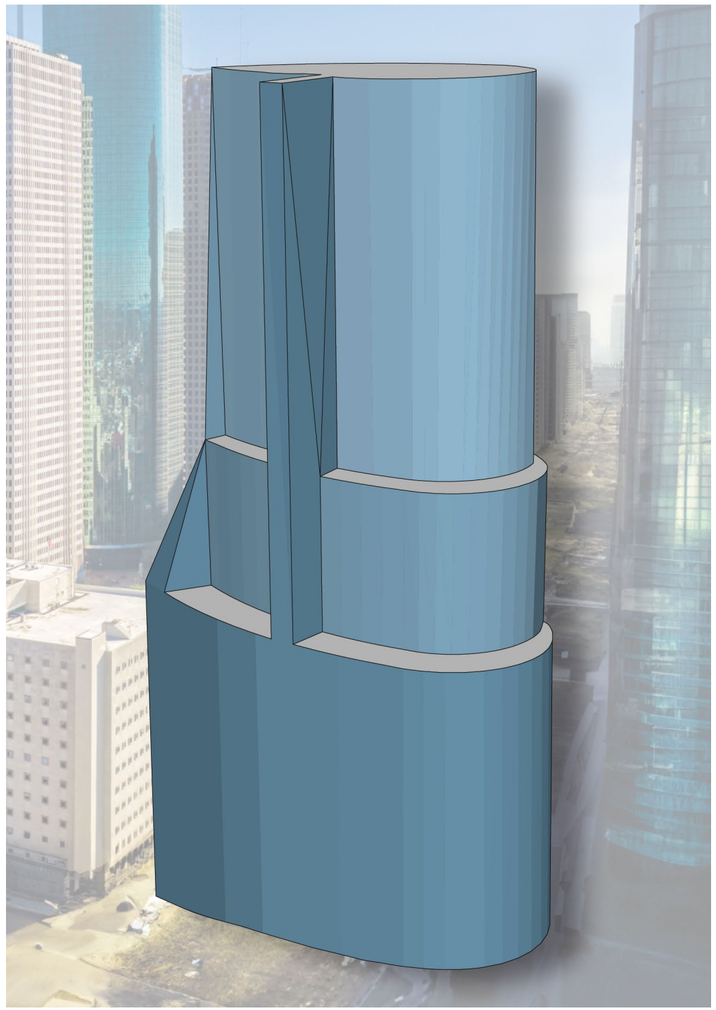
Heating Challenges

Limited Roof Space



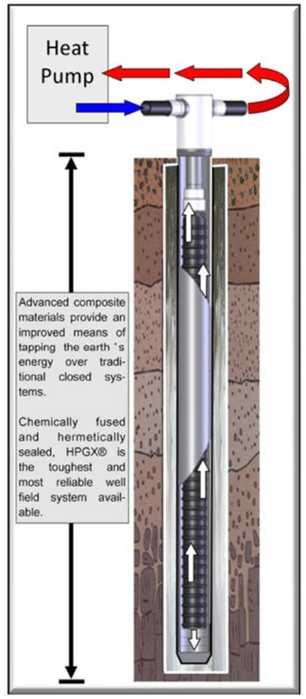
Heating Challenges

Limited Available Land



Ground Heat Exchangers

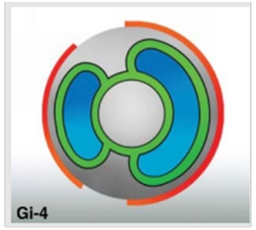
Rygan

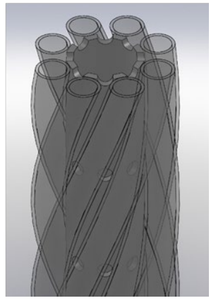


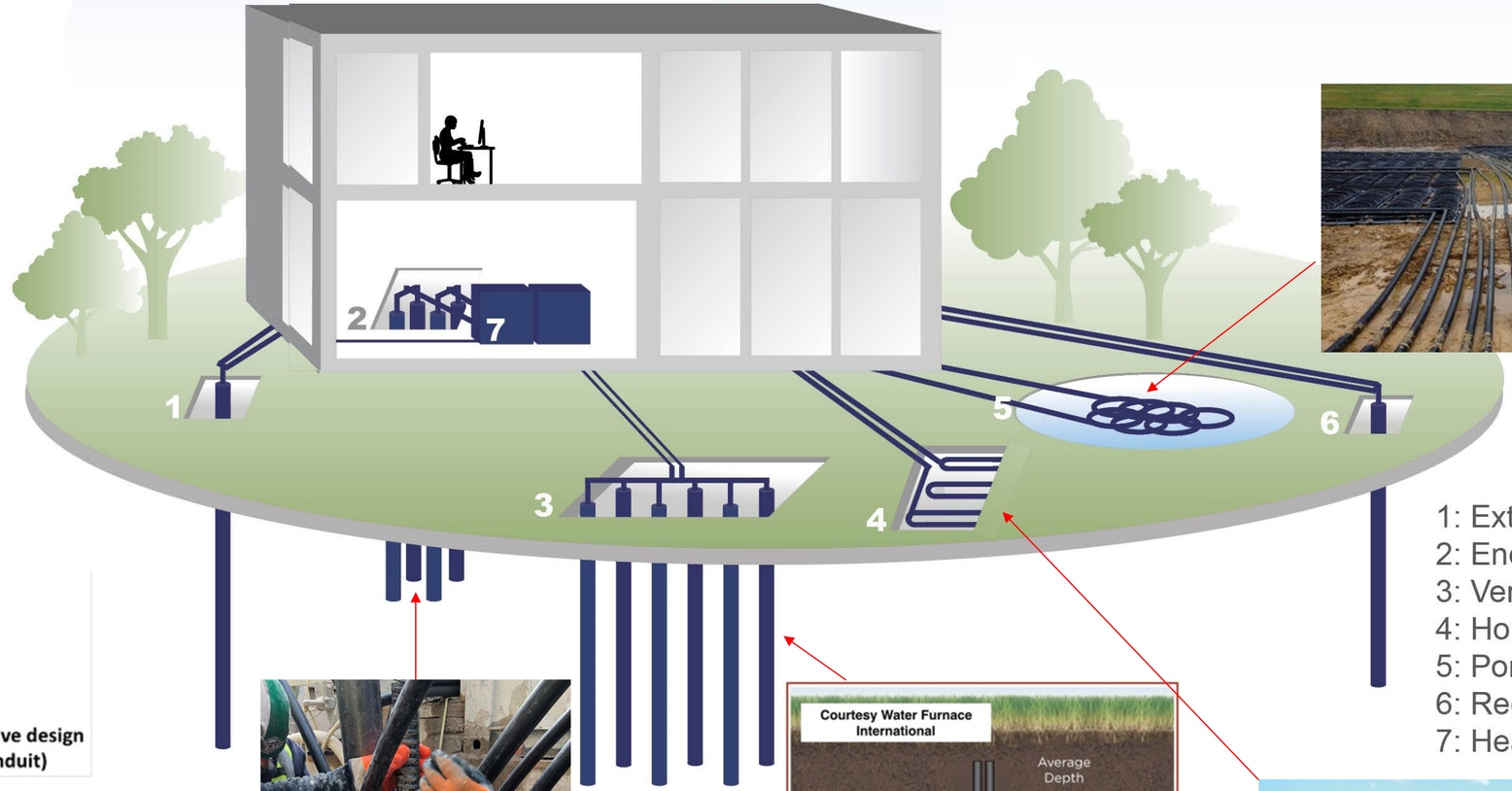
Double Loop

Twister

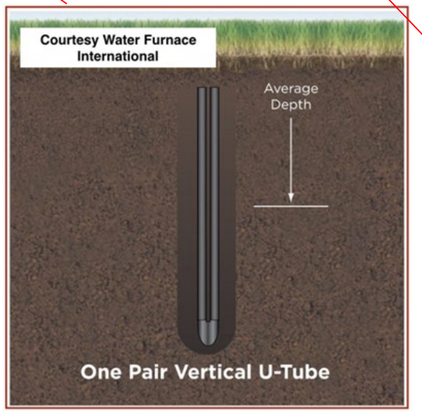
Gi4





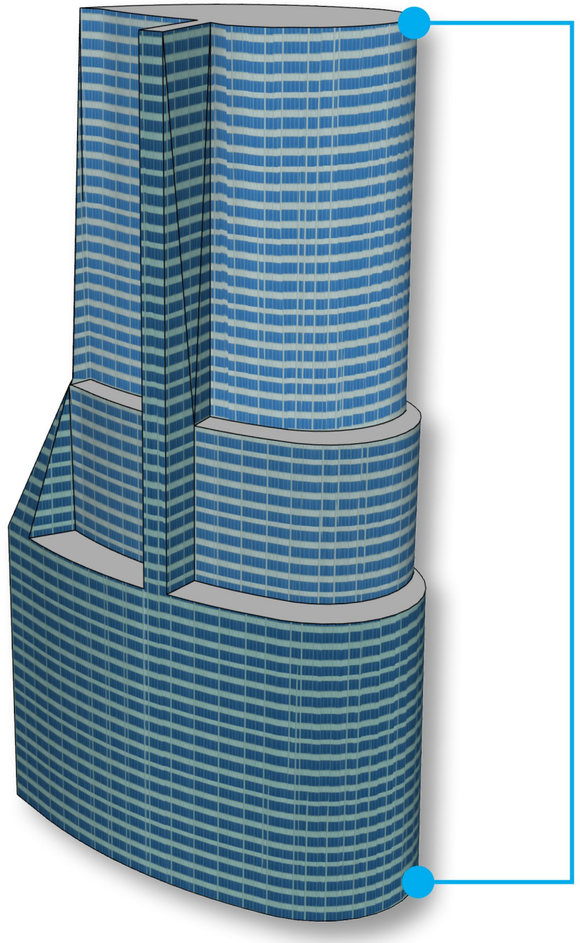


1: Extraction Well
2: Energy Files
3: Vertical Loops
4: Horizontal Loops
5: Pond Loops
6: Recharge Well
7: Heat Pumps



