THE PATH TO DECARBONIZATION – DOMESTIC HOT WATER ASHP

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Introducing a Daikin All-Electric
Heat Pump Hot Water Generation system

Mega-Q

DAIKIN

The Basics – Mega-Q for DHW

- High efficiency Inverter Air cooled HP
- R410A Refrigerant

- Cascade Unit - Refrigerant to water
- Built-in variable capacity water pump

- Tank control kit
- Connect up to 6 MEGA Q systems to 1 water loop.

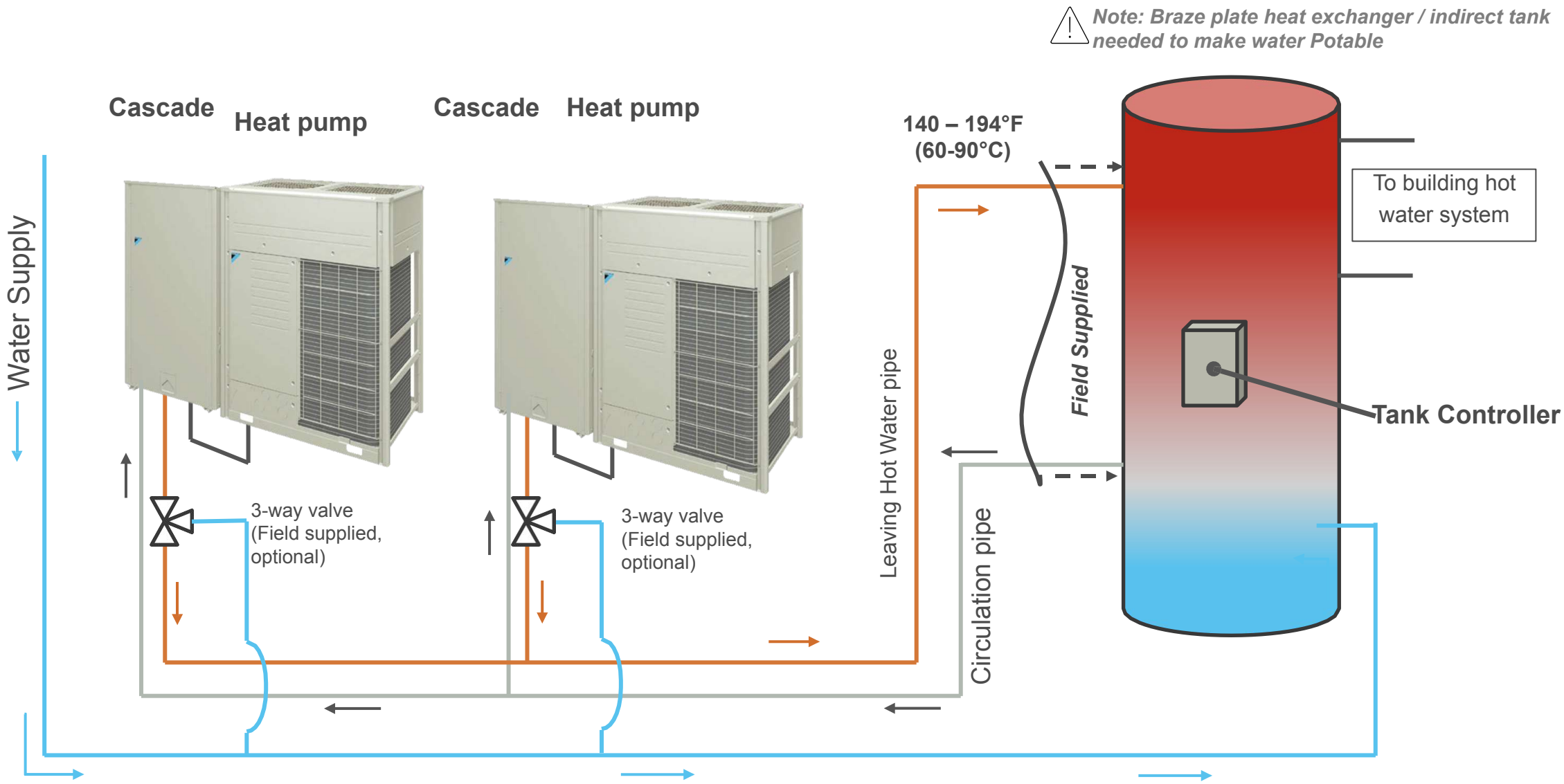
Mega-Q Specification

- Variable capacity system to adapt to changing water demand
  - H/P unit contains inverter compressors & inverter outdoor fans
  - Cascade unit contains inverter water pumps
- Specific control logic to optimize performance for small or large water heating loads
- High heating performance down to -4F
- COP's of up to 4.6, part load COP greater than 6
- High supply temperatures of up to 194F
- Low sound levels <60dBA
- Split systems allows for installation flexibility with components inside or outside

MEGA Q Specification	
Nominal Capacity MBH	120
Capacity @14F	94%*
Capacity @5F	87%*
Ambient HP Temp Range	-4F to 109F
Supply Temp Range	140 to 194F
Inlet Water Temp Range	41 to 176F
Max Water Pressure	72.5psi
Sound Pressure	<60dBA
Split System	Yes
Max Pipe Length	65ft
***based on 41F EWT, 149F LWT**	

