

# CO2 Heat Pump Water Heating in Multifamily Buildings



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**ACEEE Hot Water Forum**  
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# Presentation Objectives

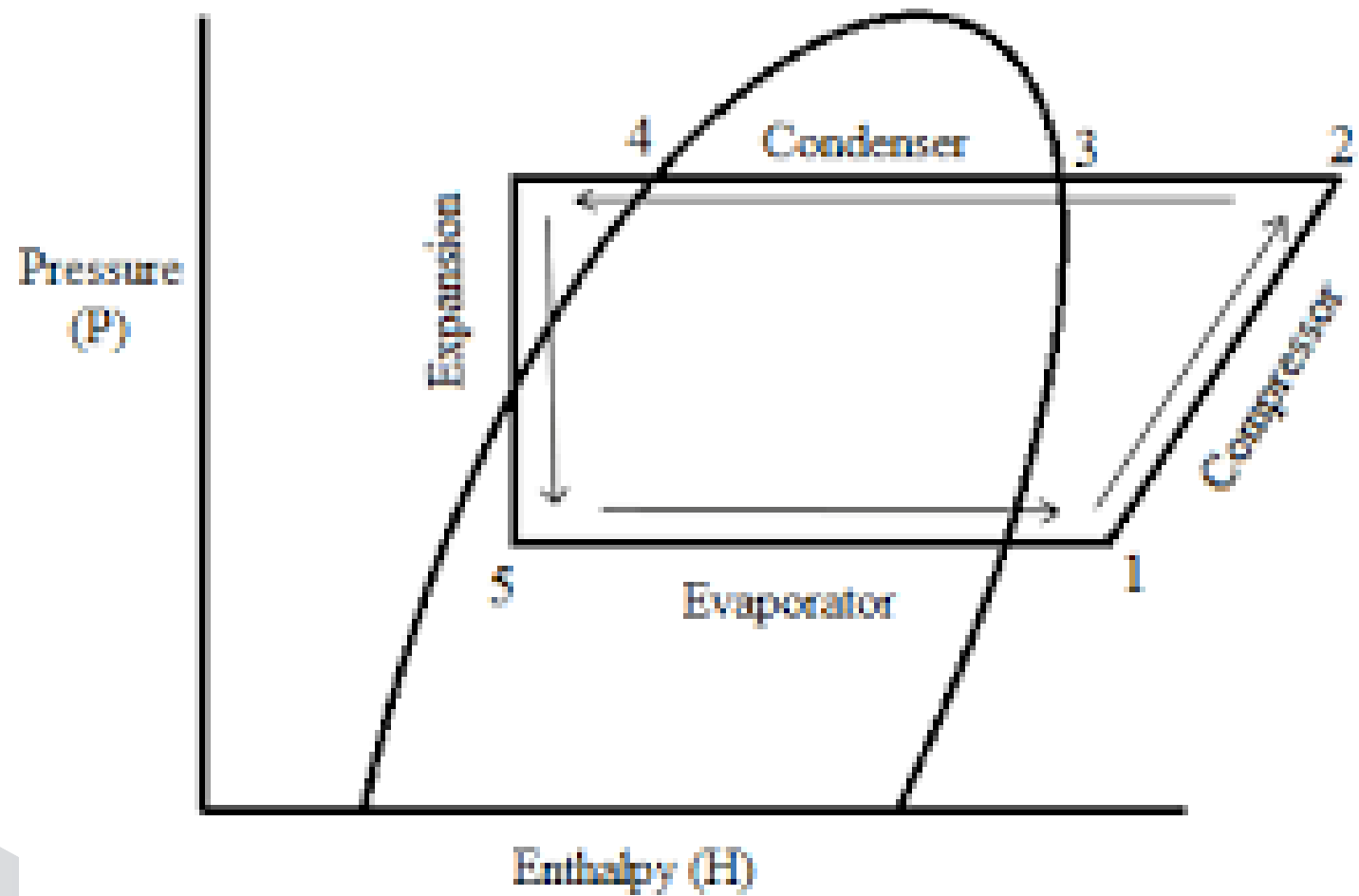
- A Few Fundamentals for Heat Pump Water Heaters
- CO<sub>2</sub>-Specific Design Challenges
- Case Study Applications