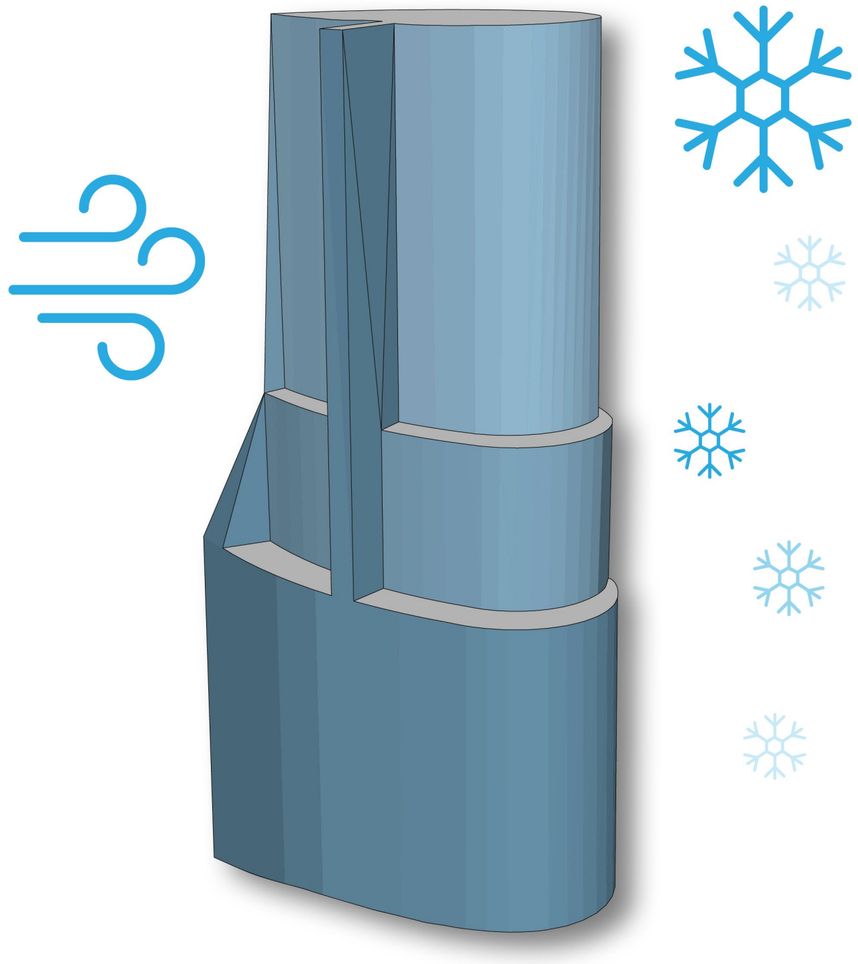
Heating Challenges

High Window-to-Wall ratio



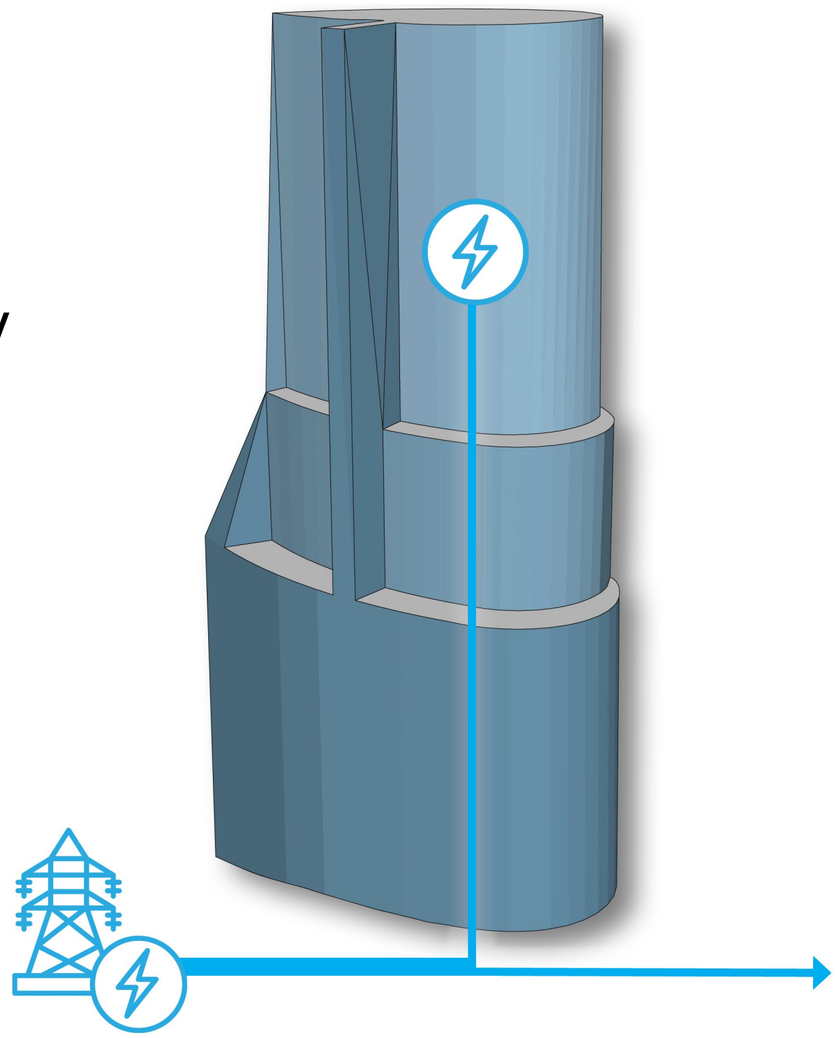
Heating Challenges

Low Ambient Air Temperatures



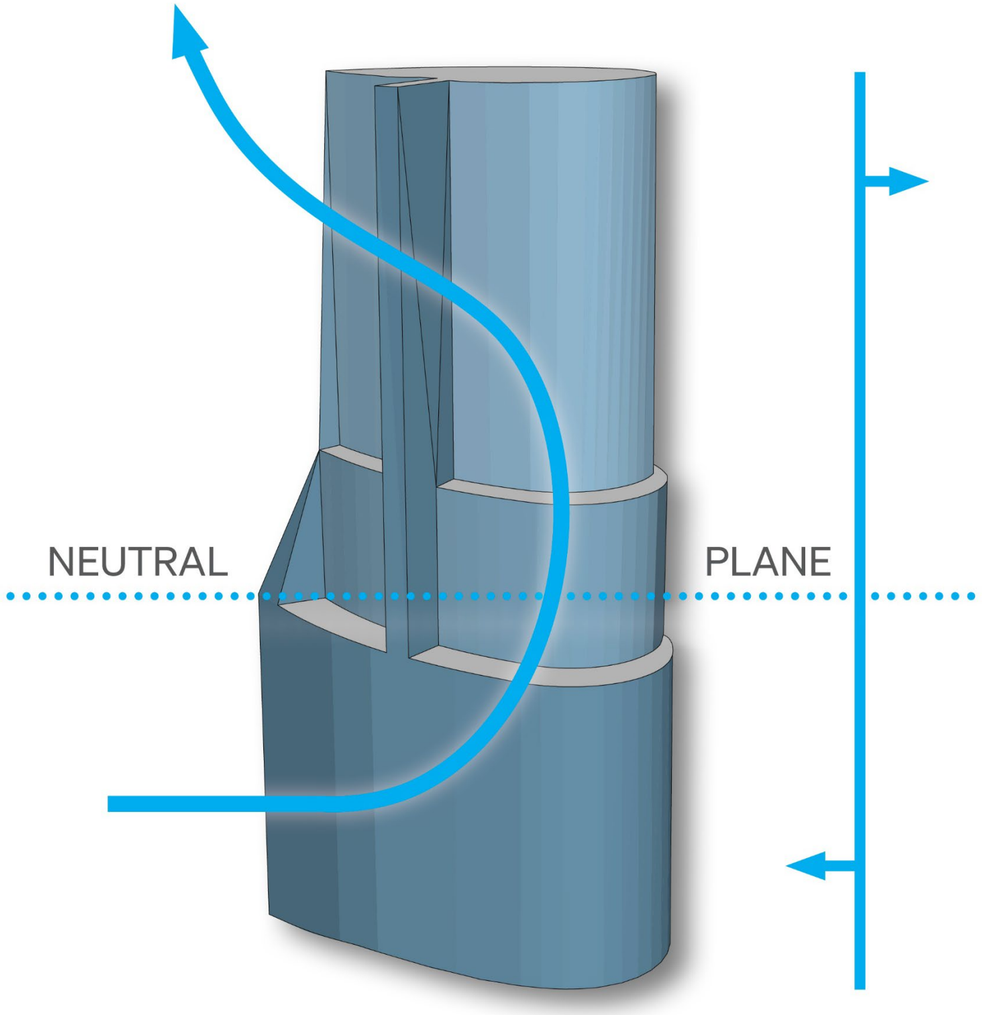
Heating Challenges

Electrical Capacity



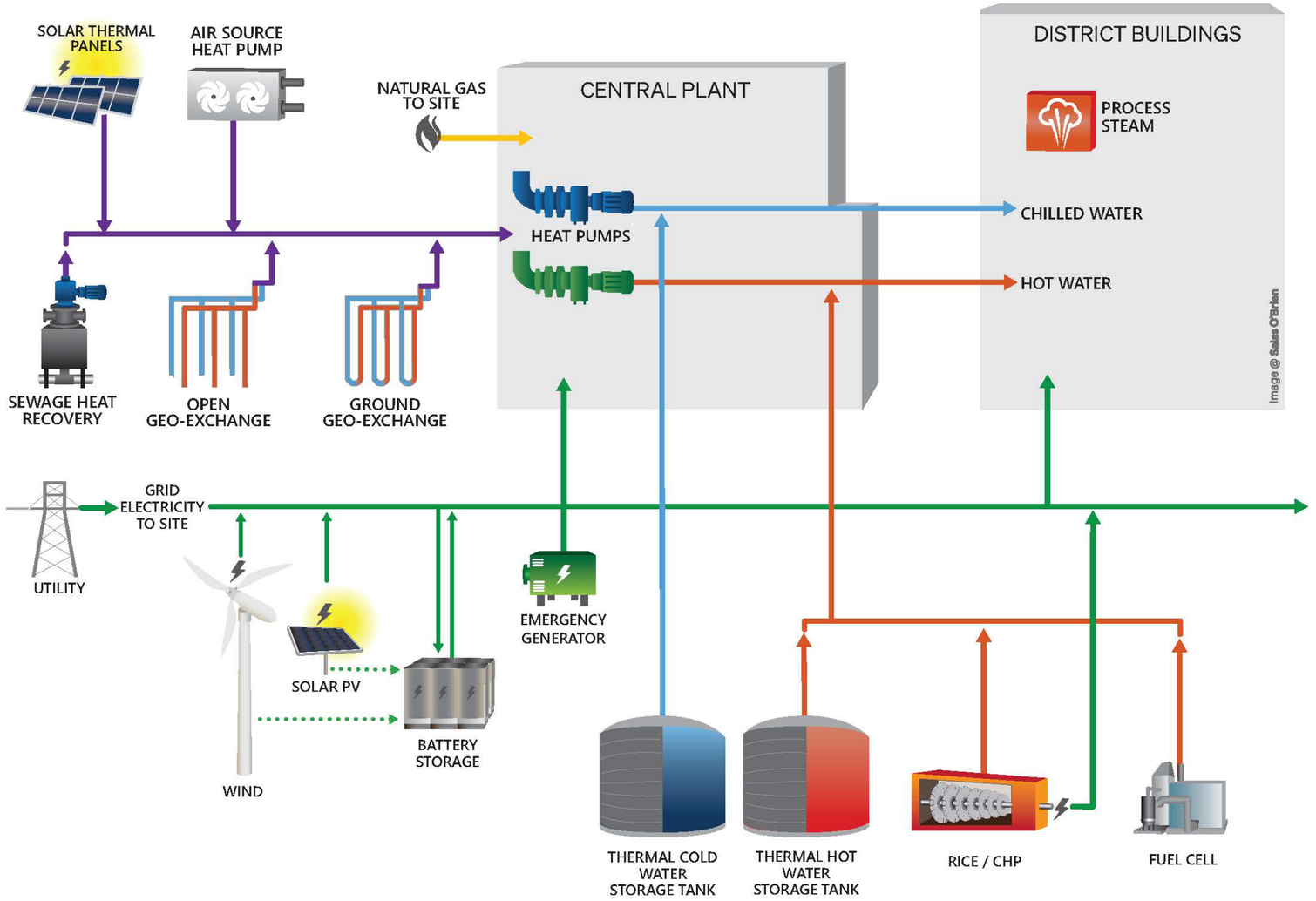
Heating Challenges

Stack Effect

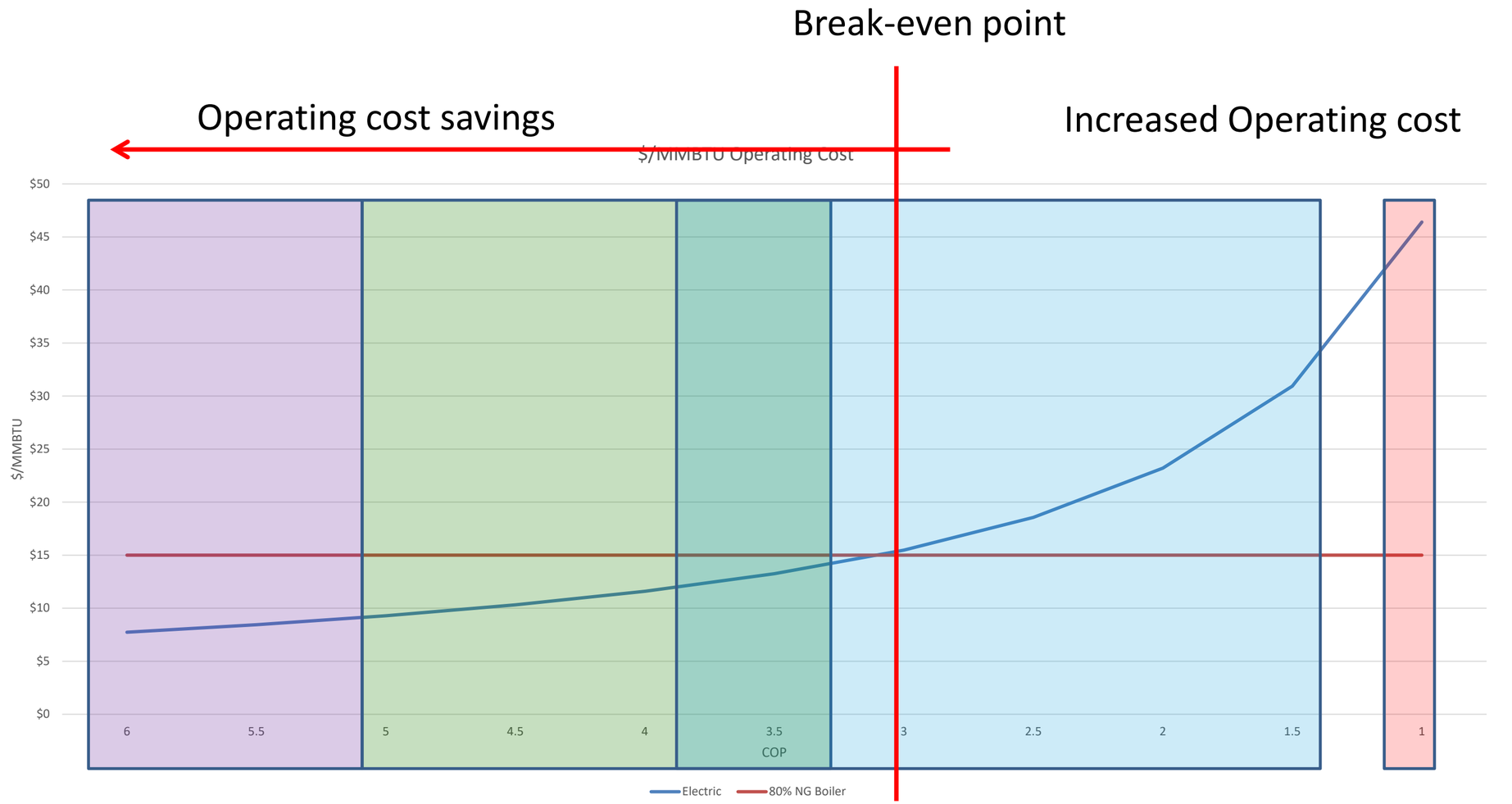


Potential Heating Sources

- Gas
- Solar
- Air
- Electric Resistance
- Wastewater
- Heat Recovery
- Geothermal (Ground/River/Pond/Aquafers)

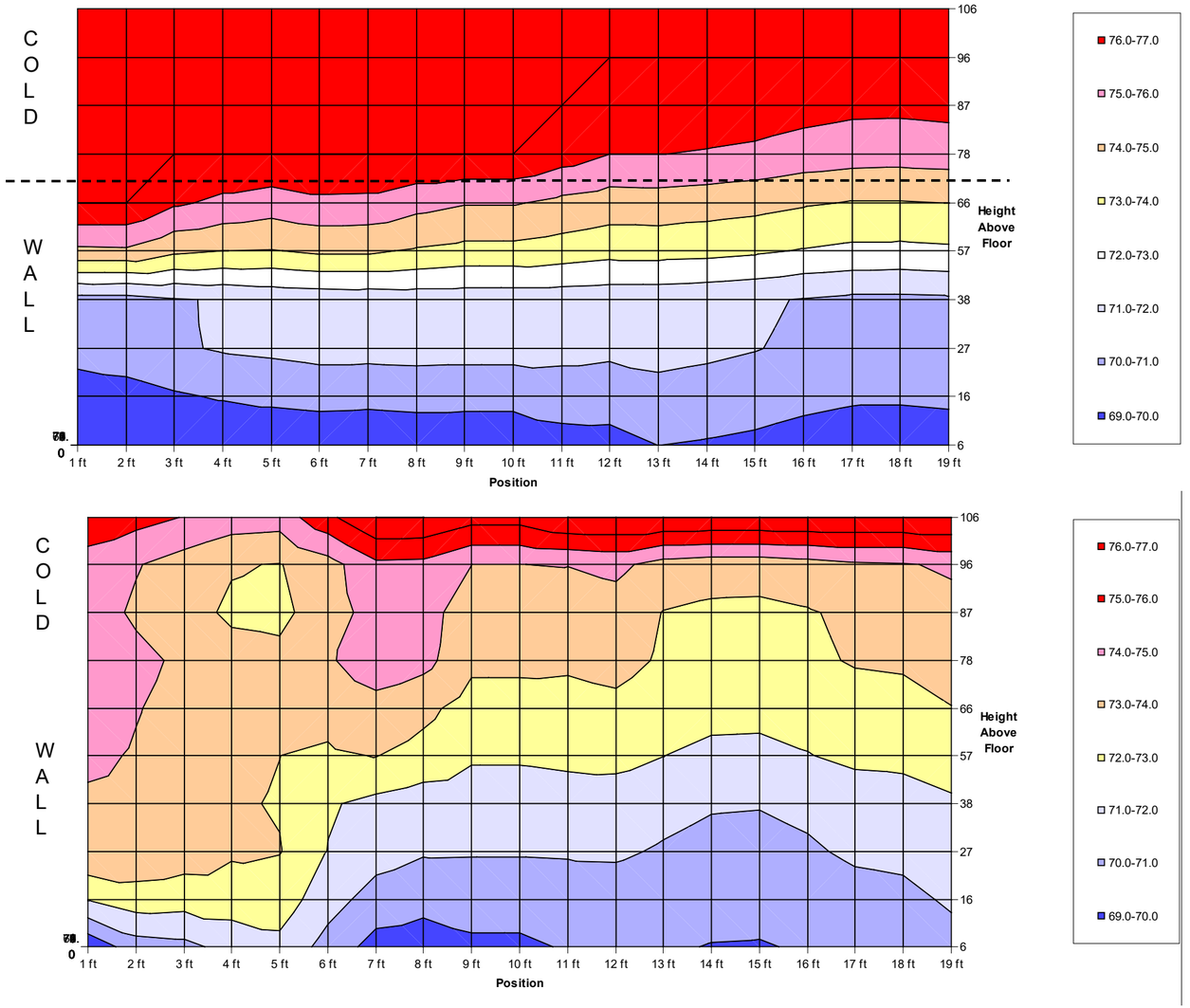


Potential Heating Sources



Space Heating

- High Heat Loss at Perimeter
- Supply Air Delivery is Critical
  - Comfort & Window Condensation
  - Optimal Location Depends on Supply Air Temperature
- Select Equipment That Can Use Water at 105^0F or Less (Condenser or Hot Water) to Offer Equipment Flexibility



Space Heating

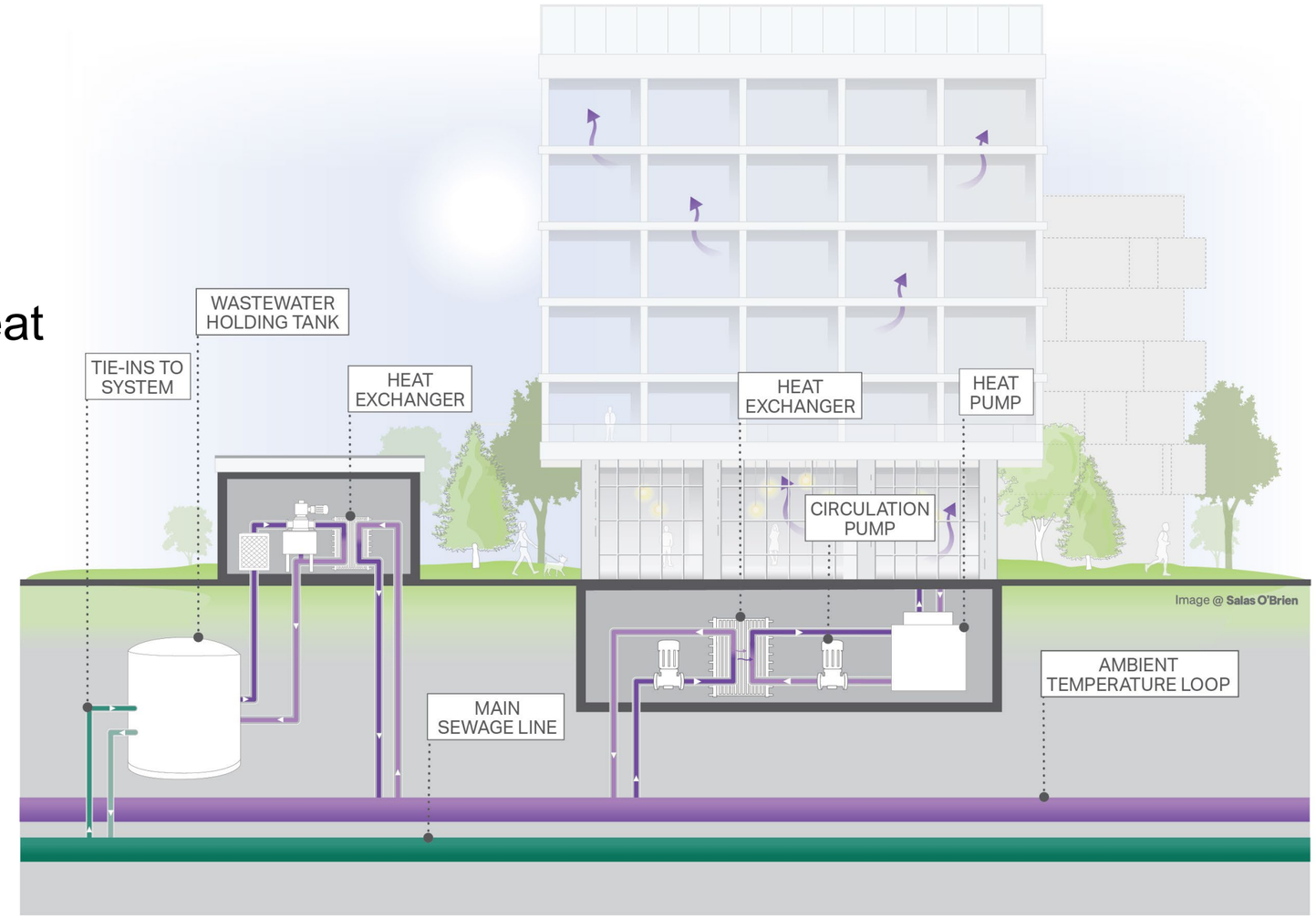
Types of Equipment

- HP (Water or Air Source) – Supply Air Delivery Close to Exterior
  - Vertical Stack HP at Perimeter with No or Minimal Ductwork
  - HP in Interior Closets Ducted to Perimeter
- HW Fan Coil –
  - Flexible Placement due to Controlled DAT
- Electric Baseboard
- PTAC/VTAC –
  - Increased Influence of Stack Effect Caused by Penetration of Exterior
- VRF (Water or Air Source)
  - Air Source Limited by Refrigerant Piping Length (Building Height)
  - Water Source Greater Heat Rejection System Length More Suited to Tall Buildings