DAIKIN AIR INTELLIGENCE

Typical layout



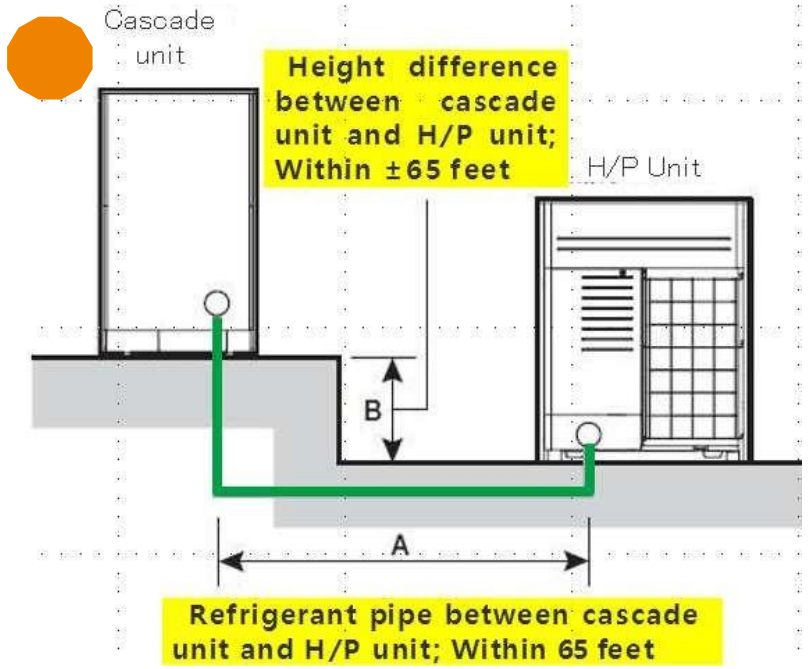
Installation Flexibility

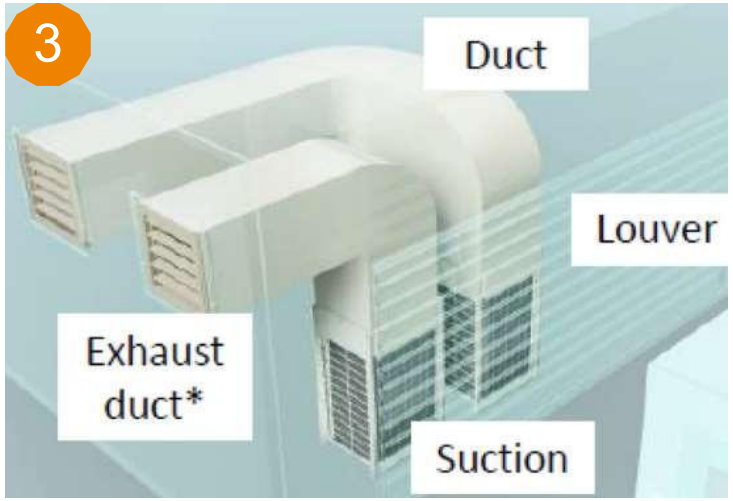
3 installation patterns

1. The H/P unit & cascade unit installed outside side by side

2. The cascade unit can be installed up to 65ft away. This includes the cascade unit being moved indoors

3. Both the H/P unit & cascade unit installed inside. Note that the H/P unit would need to be ducted to the outside





Split System design

Cascade - Indoors

HP Source - Outdoor

Tank - Indoors

Refrigerant piping

Hydronic Piping

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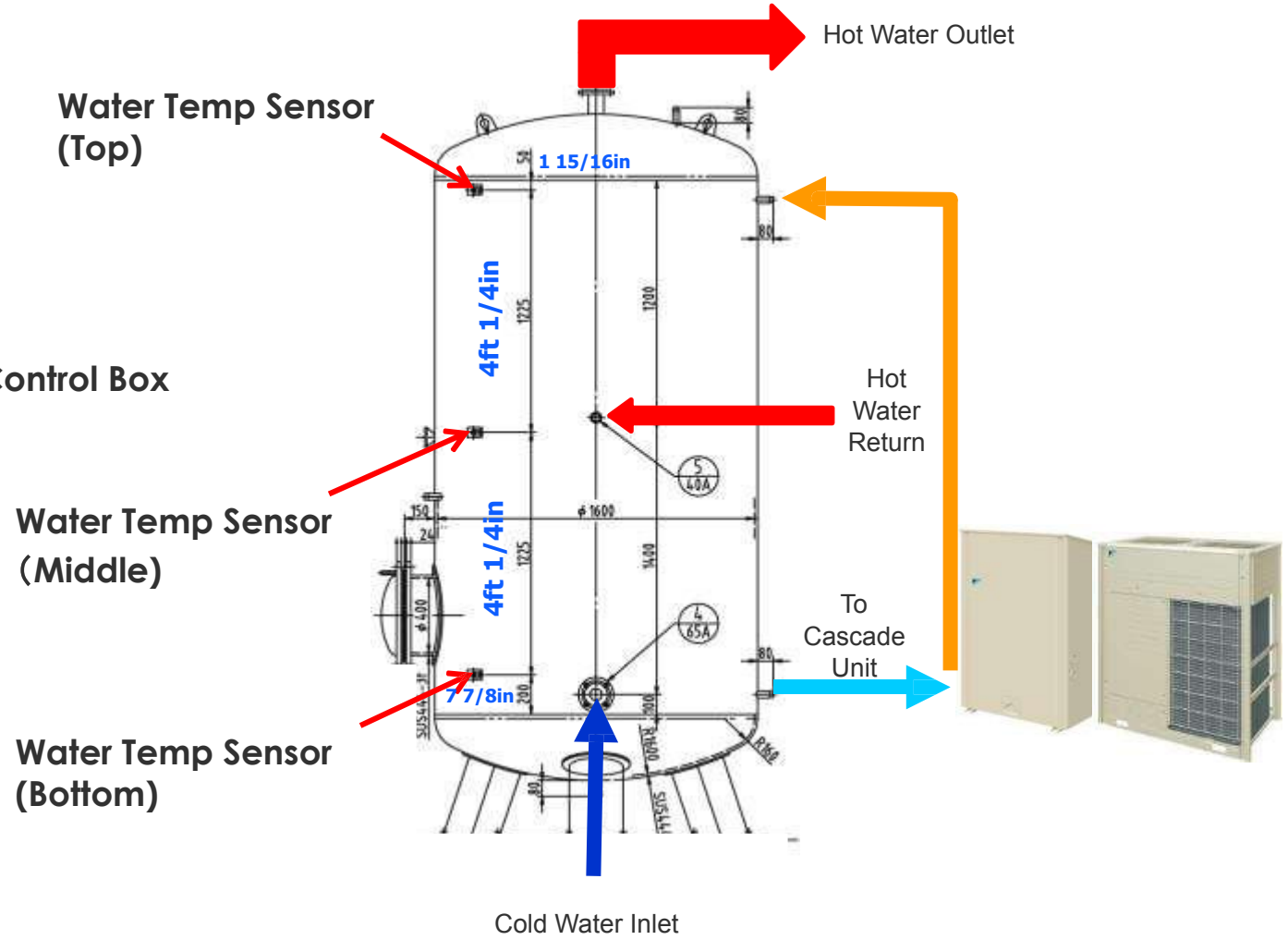
DHW Control & Tank Sensor Kit

- Tank Sensor Kit attached on-site
- 3 temperature sensors control the HP unit operation



MEGA Q

- Mega Q is a tried and tested Daikin solution used in overseas market for several years
- Now adapted for the North American region and combined it with HP units assembled in USA (Texas)