# Global Warming Potential

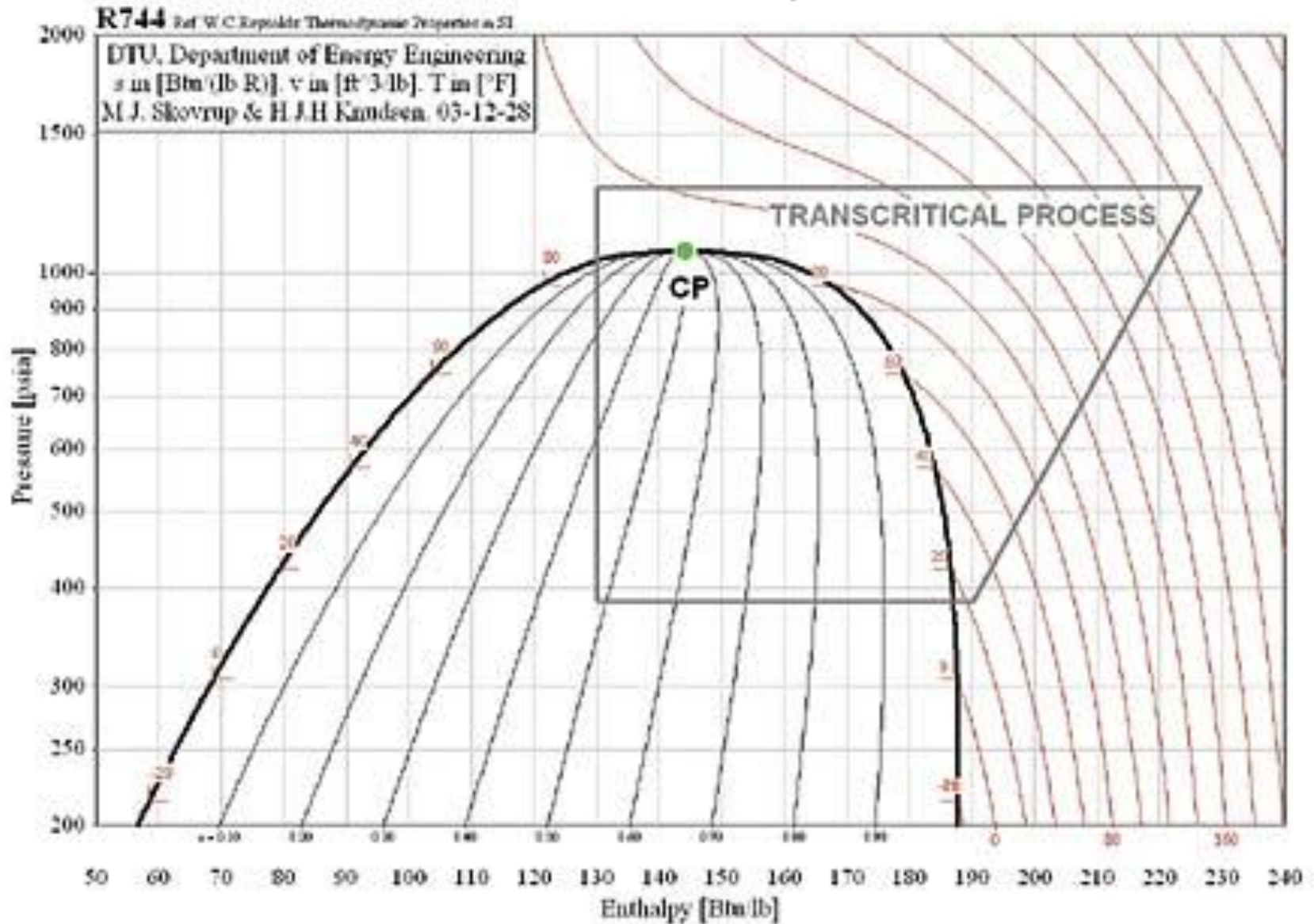
Refrigerant	GWP
CO2	1
R134a	1430
R410a	2100

- Refrigerants have ~10% of the Climate-Forcing Impact of CO2 Emissions
- Eventual Phase-out of Traditional Refrigerants