Domestic Hot Water

Central Systems - Water Source

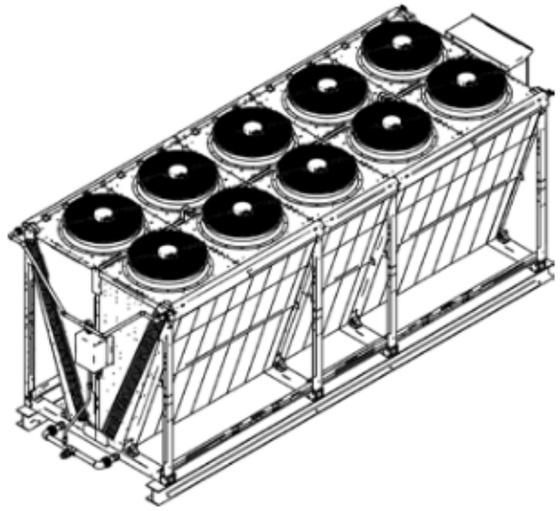
- Wastewater
- Ambient Loop
- Geothermal
- Hot Water with Domestic Water Heat Exchanger
  - Requires 130^0F Primary Hot Water

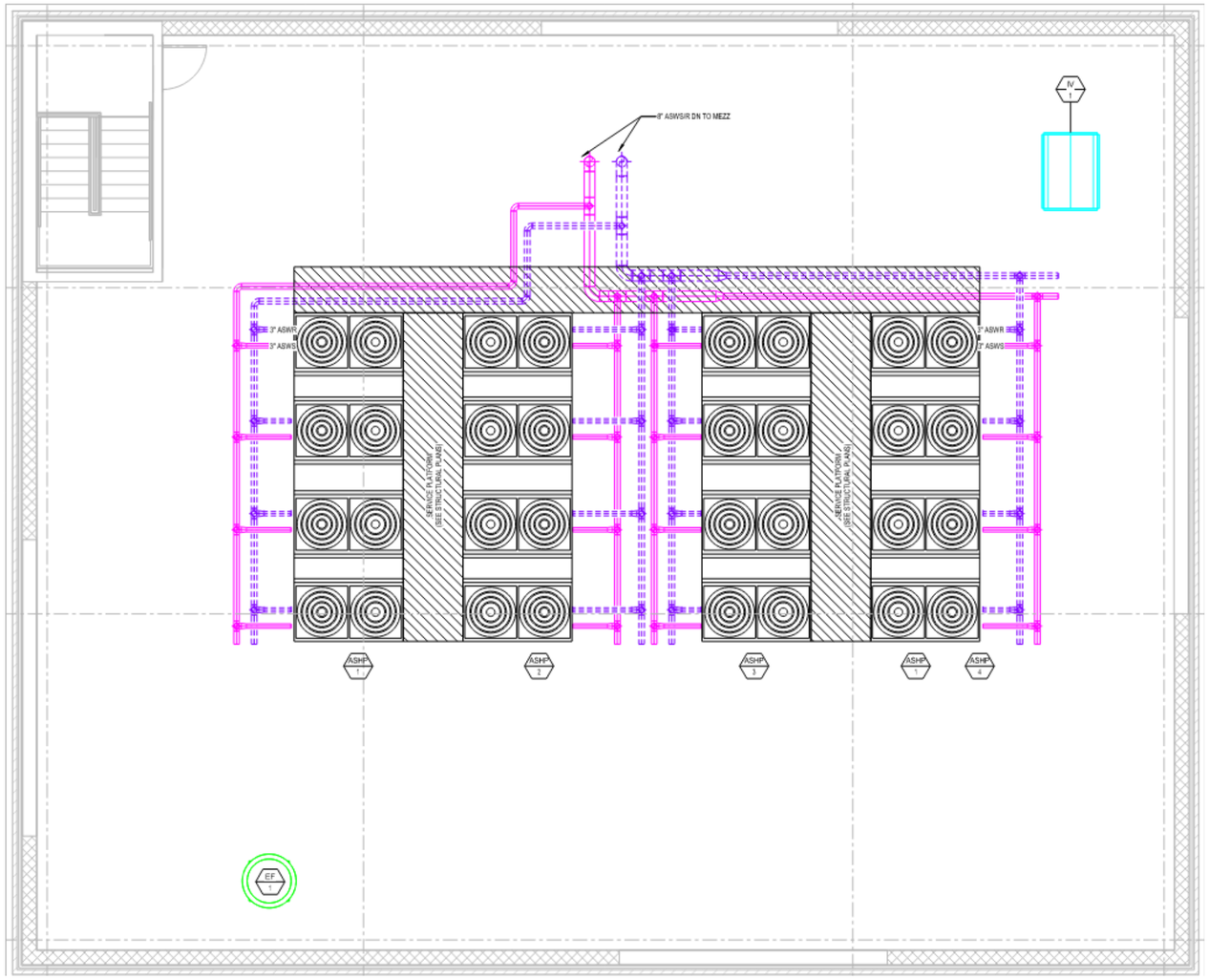


Domestic Hot Water

Central Systems – Air Source

- Uses Ambient Air
- Requires Large Outdoor Area

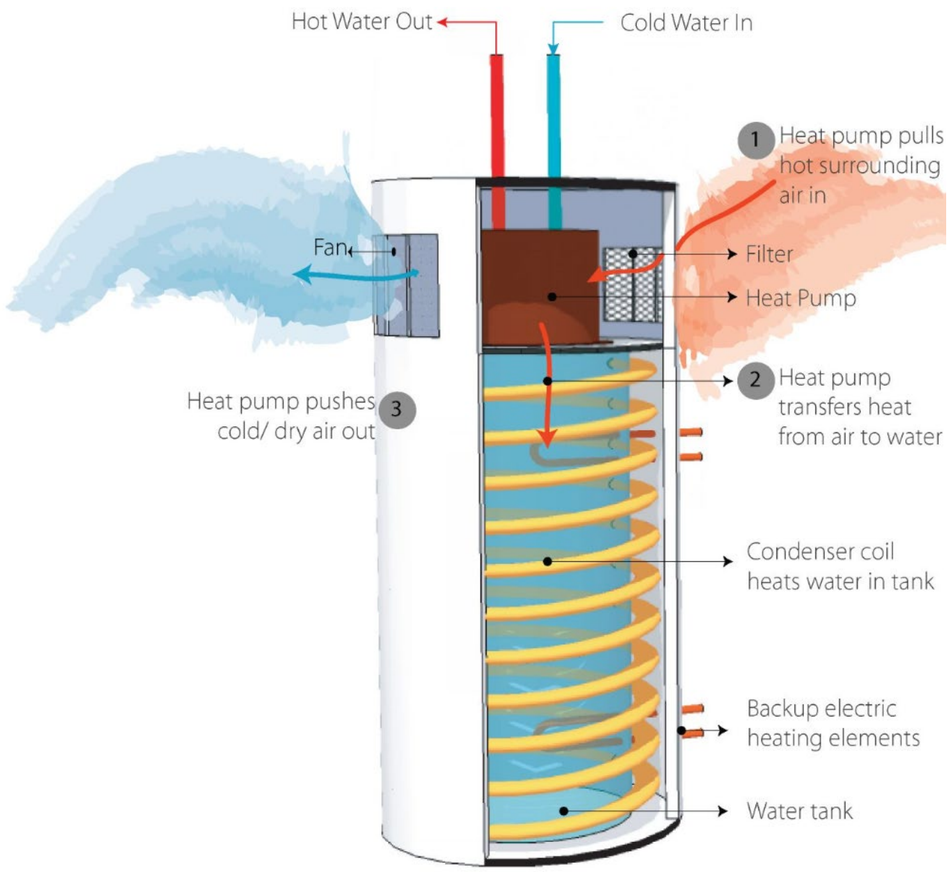




Domestic Hot Water

Unitary

- Electric Resistance
- Air Source Heat Pump



Ventilation

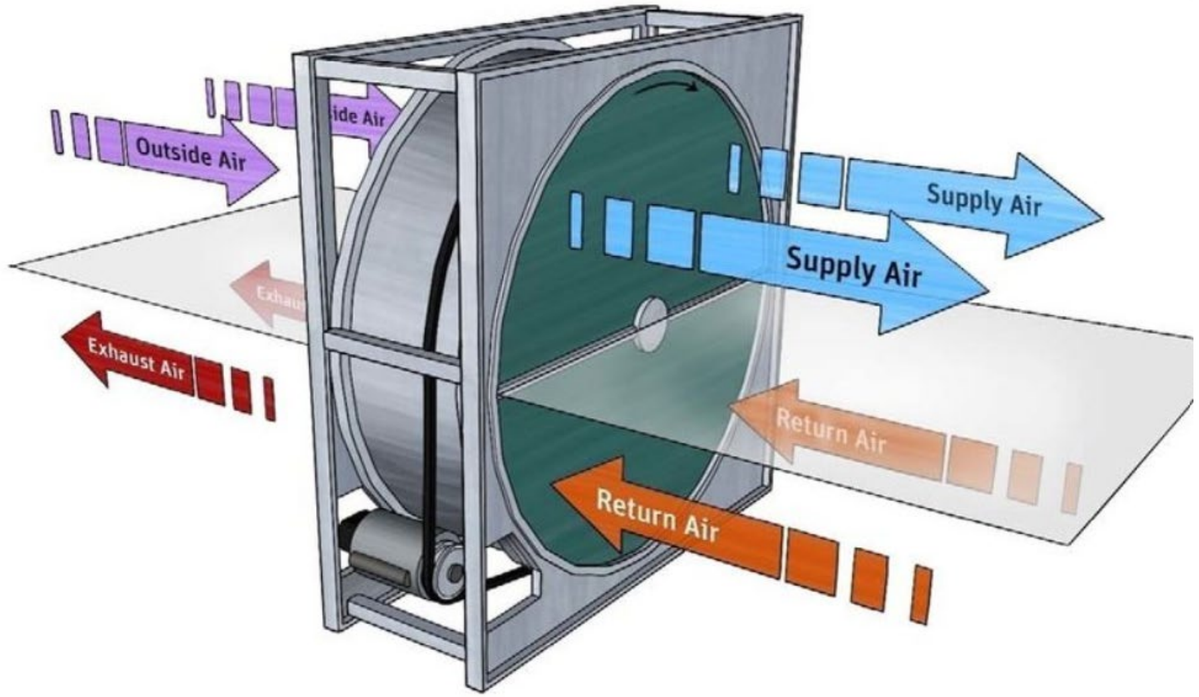
- Purposes
  - Code Ventilation
  - Make-Up Air (Greater than Exhaust Air)
  - IAQ
  - Pressure Control (Stack Effect)
  - Condensation Mitigation

Ventilation

- Methods Of Delivery
  - Individual Dwelling Unit Supply
    - Ducted Directly into Dwelling Unit
    - Control Requirements
  - Corridor Pressurization with Unit Transfer into Dwelling Units
    - Code Verification Required in many Localities
    - Capacity Limitations
  - Unitary ERV within Dwelling Unit
    - Impact on Leakage and Stack Effect
    - Maintenance of Louvers and Dampers
    - Condensation of ERV Ductwork
  - Natural Ventilation
    - Code Required in Some Localities

Ventilation

- Methods
  - Gas Furnace
  - Low Temp Hot Water
  - Water Source Heat Pump
  - Air Source Heat Pump
  - Electric Resistance
  - Energy Recovery