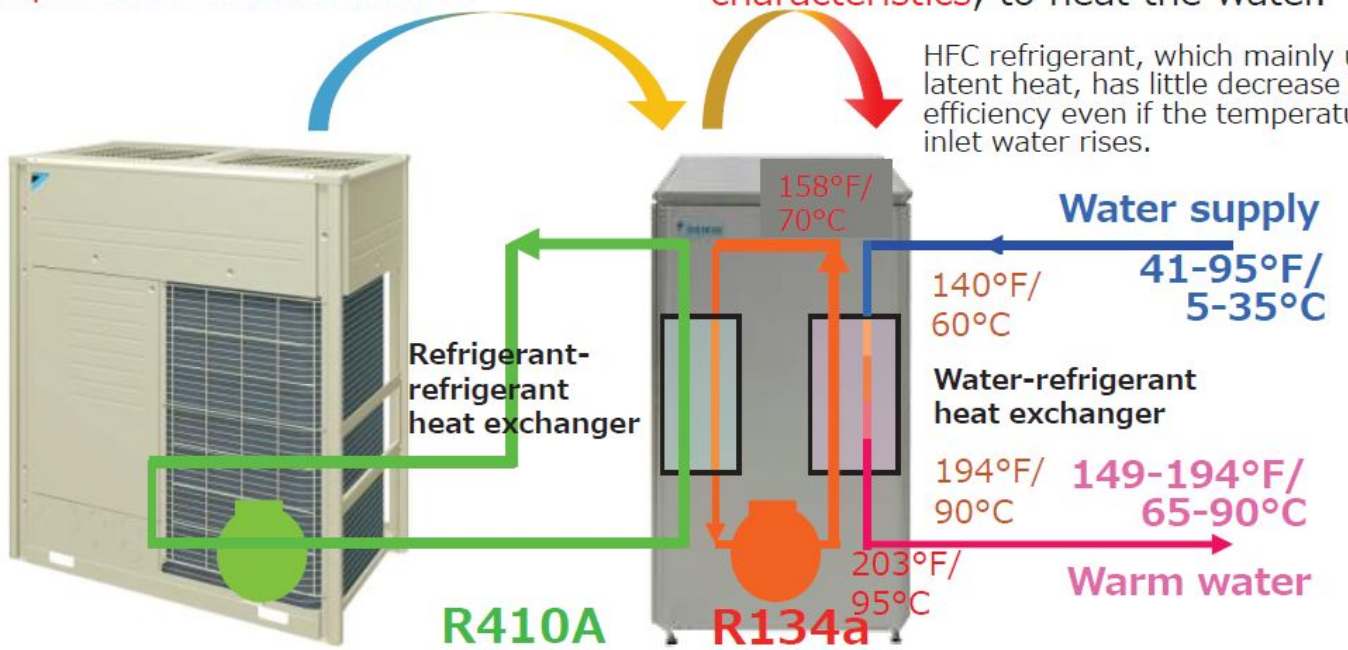
Cascade System Operation

Characteristics of refrigerants for hot water supply (HFC)

・Q has a two-source refrigerant cycle that combines two heat pump cycles.

Collects heat from the air with R410A, which has excellent low-temperature characteristics

The collected heat is further heated by R134a, which has excellent high-temperature characteristics, to heat the water.

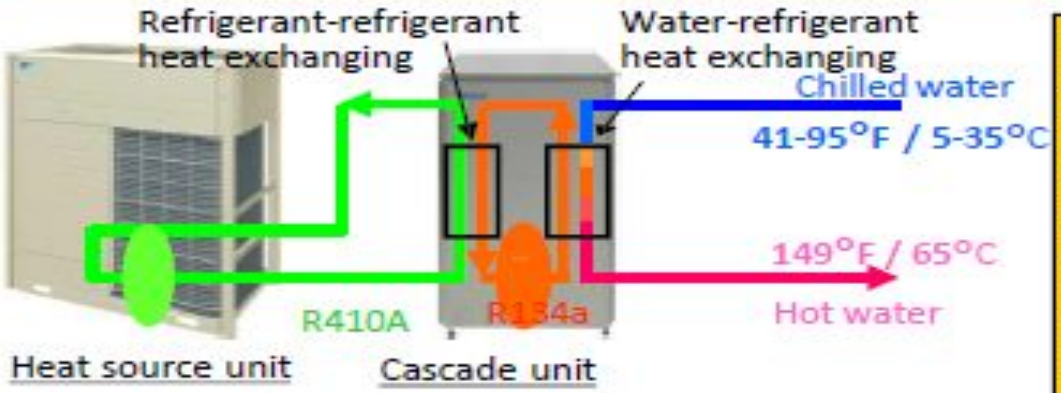


High efficiency, high capacity, and high hot water tapping temperature are realized by adopting a two-source refrigerant circuit (cascade)

Two types of refrigerants (two-source system) enable high-capacity operation and high-temperature hot water tapping even the outdoor temperature is low.

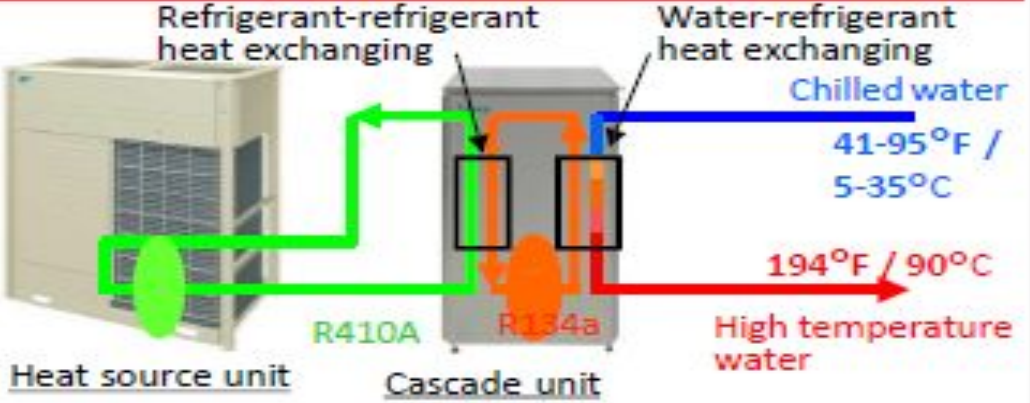
A Model (149°F/65°C: default) B Model(140-194°F / 60-90°C)

Hot water storage operation (hot water tapping at 149°F / 65°C)

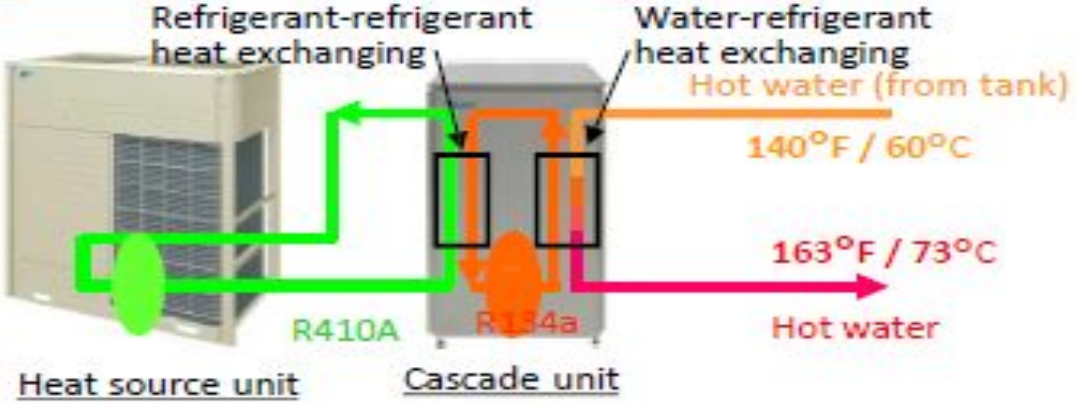


If the temperature of hot water in the tank drops during hot water storage operation, it is switched to high temperature hot water tapping. Operation flow is described in the Service Manual.