# Sub-Critical Vapor Compression Cycle

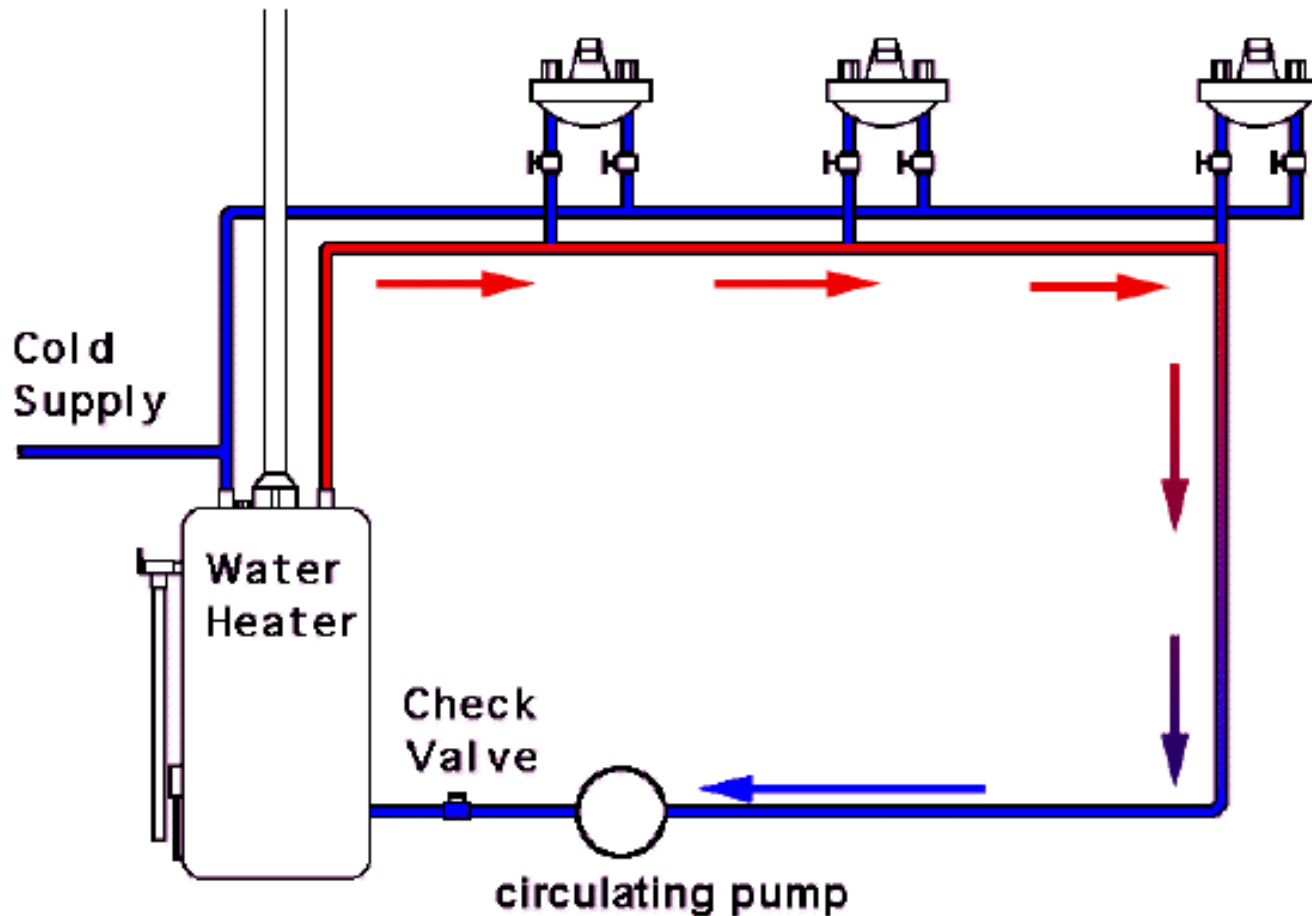


# Transcritical Cycle



# Hot Water Maintenance

Traditional type hot water circulating system.



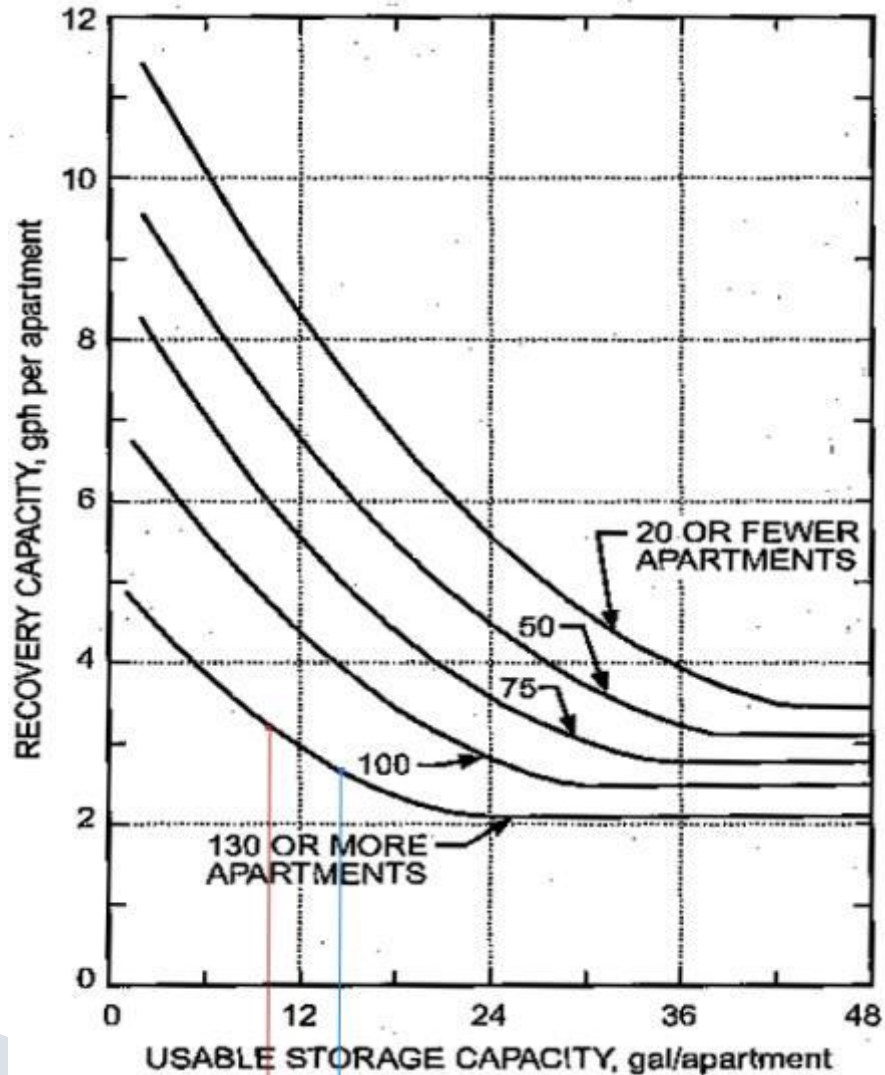
# Hot Water Maintenance

- 30-45% of thermal energy lost in Recirculation/Distribution
- Super-insulate Hot Water Distribution Pipes
- Separate R410a Recirculated water heater  
OR  
Electric Heat Trace – no Recirculation