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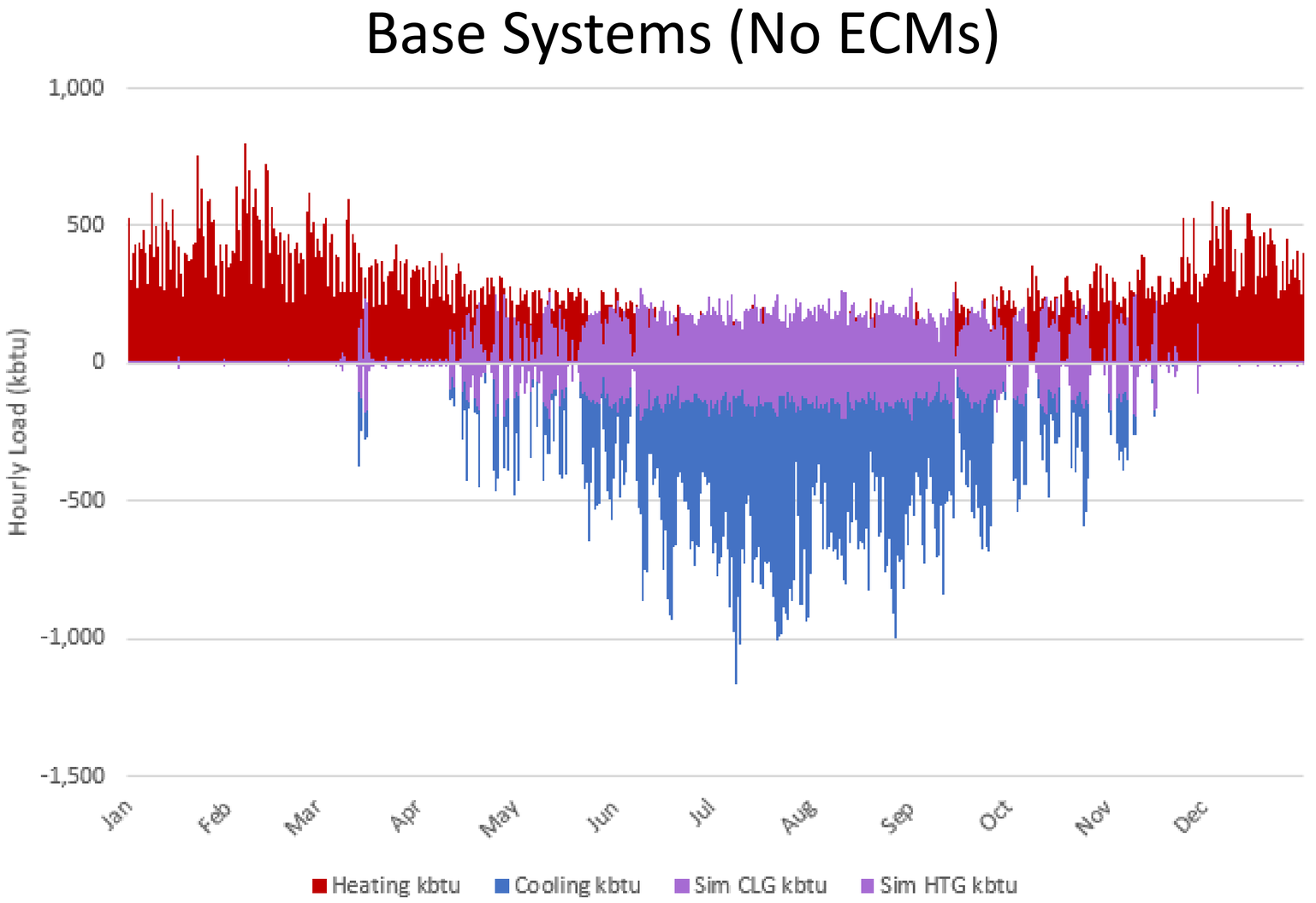
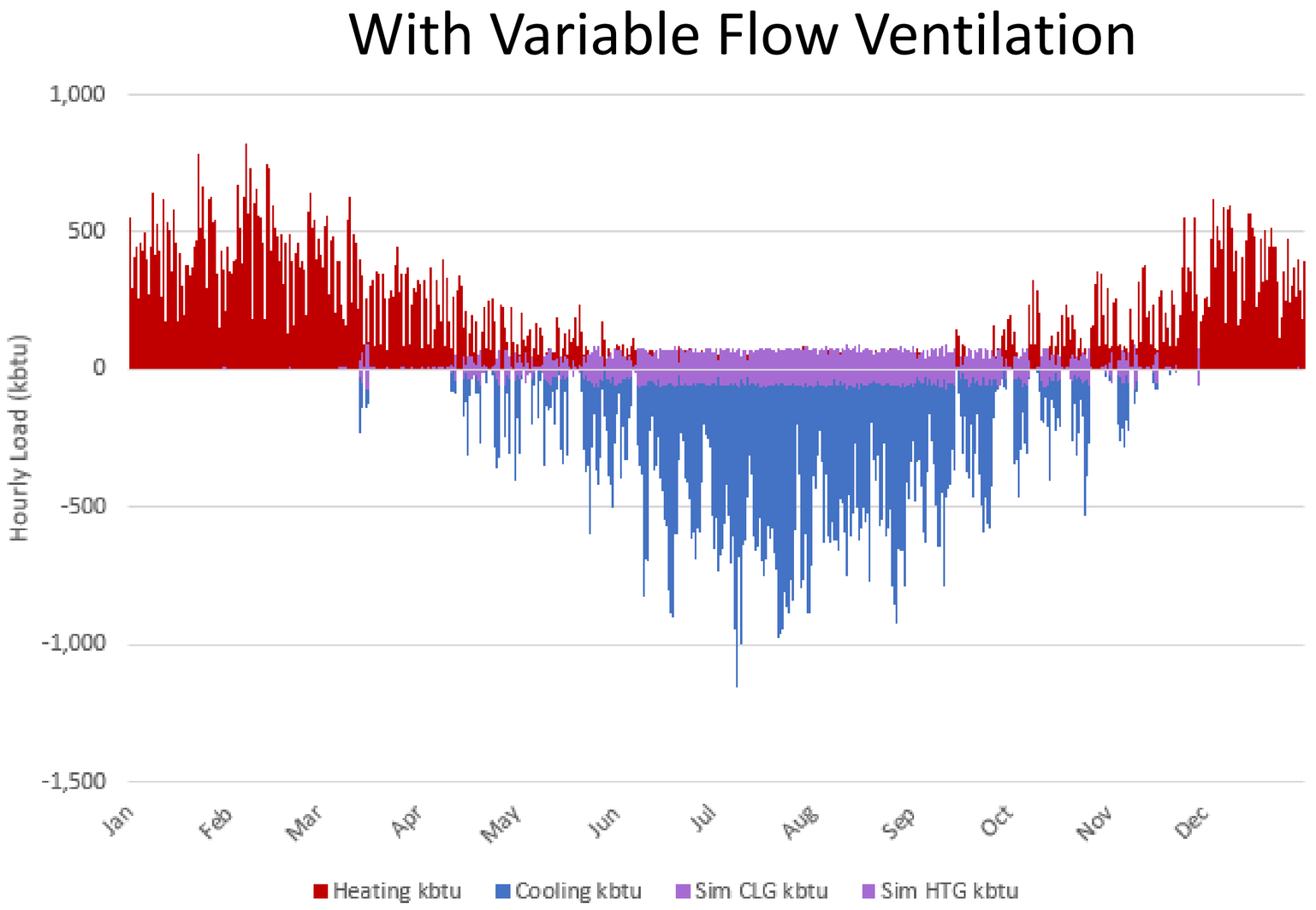
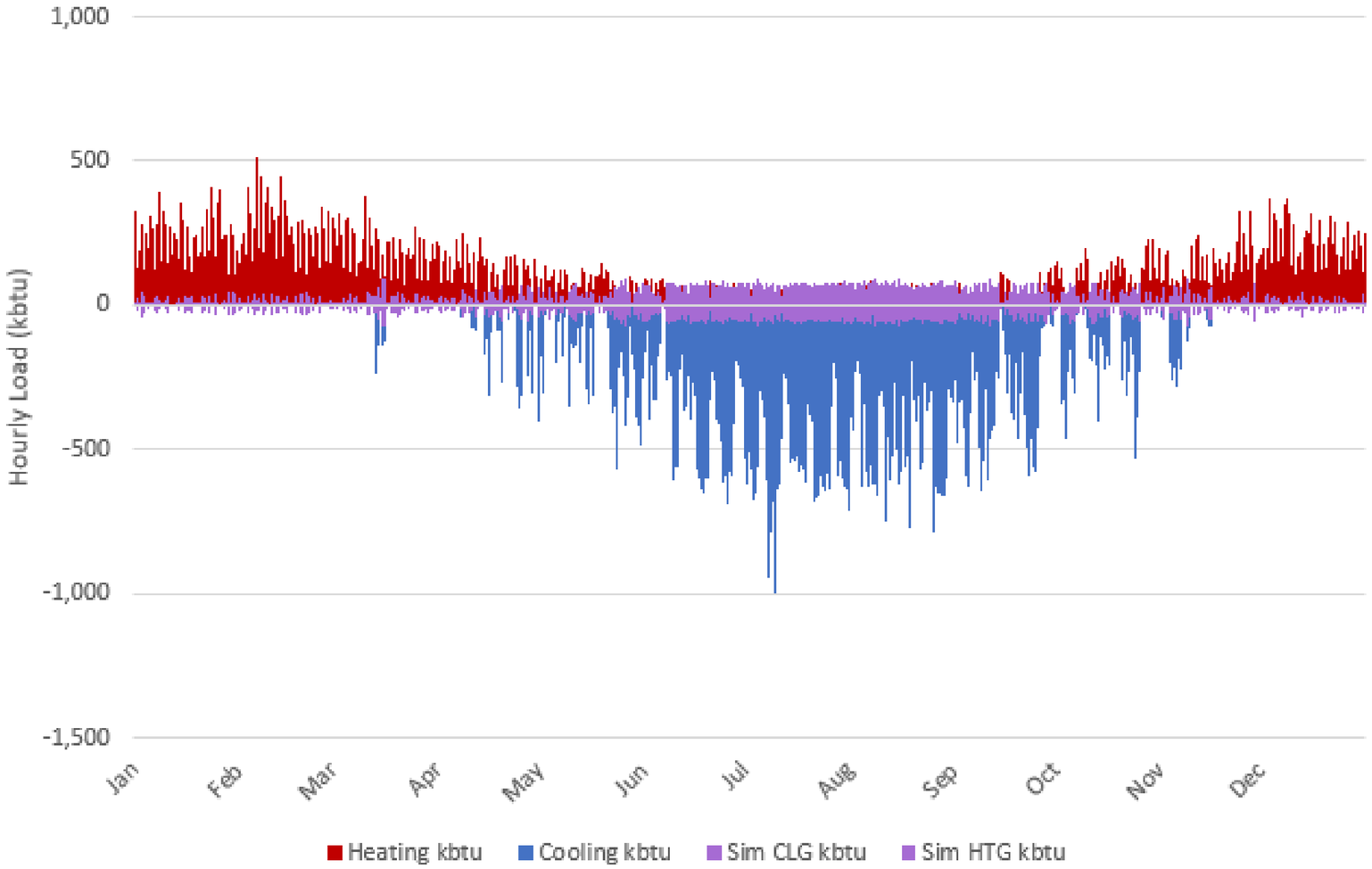


Ventilation



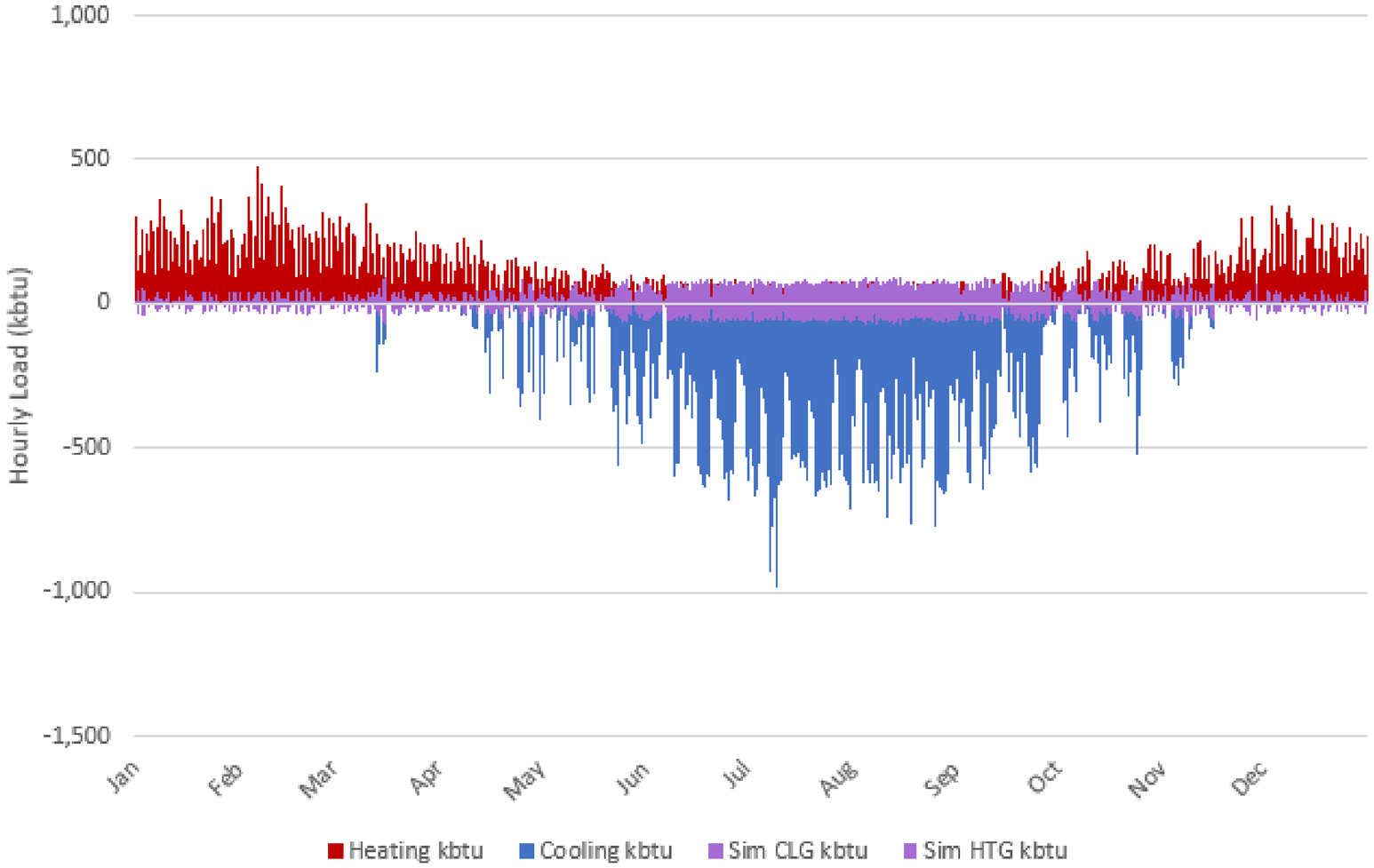
Ventilation

With Variable Flow Ventilation + Energy Recovery

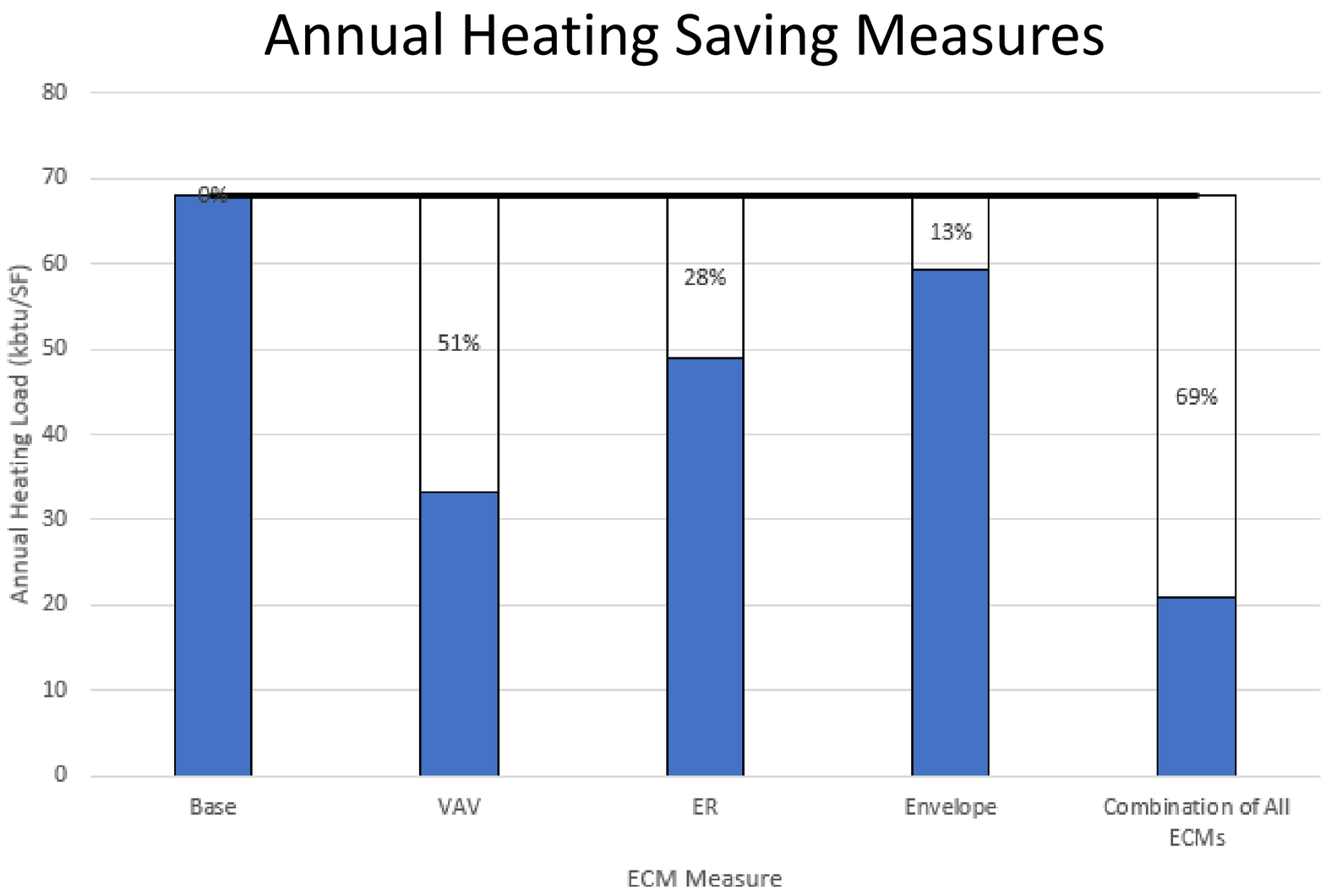


Ventilation

With Variable Flow Ventilation + Energy Recovery + Envelope Improvements



Ventilation



Course Questions

1. What are at least two (2) of the challenges with heating/cooling tall buildings?
2. How does the thermal load profile impact decisions regarding the HVAC system design?
3. How does ventilation/outside air requirements change the load profile and impact sizing of a geothermal system?
4. How are limited building footprint and roof space limiting factors to equipment sizing and hybrid design?