Hot water storage operation (hot water tapping at 194°F / 90°C)



Heat retention operation (140-163°F / 60-73°C)



A two-source refrigerant circuit with two types of refrigerant (low-temperature side R410A, high-temperature side R134a) demonstrates high efficiency in both hot water storage and heat retention.

☐Hot water storage operation (140-194°F / 60-90° C, set in 1°C increments)

- Hot water for general hot water supply (149°F / 65°C) is tapped with high efficiency of COP: 4.0
- Even with HFC (R134a), hot water is tapped at a high temperature (194°F / 90°C) equivalent to that of CO2 refrigerant.
  * Can also be used for factory process applications

☐Hot water storage tank heat retention operation

(no reheating unit or electric heater required)

- Reheats heat loss from the hot water storage tank and circulation pipes
- Highly efficient heat retention operation with COP: 3.0 realized by HFC refrigerant

  * Operable down to -4°F / -20°C outdoor temperature

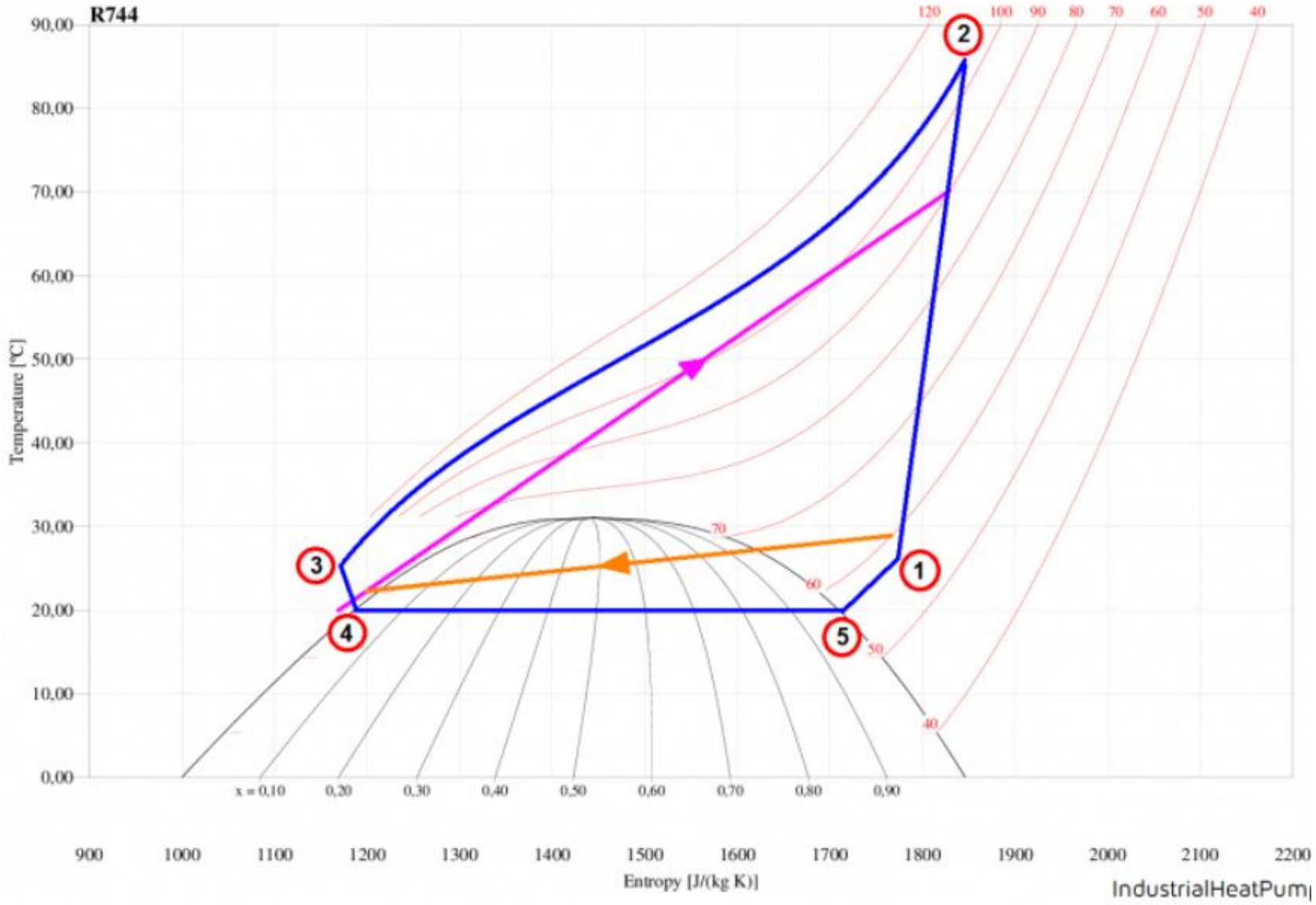
DOMESTIC HOT WATER AND CO2 ASHP

CO2 Advantages

- Low GWP
- Natural Refrigerant
- Produces High Temperatures at Low Ambient

General Challenges of CO2 Hot Water Heat Pumps – EWT Limitations

- CO2 performs well with low entering water temperature and high demand (lift)
- The weakness of the CO2 hot water supply system is that it is inefficient and cannot stably operate when the return water temperature is high such as part load operation
- Requires High Delta T