# Capacity vs. Storage

## Older ASHRAE Applications Handbook



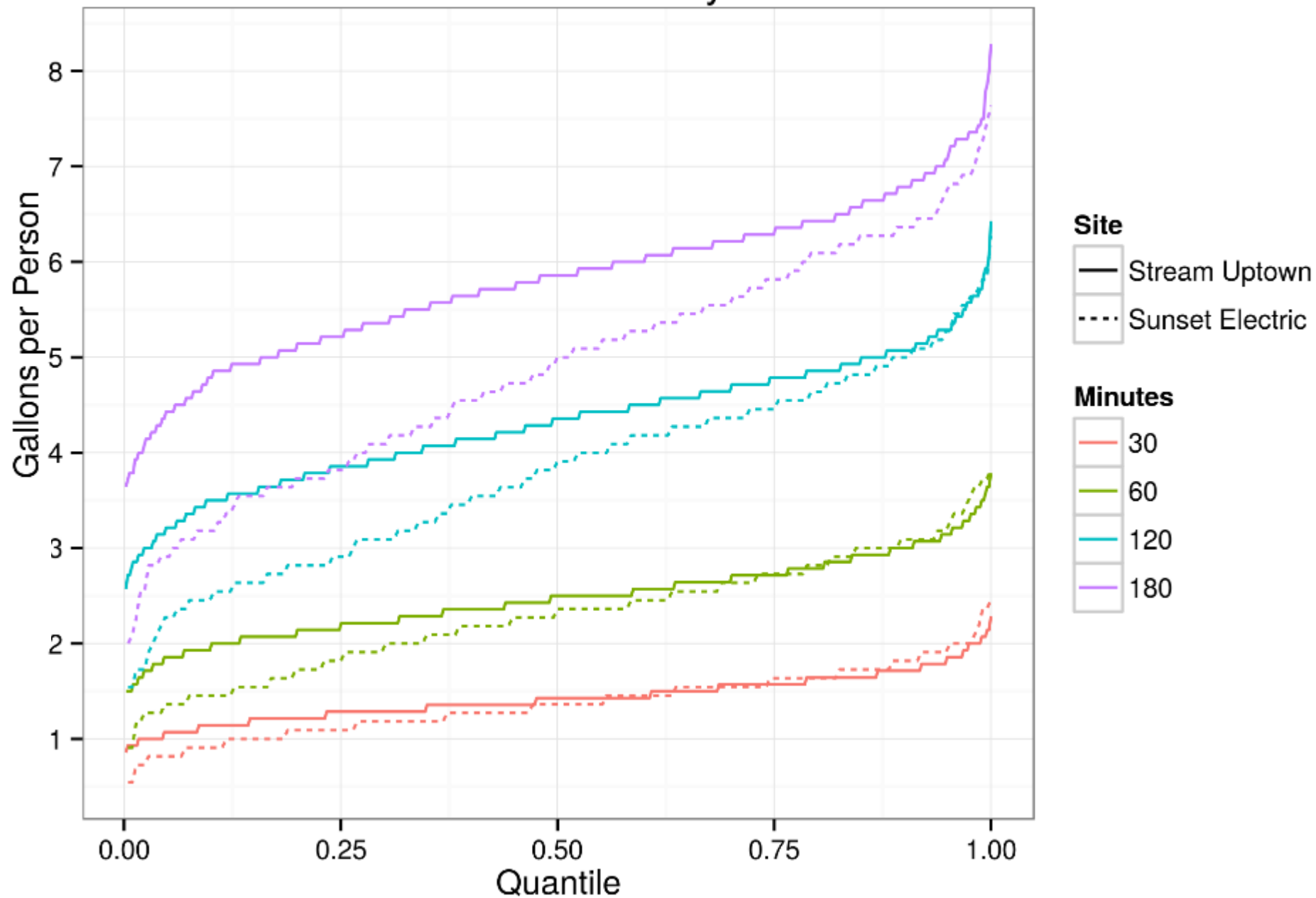


# 2015 ASHRAE HVAC Applications

## Chapter 50, "More Accurate Method"

Low	"More Accurate Method"		
	Minutes	Gal/person	Total Gal.
5	0.4	185	28
15	1	462	22
30	1.7	785	17
60	2.8	1294	13
120	4.5	2079	12
180	6.1	2818	7
1440	20	9240	6

# Distribution of Observed Daily Peak Flow



## Multi-Pass vs. Single-Pass

- Multi-Pass: Constant Flow, Constant Output = Variable Temperature
- Single-Pass: Variable Flow or Variable Output Capacity = Fixed Delivery Temperature

# Residential Scale Product

- ~15,000Btu/Hr
- Single-Pass
- Potable Water
- High Temperature Storage (150F)



# High Temperature Storage

- Single Pass delivers 150F to top of tank.
- Effectively increases storage capacity by ~40%.
- Eliminates any Legionella concerns.
- Highly stratified storage allows for high efficiencies.
- **NO RECIRCULATION ALLOWED**

## Small Capacity + Large Storage

- 10 Apartments w/ 15 People
- 300 Gal. of 120F per Day (210 Gal. of 150F)
- Average load of 7300BtuH (50% duty cycle)
- Single Sanden w/ 200 Gal. Storage