Geothermal for High-Rise Buildings: Design Considerations

Jason Eitel / *EJS New York*


omega
HEAT PUMP


EJS

About Omega…

Sigma Heating & Cooling

- Est. 1997
- 120,000 SQ-FT manufacturing across 3 plants, 240 staff
- Industry expertise in Vertical Stack Fan Coils and Heat pumps

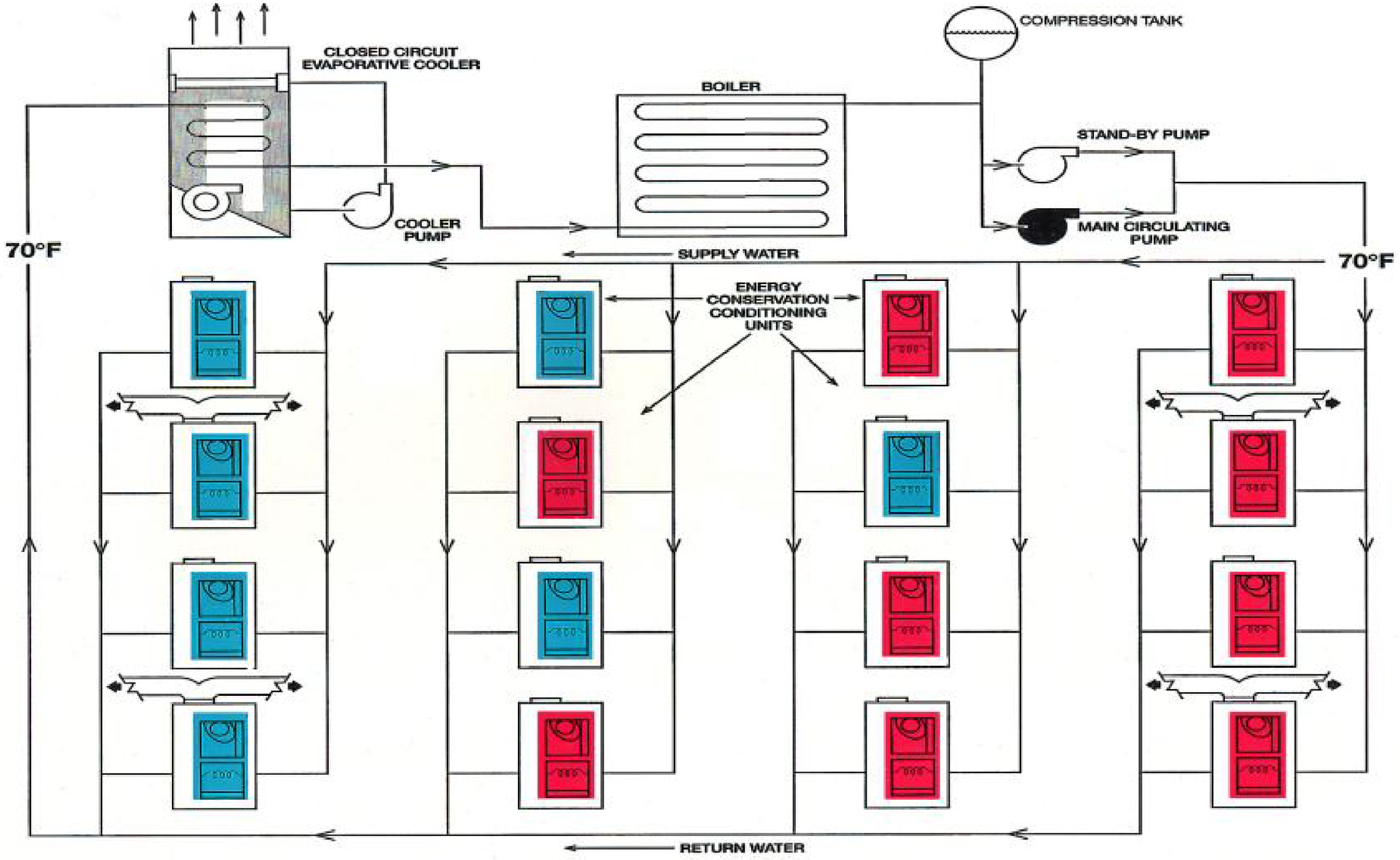
Sigma Divisions:

- Omega Vertical Stack Heat Pumps
- Sigma Vertical Stack Fan Coil
- Commercial Self Contained – JCI Acquisition
- Sigma Wet Heat – Hydronic Heating

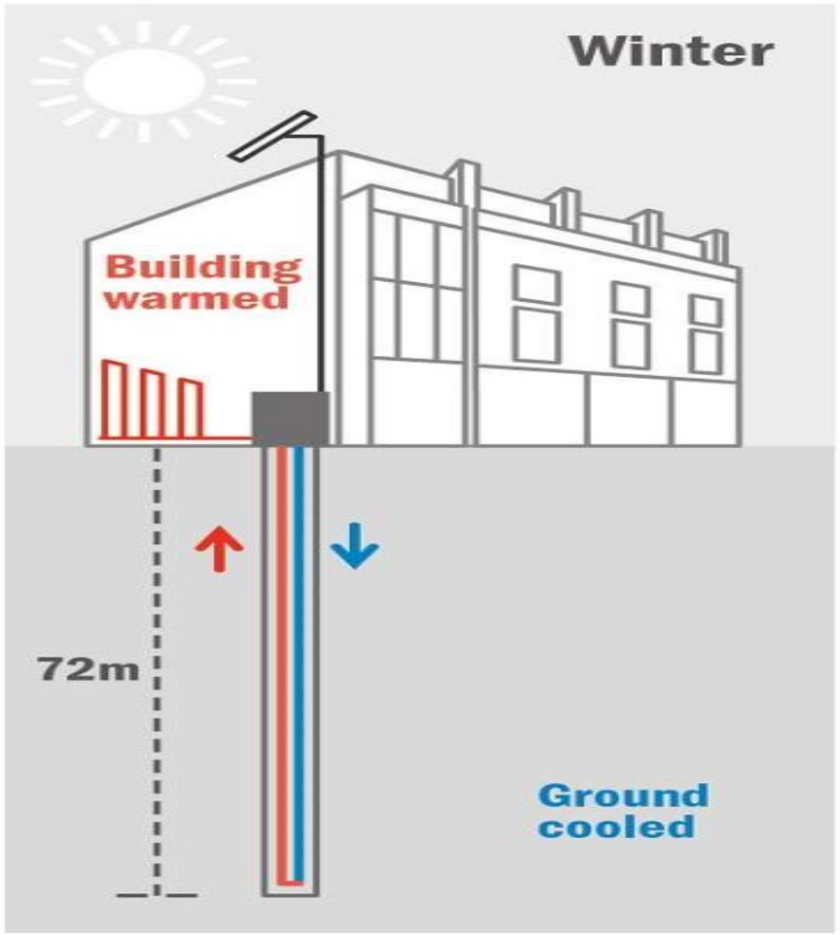
Heat Pump Products

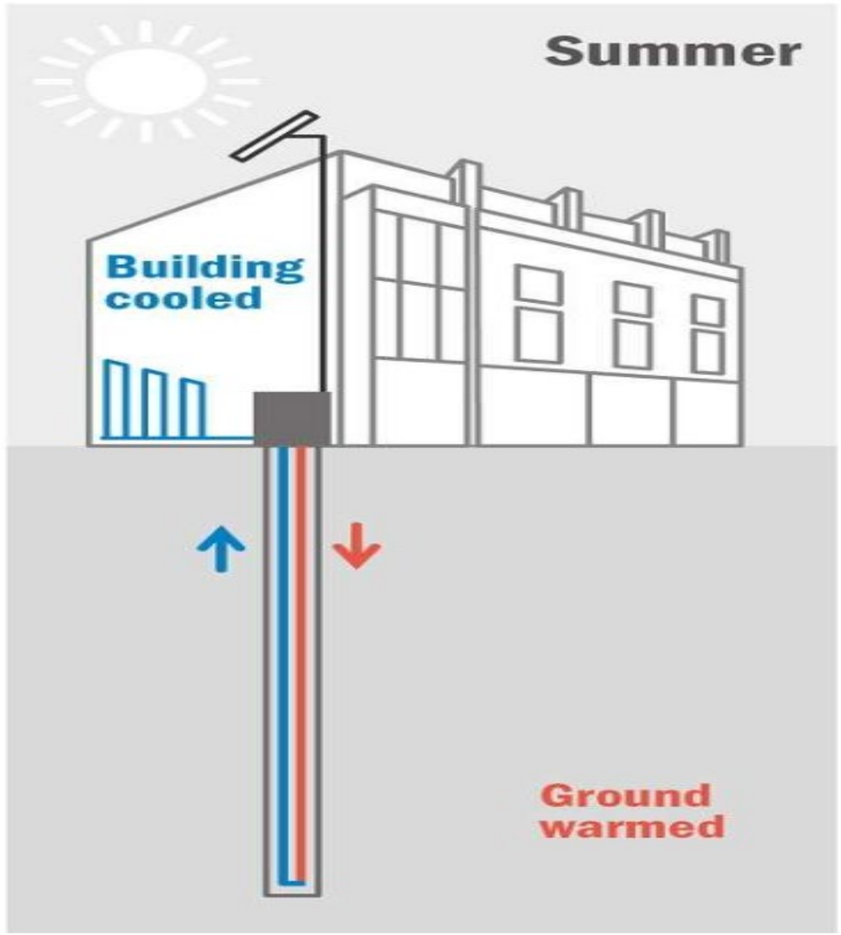
- **VSHP** – Standard Vertical Stack Heat Pump
  - Comes in Standard Efficiency (SE) and High Efficiency (HE)
  - Standard or geothermal CW application
  - ½ Ton to 3 Ton
- **VSHY** - Hybrid Vertical Stack Heating and Cooling
  - High Efficiency (HE) chassis only
  - ½ Ton to 3 Ton
- **VSHPe/VSHYe** – Vertical Stack w/ Integrated ERV
  - Single source power
  - Integrated ERV Core
  - Single point service access

Conventional Heat Pump Loop

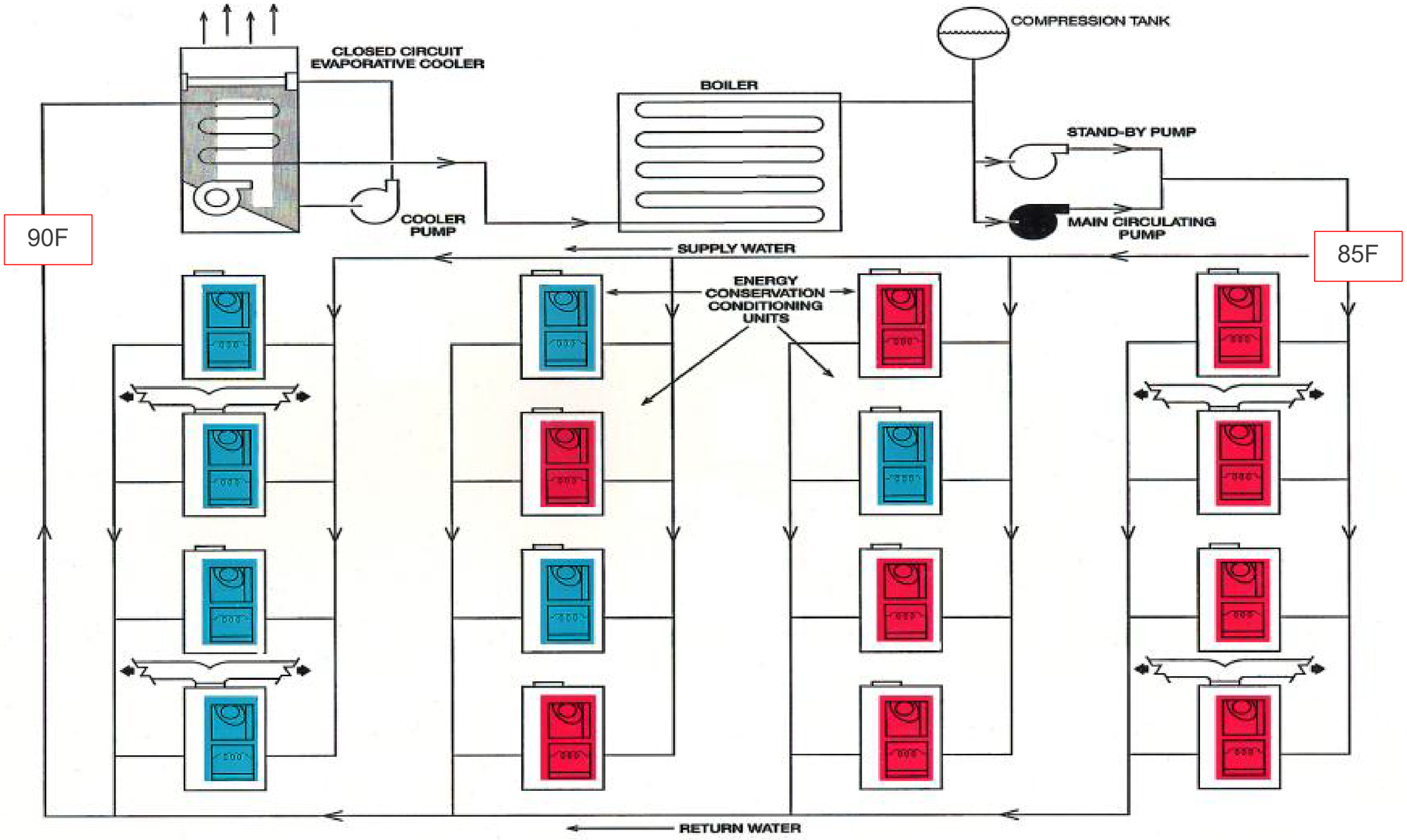


Geothermal Heat Pump Loop

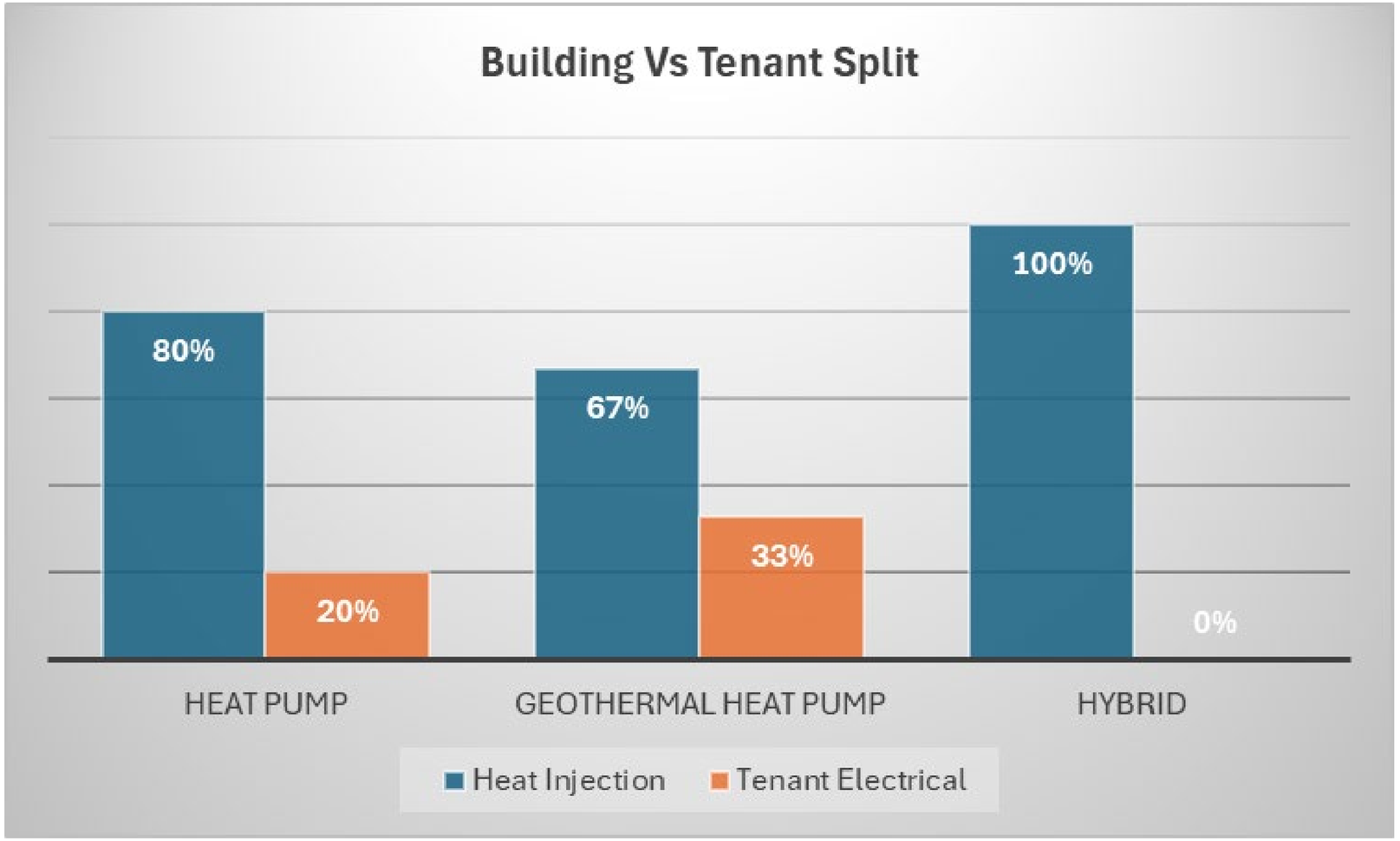




Hybrid Heat Pump Loop



Building Heat Source



System Comparisons

VRF

- Ventilation shaft requirements, installation expertise
- VRF terminal units are unique to each refrigerant type and manufacturer
- Capital and Install Costs on large systems