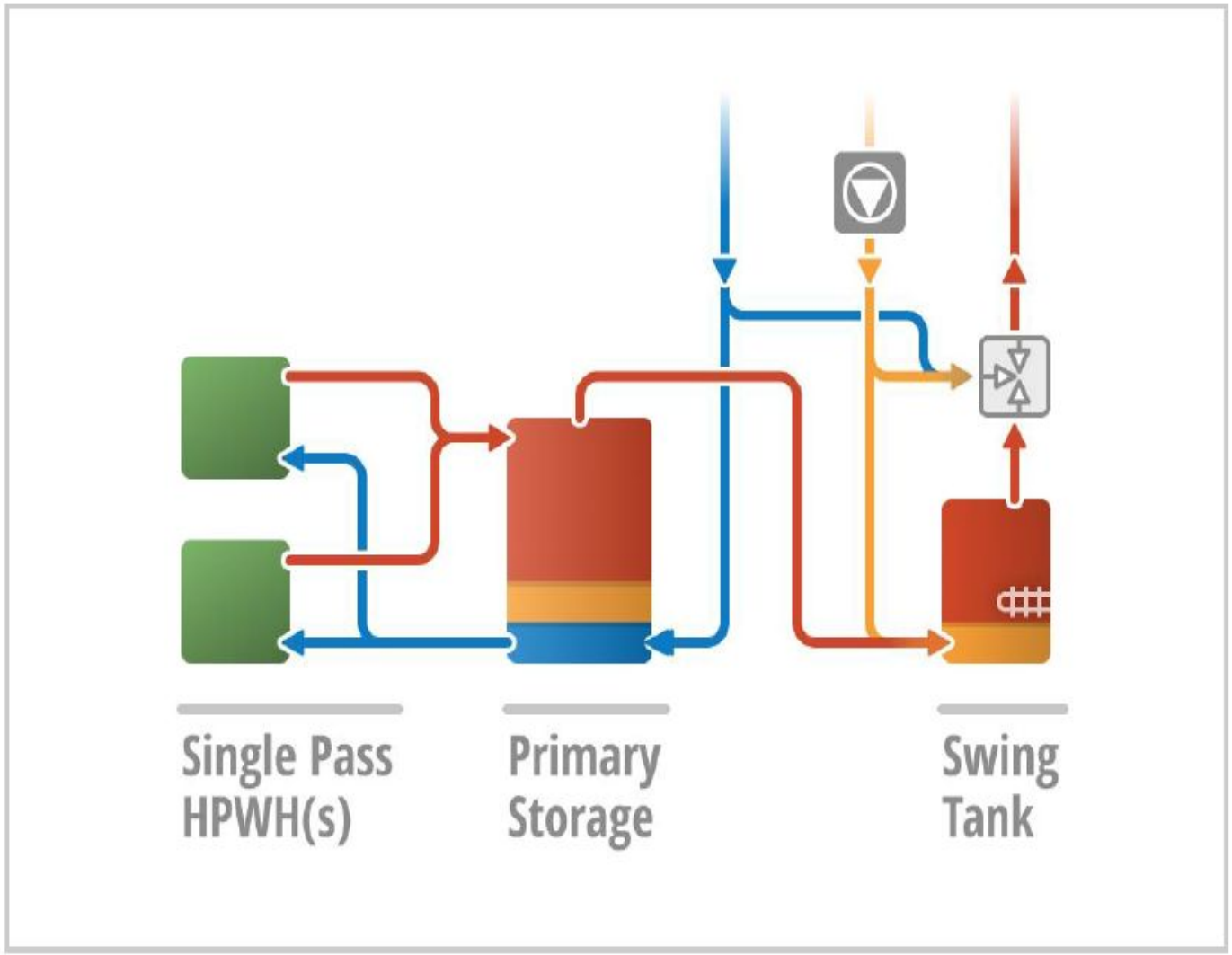
CO2 ASHP Maximum Inlet Water Temp of 86F

Technical Data

			250	350	500
Performance	Nominal Heating Capacity** @ 77°F air	MBH	210	329	494
	Input Power**	kW	16.1	26.8	41.9
	Nominal Recovery Capacity	GPH	233	365	549
	COP		3.8	3.6	3.5
	Primary Outlet Water Temperature Range		140-180°F (60-82°C)		
	Storage Water Temperature		120-170°F (49-77°C)*		
	Ambient Temperature Range		-4-113°F (-20-45°C)		
	Maximum Return Water Temperature		86°F (30°C)		

General Challenges of CO2 Hot Water Heat Pumps – EWT Limitations

- Most DHW centralized systems require a hot water recirculation loop
- The hot water supply to the fixtures is designed at 120F
- The recirculation return temperature is designed at 110F
- The return temperature is too high for the CO2 heat pump to operate
- Low load and tank retention requires electric heat supplement



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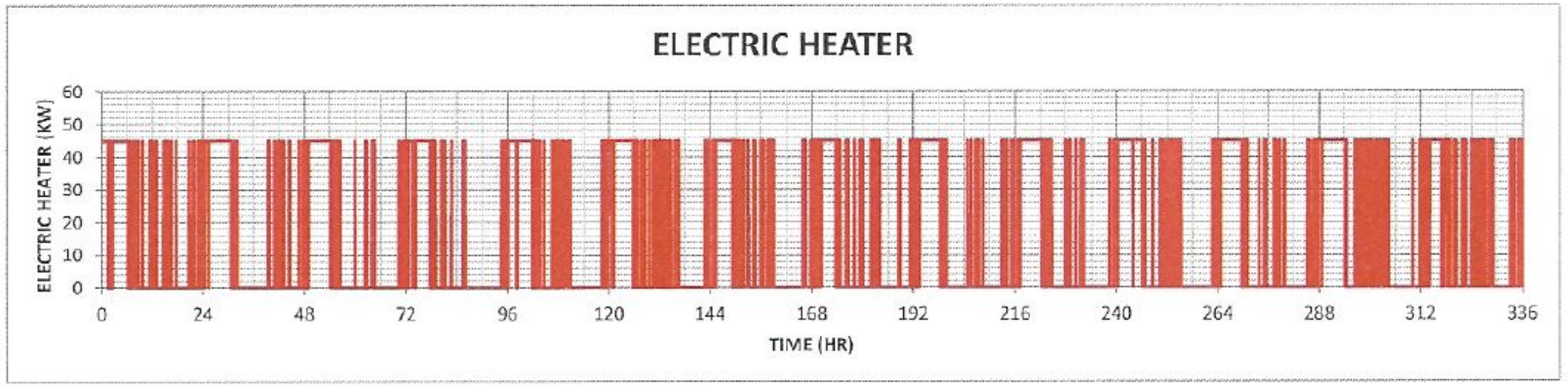
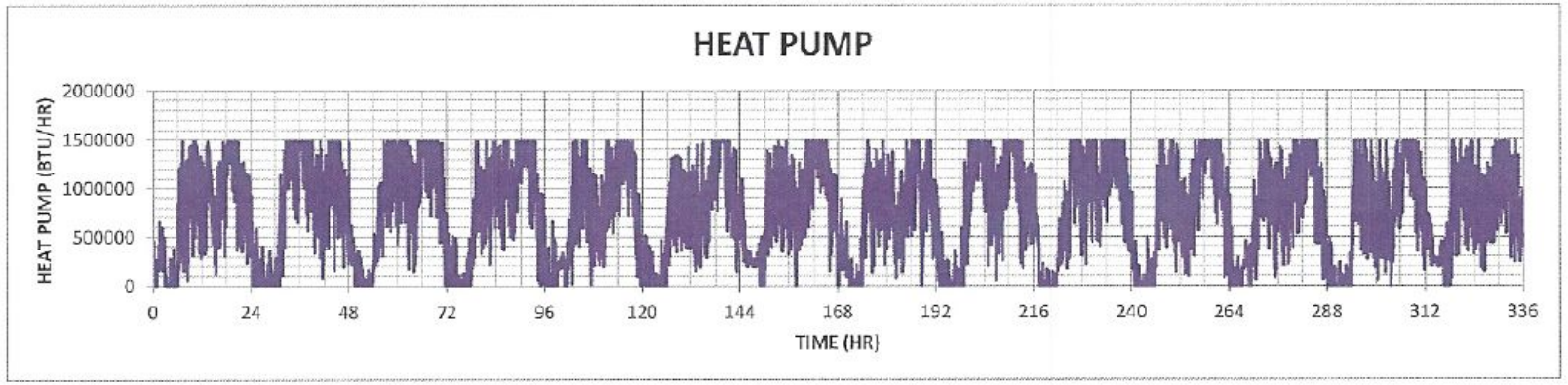
Multyfamily183 Apartments—2 Week Evaluation

- Design is a CO2 ASHP Domestic Hot Water with a 47kW electric heater in the swing tank

- Electric heater consumption was 4700kW over the two week period, 20% of the total system consumption





TANK MIN. TEMP (F)	165.9
TANK AVE. TEMP (F)	170.0
ELECTRIC HEATER CONSUMPTION IN TWO WEEKS (kWh)	4,688
HEAT PUMP EFFICIENCY (COP)	3
HEAT PUMP CONSUMPTION IN TWO WEEKS (kWh)	24,942

CO2 vs 410a

The GWP of CO2 was said to be the major differentiator between it and the R410A unit. While the CO2 emissions linked to the materials used in the units were higher for the CO2 unit (since the unit is twice the size of the R410A one) and the CO2 unit consumed more energy, the CO2 unit revealed 21% lower life cycle emissions over a 10-year life cycle.