# Defrost?



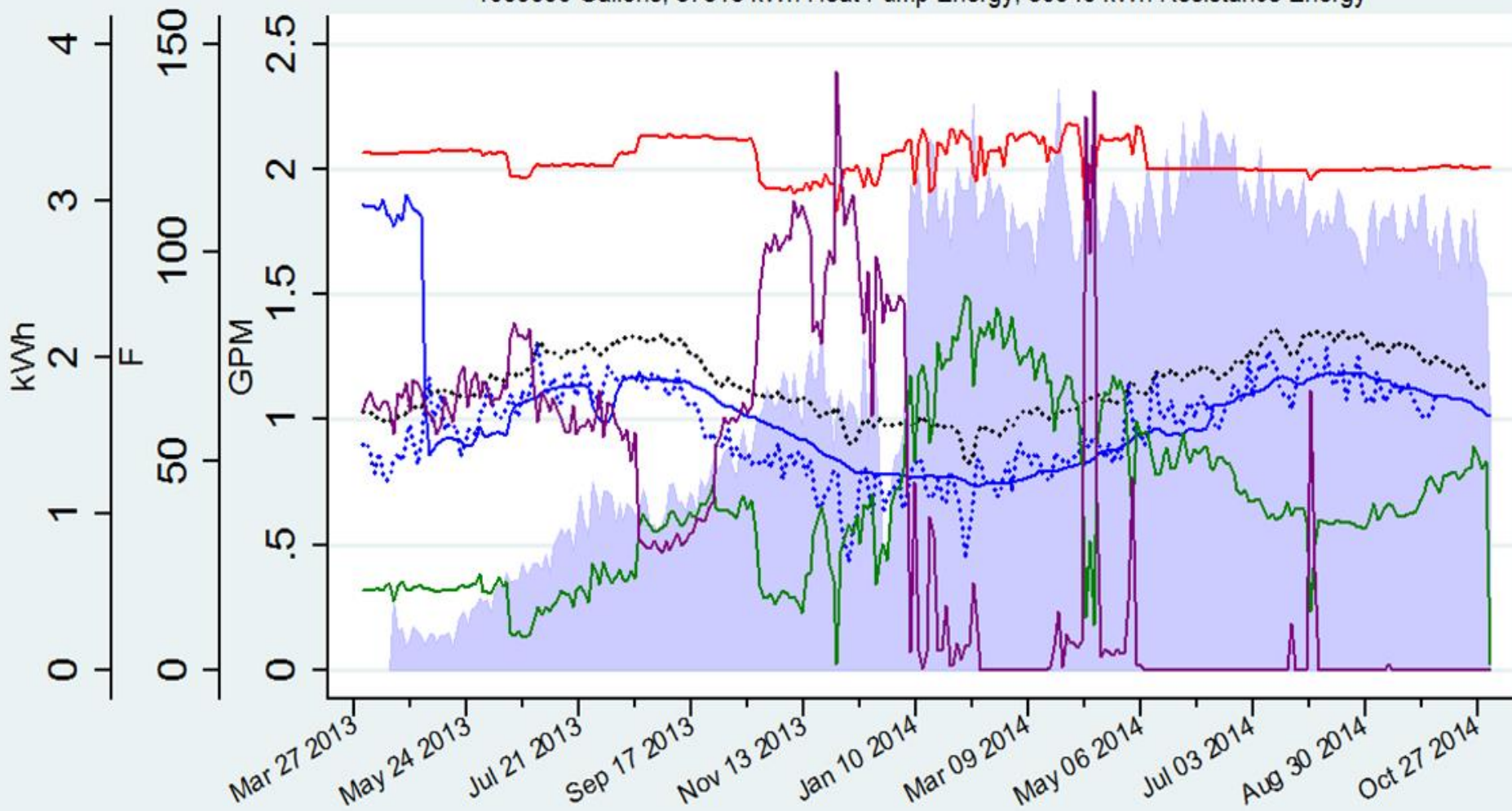
# Freeze Protection



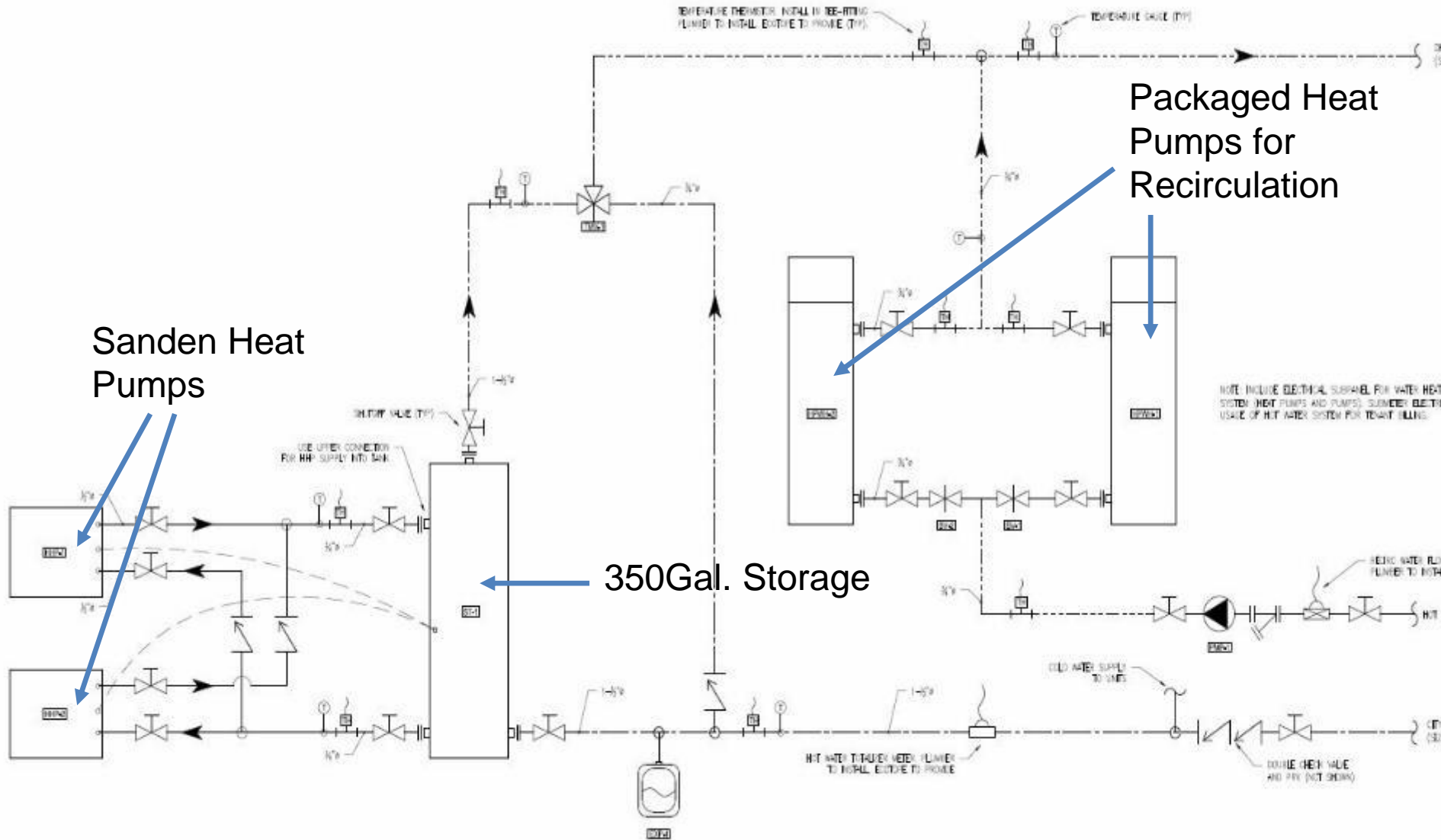


580 days starting from April 1, 2013

1059590 Gallons, 87818 kWh Heat Pump Energy, 80945 kWh Resistance Energy