Horizontal HP/FCU

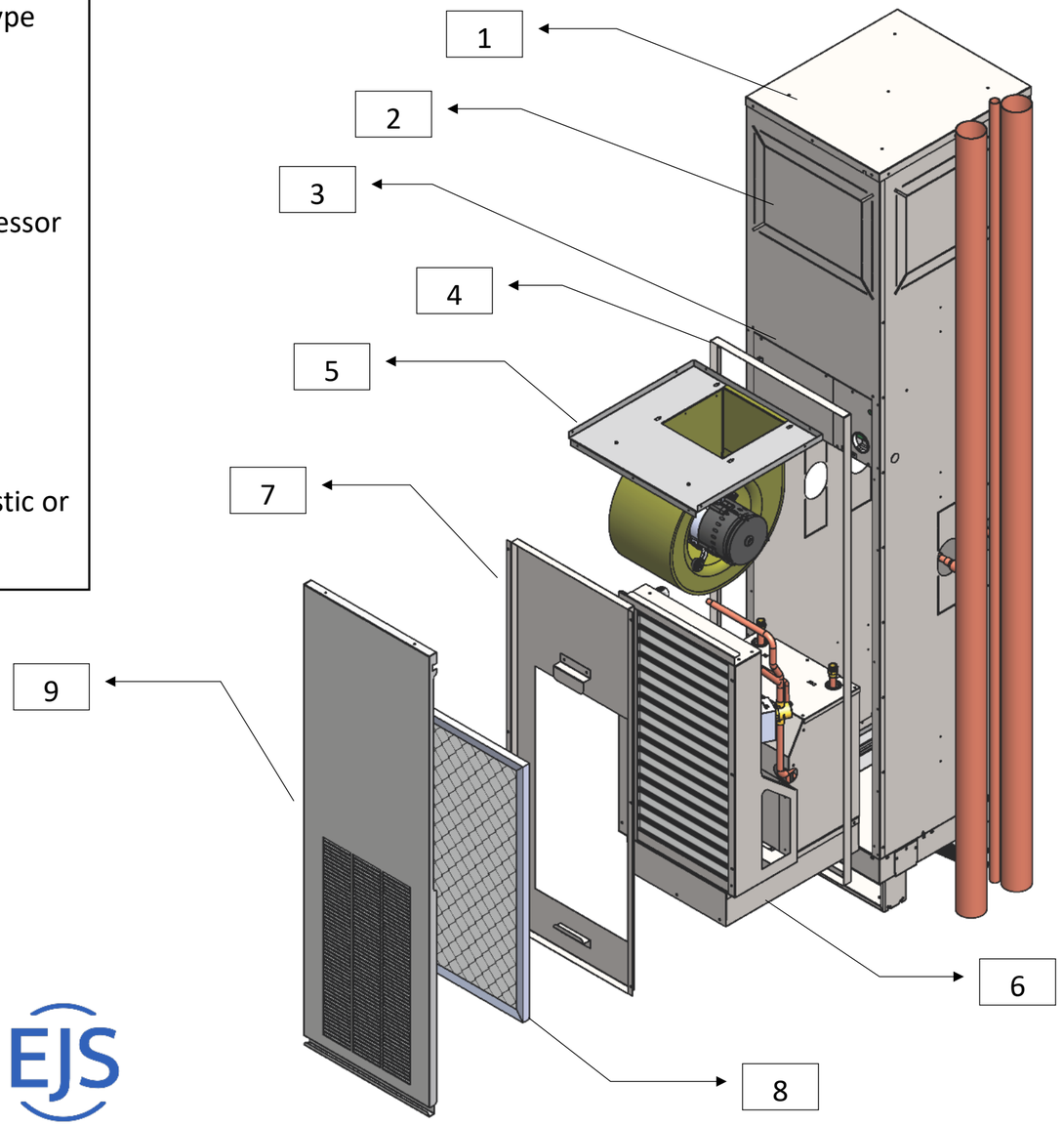
- Horizontal equipment requires full replacement
- Limited access for servicing & noise mitigation is crucial
- Lose ceiling height

Vertical Stack HP/FCU

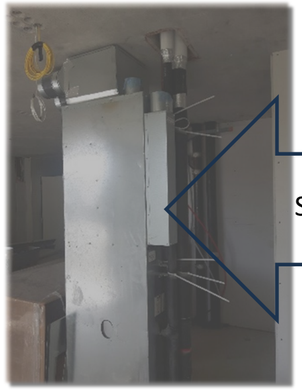
- Easy service & maintenance
  - Reduced service times
  - Slide-out chassis for off-site diagnosis – quick install of attic stock for minimal downtime
  - Large market for replacement chassis options from R410A, R454B to future A3 refrigerant standards
  - Future proof with existing cabinets

VSHP

- Supply, return and condensate risers. Type ‘M’ or ‘L’ copper
- Field “knockout” supply air openings (Front/Back/Side/Top) with 1-1/2” duct flange.
- Electrical box with advanced microprocessor
- (Optional) 1 inch perimeter flange
- Removable Blower / Fan assembly
- Heat pump chassis (VRHY shown)
- Chassis service cover panel
- 1 inch MERV 10 pleated air filter
- Return air (R/A) panel available in acoustic or perimeter (Acoustic shown)



Phases of VSHP Install



Stage 1: Cabinet Casing & Risers

Stage 3: Furring & Chassis

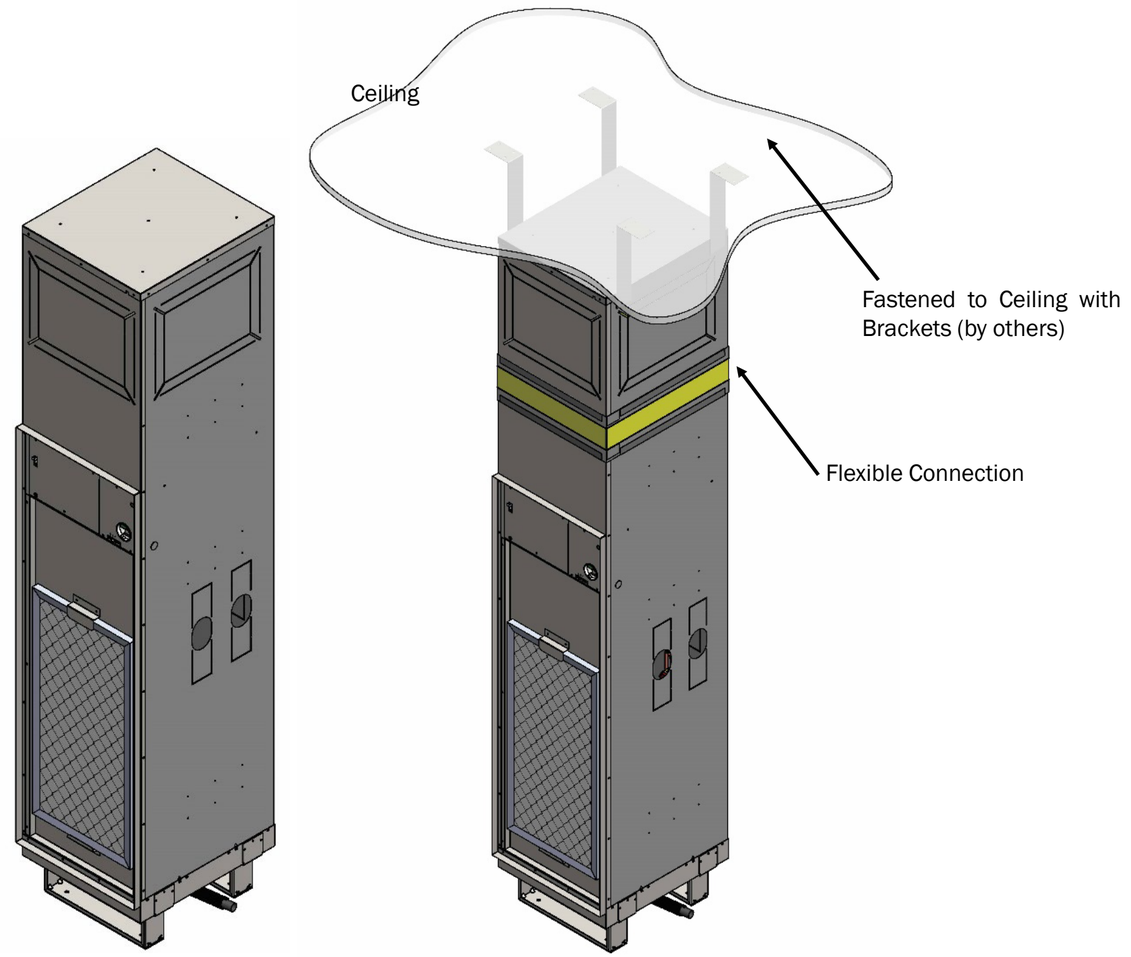
Stage 2: Walls & Insulation

Stage 4: Panels and Finishing

VSHP Series: Vertical Stack Heat Pump

Vertical Stack Heat Pump

- Available in *Silver* or *Gold Series*
  - Gold Series feature integrated flexible duct collar
- Dynamic Heights available
  - ~ 72-in to 120-in cabinet height
- Dynamic Supply Discharge Opening Sizes
  - Select size based on design criteria
- Microprocessor controller
  - On-board Webpage diagnostics, data logging
  - 3-Strikes Rule
  - Suction Line Temperature Freeze Protection



Silver Series **Gold Series**

VSHP Series: Vertical Stack Heat Pump

Standard Features

- 4 temperature sensors: EWT, LWT, Refrigerant Suction (RST), Supply Air Temp (SAT)
- 3 Speed fan control
- Double isolated compressor base
- 1-inch thick cabinet insulation
- Freeze protection and hard lock out

Options & Accessories

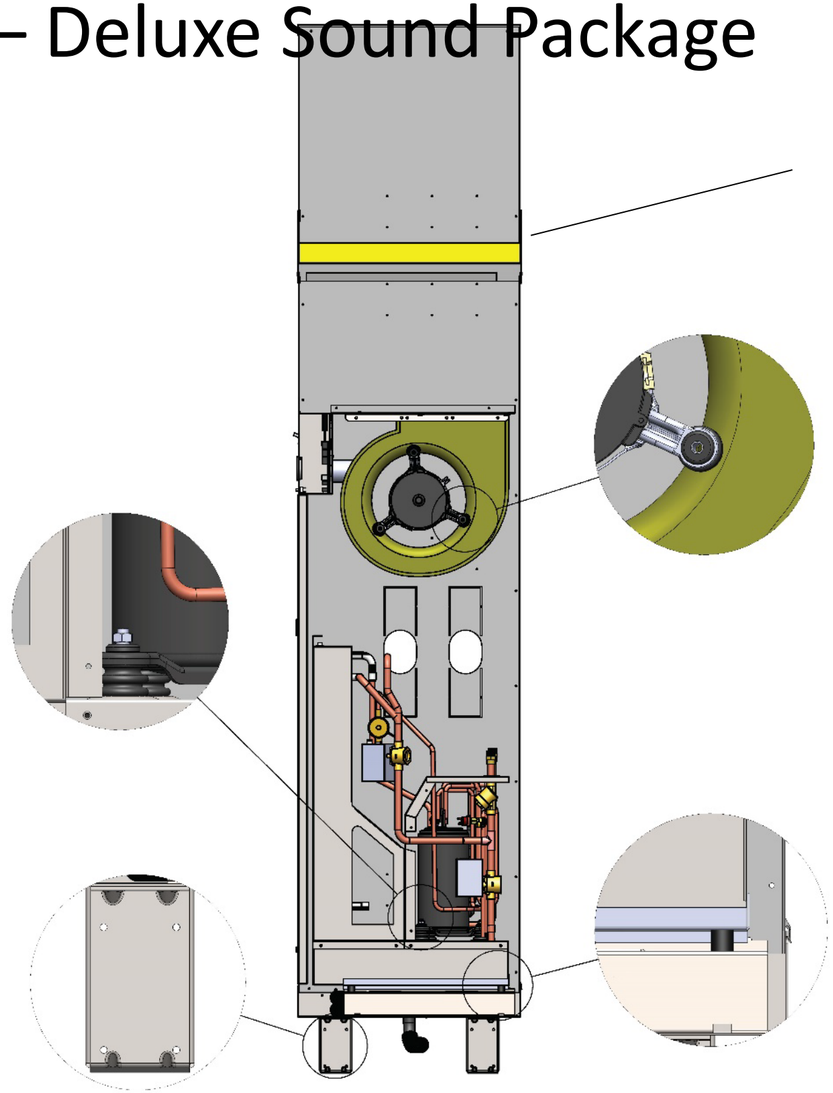
- Customizable Alarm outputs on Deluxe Board
- LTW Option - Optional Water Side High Pressure Switches

- VSHP & VSHY

EJS

Sound Isolation – Deluxe Sound Package

– **Deluxe Sound Package is Standard - Omega Features 4 Standard methods and 1 Optional Option**



Flex Duct Isolator (Optional)

Units with the optional **Gold Series** option feature a factory installed flexible canvas duct collar.

Motor Mount Isolators

Motors are attached to the blower housings with rubber isolation fasteners.

Compressor Mounts

Compressor vibration dampening inserts

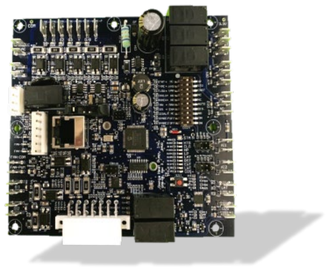
Unit Foot Insulation

1/4” closed cell foam pads under the cabinet base.

Vibrational Rail

The refrigeration chassis is mounted on a double isolated base with rubberized dampeners to isolate the chassis.

Microprocessor Controller – Deluxe Board



- Local WIFI Access through smartphone via mini-router
- Real-Time Data Reading
- View Data Logging of past runs
- Parameter Adjustments (…Fan Speed Settings)

Omega Heat Pump Controller Interface — **Software V5.4.0**

Settings | LogDump | CSVDump

DIP SWITCHES/GEO JUMPER :

Stat Type	HP Type	Flow Type	Cx Valve	HC-RV Valve	FanMode	GeoJumper
OFF	OFF	OFF	OFF	OFF	ON	CLOSE
H/C Tstat	Hyb HP	Var Flo	NO CxVlv	NO HCVlv	Auto/TstatInp	STDTemp

STATUS LEDS :

HP	LP	WLDT	CO	RST	WLST	STA	CLG	HTG
○	○	○	○	○	○	○	○	●

THERMOSTAT INPUTS/ FAN SWITCH INPUTS :

G1(Fan1)	G2(Fan2)	G3(Fan3)	Y(Cpr/Clg)	O/B (Rv/Htg)		SWLO(Fan1)	SWMD(Fan2)	SWHI(Fan3)
CLS	CLS	OPN	CLS	CLS		OPN	OPN	OPN

FAN OUTPUTS :

FanSpdL	FanSpdM	FanSpdH	FanPWM(%)		Cpr	FvCx Vlv	Rv/Hc Vlv
OFF	ON	OFF	66		OFF	ON	OFF

CHASSIS INPUTS:

HPS	LPS	COS	LvgAir	ReFrgSuction	WaterLoopSupply	WaterLoopDischarge
CLS	CLS	1	73.6	68.2	69.7	69.8

GENERAL I/O :

AI1(A/D)	AI2(A/D)	DI1	DI2	DO_ALARM	DO1	DO2
1023.0	381.0	CLS	OPN	NRM/OPN	OFF	OFF

COMPRESSOR CALL LOGIC:

	CPR Relay	CPR Call	ARTimer Exp	HP Alarm	HP OK2Run	LP Alarm	LP OK2Run	COS Alarm	COS OK2Run	WLST Safe	WLDT Safe	FanRequest	Fan On Timer	Vlv Opn Timer
Value:	OFF	FALSE	Expired	NRM	NO	NRM	NO	NRM	NO	ALM	ALM	TRUE	Expired	0/10
Special Mode:	-													

CONTROLLER STATES :

	HPS : Alarm on OPEN	LPS : ALARM on OPEN > 5 sec	COS : ALARM on OPEN (COS over 500 for 5 sec)
Raw Input	CLS	CLS	1
Timing	-	0/5	0/5
Safety Value	NRM	NRM	NRM
State	0	0	0
Time Delay	-	0/20	-
ASCD Delay	Expired	Expired	Expired
LockOut Value	0	0	0
RunTimer(Sec)	0	0	-

NOTE:Compressor permissible enable if HPState=1,6 or 8 and LPState=1,5,8,9,12,or 13 and COSState=3 and 5