Daikin reports that the R410A unit performs notably better and is 13% more energy efficient.

CO2 Conveni-Pack has better LCCP but lower efficiency

2 OCT 2023

BELGIUM: Tests on an optimised CO2 version of Daikin's Conveni-Pack refrigeration system is said to have shown 21% lower life cycle emissions compared to traditional R410A.

https://www.coolingpost.com/world-news/co2-conveni-pack-has-better-lccp-but-lower-efficiency/

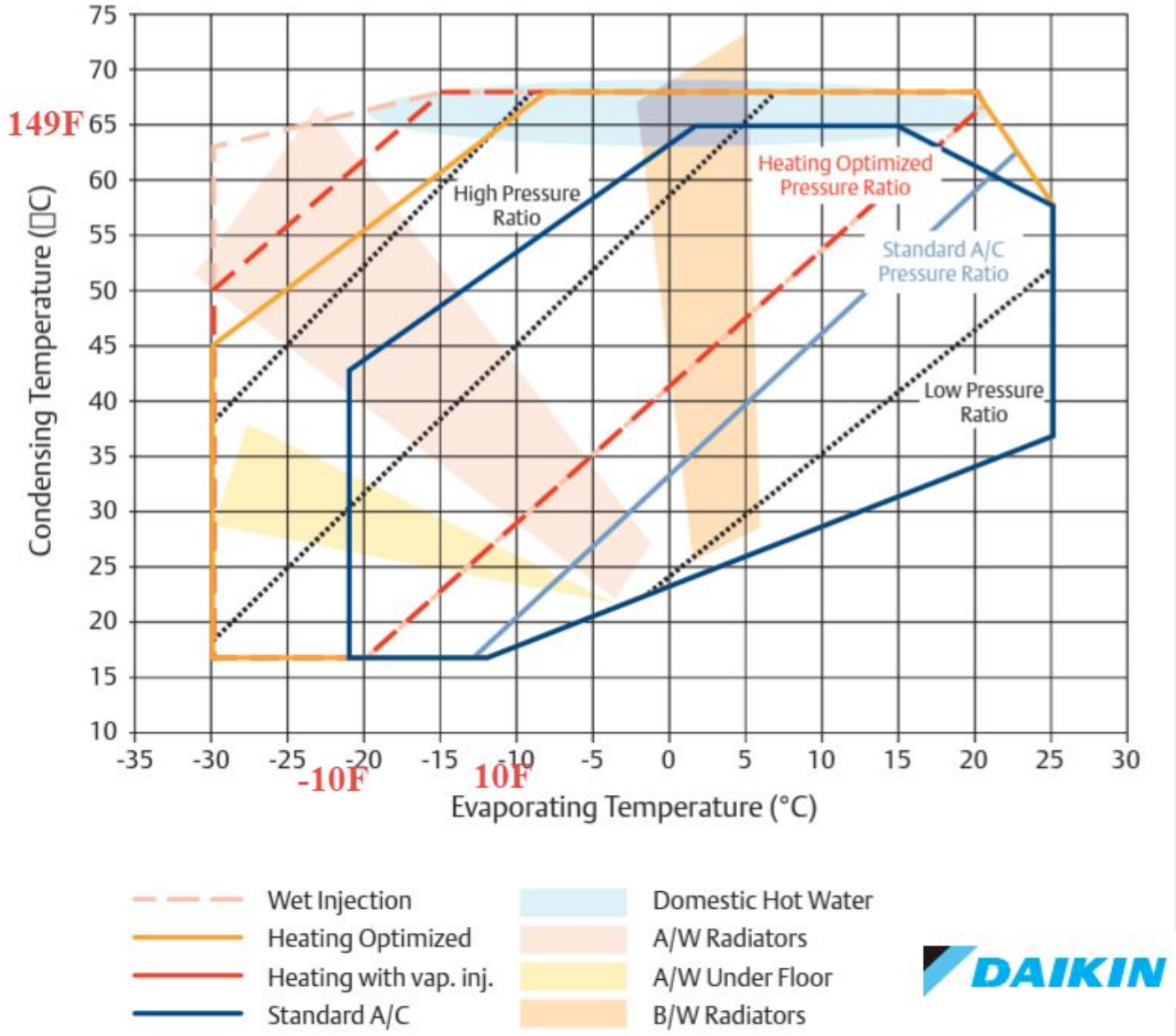
CO2 Challenges in DHW Application

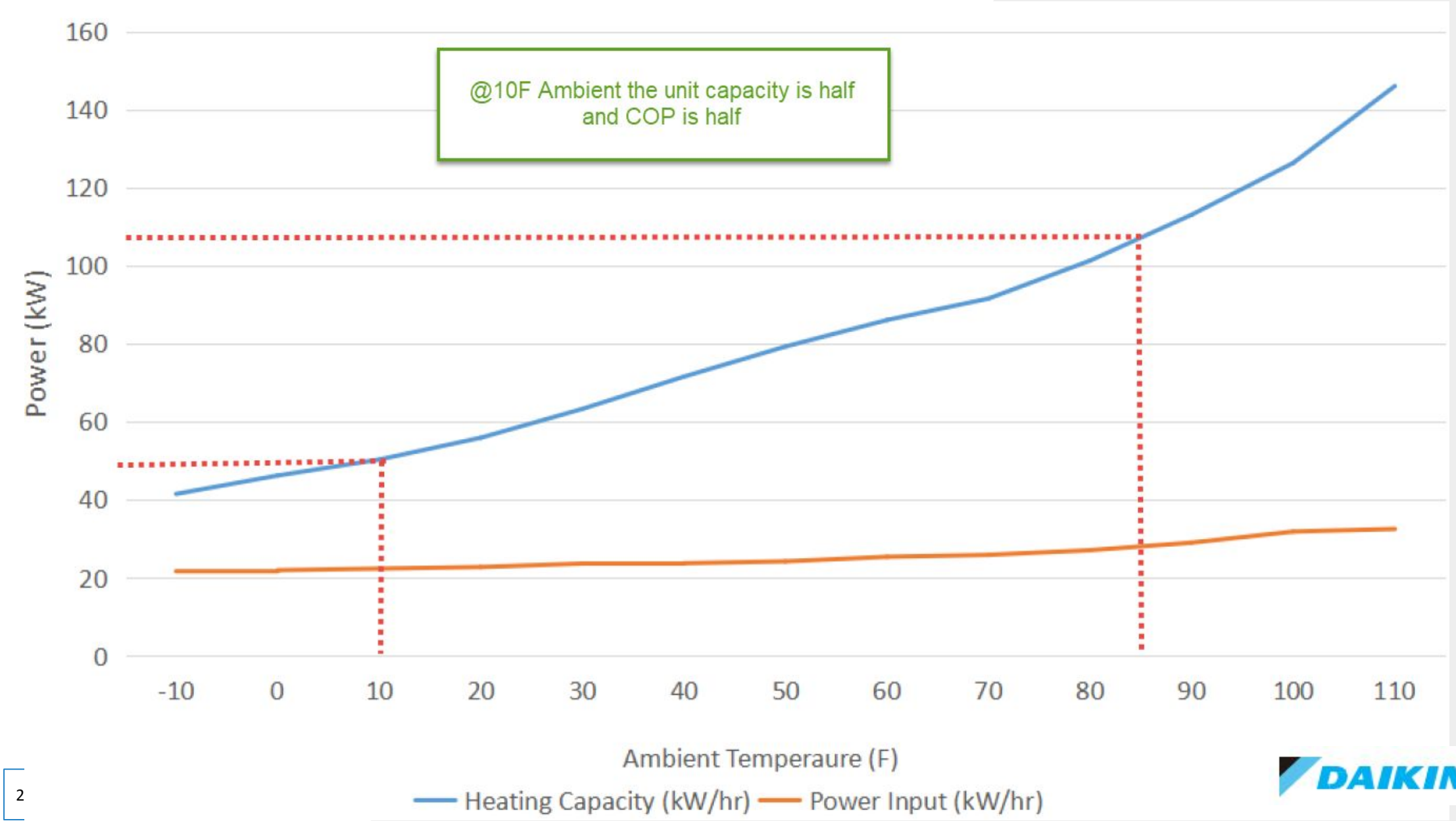
- Unstable inefficient operation when delta T is less than 50F
- Example = 140F storage tank would require a max entering water temperature of 80F for stable operation
- CO2 considerably less efficient than HFC's and HFO's
- Auxiliary electric heat and multiple tanks (swing tank required)
- First Cost
- Service and support

DOMESTIC HOT WATER AND SINGLE STAGE HFO ASHP

R-454b Scroll Compressor Performance

- Approach on the evaporator is 20^{0}F
- @ 10^{0}F ambient the saturated evaporator temperature is -10^{0}F
- Compression ratio is in the “High Pressure Ratio” area
- How does this effect ASHP Performance?




@10F Ambient the unit capacity is half and COP is half
Power (kW)