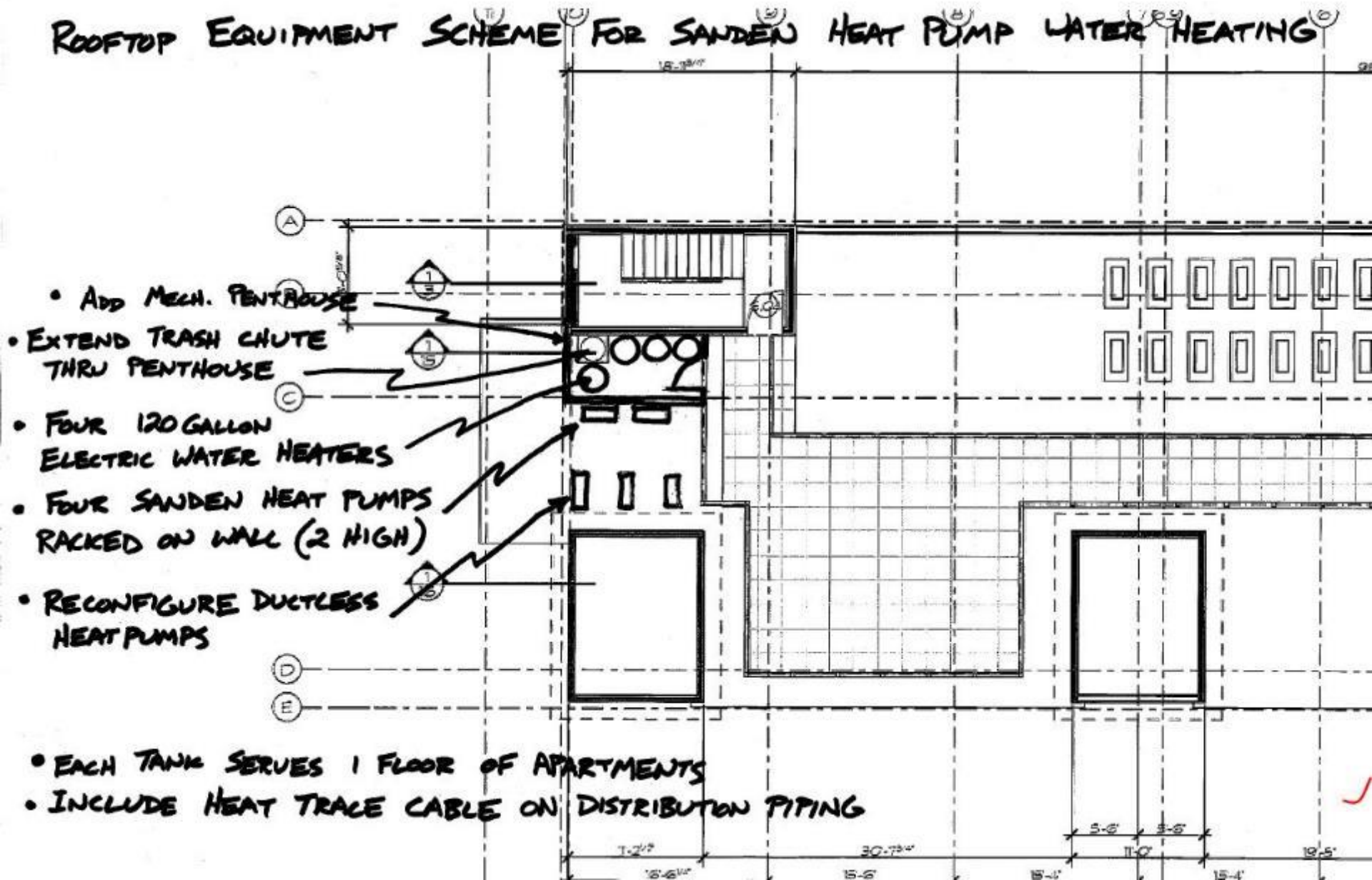


# 18-Unit Case Study: Central System



# 36-Unit Case Study: Floor-by-Floor

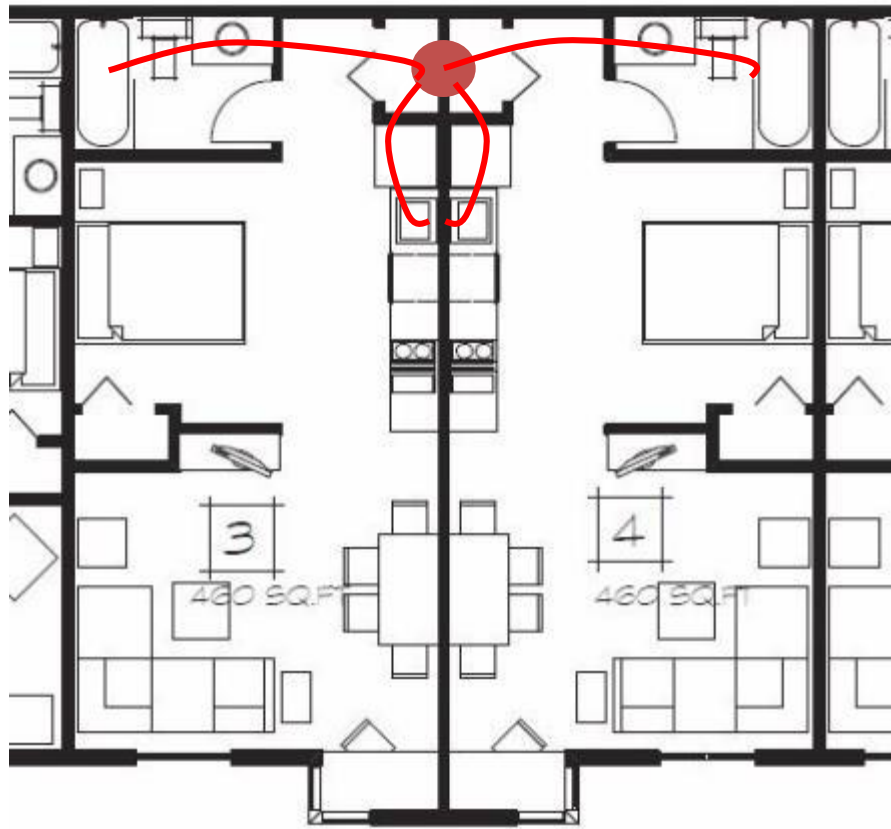
## ROOFTOP EQUIPMENT SCHEME FOR SANDEN HEAT PUMP WATER HEATING



- Add MECH. PENTHOUSE
- EXTEND TRASH CHUTE THRU PENTHOUSE
- FOUR 120 GALLON ELECTRIC WATER HEATERS
- FOUR SANDEN HEAT PUMPS RACKED ON WALL (2 HIGH)
- RECONFIGURE DUCTLESS HEAT PUMPS