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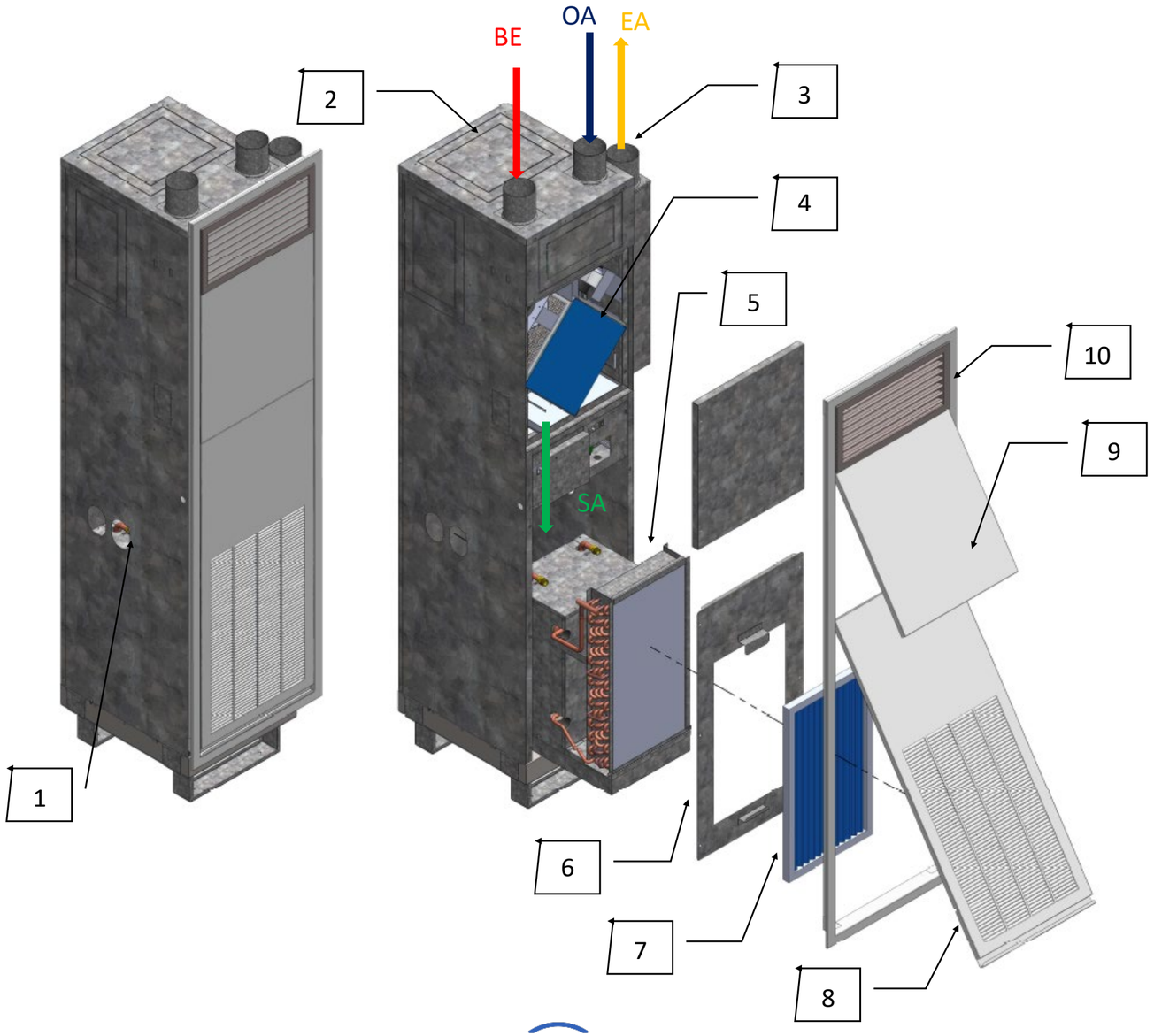
VSHPe Series: with Integrated ERV

Features

- Easy ERV Service Access
- *NEW*High Efficiency Counter Flow Core +80% Sensible@50CFM
- Outdoor Air Damper is Fully Modulating w/ Safety Spring Return
- High Output = Up to 150 CFM @ 0.2” ESP
- ERV frost protection sequence



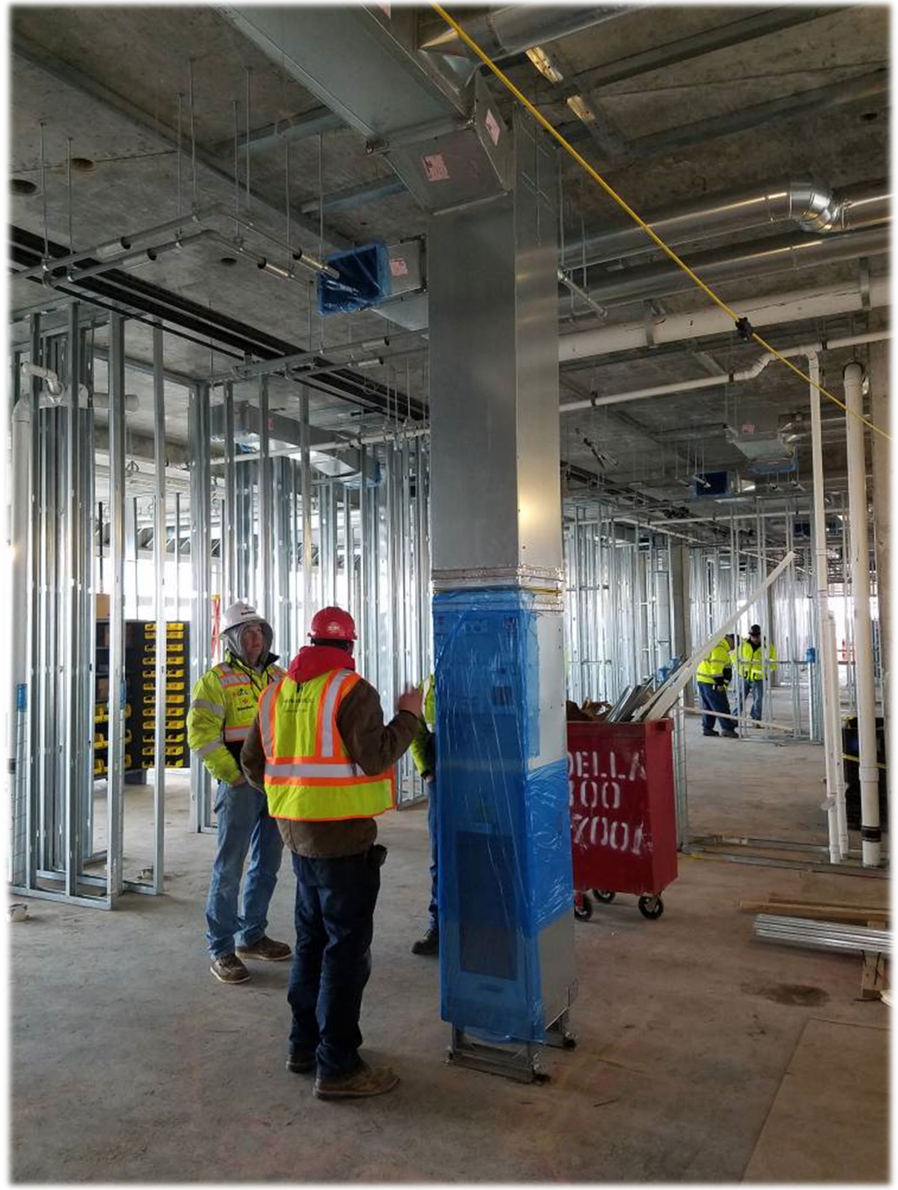
1. Supply, return and condensate riser field “knockouts”.
2. Field “knockout” supply air openings (Front/Back/Side/Top) with 1-1/2” duct flange.
3. ERV Ports—Bathroom Exhaust, Exhaust Air, Outside Air.
4. Removable ERV core.
5. Heat pump chassis.
6. Chassis service cover panel.
7. 1” air filter.
8. Acoustic return air (R/A) panel for chassis, blower and electrical compartments.
9. ERV service panel.
10. Removable optional supply discharge grille panel.

Vertical Stack Heat Pump – Standard & High Efficiency Chassis

2-Tier Efficiency VSHP Offering:

- VSHP (Standard Efficiency - SE)
  - Cost competitive
  - Above AHRI 90.1 Min. Efficiency Standards
    - WLHP: 12.7 – 15.4 EER / 4.7 – 5.2 COP
    - GLHP: 14.4 – 16.9 EER / 3.3 – 3.4 COP
- VSHP (High Efficiency – HE)
  - Typical geothermal application
  - Higher Efficiency chassis above AHRI standards 90.1
    - WLHP: 13.5 – 17.4 EER / 5.1 – 6.0 COP
    - GLHP: 15.4 – 19.7 EER / 3.4 – 3.8 COP

AHRI CERTIFIED®
www.ahridirectory.org
Water Source HP
ANSI/AHRI/ASHRAE/ISO 13256



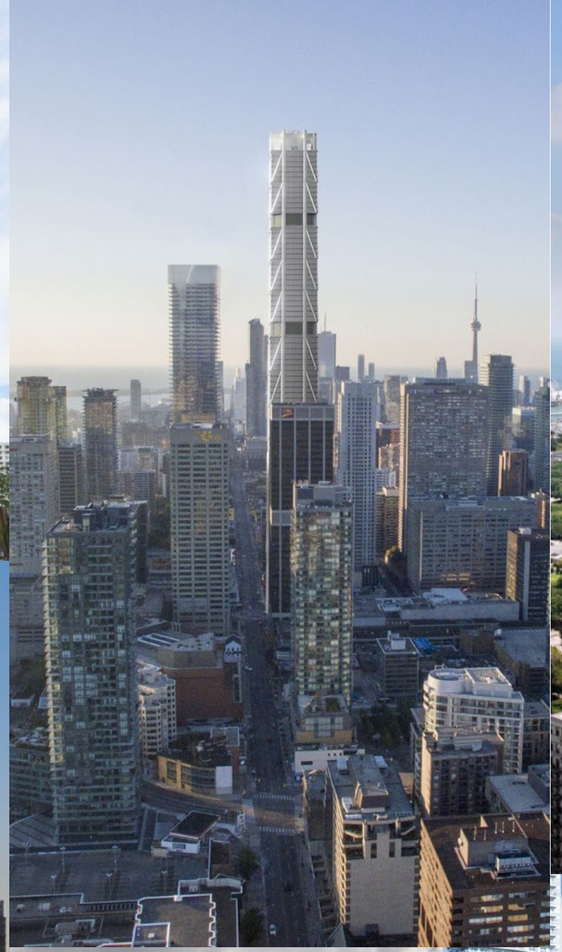
Tested & Certified

In-House Psychrometric Testing Chamber

- Allows for R&D of new products
- Verified performance & 3rd Party Tested
- Real world testing and extreme event Min-Max testing of each Heat Pump operating envelope










Geothermal for High-Rise Buildings: Design Considerations

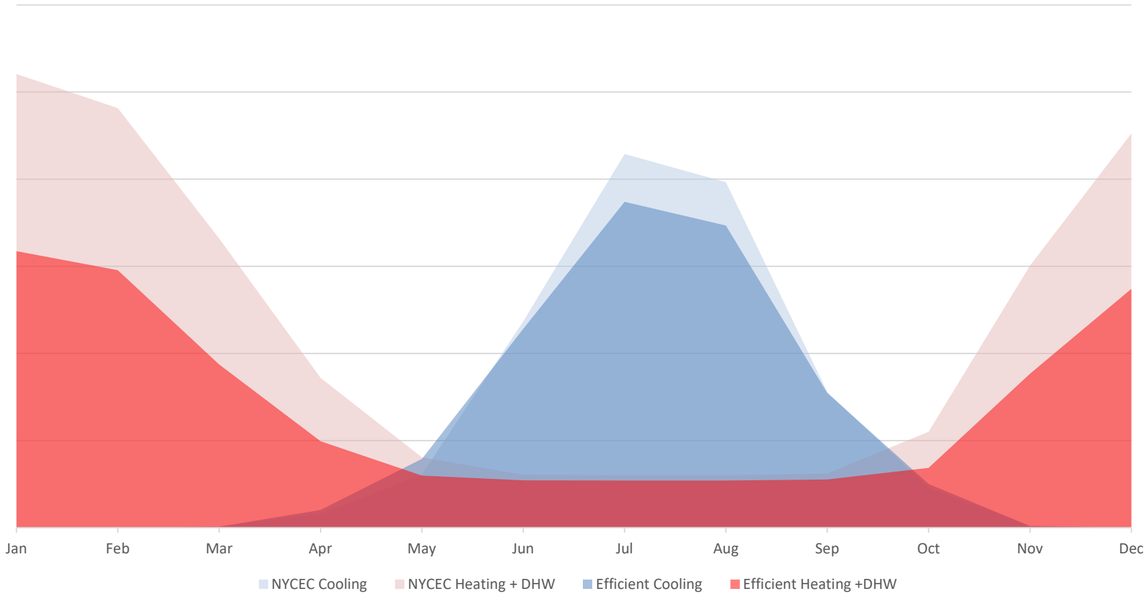
Sam Gerber / *CDM Smith*

Efficiency vs. Thermal Balance

Efficient high-rise buildings tend to have:

- High-performance windows
- Improved insulation
- Low infiltration
- High efficiency ventilation heat recovery
- Efficient water fixtures

These all reduce energy usage and demand, but reduce heating loads more than cooling loads



Heating load goes from 2x cooling to 1.4x with efficiency measures

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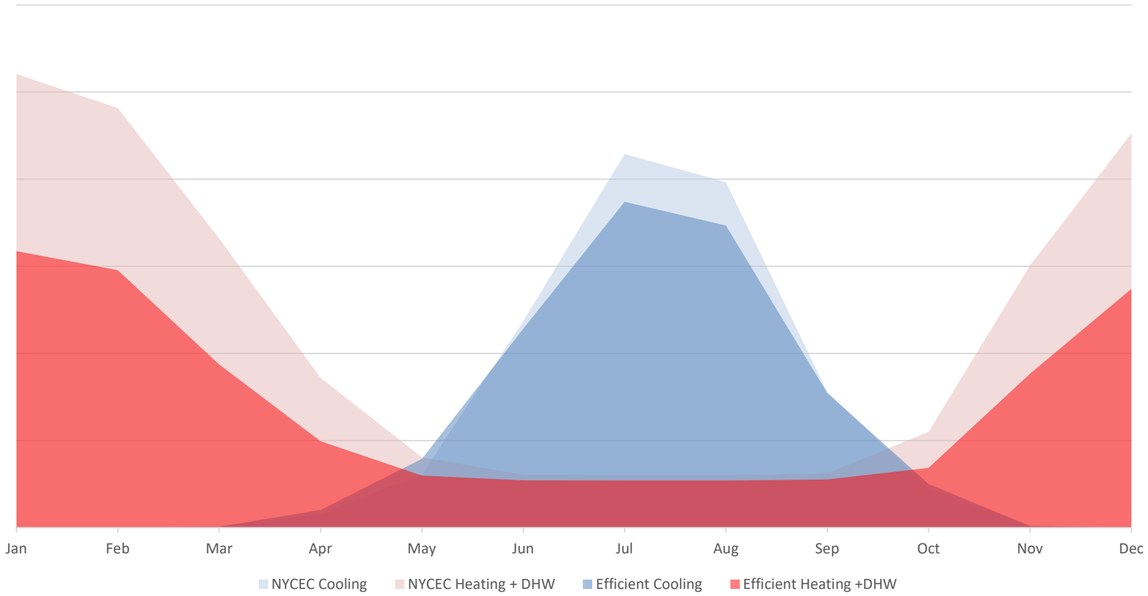
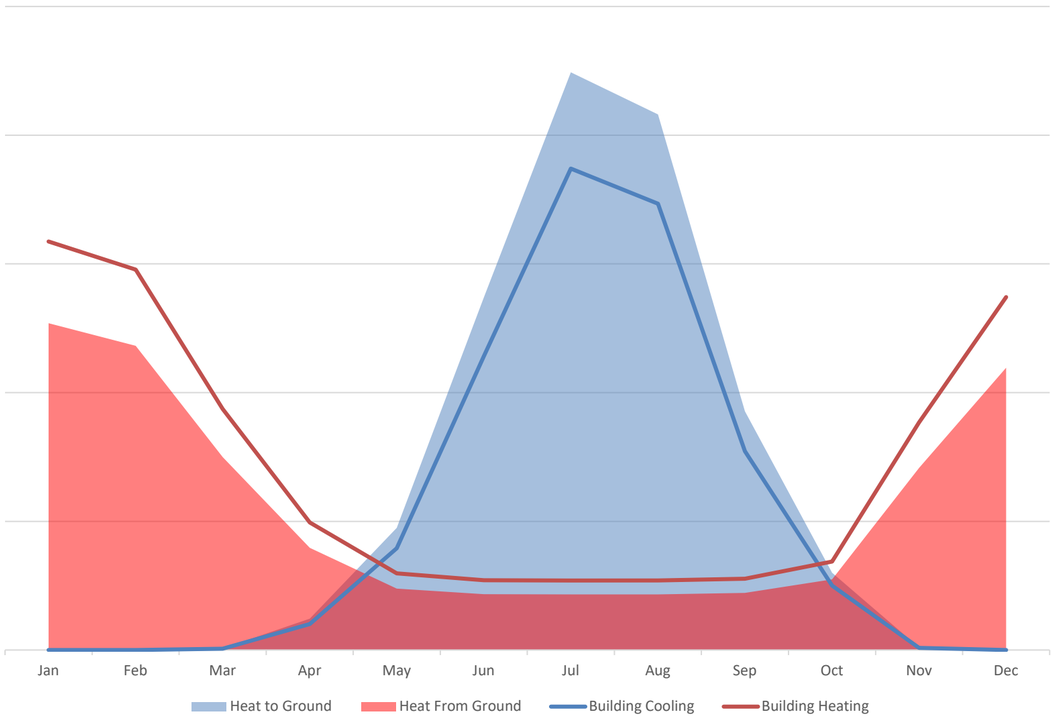