160
140
120
100
80
60
40
20
0
-10
0
10
20
30
40
50
60
70
80
90
100
110
Ambient Temperaure (F)
Heating Capacity (kW/hr)
Power Input (kW/hr)

Multifamily Example

- Occupancy of 316 people
- Total of 126 Units
- Ecosizer requires 1500 gallons of storage at 150F
- Total HP capacity required 377kBtu/hr

Specified Equipment

- One 50kW heater to maintain the recirculation load
- Two units totaling 12,700mbh required to meet the 377mbh load on a design day

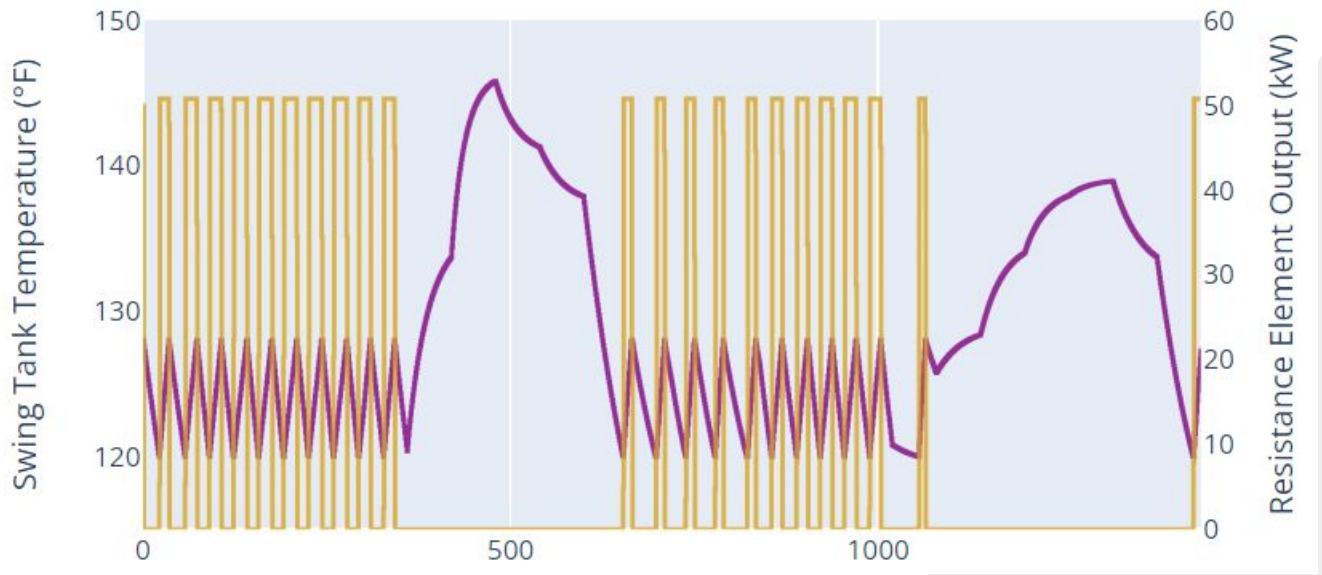
Performance Specifications					
Dry Bulb Temperature (68°F) Wet Bulb Temperature (59°F) Inlet Water Temperature (59°F) Outlet Water Temperature (131°F)	Heating Capacity (Btu/H)	306,000	637,300	310,800	647,400
	Input Power(kW)	21.4	45.0	20.7	43.1
	COP	4.2	4.15	4.4	4.4
Dry Bulb Temperature (45°F) Wet Bulb Temperature (43°F) Inlet Water Temperature (48°F) Outlet Water Temperature (131°F)	Heating Capacity (Btu/H)	248,000	516,600	251,900	524,800
	Input Power(kW)	22.0	45.9	21.4	44.6
	COP	3.3	3.3	3.45	3.45
Dry Bulb Temperature (10°F) Wet Bulb Temperature (7°F) Inlet Water Temperature (43°F) Outlet Water Temperature (131°F)	Heating Capacity (Btu/H)	160,300	333,800	162,800	339,100
	Input Power(kW)	22.4	46.6	21.7	45.2
	COP	2.1	2.1	2.2	2.2