- EACH TANK SERVES 1 FLOOR OF APARTMENTS
- INCLUDE HEAT TRACE CABLE ON DISTRIBUTION PIPING

# 70-Unit Case Study: Distributed Stacks



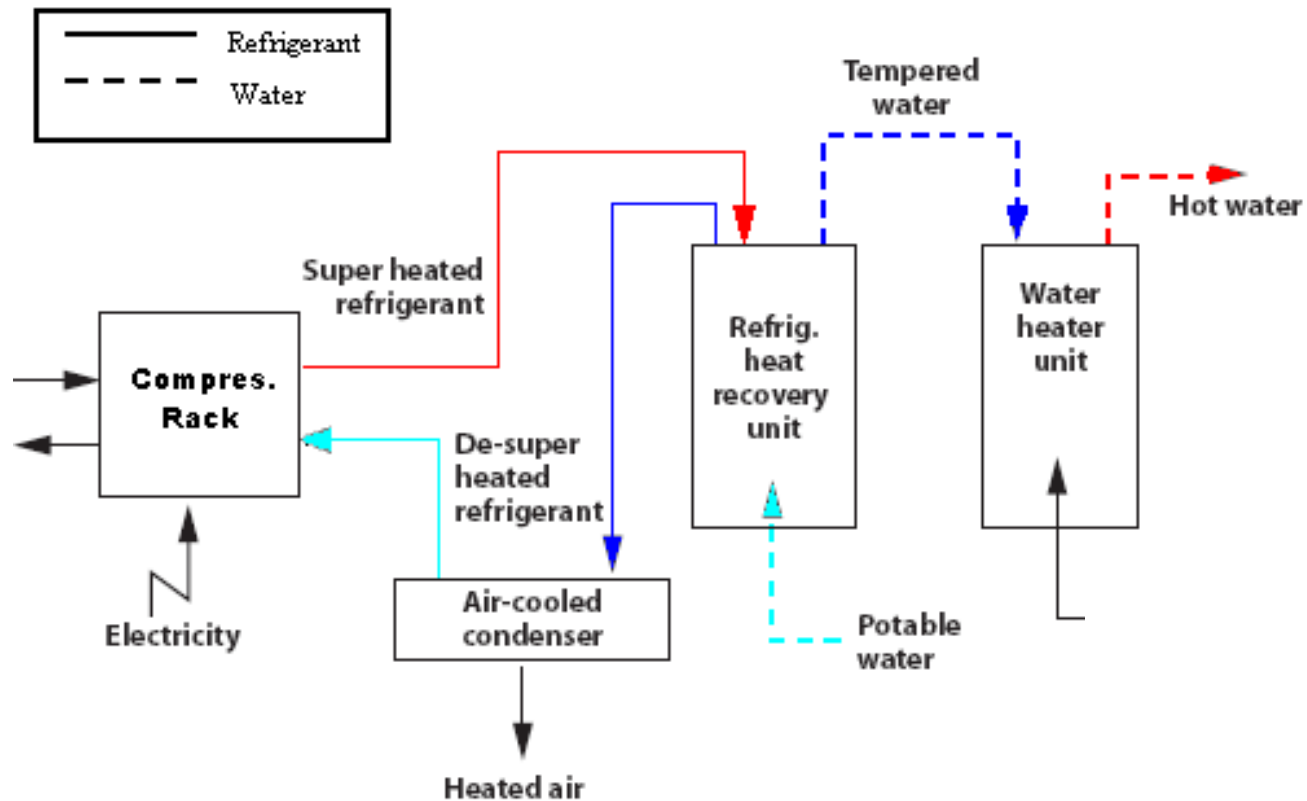
# Commercial CO2 Equipment



# 400-Unit Case Study: Grocery Store



# Heat Recovery Chiller Application

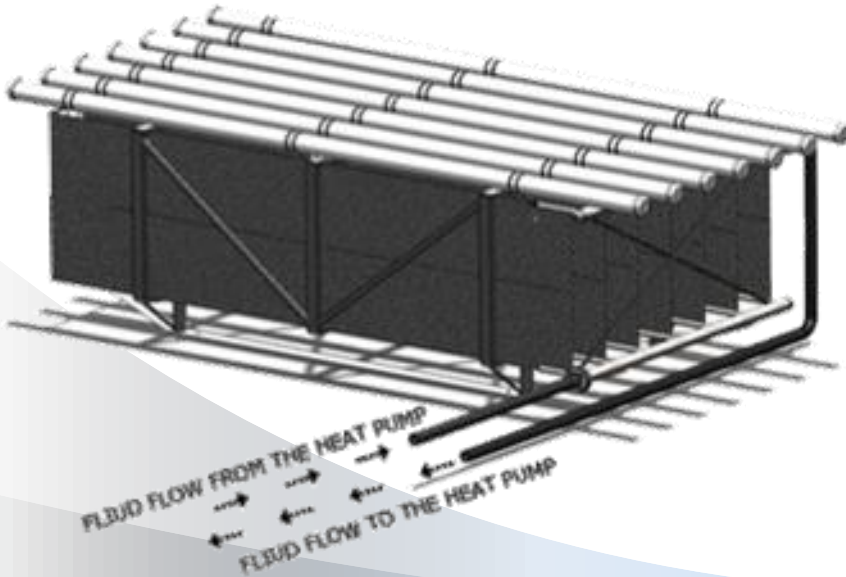
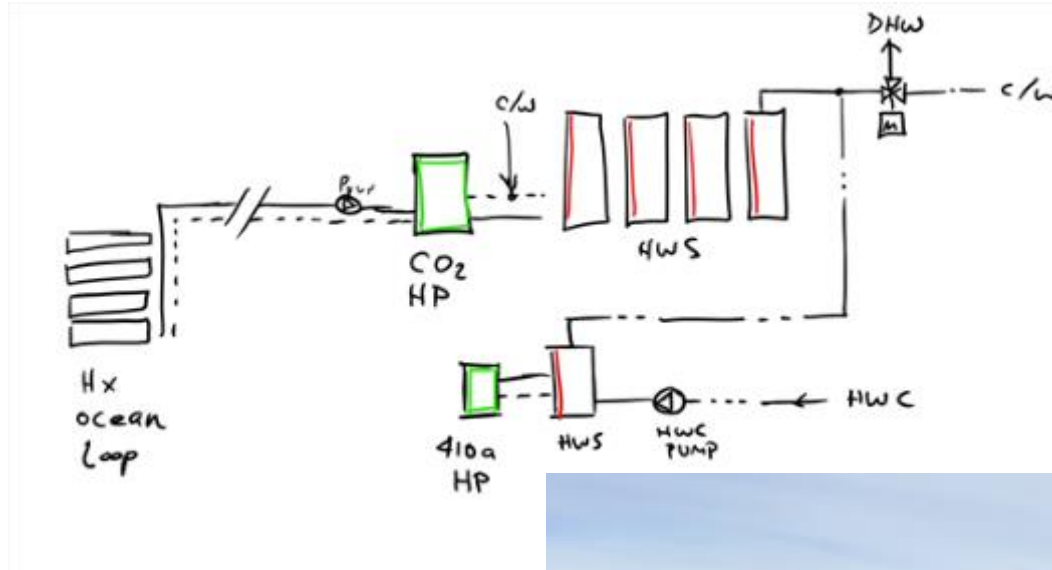


# 260-Unit Case Study: Ocean Source





# Closed Loop w/ Heat Exchangers



**Questions?**

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