Heating load goes from 2x cooling to 1.4x with efficiency measures

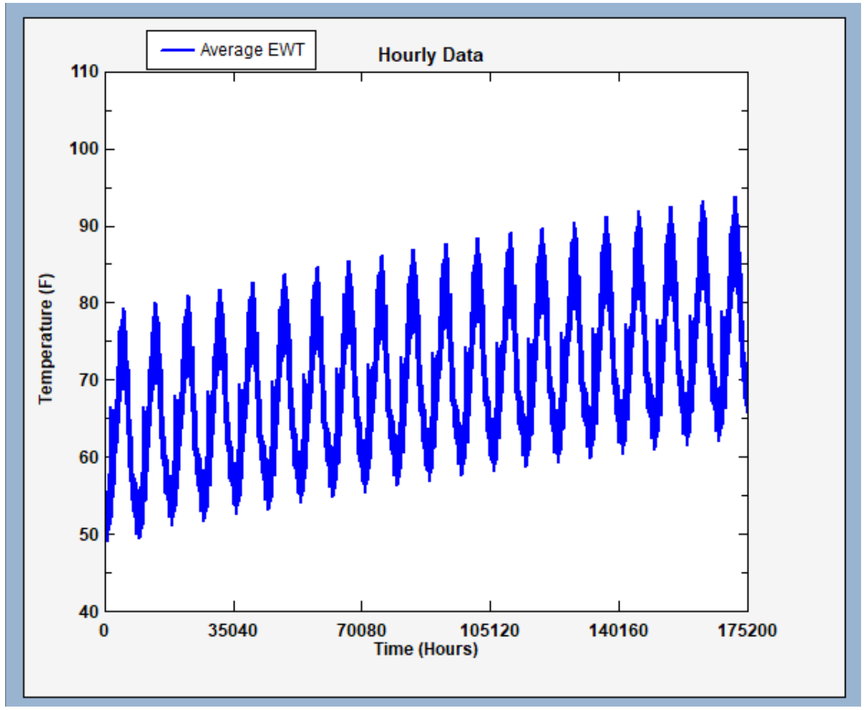
Heat of Compression

- In heating mode, the energy put into the heat pump also serves to heat the space, reducing the heat pulled from the ground
- In cooling mode, the energy put into the heat pump must be rejected to the ground in addition to the building load
- This further tilts the thermal balance towards cooling



Final heat to the ground is 10% less than the heat from the ground

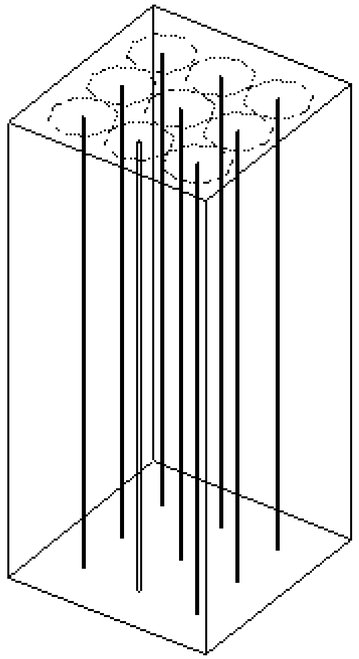
Thermal Imbalance

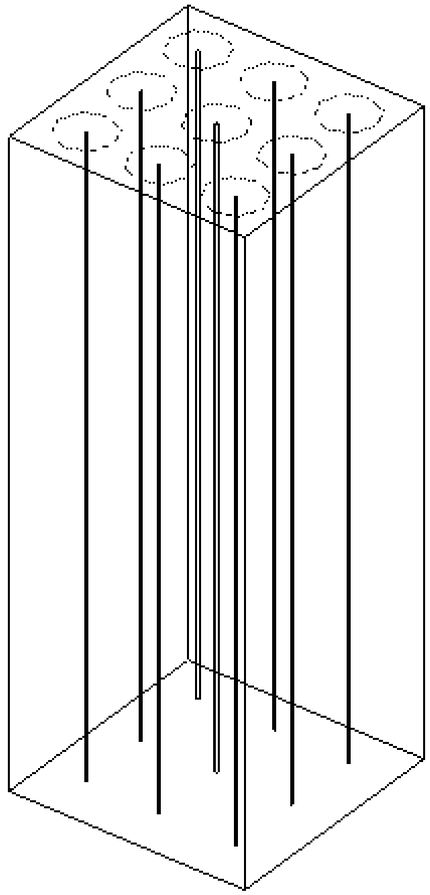


- With more heat put into the ground than taken out, system will experience “Thermal Drift”
- Rising condenser water temperatures reduce efficiency and eventually lock out compressors
- To counter this, excess heat must be removed.

Countering Thermal Imbalance – Expanded Borefields

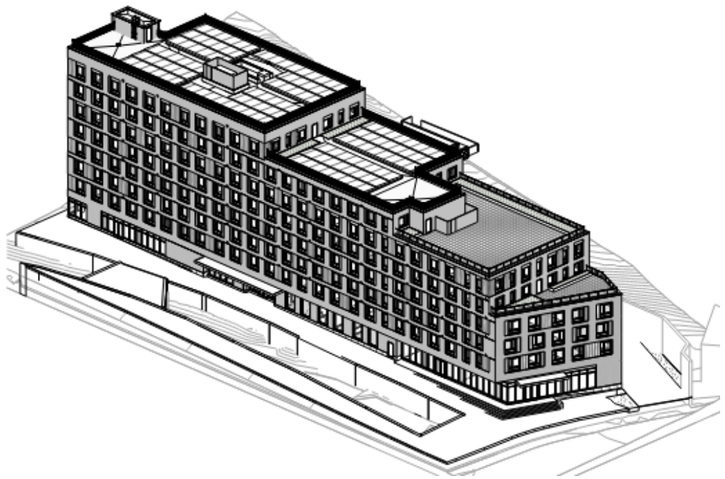
- By increasing the “surface area” of the borefield, more heat is transferred away from the system
- Boreholes can be further spread out or drilled deeper as site constraints permit

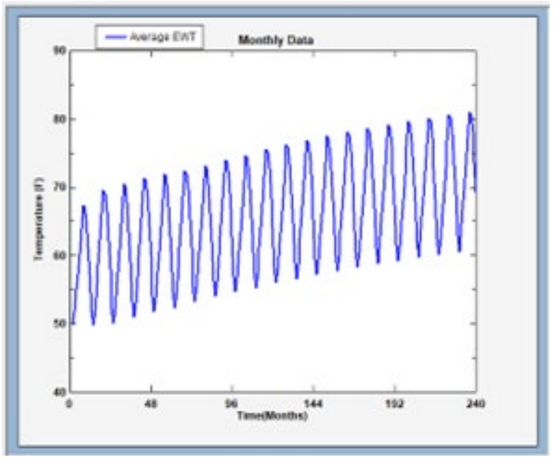




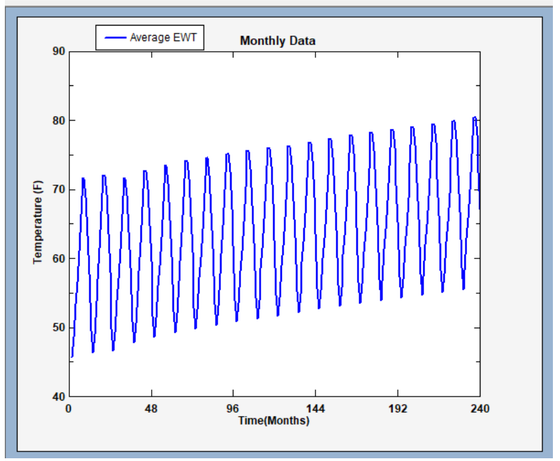
Expanded Borefield – 30 Water St

- Project in Ossining NY, 109 affordable apartment units
- Increasing borehole spacing to 30’ on center and increasing depth from 600’ to 650’ kept temperatures within bounds and reduced the number of boreholes required from 56 to 36





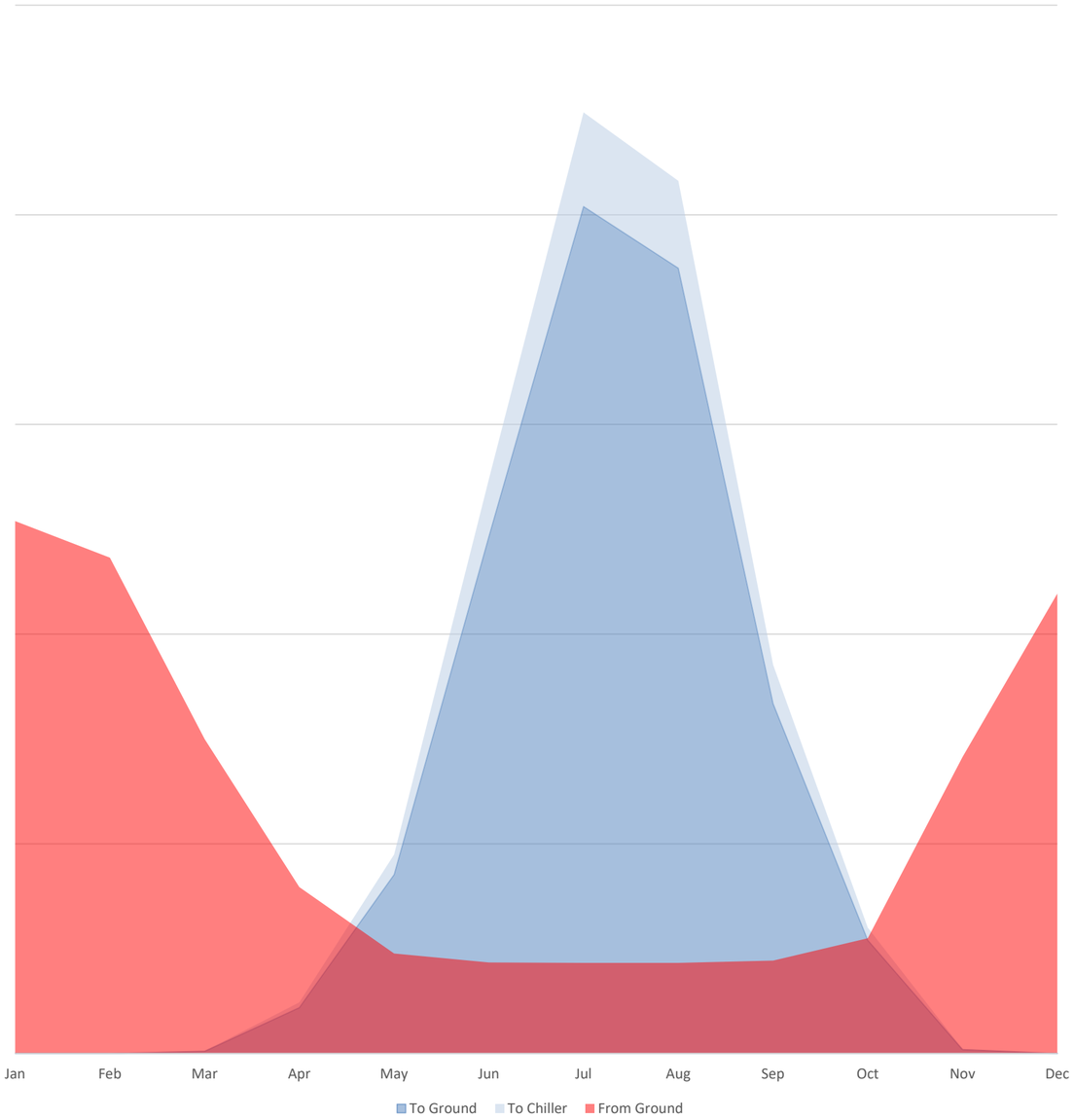
56 boreholes, 600’ depth, 20’ spacing



36 boreholes, 650’ depth, 30’ spacing

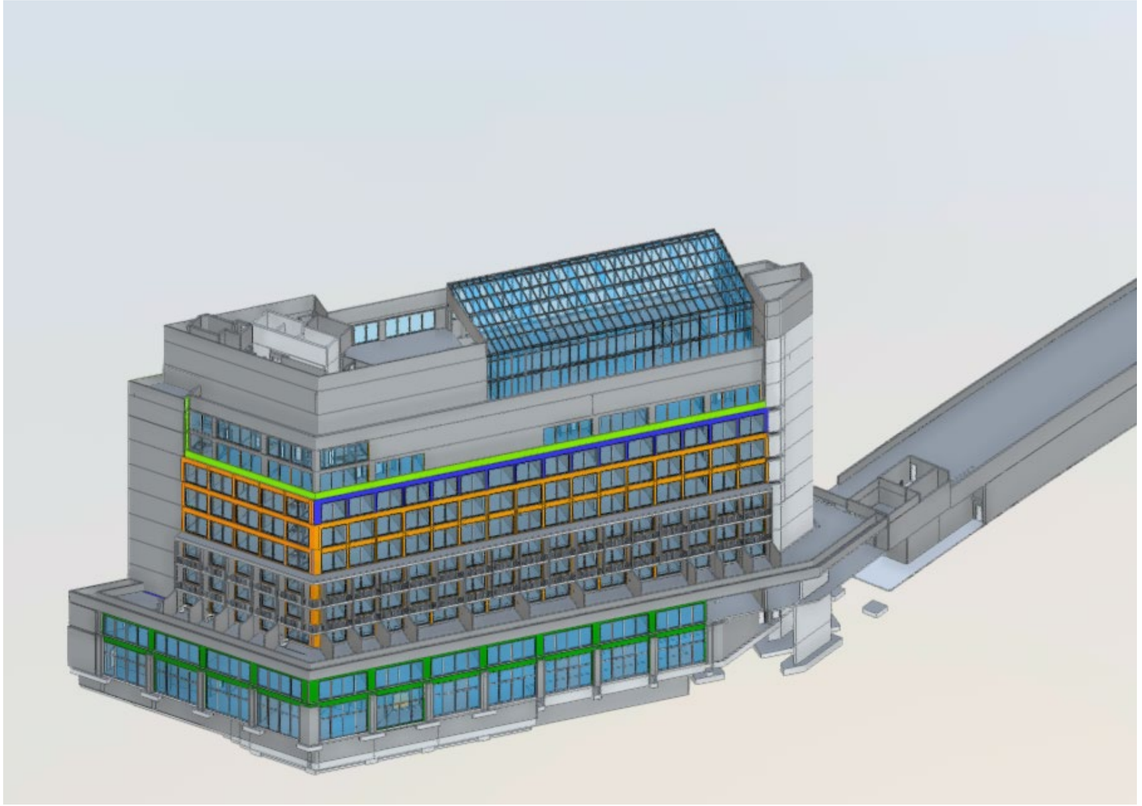
Countering Thermal Imbalance – Hybrid Systems (Peak Operation)

- Borefield can be sized to meet the annual heating load and an equivalent amount of the annual cooling load
- The remainder of the load is met by chillers, sewer heat recovery, or other thermal resources



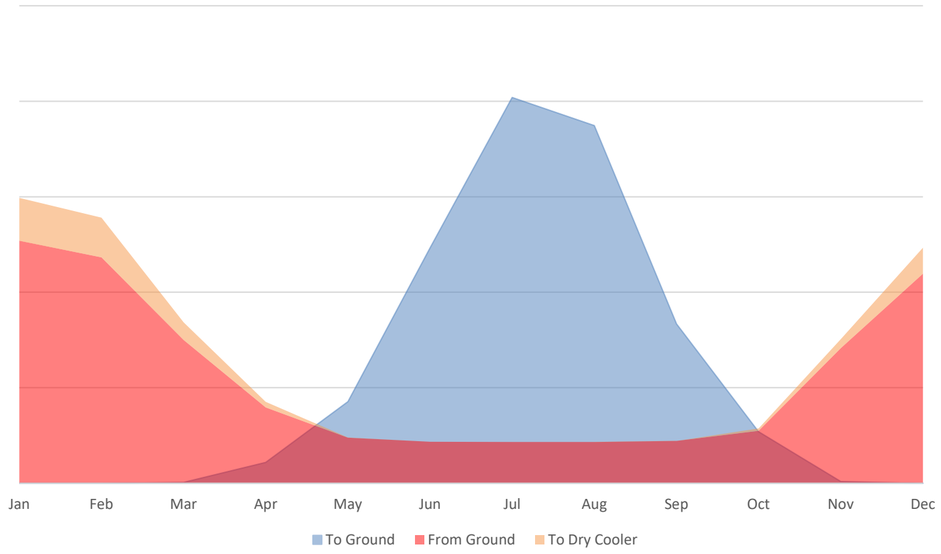
Hybrid System – 25 Stewart Avenue

- 11-Story hotel in Bushwick, limited space for boreholes on site
- System is balanced with 8 air-source reversible chillers that keep condenser loop temperatures in bounds



Countering Thermal Imbalance – Hybrid Systems (Winter Operation)

- As an alternative, heat rejection can be scheduled for colder months
- Increases controls and design complexity, but is generally more efficient



Hybrid System – 1515 Surf Avenue

- 26- and 16-story towers with 461 total apartment units, completed in 2024
- Dry cooler located on the roof of the building operates when temperature differential between condenser water and outdoor air is optimal
- BTUs from and to the ground are tracked and totalized to determine the total dry cooler run hours required during the year.

Options Analysis

	Expanded Borefield	Hybrid System – Peaking	Hybrid System - Winter
Capital Cost			
Operating Cost			
Schedule Impact			
Control Complexity			
Rebate/Incentive Impact			
Footprint (Below Grade)			
Footprint (Above Grade)			

Geothermal for High-Rise Buildings: Design Considerations

Moderator: Colin Rojas / Con Edison

Speakers: Sam Gerber / CDM Smith
Brian Urlaub / Salas O'Brien
Jason Eitel / EJS New York