DHW RECIRC REHEAT WATER HEATER SCHEDULE

TAG NO.	SERVES	Q-TY	MANUFACTURER	MODEL NO.	STORAGE (GALS)	RECOVERY RATE (GPM)	ΔT °F	DHW MAWP RATING (PSIG)	CONNECTION SIZE	TOTAL INPUT (KW)	VOLT/ PHASE
EWH-R	ZONE 1 RECIRC	1	HUBBLE	TXA50-12R	-	34.1	10	150	1"	50	208/3

NOTE:
1. HEAT PUMP SOLUTIONS THAT REQUIRE SUPPLEMENTAL ENERGY TO MEET DESIGN CONDITIONS ARE NOT ACCEPTABLE
2. DIMENSIONS & WEIGHTS SHOWN ARE PER UNIT EXCLUDING INSTALLATION CLEARANCES (SEE MANUFACTURE'S CLEARANCE DETAIL FOR SPACE PLANNING)
3. ELECTRICAL DATA SHOWN REPRESENTS THE REQUIREMENTS FOR (1) ELECTRIC WATER HEATER. ELECTRICAL DESIGN SHOULD ACCOUNT FOR THE TOTAL NUMBER OF EQUIPMENT SPECIFIED
4. GLASSOLINED DHW STORAGE TANKS OR TANKS THAT REQUIRE SACRIFICIAL ANNODES ARE NOT ACCEPTABLE
5. PROVIDE INSTANTANEOUS ELECTRIC WATER HEATERS TO SATISFY DHW ZONE RECIRC DEMAND. HEATER SHALL BE SIZED PER KW SCHEDULED

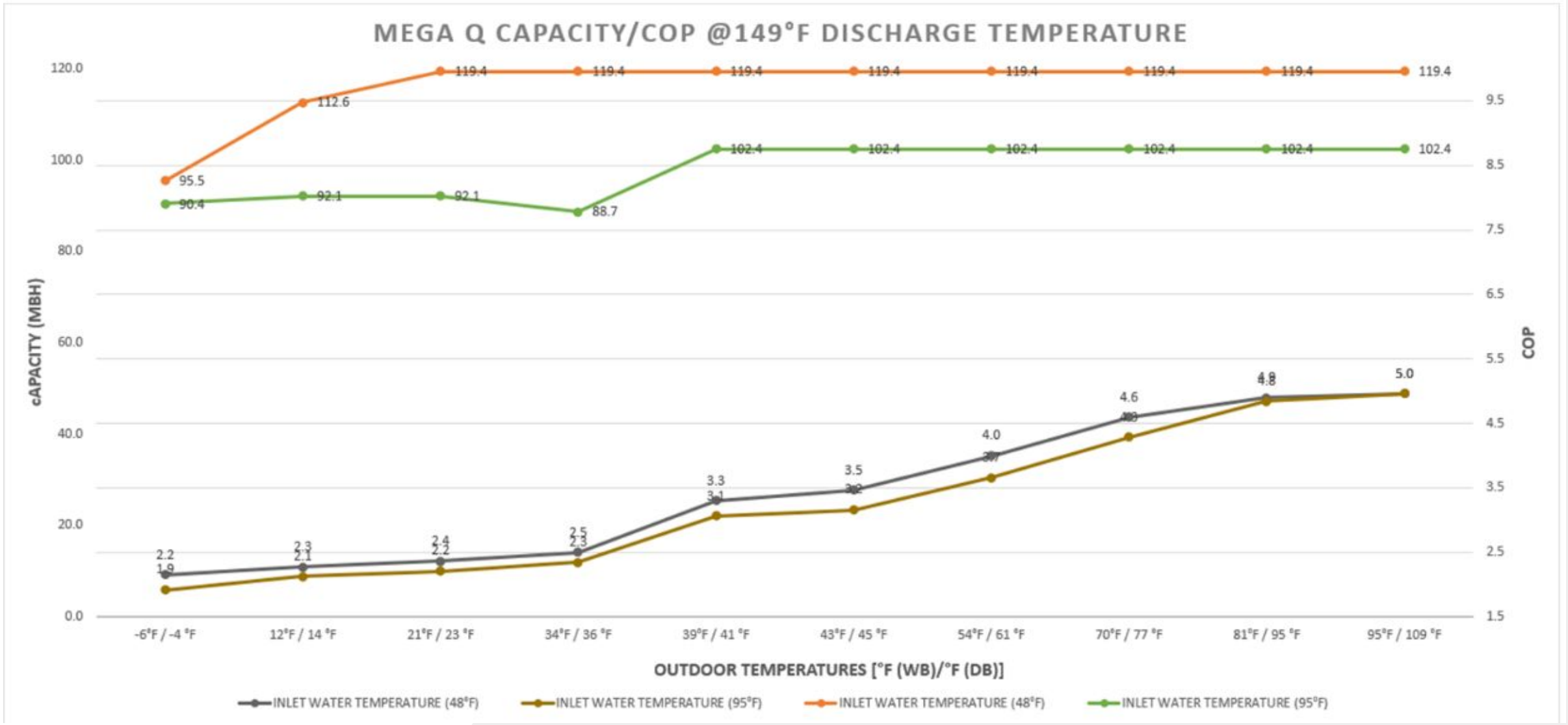
Decarbonization?



Electric Heater Operation

- Ecosizer estimates that the 50kW heater will operate 8hrs/day
- The heater alone will use 146,000kWh/year
- $48,000 for the recirc heater alone
- What controls the heater and ASHP operation to ensure efficient operation

Mega-Q Performance



Daikin Mega-Q Solution

- Total of 4 Mega-Q units required with no electric heater—total capacity of 450mbh
- Mega-Q maintains the tank storage temperature and recirculation temperature
- Booster system installed indoors, no freeze protection or glycol required

Saves 98kWh annually ($32G) on recirculation costs alone

FLA of 212amps VS 423amps

WHY IS THE DAIKIN MEGA-Q PART OF THE PATH TO DECARBONIZATION?

#1 Reason: EFFICIENCY

MEGA-Q Advantages

- Cascade Systems delivery high lift with low compression ratio
- Lowest FLA/MBH of heating—*No Auxiliary Electric Heater*
- Maintain high temperature, efficiency and capacity at low ambient
- Utilize technology that is familiar to HVAC market
- Have been used in the industry since 2009 specifically for high temperature hot water with NYC annual COP of 3.4

THANK YOU FOR YOUR TIME AND ATTENTION

For more information, contact:

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- Scott.Shufflebotham@daikinapplied.com

What about R-410A Phase-down?

To mitigate global warming, Kigali Amendment phases down (not phases out) HFC usage.

There is no phase down of HFC's in ASHP Domestic Hot Water Heaters

ASHP's are quickly moving to 0 ODP and Low GWP refrigerants